Appendix N
Low Impact Development and Sustainability

1. -Final Comprehensive Drainage and Low Impact Development Implementation Study

2. Sustainability Program Summary Report

Appendix N – Low Impact Development and Sustainability

Final

Comprehensive Drainage and Low Impact Development Implementation Study

FINEGAYAN MAIN CANTONMENT AREA, GUAM

April 2010

JOINT GUAM PROGRAM OFFICE

Department of the Navy
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite 100
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NAVFAC
Naval Facilities Engineering Command
NAVFAC PACIFIC

Contract Number N62742-06-D-1870, CTO 0043

Final

Comprehensive Drainage and Low Impact Development Implementation Study

FINEGAYAN MAIN CANTONMENT AREA, GUAM

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Prepared for:

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EXECUTIVE SUMMARY

OBJECTIVE

On behalf of Naval Facilities Engineering Command (NAVFAC), and in support of the United States (U.S.) Marine Corps relocation initiative to Guam, the TEC JV has prepared a draft Comprehensive Drainage and Low Impact Development (LID) Implementation Study for the Finegayan Main Cantonment Area. The LID study was prepared to determine the pre- and post-development hydrology of the site and to determine the stormwater runoff quantities and qualities that need to be accommodated. This characterization of stormwater runoff will allow LID planning to proceed, using a variety of natural and built features that reduce the rate of runoff, filter out pollutants, and facilitate the infiltration of water to the ground. This LID study provides the foundation for the Basis of Design for permanent stormwater infrastructure at the site.

STUDY ELEMENTS

This study provides a step-by-step approach to assessing hydrology on the Finegayan Main Cantonment Area and evaluating sustainable LID stormwater management practices. The elements of the study are identified in Section 1.

A summary of the major elements of the study and findings of the evaluation are provided below.

SUSTAINABILITY AND LID

With the goal of sustainably managing water resources on the Finegayan Main Cantonment, this strategy focuses on resource protection through reuse, treatment, and infiltration of stormwater runoff to reduce impact to Guam's natural resources including the underlying groundwater aquifer.

The goals for LID implementation include:

- Protect existing natural features and ecological processes
- Minimize maintenance requirements
- Maintaining, to the maximum extent technically feasible, the predevelopment hydrology regarding the temperature, rate, volume, and duration of flow
- Integrating water management measures into the development form and landscape to ensure efficient use of landscape spaces and maximize the visual amenity
- Protecting groundwater quality by pre-treating stormwater flows, as appropriate
- Utilizing vegetation for water quality enhancement
- Maximizing water harvesting for non-potable uses

Stormwater management requirements for the Finegayan installation include meeting LEED (Leadership in Energy and Environmental Design) for water quality and quantity. To comply with LEED credit 6.1, it is essential to plan for stormwater volume control from the onset of the project. Stormwater management elements must be included into the master plan at appropriate locations and sizes. To comply with LEED credit 6.2, it is essential to provide water quality treatment for stormwater as close to the source as possible. This is best achieved by utilizing best management practices (BMPs) that act to both meet volume and flow requirements in credit 6.1 and also provide high levels of water quality treatment. Recommendations to meet LEED credit 6.1 and 6.2 and other related credits are detailed in Section 4.2.1. Sustainable LID drainage will also assist in meeting hydrological requirements under the Energy Independence and Security Act 2007 of (elaborated on in Section 2.5).

PRE-DEVELOPMENT STORMWATER RUNOFF MODELING

Pre-development site hydrology was analyzed to obtain a basis of existing stormwater runoff from the site. For pre-development site hydrology, a two dimensional dynamic hydrologic/hydraulic model was developed using FLO-2D for pre-development land use conditions in order to characterize drainage basins and quantify the stormwater runoff (peak and volume) that must be accommodated within the study area. The model was generated based on rainfall, land use and soil information. Simulations were prepared for the 1, 2, 10, 25, 50, 100, and 500-year, 24-hour storm events and the 80, 90, and 95 percent annual exceedance, 24-hour storm events.

The pre-development model results indicated the following:

- The 95 percent exceedance storm event resulted in zero ocean discharge (total outflow volume) and minimal maximum flow depth
- Storm events less than a 1-year storm recurrence interval resulted in zero ocean discharge and minimal maximum flow depth
- Storm events equal to and greater than the 10-year storm recurrence interval resulted in varying volumes of ocean discharge (1.51 million cubic meters at 10-year storm event) and varying maximum flow depths increasing with larger recurrence interval
- The 50-year storm recurrence interval resulted in 5.98 million cubic meters of ocean discharge and standing water across the entire drainage area
- The 100-year storm recurrence interval resulted in 7.27 million cubic meters of ocean discharge and standing water across the entire drainage area

POST DEVELOPMENT STORMWATER RUNOFF MODELING

The FLO-2D model developed for the pre-development stormwater modeling was modified for the post-development conditions. Post-development hydrology was based on the Guam Joint Military Master Plan (GJMMP), Site Development Plan dated September 18, 2009 (NEPA Alternative A) and Notional Grading Plan (Appendix B.1).

The post-development model results indicated the following:

- Generally, ocean discharge occurred at less than the one year storm interval and intensifies throughout the increasing storm event
- The 95 percent exceedance storm event resulted in 1,540 cubic meters of ocean discharge and minimal maximum flow depth
- The 1-year storm recurrence interval resulted in 16,000 cubic meters of ocean discharge and standing water across the entire drainage area
- The 10-year storm recurrence interval resulted in 2.72 million cubic meters ocean discharge and standing water across the entire drainage area
- The 50-year storm recurrence interval resulted in 8.59 million cubic meters of ocean discharge and standing water across the entire drainage area
- The 100-year storm recurrence interval resulted in 10.81 million cubic meters of ocean discharge and standing water across the entire drainage area

The results of the large-scale FLO-2D model will help future site developers understand the pre-development and post-development drainage patterns on a site-wide basis for these design storm events. In particular, the model results should be consulted prior to final design of detention basins. The model results are also useful to understand natural ocean discharge locations, sinkhole locations and natural stormwater storage, general drainage patterns during different storm events, natural flooding characteristics, run-on distribution to the project site, and total project related change in infiltration/storage/runoff excluding engineered stormwater control (e.g., BMPs and detention basins).

NOTIONAL GRADING PLAN

A notional grading plan was prepared as a tool to develop post-development hydrology. The notional grading plan contemplates mass grading of the entire cantonment site with the exceptions of the Naval Communications Reserved Areas (NAVC) parcels (existing Naval Computer and Telecommunications Station [NCTS] Finegayan communications equipment areas), proposed OS-P parcels (open space preserve), and HSG parcels (accompanied housing areas). Mass grading depicted in the notional grading plan is based on existing LIDAR topography supplied by the Navy. The notional grading plan was derived from several precedent projects such as the Government of Japan (GoJ) Phase 1 U&SI program, the GoJ Phase 2 utilities and site improvement (U&SI) program, and other studies involving grading and earthwork, plus original mass grading concepts derived under this project. The notional grading plan is contained in Appendix B.1 and incorporates the following key aspects:

- A maximum 2(h) to 1(v) slope gradient, but milder slopes are encouraged where feasible
- A 1 percent (%) minimum to 4% maximum gradient on developable areas
- Grading of the Smart Growth areas in concert with the U&SI programs

DRAINAGE IMPACTS

After preparation of the notional grading plan and development of the post-development hydrology for the project area, drainage routes with each parcel of developable area were designed in context with the proposed treatment trains depicted in Section 12. While 1, 2, 10, 25, 50, 100 and 500-year, 24-hour storm events and the 80, 90, and 95 percent annual exceedance storms were modeled in Section 8, a combination of storm events ranging from a 2-year 24-hour event up to a 100-year 24-hour storm was chosen as the basis of drainage facility sizing for onsite detention and storage systems. In general the detention systems modeled within this study were sized by first determining the total storm discharge in a 100-year 24-hour event. Ultimate disposal sites were selected for storm water disposal and volumes were calculated. Subtracting the total disposal available from the total storm yielded a total detention requirement. This total on-site detention requirement was then dispersed throughout the GJMMP. These on-site detention and storage systems were placed in context of the GJMMP in almost all cases with little or no effect on the GJMMP. In a few instances, proposed drainage facility sizes were so large or were within a wellhead protection area that conflicts arose. When conflicts arose and no other logical, cost effective solution was present, the conflicts were placed into a conflict table for documentation. These conflicts are outlined in the Conflict Table (Table A.1 in Appendix A). Outflow from the drainage devices, or "secondary overflow" as it is referred to in the report, was conceptualized for the main cantonment area. Secondary overflow routes show the discharge locations and overland routes from drainage facilities to the ultimate disposal site of stormwater flows. Secondary overflow routes can be seen on the Notional Grading Plan (Appendix B.1) as well as the Detention Basin Plan (Appendix B.2). Key aspects of the drainage impacts are:

- 465 hectares (1,150 acres) of grading anticipated within the main cantonment area

- The site has several sinkholes present. Care should be taken to avoid untreated stormwater from entering sinkholes for storms with a return frequency less than 100 years unless required for ultimate disposal
- Sinkholes are acceptable areas of stormwater discharge for storm events greater than a 100-year event
- Buildings (habitable structures) need protection from flooding up to and including a 100-year event
- Drainage facilities for each drainage subbasin should be sized to store storm events ranging from 2-year, 24-hour events to 100-year, 24-hour events depending upon location and downstream ultimate disposal storage volumes
- Stormwater detention basins, underground stormwater storage areas, site micro-storage are all considered appropriate means and methods of storing a 50-year 24-hour storm event
- Detention basins shall utilize flow spreaders to discharge stormwater flows in excess of design capacity as a means of safely discharging secondary overflow
- Secondary overflow routes are conceptually shown within this study, but need careful consideration by future designers for insuring protection of building flooding up to and including a 100-year storm event
- Limits of grading and limits of site disturbance should not encroach onto OS-P (open space preserve) parcels
- Detention basins should be located outside the existing domestic water well protection zones, wherever possible

OVERALL DRAINAGE AND INFILTRATION SCHEMES

Existing drainage primarily flows overland and infiltrates into the natural ground. In as much as practicable, the proposed drainage scheme and infiltration schemes emulates the existing condition. Post-development 95 percent exceedance stormwater flows, computed in Section 12, are captured, treated, and routed through the various sites, in predominantly surface flow devices. In some instances, subsurface piping is necessary to cross driveways, sidewalks and other GJMMP land uses. Ultimately, after traveling through the Integrated Management Practice (IMP)/BMP treatment trains (discussed in Sections 11 and 12), stormwater flows in excess of the 95 percent exceedance storm event are directed to an underground stormwater detention system and an open-air detention basin(s) for each parcel. For both the underground detention system and the detention basin, the ultimate outflow of storm events deposited in the detention facilities is through infiltration into the underlying coralline limestone formation. Overflow from the detention basins in multiple back-to-back storm events that are greater in size than a detention basin's capacity, or a singular storm greater than a a detention basin's capacity ("secondary overflow" as it is referred to in the report) was conceptualized for the main cantonment area. Secondary overflow routes show the discharge locations and overland routes from drainage facilities to the ultimate disposal site of stormwater flows. Secondary overflow routes are shown on the Notional Grading Plan (Appendix B.1). Detention basin facilities and underground detention systems are depicted on the Detention Basin Map (Appendix B.2). Key aspects of the drainage and infiltration schemes are:

- Infiltration rates are quite high in the permeable coralline limestone formation
- Detention basins have no planned outfalls: infiltration of stormwater into the underlying limestone formation is anticipated

- Siting of stormwater detention basins is conceptualized in this report at the low point of each parcel to accept as much upstream stormwater flow as possible
- Underground stormwater detention systems are conceptualized in this report below paved areas to assist in storing stormwater and to minimize footprints of stormwater detention basins
- Detention basins footprints in non-residential areas are conceptually shown with 2m and 3m depth

POTENTIAL FOR GROUNDWATER CONTAMINATION

The bedrock at NCTS Finegayan, including the Main Cantonment Area is entirely karst limestone, which is in a continual state of dissolution from percolating rainwater. Rainfall amounts to between 85 and 105 inches annually, of which about 80 percent infiltrates the land surface, and 20 percent is returned to the atmosphere through evapo-transpiration. The limestone plateau, which stands 350 to 500 feet above sea level, is fractured and faulted and contains numerous sinkholes and closed depressions. When rainfall is moderate, water infiltrates the land surface and works its way slowly down through the limestone to the water table, which is typically 3 to 5 feet above sea level. Heavy rains cause runoff, which can find its way down hill to sinkholes and depressions. Water may pool in these low areas temporarily, but then it rapidly infiltrates. In the extreme case, sinkholes may short-circuit water directly to the water table along shafts, fractures, faults and other voids in the limestone. Runoff enlarges sinkholes through dissolution, making the sinkhole a more ready conduit for water to flow from the ground surface to the water table. Closed depressions may represent incipient sinkholes. The overall concern is that the karst limestone is a poor filter for contaminants. This is particularly so at sinkholes, faults and similar features, which represent preferential pathways for the movement of water and pollutants.

NCTS Finegayan rests on top of the Northern Guam Lens Aquifer (NGLA), which is the term for the approximately 67 square-mile limestone aquifer underlying nearly all of northern Guam. The United States Environmental Protection Agency (EPA) has designated the NGLA a Sole Source Aquifer. This designation gives EPA review authority over federally funded projects planned in a Sole Source Aquifer, with the purpose of protecting groundwater. The NGLA is divided into several subbasins: NCTS Finegayan is in the Finegayan subbasin. The sustainable yield of the NGLA is approximately 80 million gallons per day (MGD), and the Finegayan subbasin has a sustainable yield of at least 11.6 MGD. Seven public water supply wells are currently operating at NCTS Finegayan, and another 11 wells nearby are being operated by the Guam Water Works Authority (GWA). Most of these wells produce between 100 and 200 gallons per minute (gpm), or about 0.14 to 0.29 MGD. While the highly transmissive limestone of the NGLA would support much higher withdrawal rates, pumping is limited to avoid up-coning of saltwater, which underlies the freshwater lens of the NGLA.

Compared to other parts of Guam, NCTS Finegayan and the Finegayan subbasin in general have relatively few potential sources of groundwater contamination, i.e., hazardous wastes, solid wastes, underground storage tanks, and the like. Only one Installation Restoration Program (IRP) site – Potts Junction Tank Farm – has been identified in the Finegayan sub-basin, but to date no contaminant releases have been identified here. IRP sites are those that originate from US Military activities. Cleanup activities (soil removal or remediation) have been recommended at a few of the sites identified. The remaining sites identified either: 1) are yet to be investigated, 2) appear to be minor, 3) are unconfirmed, or 4) require no further action. Nitrate and coliform bacteria are common in public water supply wells in the NGLA. These undoubtedly originate from septic systems, fertilizer applications and perhaps animal feedlots.

In summary, the hydrogeologic conditions at NCTS Finegayan present a challenge in designing for LID and protecting groundwater quality. Sinkholes, faults, fractures, and other karst features – which are widespread on this site – represent preferential pathways for pollutants to enter the NGLA and degrade water quality. The locations of many of these karst features are known, but others may yet to be discovered. In addition, the limestone in general is a poor filter for contaminants. Stormwater runoff should be minimized, and directed away from sinkholes, similar preferential pathways, and known or suspected waste sites.

WATER QUALITY PROTECTION STRATEGIES

Proposed water quality protection strategies for the Finegayan Main Cantonment Area consist of employing green stormwater management principles and IMP designs to the maximum extent practicable within each of the subbasins located within the project area. The LID stormwater management strategy for the Finegayan Main Cantonment Area employs both nonstructural and structural approaches, and an overview of these approaches is included in this study. To create a stormwater pollutant removal strategy for the Finegayan Main Cantonment Area, target pollutants of concern must first be identified. The main pollutants of concern as addressed in this study are: total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN), metals, bacteria, and hydrocarbons. Impervious surfaces can accumulate these pollutants which in turn can be rapidly washed off during storm events and transported downgradient to sensitive receptors. Certain locations within the Finegayan Main Cantonment Area would likely contain land uses and activities with higher pollutant loading such as hydrocarbons and trace metals. These locations are referred to as stormwater "hotspots" and would require additional levels of consideration when choosing specific IMPs and treatment trains.

The palette of options for structural IMPs considered for this study was compiled from a variety of sources, including the Department of the Navy Strategic Forward Basing Initiatives *Low Impact Development Manual*, the *CNMI and Guam Stormwater Management Manual*, LID UFC 3-210-10 and LID UFC 3-210-10N, and Sustainability UFC 4-030-01, and other continental United States stormwater management sources. Information compiled included: a description of the IMP, typical IMP treatment train function/position (rooftop evapotranspiration, pre-treatment, conveyance, treatment, infiltration, and storage), primary advantages/disadvantages, pollutant removal efficiencies (where known), constructability and other considerations, maintenance requirements, and a recommendation of whether or not the IMP is suitable for use in the Finegayan Main Cantonment Area or has limited/specific application. Many of the IMPs are variations of the same general IMP type, but are still included in Table 11-3 for comparison purposes because there is no one "correct" IMP to satisfy every situation. Thus, during the final design of the stormwater management system of the cantonment, situations may arise where the site designers may need to substitute one of the recommended IMPs in a treatment train for another IMP option in the palette in order to solve a specific design constraint within a subbasin.

The goal of identifying and evaluating a variety of possible IMP options is to reduce these options based on a variety of factors, including pollutant reduction efficacy, and then group these IMPs into "treatment trains" to effectively reduce pollutants of concern within a particular portion of a subbasin. These treatment trains refer to the grouping and sequencing of a series of selected structural IMPs to achieve improved stormwater quality in a step-wise fashion as stormwater flows from one IMP to the next.

ASSESSMENT OF LONG-TERM IMP SCENARIOS

In order to further reduce the palette of 23 potential stormwater IMPs and one IMP accessory and determine if an IMP is recommended, not recommended, or of limited or special applicability for the Finegayan Main Cantonment Area, the following parameters were assessed for the IMP selection process: land use, physical feasibility, watershed protection goals, stormwater management capability, pollutant removal, and community and environmental concerns. Constraints as well as opportunities are anticipated to be present for implementing integrated stormwater management components at the Finegayan Main Cantonment Area. These constraints and opportunities were also taken into account in selecting IMPs for treatment trains. While pollutant reduction efficacy is one of the most important parameters in determining the appropriateness of an IMP, no one parameter used for the assessment determined the final recommendation of an IMP; all of these factors were considered together to make the determination.

Recommended IMPs as identified in this study include: drywells, stormwater oil/sediment separators, filter strips, dry swales, bioretention basins, subsurface stormwater infiltration systems, proprietary subsurface TSS filter chambers, and dry detention basins. The following IMPs and IMP accessories were among those identified as having limited or special application: rain barrels and cisterns, porous pavement, and inlet protectors.

Based upon the selection of recommended IMPs and also considering IMPs with limited or specific application for particular scenarios, these IMPs were then grouped into treatment trains by function. Each of the five treatment trains represents a recommended sequencing of IMPs to address a specific pollutant source scenario. The five treatment trains include: Treatment Train A: Rooftop Runoff; Treatment Train B: Impervious Paved Areas with Insignificant Oil/Suspended Metals; Treatment Train C: Impervious Paved Areas with Significant Oil/Suspended Metals, or Large Areas for Vehicle Parking; Treatment Train D: Impervious Paved Roadways with Insignificant Oil/Suspended Metals; Treatment Train E: Landscaping, Grass, and Recreation Areas. These five treatment trains represent the typical treatment train types to be used on site and are generally modeled after the five treatment trains identified in the *Low Impact Development Manual*. Variations of one or more of these five treatment trains would likely be needed under certain circumstances in order to adapt to a particular site constraint within a particular subbasin. Hence, the IMP sequences presented for each treatment train are flexible. Alternative IMP options could be substituted from the palette of options provided.

Step-wise pollutant reduction efficiencies for each pollutant of concern are provided for each treatment train up to the 95 percent exceedance storm. In addition, schematic flow diagrams of each of the five treatment train types are provided. Each diagram shows both the specific recommended IMP and the function that IMP provides for each step in the treatment train.

STORMWATER IMP LAYOUTS

In order to demonstrate the ability of the recommended treatment trains to manage and treat stormwater runoff within the proposed development for the Finegayan Main Cantonment Area, five representative subbasins were assessed. These ranged from a relatively open area consisting of apartment housing complexes and associated parking areas, to an almost completely impervious subbasin with storage and vehicle maintenance areas. The primary objective in assessing long-term stormwater management options was to provide storage and treatment for all runoff generated within each subbasin by the 95 percent exceedance storm event (the water quality volume), with an emphasis on above ground BMPs to encourage evapotranspiration, create a base-wide aesthetic benefit, and protect groundwater resources.

Stormwater runoff within each of the five representative subbasins was simulated using HydroCAD stormwater modeling software. HydroCAD is one of the standard methods used for these types of analyses, and was used to determine peak discharge rates, as well as to size the various surface, subsurface, and conveyance BMPs. The treatment train components include dry wells (for roof runoff only), dry swales, filter strips, bioretention basins, oil/sediment separators, and subsurface infiltration systems. GIS based figures showing the recommended IMP treatment train layouts for each subbasin are presented in Section 12.

NON-POINT SOURCE CONTAMINATION ASSESSMENT

TSS, TP, and TN pollutant loads to each subbasin in the Study Area through stormwater runoff were estimated using the Simple Method (Schueler 1987) for both existing and future conditions (i.e. implementation of land uses proposed in the Draft GJMMP). The Simple Method estimates stormwater pollutant loads by: 1) estimating runoff volumes using runoff coefficients for the land uses within the watershed to convert rainfall data into runoff volumes; and 2) estimating pollutant loads using runoff volumes and pollutant event mean concentrations (EMCs). The sources of data used for the non-point source pollutant loading assessment are detailed in Section 10.1.1.

The results of the non-point source pollutant loading model, which are presented in Section 10.1.2, indicate that non-point source loads increase from the existing to the future land use condition for all three parameters as a result of the proposed development, with TP and TN loads more than doubling. It is important to note that these results are based on the assumption that no stormwater management practices (i.e. BMPs or IMPs) are in place for both existing and future conditions.

To assess the potential for pollutant load reductions to the future conditions, non-point source modeling was also conducted to estimate future loading estimates with recommended IMP treatment trains proposed for the five representative subbasins in place. These recommended treatment trains are identified in Section 12.4. For this assessment, the modeled future land use pollutant loads presented in Section 10 for each subbasin were used for the pre-treatment annual loads. Then, the estimated IMP treatment train reduction efficiencies identified in Table 12-1 were applied to determine the amount of pollutant loads removed from the various land use categories. As shown in Table 12-2 through Table 12-4, this process resulted in estimated TSS reductions of 83.7% to 90.3%, TP reductions of 9.4% to 49.9%, and TN reductions of 11.2% to 62.6% for the representative subbasins. These results illustrate that use of IMPs can achieve significant reductions to non-point source pollutant loads.

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APPENDIXES

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

%	percent
°F	degree Fahrenheit
AFB	Air Force Base
AMC	antecedent moisture condition
AOC	area of concern
ARI	average return interval
BMP	best management practices
CADD	computer-aided design and drafting
cfs	cubic feet per second
CNMI	Commonwealth of the Northern Mariana Islands
DEIS	Draft Environmental Impact Study
EISA	Energy Independence and Security Act of 2007
EMC	event mean concentration
EPA	Environmental Protection Agency, United States
ESI	Engineering Solutions, Inc.
fps	feet per second
ft	feet
ft/day	feet per day
ft/sec	feet per second
ft^2	square foot
ft^3	cubic foot
GI	green infrastructure
GIS	geographic information system
GJMMP	Guam Joint Military Master Plan
GOJ	Government of Japan
gpm	gallons per minute
GWA	Guam Waterworks Authority
HSG	hydrologic soil group
IMP	integrated management practices
in/hr	inch per hour
IR	Installation Restoration
LEED®	Leadership in Energy and Environmental Design
LID	low impact development
LIDAR	Light Detection and Ranging
LS	Lump Sum
m^2	square meters
m^3	cubic meters
MFA	Masa Fujioka & Associates
mg/L	milligrams per liter
mm	millimeter
msl	mean sea level
NAVAL	Naval Communications
NAVC	Naval Communications Reserved Areas
NAVFAC	Naval Facilities Engineering Command
NBG	Naval Base Guam
NCTS	Naval Computer and Telecommunications Station
NED	National Elevation Dataset

NGLA	Northern Guam Lens Aquifer
No.	number
NOAA	National Oceanic and Atmospheric Administration
OS	Open Space
OS–P	Open Space–Protected
PCS	potential contaminant sources
POV	privately owned vehicle
PUB	Public Utilities Board
PV	photovoltaic
SCS	Soil Conservation Service
SSIM	Sustainable Systems Integration Model
SWPPP	Stormwater Pollution Prevention Plan
TN	total nitrogen
TP	total phosphorus
TR	Technical Release
TSS	total suspended solids
U&SI	utilities and site improvement
U.S.	United States
UFC	Unified Facilities Criteria
UIC	underground injection control
URS	URS Corporation
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WERI	Environment Research Institute of the Western Pacific, University of Guam
WHPA	Wellhead Protection Area
WQ_v	water quality volume

1. Introduction

1.1 PURPOSE

On behalf of NAVFAC, and in support of the United States (U.S.) Marine Corps (Marine Corps) relocation initiative to Guam, the TEC JV has prepared a draft Comprehensive Drainage and Low Impact Development (LID) Implementation Study for the Finegayan Main Cantonment Area. The LID study is being developed to determine the pre- and post-development hydrology of the site, which will be used to determine the stormwater runoff quantities and qualities that will need to be accommodated. This characterization of stormwater runoff will allow LID planning to proceed, using variety of natural and built features that reduce the rate of runoff, filter out pollutants, and facilitate the infiltration of water to the ground. LID planning will ultimately provide the foundation for the Basis of Design for permanent stormwater infrastructure at the site.

1.2 SCOPE OF WORK

To achieve the stated objective, a step-wise approach outlined in the following project scope of work has been followed.

- For the predevelopment state, characterize stormwater runoff generation (rates, volumes, durations, overland flow patterns) and infiltration patterns using available topographic and soil/geologic information, for the following storm events:
  - 1-year and 2-year 24-hour storms;
  - 10-, 25-, 50-, 100-, and 500-year 24-hour recurrence event storms; and
  - 80 percent (%) (0.8-inch), 90% (1.5-inch), and 95% (2.2-inch) annual exceedances.

  Evaluate the contribution of offsite runoff into the area of interest for each storm event. Determine if there are discharges to the ocean from the area of interest during the storm events of interest. Characterize the relationships on site between stormwater and groundwater in terms of ranges of infiltration rates and percolation time to groundwater. (Please refer to Sections 5 and 8 for additional detail.)

- Based on available references, provide preliminary grading schemes to accommodate the facilities depicted in the current version of the Guam Joint Military Master Plan (GJMMP) dated September 18, 2009 (NEPA Alternative 2), including minimum and maximum site slopes; objectives to minimize cut and fill quantities; and preliminary grading schemes for the undetermined future uses of Smart Growth Areas. (Please refer to Section 6 for additional detail.)
- Based on the grading schemes developed, provide notional stormwater routing scenarios. Provide preliminary siting and sizing of stormwater detention basins based on the development plan and associated imperviousness. Address Smart Growth Areas in their interim undeveloped state and at buildout using a range of postdevelopment imperviousness. Address the need for dry wells and placement constraints, and stormwater routing near sinkholes. (Please refer to Section 9 for additional detail.)
- Assess drainage impacts resulting from the proposed site development and grading schemes. Provide the limits for site disturbance, including setbacks from the shoreline and steep slopes, and address wellhead protection setbacks. (Please refer to Section 7 for additional detail.)
- Address site contamination (runoff and/or leaching from installation restoration [IR] sites) and water quality issues. Based on the most current land use plan, estimate loading of total suspended solids (TSS), nutrients, and contaminants of concern from various areas. Address

groundwater contamination issues related to sinkholes in terms of preferential pathways for percolation to groundwater. (Please refer to Section 10 for additional detail.)

- Address maintaining predevelopment hydrology to protect water quality (based on most current land use map). Based on available references, assess efficacy of bioretention, filtration, and other strategies for removal of pollutants. Address the potential impacts to groundwater from stormwater infiltration. (Please refer to Section 11 for additional detail.)
- Based on current available references, recommend best management practices (BMPs) and Integrated Management Practices (IMPs) best suited for the Northern Guam environment. Provide notional layouts of IMPs throughout the development. These should include potential layouts of site-specific IMPs at various sites and land uses within the development plan, and a conceptual configuration of "neighborhood level" IMPs at various areas within the base (with associated stormwater runoff routing requirements). (Please refer to Section 12 for additional detail.)
- Estimate the required sizing and placement of onsite stormwater detention basins and the interaction of the basins with stormwater routing and water quality improvement IMPs. Address the potential use of Anti-Terrorism/Force Protection setbacks, roadway shoulders, open space, and Smart Growth Areas for IMPs. (Please refer to Sections 9 and 12 for additional detail.)
- Address strategies for avoiding/minimizing traditional underground storm drainage infrastructure. (Please refer to Section 9 for additional detail.)
- Provide Guam budgetary construction cost estimates for recommended IMPs identified. (Please refer to Section 13 for additional detail.)
- Prepare a sustainability study documenting stormwater resource issues associated with green building practices such as, preserving/enhancing site permeability; rainwater harvesting; stormwater adopting quantity and quality strategies; and using green roofs. The study should also provide recommendations for architectural and aesthetic stormwater elements. (Please refer to Sections 4 and 11 for additional detail.)

2. Regulatory Framework

From planning through operation and maintenance, the local and federal regulatory framework should be considered in every stage of the development process. These regulations provide planners, designers, and engineers with design criteria and guidelines to aid in creating sustainable development that protects the water resources of Guam. This section provides a brief overview of five of the primary regulations that apply to the Finegayan Main Cantonment and how this LID planning document should be utilized in meeting the standards set forth in each regulation.

2.1 CNMI AND GUAM STORMWATER MANAGEMENT MANUAL

The Commonwealth of the Northern Mariana Islands (CNMI) and Guam Stormwater Management Manual was prepared by Horsley Witten Group, Inc. for the CNMI and Guam for the engineers, plan reviewers, and regulated community of the CNMI and Guam (Horsley Whitten Group 2006). Horsley Witten Group, Inc. compiled stormwater management techniques developed in the United States to create a single comprehensive reference manual that promotes the protection of water resources in Guam and the Northern Mariana Islands. The manual is intended to update and replace existing reference manuals, including of the *Guam Storm Drainage Manual* (USACE 1980) and the *Erosion and Sediment Control Manual* (GEPA 2000), and *Stormwater Control Handbook* (Northern Islands Company 1989). Designers, reviewers, and the regulated community shall continue to use existing reference manuals as references for general hydrology, drainage design and pipe sizing, floodplain management, and design specifications for erosion and sediment control practices.

Volume I of the manual includes an overview of local stormwater management concerns, design criteria and performance standards, and acceptable BMPs. The manual sets forth a set of 11 erosion and sediment control standards to adhere to during construction (Volume I, Chapter 2.1) and 13 post-construction performance standards (Volume I, Chapter 2.2) for all new development and redevelopment projects. Volume II includes detailed design and analysis tools for site layout, BMP selection and construction, landscape planning, and long term maintenance planning.

A full suite of acceptable BMPs (Volume I, Chapter 3) along with six comparative matrices (Volume II) are provided for BMP selection based on site specific factors including land use, physical feasibility, watershed, stormwater management capability, pollutant removal, and community and environmental. The analysis provided in the following Sections of this report will aid in better defining these characteristics at the Finegayan Main Cantonment Area. Furthermore, recommendations on BMP selection and overall site design based on water quality protection, the limestone geology, and other governing design factors specific to the Finegayan Main Cantonment Area are also provided herein.

2.2 GUAM STORM DRAINAGE MANUAL

The Guam Storm Drainage Manual was prepared by the U.S. Army Corps of Engineers in 1980, and preceded the *CNMI and Guam Stormwater Management Manual (*Horsley Whitten Group, Inc. 2006) referenced above. Although the *CNMI and Guam Stormwater Management Manual* is intended to update and replace existing reference manuals, the Guam Storm Drainage Manual contains important information that is not captured elsewhere and shall continue to be referenced by designers, reviewers, and the regulated community to provide technical guidance for stormwater planning and design. As noted in the previous section, this manual should be referenced for seeking guidance on general hydrology, site runoff, drainage system design, and floodplain management.

2.3 UFC 3-210-10, DESIGN: LOW IMPACT DEVELOPMENT MANUAL

UFC 3-210-10, Design: Low Impact Development Manual is part of the Unified Facilities Criteria (UFC) system that is implemented in all new Department of Defense projects, redevelopment projects, and capital improvement projects (DoD 2004). In order to protect natural water resources and comply with environmental regulations, UFC 3-210-10 provides guidelines for planning, incorporating, and maintaining LID strategies for stormwater management. The manual presents basic guidance for LID design with an overview of associated operation, cost, and maintenance considerations. Examples of successful LID projects and comparisons to conventional stormwater management techniques are also provided.

UFC 3-210-10 emphasizes the use of IMPs as an LID design strategy. IMPs are "distributed, multifunctional, small-scale controls, selected based on their ability to achieve the site design water quality and quantity objectives in a cost effective manner" (DoD 2004). Refer to Sections 11 through 14 of this report for recommendations regarding IMP strategies, costs, and design at the Finegayan Main Cantonment Area.

2.4 NAVY REGION'S STORMWATER POLLUTION PREVENTION PLAN (SWPPP) VOLUME 6: BMP MANUAL

The SWPPP Volume 6: BMP Manual provides an overview of BMPs that shall be implemented at Naval Base Guam (NBG) industrial facilities in order to comply with the U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System Multi-Sector Stormwater General Permit. The manual recommends BMPs that promote good housekeeping practices, minimize stormwater exposure to potential pollutant sources, provide erosion and sediment control, and manage runoff. The manual recommends implementing a combination of BMPs to achieve these objectives.

The BMPs are tabulated into the eight industrial sectors represented at NBG. However, each individual BMP could potentially be applied across all sectors. Therefore, all of the BMPs included in the manual should be considered for use at the Finegayan Main Cantonment. The BMP recommendations provided in this report based on the specific characteristics of the Finegayan Site should be considered during BMP selection as well.

2.5 TECHNICAL GUIDANCE ON IMPLEMENTING THE STORMWATER RUNOFF REQUIREMENTS FOR FEDERAL PROJECTS UNDER SECTION 438 OF THE ENERGY INDEPENDENCE AND SECURITY ACT

In December 2007, Congress enacted the Energy Independence and Security Act (EISA) of 2007. Section 438 of that legislation establishes strict stormwater runoff requirements for federal development and redevelopment projects. The provision reads as follows:

> "**Stormwater runoff requirements for federal development projects.** The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow."

The intent of Section 438 is to require federal agencies to develop and redevelop applicable facilities in a manner that maintains or restores stormwater runoff to the maximum extent technically feasible.

More recently, President Obama signed Executive Order 13514 on "Federal Leadership in Environmental, Energy, and Economic Performance" calling upon all federal agencies to "lead by example" to address a wide range of environmental issues, including stormwater runoff. The EPA published technical guidance that provides a step-by-step framework to help federal agencies maintain predevelopment site hydrology by retaining rainfall on site through infiltration, evaporation/transpiration, and reuse to the same extent as occurred prior to development. The technical guidance provides background information, key definitions, case studies, and guidance on meeting the new requirements. Federal agencies can comply with Section 438 by using a variety of stormwater management practices often referred to as “green infrastructure” (GI) or “low impact development” practices (EPA 2009).

To minimize hydrologic impact during and after development, the guidance recommends implementing GI/LID techniques that are designed to either (1) retain the 95th percentile storm on site, or (2) maintain predevelopment runoff conditions through site-specific hydrologic analysis. The design strategies provided in the following sections are based on accomplishing the first objective, which is retaining the 95th percentile storm on site. The provided stormwater runoff modeling and analysis characterizes the 80th, 90th, and 95th percentile storm at the Finegayan Main Cantonment Area pre- and post-development to ensure Section 438 compliance.

2.6 DOD POLICY ON IMPLEMENTING SECTION 438 OF THE ENERGY INDEPENDENCE AND SECURITY ACT (EISA)

In response to EISA Section 438, the DoD released the DoD Policy on Implementing Section 438 of the EISA to update UFC 3-210-10, dated October, 2004. The Policy provides a summary of Section 438 as it relates to DoD projects and establishes overall design objectives, project evaluation criteria, final design requirements, and requirements for documenting design and construction costs for implementing Section 438. Section 438 and UFC 3-210-10 are described above.

The DoD Policy states that, “The overall design objective for each project is to maintain predevelopment hydrology and prevent any net increase in storm water runoff.” The design guidance further states that if this design objective cannot be met within the project footprint, LID measures may be applied at nearby locations on DoD property (downstream from the project) within available resources. For the design of the Finegayan Main Cantonment Area, if the entire or partial LID volume cannot be accommodated in one development area, use of neighboring downstream development areas could be considered, provided that the design is approved by the Navy and drainage and space requirements can be coordinated.

2.7 GUAM SOIL EROSION AND SEDIMENT CONTROL REGULATIONS

To protect the waters of Guam and the health and welfare of the public, the Guam Environmental Protection Agency established this set of regulations under the authority of Guam’s Water Pollution Control Act. This document regulates all grading, clearing, grubbing, and stockpiling activities and sets minimum standards for erosion and sedimentation control. The construction and design of the Finegayan Main Cantonment Area should adhere to the requirements set forth in this document, which include but are not limited to completing the initial permit application process, submitting a sediment and erosion control plan, and submitting final as-built, soils and conformity documentation. Attention should be given to the Section 10106 Special Requirements, which contains text regarding sink holes and safety precautions for earth moving activities that involve objects that are likely to cause injury, such as unexploded ordnances.

2.8 LEED GREEN BUILDING RATING SYSTEM™

Leadership in Energy and Environmental Design (LEED) is an internationally recognized green building rating system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, reduction of carbon dioxide emissions, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts (USGBC 2009).

LEED is flexible enough to apply to all building types—commercial as well as residential. It works throughout the building lifecycle: design and construction, operations and maintenance, tenant fit out, and significant retrofit. LEED for Neighborhood Development extends the benefits of LEED beyond the building footprint into the neighborhood it serves.

The latest version of LEED design standards for New Construction is the v-3 or 2009 release. Within the New Construction criteria is a "Sustainable Sites" section that focuses on numerous site requirements including stormwater design for quantity and quality of stormwater release (USGBC 2009). The criteria for these are listed below.

2.8.1.1 CREDIT 6.1 (STORMWATER DESIGN—QUANTITY CONTROL)

Intent: To limit the disruption of natural hydrology by reducing impervious cover, increasing onsite infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants.

Requirement: Postdevelopment stormwater must not exceed predevelopment peak discharge rate and quantity for 1- and 2-year, 24-hour design storms (for sites with 50% or less existing impervious cover).

2.8.1.2 CREDIT 6.2 (STORMWATER DESIGN—QUALITY CONTROL)

Intent: To limit disruption and pollution of natural water flows by managing stormwater runoff.

Requirement: Reduce impervious cover, promote infiltration and capture, and treat stormwater runoff from 90% of average annual rainfall using BMPs. The BMPs must remove 80% of the average load of annual total suspended solids load after development based on existing monitoring reports.

3. Site Description - Existing Conditions

Understanding the existing physical conditions at Naval Computer and Telecommunications Station (NCTS) Finegayan is fundamental to designing LID. The physical conditions of Guam in general and of NCTS Finegayan, in particular, are presented below. The physical conditions described below relate to topography, climate, land use, vegetation, geology and soils, hydrogeology, and sensitive areas. Finally, we include a summary of our sources of information on the physical conditions.

3.1 TOPOGRAPHY

The island is sharply divided into two distinct physiographic provinces by a northwest-southeast-trending fault near the island's center (Figure 3-1) (Note: figures are located at the end of the section.) North of the fault is a low-relief limestone plateau that rises in elevation towards the northeast, with coastal cliffs standing from 200 to 600 feet (ft) above mean sea level (msl). The limestone is so permeable that normal stream drainage has not been able to develop. Instead a gentle, karst topography is present wherein drainage is internal, either by direct infiltration into the ground or through sinkholes. South of the fault is a rolling to sharply dissected terrain dominated by extrusive and pyroclastic volcanic rocks that are fringed in the east by an uplifted fossil-reef limestone, which is contemporaneous with limestones in the north. In contrast to the north, the volcanic rocks of the south promote intensive drainage through steeply sloping parallel streams and dendritic streams.

NCTS Finegayan lies north of the island's central fault on the internally drained limestone plateau (Figure 3-2). The plateau ranges from about 500 ft above msl on the northeast to approximately 300 ft above msl in the southwest before the coastal cliffs plunge into the Philippine Sea. The landscape is gently rolling with numerous shallow closed depressions and sinkholes. Also notable is a 1-mile long scarp trending north-south just east of Haputo Beach. Elevation along the scarp drops some 60 ft, from 410 ft above msl on the east to 350 ft above msl on the west. The scarp is produced by a normal fault zone, along which numerous prominent sinkholes have developed.

3.2 CLIMATE

The climate on Guam is warm and humid throughout the year. Average temperatures range from 85 to 89 degrees Fahrenheit (°F) in the afternoon and 70°F to 75 °F in the evening. The relative humidity is 65–75% in the afternoon, and 85–100% in the evening.

The constant northeasterly trade winds result in a well-defined dry season that runs from January through May, which is broken by an occasional shower. July to November is the wet season during which trade winds are frequently interrupted by tropical storms with heavy rain. The months of June and December separate the two seasons and are transitional in nature.

The average annual rainfall on Guam is 80–90 inches, but is locally variable. Near Apra on the western coast, the mean is 85 inches, while it averages 115 inches in the southern mountains. On the northern limestone plateau, including NCTS Finegayan, rainfall averages between 85 and 105 inches annually. About 68 to 73 % of the annual precipitation occurs during the wet season and 15 to 20 % during the dry season. The remainder occurs during the transitional months.

3.3 LAND USE AND VEGETATION

NCTS Finegayan is largely undeveloped and vegetated. The vegetated area consists primarily of limestone forest and shrub/grasslands. Most of the developed land is located in the central and southern portions of the Study Area and consists of residential, commercial/base operations, and industrial land use. Areas used for Naval Communications facilities are generally located in the central, northern portion of the project area. See Section 10, "Assessment of Existing and Future Site

Contamination", for a detailed breakdown of land use categories by acreage as well a figure depicting existing land use conditions.

3.4 GEOLOGY AND SOILS

The northeast–southwest-trending Pago-Adelup fault in the island's waist sharply divides Guam into two distinct geologic provinces of approximately equal size. North of the fault the landscape is dominated by a limestone plateau, while a dissected volcanic upland with minor limestone lies south of the fault. The northern limestone plateau is underlain by volcanic rock, which is exposed only in two minor locales, at Mt. Santa Rosa (858 ft above msl) and Mataguac Hill (630 ft above msl). The uppermost surface of the volcanic rock, which slopes seaward from the northern interior, was eroded before limestone deposition. Refer to Figure 3-3 for a generalized geologic map.

The oldest rocks on Guam are Late Middle Eocene pillow and basalt flows, which originated from a volcano located west of Guam. These rocks are overlain by Late Eocene to Early Oligocene tuffaceous shale and sandstone that is interbedded with breccia and lava flows. A second volcanic center developed to the southwest and produced extensive lavas and pyroclastic deposits until its final collapse in the Early Oligocene. Volcaniclastic sedimentation continued through the Late Oligocene to the Early Miocene, when massive reef and lagoonal limestone formation began to cover the volcanics.

The Miocene Bonya Limestone and the Miocene-Pliocene Alifan Limestone are found directly on top of the volcanic units in the interior highlands of southern Guam. The Alifan Limestone is also found in the northwest comer of the southern province and on the flanks of Mt. Santa Rosa in the north. The Alifan Limestone was succeeded by deposition of fine-grained, detrital, Miocene-Pliocene Barrigada Limestone, which is an extensive unit exposed in the interior of the northern plateau. The Barrigada Limestone is greater than 540 feet thick. This unit is the principal aquifer in the north and extends well above and below the position of the freshwater lens. The Barrigada Limestone grades laterally and upward into the Pliocene-Pleistocene Mariana Limestone, a reef and lagoonal deposit that dominates the surface of the northern plateau. The high cliffs north of the Pago-Adelup fault are exposures of the Mariana limestone, as are the cliffs at NCTS Finegayan. The Mariana Limestone is at least 500 ft thick in places but may thin to zero inland.

The Mariana Limestone has been interpreted as a shallow-water fringing and barrier reef deposit that is thickest along the periphery of the northern peninsula. The Mariana contains large openings, voids and caverns, which are typical of massive coral growth. Inland, a lagoonal facies of the Mariana Limestone grades into the Barrigada Limestone, which is interpreted as a deep-water limestone of bank and off-reef detrital deposits. These deposits are heterogeneous and are often cemented and filled with fine calcareous mud.

The Barrigada Limestone accounts for the greatest volume of the fresh-water aquifer lens in the northern plateau. Most of the limestone bedrock of Guam has undergone extensive fresh-water diagenesis, resulting in significant changes in primary porosity most notably modification by karst processes. In northern Guam, infiltrating rainwater dissolves the limestone creating karst features such as sinkholes, caves, and widening fissures. Generally, the result is an increased hydraulic conductivity. In southern Guam, karst processes have resulted in caves and spring development.

At NCTS Finegayan, Mariana Limestone is the primary bedrock unit found at the ground surface. The Barrigada Limestone, which underlies the Mariana, is prominent in the eastern half of NCTS Finegayan (Figure 3-4). A north-south trending normal fault in the Mariana Limestone extends from the cliff at Pugua Point more than 2 miles to the south. The fault produces a visible scarp, across which the elevation drops some 60 ft (410 ft above msl on the east to 350 ft above msl on the west). Several visible, deep sinkholes occur along or near the fault trace. Engineering Solutions, Inc. (ESI) (ESI

2008) has tentatively identified several additional faults in the Barrigada Limestone along the eastern edge of NCTS Finegayan, with associated minor clay-filled depressions or sinkholes along these faults. ESI has interpreted the clay filling to be related to ponding of runoff after heavy storms. Still other "shallow basins" are identified along the contact between the Barrigada and the Mariana Limestones. ESI also has mapped other areas of possible faults, depressions, or subsurface karsting throughout the site. Faults, sinkholes, and subsurface karsting have significance in that they provide preferential pathways for movement of water from the ground surface into the underlying aquifer. Identifying the locations of these features is, therefore, the first step in a strategy to protect groundwater from pollutants. Refer to Figure 3-5 for karsting and other geologic features that constitute preferential pathways for percolation to groundwater.

According to the Soil Survey of the Island of Guam, the soils found at NCTS Finegayan consist largely of Guam Series soils. These are described as "…well drained, moderately rapidly permeable soils that are very shallow to limestone bedrock…. Depth to bedrock is dominantly 10–25 centimeters, but it ranges from 5–41 centimeters…" According to the U.S. Department of Agriculture Soil Conservation Service (USDA SCS), now known as the U.S. Natural Resources Conservation Service (NRCS) the clay content ranges from 60% to 95% in lab tests, and from 35% to 55% based on field examination.

USDA SCS soil descriptions are slightly at odds with those of ESI. Based on the completion of 38 soil borings and 17 test pits throughout NCTS Finegayan, ESI observed that the soils in general consist of silty sands with or without gravel, ranging from 0 to 5 feet thick, overlying coral limestone. The silty sands are interpreted to represent the residue of slow but persistent dissolution of limestone bedrock, leaving behind only the impurities in the original limestone. The silty sands, which are broadly distributed, are described as "alluvial," implying that they have been transported by water, at least for short distances. Similarly, the clays soils found at the base of some sinkholes are described as "alluvial." ESI concludes that these "clay alluvial soils" possibly resulted from temporary ponding of runoff in sinkholes after heavy rains.

The use of the word "alluvial" has significance with respect to groundwater protection because it implies the transport of soil particles–and associated pollutants–by water. There is no doubt that the soils in northern Guam have a very high infiltration capacity, otherwise there would be streams or stream channels. However, it is also clear that heavy rains do cause puddling and sheet flow. If the rain is heavy enough, sheet flow becomes widespread and the water and sediment move downhill, collecting in sinkholes or other low spots.

Directly beneath the soils, ESI found generally fresh to highly weathered limestone. ESI concluded that the degree of limestone weathering followed no predictable pattern. In karst geology, the uppermost weathered limestone is termed the "subcutaneous zone." Rainfall, which is undersaturated with respect to calcium carbonate, takes advantage of minor fractures and joints to dissolve the limestone and produce this subcutaneous zone. The process gradually widens fractures and joints and causes them to extend farther downward. If the weathering becomes deep enough, a sinkhole develops. ESI noted the limestone in at least one borehole was weathered to "rubble."

3.5 HYDROGEOLOGY

Nearly all of Guam can be described in terms of two rocks types: limestone and volcanics. Generally speaking, the volcanics can be considered aquicludes when they are associated with limestone. In a strict sense, both the limestone and the volcanics are aquifers; however, aquifer properties of the limestone make it favorable for use as an exploitable fresh water source. In southern Guam, the lack of extensive limestone deposits and the unfavorable hydraulic properties of the volcanic rock typically preclude the exploitation of groundwater as a fresh water source. The primary water supply in the south is surface water in the form of the Navy Reservoir, which is supplemented to a minor degree by springs. In northern Guam, the sole water source is the limestone aquifer that contains a freshwater body within the Mariana and Barrigada Limestones called the Northern Guam Lens Aquifer (NGLA) (Mink 1976, CDM 1982). The EPA has designated the NGLA a Sole Source Aquifer. This designation gives EPA review authority over federally funded projects planned in a Sole Source Aquifer, with the purpose of protecting groundwater.

Hydraulic characteristics of the limestone aquifer are highly variable in both the horizontal and vertical direction. Mink (1976) suggested that the hydraulic conductivity of limestone units, particularly the Barrigada Limestone, is “profoundly affected by the quantity of clay mixed with the limestone components”. He also drew a distinction between “local” hydraulic conductivity and “regional” hydraulic conductivity. Local hydraulic conductivity values are skewed to lower values, because of local conditions at a specific location (e.g., a well). On the other hand, regional conductivity values are generally higher, because they represent an average between impermeable rock and open caverns or fractures. Mink classified argillaceous limestone as those containing up to 10% clay content and having a local hydraulic conductivity as low as 20 ft per day (ft/day). This compares to a “clean” limestone, which has low clay content and a local conductivity of about 200 ft/day. Regional hydraulic conductivities are lowest in the more argillaceous southern portion of the NGLA, ranging from 500 to 1,500 ft/day, whereas clean limestone to the north can reach as high as 15,000 to 20,000 ft/day (CDM 1982). An average regional hydraulic conductivity of 2,000 ft/day was proposed by Mink (1976); however, modeling studies suggest that best fit simulations require a regional hydraulic conductivity of around 20,000 ft/day (Jocson et al. 2002).

Based upon these earlier studies, preliminary estimates of local, average hydraulic conductivity in the limestone were proposed for well productivity purposes (Mink 1976, CDM 1982);

• Clean limestone:	190 ft/day
• Probable limestone:	120 ft/day
• Argillaceous limestone:	52 ft/day
• Very argillaceous limestone:	26 ft/day

The freshwater of the NGLA is generally lens-shaped in cross-section and is underlain by denser seawater; however, the base is modified where it contacts the relatively impermeable basement volcanic rock. Mink (1976) proposed the term “basal zone” where the lens is underlain by seawater, and “para-basal zone” where the base of the lens is volcanic rock. Figure 3-6 is a generalized profile showing the occurrence of freshwater in the basal and para-basal zones. Typical steady-state hydraulic head in the basal zone is approximately 1 meter above msl; in the para-basal zone it can range from 2 to 5 meters above msl, depending on local hydraulic conductivity. Lens geometry in the para-basal zone depends on freshwater recharge rates, basement elevations, basement slopes, and hydraulic conductivity.

Figure 3-5 represents the approximate water-table surface at NCTS Finegayan. It is based on observed and inferred groundwater contours developed in 2008 for Anderson Air Force Base (AFB) Northwest Field, which borders NCTS Finegayan on the north. To develop these water-table contours for NCTS Finegayan, AECOM simply projected the Andersen AFB contours to NCTS Finegayan along the volcanic basement contours. Using this methodology, the groundwater elevation at NCTS Finegayan ranges from about 5 feet msl near Route 3 to, presumably, zero at the shoreline. Groundwater flows perpendicular to the coast (i.e., westerly) on a regional basis. The fresh groundwater at NCTS Finegayan is in the basal zone.

Based upon basement, volcanic-rock, elevation contours, the NGLA was divided into a series of six subbasins (CDM 1982). The subbasin boundaries reflect the basement topography forming hydrological divides in the subsurface. Subbasin boundaries were subsequently revised based on updated basement contours. NCTS Finegayan is in the Finegayan subbasin, as shown on Figure 3-5. According to Barrett (1992), the sustainable yield of the entire NGLA (about 100 square miles in area) is approximately 80 million gallons per day (mgd); the sustainable yield of the Finegayan sub-basin is approximately 11.6 mgd. Mink indicates that sustainable yield represents about 30 per cent of the total volume of rainwater that infiltrates into the NGLA.

A preliminary framework for understanding groundwater recharge has been proposed in WERI Technical Memo No. 88, (Jocson et al. 1999). In summary, the authors conclude the following:

- Rainfall that occurs in daily amounts of less than 0.6 centimeters (1/4 inch), is probably lost entirely to evapo-transpiration, and does not infiltrate the land surface. These rain events represent 20% of the total annual rainfall.
- Whenever it rains more than 5 centimeters (2 inches) in a 24 hour period, even though water infiltrates the ground and moves down to the water table, it short circuits to the coast along enlarged openings in the karst limestone, and most likely does not become usable recharge. These heavy rain events represent about 20% of the annual rainfall.
- The remaining 60% of the annual rainfall occurs in daily amounts of 0.6 to 5 centimeters. Virtually all this water slowly infiltrates the unsaturated zone and probably becomes long-term groundwater recharge. Rainfall from these events is heavy enough to escape evapo-transpiration, but not too heavy to wind up as surface runoff or be rejected by the aquifer.

Of course, the recharge “cut-offs” discussed above are not “hard-and-fast” rules. They are, however, useful guidelines based on hydrogeological studies. The geological processes involved in infiltration and aquifer recharge are still poorly understood.

It is not clear whether development at NCTS Finegayan will have an impact on aquifer recharge. However, this is probably a moot issue. Most recharge at NCTS Finegayan is so close to the coast that it is unusable for groundwater supply because wells nearer the coast are more vulnerable to saltwater upconing. Groundwater flows westerly or west-northwesterly as implied by the groundwater contours shown on Figure 3-5. Therefore, the recharge areas for the NCTS Finegayan wells are largely east and southeast of the wells. The Northern Guam Lens Study (NGLS) (1982) (CDM 1982) proposed guidelines that prescribe appropriate well depths and pumping rates for basal and para-basal zones of the NGLA. Based on these guidelines, the recommended criteria for NCTS Finegayan wells are as follows:

	Max. Capacity (gpm)	Min. Spacing (ft)	Ideal Depth (ft)	Max. Depth (ft)
Basal Zone				
Groundwater Elevation < 4 ft above msl	200	300	<25	40
Groundwater Elevation > 4 ft above msl	350	300	<35	50

Table 3-1 shows the pumping rates for existing wells at NCTS Finegayan and nearby Guam Waterworks Authority (GWA) wells.

Table 3-1: Well Yields NCTS Finegayan Wells and nearby GWA Wells

Well Locations	Yield (gpm)
NCTS Wells	
NCTS A	180
NCTS #5	100
NCTS #6	125
NCTS #7	235
NCTS #9	200
NCTS #10	180
NCTS #11	180
NCTS #12	180
GWA Wells	
F-01	144
F-02	154
F-03	157
F-04	142
F-06	220
F-07	0
F-10	204
F-11	189
F-19	219
F-20	254

gpm gallons per minute
Pumping rates obtained from *Guam Water Utility Study Report for Proposed USMC Relocation*, July 2008

3.6 SENSITIVE AREAS

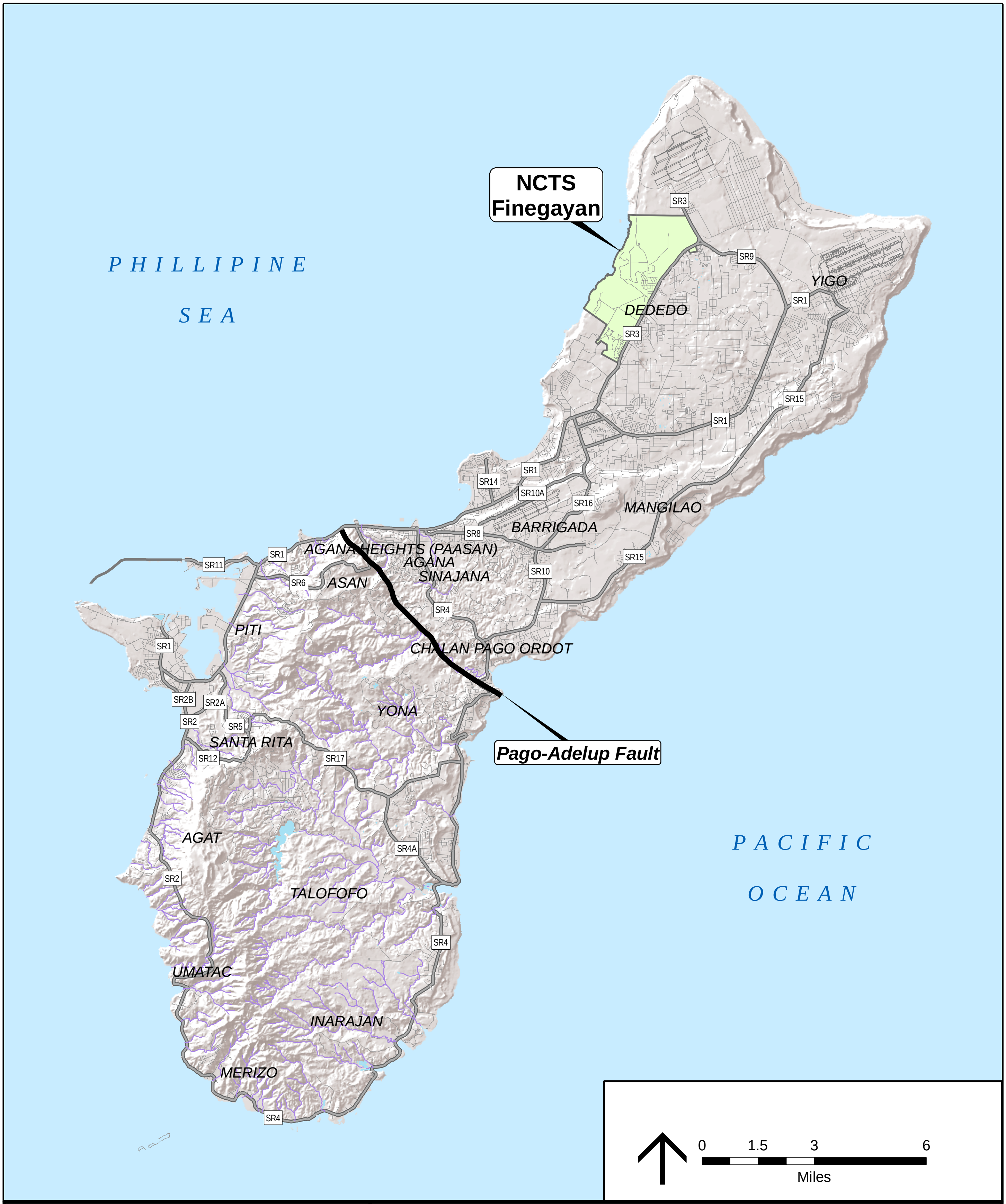
Much of the project area is located within a Department of Defense “overlay refuge” that is associated with the U.S. Fish and Wildlife Service’s Guam National Wildlife Refuge. The overlay refuge provides critical habitat for several endangered species located on the island. It includes all cliffs, bluff tops, and shoreline within the project area, as well as the 252 acre Haputo Ecological Reserve Area on the west coast (see Figure 3-7). Haputo Bay is a unique natural resource, and is of significant scientific and aesthetic value (Jenson, personal communication 2010). A portion of the overlay refuge located within the project area has been preserved and is designated as OS-P (Open Space – Protected) in the USMC Main Cantonment Land Use Plan and the GJMMP (identified as “Forest/Grasslands” on Figure 10-2). It is critical that there is no increase over predevelopment conditions for surface and, to the extent practicable, coastal (groundwater) discharge for sensitive areas; in particular the Haputo Bay Ecological Reserve.

3.7 INFORMATION SOURCES

In preparing the foregoing description of the physical conditions, we relied principally on the following documents:

- *Guam Water Utility Study Report for Proposed USMC Relocation*, July 2008, prepared by Earth Tech, Bloomfield, NJ.
- *Site Characterization Study, NCTS Finegayan, Guam, Mariana Isla*nds, July 31, 2008, Engineering Solutions, Inc., Pearl City, Hawaii.
- *Hydrologic Resources of Guam*, Water Resources Investigation Report 03-4126, 2003, prepared by Stephen B. Gingerich, U.S. Geological Survey.
- *Karst Inventory of Guam, Mariana Islands*, August 2006, prepared by Danko Taborosi, Water and Environment Research Institute of the Western Pacific, University of Guam (WERI).

- *Soil Survey of Territory of Guam*, May 1988, prepared by US Department of Agriculture, Soil Conservation Service.
- Final Engineering Report, Groundwater in Northern Guam, Sustainable Yield and Groundwater Development. May 26, 1992. Prepared by Barrett Consulting Group in Association with John F. Mink
- *Numerical Modeling and Field Investigation of Infiltration, Recharge, and Discharge in the Northern Guam Lens Aquifer*. October 1999. Water and Environment Research Institute of the Western Pacific, University of Guam (WERI), Technical Report No. 88, Jocson, J.M.U., Jenson, J.W., and Contractor, D.N.



AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study

Figure 3.1 Location Map

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DATE: 12/29/2009

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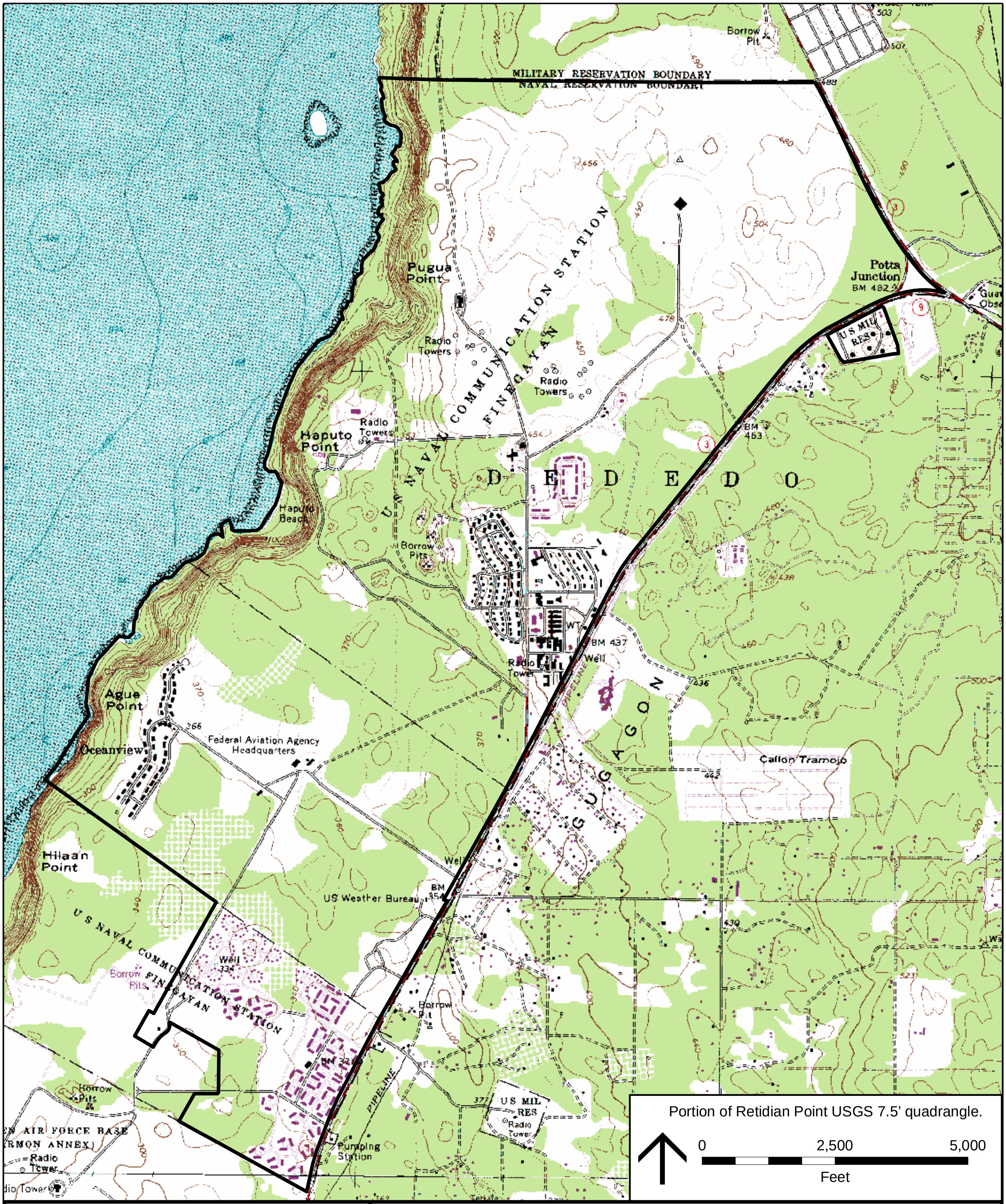

Portion of Retidian Point USGS 7.5' quadrangle.

AECOM

NAVFAC Pacific

Guam Drainage & Low Impact Development Study

Figure 3.2 USGS Topo Map - NCTS Finegayan

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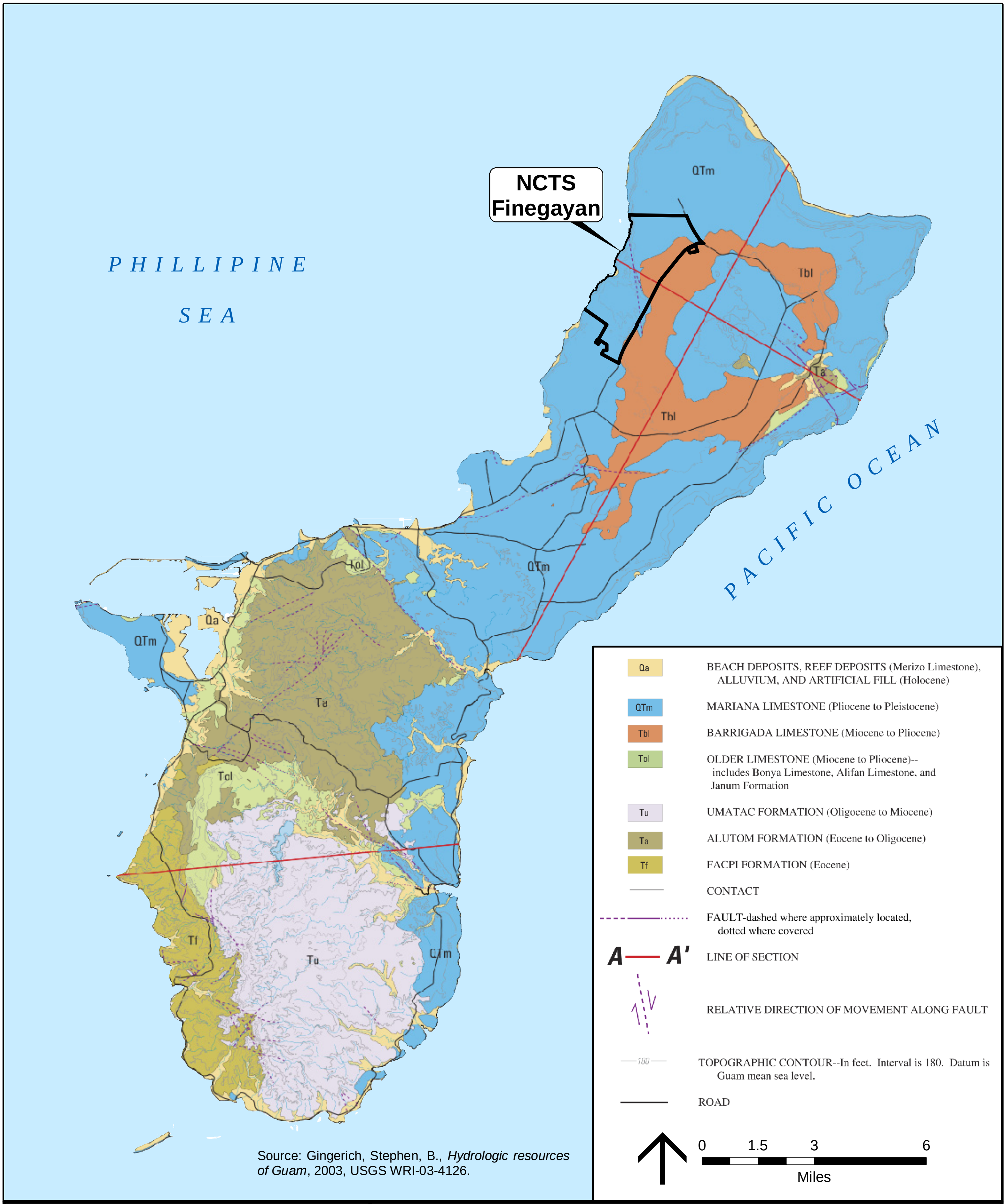

Source: Gingerich, Stephen, B., *Hydrologic resources of Guam*, 2003, USGS WRI-03-4126.

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Figure 3.3 Generalized Geologic Map

GIS FILE:

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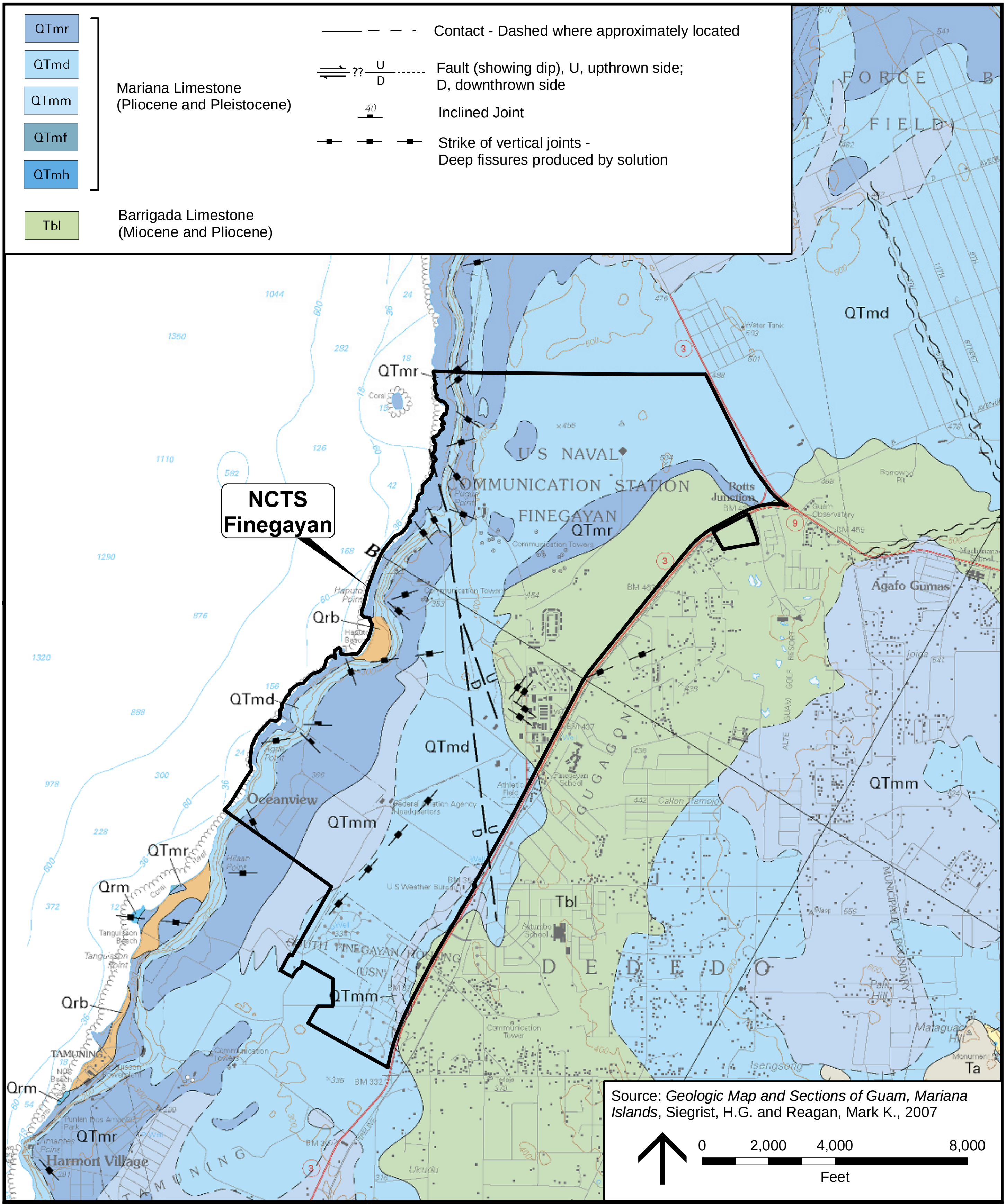

Source: *Geologic Map and Sections of Guam, Mariana Islands*, Siegrist, H.G. and Reagan, Mark K., 2007

Map Document: (L:\work\106374\GIS\Finegayan_Devel\maps\GeologicMap.mxd)
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Figure 3.4 Geologic Map of NCTS Finegayan

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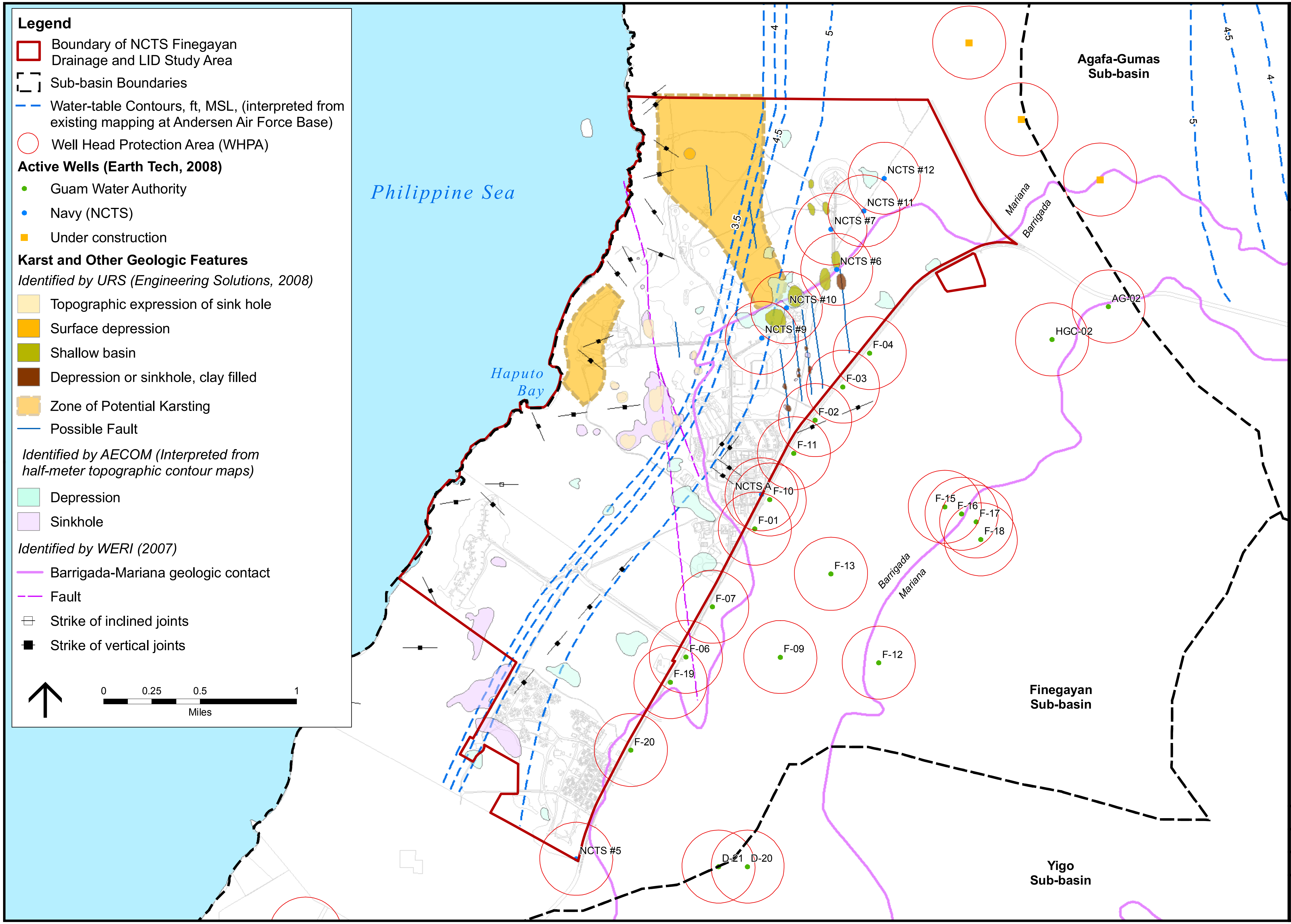

AECOM

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Figure 3.5
Karsting and Other Geologic Features - Preferential Pathways for Percolation to Groundwater

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DATE: DATE: 04/23/2010

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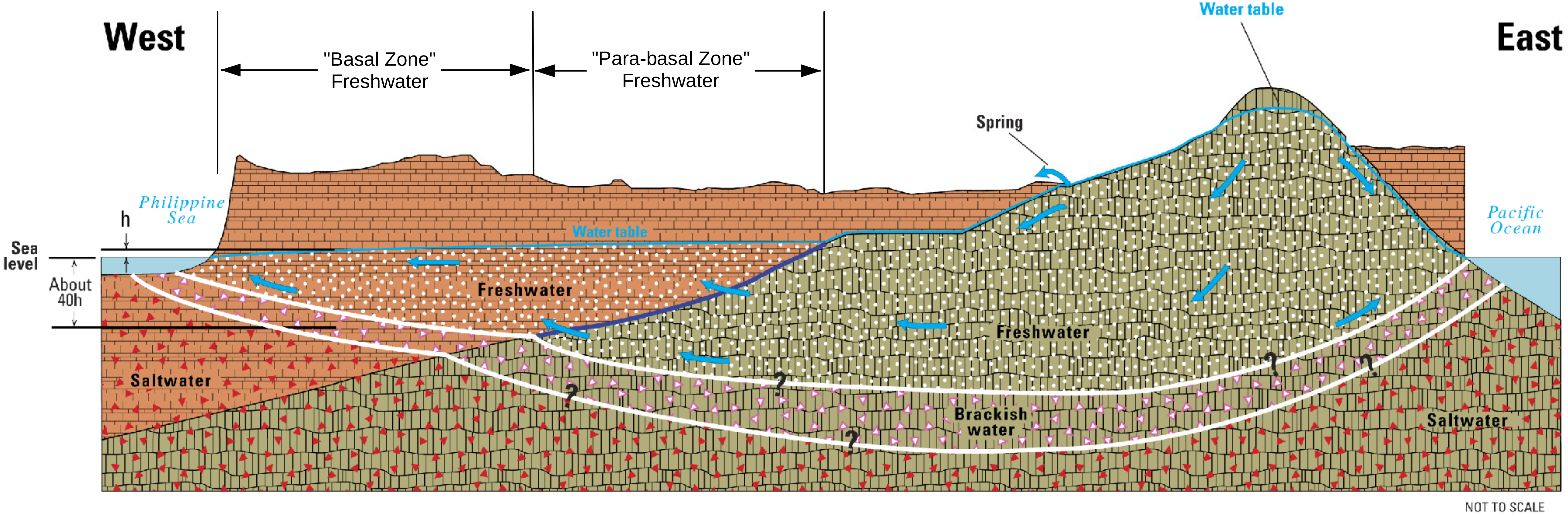

EXPLANATION

▨ LIMESTONE

▥ VOLCANIC ROCKS

→ GENERAL DIRECTION OF FRESH GROUND-WATER FLOW

— ZONE WHERE FRESHWATER IN LIMESTONE IS IN DIRECT CONTACT WITH FRESHWATER IN UNDERLYING VOLCANICS (PARA-BASAL)

Source: Gingerich, Stephen, B., *Hydrologic Resources of Guam*, 2003, USGS WRI-03-4126.

Map Document: (L:\work\106374\GIS\Finegayan_Devel\maps\Parabasal_Vs_Basal_X_sect.mxd)
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NAVFAC Pacific
Guam Drainage & Low Impact Development Study

Figure 3.6 Para-basal vs. Basal

GIS FILE:

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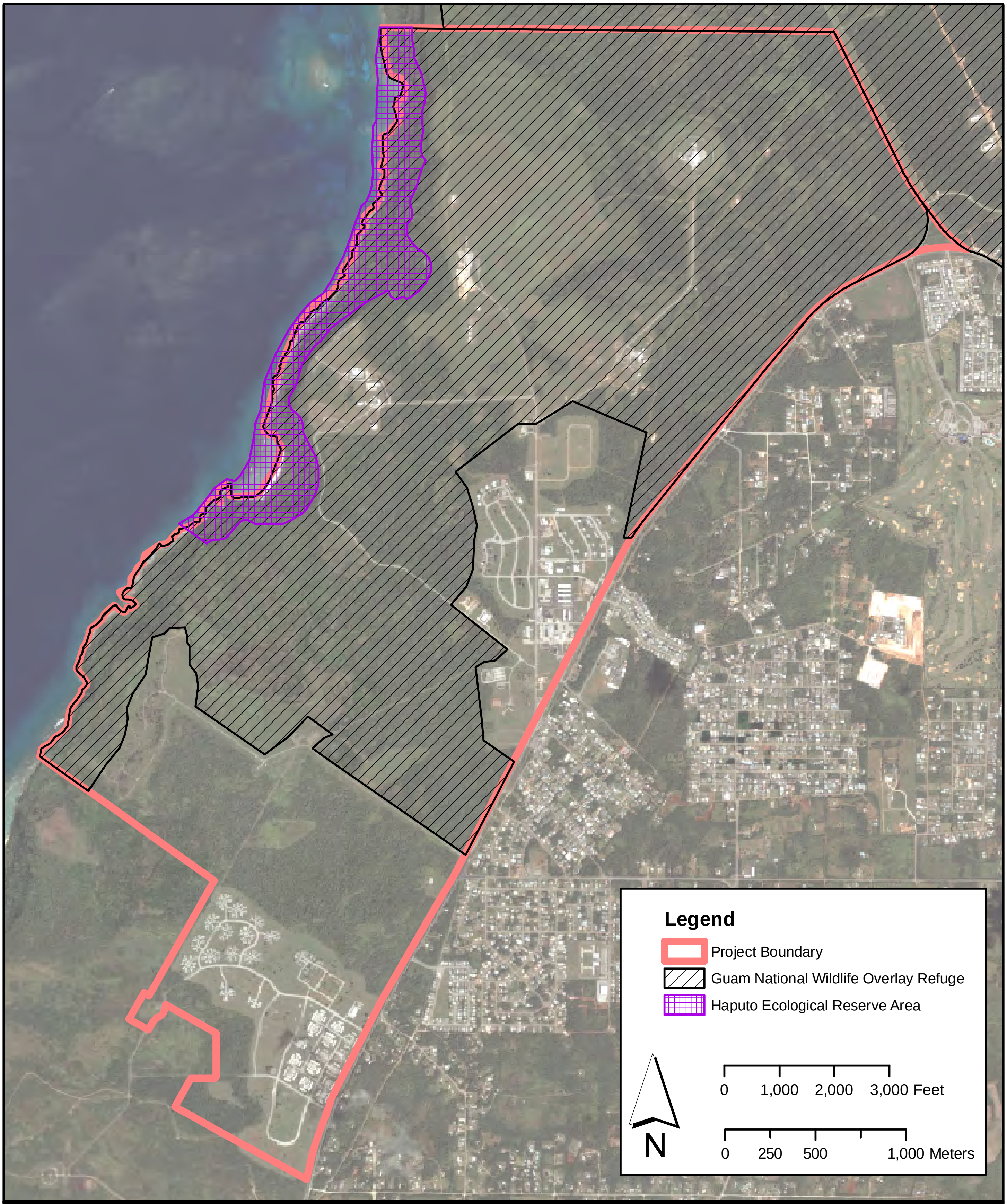
DATE: DEC. 29, 2009



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Sensitive Areas

GIS FILE: Fig3-7_SensitiveAreas.mxd

SCALE: AS NOTED

DATE: 03/04/2010

Figure 3-7

4. Stormwater Sustainability Plan

The purpose of this *Stormwater Sustainability Plan* is to outline goals, guiding principles, and overall approach for sustainable water resources management within the Finegayan Main Cantonment. With the goal of sustainably managing water resources on the Finegayan Main Cantonment, this strategy focuses on resource protection through reuse, treatment, and infiltration of stormwater runoff to reduce impact to Guam's natural resources including the underlying groundwater aquifer. This study documents stormwater resource issues associated with green building practices such as rainwater harvesting and reuse, quantity (volume and rate) and water quality strategies, and green roofs. In addition, this study outlines recommendations for preserving site permeability and opportunities for architectural and aesthetic stormwater elements. This plan will support project efforts to meet or exceed federal mandates in a cost effective manner.

Sustainability is an essential aspect of the project to ensure the protection of Guam's valuable natural resources, meet federal regulations and design criteria, and ensure the long-term viability of the project.

LID represents a fundamental change in the way urban development and stormwater management is conceived, planned, designed, and built. Rather than using traditional approaches to impose a single form or structural solution across all locations, LID design considers ways in which urban infrastructure and the built form can be integrated with a site's natural features. It aims to minimize impacts on the natural environment and protect the health of aquatic ecosystems. This plan will explore sustainable implementation of LID and other green stormwater infrastructure techniques. It also provides key coordination with the ongoing *Guam Joint Military Master Plan* (GJMMP) effort and larger Sustainability Program (Figure 4-1).

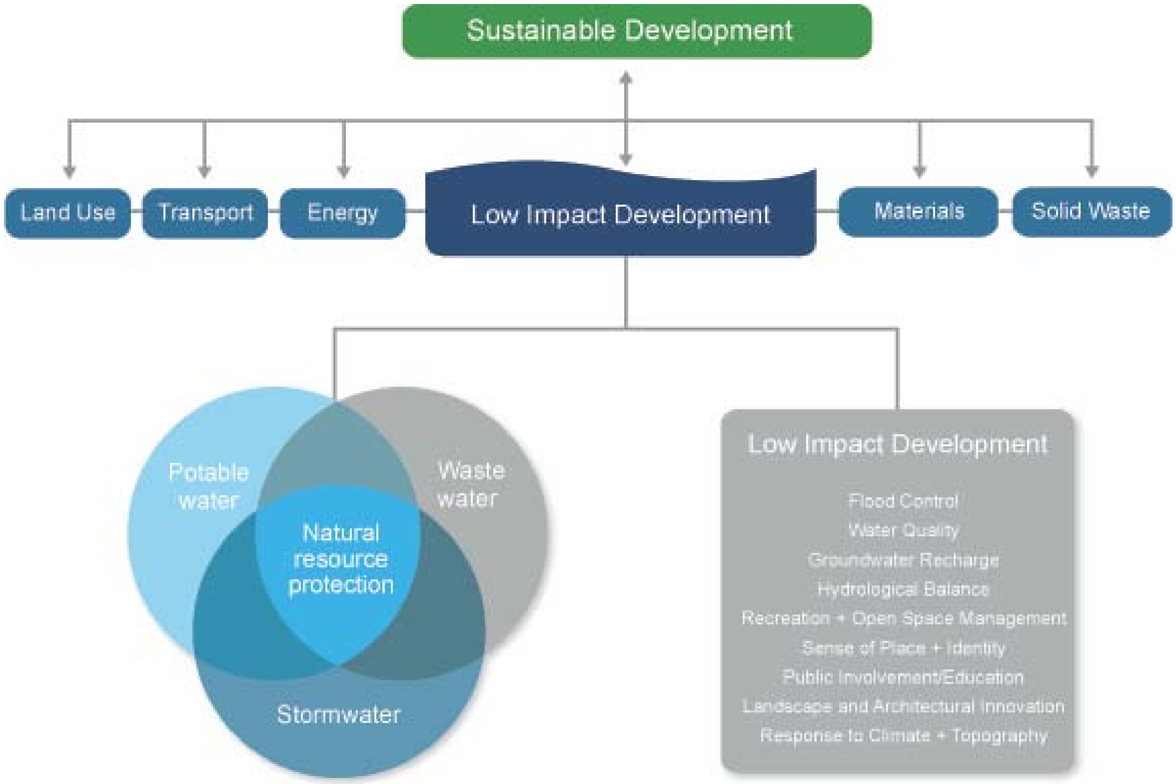


Figure 4-1: Low impact development is an essential component to sustainable development of the landscape.

4.1 SUSTAINABILITY GOALS

Sustainability goals act as the basis for this Comprehensive Drainage and LID Implementation Study. In 2006, the *Federal Leadership in High Performance and Sustainable Building Memorandum of Understanding* was enacted. Signatory federal agencies committed to design, construct, and operate their facilities in an energy-efficient and sustainable manner. In the context of the Finegayan Main Cantonment project, the goals for sustainably managing water resources of the LID implementation strategy are to convey, treat, and store large stormwater flows to protect public health and safety and existing infrastructure and to treat and infiltrate stormwater to recharge and protect the underlying groundwater aquifer. The goals for LID implementation listed below were established in response to the characteristics of the project site and receiving environment.

The goals for LID implementation include:

- Protect water quality of surface water and groundwater.
- Protect existing natural features and ecological processes.
- Maintain natural hydrologic behavior of catchments.
- Minimize demand for potable water.
- Minimize maintenance requirements.
- Integrate water into the landscape to enhance visual, social, cultural, and ecological values.

This LID Implementation Study has been established in accordance with principles outlined in *Federal Leadership in High Performance and Sustainable Building MOU* to allow full flexibility in the integration of stormwater elements into the urban and landscape design. These guiding principles will be achieved by:

- maintaining, to the maximum extent technically feasible, the predevelopment hydrology regarding the temperature, rate, volume, and duration of flow;
- integrating water management measures into the development form and landscape to ensure efficient use of landscape spaces and maximize the visual amenity;
- protecting groundwater quality by pre-treating stormwater flows, as appropriate;
- utilizing vegetation for water quality enhancement; and
- maximizing water harvesting for non-potable uses.

With all elements working together, the stormwater management system in the Finegayan Main Cantonment area treats pollutants, recharges the groundwater, maintains the water table, and provides flood control, while preventing destructive effects downstream (Figure 4-2).

Figure 4-2: Low impact development stormwater management (source: PUB 2009)

4.1.1 Sustainable Systems Integrated Model Pilot Study for the GJMMP

The Water Sub-Module of SSIM is used to understand how the development could perform with a limited groundwater or other potable water supply. The annual water supply necessary to satisfy a business-as-usual, baseline project and three high-efficiency approaches for landscaping and interior water use can be evaluated. Cost and benefit analysis of the components making up alterative water-conservation packages can be performed to understand effective synergies and identify any potential "sweet spots" relative to initial capital investment and water conservation. Water reuse strategies, including using recycled wastewater and harvesting stormwater as resources for irrigation within the public and private realm, can be considered and quantified and preferred alternatives identified and presented in graphical and quantitative formats.

AECOM's Sustainable Systems Integrated Model (SSIM) is a unique modeling platform and integrated land planning tool that measures the cost and benefit of a tailored sustainable development program. Organized around the core themes of water, mobility, energy, building technology, socio-cultural factors, ecology, and carbon footprint, this process is designed to optimize aspects of economic, social, and environmental health.

The SSIM model takes sustainability further by evaluating all of the proposed sustainable system approaches and checking for LEED points for the new 2009 rating system. As the efficiency level of each system is modified to create the desired results with the best life cycle and cost return, tracking the project's LEED score occurs automatically.

As part of a similar ongoing effort for master planning and sustainability on the Finegayan installation, the LID strategies from this report, including rooftop rainwater harvesting, will be incorporated into our SSIM model to maximize the use of all available water sources and improve the overall balance and sustainability of the facility (Figure 4-3).

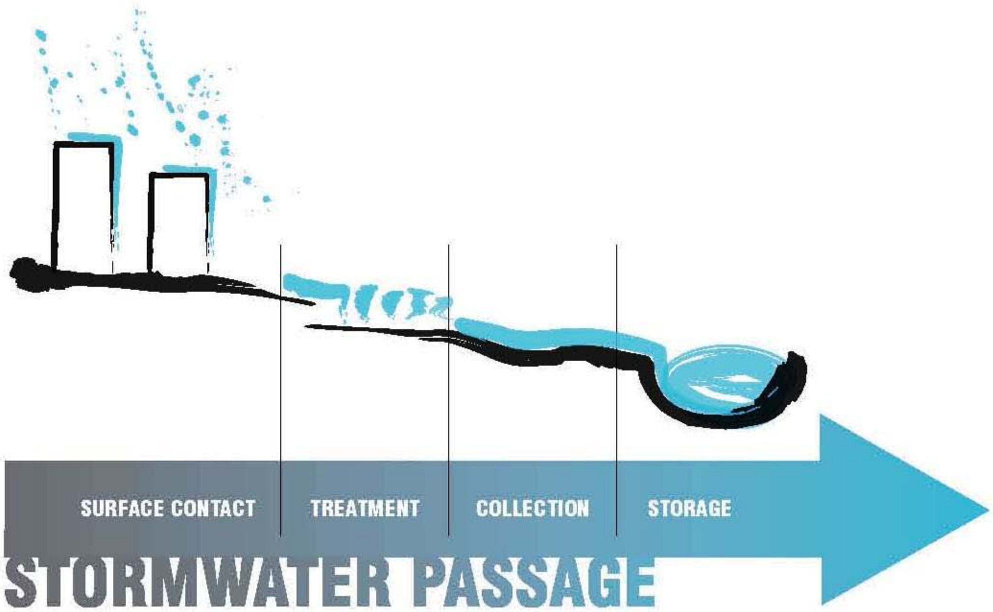


Figure 4-3: Low impact development (also known as water sensitive urban design) water balance in an urban environment.

4.2 SUSTAINABILITY POLICIES

A number of key sustainability policies exist for which the project will strive to achieve, including the LEED Silver requirements and Section 438 of the Energy Independence and Security Act of 2007. A summary of each policy is found below.

4.2.1 Leadership in Energy and Environmental Design

LEED is an internationally recognized green building rating system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, reduction of carbon dioxide emissions, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts (USGBC 2009).

LEED is flexible enough to apply to all building types—commercial as well as residential. It works throughout the building lifecycle—design and construction, operations and maintenance, tenant fit out, and significant retrofit. LEED for Neighborhood Development extends the benefits of LEED beyond the building footprint into the neighborhood it serves.

The latest version of LEED design standards for New Construction is the v-3 or 2009 release. Within the New Construction criteria is a “Sustainable Sites” section that focuses on numerous site strategies including stormwater design for quantity and quality of stormwater release (USGBC 2009). The criteria for these are listed below.

4.2.1.1 CREDIT 6.1 (STORMWATER DESIGN—QUANTITY CONTROL) 1 POINT

Intent: To limit the disruption of natural hydrology by reducing impervious cover, increasing onsite infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants.

Requirement: Post-development stormwater must not exceed predevelopment peak discharge rate and quantity for 1- and 2-year, 24-hour design storms (for sites with 50% or less existing impervious cover).

Project Application: Because the installation will contain very large areas of impervious cover, the proposed stormwater management system design will require efficient use of best management practices (BMPs) and large ponds to maintain the pre-development peak discharge rates. This credit is achievable, but will take a great effort to meet the requirements.

Method to Comply: To comply with LEED credit 6.1 it is essential to plan for stormwater volume control from the on-set of the project. Stormwater management elements must be included into the master plan at appropriate locations and sizes. Recommendations to meet LEED credit 6.1 at the Finegayan Main Cantonment are:

- Plan for stormwater management from master planning stages by setting aside needed land for stormwater management
- Incorporate stormwater reuse.
- Utilize infiltration and detention IMPs as listed below.
- Treat stormwater as close to its origin as possible by distributing small-scale IMPs throughout the site.
- Cluster development to reduce impervious surface and site compaction.
- Grade to encourage sheet flow and increases the amount of time stormwater flows over the site.
- Disconnect impervious surfaces by directing runoff into or across vegetated areas to help filter runoff and encourage recharge, or leaving a 2- or 3-foot-wide pervious strip between the edge of a street and the beginning of a driveway or sidewalk to allow infiltration.
- Minimize curb and gutter infrastructure.
- Integrate stormwater controls into the design as both flood control and site amenities.
- Minimize impervious surfaces by reducing roadway width and length and parking areas.
- Consolidate activities such as staging and parking in already-disturbed areas that have low functional potential. Designate a single access route into impacted areas. Prior to start of construction,
- Once treated, encourage stormwater to infiltrate into the ground as close to the source as possible.
- Fence off protected areas and sign each area clearly. If saving individual trees, protect the root system from compaction.

Toolkit for achieving LEED credit 6.1:

- Green Roofs
- Cistern/Rain Barrels
- Dry Wells
- Dry Swale
- Porous Paving

- Bioretention Basins
- Detention Basins
- Downspout Disconnection

For more information on suggested tools see Section 2.5. Current Federal requirements for stormwater management, such as the Energy Independence and Security Act of 2007 Section 438, will most likely ensure that the project meets LEED credit 6.1 (see Section 2.8 for more information). In addition, meeting credit 6.1 will allow the project to more easily meet LEED credit 6.2.

Related LEED credits:

- SS Credit 2 Development Density and Community Connectivity
- SS Credit 5.1 Site Development – Protect or Restore Habitat
- SS Credit 5.2 Site Development – Maximize Open Space
- SS Credit 6.2 Stormwater Design – Quality Control
- SS Credit 7.1 Heat Island Reduction – Non Roof
- SS Credit 7.2 Heat Island Reduction – Roof
- WE Credit 1 Water Efficient Landscaping
- WE Credit 3 Water Use Reduction

4.2.1.2 CREDIT 6.2 (STORMWATER DESIGN—QUALITY CONTROL) 1 POINT

Intent: To limit disruption and pollution of natural water flows by managing stormwater runoff.

Requirement: Reduce impervious cover, promote infiltration and capture, and treat stormwater runoff from 90% of average annual rainfall using BMPs. The BMPs must remove 80% of the average load of annual total suspended solids load after development based on existing monitoring reports.

Project Application: In conjunction with the above credit 6.1 and assuming that the ability to reduce impervious cover is not possible, this credit will also require extra effort and attention to the efficient use of many BMPs and very large onsite treatment ponds. Due to the porous nature of the existing soil and underlying limestone layers, infiltration should be fairly simple to achieve. However, ensuring that a high quality of infiltrating water is maintained will require additional attention.

Method to Comply: To comply with LEED credit 6.2 it is essential to provide water quality treatment for stormwater as close to the source as possible. This is best achieved by utilizing BMPs that act to both meet volume and flow requirements in credit 6.1 and provide high levels of water quality treatment. Recommendations to meet LEED credit 6.2 at the Finegayan Main Cantonment are:

- Plan for compliance starting at the master planning stages by setting aside needed land for stormwater management.
- Provide water quality treatment train approach for all stormwater flows that includes pre-treat IMPs such as sedimentation basin, grass filter strip, dry swale, bioretention basin, or an oil and oil/sediment separator.

- Integrate stormwater controls into the design of the site and use the controls as site amenities utilize vegetation for water quality enhancement.
- Manage stormwater as close to its origin as possible by using many, small scale LID techniques.
- Limit curb and gutter infrastructure to encourage overland flow.

Toolkit for achieving LEED credit 6.2:

- Bioretention Basins
- Oil/sediment Separator
- Sedimentation Basin
- Filter Strip
- Dry Swale
- Downspout Disconnection

The approach and recommendations for Credits 6.1 and 6.2 are similar; therefore, achieving one will assist in achieving the other. For more information on suggested IMPs see Section 11.4.

Related LEED credits:

- SS Credit 5.1 Site Development – Protect or Restore Habitat
- SS Credit 5.2 Site Development – Maximize Open Space
- SS Credit 6.1 Stormwater Design – Quantity Control
- SS Credit 7.1 Heat Island Reduction – Non Roof
- SS Credit 7.2 Heat Island Reduction – Roof
- WE Credit 1 Water Efficient Landscaping

4.2.1.3 CREDIT 7.1 (HEAT ISLAND EFFECT - NON ROOF) 1 POINT

Intent: To reduce heat islands and minimize adverse impacts on microclimates and human and wildlife habitats.

Requirement: (Option 1) Reduce heat island effect by implementing any combination of the following strategies for 50% of the site hardscape including roads, sidewalks, courtyards and parking lots.

- Shade from trees
- Shade from structures covered by solar panels
- Shade from architectural devices or structures with a high solar reflectance index (SRI)
- Use hardscape materials with an SRI of at least 29
- Use an open-grid pavement system with at least 50% pervious

(Option 2) Place a minimum of 50% of parking spaces under cover. Any roof used to shade or cover parking must have an SRI of at least 29, be a vegetated green roof or be covered by solar panels that produce energy used to offset some nonrenewable resource use.

Project Application: In conjunction with LEED credit 6.2, the use of pervious pavement as a BMP will also contribute to obtaining this credit by introducing not only additional means for stormwater treatment and infiltration, but also reducing surface heating of pavement areas. In addition to offering a stormwater benefit and groundwater recharge, the use of select materials with high SRIs will also lower the overall urban area heating which will reduce the cooling demand and water demand associated with the cooling demand in addition to the costs associated with each.

Method to Comply: To comply with LEED credit 7.1, it is important to maximize the use of other LEED credits such as credit 5.2 and 6.2 which, when implemented, will work towards achieving the 7.1 credit by reducing the overall impervious pavement and in turn reducing the heat island effects.

- Maximize use of credits 5.2 and 6.2
- Calculate benefit of reduced urban heating on cooling system loads
- Calculate benefit of associated water savings with reduced cooling loads
- Calculate benefit of carbon sequestration through reduction in pavement and increase in plant material, especially trees used for shading purposes.

Recommendations to meet LEED credit 6.2 at the Finegayan Main Cantonment are:

- Plan for compliance starting at the master planning stages by setting aside needed land for stormwater management.
- Provide water quality treatment train approach for all stormwater flows that includes pre-treat IMPs such as sedimentation basin, grass filter strip, dry swale, bioretention basin, or an oil/sediment separator.
- Integrate stormwater controls into the design of the site and use the controls as site amenities utilize vegetation for water quality enhancement.
- Manage stormwater as close to its origin as possible by using many, small scale LID techniques.
- Limit curb and gutter infrastructure to encourage overland flow.
- The overall LID study does not establish specific locations for BMPs and IMPs to determine if LEED credit criteria (SSc6.1 or 6.2) is being met. LEED is primarily focused on specific facilities and is generally considered during the design phase of a project.

Toolkit for achieving LEED credit 7.1:

- Use of shade trees
- Use of solar photovoltaic (PV) panel shade structures
- Use of other shade structures
- Pavement and hardscaping reduction
- Use of pervious pavement
- Use of high reflectivity materials (SRI) of at least 29

Related LEED credits:

- SS Credit 4.4 Alternative Transportation – Parking Capacity

- SS Credit 5.2 Site Development – Maximize Open Space
- SS Credit 6.1 Stormwater Design – Quantity Control
- SS Credit 6.2 Stormwater Design – Quality Control
- WE Credit 1 Water Efficient Landscaping
- MR Credit 1 Building Reuse

4.2.1.4 CREDIT 7.2 (HEAT ISLAND EFFECT - ROOF) 1 POINT

Intent: To reduce heat islands and minimize adverse impacts on microclimates and human and wildlife habitats.

Requirement: (Option 1) Use roofing material with a SRI of 78 or higher for flat roofs and 29 for sloped roofs over 75% of the roof surface.

(Option 2) Install a green roof that covers at least 50% of the roof area.

(Option 3) Install high-albedo and green roof surfaces that, in combination, meet a SRI of 78 or higher for flat roofs and 29 for sloped roofs.

Project Application: Urban Heat Island is the term used to describe the rise in temperature in cities across the country and around the world. This increase in temperature is caused by two factors: 1) the hard surfaces that dominate city streets – roofs, pavement, buildings, and roads – which store heat during the day and release it at night, and 2) the heat emissions from vehicles, industrial machinery and heating, ventilation, and air conditioning systems. The goal of this credit is to promote the use of "cool roofing" – systems that are light-colored and/or vegetated, often suitable for roofs and plazas over occupied space. These systems do not store and emit heat. Plants are particularly beneficial because they create a cooling effect in the air immediately around them.

Method to Comply: Implement the use of roof materials with a high SRI across the installation. Where applicable and feasible, the use of rooftop mounted or applied solar collector PV panels may fall within an acceptable material. The use of green roof systems will also reduce the urban heat effect and lower cooling costs.

Toolkit for achieving LEED credit 7.2:

- Use roofing materials with a high SRI
- Install rooftop PV panels where applicable
- Install green roofs where applicable and using appropriate products for Guam

Related LEED credits:

- SS Credit 5.1 Site Development – Protect or Restore Habitat
- SS Credit 5.2 Site Development – Maximize Open Space
- SS Credit 6.1 Stormwater Design – Quantity Control
- SS Credit 6.2 Stormwater Design – Quality Control
- WE Credit 3 Water Use Reduction
- EA Credit 1 Optimize Energy Performance

4.2.2 Energy Independence and Security Act of 2007 Section 438

In December 2007, Congress enacted the Energy Independence and Security Act of 2007. Section 438 of that legislation establishes strict stormwater runoff requirements for federal development and redevelopment projects. The provision reads as follows:

> **Stormwater runoff requirements for federal development projects.** The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.

The intent of Section 438 is to require federal agencies to develop and redevelop applicable facilities in a manner that maintains or restores stormwater runoff to the maximum extent technically feasible.

More recently, President Obama signed Executive Order 13514 on “Federal Leadership in Environmental, Energy, and Economic Performance” calling upon all federal agencies to “lead by example” to address a wide range of environmental issues, including stormwater runoff. The U.S. Environmental Protection Agency published technical guidance that provides a step-by-step framework to help federal agencies maintain pre-development site hydrology by retaining rainfall on site through infiltration, evaporation/transpiration, and re-use to the same extent as occurred prior to development. The technical guidance provides background information, key definitions, case studies, and guidance on meeting the new requirements. Federal agencies can comply with Section 438 by using a variety of stormwater management practices often referred to as "green infrastructure" or "low impact development" practices (EPA 2009).

4.3 LOW IMPACT DEVELOPMENT APPROACH

The objective of LID design is to treat and retain stormwater “near the source” thereby allowing post-development hydrology to mimic pre-development hydrology to the maximum extent practical. LID technology employs microscale and distributed management techniques, called IMPs to achieve desired post-development hydrologic conditions. The approach is to manage runoff at the source rather than at the end of pipe. This has the benefit of avoiding higher downstream flows and allowing runoff to infiltrate the ground at multiple locations on the site.

Preserving the hydrologic regime of the predevelopment condition may require both structural and nonstructural techniques to compensate for the hydrologic alterations of development. Structural LID solutions, such as bioretention, infiltration basins, and swales, are best used to treat small, frequent storm events (2-year event and less). These systems encourage infiltration while slowing water on the landscape. During flood events, it is important that high flows do not scour or damage IMPs. LID seeks to develop efficiencies within the urban water streams, namely stormwater, potable water, and wastewater to restore the water balance of the landscape.

Land development plans for the area combined with the region’s unique limestone and sensitive water resources mean that sustainable stormwater management is a significant environmental and economic issue (CNMI 2006). With an average annual rainfall of approximately 98 inches per year and typhoons that can drop 10–15 inches of precipitation in one storm event, flood control is of primary importance (URS 2008). Stormwater on Guam has historically been viewed as strictly a drainage or flooding issue. This resulted in flood flows being routed to the nearest discharge location and allowing for infiltration into the highly permeable limestone with little or no pre-treatment (Horsley Witten Group 2006).

The Finegayan Main Cantonment area has experienced little development with the majority of the landscape covered in gently sloping mowed areas, tall grasses and occasional trees, or dense jungle (URS 2008). Development on the site would change the hydrology by decreasing the infiltration capacity through site grading, compaction, and development, leaving much of the landscape imperviousness. Development and its associated impacts eliminate much of the inherent storage and absorption capacity provided by the natural topography and ecology.

4.3.1 Benefits and Constraints of Low Impact Development

A LID design approach provides benefits that are physical, environmental and social in nature. LID is recognized as both a tool to manage stormwater (reduce flooding), treat water quality, and to "green" the landscape, enhancing the livability of a community. Conversely, LID design has recognized physical and social limitations. Table 4-1 outlines both the benefits and constraints of a LID approach.

Table 4-1: Benefits and Constraints to LID

Benefits	Constraints/Limitations
Hydrological balance: maintains the hydrological balance by using natural processes of storage, infiltration and evaporation.	Existing regulations, ordinance, design practices: LID may conflict with local regulations or existing guidance such as airfield drainage design.
Sensitive resource protection: protects environmentally sensitive areas from urban development	Topography and erosion: opportunities are limited in areas of deeply dissected terrain and high slopes
Waterway restoration: restores and enhances urban waterways	Public Perception and Attitudes: integral nature of LID may be viewed as unnecessary or a nuisance as it relates to site design.
Impact reduction: minimizes the impact on the environment of urban development	Research and standardized procedures: LID is an evolving practice with significant research gaps. Lack of design criteria and information
Groundwater recharge: replenishes aquifers	Maintenance: Required for most IMPs. Maintenance program should be established.
Community linkages: opportunities to connect development areas through public open space	Soils and water table depth: solutions more challenging in areas of poor infiltration. opportunities are limited in areas with high water table
Greening the landscape: minimizes impervious surface while providing additional vegetation and canopy within the landscape	
Water quality treatment: reduces pollutants such as suspended solids, nutrients, hydrocarbons from entering groundwater or downstream receiving waters	

Source: Adapted from Navy 2009 and the *Urban Stormwater—Best-Practice Environmental Management Guidelines*, 2006. Victoria. Stormwater Committee, Australia

4.3.2 Adapting to Guam's Climate and Landscape

Guam's unique climate and landscape require an adaptive approach to stormwater management. A number of important stages exist in the successful planning and design of a LID strategy on the Finegayan Main Cantonment.

This section outlines two applicable case studies, key site interpretation requirements, and adaptive design responses.

4.3.2.1 CASE STUDIES

LID design has been successfully applied in areas with similar climates, rainfall patterns, and soil properties. Two case studies are presented to examine successful interpretation of LID design.

The first case study is located in Singapore, which experiences yearly rainfall and temperatures comparable to Guam. Singapore and Guam's climates are both characterized by uniform temperature, high humidity, and abundant rainfall. Singapore experiences an average annual rainfall around 93 inches while Guam's northern limestone plateau averages between 85 and 105 inches annually. The annual average daytime temperature in Singapore is 88 ºF, while Guam's average daytime temperature ranges from 85 to 89°F (URS 2008). Stormwater management solutions in this project are for a high density residential area with treatments focusing on bioretention basins in parkland.

The second case study is located in Pennsylvania, USA. This residential development is located in a sinkhole-prone karst topography. Stormwater management solutions for the property focused primarily on water quality treatment and infiltration. This 59-acre development drained to closed depressions, with no apparent surface runoff occurring. The stormwater management plan resulted in more than 100 storage/infiltration BMPs distributed throughout the site.

Tapping into Singapore's Urban Stormwater

The ambitious project to turn Singapore's fully urbanized environment into a water supply catchment is attracting attention from around the globe. Singapore's Public Utilities Board (PUB) has commenced to convert Marina Bay, in the heart of the city, into a freshwater reservoir fed by stormwater runoff from a third of the metropolis. Professor Tony Wong and colleagues at AECOM have been advising PUB on the implementation framework for low impact development in the catchment.

As part of Singapore's Active Beautiful and Clean Waters initiative, the PUB has developed two pilot projects. One project is a 2,580 ft^2 'rain garden' designed to collect and filter runoff from a 1.5 acre residential estate. The other is a vegetated bioretention swale (bioswale), 580 ft long, beside a new arterial road. The installation occupies two sides of Sengkang West Way, and for experimental purposes each side is different.

The rain garden was retrofitted into the Balam residential estate in 2007. It consists of a sandy loam filter layer 16–20 in thick, which sits on top of a 16 in submerged zone; at the bottom is a gravel drainage layer intersected by perforated pipes which take the water away. The rain garden is planted with a wide range of vigorous and hardy plants whose root systems keep the filter material open. They also help remove nutrients.

The submerged zone—or saturated anoxic zone—has a special configuration to turn NOx into nitrogen gas. It does this through a series of nitrification and denitrification steps involving anaerobic microbes. Coarse wood chips are added (about a third by volume) to provide the microbes with the necessary source of carbon.

The bioswale works in a similar, if simpler, way. It is designed as a linear structure beside the road without a submerged zone. It collects the water from the pavement and filters it through a medium before draining away. Again, suitable vegetation adds to the effectiveness and attractiveness of the system.

Finished in September 2008, testing of the systems is underway, and results will allow the most effective design to be adopted for larger scale use. The preliminary results from Balam Estate have been impressive, indicating that total dissolved solids could be reduced by 98% and total nitrogen by 85%.

The Village at Springbrook Farms, Pennsylvania

The Village at Springbrook Farms is a 59-acre, 259-unit residential community that sits on sinkhole-prone karst topography. Recognizing the problems associated with detention basins and the need to sustain groundwater supplies, South Londonderry Township requires infiltration wherever possible on new development sites. Springbrook Farms developed a fully integrated system of more than 100 BMPs.

The original site featured gently rolling topography with closed depressions and sinkholes and was underlain entirely by limestone formations susceptible to subsidence. To maintain the natural pre-existing infiltration regime, it was crucial to undertake a detailed site investigation to ensure that the stormwater management plan would avoid sinkholes (and potential sinkhole areas), avoid overconcentration in any single area, and allow for infiltration into a suitable depth of soil mantle to remove pollutants and control the infiltration rate.

Rather than using large detention basins as was called for in the original development plan, engineers studied the site's natural conditions and created a stormwater management system that mimicked the existing regime. The overall approach was to keep the stormwater as close to the source as possible, cleansing and recycling it with a variety of BMPs. Porous asphalt pavement was used extensively—for sidewalks, paths, and parking areas—and typically had stone-filled recharge beds built underneath to purify runoff before allowing it to seep back into the ground. Infiltration beds were also used underneath nonporous driveways, while rain gardens, vegetated swales, and other landscape features were incorporated throughout the site to mitigate any potential impacts from runoff.

After an extensive site investigation, soil and infiltration tests took place. It was determined that the predevelopment stormwater runoff condition was essentially zero for both rate and volume of runoff because the many closed depressions acted as small catchments. Rather than overengineer to create a costly and ineffectual collection and conveyance system, the site would be treated as though runoff could occur during extreme weather events. For volume control, the various BMPs were designed to ensure no increase in the volume of stormwater or rainwater runoff for the 2-year, 24-hour storm. For peak rate control and to prevent localized flooding, the various BMPs were interconnected with a shallow piping system capable of conveying the 100-year flows without overtopping the BMPs or creating damaging flooding.

The site analyses showed that much of the site drained to the closed depression areas, with no apparent surface runoff occurring. Runoff infiltrated within each small catchment, sometimes forming shallow ponds which slowly infiltrated. Direct surface runoff did not occur beyond the closed depressions for much of the site under normal conditions. Because of this topography, conventional stormwater collection and conveyance systems would have required excessive grading and excavation, a costly and undesirable approach in soils over limestone formations.

Based on discussions with the local reviewing agencies, the site was analyzed as though runoff could occur from the closed depressions during extreme events, and the following stormwater management strategy was applied:

- For volume control, the various BMPs were designed so that that there would be no increase in the volume of runoff after development for the 2-year, 24-hour storm event.
- For peak rate control and to help with flood control, the various stormwater BMPs were interconnected with a shallow piping system capable of conveying the 100-year flow rates without overtopping the BMPs or creating damaging flooding.

This strategy was achieved by the use of 124 storage/infiltration elements distributed throughout the site. These elements are integrated into the built landscape and include vegetated infiltration beds, pervious concrete sidewalks, vegetated infiltration swales, rain gardens, infiltration beneath standard driveway parking areas, porous asphalt pathways and pavement, and similar landscape/stormwater elements.

4.3.2.2 SITE INTERPRETATION

Understanding the characteristics of the site is critical in achieving principles of sustainable and integrated management of land and water resources, and incorporating best practice stormwater management, water conservation/reuse, and environmental protection. This requires developing an understanding of topography, drainage, climate, site geology and soils, hydrology, ecology and environmental conditions.

Topography and Drainage

The Finegayan site is located along the northwestern edge of a gently undulating limestone plateau and is flanked by steep cliffs. The ground surface elevation of the site generally grades downward from east-northeast. The surface of the north plateau is characterized by karst topography and numerous sinkholes (URS 2008).The limestone is so permeable that normal stream drainage patterns have not been able to form; instead, a gentle karst topography has developed and drainage takes place directly into the ground or through sinkholes. Little to no standing or ponding water is found on the surface during the dry season because of the high rate of infiltration.

Project evaluation should include:

- topographic elevations and slopes as LID design requires varied solutions on steep versus flat sites; and
- natural or historic drainage patterns across a site.

Climate

The site is located in an area of high rainfall. On the northern limestone plateau, rainfall averages between 85 and 105 inches annually. About 68 to 73 % of the annual precipitation occurs during the wet season and 15 to 20 % during the dry season. The remainder occurs during the transitional months. The average daytime temperature ranges from 85 to 89°F (URS 2008).

Project evaluation should include:

- catchment rainfall characteristics;
- intensity, frequency, and duration of local storm events; and
- development pattern and percentage of impervious areas.

Geology and Soils

The site is located over the highly permeable Northern Guam Lens Aquifer, which is an EPA sole drinking water aquifer for northern Guam. This karst geologic condition is rare and offers both opportunities and constraints. LID is most effective in areas of high permeability (such as the site), thereby making hydrologic goals related to peak flow and volume more attainable. However, this geologic condition offers little protection to water quality in the underlying aquifer.

Project evaluation should include:

- soil moisture storage characteristics,
- capacity of native soils to filter contaminants,
- existing and potential sinkhole formations,
- infiltration capacity, and
- groundwater elevation.

Receiving Environment

Commonly downstream receiving environments are lakes, streams, or coastal waters. In this case, the highly permeable limestone layer did not allow streams to form on the landscape. Therefore, stormwater has historically either been absorbed directly into the landscape or has drained to local sinkholes during large storm events. There are no jurisdictional wetlands located within the development site.

Post-development, this natural drainage pattern may remain intact during large storm events; however, it is essential that stormwater flows from the developed landscape are treated to eliminate possibility of groundwater contamination.

Project evaluation should include:

- known sensitivity of downstream receiving waters to changes in hydrology or water quality;
- history of contamination or other water quality issue; and
- water resource declared beneficial uses, such as drinking water supply.

4.3.2.3 DESIGN RESPONSES FOR THE FINEGAYAN MAIN CANTONMENT

The following recommendations and design responses have been developed specifically for the Finegayan Main Cantonment climate, geology, topography, and proposed development type.

Focus on Treatment

Development can lead to a depletion of groundwater resources, increased saltwater intrusion to drinking water wells, and increased concentrations of other pollutants derived from urban runoff (Horsley Witten Group 2006). As stated in the *Low Impact Development Manual 2009* (Navy 2009):

> In northern Guam, the overriding criterion is to protect groundwater from contamination. Drainage design and application of LID principles must achieve quality of runoff water to be acceptable for groundwater recharge.

Groundwater serves as the primary source of drinking water in northern Guam; therefore, minimizing the potential for contamination is critical. The only source of groundwater recharge is precipitation, which infiltrates to the subsurface and recharges the underlying water table. Runoff should be pretreated, treated, stored and allowed to infiltrate into the ground as close to the source as possible. In particular, runoff from areas with significant pollutant loading (such as Regime C, D, and E) need to be pretreated through an oil/sediment separator or oil/water separator, sedimentation basin, grass filter strip, and/or dry swale.

Protect against High Flows

In order to protect IMPs from damage such as vegetation scour and erosion, allow for a high-flow bypass (up to the 50 average return interval [ARI] storm) around all systems. Velocity within swales and other conveyance mechanisms should be less than 1 feet per second (fps) for a 1.5-inch rain event (Navy 2009). In addition, it is preferable that storm flow velocities through a bioretention basin or other vegetated system should not exceed 6.5 fps for flood events (50 ARI storm).

LID in High Density Developments

Stormwater management in high-density development is always challenging, requiring innovative and integrated solutions. In a high rainfall region, this is particularly true. As the site is required to treat water quality, recharge the groundwater aquifer and manage the 100-year flood event, a dual approach will be required that uses both IMPs and traditional stormwater storage areas such as detention basins. While detention basins normally require large contiguous areas, IMPs are designed as small distributed systems that act as a functional part of the landscape; therefore, the LID approach can be adequately adapted for high-density developments.

Key design requirements include the following:

- Manage stormwater as close to its origin as possible by using many, small scale LID techniques.
- Reduce potable water and energy demands by collecting and reusing rooftop runoff.
- Integrate stormwater controls into the design of the site and use the controls as site amenities.
- Utilize structural solutions such as pervious pavers, green roofs, bioretention basins, and infiltrations basins as appropriate.

Preserving Site Permeability during Construction

Soil compaction during construction is a common issue on development sites because of heavy machinery and repeat vehicle trips across the landscape. Soil compaction reduces rainfall infiltration and increases runoff that causes erosion. This is particularly true in karst areas, as limestone can, in combination with water, form a cement-like hardpan that will drastically reduce infiltration capacity. Compacted soil also physically hinders root development. It is imperative to consider soil compaction when planning projects.

Soil disturbance and compaction can be limited or prevented in a number of ways, including the following:

- Identify depressional areas or other areas of high infiltration capacity or those areas with the highest quality ecological functions and cordon or limit disturbance in these areas.
- Consolidate activities such as staging and parking in already-disturbed areas that have low functional potential.
- Designate a single access route into areas with impacts. Before construction starts, fence off protected areas and sign each area clearly. If saving individual trees, protect the root system from compaction.

Solutions for Steep Site - End-of-line Treatment Systems

For steep sites (grades greater than 4 – 5%), larger "end-of-line" solutions are recommended. Flows are collected in traditional stormwater networks (pipe or swale) and conveyed to an IMP such as bioretention basin, constructed wetland, infiltration basin, detention basin.

These systems are able to accept stormwater from large catchments. They result in fewer treatment systems needing to be built. However, in high rainfall regions they can also concentrate flow. It is essential that catchments with end-of-line solutions are sized carefully to eliminate possibility of flooding. They require larger topographic differences to ensure the systems can gravity flow stormwater to the system and then are able to freely drain to the receiving environment. This may result in the systems having to be depressed into the surrounding landscape.

While end-of-line systems work better on steeper sites, on flat sites, oversized pipes laid on flat grade or low slope swales would be necessary to convey stormwater. This is less desirable as it can create additional cost and maintenance requirements.

Implement Solutions for Flat Sites—Near Source Treatment Systems

For flat sites (grades less than 4–5%), the recommended solution is microscale IMPs located in, for example, streetscape right-of-ways, plazas, and landscape areas. Stormwater is treated at surface (rather than being piped in to a larger system). Stormwater can be conveyed along the road surface through dry swales or along hardscape areas to microscale bioretention basins, infiltration basins or other IMPs as appropriate.

Microscale IMPs can be incorporated into nodes of landscape development creating multifunctional elements such as traffic slow down points, courtyard raingardens, parkland wetlands, or recreational detention basins. Integration into the landscape adds function and character. Residents are able to make a visual connection between their local urban environment and the stormwater treatment systems. The adoption of either approach or a combination should ideally be done in conjunction with the master planners for the site in order to determine the best location for these systems.

Use Native Vegetation

Selecting suitable plant species is critical to the long-term functional performance and structural integrity of vegetated IMPs. It is recommended that native plant species be utilized in all vegetated systems. Nonindigenous natives and exotics should only be considered when there is a specific landscape need and the species has the appropriate growth form and habit. If nonindigenous natives and exotics are chosen, careful consideration should be given to the potential impacts on downstream receiving ecosystems. Species (including natives) that have the potential to become invasive weeds should be avoided. Maintenance costs can also be reduced by careful selection of plant species and by adopting suitably high planting densities.

Control Mosquitoes

Stormwater management solutions should be designed to prevent mosquito breeding by eliminating conditions that are favorable for mosquito breeding, e.g., impervious depressed areas or plants that have receptacles or thick axils to trap water. Standing water is unlikely to persist for extended periods of time because of the high permeability of the soils on site. However, during high rainfall periods vector management techniques include:

- removing grass cuttings, trash and other debris, especially at outlet structures;

- maintaining and cleaning out temporary erosion and sediment control traps and basins; and
- avoiding small isolated pools or ponding areas.

Summary of Sustainable Design Recommendations for the Finegayan Main Cantonment

Table 4-2 provides a summary of the recommendations outlined above.

Table 4-2: Summary of Sustainable Design Recommendations for the Finegayan Main Cantonment

Design Recommendations for the Finegayan Main Cantonment
Manage stormwater as close to its origin as possible by using many, small scale LID techniques.
Reduce potable water and energy demands by collecting and reusing rooftop runoff.
Integrate stormwater controls into the design of the site and use the controls as site amenities.
Utilize structural solutions such as pervious pavers, green roofs, bioretention basins, and infiltrations basins as appropriate.
Utilize treatment trains that include pretreatment for stormwater management.
Once treated, encourage stormwater to infiltrate into the ground as close to the source as possible.
BMPs for pretreatment may include, but are not limited to, oil/sediment separator, sedimentation basin, grass filter strip, and/or dry swale.
Velocity within swales and other conveyance mechanisms should be less than 1 feet per second (fps) for a 1.5-inch rain event.
Velocities through a bioretention basin or other vegetated system should not exceed 6.5 fps for flood events (50 ARI storm).
Utilize microscale IMPs for flat sites (grades less than 4–5%) by locating IMPs in streetscape right-of-ways, plazas, medians, and other landscape areas.
Utilize larger “end-of-line” solutions for steep sites (grades greater than 4–5%). Flows are collected in traditional stormwater networks (pipe or swale) and conveyed to an IMP such as bioretention basin, constructed wetland, infiltration basin, detention basin.
Utilize native plant species be utilized in all vegetated systems.
Limited soil compaction by identifying depressional areas or other areas of high infiltration capacity or those areas with the highest quality ecological functions and cordon or limit disturbance in these areas; consolidating activities such as staging and parking in already-disturbed areas that have low functional potential; and designating a single access route into areas with impacts. Before construction starts, fence off protected areas and sign each area clearly.
Reduce mosquitoes and other vectors during high rainfall periods by removing grass cuttings, trash and other debris, especially at outlet structures; maintaining and cleaning out temporary erosion and sediment control traps and basins; and avoiding small isolated pools or ponding areas.

5. Pre-development Stormwater Runoff Modeling

Pre-development stormwater modeling and post development stormwater modeling (Section 8) provided comparison of the pre-development and post-development land use for the Finegayan Main Cantonment Area. Pre-development land use conditions were incorporated into a two dimensional hydrologic/hydraulic model (FLO-2D) to characterize drainage basins and quantify the stormwater runoff (peak and volume) that would need to be accommodated at the project site (regulatory criteria is discussed in Section 2). This section summarizes the results of predevelopment hydrology development and stormwater runoff modeling. Hydrology for the following storm events was analyzed:

- 24-hour storm events with 1, 2, 10, 25, 50, 100, and 500-year recurrence
- 80, 90, and 95 % annual exceedance 24-hour storm events.

FLO-2D is an effective model for holistic evaluation of the project locale and surrounding areas that impact runoff conditions within the project site. Detention basins are sized for varying storm events ranging from a 2-year, 24-hour event to a 100-year, 24-hour event. BMPs are designed based on the 95th percentile storm exceedance. The design of detention basins and BMPs must use a small-scale evaluation of drainage areas utilizing different modeling software. The results of the large-scale FLO-2D model will help the site developer understand the pre-development and post-development drainage patterns on a site-wide basis for these design storm events. In particular, the model results should be consulted prior to finalization of detention basins. The model results are also important to understand natural ocean discharge locations, sinkhole location and natural stormwater storage, general drainage patterns during different storm events, natural flooding characteristic, run-on distribution to the project site, and total project related change in infiltration/storage/runoff excluding engineered stormwater control (e.g., BMPs and detention basins).

5.1 DESCRIPTION OF EXISTING STORMWATER DRAINAGE SYSTEM

Limited stormwater drainage collection facilities exist at NCTS Finegayan. For the most part, stormwater is drained via street collection and unlined or vegetated drainage ditches with its ultimate discharge to the jungle. There is currently no treatment, detention or other mitigation facilities associated with the drainage system.

5.2 SUBBASIN DELINEATION

Basin and subbasin delineation is a complex task at the project location due to lack of developed stream network. United States Geological Survey (USGS) National Elevation Dataset (NED) at 30 meter Digital Elevation Models (DEM) was used as a base map in geographic information system (GIS) to delineate drainage basins and subbasins. The entire island was initially analyzed for watershed delineation. This evaluation identified all subbasins and their direction of flow and flow accumulation. From this initial analysis, subbasins contributing to the drainage subbasins in the project site were identified and used as inputs in the extents of the model. Model extents (described further in Section 5.6.1) were developed from the watershed delineation. The final model extents included an overall drainage area of the approximately 20.7 square kilometer project area and 94.9 surrounding square kilometers (north, east, and west of the project area).

5.3 HYDROLOGIC REGIME OF THE SITE

The island of Guam is warm and humid throughout the year. The dry season on Guam is January through May and the wet season is July to November. The seasons are well defined affected by the continuous northeasterly trade winds. Annual rainfall on the island is 80 to 90 inches and varies locally. Average rainfall in the area of the project site is 85 to 105 inches.

The geologic structure of the north half of the island includes a thin (up to approximately 0.3 meters deep) layer of topsoil with underlying limestone and volcanic rock beneath the limestone. Undeveloped areas, which describe the majority of the project site, are generally vegetated jungle.

The URS Corporation (URS) report classified project site soils in general as silty sand with gravel. The topsoil has infiltration rates in the range of 1.2 to 3.9 meters per day. In general, the topsoil is the limiting factor to infiltration rates as the subsurface limestone has an extreme infiltration capacity. The project area is a low-relief limestone plateau. Characteristic of karst topography, a number of sinkholes exist in the project area. Sinkholes can be filled with up to 14.5 meters of clay, which would result in very slow infiltration. However, the side slopes of the depression allow very high infiltration. Infiltration rates used to model sinkholes is discussed further in Section 5.6.4. Because of the high infiltration rates of the topsoil and through the sinkholes, streams have not been able to form and storm drainage infiltrates directly into ground. Typically, (i.e., during frequent and less intense storms) no runoff to the ocean occurs from the project site. Only during infrequent larger storms evapotranspiration and infiltration would not prevent runoff.

Additional details of site hydrology are provided in Section 3.

5.4 MODELING APPROACH

The selected modeling program for storm hydrology characterization was FLO-2D. This modeling program is two dimensional analysis software specifically designed for simulating unconfined overland flow where channels may not be well defined and runoff may change direction based on flow depth. In addition to the ability to model unconfined flooding, the model also considers infiltration.

The model is generated based on rainfall, topography, land use, and soil information. Inputs to the model include elevations, roughness coefficients, runoff characteristics, rainfall intensity and distribution, inflow and outflow conditions, and flow obstructions (e.g., buildings).

The two dimensional model was selected because it was consistent with the overall approach where addressing the unconfined flow hydrology was the goal.

5.5 MODEL RESULTS FOR DESIGN STORMS

The results presented in this section reflect the current flow patterns and runoff characteristics at NCTS Finegayan. The sections following describe the methodology and model inputs in detail.

Predevelopment model results aid in the design of stormwater control components that comprise a management system that will limit post development runoff exiting the project site. LID measures will be selected and designed to mitigate any changes in site hydraulics that result from development and is further discussed in later Sections.

Model results indicate that the storm events up to the 1-year storm recurrence interval result in no runoff. There is an insignificant runoff based on the results at the two year recurrence interval and increasing runoff at the 10 and more year recurrence intervals. The 1-year recurrence interval storm shows standing water only on the impervious areas. The results show in the larger storm events (10-year recurrence interval and greater) that the entire drainage area becomes flooded (i.e., standing water) above 0.02 meters of depth. Ocean discharge occurs primarily at Haputo ecologic reserve areas and the discharge exiting at the southern project boundary will eventually go to Tumon Bay.

Table 5-1 shows the model results of the 24-hour storm events. A summary of the annual exceedance storm events (all less than the one year recurrence interval storm) model results are shown in Table 5-2. The following definitions are provided for the result tables presented:

- *Total point rainfall.* The rainfall depth assigned to the model event. More information for rainfall depths and calculations can be found in Section 5.6.5.
- *Rainfall Volume.* The total volume of rainfall that has precipitated at the project site.
- *Inflow Hydrograph.* Quantifies the total volume of inflow that was assigned to the model. The inflow was assigned as a hydrograph at each cell along the interior border of the project. Section 5.6.1 describes the inflow assignment in more detail.
- *Overland Infiltrated and Intercepted Water.* The amount of rainfall that was lost to infiltration and floodplain storage.
- *Water Lost to Infiltration and Interception.* The total volume of water that was lost through ground infiltration.
- *Peak Outflow Discharge.* The highest flow rate of surface runoff experienced at the outflow boundary. The outflow hydrograph for each storm event is shown on Figure 5-2. Storm events less than and equal to the 1-year storm do not discharge to the ocean.
- *Total Outflow Volume.* The volume of water in the form of surface runoff that left the model through an outflow boundary. Outflow boundary elements were designated at the coastline and at the southernmost model boundary where flood flows were determined to exit. The water that leaves the model at this southern boundary will follow the streamlines shown on Figure 5-1, and discharge to the ocean.

Table 5-1: Pre-Development 24-hour Storm Event Model Results

Storm Event	1-year	2-year	10-year	25-year	50-year	100-year	500-year
Total Point Rainfall (mm)	83.82	203.20	332.74	426.72	520.70	574.04	1,287.78
Rainfall Volume (m^3)	1,702,000	4,125,000	6,755,000	8,663,000	10,571,000	11,655,000	26,142,000
Inflow Hydrograph (m^3)	—	215,000	369,000	174,000	237,000	251,000	1,568,000
Overland Infiltrated & Intercepted Water (mm)	82.86	182.38	255.57	294.75	326.18	341.39	454.54
Water Lost To Infiltration & Interception (m^3)	1,682,000	3,702,000	5,187,000	5,982,000	6,620,000	6,930,000	9,225,000
Peak Outflow Discharge (cms)	—	1	41	101	140	166	993
Total Outflow Volume (m^3)	—	12,000	1,506,000	3,450,000	5,979,000	7,273,000	43,373,000

cms	cubic meters per second
m^3	cubic meter
mm	millimeter

The 95 % exceedance storm was used for developing the BMPs presented in Section 12. The goal of these BMPs is to limit the post-development runoff to the pre-development quantities presented in Table 5-2 and graphically shown in the 95th percentile figures at the end of this section. Figure 5-3 shows the maximum flow depth for the 95th % exceedance storm. Standing water occurs in minimal amounts on the impervious areas and no ocean discharge is experienced. The maximum flow depth within the project site is 0.05 meters. Figure **5-4** shows the maximum velocities for the 95th % exceedance storm. The maximum velocity within the project site is 0.14 meters per second. The general flow directions are shown on Figure **5-5**

The detention basins described in Section 9 were designed based on the volumes of runoff during the 50-year, 24-hour storm. The maximum flow depths experienced for pre-development conditions during the 100-year, 24-hour storm are presented on Figure 5-6. The maximum flow depth within the study area is 27.4 meters. This depth occurs within a sinkhole at the center of the NCTS Finegayan site. The sinkholes, noted by a dashed line on the figures, collect a significant amount of the stormwater runoff. The average flow depth within the project area is 0.34 meters.

Table 5-2: Pre-Development Annual Exceedance Storm Event Model Results

Storm Event	80%	90%	95%
Total Point Rainfall (mm)	20.31	38.10	55.88
Rainfall Volume (m^3)	413,000	775,000	1,135,000
Inflow Hydrograph (m^3)	-	-	-
Overland Infiltrated & Intercepted Water (mm)	20.30	38.01	55.60
Water Lost To Infiltration & Interception (m^3)	413,000	773,000	1,129,000
Peak Outflow Discharge (cms)	—	—	—
Total Outflow Volume (m^3)	—	—	—

Figure 5-7 shows the maximum velocities during the 100-year storm. The maximum velocity is 3.83 meters per second. The general flow directions are shown on Figure 5-8. This figure shows the stormwater routing to sinkholes, discharge points directly to the ocean and discharge that occurs at the southern boundary.

Figures for the remaining pre-development storm events can be found in Appendix A.1.

5.6 METHODOLOGY

A summary of the modeling methodology followed is below and is explained in detail in the following Section.

- Identify model extents
- Determine and input variables
- Identify design storm values
- Validate the model (described in Section 5.7)
- Perform simulations (described in Section 5.5)

5.6.1 Model Extents

Two models were necessary to predict stormwater runoff at the project site. The absence of streams and rivers on the north half of Guam makes it difficult to determine where inflow to the project area would occur during flooding scenarios. A large-scale model was used to determine boundary conditions of a second smaller model which was confined to the project area. The second (project area) model was developed at a smaller scale to provide the level of detail required for this analysis. The large model was developed to include all of the watersheds that contribute flow to the project area. The grid size used for the large scale model was 100 meters. The input parameters of the large model were developed using the pre-development site conditions. The small scale model includes only the project area and its immediate surroundings to the limits of adjacent subbasins and has a smaller grid size of 25 meters. The smaller grid increases the accuracy of the runoff predictions for the project site. Rainfall collected by topographic characteristics of the large scale model is the only form of inflow to the project area (i.e., small scale model). Figure 5-1 (at end of section) shows delineated basins and both model extents. The streamlines within each basin were generated in GIS as part of the subbasin delineation. These do not represent existing streams; they are an estimate of flow accumulation interpolated from the existing topography.

Cross-sections were assigned to the large scale model around the border of the small scale model extents. The hydrographs from these cross sections were assigned as an inflow to the project model for each storm event. Figure 5-9 (at end of section) shows a hydrograph for total inflow to the project site for each of the storm events. Hydrographs with negative values indicate outflow from the project area as opposed to inflow. Large negative values were observed at the southern border of the project site. Elements in the small scale model located on the boundary of the cross sections with large negative values were assigned as outflow elements (no inflow hydrograph). Inflow was not assigned to the 1-year, 95%, 90%, and 80% recurrence intervals because no flow was experienced at the cross sections by the large-scale model (Figure 5-1).

5.6.2 Elevation

A DEM from the USGS National Elevation Dataset was used for the large-scale model. The DEM contains points on a 30-meter grid. The points were uploaded to the model grid and averaged within each 100-meter element. The same 30 meter DEM was used as a base for the small scale model. Elevation data collected by the (LIDAR) survey was added to the small-scale model for the pre-development conditions. LIDAR data was used as is. The accuracy of the data is not known. Both datasets, the DEM and LIDAR, were averaged within each 25 meter element in the small scale model.

5.6.3 Manning's Roughness Coefficient

Manning's roughness coefficient (n) is used to describe the impact of surface cover roughness on run-off. Higher roughness values (typically associated with dense vegetation) cause slower flow velocities and increase time to peak, whereas low roughness values (typically associated with smooth surfaces like pavement) cause higher velocities and quicker time to peak (i.e. flashier runoff conditions).

For the project site, four different surface types were identified: open space, impervious areas, gravel roads and woods. From the pre-development conditions computer-aided design and drafting (CADD) drawings, a GIS shapefile was created for surface type. Each surface type was assigned a manning value. FLO-2D interpolated the shapefile averaging the Manning's numbers for each grid element. For areas outside the extent of the CADD drawing a base map from the USGS was used to distinguish between open space, impervious areas, and woods. White space on the map was assigned the value for open space, green space was assigned the woods value, and gray space was a combination accounting for buildings and other obstructions. The USGS map was used because the different surface types were easily distinguishable. The USGS map was compared to aerial photos and was similar in surface types. A summary of the total area by surface type is in Table 5-3.

The total roughness coefficient was derived using the methodology outlined in the *USGS Water-supply Paper 2339 titled "Guide for Selecting Manning's Roughness Coefficients."* A base roughness value was assigned to each surface type based on soil bed material and adjustment values were added. Soil bed materials include sand, gravel and concrete. Adjustment values include degree of irregularity, variation in channel cross section, effect of obstruction, amount of vegetation and degree of meandering.

Table 5-3: Total Area by Surface Type

Cover Type	Area (square kilometers)
Open Space	3.32
Impervious Areas	0.45
Gravel Roads	0.10
Woods	9.85
Total Area	13.72

Using Equation 1, which takes into account the base roughness value and all adjustment values, total roughness coefficients were calculated. Results are shown in Table 5-4.

Equation 1: Total Manning's n Roughness

$$n=(n_b+n_1+n_2+n_3+n_4)m$$

The URS report classified project site soils in general as silty sand with gravel. A base value of medium size sand, particle size diameter D_{50}=0.5 millimeters (mm) was used for open space and wooded surfaces while a base value of 0.012 and 0.03, respectively, were used for impervious and gravel roadway surfaces. All project site surface types were assigned a minor degree of irregularity, which is defined as a flood plain slightly irregular in shape. Variation in channel cross section was not applicable (NA) because there are no streams or rivers on the northern half of the island. Variation in channel cross section is not applicable to floodplain roughness. The effect of obstruction was also assigned a minor value as obstructions occupy less than 15 % of the cross-sectional area. The amount of vegetation adjustment values varied greatly between the open space and wooded surfaces. The open space surfaces were given an adjustment value consistent with little vegetation whereas the wooded surfaces were given an adjustment value consistent with significant amount of vegetation. The Degree of Meandering was NA not applicable because no streams are present; meandering is not applicable to floodplain roughness. A value for pavement was calculated and was applied to all of the impervious area. The buildings were input to the model as completely blocked cells. No flow would be allowed through the buildings so a roughness value is not applicable.

Table 5-4: Manning's Coefficient Calculations

Variable	Description	Open Space	Impervious Areas	Gravel Roads	Woods
n_b	Base roughness value:	0.022 Sand D_{50}=0.5	0.012 Concrete	0.03 Gravel D_{50}=2-64	0.022 Sand D_{50}=0.5
n_1	Degree of Irregularity: Minor	0.003	0.003	0.003	0.003
n_2	Variation in Channel Cross Section: N/A	0.0	0.0	0.0	0.0
n_3	Effect of Obstruction: Minor	0.002	0.002	0.002	0.002
n_4	Amount of Vegetation: Small/Large	0.005	0.0	0.0	0.15
m	Degree of Meandering: N/A	1	1	1	1
Total n		0.032	0.017	0.035	0.177

5.6.4 Infiltration Rates

USDA Technical Release (TR)-55 (TR-55) titled, *Urban Hydrology for Small Watersheds* was used to assign curve numbers. High curve numbers represent a high runoff potential and lower curve numbers have low runoff potential. The factors that affect curve numbers are: hydrologic soil group, cover type, treatment, hydrologic condition, and antecedent moisture condition (AMC).

Infiltration rates of different soil types are influenced by subsurface permeability and surface intake. There are four hydraulic soil groups characterized by their minimum infiltration rate. Soil group classes are A, B, C, and D, which vary from highest infiltration rate to lowest respectively. The hydrologic soil group for the north side of the island is defined by the Soil Survey Territory of Guam as "D". It is known that the soils have a very high infiltration rate due to the subsurface limestone; therefore, curve numbers for soil group "A" were used as opposed to "D". Soil group A is consistent with the URS report observations, which indicated silty sand soil. Type A soils used in modeling equate to about 0.6 meters per day (1 inch per hour [in/hr]) infiltration rate. The URS reports the infiltration rate in northern Guam to be 1.2 to 3.9 meters per day (2.0 to 6.4 in/hr); this would result in CNs that are below 20, which is outside of the range of conventional classification. Hence, use of CNs resulting in infiltration rate above 0.6 meters per day (1 in/hr) requires site specific data to provide realistic/conservative estimates.

Infiltration is also affected by land use. TR-55 presents cover types categorized by vegetation, bare soil, and impervious surfaces. Appendix A.2 includes Tables 2.2a and 2.2c from TR-55; the curve numbers presented in these tables are applicable for urban areas and agricultural lands. The cover types applied to the model are open space (lawns, parks, golf courses, cemeteries, etc.), impervious areas (paved parking lots, roofs, driveways, etc), gravel streets and roads, and woods. Treatment is a modifier of cover type used to describe agricultural management; treatment is not applicable for the tables used. The curve number method takes evapo-transpiration into account by defining initial abstraction. Initial abstraction incorporates losses before runoff begins including the following: water retained in surface depressions, water intercepted by vegetation, evaporation and infiltration. The effect of a cover type on infiltration and runoff is defined by hydrologic condition; often estimated by plant density. The hydrologic condition of northern Guam was assumed to be good; 75% or more ground cover. This assumption was verified by site photos provided by Base Comprehensive Development Study during the site visit dated 7 December 2009 to 8 December 2009.

AMC is an indicator of runoff potential before a storm event. There are three types of AMC (I, II and III) representing lowest to highest runoff potential. AMC II was applied to the model. AMC I (extremely dry conditions) was not used because of the frequency and amount of annual rainfall and AMC III was not used because the soils and underlying limestone are well drained. TR-55 presents curve numbers for AMC II because it is commonly used for design applications.

Sinkholes are a unique component of the Guam landscape. Because infiltration can occur through the sidewalls of the sinkhole it was modeled to be equal to the surrounding area.

All of the factors described above were used to choose curve numbers that would be representative of the project site. Table 5-5 below shows the curve numbers that were assigned to the model.

Table 5-5: Curve Number

Cover Type	Curve Number
Open Space	39
Impervious Areas	98
Gravel Road	76
Woods	30

Curve numbers were assigned using the same methodology as the Manning's roughness values. FLO-2D interpolated the shapefile averaging the curve numbers for each grid element. The USGS base map was used for areas outside the pre-development conditions CADD drawing extent. White space on the map was assigned the value for open space, green space was assigned the woods value, and gray space was a combination accounting for buildings and other obstructions. See Figure 5-10 showing the land use assignments, Manning value and curve numbers associated with each land use type.

5.6.5 Rainfall

Rainfall depths for each of the events analyzed can be found in Appendix A.3 "Rainfall Frequency Intensity- Finegayan Main Cantonment Area". The 1- and 500-year recurrence intervals were interpolated from "Rainfall Climatology for Saipan: Distribution, Return-periods, El Nino, Tropical Cyclones, and Long-term Variations." All other storm events (excluding the 95th percentile) were taken from the *Guam Storm Drainage Manual* (USACE 1980). The 95th percentile event was not included in either reference. The rainfall amount for the 95th percentile was calculated using the methodology given by EPA's Section 438 Technical Guidance titled "*Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*", December" (EPA 2009) (included in Appendix A.4). Precipitation data for the period between 1 October 1988 and 2 December 2008 was available from the USGS at station Dededo. Dededo is the closest rainfall gage to the project site. The 20-year period contained 7,368 storm events. After all events with less than 0.1 inches of precipitation and erroneous data were removed 2,405 storm events remained in the data set. A figure of all rain events at USGS site Dededo is included in Appendix A.5. The 95th percentile rainfall amount was calculated from the modified data set (2,405 storm events). The 80th and 90th percentiles were also calculated in this way to check the accuracy of the calculation and were consistent to the reference. The duration of each model run was 48-hours; rainfall was only applied during the first 24-hours of the simulation. The rainfall values for each 24-hour storm event can be seen in Table 5-6.

Table 5-6: Rainfall Depths

Storm Event	Rainfall (mm)	Rainfall (in)
80%	20.32	0.8
90%	38.10	1.5
95%	55.88	2.2
1-year	83.82	3.3
2-year	203.20	8.0
10-year	332.74	13.1
25-year	426.72	16.8
50-year	520.70	20.5
100-year	574.04	22.6
500-year	1,287.78	50.7

in inch

FLO-2D requires a cumulative distribution verses timetable for rainfall. A temporal distribution from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Volume 5 for the Pacific Islands was applied to the model. Figure 5-11 shows the temporal distribution for a 24-hour rainfall duration. Documentation for the temporal distribution of the pacific islands can be found in Appendix A.6.

The cumulative percent of duration ranges from 0 to 24 hours. Each of the curves represents a probability of occurrence (10–90%). The curve for a 50% cumulative probability of occurrence was used. The 50% probability of occurrence represents the median temporal distribution.

5.7 MODEL VALIDATION

No quantifiable data was available to complete model validation for this analysis. However, a qualitative validation was completed using available resources.

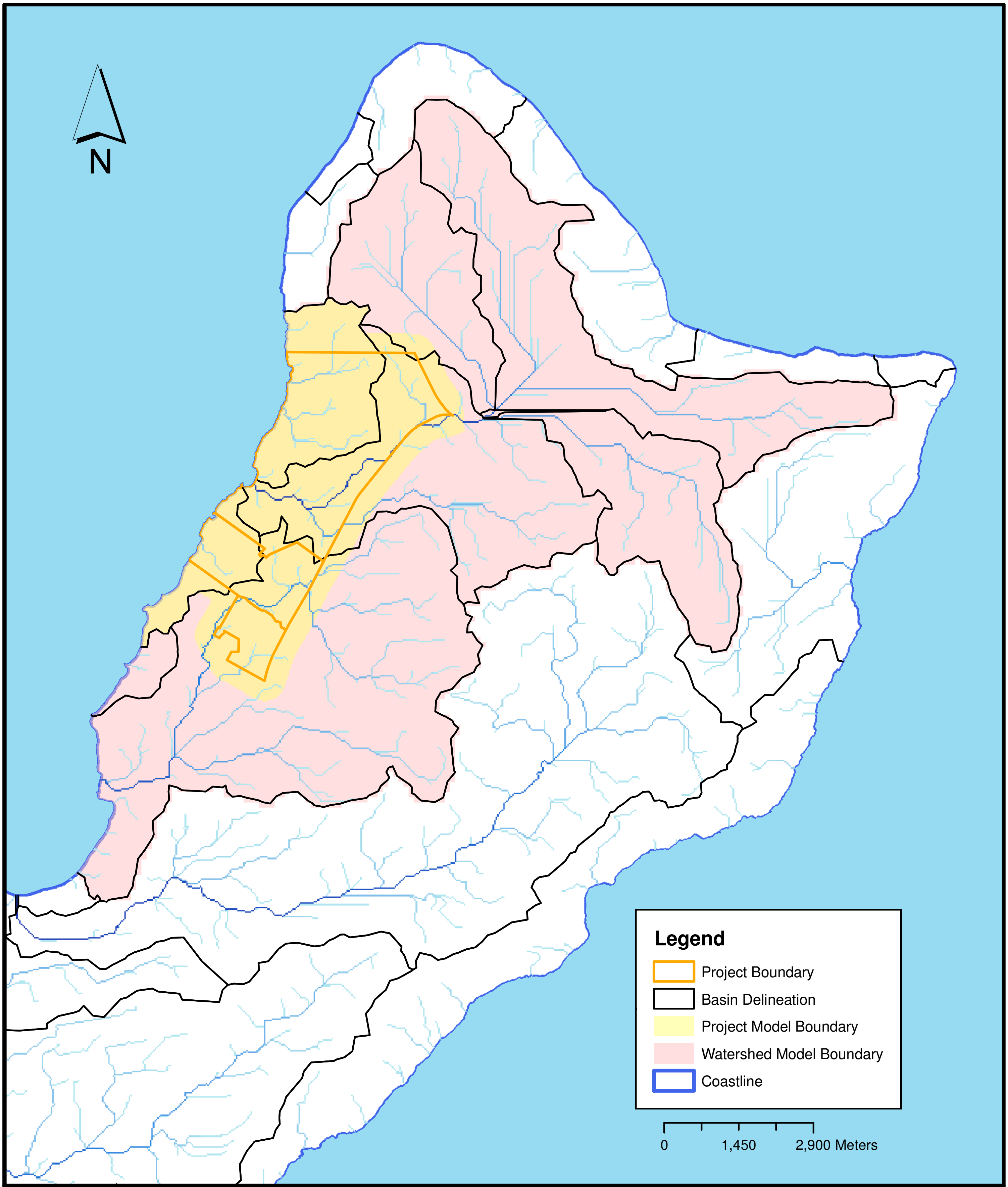
Volume I of the *Stormwater Pollution Prevention Plan* for the U.S. Naval Forces Region Marianas, June 2009 (US Naval Forces Marianas 2009) states the following "The highly permeable limestone plateau on which the NCTS facility are located allows for rapid precipitation infiltration; therefore, stormwater runoff does not occur". Model results were consistent with the SWPPP and anecdotal information provided by site representatives up to the 10 years storm recurrence interval as shown in Section 5.5.

A similar statement was made by Wuerch et. al. (November 2007) in their analysis of Northern Guam Lens Aquifer. They stated that:

- Rainfall of less than 6 mm (1/4-inch) in a 24-hour period results in 100 % evapo-transpiration.
- Rainfall of between 6 mm per day and 50 mm (2 inches) per day result in aquifer recharge. 60 % of the annual rainfall reaches the NGLA as recharge.
- Any rainfall in excess of 50 mm per day results in coastal discharge and does not provide any additional amount of recharge to the aquifer (i.e., surface infiltration to groundwater aquifer discharges direct from groundwater aquifer to the ocean).

The above-mentioned information is consistent with the model results. The 50 mm value corresponds to a storm between 90th (38 mm) and 95th (56 mm) percentile annual exceedance storm event. These events show no ocean discharge through surface water runoff. Surface water outflow to the ocean does not begin until the 2-year event which corresponds to 203 mm. Discussion of surface water discharge was not available in Wuerch's text. This is consistent with the model results which indicated that there is no runoff generated during the 80th percentile storm, and significant ocean discharge starts when rainfall in 24 hours is somewhere between 80 and 200 mm. With this basis, the model passed qualitative validation.

As discussed previously, the model was used without consideration for proposed BMPs and detention basins.

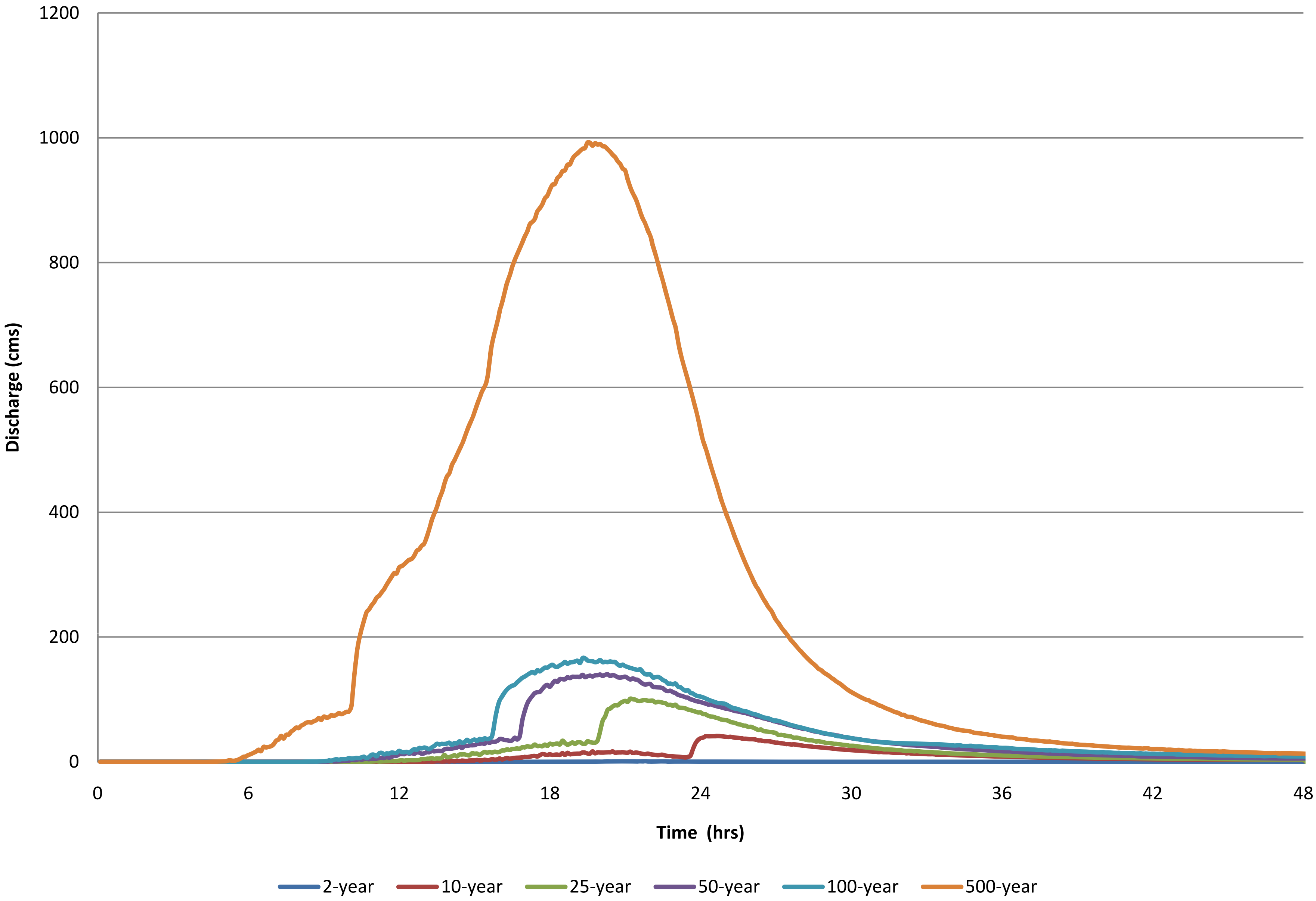


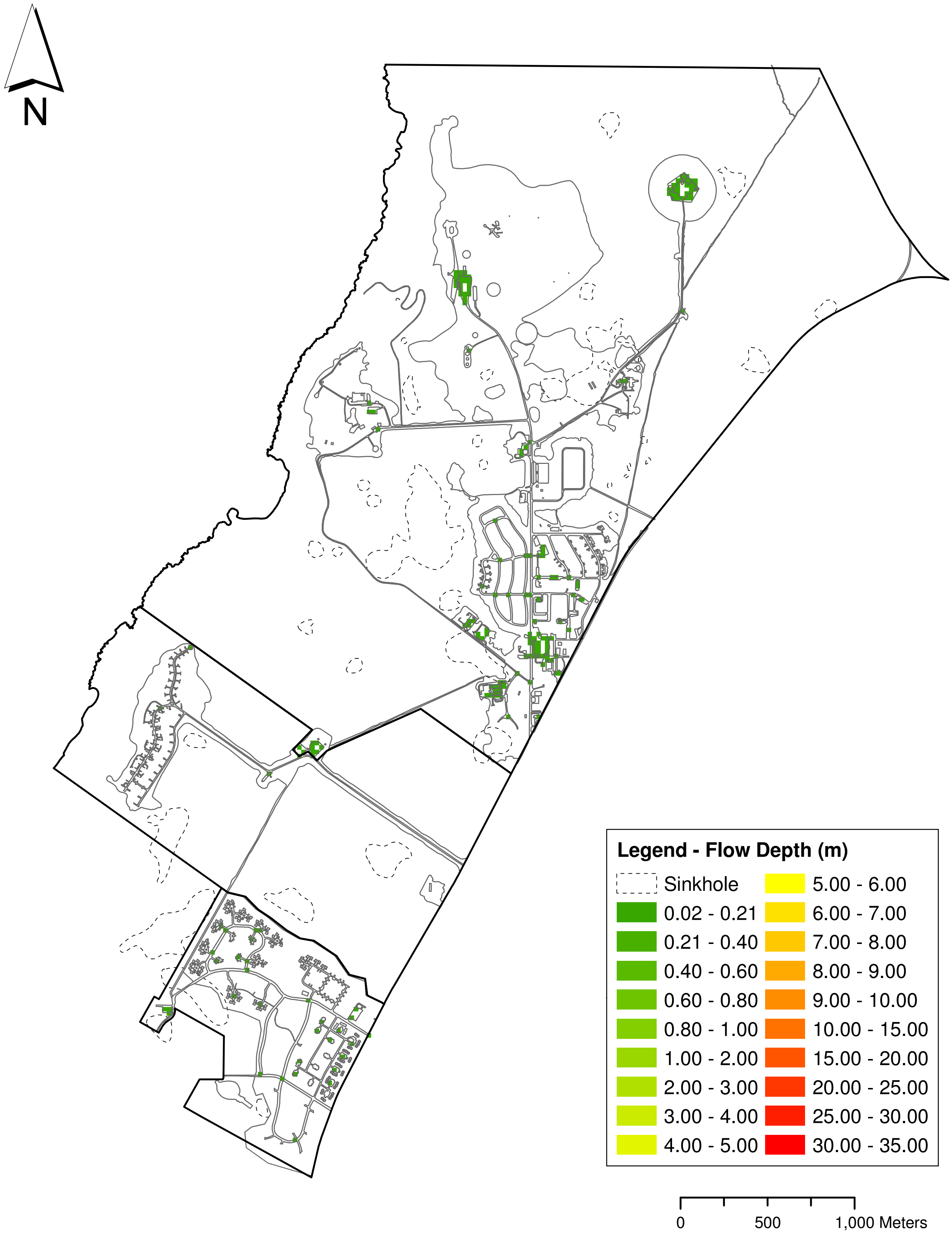
AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Subbasin Delineation and Model Extents

GIS FILE:	SCALE: AS NOTED	DATE: 12/17/2009	Figure 5-1

Figure 5.2: Pre-Development Outflow Hydrograph

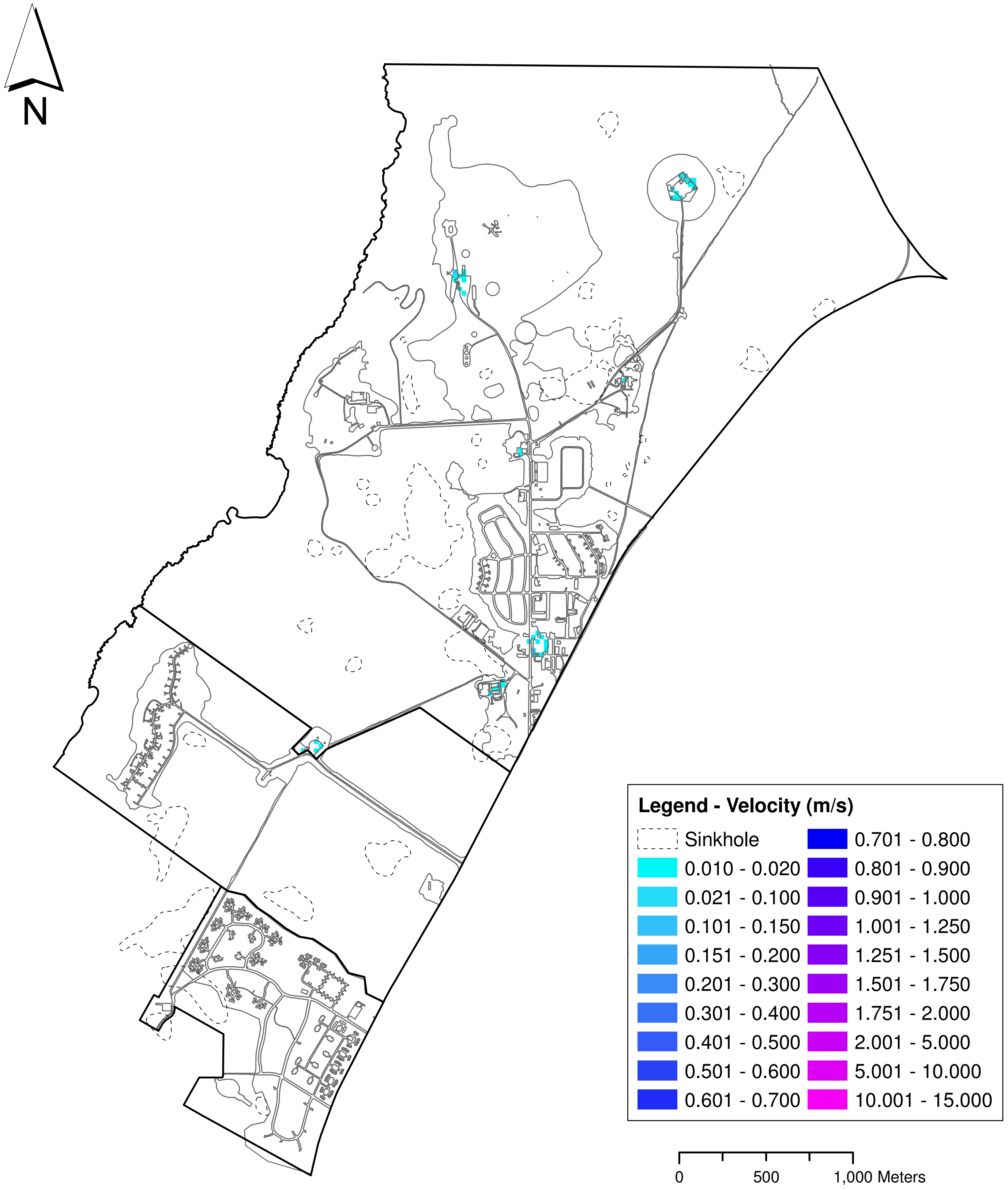




AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 95 Percent

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 5-3



AECOM

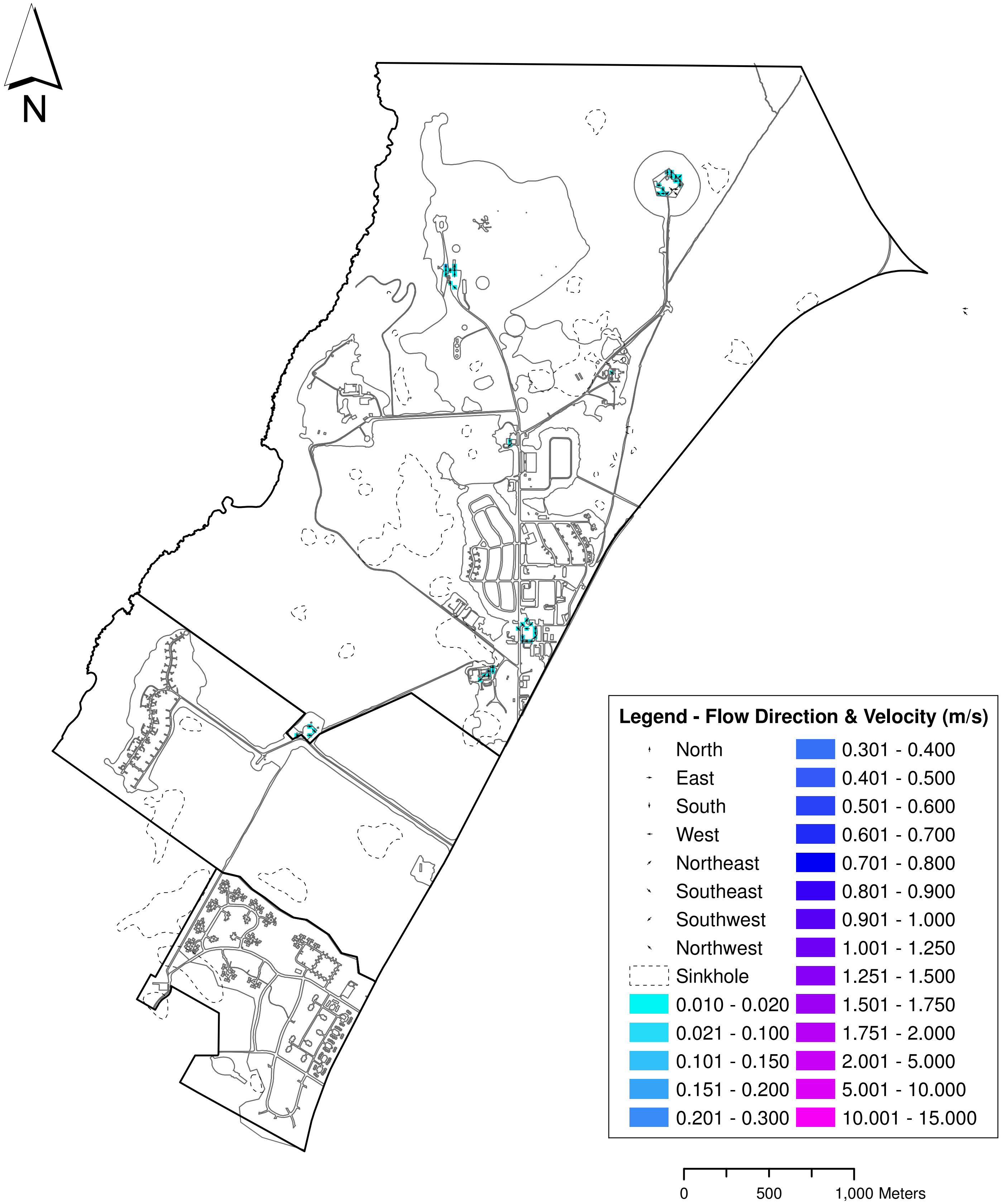
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 95 Percent

GIS FILE:

SCALE: AS NOTED

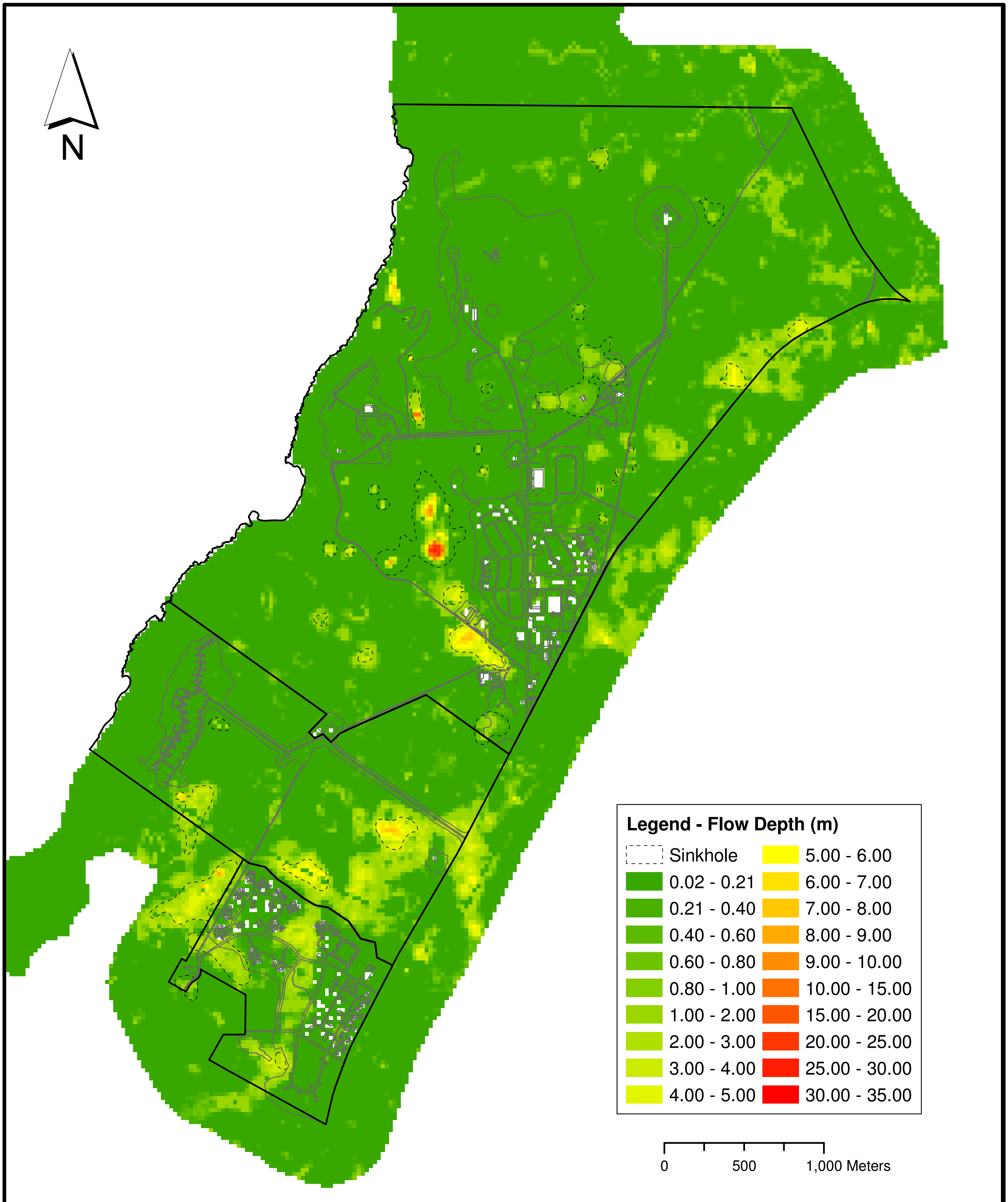
DATE: 02/24/2010

Figure 5-4



NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Max Velocity with Vectors - 95 Percent

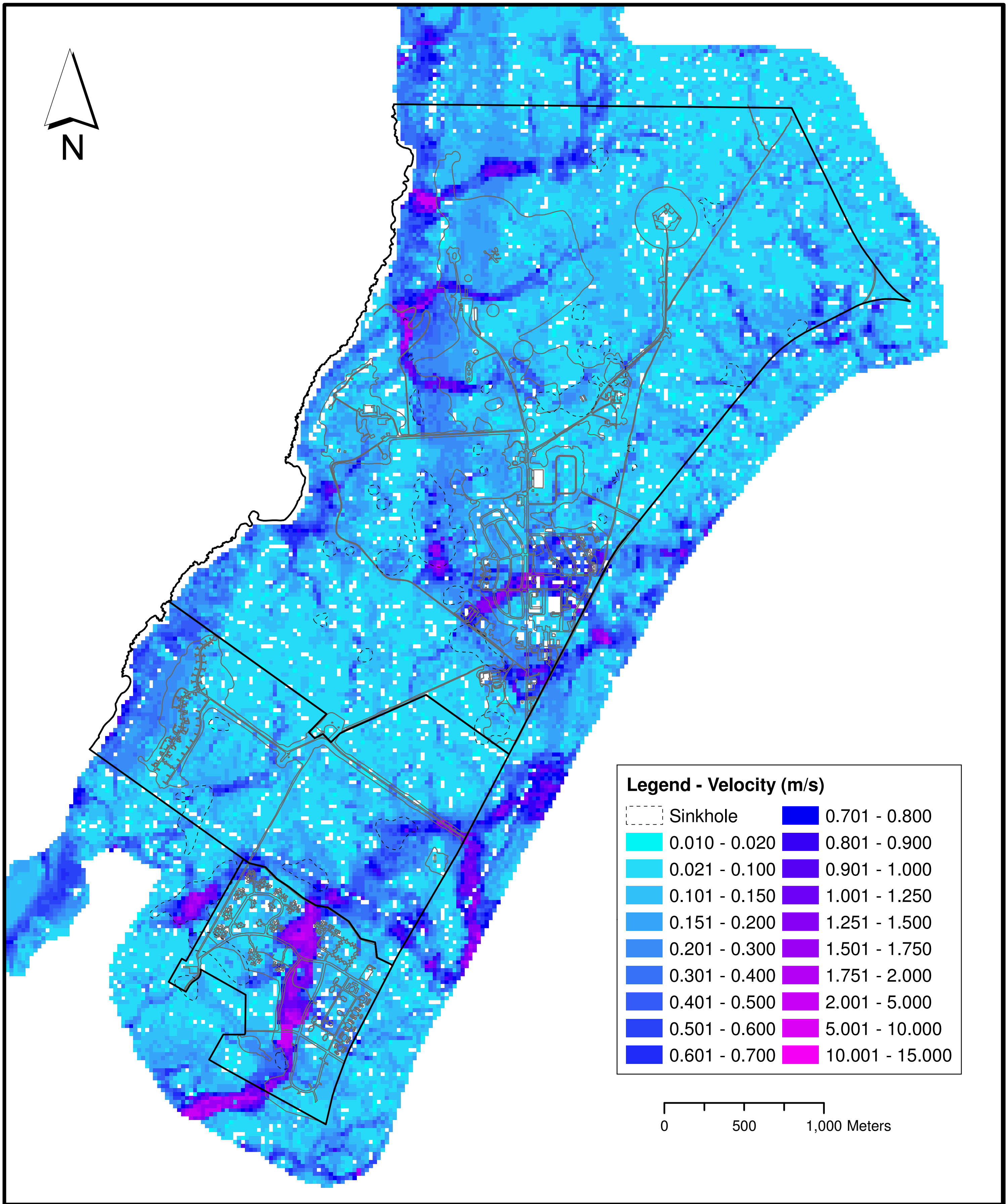
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 5-5



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 100 Year

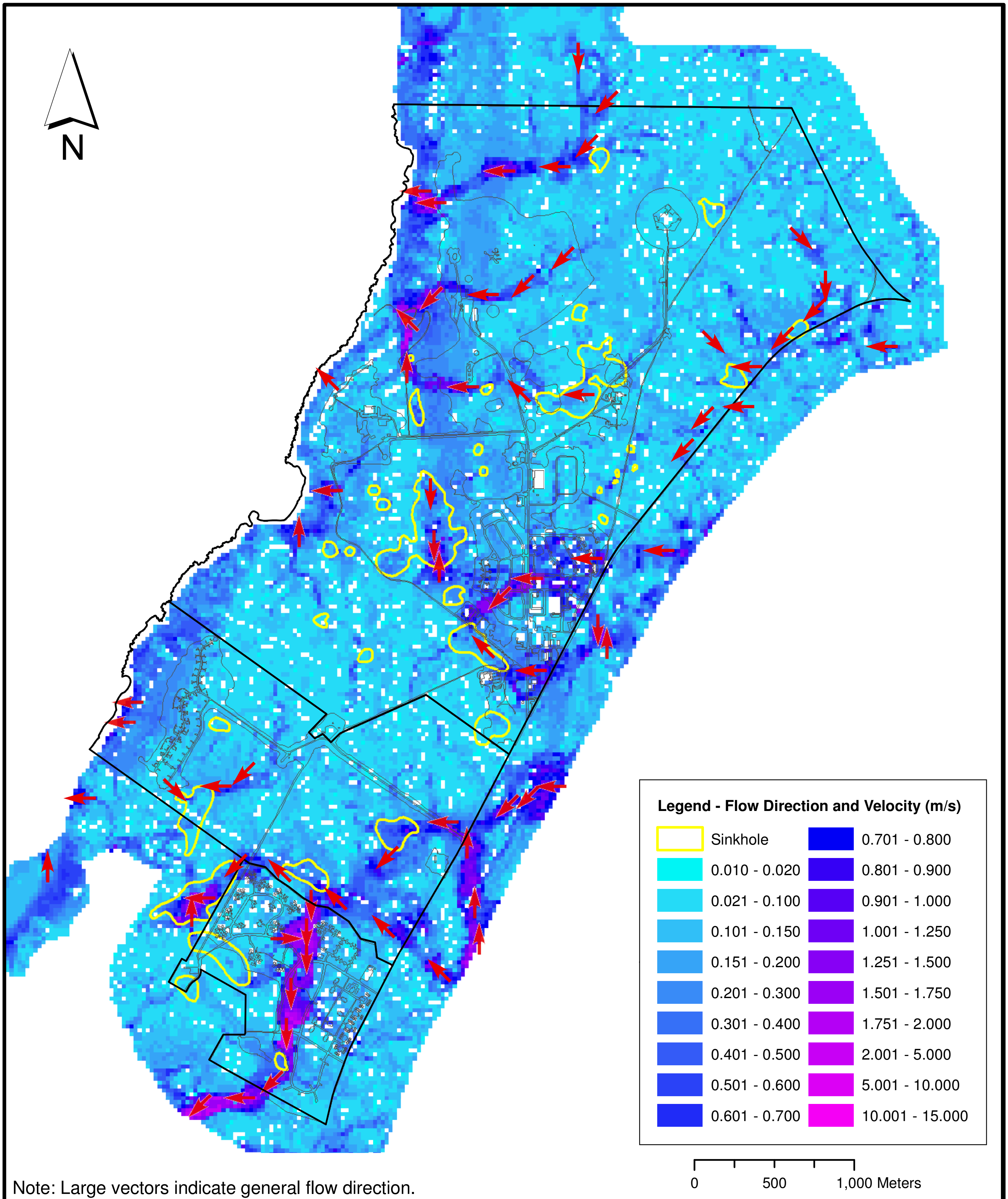
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 5-6



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 100 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 5-7



Note: Large vectors indicate general flow direction.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Max Velocity with Vectors - 100 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 5-8

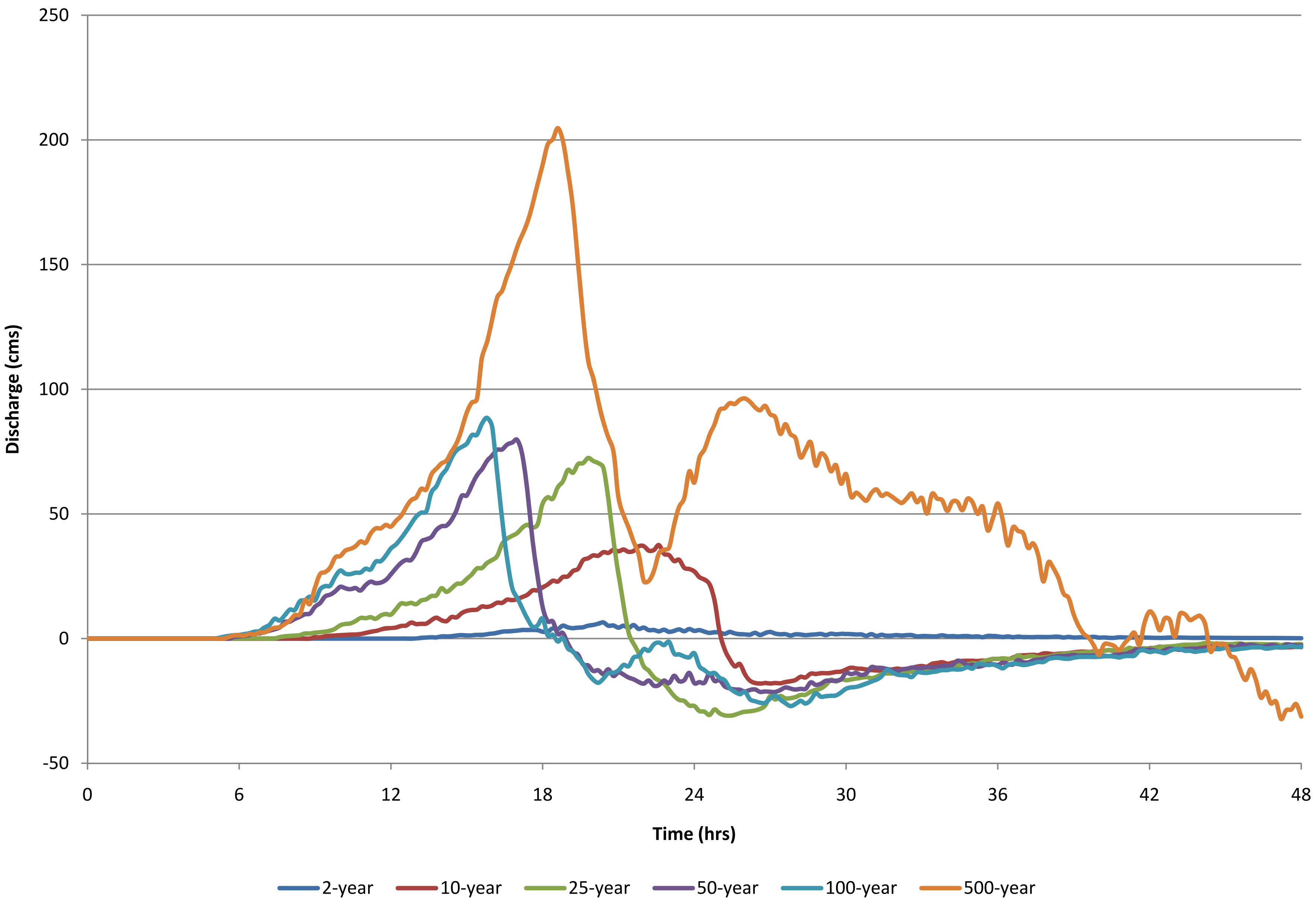
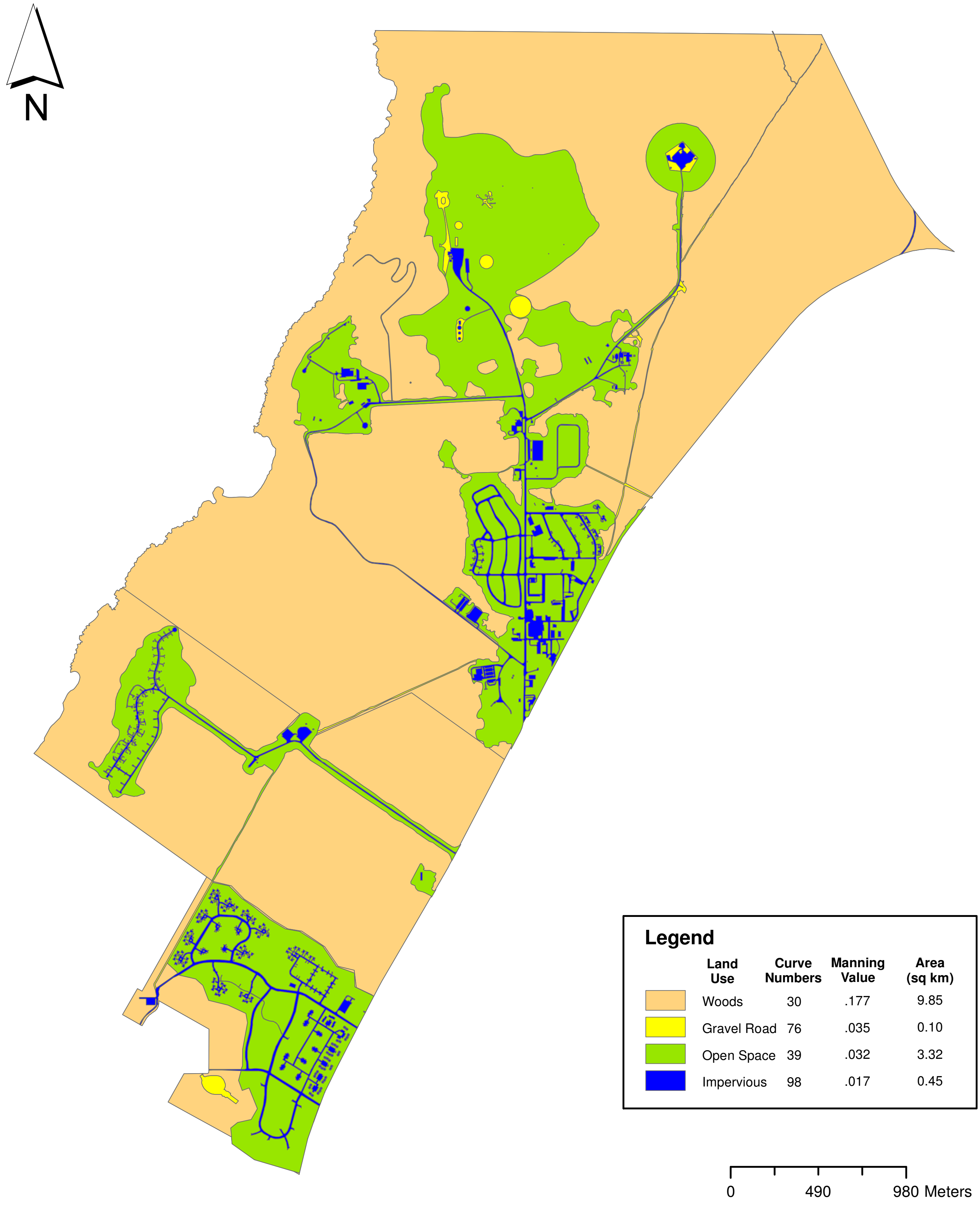


Figure 5.9: Inflow Hydrograph



Legend

	Land Use	Curve Numbers	Manning Value	Area (sq km)
🟧	Woods	30	.177	9.85
🟨	Gravel Road	76	.035	0.10
🟩	Open Space	39	.032	3.32
🟦	Impervious	98	.017	0.45

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Land Use Conditions

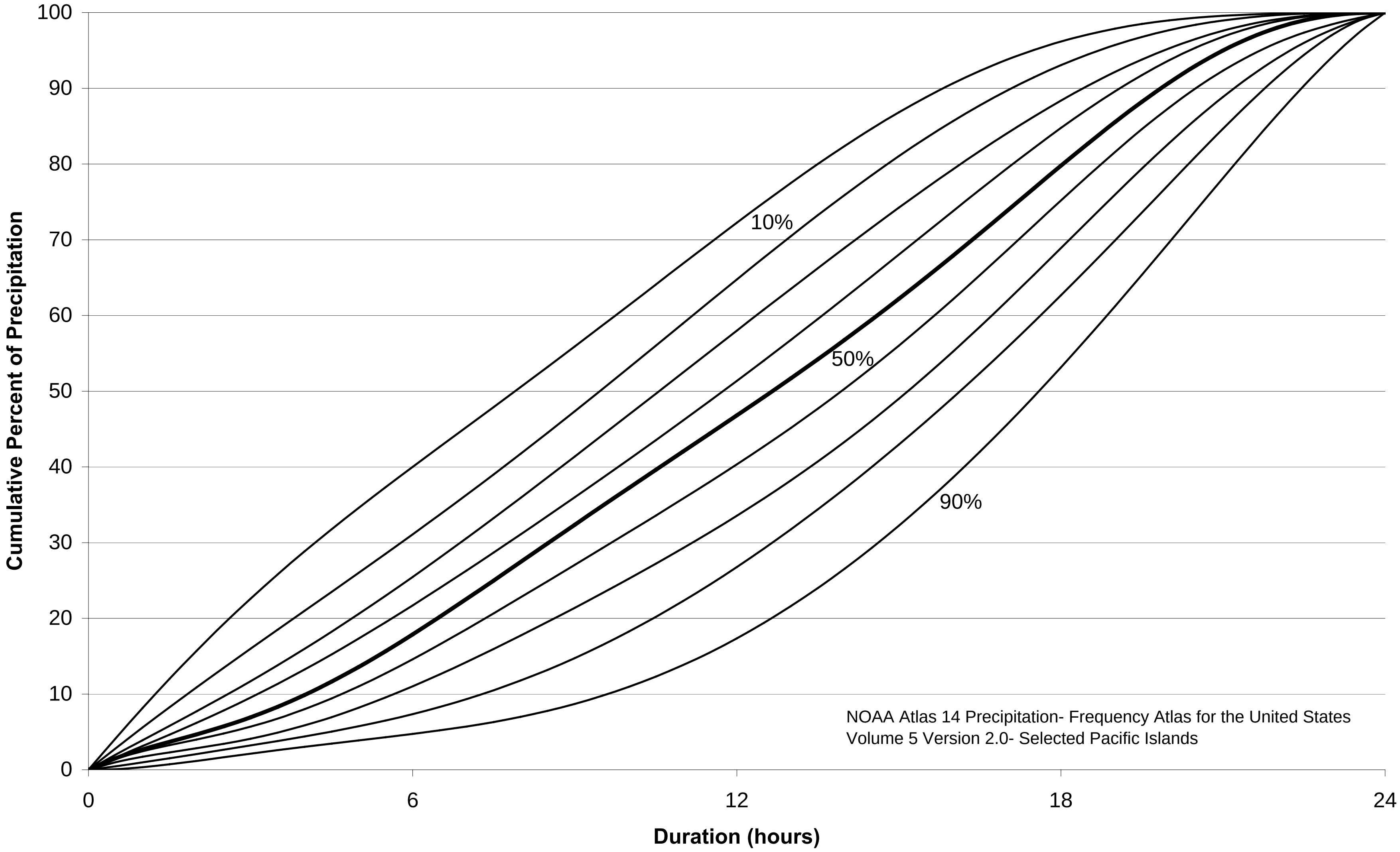
GIS FILE:

SCALE: AS NOTED

DATE: 12/17/2009

Figure 5-10

Figure 5.11: Pacific Island Temporal Distribution for 24-hour Rainfall Duration



NOAA Atlas 14 Precipitation- Frequency Atlas for the United States
Volume 5 Version 2.0- Selected Pacific Islands

6. Notional Grading Plan

6.1 INTRODUCTION

The Notional Grading Plan within this report (Appendix B.1) is based on input from several sources including previous work in the Government of Japan (GoJ) Phase 1 Utilities and Site Improvement (U&SI) project and the GoJ Phase 2 U&SI projects. The grading information from these two projects were used as a basis of design and then expanded upon for use in the work for this report. The road alignments within the Notional Grading Plan are also based on the two U&SI projects above, with the balance of the road alignments on Finegayan modeled after the GJMMP dated 09/18/09. Naval Facilities Engineering Command (NAVFAC) Pacific supplied the LIDAR aerial topographic mapping of the existing conditions at Finegayan upon which all proposed road alignments and grading studies contained within this report are based. In subsequent project studies on Finegayan Main Cantonment Area it has been found that the LIDAR topography provided by NAVFAC Pacific has differed from actual ground surveys as much as 2 feet to 3 feet in the vertical dimension. As such, the validity of any studies based upon the LIDAR topography should be assessed prior to any final designs. Generally the purpose of the Notional Grading Plan was to inform the balance of work within this report as to ultimate directions of drainage and size of proposed drainage subareas. The Notional Grading Plan was not intended as any level of grading plan from which earthwork quantities are to be derived.

The Notional Grading Plan was developed by Huitt-Zollars, Inc., a subconsultant to the TEC JV team assigned with the preparation of this report. The Notional Grading Plan was developed by implementing the following steps for roadway grading and mass grading:

- In general, roadway elevations were kept slightly higher than the surrounding parcel areas to allow roadway drainage to flow down onto parcels. The elevation of the roadway helps to eliminate the need for long reaches of underground storm drain systems and allows for LID policies to be implemented outside the road right-of-way.
- The horizontal road alignments and vertical road profiles were imported from GoJ Phase 1 and Phase 2 projects.
- Horizontal road alignments for the balance of the roads in the main cantonment area were developed from the GJMMP. Note that road alignments within the family housing area, the southern third of Finegayan, were not developed as a part of this project. Roadway longitudinal gradients were held between 0.5% minimum and 8% maximum.
- Vertical road alignments for the balance of the roads in the main cantonment area were developed first using an approach that would follow the existing ground surface as closely as possible. Road vertical profiles were then slightly adjusted up and down to achieve strategic high and low points for drainage purposes. For instance, if a low spot on the natural terrain was found to be at or near an intersection of roadways, the road vertical profiles were adjusted to move the low point out of the intersection, creating a safer design.

After the road profiles were developed, the mass grading design for the parcels of land between the roadways was developed by implementing the following steps:

- Mass grade elevations for the individual building parcels were developed to match the existing topography as much as possible, thus minimizing proposed grading efforts. Mass grade elevations were designed to hold a 1 % minimum and 4 % maximum gradient on the parcels.
- Parcel drainage patterns and direction were designed to coincide with high points and low points of roadway drainage systems. This allows the potential for combining of road-related LID and Drainage systems with those of the development parcels.

- Parcel mass grade elevations were manipulated up and down to minimize the perimeter slopes.

Lastly, the resultant Notional Grading Plan was analyzed for secondary overflow routes. The purpose of secondary overflow routes is to provide a safe alternative flow path for stormwater in the event a storm drain system does not function properly and flooding occurs, or in the event that a storm of greater magnitude is experienced than for what the storm drainage system was designed.

6.2 SLOPES

The earthen material found likely to be encountered at Finegayan is composed of coralline limestone with minor thin surficial deposits of silty sands. The thin deposits of silty sands tend to be found at the intermittent shallow low points found throughout the natural terrain at Finegayan, while the entirety of Finegayan is underlain with coralline limestone of the Mariana and Barrigada formations. A thin topsoil layer of a few centimeters to a half-meter exists over most of the site. The Notional Grading Plan contained herein depicts cuts and fills generally within a 2~3 meter range over the Finegayan site, thus excavations into the coralline limestone formations would be required. The limestone formations in Finegayan are coralline based formations and are highly fractured in their in-situ state, allowing for a relatively easy ripping and excavation process. The limestone would be excavated from its natural state and processed (crushed) into smaller pieces suitable for general fill. The excavated materials, once processed and compacted are suitable for use as fill in slope areas. This excavation, processing, placement methodology for slopes is a relatively inexpensive methodology for creating slopes. While slopes do take up developable land, it is believed that the slopes would be much less costly to build than a conventional retaining wall. Conversely, retaining walls take up less developable land, but are more expensive to build. For the purposes of the Notional Grading Plan and this report, it is assumed that slopes would be used in lieu of retaining walls.

- *Roadway slopes.* Perimeter slope gradients and ratios for the area from 1 meter behind the back of the sidewalk to approximately 18 meters from the back of walk shall vary from a gradient of ± 1% minimum to slope ratios of between 5:1 and 2:1 maximum. Slopes can be designed to slope either up or down from the walk (Figure 6-1 at end of section).
- *Major parcel slopes.* For the Notional Grading Plan major parcel slopes necessary to transition from parcels to natural terrain were avoided whenever possible. However, in a few instances, major parcel slopes (over 9 meters high) were necessary due to the steep nature of existing terrain and the desire to maintain a relatively flat, usable parcel. In the instance of these major parcel slopes the required terrace drains and bench drains were not graphically depicted; however a design slope ratio of 2.5:1 was used to achieve a spatial placeholder for terrace drains. When final design occurs, slopes greater than 9 meters in height should be avoided. However, if necessary, slopes greater than 9 meters in height should be designed with terrace drains and downdrains to adequately drain the slopes and protect the slopes from the erosive forces of storm runoff. Major parcel slopes shall be designed wholly within the parcels to not encroach onto Naval Communications Reserved Areas (NAVC) or Open Space – Protected (OS-P) parcels (Figure 6-2).
- *Minor parcel slopes.* Slopes shall be designed to avoid encroachment into open space areas and to minimize encroachment into NAVC areas. Minor slopes resulting from roadwork vertical positioning shall be allowed to encroach onto NAVC and OS-P parcels.
- *Interior parcel slopes.* Intermediate interior slopes (slopes within and crossing a given parcel) shall be avoided wherever possible. f it is necessary to design intermediate interior slopes, great care should be given to the proposed layout of the planned facilities within the parcel, setbacks of building foundations from the face of the slopes, and drainage of the interior intermediate slopes (Figure 6-3).

- *Pad slope gradients.* Pad slope gradients are the gradients of graded parcels in the developable areas (non-slope areas). Pad gradients less than 1 % would create situations where mass graded parcels do not drain well in their interim state and shall be avoided. Pad slope gradients greater than 4% can create erosive stormwater velocities and additional earthwork during site development. Final design of mass graded pads (developable areas) shall vary from a gradient of 1% to 4% (Figure 6-4).

6.3 MINIMIZING CUT/FILL QUANTITIES:

Upon completion of the roadway grades, pad grades, and resultant slopes, a quick earthwork summary was undertaken to review balance of the Notional Grading Plan. To assist in minimizing the resultant cut/fill quantities and potential project imbalances the following steps were undertaken:

- The vertical road profiles have been adjusted up and down to closely match the existing topography.
- Pad grading scenarios were adjusted up and down to closely match the existing topography while minimizing slopes up or down to adjacent roads.
- Shifting of large groups of individual pads up and down achieves area-wide balance.
- Because the GJMMP is notional and the building locations depicted within the GJMMP are not precisely known, remedial grading efforts have been disregarded. For instance, in cut areas, remedial grading to achieve a consistent blanket of engineered fill under all potential building locations has been disregarded. Further GJMMP Site Development Plans for individual buildings would determine if remedial grading is warranted on a site-by-site basis.
- Each proposed U&SI Phase has been balanced within itself, thus eliminating the need for trucking of soils between the U&SI projects.

Cut/fill quantities are raw quantities and do not include the effects of earthwork design parameters including shrinkage, bulking, subsidence, and organic removals. All of these earthwork design parameters, while minor issues within their own right, can substantial change the overall cut/fill quantities on a project as large as the GJMMP. While it would be important to understand each of these earthwork design parameters, it is certainly outside the scope of the Notional Grading Plan. These earthwork design parameters should be studied and incorporated into future construction documents for the U&SI projects.

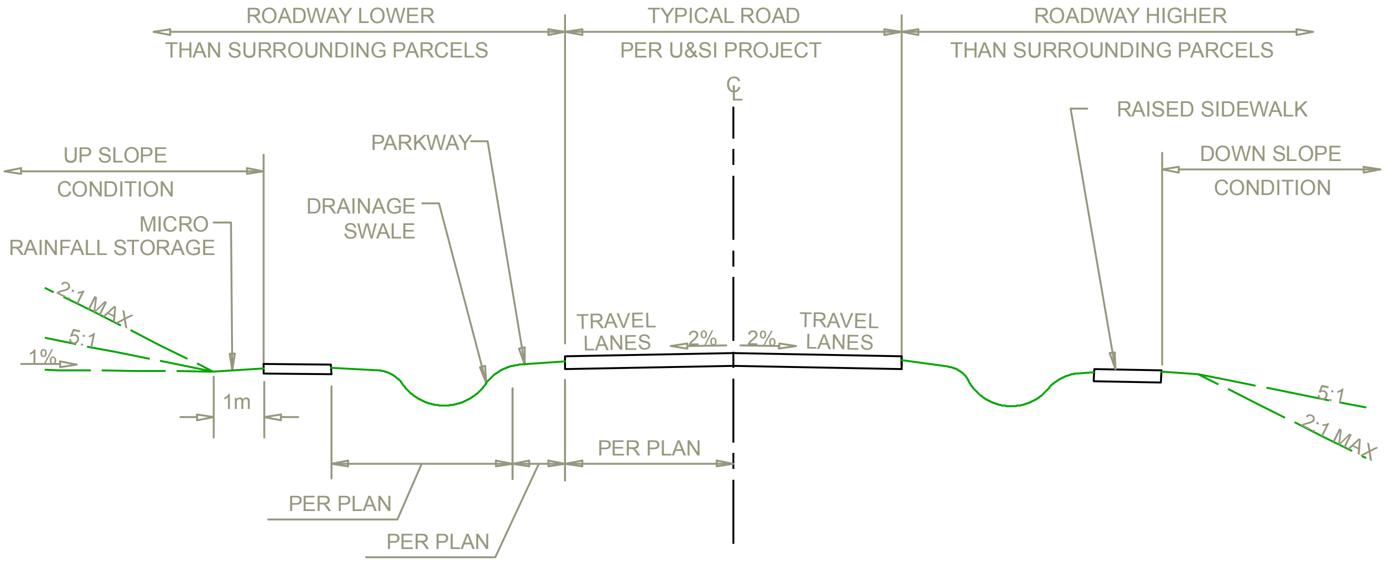
6.4 SMART GROWTH AREAS:

Smart Growth areas are defined on the GJMMP and are parcels of unused land set aside for future growth and expansion of the Finegayan project. For the Notional Grading Plan the following have been implemented in regards to the Smart Growth Areas:

- As many of the Smart Growth Areas are relatively small parcels of land, remobilizing a grading operation for future grading of the Smart Growth Areas would be costly. Therefore, Smart Growth Areas are anticipated to be mass graded during their respective U&SI project(s) and not mass graded at a future date.
- Mass grading of the Smart Growth Areas in the U&SI phases would avoid trucking soils on newly built U&SI roads.
- Mass grading of the Smart Growth Areas would incorporate several pieces of heavy equipment such as scrapers, dozers, water hauls, and backhoes. Mass grading of the Smart Growth Areas during their respective U&SI project(s) would keep this heavy equipment off of newly constructed U&SI roads.

- Smart Growth Areas are used for incorporation of proposed physical LID and drainage improvements in situations where the GJMMP does not allow room for these facilities in non-Smart Growth Areas.

The resulting Notional Grading Plan (Appendix B.1) impact to design is that proposed pad grading must yield as much developable space as possible, must function with proposed street design, and must take precedence over adherence to existing contours and resultant cut/fill quantities. Maximizing usable space for later development is of paramount concern.



NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Back of Walk Slopes

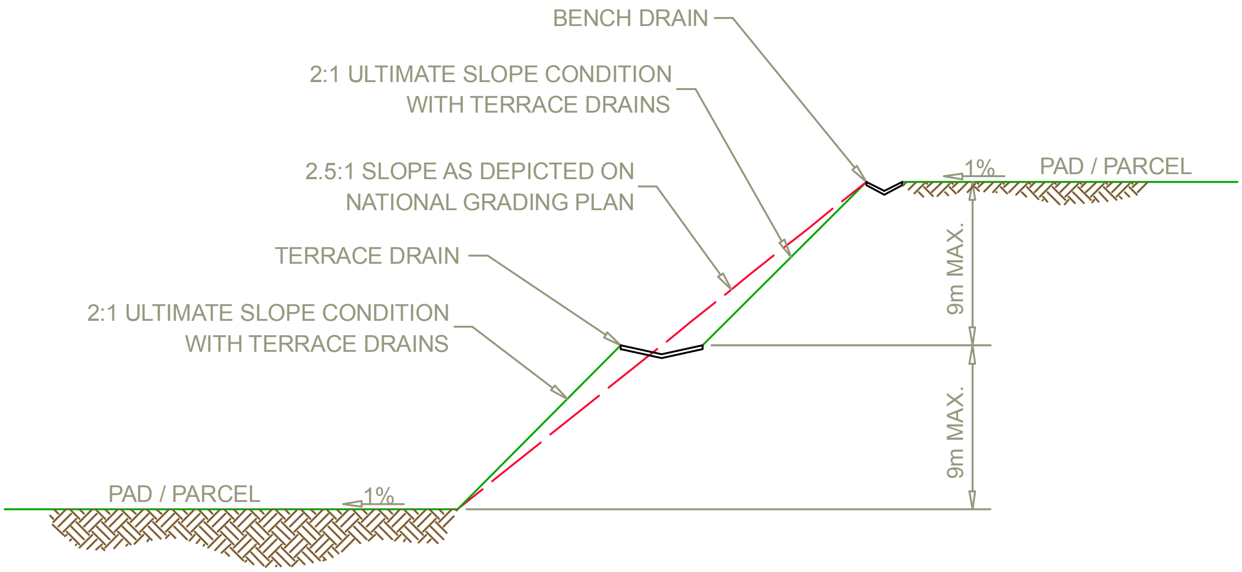
GIS FILE:

SCALE: NOT TO SCALE

DATE: 27-APR-10

Figure 6.1

ANSI A - 27-APR-10



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NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Terrace Drains

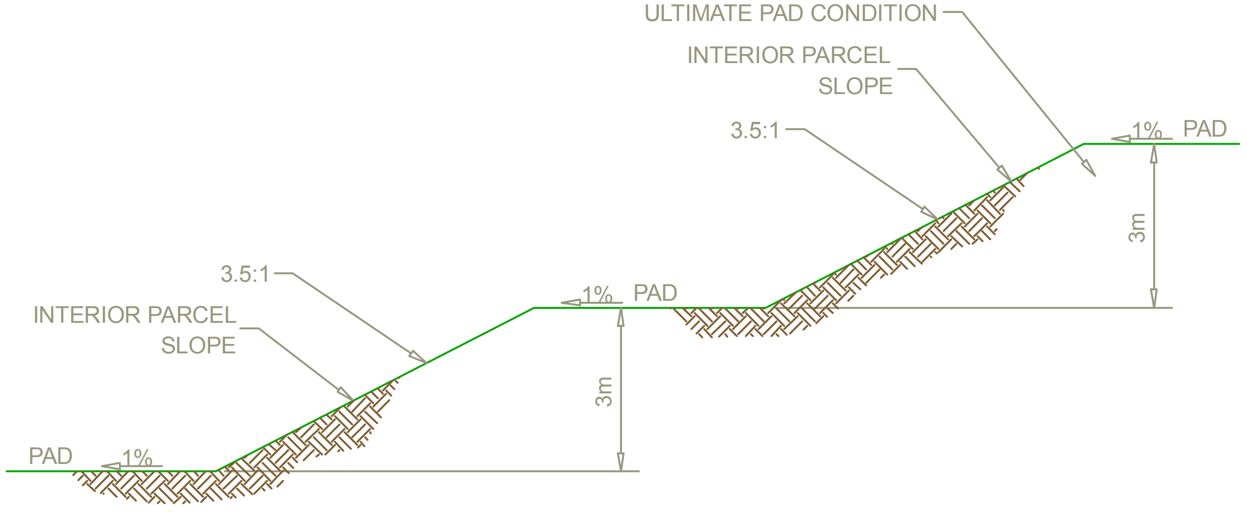
GIS FILE:

SCALE: NOT TO SCALE

DATE: 24-FEB-10

Figure 6.2

ANSI A – 24-FEB-10



NOTE: OCCURS IN PMO AREA

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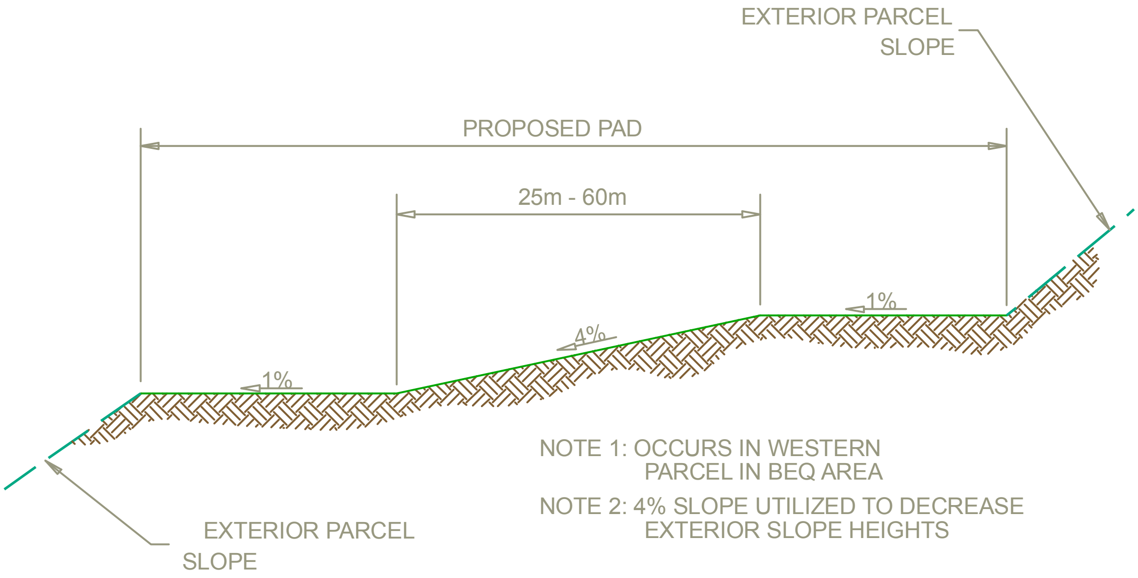
NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Interior Parcel Slopes

GIS FILE:	SCALE: NOT TO SCALE	DATE: 24-FEB-10	Figure 6.3



NOTE 1: OCCURS IN WESTERN PARCEL IN BEQ AREA

NOTE 2: 4% SLOPE UTILIZED TO DECREASE EXTERIOR SLOPE HEIGHTS

AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Pad Slope Gradients

GIS FILE:

SCALE: NOT TO SCALE

DATE: 24-FEB-10

Figure 6.4

ANSI A - 24-FEB-10

7. Drainage Impacts

7.1 INTRODUCTION

Grading improvements within the Finegayan Main Cantonment Area would cover an area of 465 hectares (1,150 acres) which do not include the designated NAVC and OS areas shown in the GJMMP. This area is located in the northwest corridor of the island of Guam. Much of the area being improved is covered with dense vegetation and has a highly permeable soil composition. The site has a number of sinkholes that can be as deep as 30 meters and are mostly located on the western edge of the site near Haputo Bay. Sinkholes play a major role in the elevations of pads and their overall drainage direction, because they are treated in a manner that retains their natural state.

The grading of the site generally follows the existing topography of the site, as described in Section 6 of this report. The proposed elevations of development parcels depicted in the Notional Grading Plan are not expected to have a negative effect on the GJMMP.

There are locations within the site that utilize slopes on the exterior and interior of pads to maintain balanced earthwork and to drain the site efficiently. Currently there are locations that the GJMMP conflicts with the notional grading scheme. Within the Bachelor Enlisted Quarters area there is an example of an interior parcel slope that was used to minimize graded slopes and to maximize developable land. The GJMMP shows a number of proposed buildings and parking lots that are located on this slope. There are also some external parcel slopes that are required because of the natural topography and drainage schemes that conflict with the GJMMP.

Due to the expected size of the proposed detention basins, there is a need to evaluate what impacts the detention basins may have on the master planned base. Potential conflicts include a detention basin site overlaid by a parking lot, building, sports field, or other used open space. Although recreational fields and used open space can be used as overflow areas, they should not be used to store high frequency storm events because of increased maintenance concerns after high frequency rainfall events.

Secondary drainage overflow was studied to insure the protection of buildings in the event that proposed drainage facilities do not operate correctly. In this event detention basins may overflow or localized drains may be clogged, which would force water to surface flow out of the parcel. The idea of secondary overflow is to give stormwater a safe route to continue to travel downstream before flooding a proposed structure. A direct example of a secondary overflow implementation is the swale proposed just west of Route 3. The notional grading scheme generally directs water toward Route 3 in the Northeast portion of the site near the proposed commercial gate. Although, stormwater runoff is intended to be stored and treated within these parcels, an event greater than the detention basin design storage event should also be accounted for. In the case of a detention basin being overtaxed from a storm event greater than the design storm event, or multiple back-to-back storm events, excess stormwater runoff would be discharged from the detention basin via a flow spreader device (typically a broad crested weir) and become secondary overland flow. In the northern portion of the cantonment area this secondary overflow would generally surface flow toward Route 3 where it would then be collected and drained south to a larger basin proposed near the Main Gate. A buffer along Route 3 should be considered in the development of the GJMMP to incorporate this secondary overflow swale (Figure 7-1 at end of Section).

For the most part the existing drainage scheme is either surface flow or swales that discharge into the jungle, with the exception of one drainage ditch that drains all of what would be the proposed Marine Air Wing, Division Administration / Operations, and NAVC areas located along the western side of Route 3. This ditch discharges into a natural low spot located in the northeast corner of the intersection proposed at "A" street and "C" street. This natural detention basin would be refined and engineered to be a permanent detention basin. For storm events greater than the refined basin's design an overflow route is conceptualized to provide a route into open space areas within the BEQ parcel for ultimate stormwater disposal.

Suggested Design Parameters

- Stormwater flows should be cleansed and infiltrated wherever practicable prior to entering a detention basin
- Secondary overflow of storm runoff may be discharged over land. Care should be taken by future designers to quantify and direct secondary overflow from its point of origin to the ultimate stormwater disposal area.
- Ultimate disposal areas for stormwater may include open space areas and recreation areas (ball fields). Ultimate discharge to the ocean may be allowed up to pre-development runoff levels naturally occurring

7.2 LIMITS OF SITE DISTURBANCE

There are several anticipated construction activities which would disturb the natural state of the site. Currently existing flow infiltrates into the ground and overflow drainage eventually drains to a sinkhole. The recharge rate of the existing surface may be decreased by grading efforts because the physical properties of the existing soil may change. A large area of the site would be covered with impermeable covering, which greatly increases stormwater runoff rates and peak flows. Grading efforts are minimized wherever possible but some areas must be disturbed to create developable land. Site disturbances are limited to edges of NAVC parcels and open space areas. To achieve the notional grading concept a buffer area outside of the edge of grading will need to be cleared for temporary work access of the grading area. Typically this additional disturbance area is 2 meters ±..

The current grading scenario as shown in the Notional Grading Plan depicts limited, minor encroachment into developable areas and NAVC areas for slopes, drainage swales (westerly base boundary) and would not propose encroachment of drainage runoff infiltration devices into portions of NAVC areas. Additionally, the Notional Grading Plan proposes a minor slope to transition the Commercial Gate Entry Road (between the Route 3 entry point and TRN 5 parcel) into the OS-P parcel's existing contours. Lastly, the Notional Grading Plan depicts no perimeter encroachment into adjacent OS-P parcel along the northerly or westerly boundaries with said areas. All slopes and drainage devices would be confined to developable parcels or, in some cases, NAVC areas.

The Grading Plan would utilize slopes and grading contours to make connection to and protect in place those facilities (well sites and select building sites). The limits of site disturbance are depicted on the Notional Grading Plan (Appendix B.1).

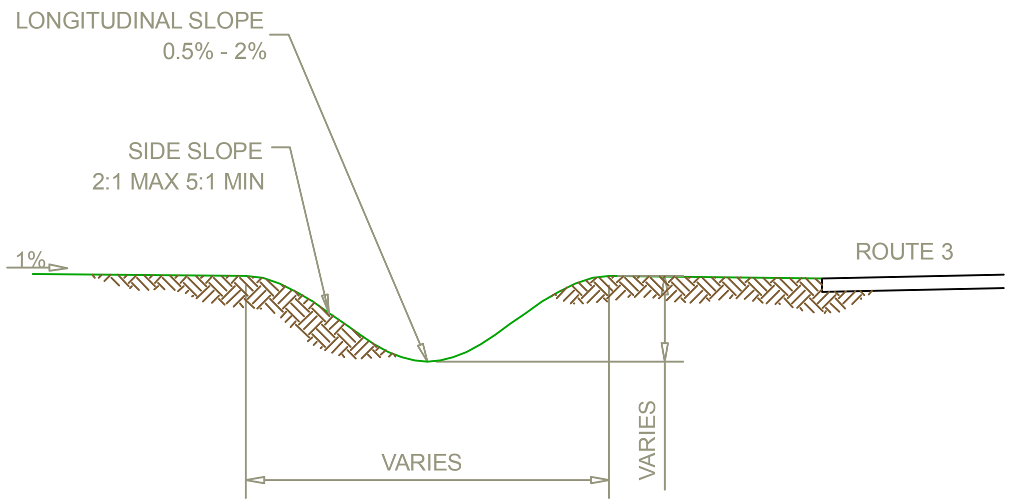
7.3 WELLHEAD AREA PROTECTION

There are a number of domestic water wells on site, several of which are expected to remain in service. The existing water wells tap into the aquifer that lies beneath the surface of the entire site and generates potable water for the existing NCTS Finegayan cantonment area. These wells can adversely function as a direct "pipeline" between polluted surface waters and the aquifer and, therefore, require special attention. The proposed development would produce a boost in pollutants such as dissolved metals and oils that would run off along with stormwater to the nearest swale or detention basin. This swale or detention basin would produce an area that has locally polluted water that would eventually be treated through long-term infiltration. Because of this stormwater runoff, BMPs shall be located at a distance from a domestic water well such that it does not affect its natural water supply.

Detention basins should not be placed within 304 meters (1,000 ft) of a wellhead, whenever practicable. Additionally stormwater runoff should be directed away from a wellhead zone unless the water is treated before infiltrating into the ground. In some instances it will be impracticable to keep detention basins outside of the 304 meters (1,000 ft) wellhead protection zone. In such cases particular care should be exercised in pre-treating stormwater runoff prior to entering the detention basin. Existing wellheads are depicted on the Notional Grading Plan (Appendix B.1). For instances of detention facilities that must be placed within the wellhead protection zone the detention facilities have been marked as having conflicts within the Conflict Table (Appendix B.3).

Suggested Design Parameters:

- Storm runoff should be directed away from wellhead protection zones wherever practicable.
- Detention basins should be excluded from wellhead protection zones wherever practicable.
- Storm runoff and detention basins that must be located inside the wellhead protection zones should have storm flows treated prior to surficial or subsurface (infiltration) release.
- Wellhead protection zones of 304 meters (1,000 ft) should be incorporated into designs wherever practicable



NOTE 1: OPTIONAL VEGETATED SWALE IF VEGETATION DOES NOT INHIBIT THE FUNCTIONALITY OF THE SWALE

AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Secondary Overflow Swale

GIS FILE:

SCALE: NOT TO SCALE

DATE: 24-FEB-10

Figure 7.1

8. Post-Development Stormwater Runoff Modeling

The FLO-2D model developed for the pre-development stormwater modeling was modified for the post-development conditions. Post-development hydrology was based on the GJMMP Site Development Plan dated September 18, 2009 (JGPO and NAVFAC 2009) and Notional Grading Plan (Appendix B.1). Proposed post-development surfaces were used to perform model simulations with applicable grading, Manning's roughness coefficients, flow obstructions (i.e., buildings) and curve numbers applied as applicable. Proposed drainage structures, such as stormwater collections systems, detention basins, BMPs, and LID features were not considered at this time. The model needed to would be updated based on the proposed stormwater system features if their presence would be considerable enough to effect model results. At this point it is assumed that BMPs, LIDs, and IMPs are going to provide local management of stormwater and significant conventional open channels and/or closed conduit systems would not be used. Post development results were developed for the 1, 2, 10, 25, 50, 100 and 500-year, 24-hour storm events and the 80, 90, and 95% annual exceedance, 24-hour storm events. Runoff from the project site and runoff into the project site were quantified using peak discharge values and volumes.

8.1 PROPOSED DEVELOPMENT PLAN

Proposed facilities for the Marine Corps' Main Cantonment Area (Table 8-1) included the following:

Table 8-1: Post-Development Facility Area Requirements

Facility Type	Total Area (m^2)
Operational	30,216
Maintenance	54,788
Supply/Storage	66,095
Medical/Dental	6,221
Admin	36,600
Housing/Comm	524,441
Total	718,361

*Values from table take from the Draft Guam Joint Military Master Plan (GJMMP), September 18, 2009

The pre-development stormwater runoff model was modified to show the post-development conditions as listed above and other impervious and semi-impervious surfaces including asphalt pavement. Elevations within the project site were updated to reflect the Notional Grading Plan.

Figure 8-1 (at end of section) shows existing and proposed surface contours for the project site.

Development is not applicable to the entire project area. There are specific regions within the project area that were designated as reserve areas. The existing land use properties were applied to these reserve areas. Elevation Curve numbers and Manning values were updated using a land use shapefile created for the post-development conditions (excluding the reserve areas). The same Manning and curve number values assigned to specific surface types in the pre-development model were used with the addition of the housing area. A detailed plan of the housing area has not been developed so assumptions were made for infiltration and roughness values. The facility requirements table, Table 8-1, shows the area requirement for the housing/commercial district as reported by the GJMMP. Proportions of impervious and open space were calculated using the housing facility requirement area and the total housing area (excluding roads) as shown in the GJMMP Site Development Plan. Table 8-2 shows the Manning's value and curve number assigned to the housing area. Flow obstructions were updated to reflect the new building layout as shown in the GJMMP Site Development Plan; stormwater cannot flow through the building cells.

Table 8-2: Housing Area Roughness and Infiltration

	Percent of Total	Manning Value	Curve Number
Impervious	24	0.017	98
Open Space	76	0.032	39
Total Housing Area	100	0.028	53

Figure 8-2 shows the land use assignments and the Manning value and curve numbers associated with each type for post-development conditions.

8.2 MODEL RESULTS BASED ON CURRENT MASTER PLAN FOR SITE DEVELOPMENT

The results presented in this section reflect the flow patterns and runoff characteristics that would result from the proposed development plan without stormwater mitigation measures. The stormwater management system should limit flows exiting the project site to similar quantities presented in Section 5 pre-development hydraulics.

Model results indicate that the storm events up to the 90 % storm recurrence interval result in no outflow from the project site. Ocean discharge begins at the 95 % annual exceedance interval and intensifies throughout the increasing storm events. The results show that in larger storm events (10-year recurrence interval and greater) that the entire drainage area becomes flooded above 0.02 meters of depth.

The results of post development model are shown in Table 8-3 and Table 8-4. Definitions for each result parameter and backup information including rainfall depth calculations and inflow hydrographs are the same as provided in Section 5.5. The modeling methodology and input parameters are also described in Section 5.5 but were based on post development conditions.

The outflow locations for pre and post development were consistent (see Figure 5-1) but volumes and rates were increased as shown in the results. It should be noted that the increases shown in Table 8-3 and Table 8-4 do not consider any stormwater mitigation measures (i.e. BMPs, LIDs, and conventional stormwater management system components like catch basins, pipes, detention basins, etc.). These measures will reduce the increases in volume and peak discharge. For small events the absolute differences are small, however, this may translate to large percent changes due to division by small numbers. The hydrograph for post-development outflow is presented in Figure 8-3 (at end of section).

Table 8-3: Proposed Conditions 24-hour Storm Event Model Results

Storm Event	1-year	2-year	10-year	25-year	50-year	100-year	500-year
Total Point Rainfall (mm)	83.82	203.20	332.74	426.72	520.70	574.04	1,287.78
Rainfall Volume (m^3)	1,702,000	4,049,000	6,630,000	8,503,000	10,375,000	11,438,000	25,659,000
Inflow Hydrograph (m^3)	—	215,000	368,000	173,000	237,000	251,000	1,568,000
Overland Infiltrated & Intercepted Water (mm)	73.19	152.18	206.64	235.10	257.65	268.49	347.52
Water Lost To Infiltration & Interception (m^3)	1,486,000	3,032,000	4,117,000	4,684,000	5,133,000	5,349,000	6,923,000
Peak Outflow Discharge (cms)	1	12	66	124	172	203	1074
Peak Outflow Discharge Difference (Post - Pre) (cms)	1 (NA)	11 (12X)	25 (61%)	23 (23%)	32 (23%)	37 (22%)	81 (8%)
Total Outflow Volume (m^3)	16,000	489,000	2,717,000	5,103,000	8,586,000	10,805,000	47,723,000
Total Outflow Volume Difference (Post - Pre) (m^3)	16,000 (NA)	477,000 (44X)	1,211,000 (2X)	1,653,000 (48%)	2,607,000 (44%)	3,532,000 (49%)	4,350,000 (10%)

Table 8-4: Proposed Conditions Annual Exceedance Storm Event Model Results

Storm Event	80%	90%	95%
Total Point Rainfall (mm)	20.32	38.10	55.88
Rainfall Volume (m^3)	405,000	760,000	1,114,000
Inflow Hydrograph (m^3)	—	—	—
Overland Infiltrated & Intercepted Water (mm)	19.34	35.49	51.07
Water Lost To Infiltration & Interception (m^3)	386,000	708,000	1,018,000
Peak Outflow Discharge (cms)	—	—	0.3
Peak Outflow Discharge Difference (Post - Pre) (cms)	NA	NA	0.3 (NA)
Total Outflow Volume (m^3)	—	—	1,540
Total Outflow Volume Difference (Post - Pre) (m3)	NA	NA	1,540 (NA)

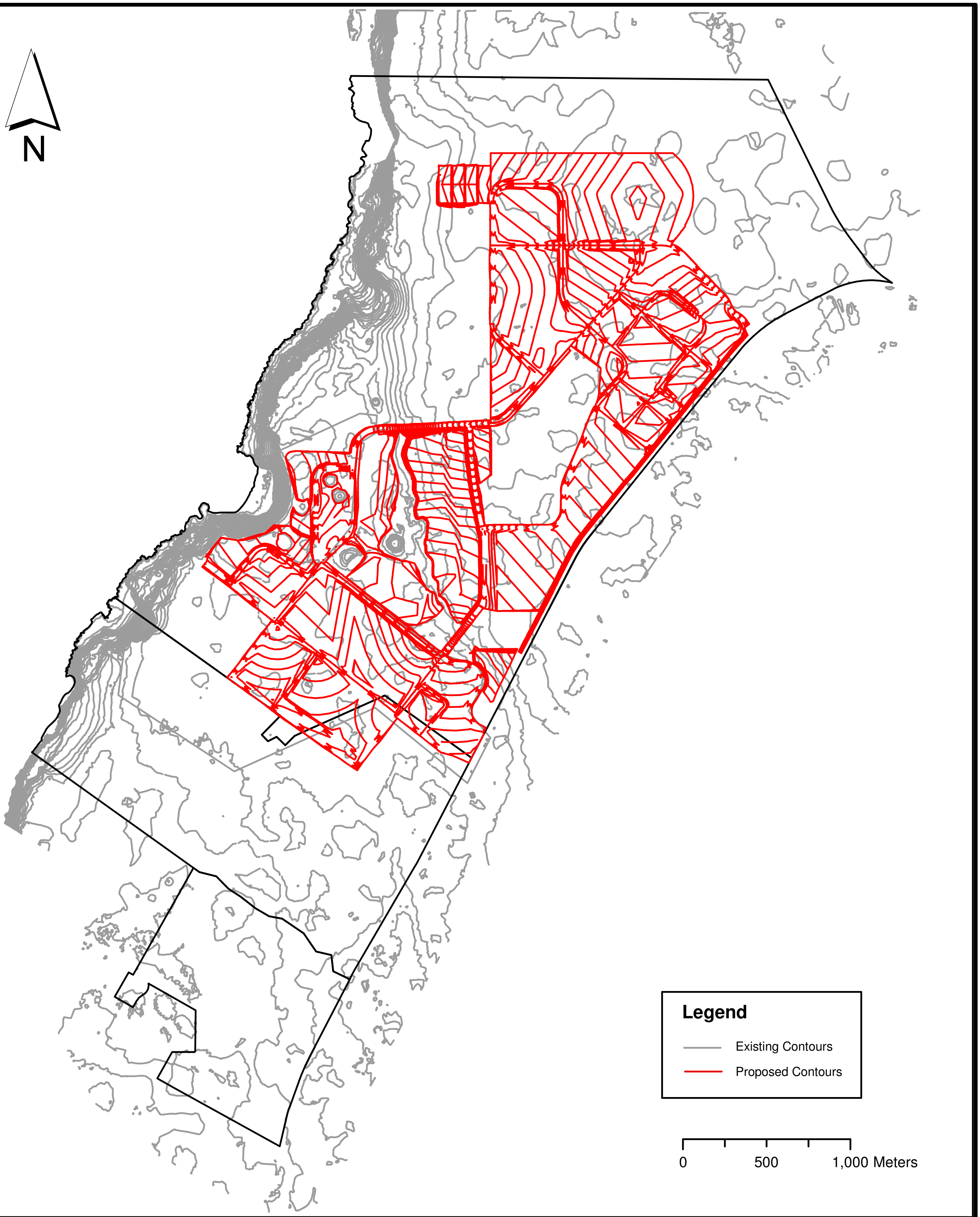
The 80% and 90% annual exceedance storm events showed standing water only on the impervious areas. At 95% annual exceedance storm event coastal discharge takes place at the northern half of the project area where runoff concentrates due to a natural depression on the topography and new grading. In all events including and greater than the 2-year storm event, the entire floodplain becomes inundated. The GJMMP Site Development Plan increased the impervious area (including the housing area contribution) by approximately seven times. An increase in flow depths and outflow is expected with such a significant change to the project area.

The 95 % exceedance storm was used for developing the BMPs presented in Section 12. Figure **8-4** shows the maximum flow depth for the 95th % exceedance post development conditions without stormwater management. Standing water occurs on the impervious areas and ocean discharge (runoff through the Western and Southern site boundaries) is experienced at this storm event. No ocean discharge occurred with predevelopment conditions. The volume of ocean discharge is 1,540 cubic meters (m^3). BMPs selected and designed for the site would be required to eliminate the difference in discharge volume between the pre and post development model results. The maximum flow depth within the project site is 1.1 meters. Figure 8-5 shows the maximum velocities for the 95th % exceedance storm. The maximum velocity within the project site is 0.46 meters per second. The general flow directions are shown on Figure 8-6. This figure shows the stormwater routing directly to the ocean.

The detention basins described in Section 9 were designed based on the volume differential between the 100-year, 24-hour storm and the total downstream ultimate disposal site volumes. The maximum flow depths experienced for pre-development conditions during the 100-year storm are presented on Figure 8-7. The maximum flow depth within the project site is 13.6 meters. This depth occurs within a sinkhole at the center of the NCTS Finegayan site. The sinkholes, noted by a dashed line on the figures, collect a significant amount of the stormwater runoff. The average flow depth within the project area is 0.21 meters. Figure 8-8 shows the maximum velocities during the 100-year storm. The maximum velocity is 9.4 meters per second. The general flow directions are shown on Figure 8-9. This figure shows the stormwater routing to sinkholes, discharge points directly to the ocean and discharge that occurs at the southern boundary.

Figure 8-10 through Figure 8-13 (at end of section) show the change in flow depth and change in velocity from pre to post-development. These figures show where the flow paths are changing and where detention basins may be more effective. They also show that the change in flow depth decreases for the 100-year storm, however, the velocities significantly increase. The grading removes the potential for pooling of stormwater in depressions, but also creates high velocity sheet flow.

Figures for the remaining post-development storm events can be found in Appendix A.7.



AECOM

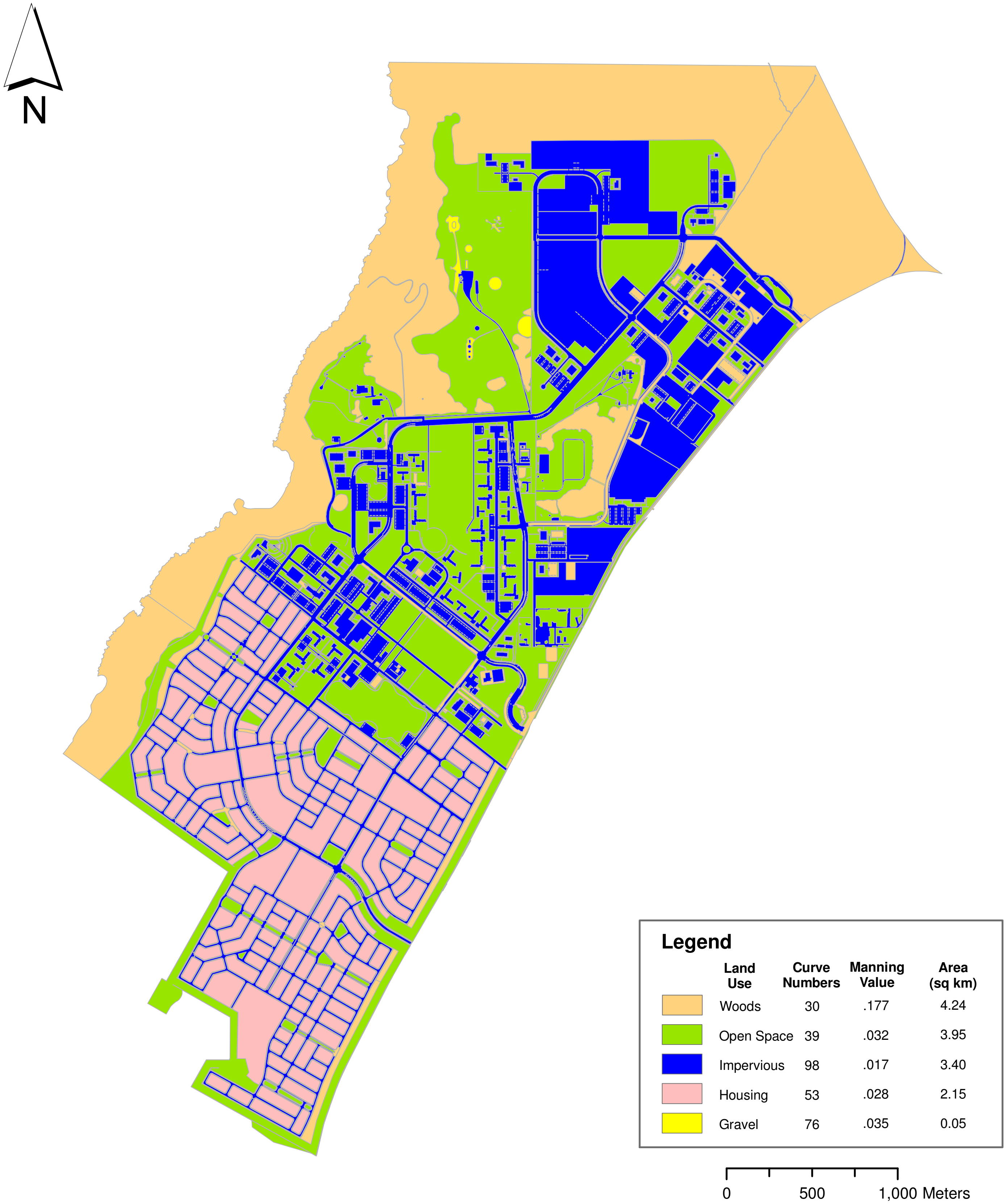
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre- and Post-Development Contours

GIS FILE:

SCALE: AS NOTED

DATE: 01/05/2010

Figure 8-1



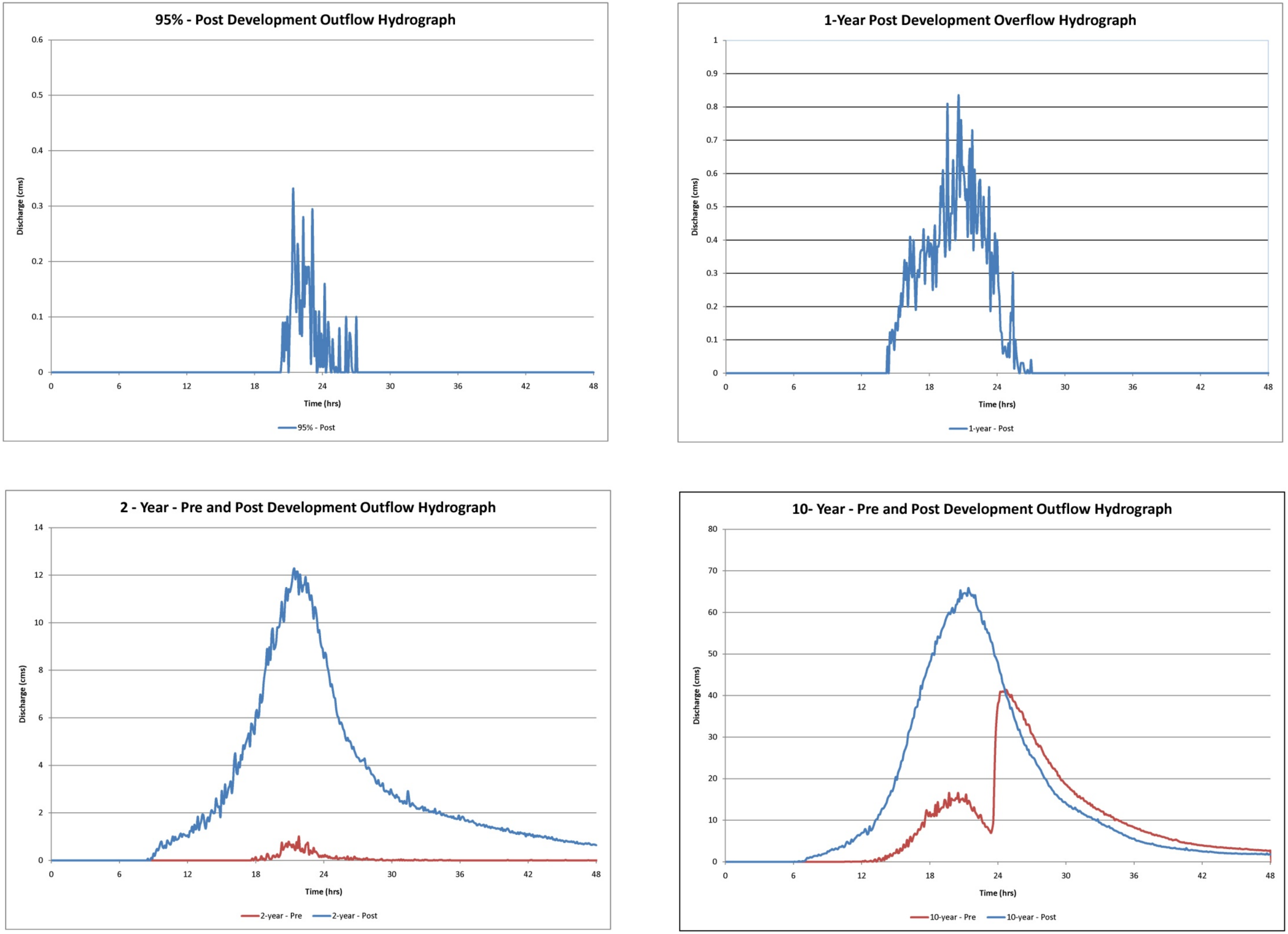
Legend

	Land Use	Curve Numbers	Manning Value	Area (sq km)
🟧	Woods	30	.177	4.24
🟩	Open Space	39	.032	3.95
🟦	Impervious	98	.017	3.40
🟥	Housing	53	.028	2.15
🟨	Gravel	76	.035	0.05

AECOM

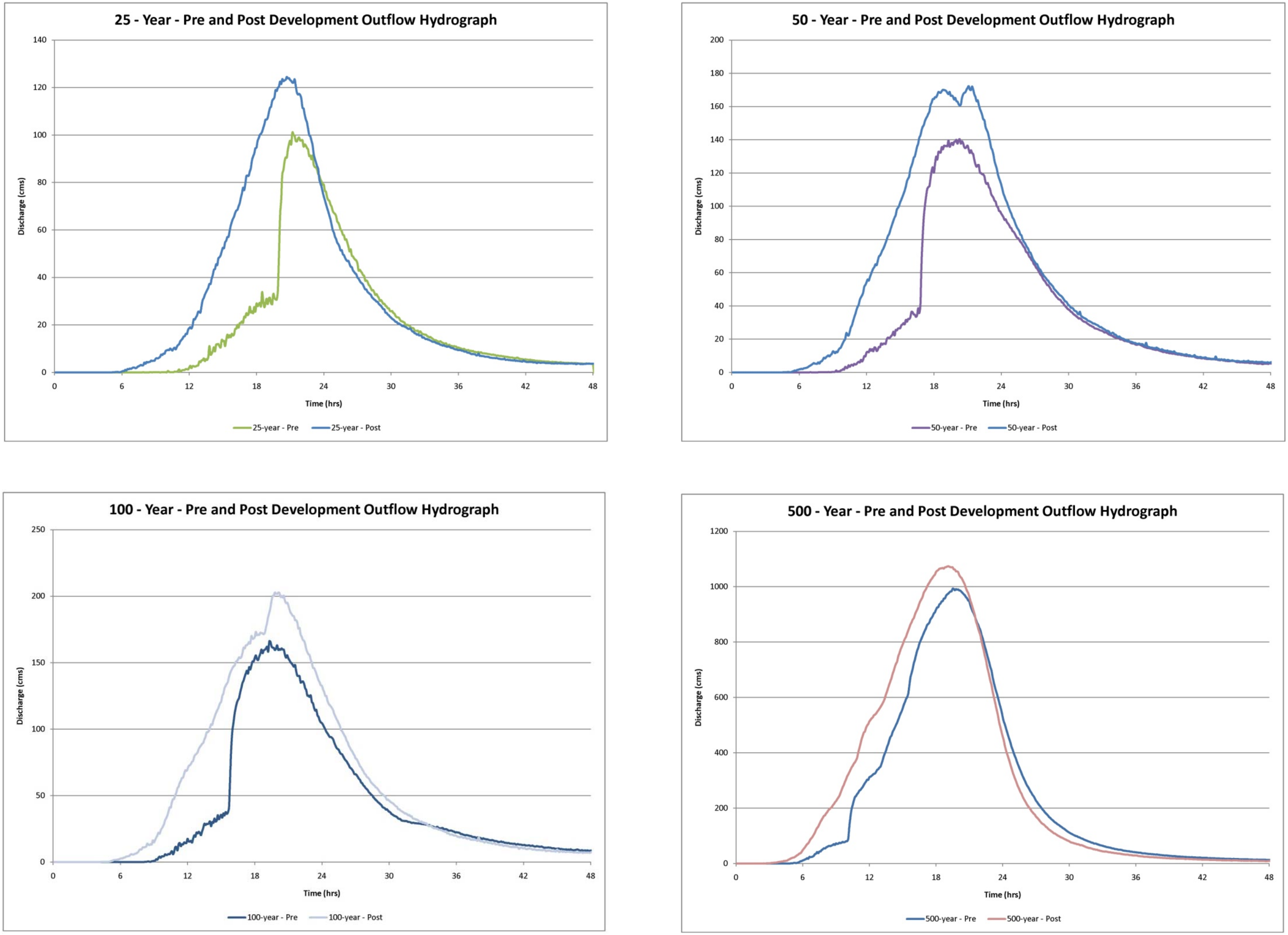
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Land Use Conditions

GIS FILE:
SCALE: AS NOTED
DATE: 12/17/2009
Figure 8-2



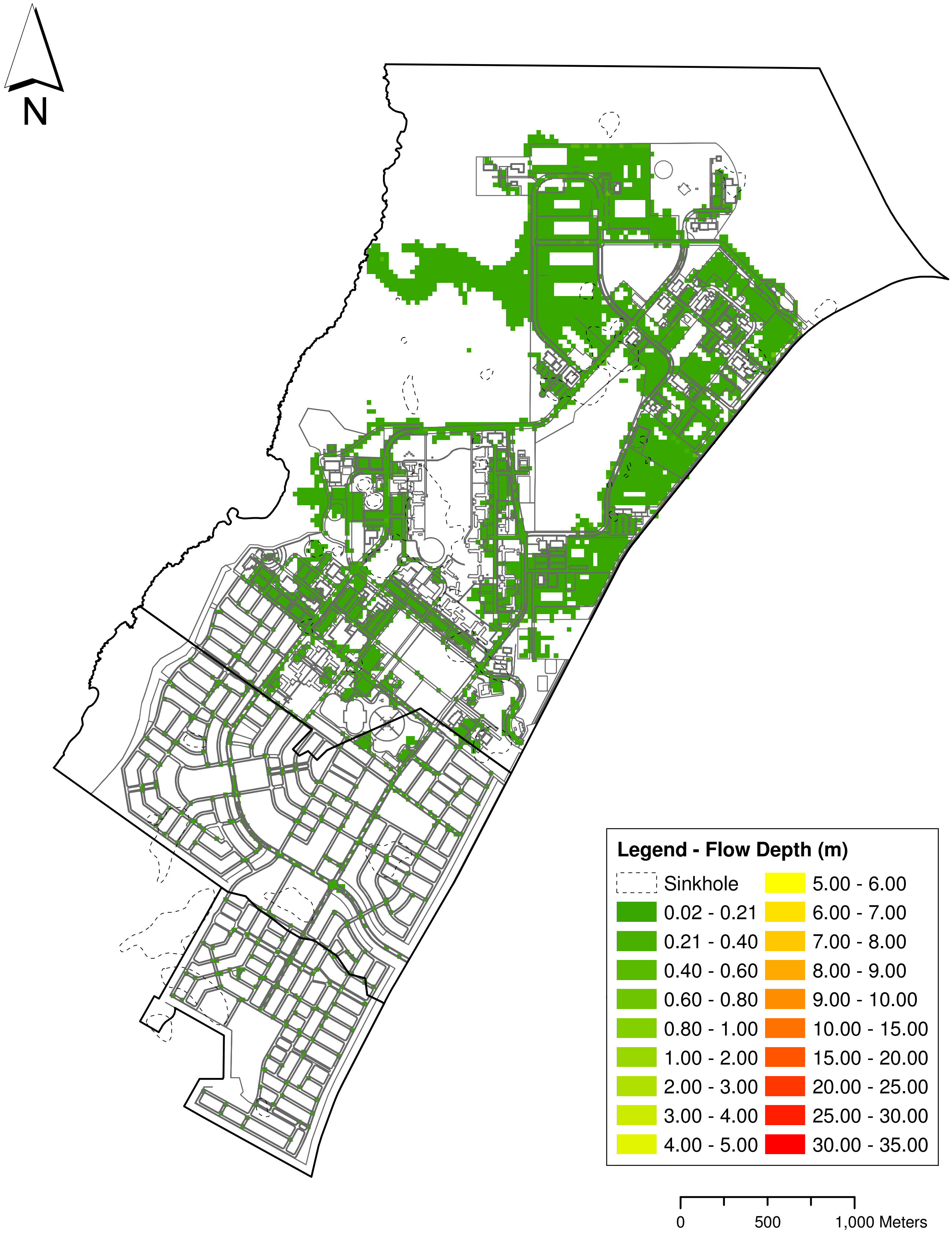
AECOM

Figure 8-3: Post-Development Conditions Outflow Hydrograph, Part A



AECOM

Figure 8-3: Post-Development Conditions Outflow Hydrograph, Part B



AECOM

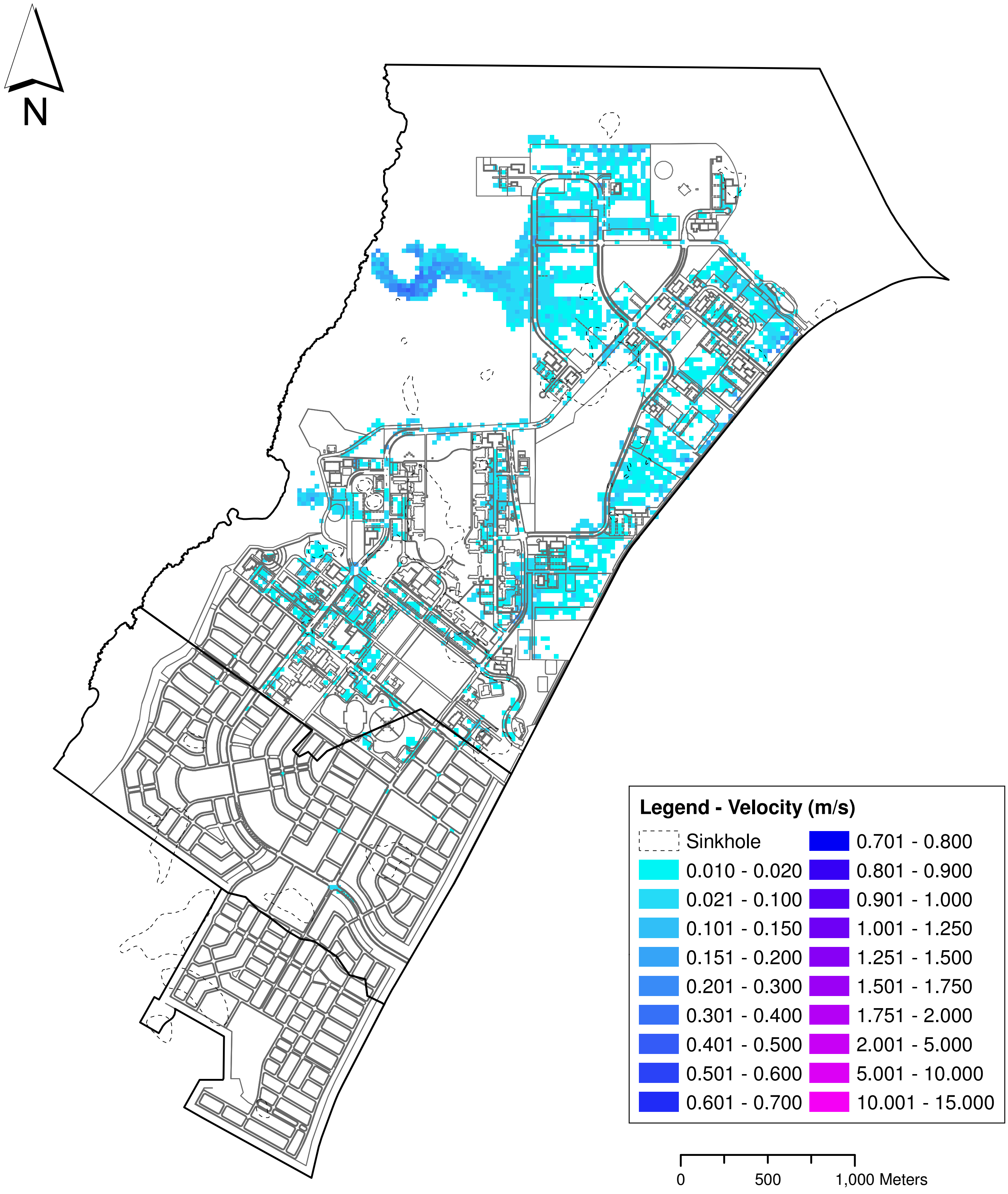
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 95 Percent

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 8-4



AECOM

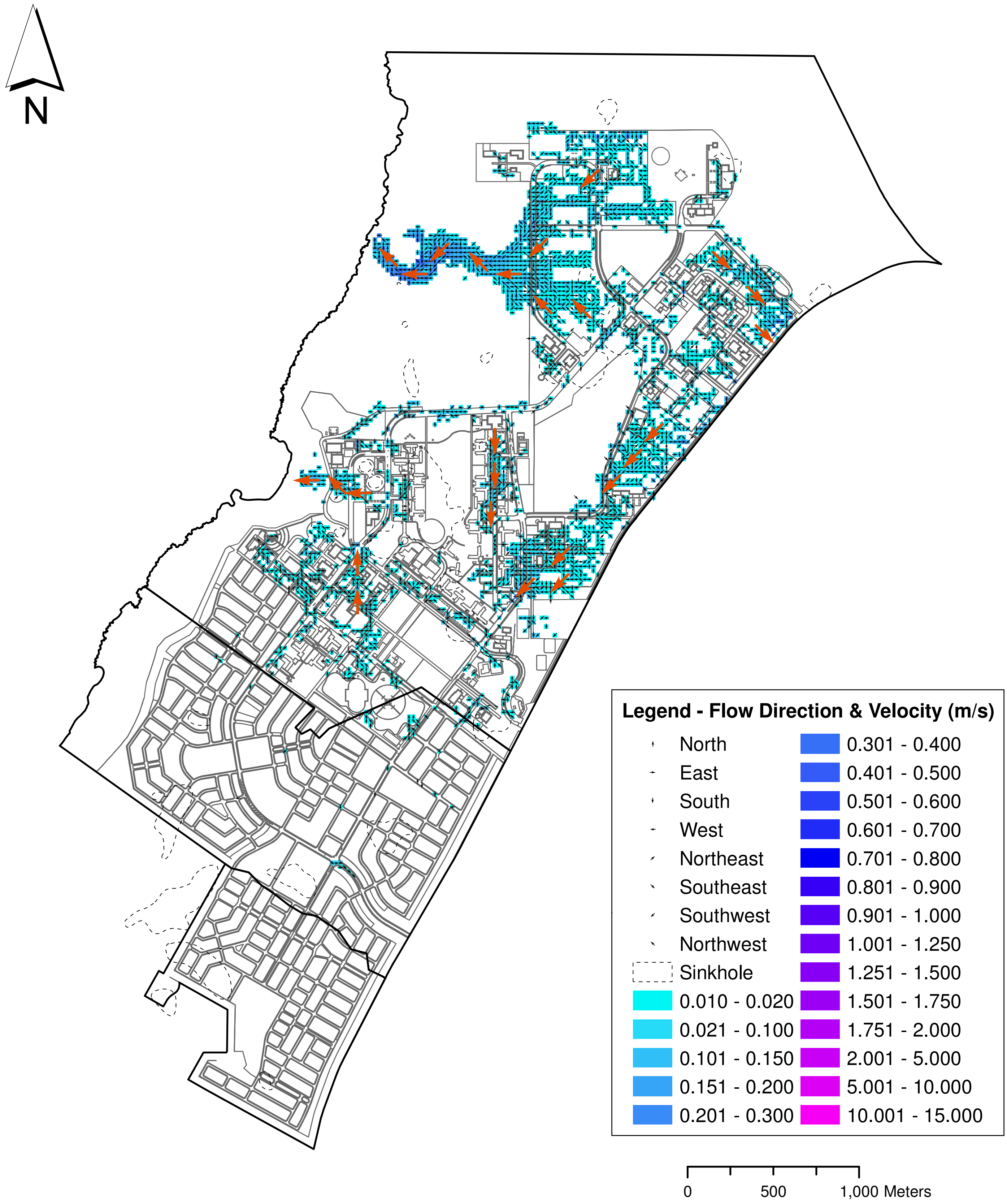
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 95 Percent

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 8-5



AECOM

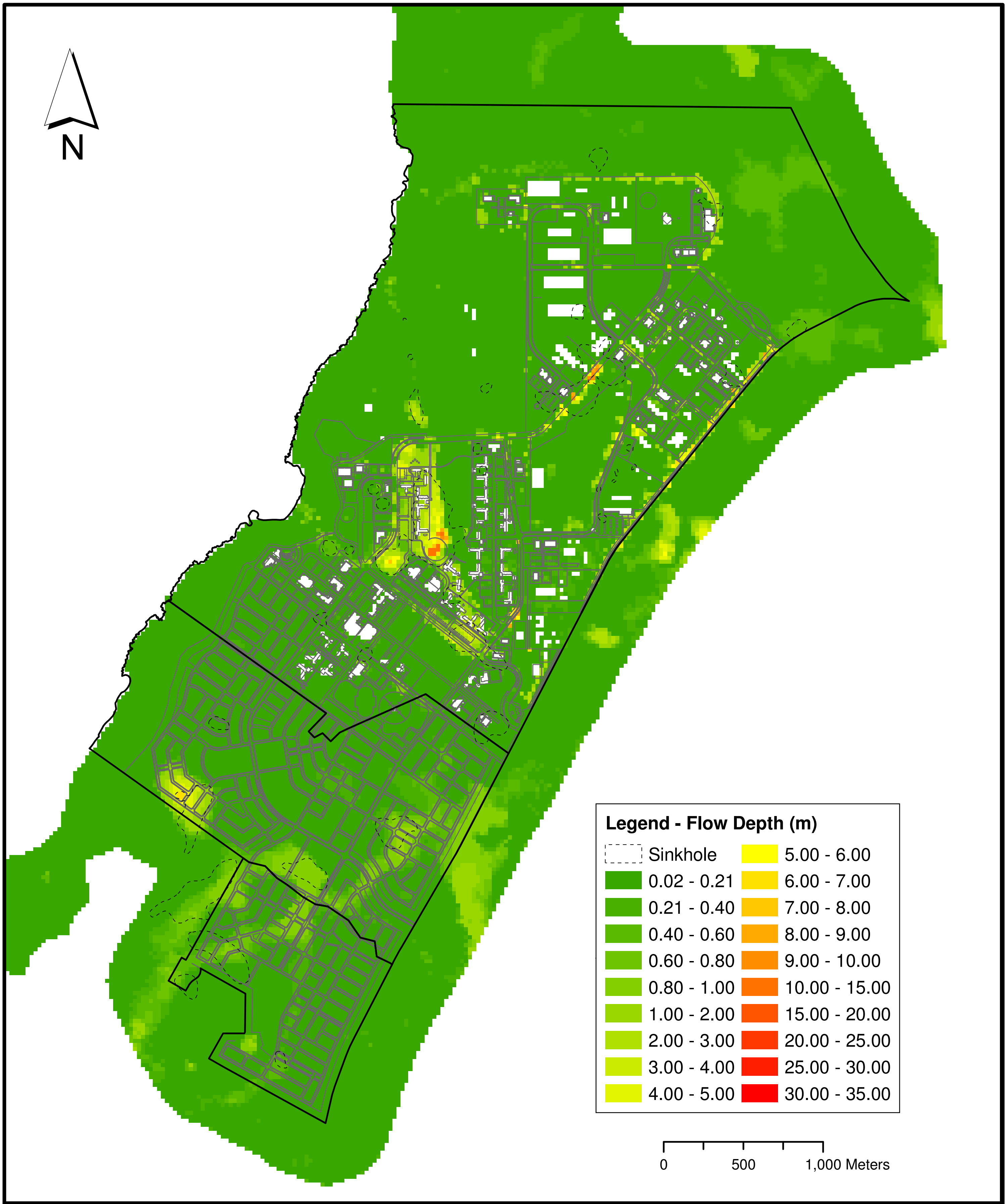
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Max Velocity with Vectors - 95 Percent

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

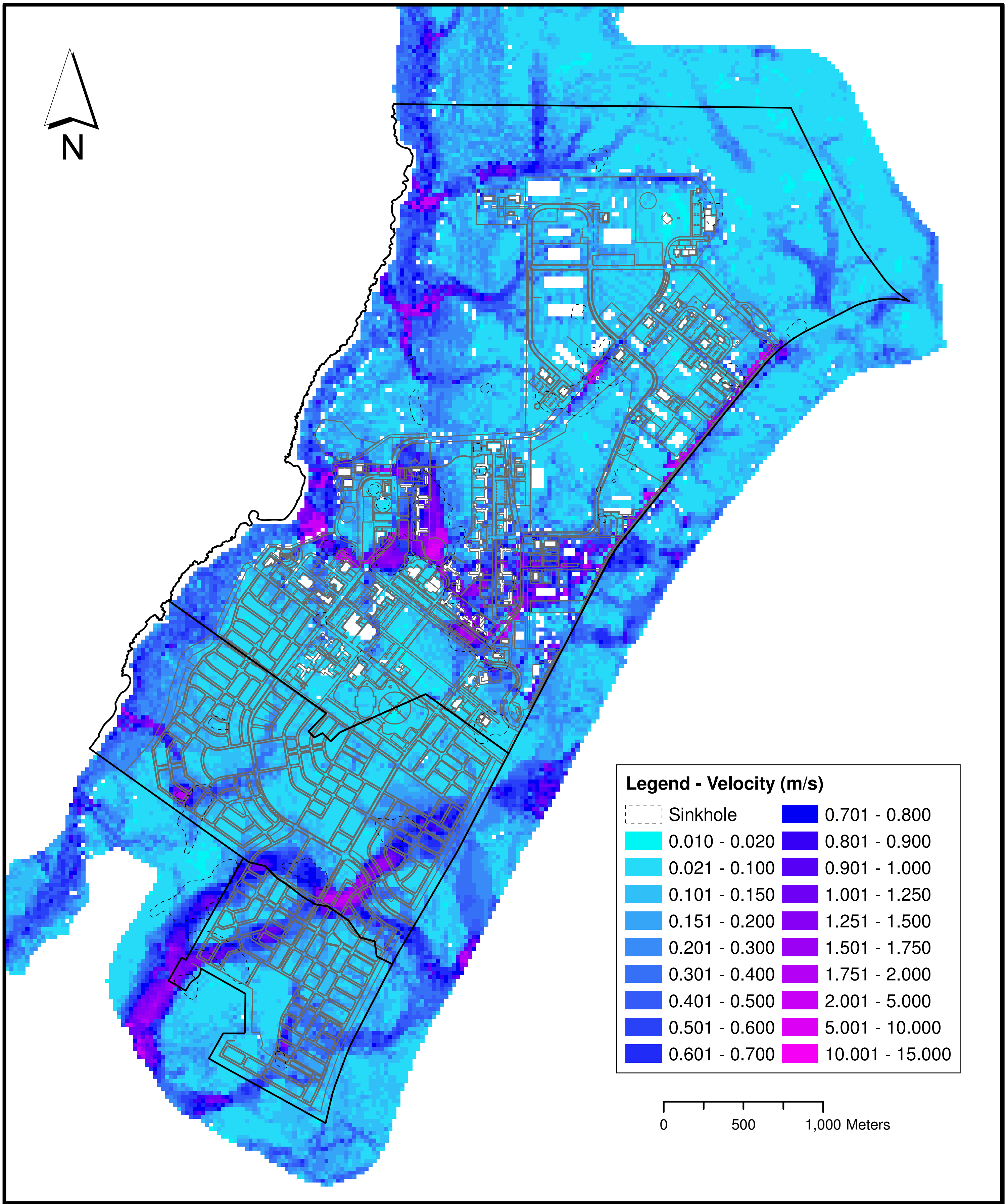
Figure 8-6



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 100 Year

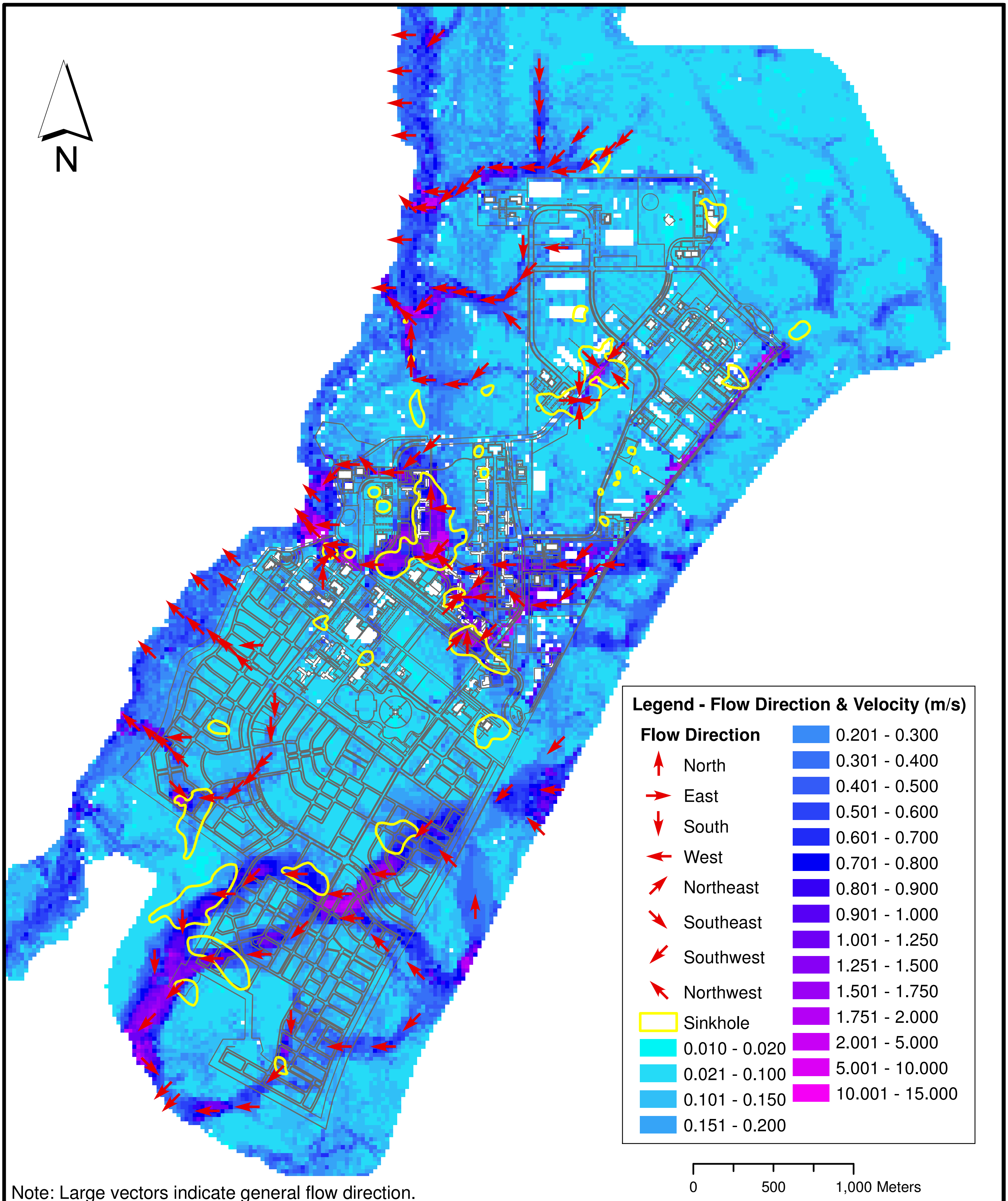
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 8-7



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 100 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 8-8

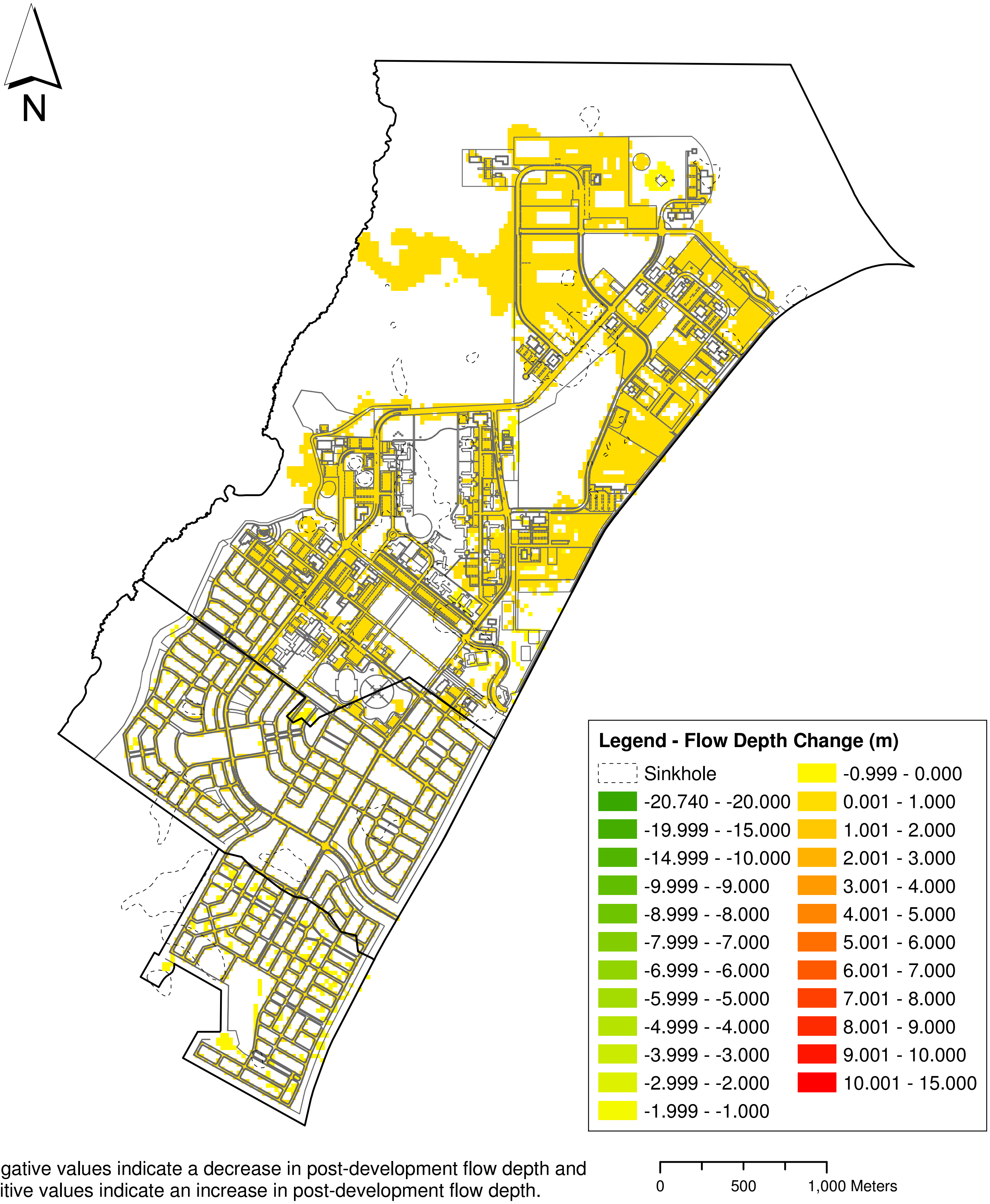


Note: Large vectors indicate general flow direction.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Max Velocity with Vectors - 100 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 8-9



*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

AECOM

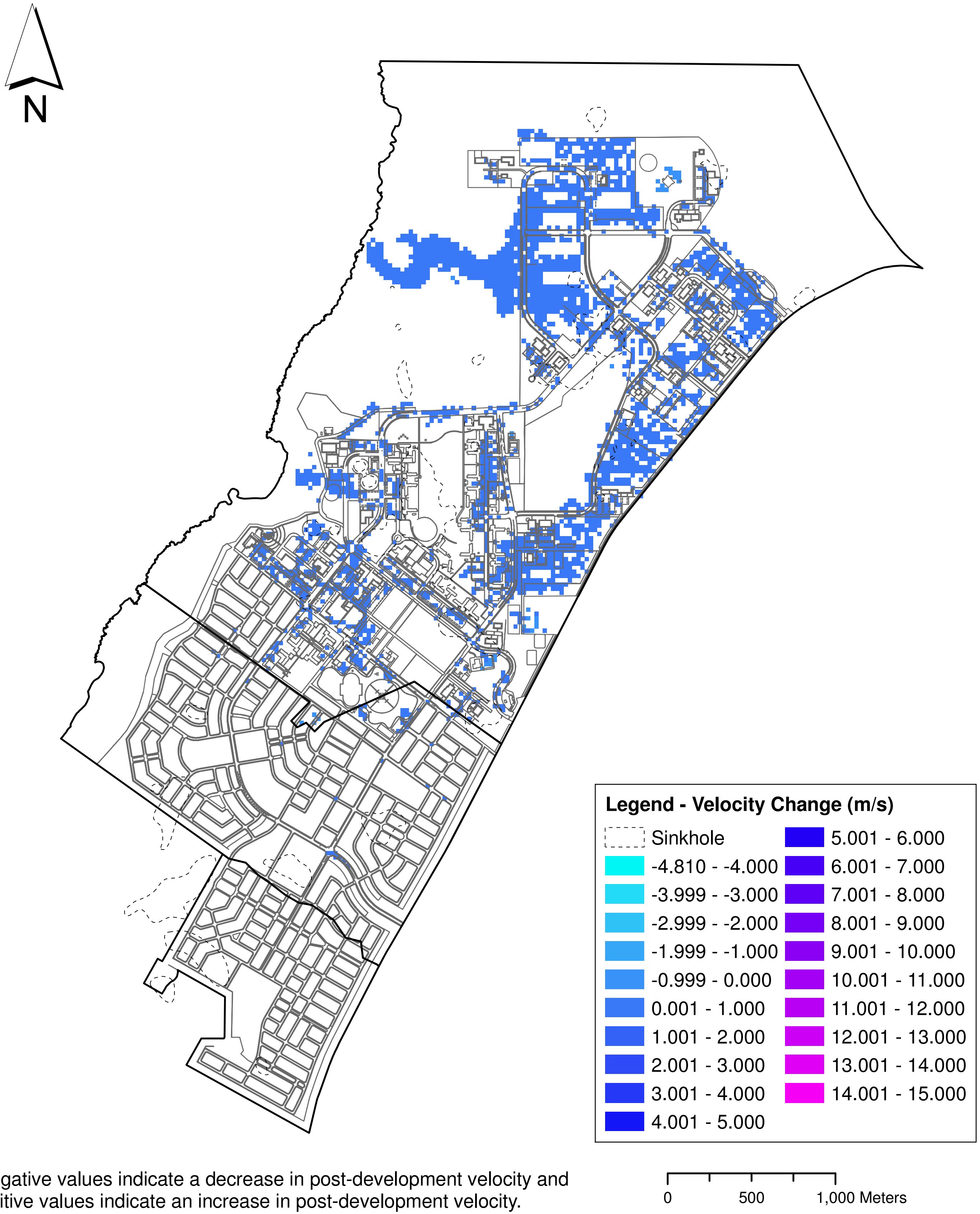
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
95 Percent Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 8-10



*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

AECOM

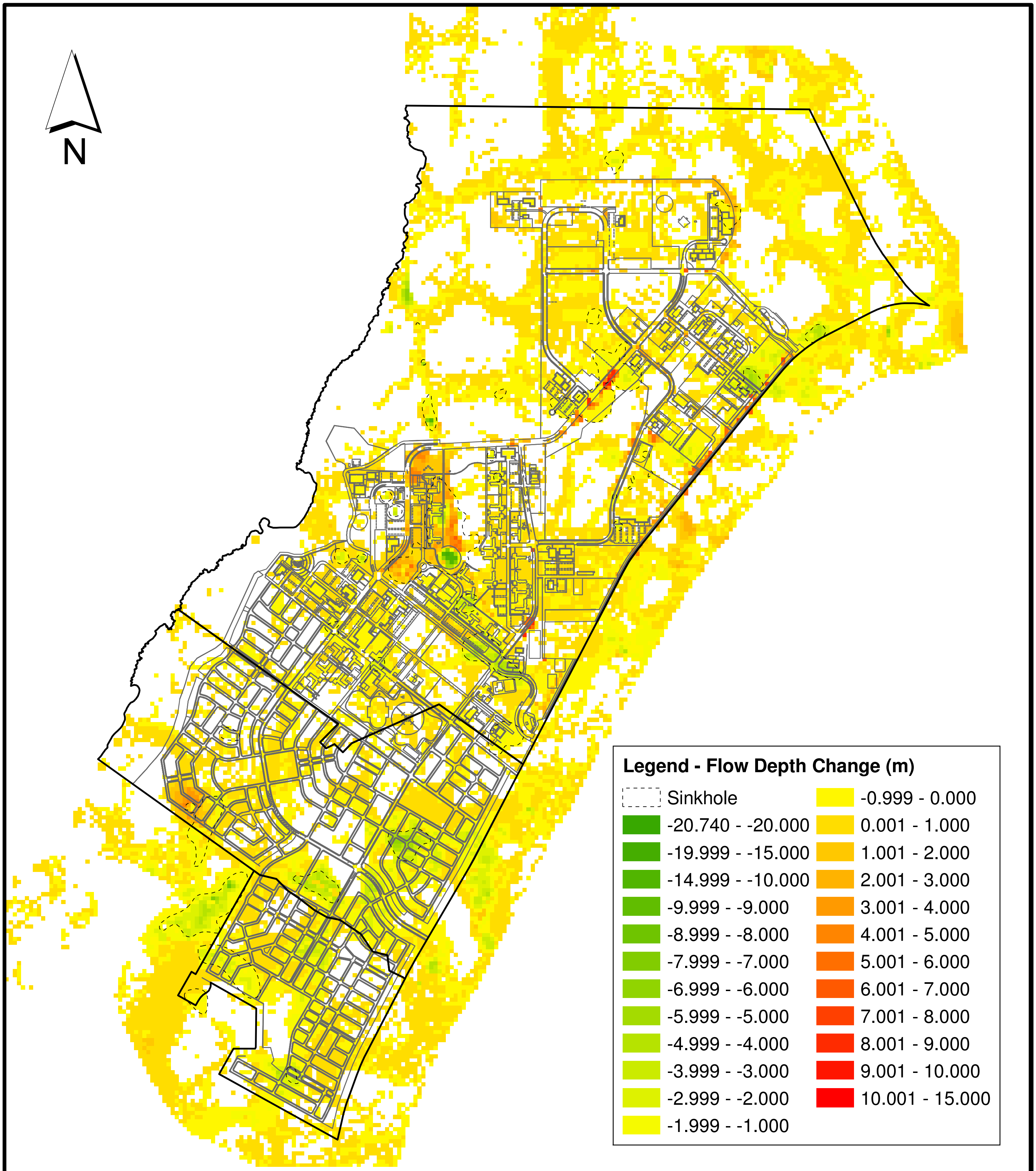
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
95 Percent Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 8-11



*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

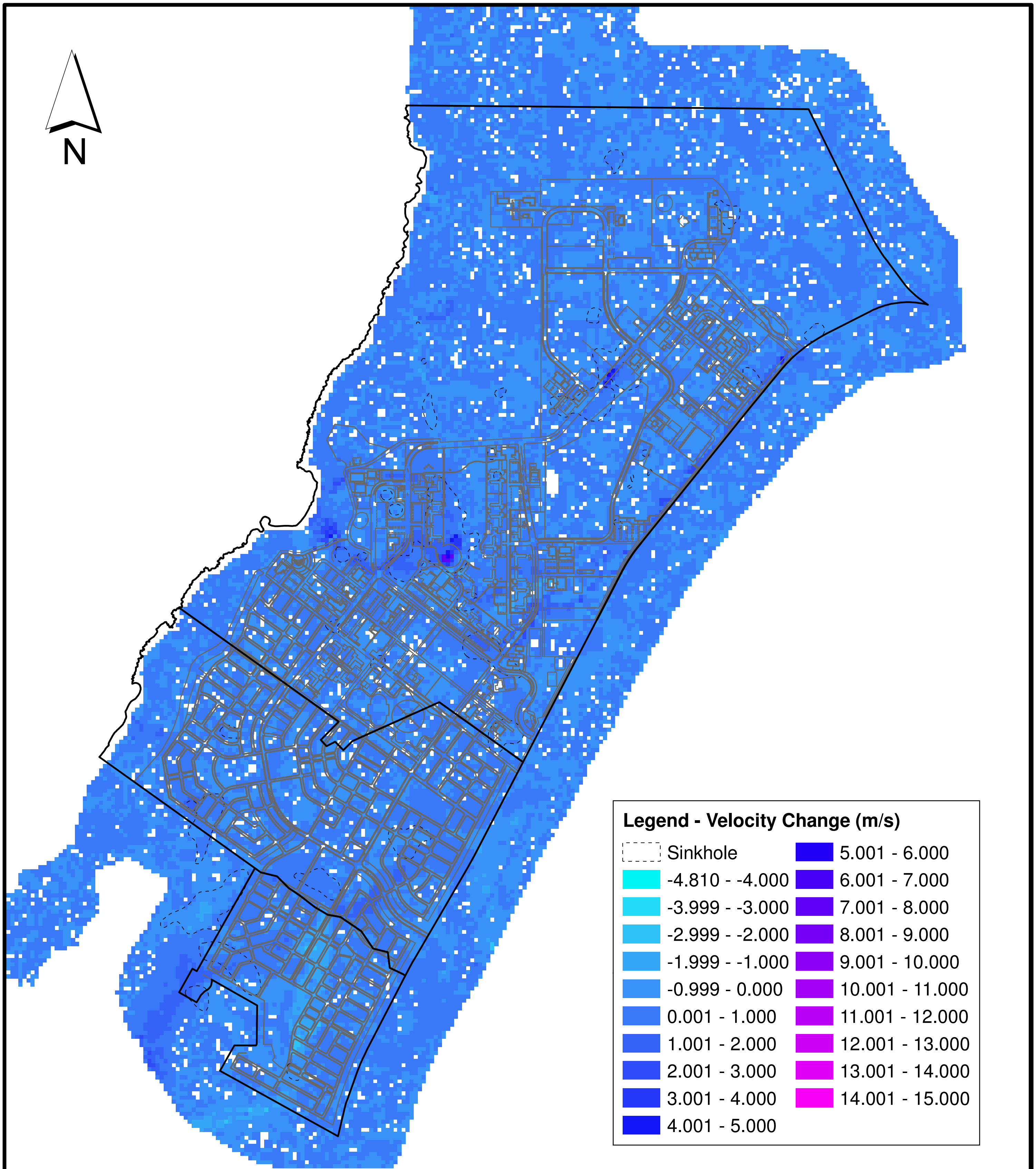
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
100 Year Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 8-12



*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
100 Year Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 8-13

9. Overall Drainage and Infiltration Schemes

9.1 INTRODUCTION

The existing drainage primarily infiltrates into the natural ground cover and recharges the aquifer. See Sections 3 and 5 for a full discussion of existing conditions. The mass grading of the site has altered the overall drainage in some ways but the overall hydrologic cycle for the island is expected to remain the same except in the fact that infiltration would be localized at detention basins, swales, and natural ground cover rather than infiltrating throughout entire site. The total drainage area for the Main Cantonment Development Area is approximately 558 hectares (1,380 acres).

The drainage concept is that every parcel shall store and treat its stormwater runoff where applicable. In some cases stormwater would flow to adjacent parcels that have a sufficient amount of stormwater storage capacity. Street drainage would not be directed to NAVC parcels but directed to an adjacent developed parcel via short storm drains and/or swales and into a detention basin designed to infiltrate the treated storm event.

The significant amount of stormwater storage volume required to store storm events may in some cases block travel ways to reach parts of the planned development. In later designs basins could be split and joined by culverts, and treated as one basin hydraulically to allow travel over the proposed basin. In siting the detention basins care was taken to avoid the facilities depicted in the GJMMP, however some conflicts due occur. Conflicts between the GJMMP and the Stormwater Routing Scenarios have been labeled and depicted in the Detention Basin Plan (Appendix B.2). Further, these conflicts and three potential resolutions have been identified in a Conflict Table (Appendix B.3).

In graded areas there could be a great reduction in permeability because the physical properties of the existing limestone change to cementious like product during crushing and compacting. Care should be taken during final construction in areas not intended for structures to remove this cementious upper layer of grading and promote good infiltration. While no specific BMP has been created for this grading nuance the following actions are suggested:

- Graded areas that underlie buildings, roadways, or impermeable surfaces need no corrective action
- Areas that are graded and are designed to provide infiltration (detention basin bottoms, porous paving subgrades, bio-swales, etc.) should have the mass graded ground scarified during final site grading preparations to break up the cementious crust, expose the underlying soils, and ensure the subgrade meets the pervious qualities needed for the particular final design being implemented
- After preparation of subgrade (above) care should be taken to keep heavy equipment off of the prepared subgrade so as not to re-form the cementions crust

9.2 STORMWATER ROUTING SCENARIOS

An overarching concept is envisioned for the drainage of each parcel of land (note: the term “parcel” refers to the developable areas situated between the U&SI roadways). Each detention basin is designed to capture and infiltrate varying levels of storms from a 2-year, 24-hour storm up to a 100-year, 24-hour rain event. In some instances stormwater runoff is directed to an adjacent parcel. Stormwater would be captured by curb inlets, area drains, swales, and dry wells. This water is then routed by storm drain to the parcels designated detention basin and is discharged into the basin by headwall or swale. The treated stormwater is then infiltrated into the ground.

In a storm event greater than a detention basin's given capacity, or back-to-back storms that total more than a detention basin's given capacity, the detention basins will overflow. Outlet structures, such as a broad-crested weir, should be provided to control the overflow of the detention basins. Outlet structures shall safely discharge the overflow in a non-point source, spreading out the overflow as much as practicable. Care should be taken by the designers of future parcels and facilities to understand the onsite and downstream effects of the release of detention basin overflows. Once released the detention basin overflows and subsequent secondary overflow routes shall be coordinated through the various designers. A preliminary review of the ultimate disposition and discharge of the secondary overflows can be seen on the Detention Basin Plan (Appendix B.2).

9.3 SITING AND SIZING OF DETENTION BASINS

9.3.1 Hydrologic Methodology

Subwatersheds were delineated based on the Notional Grading Plan (Appendix B.1). Stormwater peak discharges were calculated for each subwatershed using SCS unit hydrograph procedures. SCS methodology uses rainfall-frequency data for areas typically not less than 5 acres or greater than 200 acres, for durations of up to 24 hours, and for frequencies from 1 year to 100 years. Rainfall depths were interpreted from the rainfall-frequency-intensity maps provided in the Guam Storm Drainage Manual. A time of concentration and weighted CN values were also associated with each subwatershed. The technical data discussed in this section can be found in Appendix B.5. As described in Section 5, the soils are considered to be Type A and CN values were assigned based on TR-55. SCS Type II Unit Peak Discharge Graph was used to find the unit peak discharge for each subwatershed. A Type II graph was used based on references from the Guam Storm Drainage Manual as well as the geographical region of Guam. Finally, the peak discharge for the post development runoff analysis was then calculated for each subwatershed. The peak discharge for each subwatershed was then used to size the detention basins. The following equations were used.

Accumulated Direct Runoff equation:

$$Q = \frac{(P-0.2S)^2}{P + 0.8S}$$

Where:

Q = Depth of runoff (inches)

P = Rainfall depth (inches)

S = Maximum retention in SCS method

Peak Discharge equation:

$$Q_p = q_u A Q$$

Where:

Q_p = Peak Discharge (cubic feet per second [cfs])

q_u = Unit Peak Discharge (cfs per square mile per inch of runoff)

A = Drainage Area (square miles)

Q = Depth of runoff (inches)

9.3.2 Hydraulic Methodology

Detention basins sizing is based on the results of the hydrographs prepared in Section 9.3.1 above. The resultant hydrographs, depicted in Appendix B.5 are based on a timed increment of rainfall. The rainfall starts at time = zero, continues to a peak discharge rate, and then diminishes back to a value of zero flow at the end of the storm. This results in a bell shaped curve for the subarea hydrographs. The detention basin sizing is simply a summation of rainfall volume for each time increment from the time the storm begins (time = zero), through the peak intensity of the storm, and through the end of the storm. In general, the detention basin size (volume) is equal to the area under the hydrograph bell shaped curve. It should be noted that the detention basin sizes (volumes) do not account for the minor losses that will ultimately occur from the point of rainfall landing on the ground and flowing to the detention basin. As such, these detention basins are the upper limits of sizing (volume) needed within each subarea. During the final design phases of each project within a drainage subarea and accounting for the evapo-transpiration losses, infiltration within the treatment train, micro-storage within the treatment train, and micro-storage within the project site should be considered as a means in reducing the overall detention basin sizes.

9.3.3 Subsurface Stormwater Detention Systems

In addition to traditional detention basin facilities, below subsurface detention systems are envisioned to augment the flood control storage of the traditional detention basins discussed above. In general, the subsurface stormwater detention systems are a series of parallel, large diameter (900 mm) pipes used to house large event storm flows. The large diameter pipes are typically connected by smaller header pipes (150 mm to 200 mm) that collect storm flows from the surface and convey to the larger diameter pipes. The entire system of pipes is typically buried below grade and backfilled with a porous stone creating a highly pervious zone around the collection pipes. In addition to the stone backfill, the collection pipes are typically slotted on the sides and bottoms to promote infiltration through the porous stone backfill and into the surrounding soils, ultimately working through into the subsurface aquifer. For the purposes of this report parking lots for POVs and other relatively light weight cars within each development parcel have been shown on the Detention Basin Plan (Appendix B.2) as reasonable places for subsurface stormwater detention systems. It should be noted that these subsurface stormwater detention systems have been maximized in size to assist in reducing traditional detention basin footprints and function within the context of this Section as solely a flood control system. Further, the subsurface stormwater detention facilities referenced in Section 12 are sized based on water quality requirements as opposed to flood control requirements and, as such, are much smaller in size than those shown on the Detention Basin Plan (Appendix B.2).

9.3.4 Non-Residential Area Detention Basins

The detention basins are intended to be located in the low points of the parcel. Locating the basins at the lowest points of the parcel would make precise grading schemes within the area easier to design by decreasing the height of drainage swale walls, decreasing the depth of stormwater systems, and by reducing uphill flow scenarios.

Infiltration is relatively high with the island's natural ground cover and highly fractured limestone substrate. However, infiltration of stormwater into the ground prior to reaching the detention basins was not considered in these early stages of basin sizing. This results in slightly larger basin footprints to insure that basins are not undersized. It is best to be conservative at early planning stages, and then reduce in size (if warranted) during final construction documents. Micro storage in swales, ponds, and other treatment train facilities should also be considered to reduce the overall size of the basins in future designs.

Detention basin sizing was calculated using a bottom up methodology. The total 100-year, 24-hour storm runoff was first calculated. Subsequently the ultimate disposal areas were identified and storage volumes calculated. The difference between the total storm volume and the ultimate disposal site(s) volumes were subtracted, thus yielding the total storm volume to be detained within the cantonment area. The detention volumes were then spread around the cantonment area yielding several detention basins throughout the site. The intense rainfall amounts that the island of Guam experiences yield basin volumes that are significantly larger than usually designed in the mainland of the United States and other temperate climate zones. Basins are located such that each parcel has a designated basin or basins to drain to. In areas that are forced to have minimal basin detention volume, overflow dry wells could be considered, but permitting regulations should be well thought out and addressed prior to implementing dry wells. Detention basins contemplated in this report are generally 3 meters deep and 2 meters deep. This depth includes a freeboard amount of 0.5 meters. Side slope gradients of the detention basins have been planned at 2:1 to minimize footprints. Shallower side slopes can be utilized if desired, however the overall footprint of the detention basins would grow in size. Due to the relative depth of these basins it is anticipated that the basins would be fenced to preclude people and animals from unauthorized entry. Lastly, during final design processes the detention basin overall footprint may be reduced by careful design and grading of surrounding areas and allowing impounding of stormwater on non-critical areas. For instance, a detention basin may be shallowed and shrunk in overall footprint when the area immediately adjacent to the detention basin is a parking lot, a recreation field, open space, general landscape areas, or other non-critical facility using a shallow depth of storage in these areas to augment the basin storage. In all instances, habitable structures should always be protected from flooding up to and including the 100-year, 24-hour storm event. Stormwater management facilities such as detention basins can have a detrimental, costly effect on utilities, building foundations and roadways if not sited properly. It is suggested that a minimum distance of 5 meters be used to separate stormwater management facilities from buildings, utility lines, and roadways. A typical detention basin cross-section is depicted on Figure 9-1 (end of Section). Raw hydrograph data for sizing of the detention basins can be found at Appendix B.5, sizing of the detention basins can be seen in Appendix B.4.1, and the Detention Basin Plan can be seen at Appendix B B.2.

Suggested Design Parameters

- Detention basins should be developed utilizing a "bottom up" methodology – maximizing downstream ultimate disposal sites as much as practicable and minimizing upstream detention basin footprints and sizes.
- Total design storm storage should include detention basin storage volumes, micro-storage offered by the site, micro-storage offered by upstream LID treatment trains, and underground rainwater galleries where practicable.
- Total design storm storage should be offset (reduced) by such factors as evaporation, infiltration within the site, infiltration within detention basins, infiltration within underground rainwater galleries and infiltration within other LID treatment trains.
- Detention basins should provide 0.5-meter freeboard above design storm maximum water surfaces.
- Detention basins should have maximum side slopes of 2:1. Flatter side slopes are preferred.
- Detention basins impounding more than 0.3 meter (1 ft) of water should be fenced for protection.
- Detention basins should have access for maintenance. Multiple access points may be required for larger detention basins.

- All detention basin facilities should be fenced appropriately. Gates for maintenance access should be provided. Signage warning of intermittent flooding should be provided around the perimeter of the detention basins.

9.3.5 Residential Area Detention Basins

The process for siting and sizing detention basins in the residential areas should follow the same format as for non-residential detention basins. Detention basin should be planned at the low points of the graded sites. Ultimate disposal areas should be identified and volumes quantified. The total 100-year storm event runoff should be calculated and the ultimate disposal volumes subtracted from it. Detention facilities should be dispersed throughout the site to store the differential between the total storm and ultimate disposal volumes. Similar to the non-residential detention basins, the residential detention basins may ultimately be reduced in size during final designs by utilizing micro storage in swales, ponds, and other treatment train facilities. If adjoining parcels of land have adjacent low points it may be possible to combine two smaller detention basins into one larger basin. A few differences in the design of residential detention basins should be considered. Residential detention basins should be shallower and broader with side slopes laid back to 4:1 or 5:1. Shallowing up residential basins would allow the “walk out” ability of young children entrapped in a detention basin. In all instances, residential detention basins containing an impounded depth of more than 0.3 meters of water should be fenced off with access gates for maintenance and warning signs depicting intermittent flooding. The use of adjoining, non-critical land uses such as parks and open space for shallow flooding (less than 0.3 meters) to augment detention basin storage is encouraged and would help reduce overall residential detention basin footprints. In instances where these multifunctional areas impound less than 0.3 meters of flood storage fences and gates may be omitted. Careful planning and design of residential detention basins would be required to ensure proper flood protection of residential structures up to and including the 100-year, 24-hour storm event, aesthetic placement of basins, and protection of the individuals housed in the residential areas.

Suggested Design Parameters

- Detention basins shall be sized to handle storm events as large as possible, limiting secondary overflow as much as practicable
- Total design storm storage should include detention basin storage volumes, micro-storage offered by the site, micro-storage offered by upstream LID treatment trains, and underground rainwater galleries where practicable
- Total design storm storage should be offset (reduced) by such factors as evaporation, infiltration within the site, infiltration within detention basins, infiltration within underground rainwater galleries and infiltration within other LID treatment trains.
- Detention basins should provide 0.5 meter freeboard above design storm maximum water surfaces
- Detention basins should have maximum side slopes of 4:1. Flatter side slopes are preferred
- Detention basins impounding more than 0.3 meter (1 ft) of water should be fenced for protection.
- Detention basins should have access for maintenance. Multiple access points may be required for larger detention basins
- All detention basin facilities should be fenced appropriately. Gates for maintenance access should be provided. Signage warning of intermittent flooding should be provided around the perimeter of the detention basins

9.4 SMART GROWTH AREAS

Smart Growth Areas are areas in the GJMMP reserved for future buildout of the base. Smart Growth Areas have been identified as being graded during their respective U&SI phases (see Section 6 for complete discussion).

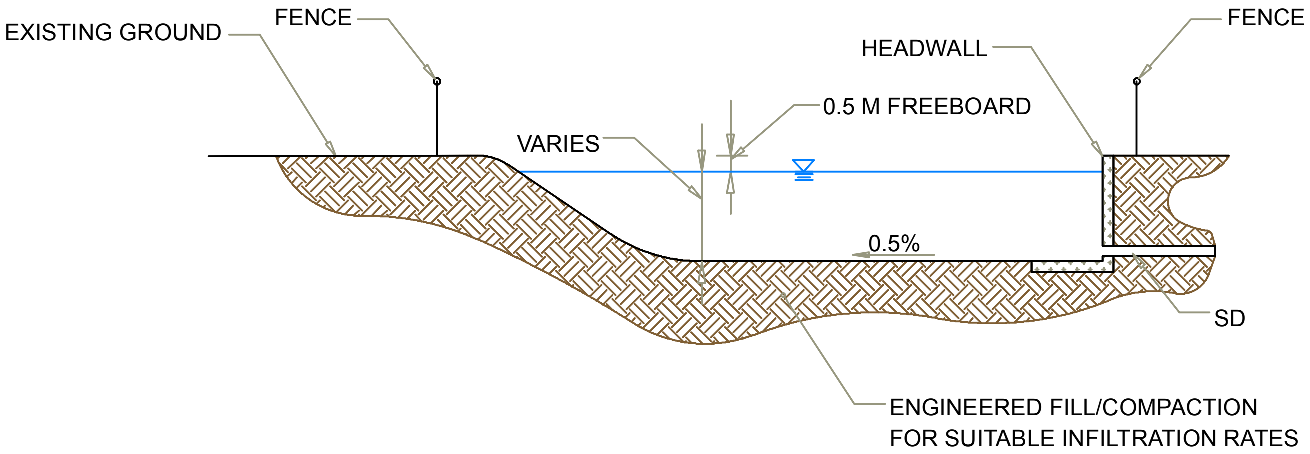
Smart Growth Areas have been hydraulically modeled in a manner similar to the proposed development adjacent to the Smart Growth Area. For instance, if a Smart Growth Area is adjacent to a large warehouse facility that has characteristics of large impervious buildings and large amounts of pavement, then the Smart Growth Area adjacent has been modeled with similar characteristics of large impervious buildings and large amounts of pavement.

In several instances the Smart Growth Areas have been used for the incorporation of drainage devices in order to eliminate conflicts between the planned facility layout in the GJMMP and the proposed drainage devices. The drainage devices are for adjacent planned development and the Smart Growth Areas in which they reside. Detention basins could be built to full capacity (development area plus “developed” Smart Growth Area) or they could be built for a lesser capacity (development area plus “undeveloped” Smart Growth Area), essentially phasing/enlarging the detention basins as Smart Growth Area development occurs.

9.5 SINK HOLES

Sink holes exist in the limestone formations of northern Guam. Sink holes are formed in limestone due to the slow dissolution of the subterranean limestone. Overtime these sinkholes expand with rainfall events because of the dissolution of the limestone. Many of these sink holes are in direct path of stormwater runoff and are said to be connecting directly with the aquifer. With the new development and increasing pollutants in the area, it is necessary to construct a berm around the sink holes and direct water away from them to prevent pollution of the aquifer (Figure 9-3).

Adding post-development flows (stormwater disposal) into the sinkholes as a means of storm volume storage is discouraged or higher frequency storms. The introduction of additional flows into the sinkholes could have a detrimental effect on the sinkholes, exasperating the dissolution process and expanding the sinkhole. A general guideline to follow in working around the sinkholes is to not allow post construction stormwater flows to enter the sinkholes up to and including a 100-year storm event unless the sinkholes are in an ultimate disposal area. As it is impracticable to keep all storm flows out of the sinkholes, post development flows that exceed the 100-year storm event may be allowed to enter the sinkholes as a means of ultimate stormwater disposal.



AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Detention Basin Detail

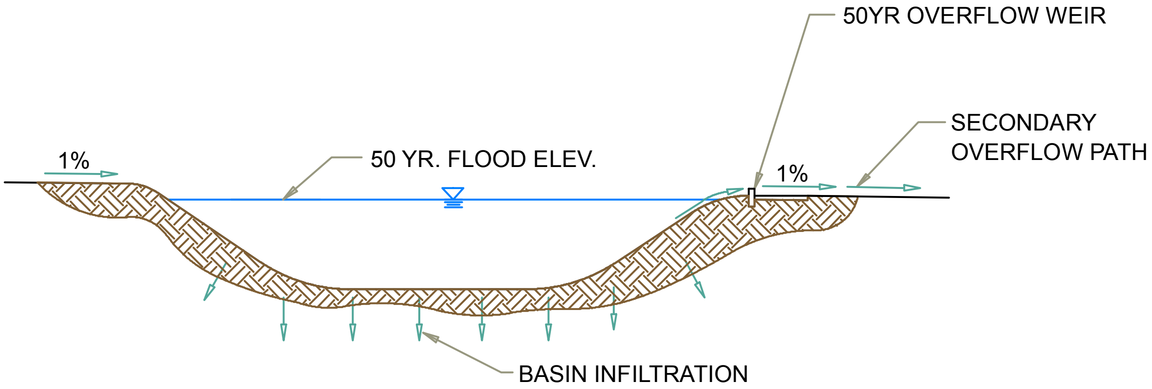
GIS FILE:

SCALE: NOT TO SCALE

DATE: 24-FEB-10

Figure 9.1

ANSI A - 24-FEB-10



NOTE: SEE APPENDIX B.2 (DETENTION BASIN MAP) FOR SECONDARY OVERFLOW PATHS

ANSI A - 24-FEB-10

AECOM

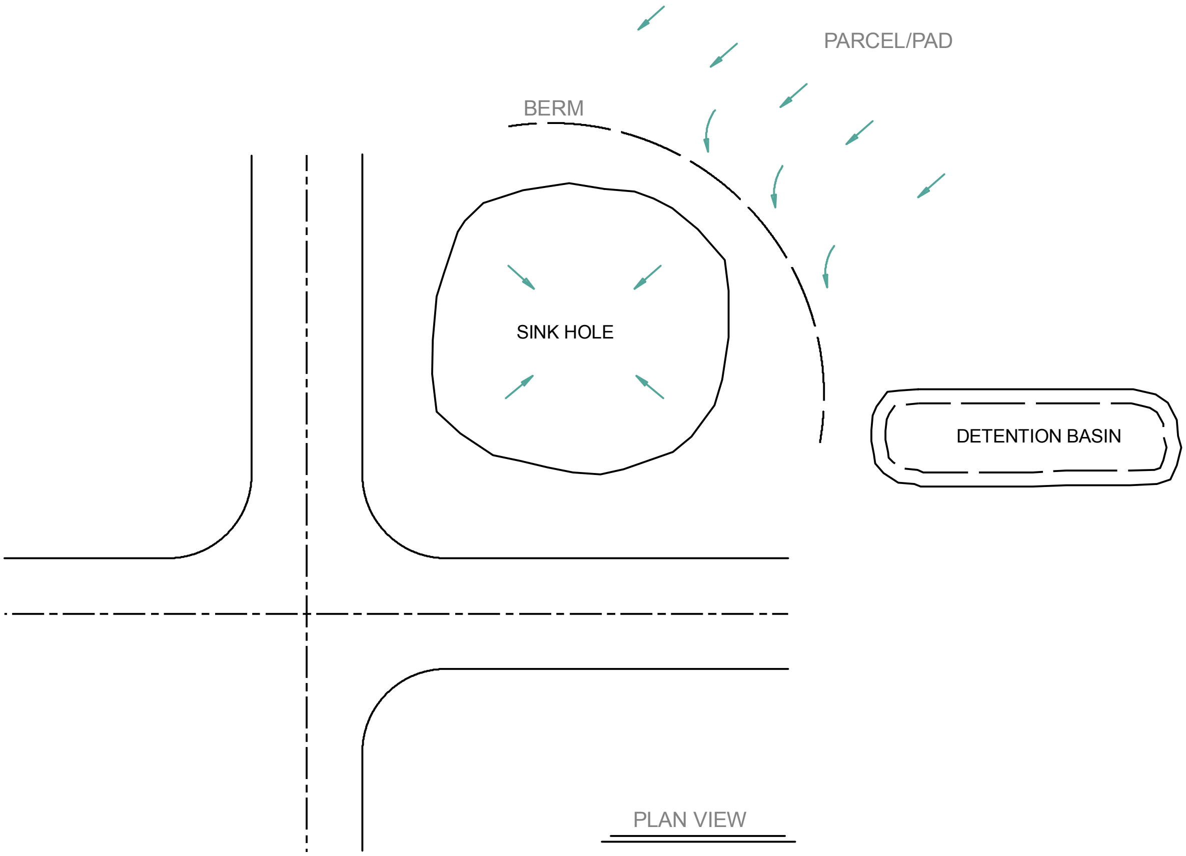
NAVFAC Pacific
Guam Drainage & Low Impact Development Study
50 Year Overflow Weir

GIS FILE:

SCALE: NOT TO SCALE

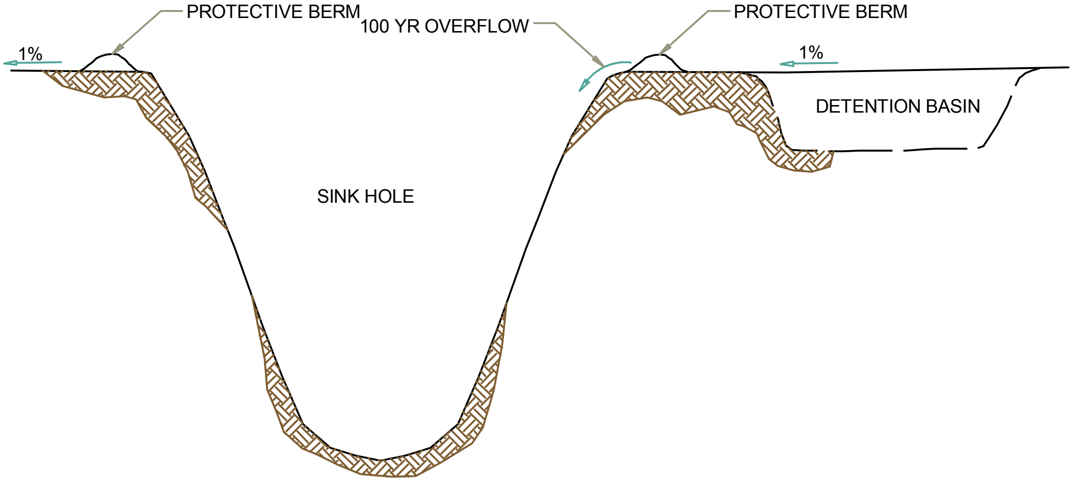
DATE: 24-FEB-10

Figure 9.2



PLAN VIEW

NOTE: GRADE AWAY FROM SINKHOLE WHEREVER POSSIBLE



PROFILE VIEW

NAVFAC Pacific
Guam Drainage & Low Impact Development Study
Sinkhole Storm Water Berm

GIS FILE:

SCALE: NOT TO SCALE

DATE: 24-FEB-10

Figure 9.3

ANSI A - 24-FEB-10

10. Assessment of Existing and Future Site Contamination

Threats to water quality in the Finegayan Main Cantonment Study Area (Study Area) include both point source (e.g., IR sites) and non-point source pollutant loadings (e.g., stormwater runoff). This section addresses potential changes in non-point source pollutant loads to the Finegayan Main Cantonment associated with projected future land use changes in the cantonment without consideration of existing or proposed BMPs or IMPs, which are the subject of subsequent sections. Use of BMPs and IMPs is recommended as an effective approach to prevent contamination of surface or groundwater, especially when they are designed and sited to treat stormwater runoff from operations or activities that are known to produce higher concentrations of pollutants of concern or have a greater risk for spills, leaks, etc. This Section also identifies possible contamination associated with IR sites in and adjacent to the cantonment area and discusses preferential pathways for percolation to groundwater. When implementing BMPs and IMPs, known IR sites should be avoided to the extent practicable unless it can be demonstrated that there is no real contamination associated with these areas.

10.1 NON-POINT SOURCE CONTAMINATION

One of the key tasks required for the assessment of contamination at the Study Area is the evaluation of pollutant loads to each subbasin through stormwater runoff based on various land uses. This section describes the method and data sources used for the non-point source pollutant loading assessment, and provides a summary of estimated loads under existing and future land use conditions.

10.1.1 Selection of Model Methodology and Data Sources

Several stormwater pollutant load methods and models are available to aid in the estimation of non-point source pollutant loads for various contaminants of concern. These methods range in levels of complexity from spreadsheet-based to continuous simulation models. For the purpose of this study, the Simple Method (Schueler 1987) was selected as the appropriate approach for estimating stormwater pollutant loads. The Simple Method is a commonly used and accepted model for smaller watersheds and affords quick and reasonable (i.e. planning level) pollutant load estimates to aid in assessing and comparing relative stormflow pollutant load changes of different land use and stormwater management scenarios (NHDES 2008, Ohrel 2000). The Simple Method is sufficient for use by site designers for the Study Area, where the effort to estimate pollutant loads is secondary to identifying IMPs and treatment trains to achieve desired pollutant reduction percentages (see Sections 11 and 12). More complex, intensive models are appropriate when there are regulatory requirements to estimate pollutant loads and more accurate results are needed.

The Simple Method estimates stormwater pollutant loads by: 1) estimating runoff volumes using runoff coefficients for the land uses within the watershed to convert rainfall data into runoff volumes; and 2) estimating pollutant loads using runoff volumes and pollutant event mean concentrations (EMCs). The following formula is used:

$$L = 0.226*R*C*A$$

Where:

L = Annual load (lbs)

R = Annual runoff (inches)

C = Pollutant concentration (mg/l)

A = Area (acres)

0.226 = A conversion factor

Source data and the non-point source model development are presented below.

10.1.1.1 LAND USE

Existing Conditions

Existing land use cover for the Study Area was estimated using a detailed vegetation map for the island of Guam (USDA 2005), selected polyline features within a personal geodatabase obtained from the Navy, and recent aerial photographs. Existing land use cover was assigned to the following broadly defined land use categories for which pollutant EMC data are available (see Section 10.1.1.4): residential, commercial / operations, roadway, industrial, urban open, and forest. Table 10-1 presents these land use categories as well as the associated acreages for the Study Area. Land use acreage was also developed at the subbasin level (see Appendix C). A map illustrating existing land use is provided as Figure 10-1 (end of Section.)

Table 10-1: Existing and Future Land Use

Land Use Category	Existing Conditions (acres)	Future Conditions (acres)	% Change
Residential	280.5	721.5	157.2
Commercial / Operations	87.9	223.7	154.4
Roadway	72.1	415.7	476.7
Industrial	21.0	297.9	1315.5
Urban Open	388.1	894.6	130.5
Forest	2514.5	807.1	-67.9

Future Conditions

Future land use for the Study Area was derived from detailed GIS data and housing facility footprint requirements developed for the GJMMP (JGPO and NAVFAC 2009). While revisions would be made to this land use data for inclusion in the Final GJMMP, it represents the best future land use data available for use in this report. For the purpose of the non-point source modeling effort, the various land use categories utilized in the Draft GJMMP were allocated into the same general land use categories used to represent existing conditions for the Study Area to aid in the comparison of existing to future conditions. Table 10-2 identifies how the Draft GJMMP land use categories were allocated, and Table 10-1 presents the associated acreages for the Study Area. As Table 10-1 indicates, the only land use category that loses acreage in future conditions is forest, since this is the land use category that accommodates the majority of the proposed development. Land use acreage was also developed at the subbasin level (see Appendix C). A map illustrating future land use is provided as Figure 10-2.

10.1.1.2 ANNUAL RAINFALL

A long-term average annual rainfall value of 94.4 inches was used for the Study Area. The source of this value is Anderson AFB Guam data recorded between 1952 and 1995, derived from National Climatic Data Center Cooperative Stations.

10.1.1.3 RUNOFF ESTIMATION

The Simple Method calculates annual runoff (R) as a product of annual runoff volume and a runoff coefficient (Rv). Runoff volume is calculated as:

$$R = P*Pj*Rv$$

Where:

R = Annual runoff (inches)
P = Annual rainfall (inches)
Pj = Fraction of rainfall events that produce runoff (default 0.9)
Rv = Runoff coefficient

Table 10-2: Allocation of GJMMP Land Use Categories

Land Use Category Used for Non-Point Source Model	Land Use Category Included from GJMMP
Residential (Multifamily)	Bachelor Enlisted Quarters
	Bachelor Officer Quarters
	Housing
	Family Housing
Commercial / Operations	Headquarters Administration Complex
	Base Operations and Community Support
	Quality of Life
	Provost Marshal's Office and Brigade
	Army Air and Missile Defense Administration / Operations
Roadways	Primary Right of Way
Industrial	Division Administration / Operations
	III Marine Expeditionary Force
	Marine Logistics Group and Base Industrial
	Marine Air Wing
	Transit Hub / Utilities
Urban Open	Training Area
	Recreation
	Naval Communications – Reserved
	Other Open Space
	Smart Growth Area
Forest	Open Space – Protected

As discussed in Section 5, Pre-Development Stormwater Modeling, streams have not been able to form in the Study Area and storm drainage infiltrates directly into ground due to the high infiltration rates of the topsoil and through the sinkholes. Typically, (i.e., during frequent and less intense storms) no runoff occurs from the Study Area. Runoff only occurs during infrequent, larger storms when evapotranspiration and infiltration are not sufficient to prevent runoff. Therefore, for the purpose of the non-point source loading exercise, it was assumed there is no runoff up to the 95% storm (2.2 inches) for existing conditions, and a value of 0.05 was used for the fraction of rainfall events that produce runoff. For future conditions, accounting for proposed development, it was assumed there is no runoff up to the 80% storm (0.8 inches), and a value of 0.2 was used for the fraction of rainfall events that produce runoff.

In the Simple Method, the runoff coefficient (Rv) is calculated based on impervious cover in the subbasin as:

$$Rv = 0.05 + 0.9Ia$$

Where:

Ia = Impervious fraction

Due to the limited data available for existing land use regarding the extent of impervious cover (i.e. lack of building footprints, etc. for the entire Study Area), default impervious cover / land use relationships developed by the Center for Watershed Protection were used for existing conditions (see Table 10-3).

Table 10-3: Impervious Cover for Existing Land Uses

Land Use Category	Mean Impervious Cover (%)
Residential (Multifamily)	44
Commercial / Operations	72
Roadway	80
Industrial	53
Urban Open	9
Forest	N/A*

Source: Caraco 2002
*Loads from non-urban land are estimated as a product of area and a loading rate; thus, no impervious percent is used.

To arrive at estimated impervious cover for future land use, land use categories (with the exception of forest areas) were further divided and defined as 100 % impervious (for example, paved areas or buildings) or 100% pervious (for example, landscaped areas) using available detailed GIS data. Table 10-4 presents the mean impervious cover by land use category for the entire Study Area. Impervious cover was also developed at the subbasin level (see Appendix C).

Table 10-4: Impervious Cover for Future Land Uses

Land Use Category	Mean Impervious Cover (%)
Residential (Multifamily)	27
Commercial / Operations	65
Roadway	73
Industrial	87
Urban Open	4
Forest	N/A*

N/A not applicable
* Loads from non-urban land are estimated as a product of area and a loading rate; thus, no impervious percent is used.

10.1.1.4 EVENT MEAN CONCENTRATIONS

In order to determine pollutant concentrations (C) for use in the Simple Method equation, a literature review was conducted to identify EMC values to use for land use categories within the project site. An EMC is the expected mean concentration of a chemical parameter expected in the stormwater runoff discharged from a particular land use category during an average storm event. No EMC values specific to the project site or Guam in general were identified, so EMC values estimated from available nationwide (mainland U.S.) data were utilized. While there are numerous pollutants that can be transported by stormwater runoff, consistent representative data were only identified and used for the following parameters: TSS, total phosphorus (TP), and total nitrogen (TN). These are among the most common pollutants for which export coefficients are generated. Table 10-5 identifies the EMC values (and their sources) for these parameters that were used for the six general land use categories in the project site.

Table 10-5: Event Mean Concentrations by Land Use Category

Land Use Category	Pollutant		
	TSS	**TP**	**TN**
Residential[a]	100.0	0.4	2.2
Commercial / Operations[a]	75.0	0.2	2.0
Roadway[a]	150.0	0.5	3.0
Industrial[a]	120.0	0.4	2.5
Urban Open[b]	70.0	0.1	1.0
Forest *(lbs/acre/year)*[a]	90.0	0.1	1.0

Note: Amounts in mg/L unless otherwise noted.
Sources:
[a] Caraco 2002
[b] EPA 1983

10.1.2 Pollutant Loading Estimates

The results of the non-point source pollutant loading model for existing and future conditions for the Study Area are summarized in Table 10-6. Pollutant loads were also modeled at the subbasin level (see Appendix C). These results indicate that modeled non-point source loads increase from the existing to the future land use condition for all three parameters as a result of the proposed development, with TP and TN loads more than doubling.

Table 10-6: Results of the Non-Point Source Pollutant Loading Model Comparing Existing and Future Land Use Conditions

Pollutant	Load (pounds/year)		Percent Change
	Existing Conditions	**Future Conditions**	
TSS	355,694	545,443	53.3
TP	777	1,667	114.5
TN	5,258	10,836	106.1

It is important to note that these results are based on the assumption that no stormwater management practices (i.e. BMPs or IMPs) are in place for both existing and future conditions. An assessment of pollutant load reductions to the future conditions due to application of recommended BMPs and IMPs is included in Section 12 for five representative subbasins.

10.2 POTENTIAL SOURCES OF GROUNDWATER CONTAMINATION

Compared to other parts of Guam, NCTS Finegayan and areas in the Finegayan Sub-basin upgradient of NCTS Finegayan are relatively free of potential sources of contamination (see Figure 10-3). For the purposes of this report, the term "potential sources of contamination" refers to any site where human activities have resulted or could have resulted in releases of wastes, including hazardous wastes, and solid wastes. “Potential sources of contamination” also refers to on-going activities, such as underground fuel storage tanks that threaten groundwater.

AECOM reviewed several published sources to evaluate potential sources of contamination at NCTS Finegayan. Data sources included the Site Characterization Study (ESI 2008), the Draft Environmental Impact Statement (DON 2009a) and records internal to AECOM. Potential contaminant sources (PCS’s) are summarized in Table 10-7. Note that the descriptions in Table 10-7 are taken almost verbatim from the source referenced in the table. In several cases, data was unavailable for particular Areas of Concern (AOCs), and we signify this in Table 10-7 with a “DU” notation. In some cases, the data are incomplete so it is not clear that the AOC exists. However, because AECOM could not independently verify that a particular area is not an AOC, the decision was made to leave it in Table 10-7.

Masa Fujioka & Associates (MFA) (MFA’s report is appended to ESI 2008) identified 12 potential contamination sources at NCTS Finegayan, including three former landfill/dump sites, three former septic system/leach field sites, one former underground storage tank, one former firing range and four miscellaneous/abandoned sites. MFA “found no records or indications of releases of hazardous substances” at these sites. MFA reports that one of the landfills may have been used to dispose of waste oils, cleaning solvents, and polychlorinated biphenyl oils, but this is unconfirmed. Finally, MFA pointed out the possible presence of unexploded ordnance.

Three PCS’s have been identified directly upgradient of NCTS Finegayan, including “Landfill 9”, “Potts Junction Tank Farm”, and “Chemical Disposal Site Number (No.) 4”. According to the Draft Environmental Impact Study (DEIS), Landfill 9 reportedly operated from 1949 to 1955 and received a variety of solid waste, though it is uncertain whether there were any releases of contaminants. Potts Tank Farm is identified in the DEIS as an IR Program Site, but the DEIS does not indicate whether a release has occurred here, nor the nature of the release(s). Data on Disposal Site No. 4 was not available.

Stormwater disposal wells are widespread in Guam as they are capable of quickly disposing of stormwater in the karstic limestone. Sadly, they can also inject contaminants directly into the aquifer. According to Taborosi (2006), there are 171 permitted stormwater disposal wells on Guam. Fortunately, however, none of these are at or near NCTS Finegayan.

Though large areas of the Finegayan subbasin are sewered, hundreds of septic systems remain. Septic systems, which dispose of human wastewater directly to the ground, undoubtedly contribute nitrate and bacterial contamination to the groundwater system, especially considering the karst nature of the limestone bedrock. Both Coliform bacteria and nitrate are reported in public water supply wells of the NGLA. Data on nitrate and bacteria levels in NCTS and GWA wells in the Finegayan sub-basin are summarized below in Section 10.3 Animal feedlots and fertilizer applications may also contribute to nitrate and bacteria.

Article 7112 of the Guam Environmental Protection Agency’s Water Resource Development & Operating Regulations establishes a minimum 1000-foot distance between public water supply wells and sources of bacterial contamination. This 1,000-ft setback is known as the “Wellhead Protection Area” (WHPA). The WHPA is only partially effective because, as stated elsewhere, it is common for bacteria to be present in public water-supply wells. Furthermore, the WHPA does not account for contributory areas upgradient of the wells, which may extend a distance of up to two miles. The karstic nature of the limestone aquifer along with periodic, heavy rainfall makes the NCTS wells especially vulnerable to contamination from human activities upgradient.

Table 10-7: Summary of Potential Contamination Sources NCTS – Finegayan

Site Number	Identification	Name/Description	Contaminant	Program or Site Status	Data Source
AOCs within Finegayan Sub-basin Study Area					
AOC – 11	N/A	N/A	DU	N/A	AECOM
AOC – 15	Harmon Village	N/A	DU	N/A	AECOM
AOCs 27-35	N/A	N/A	DU	N/A	AECOM
AOC – 36	Andy Radio Beacon Annex	N/A	DU	N/A	AECOM
AOC 70, 71, 73, 74	Potts Junction Tank Farm	This site is included in the IR Program Sites - Andersen AFB Main Base plans provided by the DoD; however, the associated information regarding this site is not included in the reports reviewed for1 this project. According to the DoD IR Program Sites - Andersen AFB Main Base plans, this site is included in the IR Program. A review of aerial photography shows heavy vegetation cover and possible remnants of concrete pads. During a site visit in March 2009, this site was inaccessible and could not be seen from the roadway. It is unknown if there are incidents of contamination associated with this site; however, no groundwater monitoring wells were found on- or off-site.		N/A	DEIS
AOC – 79	Abandoned Aviation Gasoline Pipeline	Identified as an AOC due to the potential release of fuel-related constituents from an abandoned aviation gas pipeline. No contaminants of concern detected above PRGs	N/A	No Further Action Recommended	DEIS
AOC – 80	Clearing West of Housing	Identified as an AOC due to the presence of surface waste debris such as grease cans, metal debris, and glass bottles near a cleared area. Heavy metals found above PRGs, thus soil remedial or removal action is required	heavy metals	Soil Remedial or Removal Action is recommended	DEIS
AOC – 81	Air-to-Ground Gunnery Range	Identified as an AOC due to the presence of surface waste debris and glass bottles at the former air-to-ground gunnery range with trenches, mounds, and depression. Heavy metals found above PRGs thus soil remedial or removal action is required.	Heavy metals	Soil Remedial or Removal Action is recommended	DEIS
AOC – 82	Sanitary and Burnable Dump	Identified as an AOC due to the presence of surface waste debris such as metal debris and cylinders at a former dump site with glass and metal debris.	Dichlorodiphenyltrichloroethane, copper, and lead above residential PRGs were detected.	No Further Action is recommended based upon health risk assessment	DEIS
PESA 01	N/A	Approximate location of abandoned HVAC equipment	N/A	N/A	PESA
PESA 02	N/A	Former antenna field; two small buildings and pads present; dead vegetation around buildings	N/A	N/A	PESA
PESA 03	N/A	Approximate location of former leaching bed. Heavy metals and other contaminants from the building's wastewater may have contaminated the soil around the leach fields. If these areas are developed, environmental investigations of the former leach fields should be conducted.		N/A	PESA
PESA 04	N/A	Approximate location of two former septic tanks		N/A	PESA
PESA 05	N/A	Possible location of incinerator and ash pad used for burning documents located adjacent to Building 200. Historical drawings show an "ash pad," indicating ash may have been buried at the site. If this area is developed, the area around the incinerator should be investigated for ash and potential hazardous constituents such as heavy metals, dioxins, and PCBs.		N/A	PESA

Site Number	Identification	Name/Description	Contaminant	Program or Site Status	Data Source
PESA 06	N/A	Deteriorated paint on towers may contain lead. A thorough survey should be conducted prior to demolitions, and design documents should be prepared to guide the demolition contractor in proper abatement and disposal procedure.		N/A	PESA
PESA 07	N/A	Approximated location of oil underground storage tank (UST) at Building 200. No records of tank removal or closure found. It is possible this tank remains in the ground. Demolition of this facility should include an investigation and proper closure of UST, according to applicable UST regulations.		N/A	PESA
PESA 08	N/A	Possible dump site area	DU	N/A	PESA
PESA 09	N/A	Approximate location of former leach field and septic tank. Heavy metals and other contaminants from the building's wastewater may have contaminated the soil around the leach fields. If these areas will be developed, environmental investigations of the former leach fields should be conducted.		N/A	PESA
PESA 10	N/A	Former landfill reportedly received municipal and demolition waste. Small quantities of waste oils, cleaning solvents, insulation materials, and oils containing PCBs were reportedly disposed of in the landfill. Although groundwater samples obtained from a down gradient well in 1988 indicated no contamination of groundwater from the landfill, if this area is part of future development plans, the former landfill site should be investigated with respect to potential contaminants and geotechnical (fill compaction) issues.		N/A	PESA
PESA 11	N/A	Former landfill	DU	N/A	PESA
NEX Station	N/A	A hydraulic lift in an unlined pit was located at the former hobby shop near the site of the current NEX station. We found no records of the removal or closure of the hydraulic lift. If this area is developed, the location of the former hydraulic lift should be investigated.		N/A	PESA
Arms Firing Range	N/A	A small arms firing range and a closed skeet and trap range are located within subject property. No record of investigation for the small arms firing range found. The skeet and trap range is programmed for investigation under the Military Munitions Response Program (MMRP). Presumably, if the small arms firing range is closed, it would also be investigated under the MMRP.		N/A	PESA
South Finegayan Construction Battalion Landfill	N/A	Contained PCB release; extent of contamination unknown		N/A	AECOM
Chemical Disposal Site No 4	N/A	Former Puag production well, HGC-2, and abandoned Air Force supply well located on chemical disposal site; Hatsuho Golf Course formerly located on site; Unknown contamination		N/A	AECOM
Active Environmental Restoration Sites					
Site 7	Landfill 9	This site, located in the Northwest Field of Andersen AFB encompasses approximately 8 ac. This landfill operated from 1949 to 1955.	Sanitary trash, construction debris, and concrete	A ROD was issued in 2008 recommending no further action.	DEIS
Site 18	Landfill 23	This site is located in Harmon Annex and is approximately 1 ac. The site operated in the late 1950s.	Sanitary trash, construction debris, and concrete	A ROD was issued in 2008 recommending no further action.	DEIS
Site 19	Landfill 24	This site is located in Harmon Annex and consists of 26 ac. The site operated in the 1950s.	Sanitary trash.	A ROD was issued in 2008 recommending no further action.	DEIS
Site 31	Chemical Storage Area 4	This site consists of about 12 ac and is located in the Northwest Field. The site operated from 1952 to 1956.	Solvents, waste oils, and heavy metals. An interim soil remedial action was performed	A ROD was issued in 2008 recommending no further action.	DEIS

Site Number	Identification	Name/Description	Contaminant	Program or Site Status	Data Source
Site 37	War Dog Borrow Pit	This site is located in Andersen South and is approximately 2 ac.	Various wastes	A ROD was issued in 1998 recommending no further action.	DEIS
Site 47	Former AOC 80	This 1.4 ac site was the subject of concern due to the presence of surface waste debris that has subsequently been removed	Heavy metals, grease cans, metal debris and glass bottles.	A ROD was issued in 2007 recommending soil removal planned for 2010	DEIS

AECOM	geospatial data gathered by AECOM	DU	data unavailable
AFB	air force base	IR	installation restoration6551
AOC	area of concern	N/A	not applicable
DEIS	Draft EIS/OEIS (2009)	PESA	Preliminary Environmental Site Assessment, NCTS Finegayan, Guam (MFA, 2009)
DoD	United States Department of Defense	PRG	preliminary remediation goal

Notes on Site Wide PCS's Listed in Preliminary Environmental Site Assessment (MFA, 2009):

1. Asbestos-containing materials and lead-based paint may be present in existing structures. A thorough survey should be conducted prior to demolition, and design documents should be prepared to guide the demolition contractor in proper abatement and disposal procedures.
2. Unexploded ordnance is an issue throughout Guam and may be encountered during excavation at the subject property. Contractors involved in the development of the property must be made aware of the risks of encountering unexploded ordnance.
3. Several transformers are located at the subject property. Although they currently contain no PCBs, many of them are older and no investigations have been conducted regarding releases or spills of PCB-containing dielectric fluid on the ground around the transformers. If the transformers are removed, the soil around them should be evaluated for PCBs.
4. Herbicides have been used at the subject property to control weeds around structures. Herbicides may be present in soil in these areas.
5. The Finegayan area is reported to have high radon concentrations, and radon mitigation measures will likely be required in occupied structures.

10.3 EXISTING GROUNDWATER CONDITIONS

Section 3 describes the hydrogeology of NCTS Finegayan in some detail. The following is a summary of the main features of the groundwater system. The land surface at NCTS Finegayan ranges from about 350 to 500 ft above msl. Groundwater, which resides in a karst limestone aquifer, is present at an elevation of about 5 ft msl. Therefore, rainwater must percolate vertically through several hundred feet of unsaturated Mariana and Barrigada Limestone before recharging the NGLA. Recharge works its way downward through the limestone's primary porosity slowly, but more rapidly along secondary porosity features, such as fracture zones, faults, sinkholes, conduits and caverns, before reaching the water table. The groundwater at NCTS Finegayan is part of the "basal zone" of groundwater, because it flows through the basal lens of freshwater floating on underlying saltwater. Upgradient of NCTS Finegayan (i.e., to the east), the freshwater lens in the limestone is underlain directly by impermeable volcanic basement rocks, not by saltwater. This zone is termed the "para-basal zone." The allowable pumping rates for water supply wells placed in the "para-basal zone" are up to 750 gpm because there is relatively little concern about saltwater upconing. In contrast, the allowable rates for wells placed in the "basal zone" range from 100 to 350 gpm due to the potential for saltwater upcoming. On a regional basis, groundwater at NCTS Finegayan flows west-northwest directly toward the Philippine Sea. Locally, groundwater flow may be oblique to the coast, along secondary porosity features, such as caverns, conduits, faults, and fractures. Haputo Bay may be an outlet for concentrated local, groundwater flow originating from these secondary porosity features (Jenson, personal communication).

AECOM has identified 18 active, public water-supply wells on or adjacent to NCTS Finegayan. Eight of these are operated by the Navy, and the remaining 10 are operated by the GWA. Well yields are tabulated in Table 10-8. Well locations are shown on Figure 10-3 along with the WHPAs.

Table 10-8: Well Yields (gallons per minute), NCTS Wells and nearby GWA Wells

Well Locations	GPM
NCTS Wells	
NCTS A	180
NCTS #5	100
NCTS #6	125
NCTS #7	235
NCTS #9	200
NCTS #10	180
NCTS #11	180
NCTS #12	180
GWA Wells	
F-01	144
F-01	144
F-02	154
F-03	157
F-04	142
F-06	220
F-07	0
F-10	204
F-11	189
F-19	219
F-20	254

Pumping rates obtained from *Guam Water Utility Study Report for Proposed USMC Relocation*, July 2008

Based on the limited data available to AECOM, the water quality in public water-supply wells in the NGLA can be summarized as follows:

- The groundwater is typically hard, containing calcium and magnesium carbonate. These constituents undoubtedly result primarily from the natural dissolution of the limestone bedrock.
- Chloride levels can rise to unacceptable levels (i.e., greater than 250 milligrams per liter [mg/L]). The most recent testing of NCTS Finegayan wells (NCTS-6, -7, -9A, 10, -11, and -12) in July 2009 indicate chloride concentrations in the range of 43–186 mg/L. Chloride concentrations would be expected to fluctuate due to variations in recharge and pumping rates. Since all of these wells are in the "basal zone" of the NGLA, the chloride is believed to originate largely from the partial upconing of saltwater beneath the "basal zone."
- Total coliform and E. coli are fairly common. According to the 2006 Water Resources Master Plan, Wastewater (GWA 2006) large areas upgradient of NCTS Finegayan are sewered. However, hundreds of homes in the watershed of NCTS Finegayan continue to rely on individual wastewater disposal systems (i.e., septic systems). Discharges from septic systems are undoubtedly responsible for coliform, at least in part. Coliform bacteria can reach the water table by percolation from the ground surface. The limestone would be expected to act as a poor filter for bacteria, especially where karst features are present and especially after heavy rainfall events. Jenson (personal communication 2010) suggests that coliform contamination of wells occurs exclusively after heavy rainfall, which surcharges the sewer systems causing contaminated water to flood the ground surface and penetrate the aquifer along large openings in the karst limestone. The GWA's October 2006 Water Resources Master Plan, Water indicates that both total and fecal coliform were found in GWA's wells F-02 and F-10 on at least one occasion between 1998 and 2002, though these were not detected between 2003 and 2005. Bacteria data recently provided by the Navy for selected NCTS Finegayan wells indicate that coliform bacteria were common in the early to mid 2000's, but absent since late 2008. This same data shows that "background bacteria" – measured as the heterotrophic plate count – has normally been present over the last decade.
- Nitrate levels can also be high in public water supply wells in the NGLA. Here again, discharges from septic systems are undoubtedly responsible, at least in part, for high levels of nitrate. Fertilizer applications and animal feedlots may also contribute nitrate to the groundwater system. The GWA's October 2006 Water Resources Master Plan, Water reports that nitrate levels increased at GWA wells F-02, F-03, F-06, F-07, F-10, and F-11 between 1978 and 2000, and decreased only at F-04 during that same time period. Nitrate data recently provided by the Navy for selected NCTS Finegayan wells indicate that nitrate typically ranged from about 0.7 to 3.1 mg/L between 2005 and 2008. The maximum contaminant level for nitrate is 10 mg/L.

10.4 PREFERENTIAL PATHWAYS FOR PERCOLATION TO GROUNDWATER

AECOM reviewed several published sources to evaluate features that might represent preferential pathways for percolation of water – and possibly dissolved/suspended contaminants – to the water table at NCTS Finegayan. Much of the data on these features originated from the Site Characterization Study (ESI 2008), supplemented by USGS mapping and AECOM interpretation of topographic maps.

As discussed in other sections of this report, NCTS Finegayan rests on a karst limestone aquifer. The term "karst" refers to carbonate bedrock that has been dissolved by percolating rainwater and flowing groundwater. Dissolution can result in the formation of rubble zones directly beneath the soil layers. In the subsurface, dissolution can enlarge joints, faults and fractures, and form caves, sinkholes, vertical conduits and other solution features. All of these features represent preferential pathways for the movement of water; most, if not all of these features are represented at NCTS Finegayan.

Figure 10-3 depicts the known or potential karst features that could be preferential pathways at or near the ground surface. Figure 10-3 shows sinkholes, closed depressions, faults and possible underground karst features identified by ESI (2008), faults and fractures identified by Siegrist et al. (2007), and depressions and possible sinkholes identified by AECOM through interpretation of half-meter topographic contour maps. Figure 10-3, however, undoubtedly does not represent all the karst features in the Study Area. According to Taborosi's Karst Inventory of Guam (2006), the Water and Environmental Research Institute of the Western Pacific, University of Guam (WERI) has been compiling a GIS database of sinkholes and fractures in northern Guam since 1994. Despite attempts, AECOM was not able to obtain this database. This may be the most complete inventory of near-surface karst features at NCTS Finegayan.

To fully protect groundwater, it may not be sufficient to simply map the near-surface karst features (e.g., sinkholes and the like). The karst geology on Guam is extremely complex and unpredictable. Karst features visible at the ground surface may or may not extend deep into the limestone. Caves and conduits present deep in the subsurface may or may not connect with the ground surface. To avoid intercepting a preferential pathway, it is recommended that NAVFAC do two things before final decisions are made on the placement and design of stormwater structures:

- Examine WERI's GIS database of karst features for NCTS Finegayan;
- Complete additional borings at proposed stormwater structures.

NAVFAC should avoid building stormwater structures in any of the karst features identified on Figure 10-3. NAVFAC should also avoid installing stormwater structures in or near closed depressions. Taborosi (2006) states that he has interpreted about 35% of the depressions in northern Guam to be related to dissolution, collapse, faults, and brecciated zones. All of these are preferential pathways for percolation. Taborosi goes on to state that the remaining 65% of closed depressions mapped are of unknown origin. Therefore, the remainder may or may not be preferential pathways. NAVFAC should avoid building stormwater structures near any identified PCSs, unless field investigation reveals that actual contamination is not present. Finally, to protect existing water-supply wells, NAVFAC should avoid building stormwater structures and wastewater lift stations in WHPAs, and upgradient of public water supply wells.

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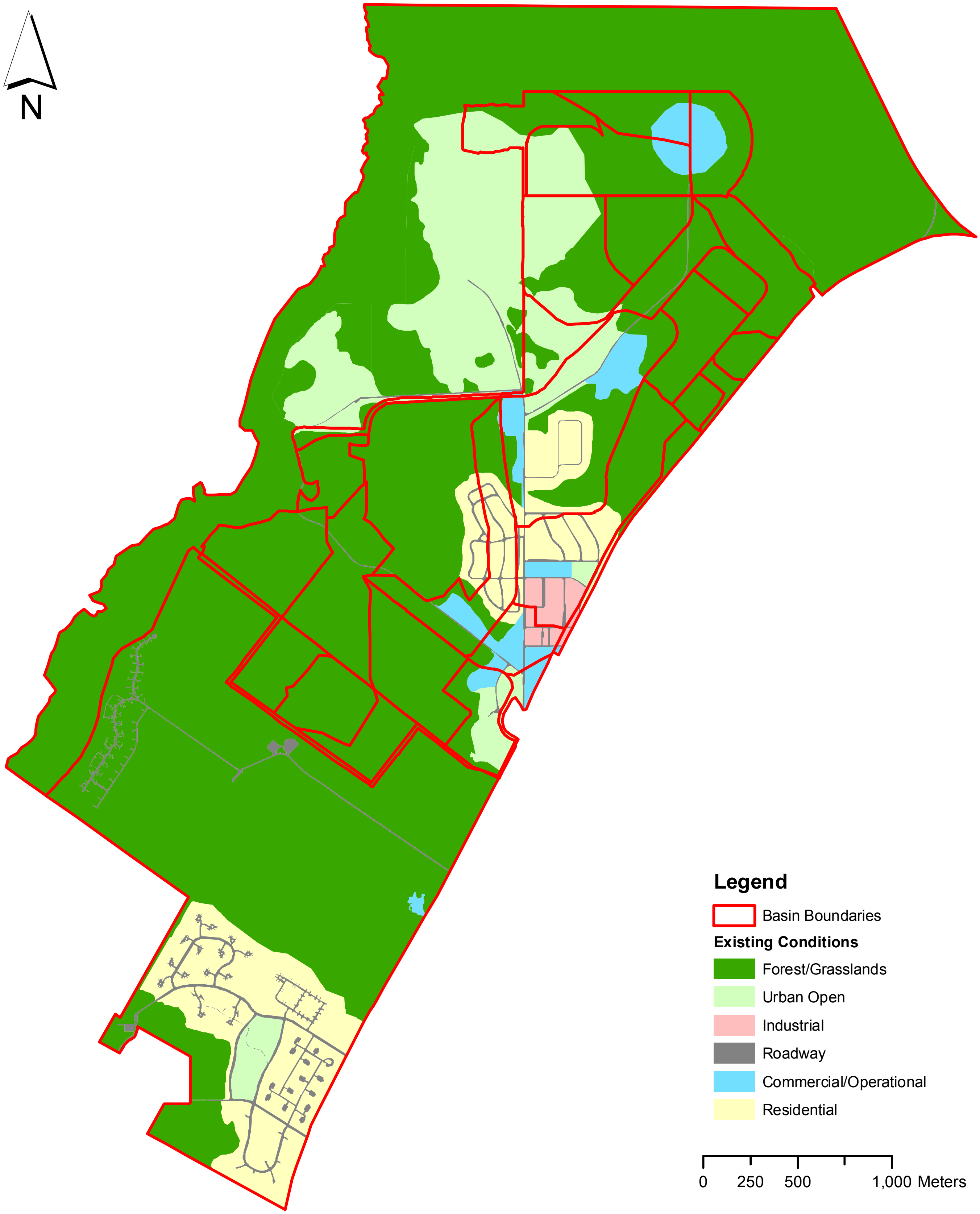
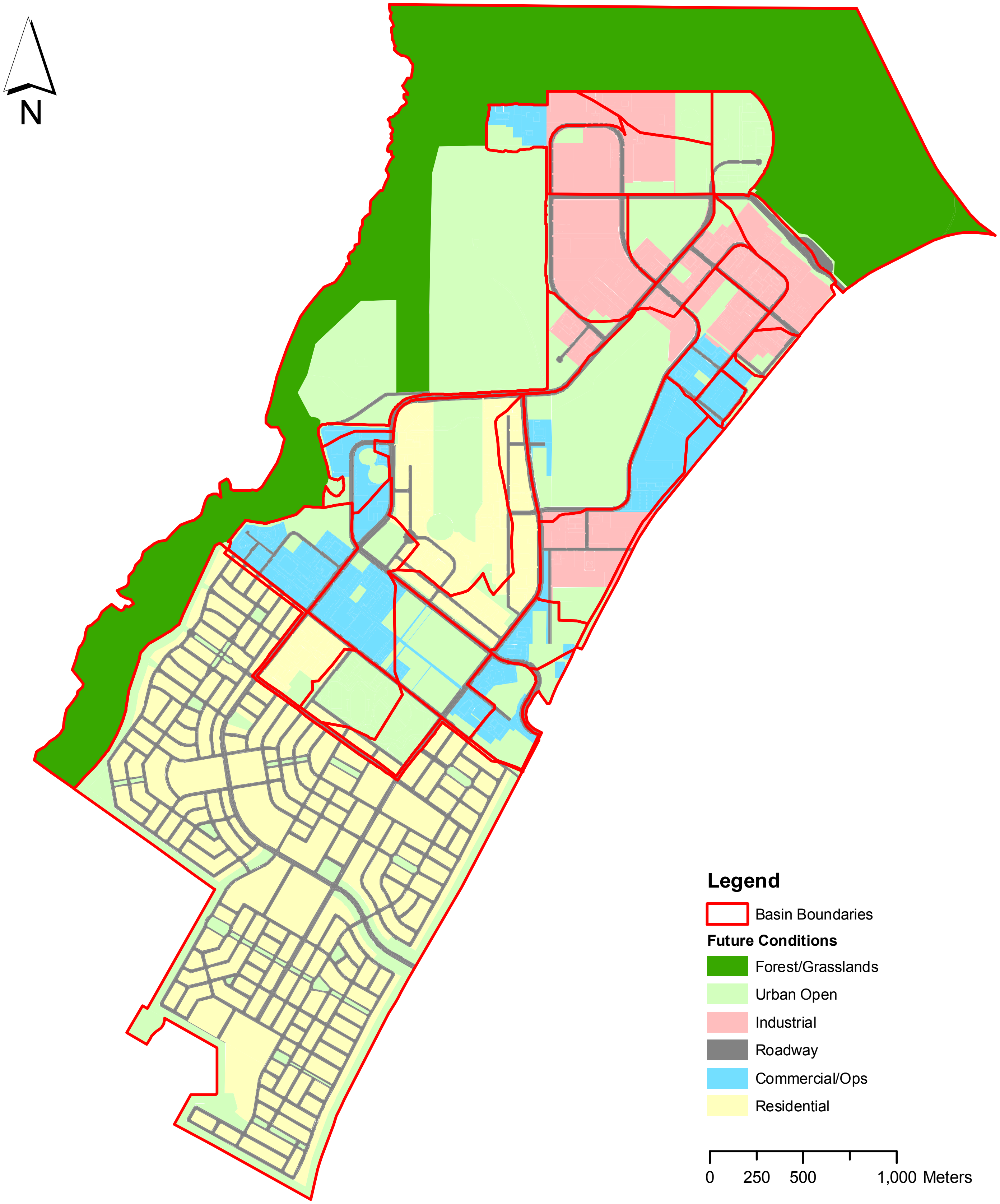


AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Existing Land Use

GIS FILE: Fig10-1_ExistingLandUse.mxd	SCALE: AS NOTED	DATE: 1/4/2010	Figure 10-1



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Future Land Use

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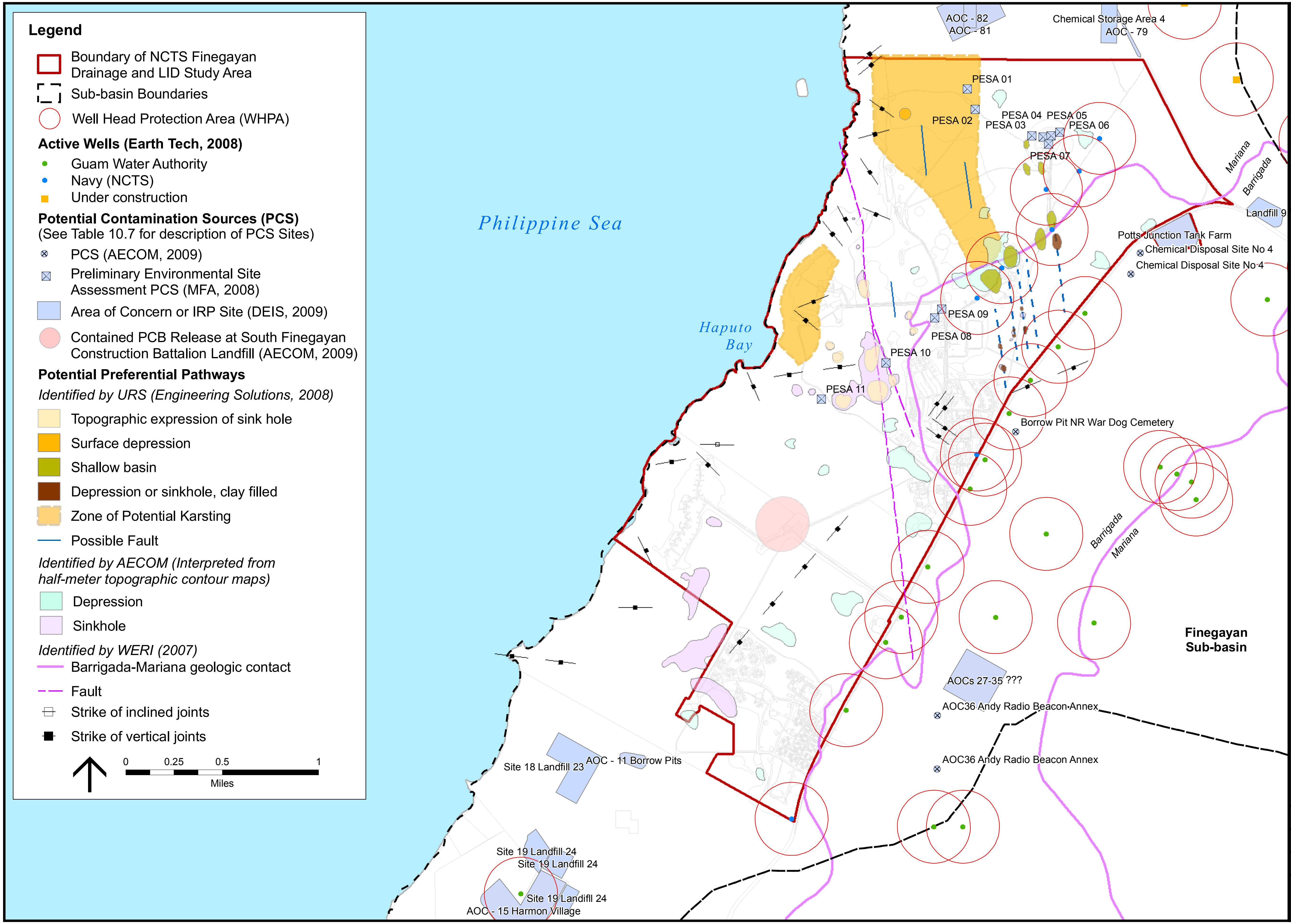
DATE: 1/4/2010

Figure 10-2



AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study

Figure 10.3
Potential Sources of Groundwater Contamination

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ANSI B - 23-APR-10

11. Water Quality Protection Strategies

Proposed water quality protection strategies for the Finegayan Main Cantonment Area consist of employing LID stormwater management principles and IMP designs to the maximum extent practicable within each of the subwatershed basins located within the study area. A general overview of the major components of LID stormwater management is provided in Section 11.1. Many of these components form the basis of the proposed water quality protection strategy for the Finegayan Main Cantonment Area. Section 11.2 addresses the opportunity for water harvesting and rainwater reuse. This opportunity is primarily considered a strategy for domestic water reduction rather than stormwater management, though there is some level of peak flow attenuation, depending on the storm level and the fill level in the water harvesting cistern. Section 11.3 provides examples of how stormwater management design can be integrated into architectural and landscape elements. Section 11.4 discusses the main stormwater pollutants of concern, the general pollutant removal strategy, and the palette of available IMP options considered as part of this implementation study. Pollutant removal efficiencies for the individual IMP options are discussed in Section 11.5 and in Table 11-3 for the pollutants of concern.

11.1 LOW IMPACT DEVELOPMENT

Low impact development seeks to provide flood control, recharge the groundwater, treat pollutants, while preventing destructive effects downstream. Implementation of these goals will be achieved by:

- maintaining, to the maximum extent technically feasible, the predevelopment hydrology regarding the temperature, rate, volume, and duration of flow;
- integrating water management measures into the development form and landscape to ensure efficient use of landscape spaces and maximize the visual amenity;
- protecting groundwater quality by pre-treating stormwater flows, as appropriate;
- utilizing vegetation for water quality enhancement; and
- maximizing water harvesting for non-potable uses.

11.1.1 Current Practices

Stormwater management in Guam has historically been viewed strictly from a flood control perspective. This has resulted in flood flows being routed to the nearest discharge or overflow location with little or no treatment. Numerous sinkholes located on highly permeable limestone formations within the Finegayan site allow for high rates of infiltration while offering little protection to groundwater quality (Horsley Witten Group 2006).

11.1.2 Nonstructural Approaches

The most effective approach to reducing stormwater infrastructure and maintenance costs is to employ upfront and nonstructural conservation and planning measures. With the goal of preserving the landscape's natural ability to absorb water, design development and stormwater management should go hand in hand. Building location and road alignments should be integrated with the design of the overall stormwater management system. Nonstructural LID techniques are outlined below:

11.1.2.1 CONSERVATION MEASURES

- Preserve native forest cover and natural drainage patterns.
- Identify sinkholes or other areas of high infiltration capacity or those areas with the highest quality ecological functions and cordon or limit disturbance in these areas.

11.1.2.2 DESIGN AND PLANNING

- Treat stormwater as close to its origin as possible by distributing small-scale IMPs throughout the site.
- Cluster development to reduce impervious surface and site compaction.
- Grade to encourage sheet flow and increases the amount of time stormwater flows over the site.
- Minimize curb and gutter infrastructure.
- Integrate stormwater controls into the design as both flood control and site amenities.
- Reduce the reliance on traditional collection and conveyance stormwater practices.
- Minimize impervious surfaces by reducing roadway width and length and parking areas.
- Consolidate activities such as staging and parking in already-disturbed areas that have low functional potential.
- Designate a single access route into impacted areas. Prior to start of construction, fence off protected areas and sign each area clearly. If saving individual trees, protect the root system from compaction.
- Disconnect impervious surfaces by directing runoff into or across vegetated areas to help filter runoff and encourage recharge, or leaving a 2- or 3-foot-wide pervious strip between the edge of a street and the beginning of a driveway or sidewalk to allow infiltration.

11.1.2.3 MAINTENANCE AND EDUCATION

- Develop reliable, long-term maintenance programs with clear and enforceable guidelines.
- Educate building owner/operators, local staff, and others as needed on proper operation and maintenance of practices, and protection of all surface waters.

11.1.3 Structural Approaches

Due to the local climate and level of development, structural measures will be required to meet both flood control and water quality parameters. A stormwater management toolkit has been developed to specifically respond to the site characteristics in Guam. This toolkit builds upon the July 2009 Low Impact Development Manual. The following structural tools are applicable for the Finegayan Main Cantonment:

- Detention Basin
- Subsurface infiltration systems
- Bioretention Basin
- Dry Swale
- Filter Strip
- Stormwater Oil/Sediment Separator
- Green Roofs
- Dry Well
- Porous Paving
- Downspout Disconnection

- Inlet Protector

Below are details on each of the components included in the IMP toolkit.

11.1.3.1 DETENTION BASIN

Description

Detention basins act as temporary storage of stormwater runoff to prevent downstream flooding with the primary purpose of attenuating peak flows. Detention basins collect stormwater runoff and allow it to either be slowly infiltrated into the native soil or to be released through a controlled outlet point. Detention basins are designed to drain within a short period of time (6–48 hours). They can therefore double as a secondary use, such as parks, athletic fields, or parking lots.

Benefits

- A cost-efficient tool for managing larger storm-events
- Can be a multipurpose space
- Longer detention times improve downstream water quality by settling out sediments

Limitations

- Special access or protection measures for basins located near residential areas are needed
- Limited at water quality improvements: ineffective at removing soluble pollutants
- Sediment requires removal after storm event in multipurpose areas
- Volume can be limited by slope, depth to bedrock or groundwater, or available footprint
- If in an infiltration area, must be sited and designed to minimize risks to foundations, groundwater, utilities, or slopes

Water Quality Treatment Capacity

- Moderate water quality treatment capacity

Siting

- Avoiding Wellhead Protection Areas
- Locations should be far enough down in watershed to most effectively reduce peak flow and capture sediment from development
- Consider multipurpose basins

Design, Sizing and Flow Considerations

- Sized to treat 95% of the annual volume for purposes of meeting water quality requirements.
- Length to width ratio of at least 1.5:1, where feasible.
- Basin depths optimally range from 3 to 6 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- Use a draw down time of 48 hours. Drawdown times in excess of 48 hours may result in vector breeding.

Maintenance

- Maintenance levels required depends on requirements of any secondary use—generally removal of any trash or debris or accumulated settled sediments

11.1.3.2 SUBSURFACE INFILTRATION SYSTEMS

Description

Subsurface infiltration systems a typically used where limited open area is available for stormwater infiltration or the use of open detention ponds is not appropriate (Figure 11-1). The use of infiltration systems is expensive and subject to permitting. Infiltration systems will be minimized and primarily used when other BMPs cannot be implemented, primarily due to space requirements. Subsurface infiltration systems may require an Underground Injection Control (UIC) Permit from the Guam Environmental Protection Agency. The systems are constructed under paved areas and active open areas where standing water is not desired, yet infiltration into the groundwater is the desired result for stormwater management. Stormwater is pretreated to reduce sediment loading using structural BMPs to reduce long-term maintenance.

Benefits

- A cost-efficient tool for managing larger storm-events
- Can install under parking, a multipurpose space, or in roadway medians
- Increases infiltration in areas where large open space is lacking

Limitations

- Stormwater must be pretreated to help minimize long term sediment removal maintenance
- Limited at water quality improvements: ineffective at removing soluble pollutants
- Volume can be limited by slope, depth to bedrock or groundwater, or available footprint
- If in an infiltration area, must be sited and designed to minimize risks to foundations, groundwater, utilities, or slopes
- More expensive to construct than open detention ponds

Water Quality Treatment Capacity

- Moderate water quality treatment capacity when combined with upstream sediment removal
- Low level of treatment for soluble pollutants

Siting

- Avoid Well Head Protection Areas
- Locations should be far enough down in watershed to most effectively collect peak flow and significant volume
- Sediment removal upstream of infiltration basin is required, and is usually a structural sediment removal system (Stormceptor®)

Design, Sizing and Flow Considerations

- Sized to treat 95% of the annual volume.

- Include sediment removal in the inlet design to reduce maintenance, primarily removal of accumulated sediment.

Maintenance

- Maintenance levels required depends on effectiveness of upstream sediment removal.

Figure 11-1: Subsurface Infiltration Systems

11.1.3.3 BIORETENTION BASINS

Description

Bioretention basins are shallow, planted stormwater facilities that rely on plants and soil to treat stormwater (Figure 11-2). They are often constructed using engineered soils, specifically designed to maximize water quality improvement, and minimize clogging. The plant species must be tolerant of periodic inundation, and some are better than others at removing pollutants. Bioretention facilities can either allow for infiltration into the native soils, or be designed with an underdrain system to pipe treated water to the stormwater drain system or a surface water body. Due to the high infiltration rates typically found in Guam's soils, it is not expected that these systems will require underdrain piping. An overflow system should be incorporated into the design in the event of storms greater than volume capacity. They can take many aesthetic forms or sizes, fitting in to any type of formal or informal landscape.

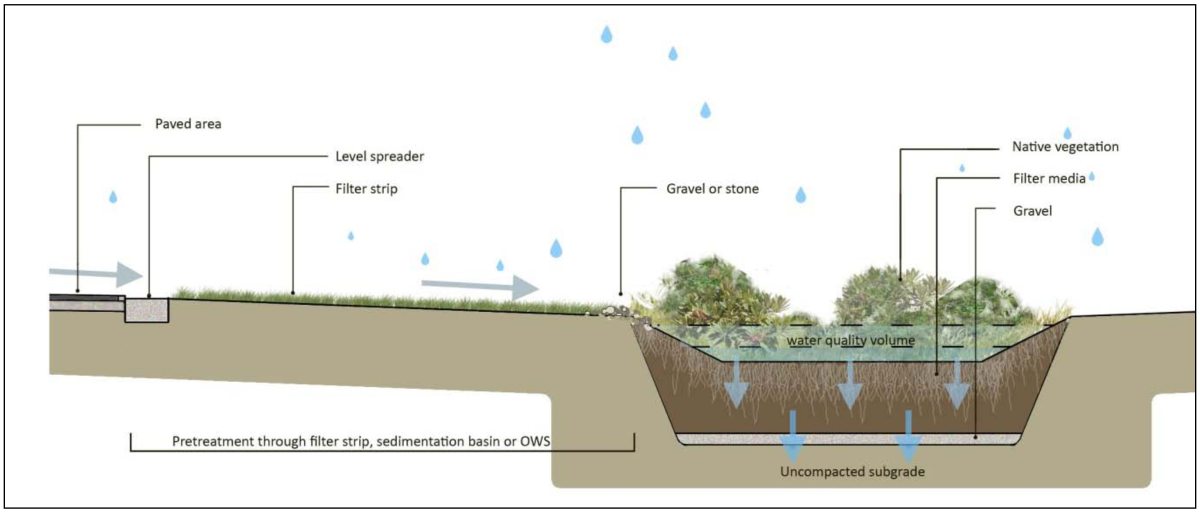


Figure 11-2: Bioretention Basin Cross Section with Filter Strip as Pretreatment Measure

Benefits

- Physically and biochemically removes pollutants
- Detains stormwater, reducing peak flow and volume
- Recharges groundwater
- Can be an aesthetic and habitat enhancing amenity
- Wide range of size and type of site suitability

Limitations

- Requires a relatively flat site
- Needs under-drainage system in noninfiltration areas
- Potential risk that trees may need to be removed if the soil filter media ever needs to be replaced

Water Quality Treatment Capacity

- High pollutant removal capacity

Siting

- Well suited to integrate into different environments

Design, Sizing and Flow Considerations

- Pretreatment required
- Sized to treat 95% of the annual volume
- Sizing factor of 0.04 of catchment suggested for planning purposes
- Suitable for small catchments
- Vegetation establishment on the basin floor may help reduce the clogging rate
- Use a draw down time of 48 hours

Maintenance

- Maintenance needs are primarily associated with the type of vegetation, and the site context—mostly weeding, clipping/mowing, and trash removal
- Monitoring required for clogging; cleanouts needed if using underdrains

11.1.3.4 DRY SWALES

Description

Dry swales are linear and planted open channels, usually designed for stormwater conveyance. However, they can be designed specifically for treatment as well (Figure 11-3). Dry treatment swales offer both conveyance capacity as well as water quality enhancement. Dry treatment swales commonly have a lower slope gradient (<1%) than conveyance systems with permeable soil or under-drain systems, or with larger vegetation or check dams to slow the flow of water. Dry swales can also provide conveyance and pretreatment by sediment removal while directing water to a storage, treatment, or infiltration facility. Check dams may be located within the swale to enhance storage capacity or reduce flow velocities on steep sites. Vegetation should be tolerant of periodic inundation and water velocity.

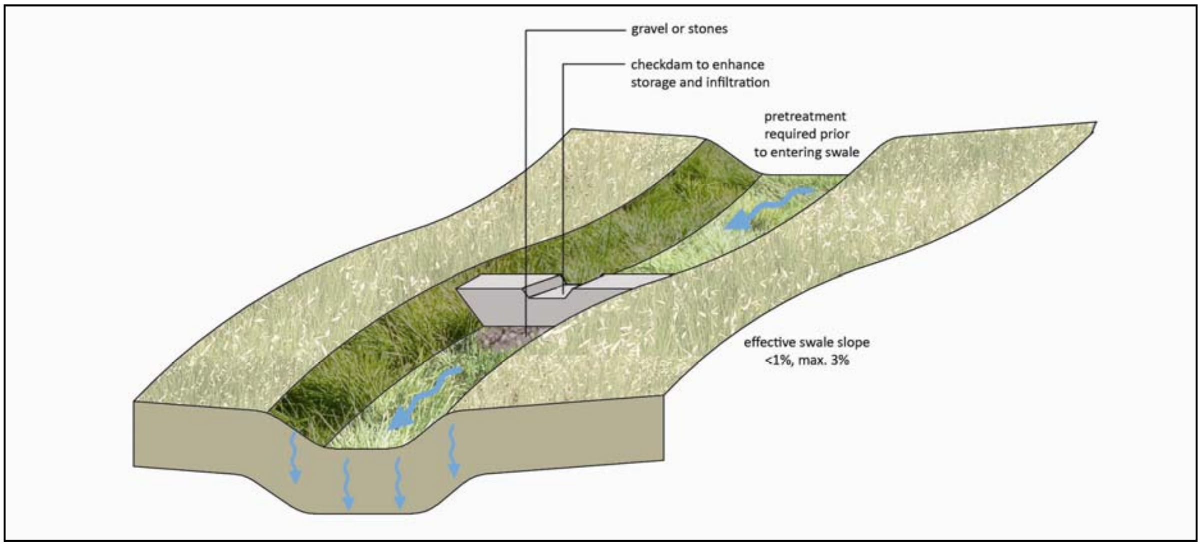


Figure 11-3: Dry Swale with Checkdam for Storage and Enhanced Infiltration

Benefits

- Transports stormwater aboveground, minimizing piping costs
- Can improve water quality
- Can be designed to detain or infiltrate runoff volume and reduce peak flow

Limitations

- Works best on a sloped site <4%
- Works best as part of treatment train of facilities

Water Quality Treatment Capacity

- Moderate treatment capacity depending on design

Siting

- Requires a certain range of slope—enough to keep water moving, but not so steep as to cause erosion
- Swales can be used on flatter sites also, however, additional grading and deeper swales will be required to achieve desired results

Design, Sizing and Flow Considerations

- If design for treatment, sized to treat 95% of the annual volume.
- If designed for pretreatment or conveyance, size to reduce scour within the channel.
- Velocity within swales should be less than 1 fps for a 1.5-inch rain event.
- Flood flow velocities should not exceed 6.5 fps (50 ARI storm) to reduce erosion and scour.
- Swale should be designed so that the water level does not exceed 2/3 the height of the vegetation at the design treatment rate.
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.

Maintenance

- Maintenance needs are primarily associated with the type of vegetation and the site context—mostly weeding, clipping/mowing, and trash removal

11.1.3.5 FILTER STRIPS

Description

Filter strips are vegetated areas (usually turf) with gentle slopes that take sheet flow from adjacent impervious areas (see Figure 11-4). They provide pretreatment of water moving to a secondary treatment facility, by removing sediment and some of other pollutants, and slowing run-off velocity. They should be used in conjunction with another treatment facility.

Benefits

- Transports stormwater aboveground, minimizing piping costs
- Improves water quality and slows peak flow

Limitations

- Works best on a sloped site, between 2–6%
- Need to be part of treatment train
- Sheet flow can be shortcut by concentrated flows, creating eroded runnels and eliminating effectiveness of filter strip
- Requires a relatively large footprint (between 15 ft and 60 ft long)

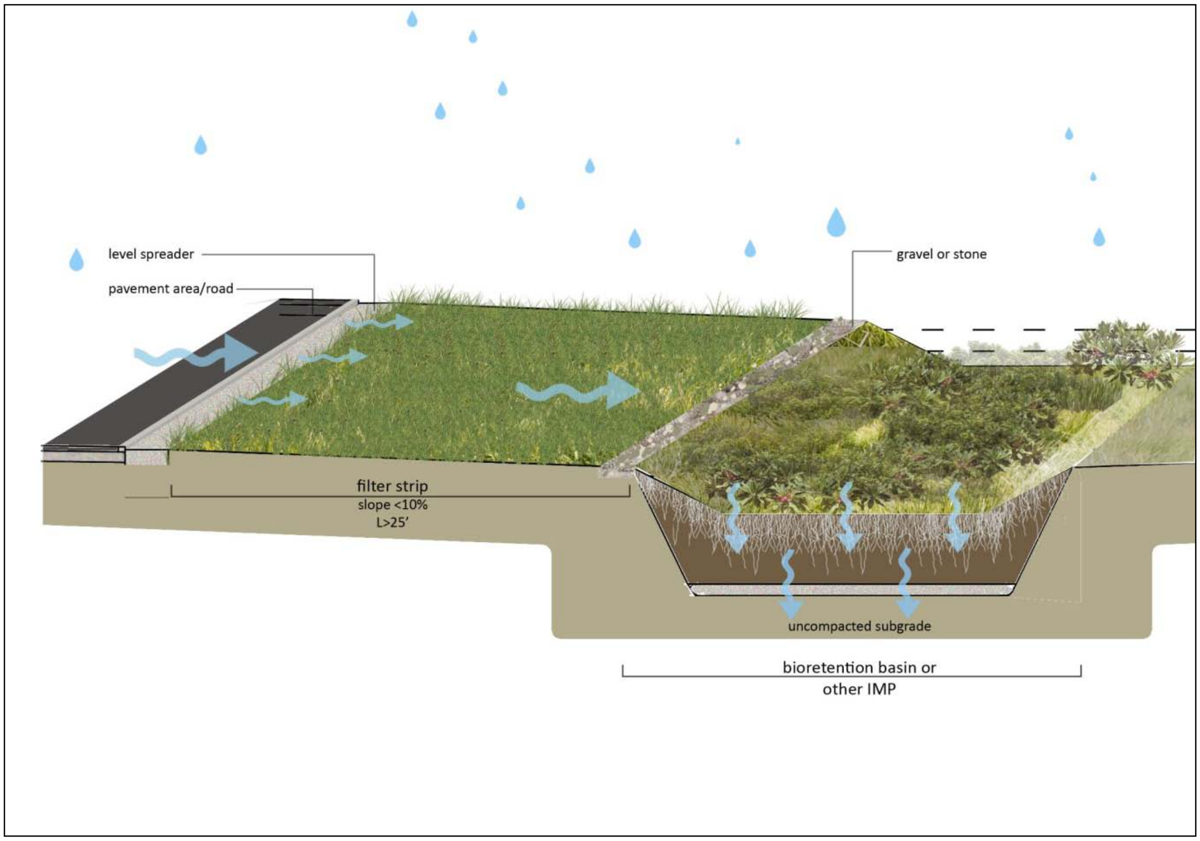


Figure 11-4: Filter Strip with Bioretention as Downstream Treatment Measure

Water Quality Treatment Capacity

- Pre-treatment capacity only

Siting

- Edging impervious area
- Requires gentle slope and enough length to be effective

Design, Sizing and Flow Considerations

- Maximum length (in the direction of flow towards the buffer) of the tributary area should be 60 feet.
- Slopes should not exceed 6%.
- Minimum length (in direction of flow) is 15 ft.
- Width should be the same as the tributary area.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified.

Maintenance

- Mowing and trash removal
- Monitoring for erosion runnels

11.1.3.6 STORMWATER OIL/SEDIMENT SEPARATOR

Oil/Sediment Separators are devices (often installed as part of a catch basin) for removing oils, greases, and sometimes solids from stormwater. Oil/Sediment Separators work using physical or chemical separation methods, including gravity, filters, coagulation, or flotation. The type used depends on expected load and regulatory removal requirements. These systems can be used for pretreatment purposes.

Benefits

- Removes oil (and sometimes solids) from stormwater, improving water quality
- Low footprint requirement—can integrate into small urban spaces

Limitation

- Can only treat the average contaminant load—will not protect against damages from larger spills or dumping
- Misconceptions of their limits can lead to dumping and the device actually being a source of environmental pollution
- Lack of maintenance can cause clogging or pollutant release

Water Quality Treatment Capacity

- Pre-treatment capacity only

Siting

- Only provides pretreatment—should be sited as part of a larger treatment train
- Works well in small urban spaces, or in areas such as loading docks or maintenance areas that are a source of oily wastewater

Design, Sizing and Flow Considerations

- Typically are sized for highly impervious drainage areas of less than 1 acre
- Oil/Sediment Separators should be used only when no other BMP is feasible.
- Designs that utilize covered sedimentation and filtration basins should be accessible to vector control personnel via access doors to facilitate vector surveillance and controlling the basins if needed.

Maintenance

- Oil/water separators must be monitored and maintained by competent and trained personnel
- Frequent inspections and an adherence to a maintenance plan are required

11.1.3.7 GREEN ROOFS

Green roofs are building roofs that are covered by a planting media and living plants (Figure 11-5). They can range greatly in aesthetics, costs, and requirements. Simpler systems are often referred to as *extensive* roofs. These are generally 2 – 6 inches in soil depth, planted with low maintenance, drought tolerant, low-growing plants, and require a much lower roof structural strength. *Intensive* roofs have greater than 6 inches of soil depth, even up to 4 – 5 ft deep to support trees. They can be planted with a greater variety of plants, and include occupiable garden terraces. They are more expensive to install and require greater weight bearing capability by the roof and building structure.

Benefits

- Retain, slow, and cleanse stormwater
- Provide noise and temperature insulation for the building, as well as cool the surrounding environment, reducing the heat island effect
- Extend life of roof membrane
- Can provide aesthetic, habitat, and recreational amenities
- Can be integrated with rooftop rainwater capture

Limitations

- Roof and building structure must be designed to handle the weight (17-82 lbs / ft^2)
- Roof slopes should be less than 3:1 (preferred)

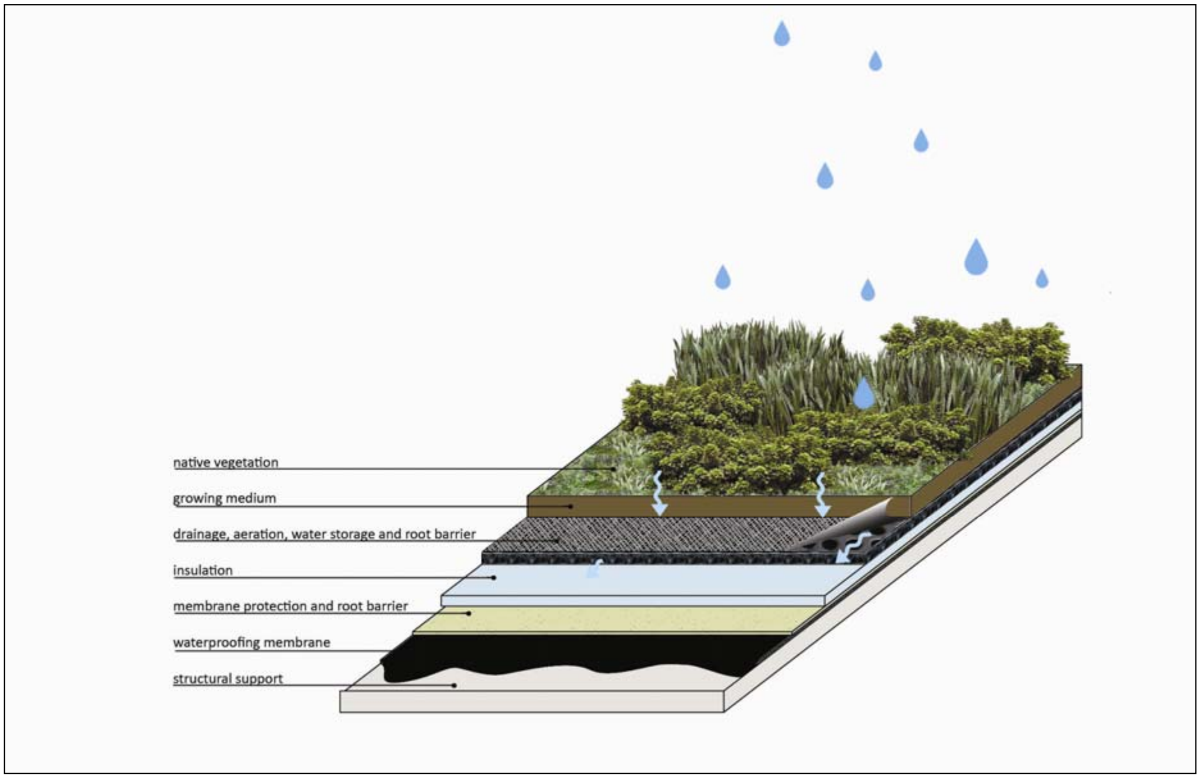


Figure 11-5: Common layers of a green roof

- High cost around $40 per ft^2
- May be adversely impacted by typhoon wind speeds

Manufacturers take various stances on the typhoon issue. Some products will not handle this condition, while others are designed to grow together creating a single planting unit rather than a series of separate tray like units. These products may handle the conditions better than others; however, it is believed that all green roofs may experience some damage during a typhoon jus as all vegetation will. The selection of the appropriate product will be critical in achieving success with a green roof in Guam.

Water Quality Treatment Capacity

- Pre-treatment capacity
- Slows and reduces peak stormwater runoff rate
- May be integrated into rooftop rainwater capture system
- Green roof assemblies should include a growing medium to hold water for plant material and a sub-surface drainage system to allow runoff of excessive rainfall, which frequently occurs on Guam. In addition, the filter fabrics and impermeable liners will help to protect and extend the life of a roofing system.
- Enhances conventional waterproofing systems by transmitting water into a collection system before it reaches the substrate.

Siting and Use

- Can be integrated into dense urban environments
- Can increase carbon sequestration utilizing areas that are otherwise unusable
- Can improve aesthetics of large roof expanses as viewed from adjacent buildings

Maintenance

Maintenance is associated with the landscape needs of the type of planting used, and should be very minimal. The primary maintenance required with a newly installed green roof besides typical observation of overall system, is during the vegetation establishment period. The plant material used for this application is designed to cover the entire media surface. Some products offer a 100% vegetated surface immediately upon installation. The humid and fast growing climate of Guam should be a benefit, not an adverse condition for the types of vegetation used. Typical Project Specification (as previously used on Guam military installations)

- Assuming new building with concrete deck roof construction
- 5 inch planting medium
- Subsurface irrigation system
- Electronic leak detection system
- Sedum plants (low maintenance plants)
- 2 ply felt membrane (a good bullet proof membrane)
- 20 year warranty on everything
- Includes visits to check the status of the system
- Maintenance plans offered for first 3 years for establishment period
- After 3 years, little or no maintenance

11.1.3.8 DRY WELL

A dry well is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from rooftops. Water quality from rooftops is generally higher than stormwater quality from surface drainage, resulting in a higher quality of infiltrated water. Roof leaders usually connect directly into the dry well, which is commonly an excavated pit filled with uniformly graded aggregate open to uncompacted native soil (Figure 11-6). Dry wells discharge the stored runoff via infiltration into the surrounding soils. In the event that the dry well is overwhelmed in an intense storm event, an overflow mechanism (e.g., surcharge pipe, splash pad, connection to larger infiltration area, etc.) will ensure that additional runoff is safely conveyed downstream.

Benefits

- Retain, slow, and cleanse stormwater
- Provide noise and temperature insulation for the building, as well as cool the surrounding environment, reducing the heat island effect
- Extend life of roof membrane
- Can provide aesthetic, habitat, and recreational amenities

Limitations

- Should not be used to treat areas with high pollutant loading
- Primarily used to treat a small catchment area

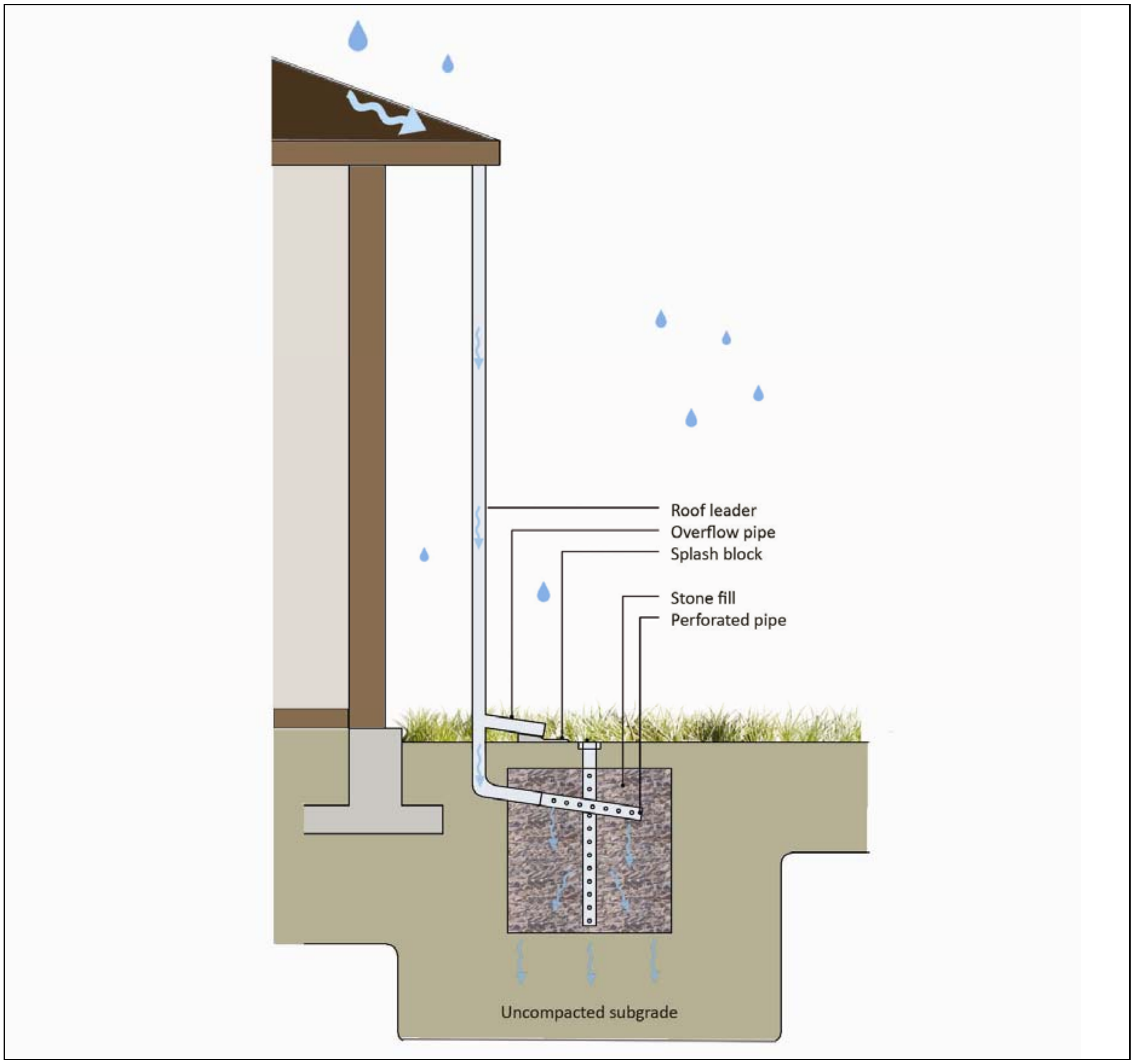


Figure 11-6: Typical Dry Well Construction

Water Quality Treatment Capacity

- No water quality treatment provided

Siting

- Can be integrated into dense urban environments
- Must be set away from buildings as required based on soil type

Design, Sizing and Flow Considerations

- Designed to capture and infiltrate 95% annual volume.
- Infiltration system should be fully drained prior to beginning of storm.
- Roof downspouts are attached to the dry well, an overflow pipe is provided for runoff in excess of design volume.

Maintenance

- Debris removal from the rain gutters and dry well surface (or chamber, depending on design)

11.1.3.9 POROUS PAVING

Porous pavement consists of a porous surface, base, and sub-base materials, which allow penetration of runoff through the surface into underlying soils (Figure 11-7). The surface materials for porous pavement can consist of paving blocks or grids, pervious asphalt, or pervious concrete. These materials are installed on a base, which serves as a filter course between the pavement surface and the underlying sub-base material. The sub-base material typically comprises a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store runoff that penetrates the pavement surface until it can percolate into the ground.

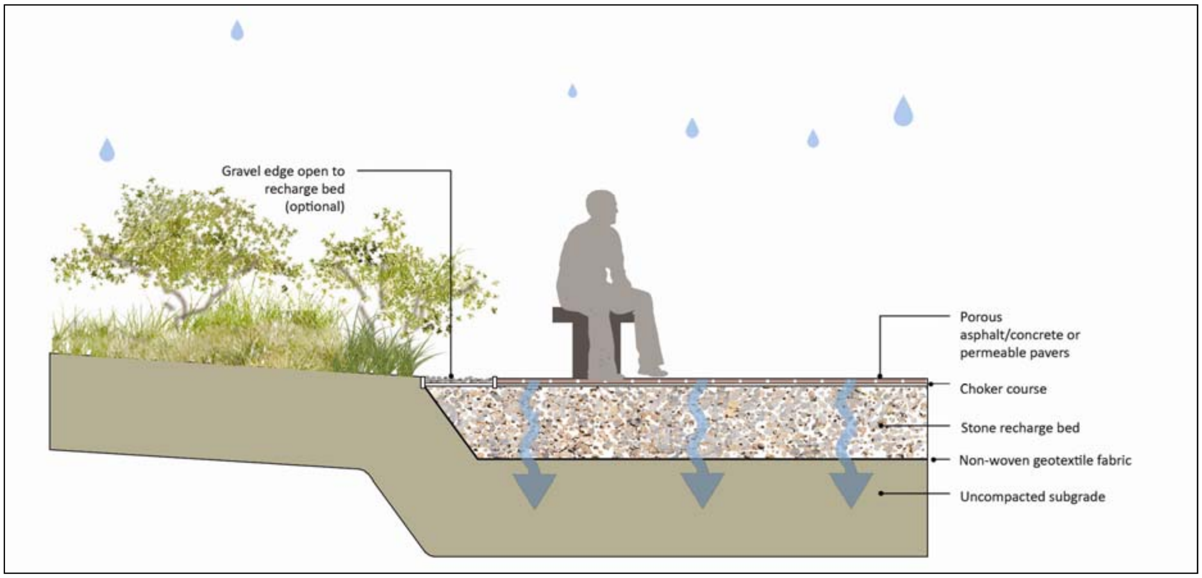


Figure 11-7: Porous paving cross section in pedestrian area

Benefits

- Groundwater recharge and reduces stormwater runoff volume
- Reduce peak discharge rates significantly

- Porous paving increases effective developable area on a site because portions of the stormwater management system are located underneath the paved areas

Limitations

- Can be prone to clogging from sand and fine sediments that fill void spaces and the joints between pavers.
- Should not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.

Water Quality Treatment Capacity

- No pollutant removal capacity

Siting

- Porous paving can only be used on gentle slopes (<5%); it cannot be used in high-traffic areas or where it will be subject to heavy axle loads.
- Porous pavements are generally applicable to low-traffic access ways, residential drives, overflow or low-use parking areas, pedestrian access ways, alleys, bikepaths, and patios.

Design, Sizing and Flow Considerations

- Porous paving require a single-size grading of base material in order to provide voids for rainwater storage; choice of materials is a compromise between stiffness, permeability, and storage capacity.
- Pavement type and thickness are selected based on anticipated load (light, moderate, heavy) and maintenance requirements.

Maintenance

- Inspect annually for pavement deterioration or spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms
- For porous asphalt and concrete, clean periodically (2-4 times per year).
- For interlocking paving stones, periodically add joint material to replace lost material

11.1.3.10 DOWNSPOUT DISCONNECTION

In urban areas, downspouts are commonly directly connected to the stormwater collection system. The cumulative effect of thousands of connected downspouts can greatly increase the volume of stormwater entering the stormwater collection system. Downspout disconnection is the process of separating roof downspouts from the stormwater piping system and redirecting roof runoff onto pervious surfaces, most commonly a lawn. Roof downspouts can also be directed to dry wells or cisterns for reuse. This simple act reduces the amount of directly connected impervious area in a catchment.

Benefits

- Enhanced infiltrate for stormwater
- Downspouts can be connected to a cistern, dry well, or lawn area.

Limitations

- Only appropriate for rooftop or elevated plaza areas
- Does not provide water quality treatment

Water Quality Treatment Capacity

- No water quality treatment provided

Siting

- Can be integrated into dense urban environments

Design, Sizing and Flow Considerations

- Due to high rainfall patterns, erosion control required at outfall

Infiltration Maintenance

- Debris removal from the rain gutters
- Maintain erosion control at discharge location

11.1.3.11 INLET PROTECTORS

Inlet protectors can be used as pretreatment to collect rubbish or other solids from stormwater. These systems can provide simple screening of solids or can be manufactured filters or fabric placed in a drop inlet to remove sediment and debris.

Benefits

- Does not require additional space as drain inlets are already a component of the standard drainage systems.
- Easy access for inspection and maintenance.
- A relatively inexpensive retrofit option.

Limitation

- Water quality protection is significantly less than treatment systems such as bioretention basins, ponds, and vaults.
- Usually not suitable for large areas
- Trash and leaves can plug or block the system.
- Does not protect against damages from larger spills or dumping

Water Quality Treatment Capacity

- Pre-treatment capacity only

Siting

- Used only for pretreatment where other treatment BMPs (such as an oil/sediment separator) are used.

Maintenance

- Frequent inspections and cleaning
- Should be cleaned after every storm

11.1.3.12 IMP STORMWATER MANAGEMENT CAPACITY

Table 11.1 summarizes the capability of each IMP to meet stormwater management goals such as recharge, water quality treatment, and flood control. For recharge, the table indicates whether the IMP supports groundwater recharge in support of meeting LEED SS credit 6.1 as well as hydromodification reduction requirements. The capacity for the IMP to provide effective water quality control, either through pre-treatment or treatment, is indicated. For more detail information on water quality treatment capacity see Table 12-1 which provides pollutant removal capacity per IMP for pollutants such as TSS, TP, TN, metals, bacteria, and hydrocarbons. Flood (or quantity) control is split into two categories – those IMPs treating up to the 2 year, 24 hour storm event and those treating larger (greater than the 2 year, 24 hour) storm events.

Table 11-1: IMP Selection Matrix Stormwater Management Capacity

IMP	Recharge	Water Quality Treatment	Flood Control (< 2 yr, 24 hr storm)	Flood Control (> 2-yr, 24 hr storm)
Detention Basin	X		X	X
Bioretention Basin	X	X	X	
Filter Strip	X	X		
Dry Swale	X	X	X	
Sedimentation Basin	X	X	X	
Oil/Sediment Separator		X		
Green Roof		X	X	
Dry Well	X		X	
Porous Paving	X		X	
Downspout Disconnection	X		X	
Inlet Protector		X		

Source: Adapted from Horsley Witten Group 2006 and NHDES 2008

11.2 WATER HARVESTING OVERVIEW

With limited water resources being taxed more every day as development and demand increases, concerns of maintaining these limited natural resources are growing. The need to harvest and reuse water is becoming more important to conserve these water resources and save costs. Given the specific nature and climate of the Finegayan Installation, some strategies may not be applicable or feasible here. However, with the average annual rainfall of nearly 100 inches, the harvesting and reuse of this water seems logical.

Some of these strategies to harvest and reuse water are directly related to the built environment such as harvesting and reuse within buildings, while others are related to natural environments such as stormwater runoff into created wetlands and ponds for reuse as wash water and irrigation.

11.2.1 Rainwater Harvesting and Reuse

When considering that Guam receives an average of over 94 inches of rainfall each year with a monthly average of 14 inches in August, rainwater harvesting is an abundant source of water for this region. Table 11-2 shows the monthly and yearly rainfall averages for a weather station on Guam.

Table 11-2: Average Monthly and Yearly Rainfall Averages in Guam

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
mm	122.7	127.8	94.6	108.7	164.4	132.8	262.5	354.6	323.4	343.7	208.8	151.6	2396.8
inches	4.8	5.0	3.7	4.3	6.5	5.2	10.3	14.0	12.7	13.5	8.2	6.0	94.4

Source: Andersen AFB Guam data derived from NCDC Cooperative Stations. Data recorded between 1952 and 1995

Weather station Andersen AFB Guam is at about 13.58° N 144.91° E. Its height is about 190 meters/623 ft above sea level. (Data from www.worldclimate.com)

Rainwater harvesting is the process of intercepting stormwater runoff and putting it to beneficial use in order to reduce the demand for potable water. Rainwater is usually collected or harvested from rooftops, concrete patios, driveways and other impervious surfaces.

Water can be diverted into rain barrels for small residential point source applications or into larger underground holding areas, tanks, or cisterns for multiple users or a user with a higher water demand (Figure 11-8, Figure 11-9, Figure 11-10). The size of the water storage device is determined based on many factors, which include the average duration, frequency, and intensity of rainfall events, the proposed water reuse demand, and the frequency of water reuse.

This captured water can be used for multiple purposes including irrigation, toilet flushing, laundry, humidifying the air, and with a higher level of treatment may also be used for other general domestic water needs such as bathing, dishwashing, etc. In order for this water to be used for these purposes, standard water supply piping must be modified to accommodate a second source. For this reason, the indoor reuse of stormwater is most applicable for new houses, facilities, or buildings, and the reuse of stormwater on existing facilities is usually confined to use as outdoor irrigation.

The reduction in potable water demand will vary with use and region, however, the typical residential potable water savings may be as much as 25% if harvested rainwater is used for irrigation and toilet flushing. In areas like Guam where rainfall is abundant, the need for irrigation is usually small, and the amount of potable water saved by reusing the harvested rainwater may not be quite as high as it would be in an area that requires more irrigation.

Typical rainwater reuse systems include some level of filtration and treatment to ensure safe water for reuse inside a home or office. The harvested rainwater used for irrigation, if used, would not require much, if any, filtration or treatment prior to use.

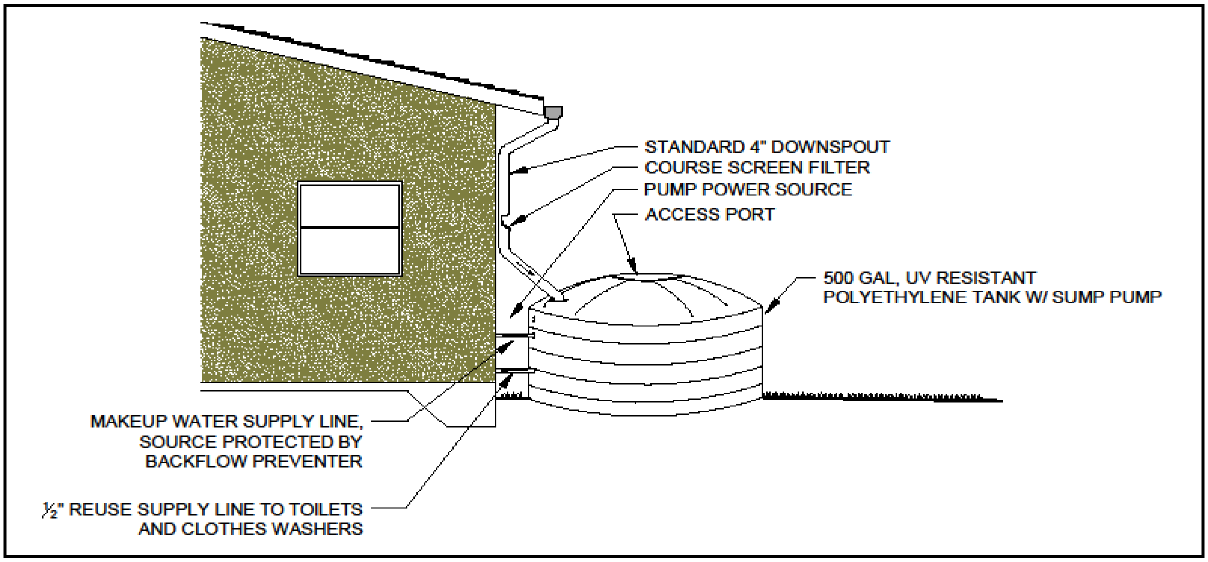


Figure 11-8: Residential Cistern, Above Ground

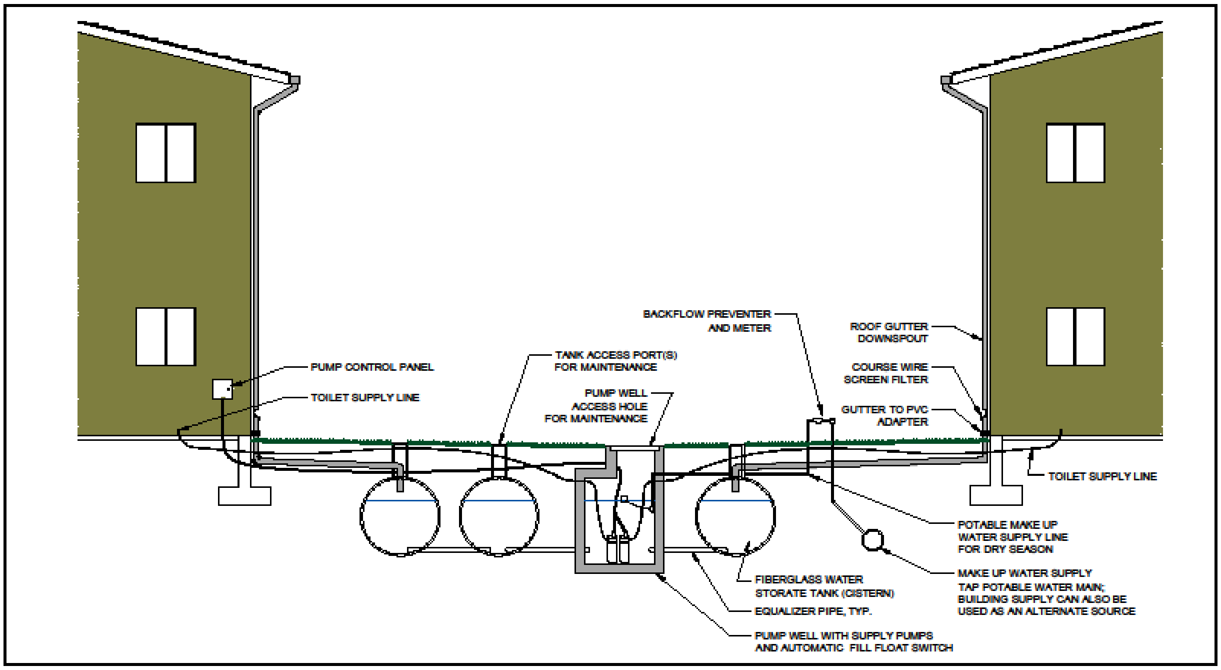


Figure 11-9: BEQ/BOQ Cistern, Profile View

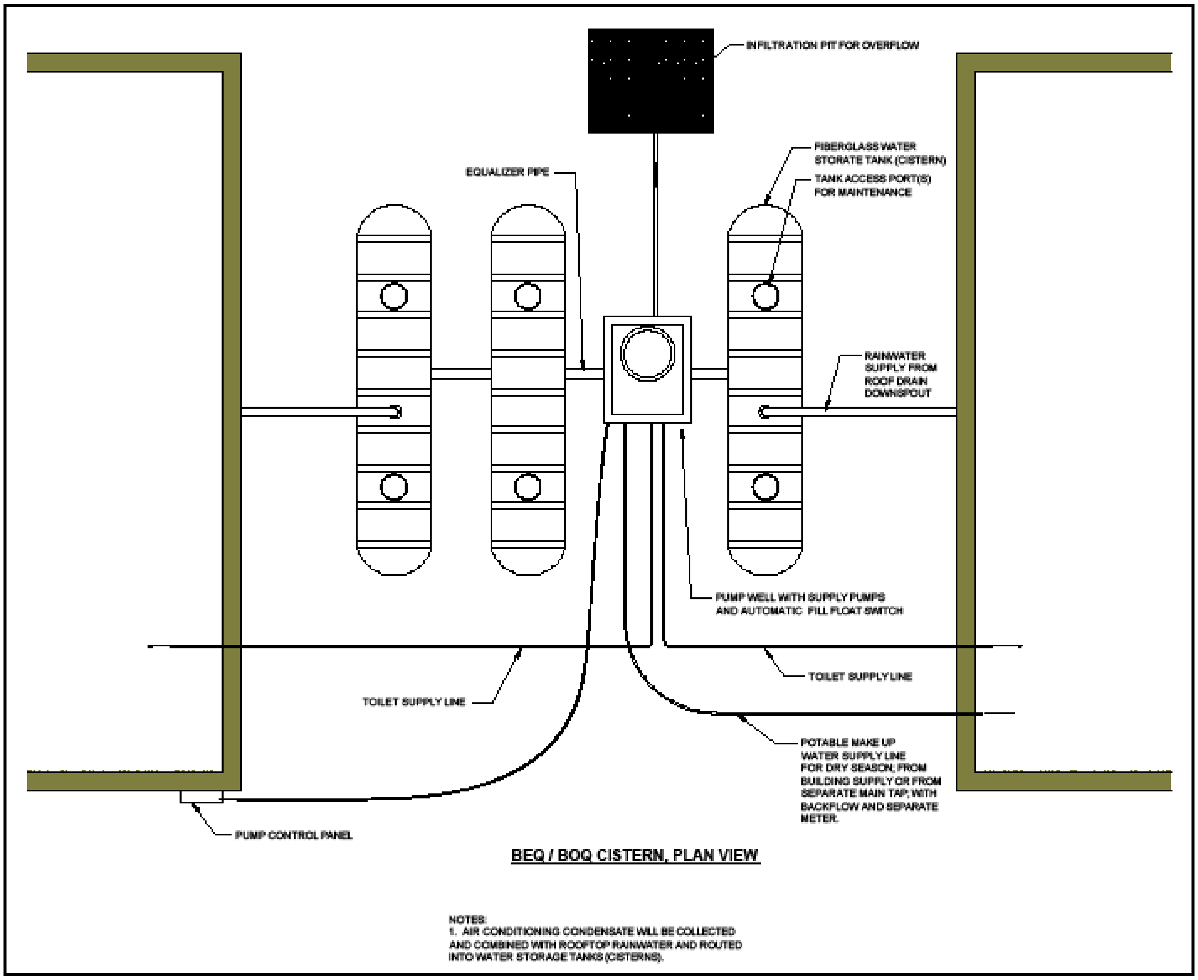


Figure 11-10: BEQ/BOQ Cistern, Plan View

11.2.2 Building Stormwater BMPs

Some typical harvesting and reuse strategies used in the built environment are:

- Rainwater harvesting and reuse (ideal for Guam due to large rainfall amounts). Can be reused as toilet flushing water, other domestic water, cooling water, and irrigation. This strategy will require holding tanks or cisterns, which collect water for reuse upon demand. A cistern system can be used to collect and hold water from various sources including rainwater capture and condensate capture. However, if gray water or other harvested sources containing higher concentrations of TSS are collected, some filtration and chlorination will be required depending on the reuse.
- Air conditioning condensate capture and reuse (good option for water supply during dry times) This water is typically used as toilet flushing water, cooling system make up water, and or irrigation. During times of low rainfall, and with the warm humid climate of Guam, the use of space air conditioning may generate a large volume of condensate water. This water can be used to supplement the harvesting and reuse of rainwater and reduce the size of cisterns while providing a larger volume of reuse water and further reducing the demand of treated potable water.
- Gray-water capture and reuse (may not be needed with availability of rainfall). Can be reused as: toilet flushing water with filtration and chlorination, and irrigation

- Treated sewage effluent (TSE) secondary or tertiary level distributed for irrigation. Typically used for irrigation (since little irrigation is required, this is not necessary).
- Cisterns. The use of cisterns for holding harvested water intended for reuse requires the accurate data for both rainfall available and water reuse. Proper storage sizing requires balancing the supply, demand, capital cost and the amount of harvested rainwater. Project goals and temporal rainfall patterns significantly affect the size and functionality of storage.

11.2.3 Exterior Stormwater Harvesting and Reuse

Design impervious areas to route stormwater into lined collection ponds for reuse as wash water and irrigation water. In general, irrigation may not be needed; however, given the large impervious area on the installation, there is the potential to capture large volumes of rainwater which could benefit the installation mission and reduce the potable water demand. These types of strategies should be evaluated for effectiveness and feasibility.

11.3 ARCHITECTURAL AND AESTHETIC STORMWATER ELEMENTS

Stormwater management and water conservation provides an opportunity to develop unique and engaging architectural elements both at the building as well as the landscape level. LID aims to integrate solutions for the urban water cycle into the planning and design of buildings and landscapes while enhancing the aesthetic look, feel, and livability of the area. LID design is a layer in the delivery of sustainable development and is the framework for integrating water cycle management with urban planning and design.

Developing architectural and aesthetically engaging stormwater elements may fall into the following categories:

- Placemaking
- Architectural Function
- Art and Inspiration

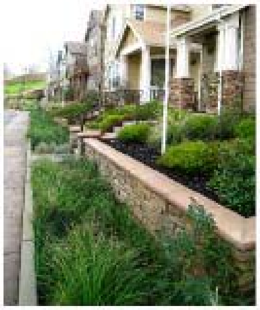
There are numerous opportunities to integrate stormwater management into architectural and landscape elements. Figure 11-11 to Figure 11-13 demonstrated how stormwater can be used in dense urban developments, parkland, community spaces such as museums and churches, and residential development to enhance the aesthetic look and feel.

Successful implementation of sustainable water resource management requires an integrated design approach that includes architects, engineers, planners, and landscape architects focused to address the goals of improving energy efficiency and water conservation while promoting safe, healthy, and productive built environments.

STORMWATER: PLACEMAKING


Green wall Westfield Shopping Mall, London, England


Bioretention basin in urban plaza, San Francisco, CA


Bioretention basin in high density residential development, Clayton, CA


Bioretention basin in museum courtyard, Adelaide, Australia


Bioswale in urban park, San Francisco, CA


Bioretention basin in community space, Pleasant Hill, CA

Figure 11-11: Examples of Placemaking in Building and Landscape using Stormwater Management Elements

STORMWATER: ARCHITECTURAL FUNCTION

Bioretention basin in residential development, Australia

Bioretention basin in urban plaza also functioning as a bench, Melbourne, Australia

Stormwater wetland overlook and bench in Sunshine Coast, Australia

Bioretention basin in urban plaza also functioning as a bench, Melbourne, Australia

Bioretention basin in high density residential development, Portland

Bioretention basin in streetscape right of way, Sydney, Australia

Figure 11-12: Examples of Architectural Function in Building and Landscape using Stormwater Management Elements

STORMWATER: ART & INSPIRATION

Downspout disconnection at Lady Bird Johnson Wildflower Center, Austin ,TX.

Stormwater wetland with art sculpture, Melbourne, Australia.

Stormwater detention pond, Melbourne, Australia.

Green roof from the California Academy of Science, San Francisco, CA.

Downspout disconnection sculpture, Roosevelt Community Center, San Jose, CA

Stormwater wetland in urban plaza, Melbourne, Australia.

Figure 11-13: Examples of Art, Sculpture and Inspiration in Building and Landscape using Stormwater Management Elements

11.4 SUMMARY AND DISCUSSION OF AVAILABLE POLLUTANT REMOVAL STRATEGIES

To create a stormwater pollutant removal strategy for the Finegayan Main Cantonment Area, target pollutants of concern must first be identified. The main pollutants of concern as addressed in this study are:

- TSS
- TP
- TN
- Metals
- Bacteria
- Hydrocarbons

Impervious surfaces can accumulate these pollutants which in turn can be rapidly washed off during storm events and transported downgradient to sensitive receptors. Sources of these stormwater pollutants vary by the particular contaminant and may include:

- TSS: mud and dirt on vehicles, atmospheric deposition, and construction activities with improper erosion control systems
- TN and TP: landscaping fertilizers, atmospheric deposition, leaking septic systems, animal waste (both wild and domestic), and organic matter
- Metals: outdoor metal surfaces such as tanks and metal roofs, vehicles, paints, motor oil and various industrial activities
- Bacteria: pet waste, urban wildlife, wastewater, unlawful connections to the storm drain system, and sanitary and combined sewer overflows
- Hydrocarbons: fuel, oil, and lubricant leaks from vehicles and machinery, fueling stations, and fuel/oil spills

Certain locations within the Finegayan Main Cantonment Area would likely contain land uses and activities with higher pollutant loading such as hydrocarbons and trace metals. These locations are referred to as stormwater “hotspots” and would require additional levels of consideration when choosing specific IMPs and treatment trains. The *CNMI and Guam Stormwater Management Manual* (Horsley Whitten Group 2006) identifies these potential pollutant hotspots as:

- vehicle salvage yards and recycling facilities
- vehicle fueling stations
- vehicle service and maintenance facilities
- vehicle and equipment cleaning facilities
- fleet storage areas (e.g., bus, truck, etc.)
- industrial sites
- outdoor liquid container storage
- outdoor loading/unloading facilities
- public works storage areas

- facilities that generate or store hazardous materials
- commercial container nurseries
- waste transfer, storage, processing, and disposal sites
- other land uses and activities designated by appropriate permitting authorities of CNMI/Guam

As indicated above, stormwater management in Guam has historically been viewed from the perspective of flood control, which has resulted in flood flows being routed to the nearest discharge location with little or no treatment. The presence of sinkholes, highly permeable limestone (and subsequently high infiltration rates), and the fact that a portion of the NGLA lies below the Study Area necessitates a more comprehensive stormwater management strategy that focuses ultimately on improving groundwater quality while considering a host of other factors.

Section 11.1 above provided an overview of green stormwater management that employs both nonstructural and structural approaches. This section explores a wider palette of options for structural IMPs originally considered for this study as compiled from a variety of sources, including the Department of the Navy Strategic Forward Basing Initiatives *Low Impact Development Manual*, the *CNMI and Guam Stormwater Management Manual*, and other continental U.S. stormwater management sources. The resulting palette of 23 stormwater IMPs and one IMP accessory, evaluated for possible use at the Finegayan Main Cantonment Area, are provided in Table 11-3. The primary purpose of Table 11-3 is to facilitate comparison of the various IMPs in order to choose the most appropriate set of IMPs to establish specific treatment trains for pollutants of concern from a stormwater source. To facilitate the comparison and selection of IMPs, Table 11-3 lists pollutant removal efficiencies for the various IMPs (where available). Many of the IMPs are variations of the same general IMP type, but are still included in the table for comparison purposes because there is no one "correct" IMP to satisfy every situation. Thus, during the final design of the cantonment's LID stormwater management system, situations may arise where the designers may need to substitute one of the recommended IMPs in a treatment train for another from Table 11-3 in order to solve a specific design constraint within a subbasin.

The ultimate goal of identifying a variety of possible IMP options is to further reduce these options based on a variety of factors, most importantly pollutant reduction efficacy, and then group these IMPs into "treatment trains" to effectively reduce pollutants of concern within a particular portion of a subbasin. The term "treatment train" refers to the grouping and sequencing of a series of these structural IMPs to achieve improved stormwater quality in a step-wise fashion as stormwater flows from one IMP to the next.

Table 11-3 also identifies a specific IMPs respective treatment train position and includes IMP options for the following general categories:

- rooftop evapotranspiration
- pretreatment
- conveyance
- treatment
- infiltration
- storage

Some IMPs may serve more than one purpose within a particular treatment train. For example, a dry swale can provide both conveyance and treatment while a bioretention basin can provide treatment of stormwater to improve water quality of the 95% storm and also provide a means of groundwater recharge. Some IMPs can also function well in more than one position in a train, for example, dry swales as a method of conveyance between other IMPs. While not a true IMP, Table 11-3 also includes inlet protectors as an IMP accessory. While one of the goals of green stormwater management is to reduce the amount of stormwater infrastructure such as curbs and gutters, there are instances where these features may be helpful to direct and guide stormwater flow to a specific location of an IMP train. Section 12.3 below describes the IMPs that are recommended, not recommended, or of limited or specific applicability for this study.

11.5 DISCUSSION OF POLLUTANT REMOVAL EFFICIENCIES

Pollutant removal efficiencies for a particular IMP can vary widely depending on the contributing land use, area of the portion of the subbasin to be treated, incoming pollutant concentration, rainfall pattern, time of year, age of the IMP, maintenance frequency, soil type, and many other factors. It is important to note that specific data regarding IMP pollutant removal efficiencies are variable for many IMPs and often scarce or absent for others. Table 11-3 includes pollutant removal efficiencies as available for the palette of IMPs considered and includes information for the main pollutants of concern: TSS, TP, TN, metals, bacteria, and hydrocarbons. Where efficiency of pollutant removal for a particular category is shown as N/A (not available), it does not necessarily mean that a particular IMP is ineffective at removing a particular pollutant, but rather the IMP's pollutant removal efficiency has not been well defined to a level suitable for calculation for this study. When the literature suggested a range of efficiencies for a particular IMP, the midpoint of the range was used for comparison purposes.

To compare the pollutant removal efficiency of an IMP for a specific pollutant of concern, IMPs and their respective efficiencies were ranked to determine preferred choices of IMPs strictly from a pollutant removal perspective. IMPs with a designation of "N/A" for a particular pollutant removal efficiency were not included in the initial ranking but were considered for use if other factors warranted it (e.g., available space, feasibility of construction, use in a specific treatment train position). The top ranked five IMPs for a particular pollutant were initially given consideration for use in a particular treatment train. However, other considerations, such as particular site constraints, further modified the specific use and position of an IMP.

Table 11-3: Low Impact Development (LID) Integrated Management Practice (IMP) Possible Options for the Finegayan Main Cantonment Area, Guam

LID Option	Description	Typical IMP Treatment Train Function	Suitability for Finegayan*	Primary Function(s)/Advantages	Disadvantages	Pollutant Removal Efficiency						Constructibility and Other Considerations	Maintenance Requirements
						Total Suspended Solids [TSS (%)]	Total Phosphorus [TP (%)]	Total Nitrogen [TN (%)]	Metals (%)	Bacteria (%)	Hydrocarbons (%)		
Vegetated Roof (Green Roof)	Permanent rooftop planting system containing live plants in a lightweight engineered soil medium designed to retain precipitation where the water is taken up by plants and transpired into the air.	Evapotranspiration-Rooftop	✗	Assists in increasing evapotranspiration of rooftop stormwater. Also provides some degree of temporary water storage, pollutant filtering, and absorbsion and detention of rainfall; helps keep buildings cooler in warmer weather.	Potential concerns regarding high winds and occasional maintenance. Roof structure needs to be designed/constructed to support additional weight of saturated green roof under windy conditions.	No active removal of suspended solids	N/A	N/A	N/A	N/A	N/A	Vegetated roofs should be located on single-story buildings in low lying areas sheltered from high wind speeds (typhoons) and use low height, well rooted, dense ground cover. As a result of wind loading issues, green roofs are generally not recommended for use in the cantonment.	Requires standard horticultural maintenance.
Rain Barrels & Cisterns	Structures that store rooftop runoff for later re-use for landscaping and other non-potable uses.	Storage	~	Rain barrels and cisterns can capture small volumes of storms for later re-use for non-potable purposes.	Not effective in attenuating larger storms.	N/A	N/A	N/A	N/A	N/A	N/A	Reuse of stormwater is generally confined to outdoor irrigation.	Occasional cleaning of leaves and debris may be necessary.
Drywells	Subsurface storage structure that stores and infiltrates stormwater runoff from rooftops.	Infiltration	✓	Capture precipitation from roofs and recharge into ground.	Should not be used to treat areas with high pollutant loading and should be used for rooftops only.	80	N/A	N/A	N/A	N/A	N/A	Stormwater runoff from roofs will be directed to drywells. Generally constructed near buildings. One drywell per downspout to localize recharge. Care must be taken that oil, nutrients, and metals do not enter the drywells. Drywell design for Guam should be developed to accommodate no-downspout roof drainage (scuppers and drip-line runoff). In areas of potential contaminants from surrounding surfaces, set top of drywell slightly above grade. Overflow can be directed to surrounding or nearby grass or groundcover.	Clearing opening of debris to ensure infiltration.
Porous Pavement	Permeable asphaltic concrete pavement allows runoff to travel through voids in the aggregate and ultimately infiltrate into subsurface soil.	Infiltration	~	Allows infiltration of runoff from paved surfaces.	Not appropriate for vehicle areas due to presence of oils or suspended metals. Best use is primarily for pedestrian areas and other areas where pollutant loading is minimal. May require vacuuming several times a year to remove sediment.	80 possible, but 0 used for calculations since not considered a TSS IMP	N/A	N/A	N/A	N/A	N/A	Can be used for walkways and other paved surfaces with low potential for contaminants. A filter fabric may be installed between the aggregate and the subsurface soil for additional pollutant filtering. However, the fabric may eventually clog, leaving the system inoperable, thus pervious pavement is not recommended as an IMP for TSS removal.	Vacuum or clean with a street sweeper at least twice a year to remove built-up sediments, organic matter, and atmospheric deposition.
Curb Inlet Protectors	A device installed at the curb inlet to prevent entrance of runoff-borne rubbish into an OWS or other stormwater IMP structure.	IMP Accessory	~	Prevents runoff-borne rubbish from entering curb inlets in the event that a curb inlet is required under specific circumstances in the final cantonment design.	Provides no protection from the entrance of debris and particles smaller than the protector openings. Used only as an accessory to IMPs.	N/A	N/A	N/A	N/A	N/A	N/A	Simple to implement.	Requires frequent inspections and periodic cleaning, particularly after storm runoff events. Should be cleaned after every storm.
Standard Oil and Grit Separators (OWS)	Underground storage tank with chambers designed to remove heavy particulates, floating debris, and hydrocarbons from stormwater.	Pre-Treatment	✗	Pre-treatment of oil and grit from "hotspots" that are likely to have some oil residue in the runoff. Located underground so lot size is less of an issue; can be installed in any soil or terrain.	Cannot effectively remove soluable pollutants, fine particles, or bacteria; sediment in OWS can become resuspended if not properly maintained; susceptible to flushing during large storm events; entrapment hazard for amphibians and other small animals.	30	5	5	N/A	N/A	N/A	May be expensive to construct and maintain	Requires frequent ongoing maintenance programs including: inspections, removal and disposal of oil and grit, and periodic cleaning.
Proprietary Oil and Grit Separators (e.g. Stormcepter®)	Proprietary modified version of standard oil and grit separator that slows incoming stormwater to create a non-turbulent treatment environment, allowing free oils and debris to rise and sediment to settle.	Pre-Treatment	✓	The system maintains continuous positive treatment of total suspended solids (TSS), regardless of flow rate, treating a wide range of particle sizes, as well as free oils, heavy metals and nutrients that attach to fine sediment. Limits inflow to prevent potential scour and resuspension of sediment. Incorporated high flow bypass. Can accommodate several inlet pipes.	Like OWS, needs regular maintenance and cleaning to operate to maximum potential.	80	N/A, although some removal is anticipated via attachment to fine sediment.	N/A, although some removal is anticipated via attachment to fine sediment.	80	N/A	93	Design allows for access at one point only.	Requires frequent ongoing maintenance programs including: inspections, removal and disposal of oil and grit, and periodic cleaning.
Filter Strips	A strip of uniformly graded vegetated surface upgradient of ponds, diversions and other structures that receive runoff from adjacent areas. Filter strips retard flow of runoff water, causing deposition of transported material, thereby reducing sediment flow.	Pre-Treatment	✓	Typically treats sheet flow or small concentrated flows that can be distributred along the width of the strip using a level spreader. Can be used as pre-treatment between paved areas and other IMPs; can be used where OWS are not required; Reduces runoff volumes and peak flows; can be used to treat runoff from parking lots and roads depending on pollutant loading; slows runoff velocities and removes sediment	Little or no treatment is provided if filter strip is short-circuited by concentrated flows; effective only on gentle slopes (<6%).	28	20	20	40	N/A	N/A	Improper grading can greatly diminish pollutant removal.	Typical vegetation maintenance such as mowing, irrigation, and weeding as required for aesthetic and safety purposes.

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Table 11-3 (Cont.): Low Impact Development (LID) Integrated Management Practice (IMP) Possible Options for the Finegayan Main Cantonment Area, Guam

LID Option	Description	Typical IMP Treatment Train Function	Suitability for Finegayan*	Primary Function(s)/Advantages	Disadvantages	Pollutant Removal Efficiency						Constructibility and Other Considerations	Maintenance Requirements
						Total Suspended Solids [TSS (%)]	Total Phosphorus [TP (%)]	Total Nitrogen [TN (%)]	Metals (%)	Bacteria (%)	Hydrocarbons (%)		
Grass Channel	An open vegetated channel used to convey runoff and to provide treatment by filtering out pollutants and sediments.	Conveyance	✗	Used for simple means of conveyance of water into or out of pre-treatment or storage devices	Provides only limited pre-treatment or storage capacity	40	25	20	30	N/A	N/A	Generally used for simple conveyance with limited pollutant removal anticipated	Typical vegetation maintenance such as mowing, initial irrigation, and weeding as required for aesthetic and safety purposes. Remove excess plant material and rubbish after storms as needed. Maintain an average grass height of 6" in grass channels.
Dry Swale	An open vegetated channel or linear depression explicitly designed to detain and promote filtration of stormwater runoff into an underlying fabricated soil matrix.	Conyeyance/ Treatment	✓	Used for conveyance of water into or out of pre-treatment or storage devices and adds a level of treatment beyond a simple grass channel.	Works best on a sloped site (<4%)	81	34	84	70	N/A	62	Use of check dams will allow water to infiltrate into the subsurface.	Typical vegetation maintenance such as occasional mowing, initial irrigation, and weeding as required for aesthetic and safety purposes. Remove excess plant material and rubbish after storms as needed.
Wet Swale	An open vegetated channel or depression designed to retain water or intercept groundwater for water quality treatment.	Conyeyance/ Treatment	✗	Used for conveyance of water and provides some level of pre-treatment and treatment.	Potential for stagnant water and other nuisance ponding. Not suitable for karst geology.	81	34	84	70	N/A	62	Wet Swales should be restricted in residential areas because of the potential for stagnant water and other nuisance ponding. In addition, they are not appropriate for use in karst geology.	Typical vegetation maintenance such as mowing, initial irrigation, and weeding as required for aesthetic and safety purposes. Remove excess plant material and rubbish after storms as needed.
Bioretention Basin	A landscaped stormwater basin which uses engineered soils and vegetation to capture and treat runoff. Runoff is treated as it flows through a soil matrix and is returned to the stormwater treatment train, or infiltrated into underlying soils or substratum.	Treatment	✓	Water quality and recharge: used to capture and treat runoff; stormwater ultimately infiltrates into the ground after treatment. Can be designed to provide groundwater recharge and preserve the natural water balance of the site; can be designed to prevent recharge when appropriate; supplies shade, absorbs noise, and provides windbreaks and aesthetic appeal.	May need to be designed in conjunction with other storage IMPs to accommodate required storage volumes; requires careful landscaping and maintenance.	86	59	38	69	37	84	Adequate pre-treatment is essential; not recommended in areas with steep slope; depth of soil media depends on type of vegetation to be planted. Treatment area should have a 4-foot deep planting soil bed, a surface mulch layer, and a ponding layer. A detailed landscaping plan is required.	Maintenance includes inspection and repair/replacement of treatment area components, vegetation pruning, removal of dead branches and plants.
Organic Filter	A filtering IMP that uses an organic medium such as compost in the filter, or incorporates organic material in addition to sand (e.g., peat/sand mixture).	Treatment	~	Filtering of runoff prior to discharge to other IMP. Stormwater filtering systems capture and temporarily store the WQv (water quality volume) and pass it through a filter bed of organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially exfiltrate into the soil.	High maintenance burden. Not recommended for areas that have high sediment content in stormwater or clay/silt runoff areas. Relatively costly to install and maintain. Possible odor problems. Cannot be installed until site construction is complete.	86	59	38	69	37	84	Organic filter beds typically have a minimum depth of 18 inches. Organic filters can have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought.	If a grass cover is present, it should be mowed a minimum of three times per growing season to maintain maximum grass heights less than 12 inches. Sediment should be cleaned out of sedimentation chamber when it reaches more than 12" in depth. Sediment chamber should be cleaned if drawdowns exceed 36 hours. Trash and debris should be removed regularly. If water ponds on the filter bed for greater than 48 hours, filter bed should be removed and replaced.
Sand/Gravel Filter	Self-contained beds of sand or gravel either underlaid with perforated underdrains or designed with cells and baffles with inlets/outlets. Sand/gravel beds can treat stormwater by settling out larger particles in a sediment chamber, and then filtering stormwater through a surface, underground, or perimeter sand matrix.	Treatment	~	Filtering of runoff prior to discharge to other IMP(s); Well-suited for parking lots with high intensity use	If anoxic conditions develop in the sand filter due to poor drainage, phosphorus levels can increase as water passes through the sand filter. Large sand filters without vegetation may not be attractive in residential areas. May not be effective in controlling peak discharges.	86	59	38	69	37	84	Sand/gravel filter beds typically have a minimum depth of 18 inches. Sand filters can have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought.	If a grass cover is present, it should be mowed a minimum of three times per growing season to maintain maximum grass heights less than 12 inches. Sediment should be cleaned out of sedimentation chamber when it reaches more than 12" in depth. Sediment chamber should be cleaned if drawdowns exceed 36 hours. Trash and debris should be removed regularly. If water ponds on the filter bed for greater than 48 hours, filter bed should be removed and replaced.

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Table 11-3 (Cont.): Low Impact Development (LID) Integrated Management Practice (IMP) Possible Options for the Finegayan Main Cantonment Area, Guam

LID Option	Description	Typical IMP Treatment Train Function	Suitability for Finegayan*	Primary Function(s)/Advantages	Disadvantages	Pollutant Removal Efficiency						Constructibility and Other Considerations	Maintenance Requirements
						Total Suspended Solids [TSS (%)]	Total Phosphorus [TP (%)]	Total Nitrogen [TN (%)]	Metals (%)	Bacteria (%)	Hydrocarbons (%)		
Infiltration Trenches/Chambers	Infiltration trench stores the water quality volume in the void spaces of a limestone aggregate trench or within an open chamber before it is infiltrated into underlying soils within the B or C soil horizons.	Infiltration	~	Infiltration trenches provide efficient removal of suspended solids, particulate pollutants, coliform bacteria, organics and some soluble forms of metals and nutrients from storm water runoff. The captured runoff infiltrates the surrounding soils and increases groundwater recharge.	Infiltration trenches/chambers cannot be placed in locations that cause water problems (such as seepage which may cause slope failure) to downgrade properties.	95	80	51	99	90	N/A	Infiltration trenches and chambers should be setback 25 feet down-gradient from building structures and any onsite wastewater disposal systems. The sides of infiltration trenches should be lined with an acceptable filter fabric that prevents soil piping.	Infiltration trenches should be inspected after large storm events and any accumulated debris or material removed. If inspection indicates that the trench is partially or completely clogged, it should be restored to its design condition. A vegetated buffer strip, if used in the design, should have healthy grass that is routinely mowed.
Proprietary Subsurface Infiltration Device (e.g. CULTEC®)	Proprietary subsurface infiltration devices such as CULTEC® plastic chambers may be used as underground retention/detention systems, as replacements for ponds, concrete structures or pipe and stone installations and are well-suited to areas with little room for surface IMPs. Where necessary, additional CULTEC® components can be grouped with infiltration chambers to provide a treatment train consisting of filtration, conveyance, storage and infiltration.	Infiltration	✓	For use where there is little room for surface IMPs. The high capacity, open bottom chambers provide greater storage and much higher infiltrative capability than conventional pipe and stone systems.	Treatment must be provided by another IMP prior to infiltration.	N/A	N/A	N/A	N/A	N/A	N/A	CULTEC® system is designed to be constructed underneath a paved area, so there is no need to use open land for the infiltration beds.	To maintain performance of the CULTEC® infiltration beds, regular maintenance needs to be performed on upgradient BMPs to ensure stormwater is being properly treated prior to entrance into the CULTEC® beds.
Proprietary Subsurface TSS Filter Chamber (e.g. CULTEC® Stormfilter)	A proprietary subsurface TSS filter chamber is a plastic chamber used in conjunction with CULTEC®-type infiltration chambers, but is located upstream from an infiltration chamber and houses a series of filter media to remove TSS prior to infiltration.	Treatment	✓	A CULTEC®-type filter chamber provides TSS removal prior to infiltration of stormwater into CULTEC® infiltration beds.	Does not remove other pollutants of concern.	77	N/A	N/A	N/A	N/A	N/A	Must be installed upstream of CULTEC® infiltration chambers/beds	Periodic removal and cleaning and/or replacement of filtration media
Infiltration Basins	Excavated basin often filled with stone aggregate (or other storage method) used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom of the basin.	Storage/ Infiltration	~	Designed to allow runoff to infiltrate into the surrounding subsurface.	Infiltration basins with slow infiltration rates have the potential to facilitate mosquito breeding and odor problems due to standing water.	95	80	51	99	90	N/A	Infiltration basins should be located downstream of other IMPs such as Bioretention Areas. Must be placed in areas where the groundwater table is at least three feet below the ground surface. Entire basin should be excavated below existing grade rather than storage accomplished with an embankment. Overflow via protected surface drainage.	Typical vegetation maintenance such as mowing and weeding as required for aesthetic and safety purposes.
Micropool Extended Detention Pond	Micropool extended detention ponds are variations of wet extended detention ponds where a small “micropool” is maintained at the outlet to the pond that prevents resuspension of previously settled sediments and also prevents clogging of the low flow orifice.	Treatment	✗	Inclusion of a micropool in the design helps to prevent re-suspension of sediments.	Potential for thermal impacts/downstream warming and potential for mosquito breeding. Not recommended for use in karst geology.	80	51	33	62	70	81	The micropool is generally constructed 4-8 feet deep, typically with a minimum storage of 0.1 inches per impervious acre of drainage.	Monitor sediment accumulation and remove periodically. Remove debris from inlet and outlet structures. Maintain side slopes and shoreline vegetation.
Wet Pond	Pond that provides storage for the entire water quality volume in the permanent pool. While normally containing a permanent pool, wet ponds can occasionally dry out during extended dry periods.	Storage/ Treatment	✗	Wet detention ponds offer the advantage of accumulating sediment and debris within the permanent pool. In addition, nutrients may be removed from the water by algae and rooted aquatic plants. Heavy metals are removed from the water during sedimentation and adsorption onto bottom sediments. Aerobic conditions at the bottom of the permanent pool will maximize the uptake of phosphorus and heavy metals by bottom sediment and minimize pollutant releases from the sediments into the water column.	Potential for thermal impacts/downstream warming and potential for mosquito breeding. Not recommended for use in karst geology.	80	51	33	62	70	81	Cannot be placed on steep unstable slopes. Need for base flow or supplemental water if water level is to be maintained. Require a relatively large footprint	Monitor sediment accumulation and remove periodically. Remove debris from inlet and outlet structures. Maintain side slopes and shoreline vegetation.
Wet Extended Detention Pond	Pond that treats a portion of the water quality volume by detaining storm flows above the permanent pool for a specified minimum detention time.	Storage/ Treatment	✗	The permanent wet pool can provide significant water quality improvement across a relatively broad spectrum of constituents, including dissolved nutrients. Wet extended detention ponds can provide aesthetic value and wildlife habitat. Ponds are often viewed as a public amenity when integrated into a park setting.	Potential for thermal impacts, downstream warming, and potential for mosquito breeding. Not recommended for use in karst geology.	80	51	33	62	70	81	Cannot be placed on steep unstable slopes.	Monitor sediment accumulation and remove periodically. Remove debris from inlet and outlet structures. Maintain side slopes and shoreline vegetation.
Extended Detention Wetland	A wetland system that provides a portion of the water quality volume by detaining storm flows above the marsh surface.	Storage/ Treatment	✗	Maximizes the removal of pollutants through wetland vegetation uptake, retention, and settling. Provides some enhancement of site aesthetics and may provide wildlife habitat.	May consume a relatively large amount of space, making it an impractical option in many subbasins. Improper design can become a breeding area for mosquitoes. Requires careful design and planning to ensure that wetland plants are sustained after installation. Not recommended for use in karst geology.	76	49	30	42	78	85	In karst topography, wetlands would need to be designed with an impermeable liner to prevent ground water contamination or sinkhole formation, and to help maintain the permanent pool.	Control of invasive species, periodic removal of accumulated sediments around inlet and outlet structures.

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Table 11-3 (Cont.): Low Impact Development (LID) Integrated Management Practice (IMP) Possible Options for the Finegayan Main Cantonment Area, Guam

LID Option	Description	Typical IMP Treatment Train Function	Suitability for Finegayan*	Primary Function(s)/Advantages	Disadvantages	Pollutant Removal Efficiency						Constructibility and Other Considerations	Maintenance Requirements
						Total Suspended Solids [TSS (%)]	Total Phosphorus [TP (%)]	Total Nitrogen [TN (%)]	Metals (%)	Bacteria (%)	Hydrocarbons (%)		
Pocket Wetland/Pond	A wetland or pond design adapted for treatment of runoff from small drainage areas. The term "pocket" refers to a wetland or pond that has such a small contributing drainage area that little or no baseflow is available to sustain water elevations during dry weather. Instead, water elevations are heavily influenced and, in some cases, maintained by groundwater.	Storage/ Treatment	×	Maximizes the removal of pollutants through wetland vegetation uptake, retention, and settling. This option may be used when there is not significant drainage area to maintain a permanent pool. Provides some enhancement of site aesthetics and may provide wildlife habitat.	Relies on groundwater inputs to maintain a permanent pool, thus not suitable for soils with high permeability (karst geology). Improper design can become a breeding area for mosquitoes. Requires careful design and planning to ensure that wetland plants are sustained after installation.	76	49	30	42	78	85	In this design, the bottom of the wetland intersects the ground water, which helps to maintain the permanent pool. In karst topography, wetlands would need to be designed with an impermeable liner to prevent ground water contamination or sinkhole formation, and to help maintain the permanent pool. Some evidence suggests that ground water flows may reduce the overall effectiveness of storm water management practices.	Control of invasive species, periodic removal of accumulated sediments around inlet and outlet structures.
Shallow Marsh	A wetland that provides water quality treatment primarily in wet shallow marsh.	Storage/ Treatment	×	Maximizes the removal of pollutants through wetland vegetation uptake, retention, and settling. Provides some enhancement of site aesthetics and may provide wildlife habitat.	May consume a relatively large amount of space, making it an impractical option in many subbasins. Improper design can become a breeding area for mosquitoes. Requires careful design and planning to ensure that wetland plants are sustained after installation. Not recommended for use in karst geology.	76	49	30	42	78	85	In karst topography, wetlands would need to be designed with an impermeable liner to prevent ground water contamination or sinkhole formation, and to help maintain the permanent pool.	Control of invasive species, periodic removal of accumulated sediments around inlet and outlet structures.
Detention Basin (Dry)	A dry detention basin consists of a settling basin with an outlet sized to slowly release detained runoff. A "dry" detention basin is designed to be empty between usages.	Storage	✓	The primary purpose of a detention basin is to attenuate peak flows and act as temporary storage of stormwater runoff. The basin can also function as a multi-purpose space such as a park or athletic field.	Ineffective at removing soluable pollutants. Site slope, depth to bedrock or groundwater can limit effectiveness.	N/A	20	28	40	<10	N/A	Should be located far enough downgradient in the watershed to most effectively reduce peak flows. Appropriate fencing/exclusionary devices should be installed for safety purposes for any potential body of standing water, particularly near family housing areas.	Typical vegetation maintenance such as mowing and weeding as required for aesthetic and safety purposes; sediment removal may be required after storm events if used as multi-purpose basin.

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12. Assessment of Potential Long-Term Stormwater IMP Scenarios

12.1 APPROACH

Based on the comprehensive assessment of potential stormwater management BMPs/IMPs discussed in Section 11, a sub-set of recommended IMPs has been developed. These individual IMPs, each determined to be applicable for use within the Finegayan Main Cantonment Area, were assessed for a variety of parameters as discussed in Section 12.3, including pollutant removal efficiencies for each of the six pollutants of concern. IMPs were then grouped together and sequenced to create five general treatment train types to address six general categories of stormwater treatment recommended for use within the study area.

In order to more efficiently develop preliminary requirements for managing and treating stormwater runoff within the proposed development for the Finegayan Main Cantonment Area, five representative subbasins were assessed. These ranged from Subbasin D, a relatively open area consisting of apartment housing complexes and associated parking areas, to Subbasin U, an almost completely impervious basin including storage and vehicle maintenance areas. The objective in assessing long-term stormwater management option was to provide storage and treatment for all runoff generated within each subbasin by the 95% storm event (the water quality volume [WQ_v] used in this study), with an emphasis on aboveground BMPs to encourage evapotranspiration, create a base-wide aesthetic benefit, and protect groundwater resources. Strategies to capture and infiltrate runoff (within each subbasin) from storms greater than the 95% event were described in Section 9.

To assess the potential for pollutant load reductions to the future conditions, non-point source modeling was also conducted to estimate future loading estimates with recommended IMP treatment trains proposed for the five representative subbasins in place. For this assessment, the modeled future land use pollutant loads presented in Section 10 for each subbasin were used for the pre-treatment annual loads. Then, the estimated IMP treatment train reduction efficiencies identified in the treatment train matrix were applied to determine the amount of pollutant loads removed from the various land use categories.

12.2 CONSTRAINTS VS. OPPORTUNITIES FOR INTEGRATED STORMWATER MANAGEMENT

Constraints as well as opportunities are anticipated to be present for implementing integrated stormwater management components at the Finegayan Main Cantonment Area. Some of the major factors are provided below:

Constraints

- High density of buildings, parking areas, and roadways relative to available open space for treatment trains leave little room for aboveground IMPs in some subbasins assessed as part of this study.
- Some Smart Growth areas are generally located in areas of higher topographic position, making them less desirable for use for stormwater treatment trains, if needed. Smart Growth areas or portions thereof could be located within lower portions of a subbasin if additional room is needed for stormwater treatment.
- While it is advisable from a stormwater perspective that Smart Growth areas be left naturally vegetated until actually needed for development, it is anticipated that Smart Growth areas will be cleared and graded along with all other areas during the U&SI programs. Leaving a Smart Growth area in its natural state will likely necessitate heavy grading equipment entering a developed site in the future, putting constructed facilities such as roadways at risk of being damaged. Therefore, from a construction perspective, it is recommended that Smart Growth areas be cleared and graded concurrently with surrounding areas. Long-term erosion

control measures should be implemented, such as stabilizing the soil surface with a grass seed mix or other low-growing vegetative cover until ready for development. SmartGrowth areas would need to be regularly maintained (mowed) to prevent establishment of aggressive/invasive species.

- High winds from typhoons may limit the number of locations where green roofs may be successfully used and are, therefore, generally not recommended for use in the cantonment..
- Resources and adequate labor would need to be provided for vegetated IMP maintenance including periodic inspection and weeding and occasional watering during extended drier conditions.
- Compaction of soil is a concern during construction activities in areas where higher infiltration rates are desirable.
- Sub-surface communication utilities present in NAVC reserve areas would need to be avoided and may affect treatment train layouts.

Opportunities

- Native soil's infiltration capacity provides for enhanced volume removal through infiltration.
- Street right-of-way allows for infiltration as utility lines run under the roadway.
- Porous pavement may be a possible option for nonvehicle areas, such as pedestrian use walkways and bus stops. However, porous pavement is not included in the recommended treatment trains; use of this feature would be by special exception only and may require vacuuming several times a year.
- Rain barrels and/or cisterns could be employed for residential and administrative buildings. While the relatively small volumes of these options would not likely have a major influence on attenuation of large storm events, they could provide a small amount of attenuation and source of nonpotable water for small-scale landscaping irrigation during drier times of the year.
- Larger cisterns, even neighborhood cisterns, could be used to harvest rooftop runoff for non-potable water uses, such as toilet flushing. Further treatment would enable other uses, such as clothes washing.
- Low building rooftops may provide an opportunity to use green roofs if protected from wind. Parapet designs for rooftops may also help facilitate the use of more green roofs in the cantonment area However, green roofs are not included in the recommended treatment trains; as noted above, green roofs are generally not recommended for use in the cantonment due to issues with wind loading.

12.3 IDENTIFICATION AND ASSESSMENT OF RECOMMENDED BMPS/IMPS

12.3.1 Methodology

As discussed above, Table 11-3 provides a palette of 23 potential stormwater IMPs and one IMP accessory evaluated for possible use at the Finegayan Main Cantonment Area. Table 11-3 also allows for comparison of the various IMPs in order to choose the most appropriate set of IMPs to establish specific treatment trains for pollutants of concern from a stormwater source and provides pollutant removal efficiencies for the various IMPs (where available). In order to further reduce these options and determine if an IMP is recommended, not recommended, or of limited or special applicability for the Finegayan Main Cantonment Area, the following parameters were assessed for the IMP selection process (generally based on parameters and methodology described in Volume II of the *CNMI and Guam Stormwater Management Manual* [Horsley Whitten Group 2006]):

- Land use (residential, commercial/operations, roadways, industrial, urban open) and specific sources of stormwater pollutants within each land use category
- Physical feasibility (soils, water table, drainage area, slope, head, available area for IMP construction within a subbasin)
- Watershed protection goals (capture and treatment of the 95% storm WQ_v, nature and sensitivity of the receiving waters (e.g. groundwater), etc.)
- Stormwater management capability (recharge, water quality, channel protection, quantity control)
- Pollutant removal (TSS, TN, TP, metals, bacteria, hydrocarbons)
- Community and environmental (maintenance, affordability, community acceptance, safety, habitat)

No one parameter described above determined the final recommendation of an IMP; all of these factors were considered together to make the determination. See Table 11-3 for the determination of recommended, not recommended, or limited/special application for each IMP considered. Based upon the selection of recommended IMPs and also considering IMPs with limited or special application for particular scenarios, these IMPs were then grouped into treatment trains by function. Each treatment train represents the recommended sequencing of IMPs to address six specific pollutant source scenarios (Table 12-1 and Figure 12-1 through Figure 12-5).

Following the example presented in Section 2 of the *CNMI and Guam Stormwater Management Manual* (2006), stormwater runoff within each of the five representative subbasins was simulated using HydroCAD Version 8 stormwater modeling software. HydroCAD is a computer program for modeling the hydrology and hydraulics of stormwater runoff, and is one of the standard methods used for these types of analyses. The model was used to determine peak discharge rates, as well as to size various types of surface, subsurface, and conveyance BMPs. For a given rainfall event, the model provides hydrograph generation and routing based on the NRCS TR-20 procedures. Runoff hydrographs are developed from rainfall using the dimensionless unit hydrograph, drainage areas, times of concentration, and SCS runoff curve numbers. Based on the results of rainfall analysis described previously in Section 5.6.5, the 95th percentile rainfall depth of 2.2 inches (24-hour duration) was used in the HydroCAD stormwater runoff analysis.

Based on guidance provided in the Guam Stormwater Management Manual, a Type IA 24-hour storm was used for the preliminary runoff analysis. As described in Section 5, the soils are considered to be Type A. Infiltration rates in the top soil range from 1.2 meters to 3.9 meters per day (3.9 ft to 12.8 ft/day). The HydroCAD analysis employed the same CN values for open space and impervious areas as used for the FLO-2D modeling (refer to Table 5-5). For the purposes of sizing subsurface infiltration BMPs (i.e., dry wells, infiltration chambers) an infiltration rate of 5 inches per hour (10 ft/day) has been assumed. The infiltration rate for bioretention basins was assumed to be approximately 3 inches/hour. These rates must be confirmed in the field before construction is initiated.

12.3.2 Treatment Train Components

Based upon the assessment methodology described above, Table 11-3 lists the determination of recommended, not recommended, or limited/special application for each IMP considered from the palette of options explored for the Finegayan Main Cantonment Area.

Recommended IMPs as identified in this study include:

- Dry wells
- Oil/sediment separators
- Dry swales
- Filter strips
- Bioretention basins
- Subsurface infiltration devices
- Subsurface TSS filter chambers
- Detention basins

The following IMPs and IMP accessory were identified as having limited or specific application:

- Green roofs
- Rain barrels and cisterns
- Porous pavement
- Inlet protectors (in the event a curb inlet is needed under special circumstances)

Additional IMPs determined to have limited applicability for a variety of reasons as discussed in Table 11-3 include: organic filters, sand/gravel filters, infiltration trenches, and infiltration basins. These limited IMPs could be employed for use in treatment trains; however, based on the assessment described above, the recommended IMPs are more suitable for application in this study.

IMPs not recommended for use include: standard grass channels, wet swales, micropool extended detention ponds, wet ponds, wet extended detention ponds, extended detention wetlands, pocket wetlands/pocket ponds, and shallow marshes. Standard grass channels are not recommended since dry swales provide similar conveyance functions with the added benefit of levels of treatment of most pollutants of concern.

Wet swales, micropool extended detention ponds, wet ponds, wet extended detention ponds, extended detention wetlands, pocket wetlands/pocket ponds, and shallow marshes are not recommended because the rapid infiltration rates of the karst geology below the cantonment. These IMPs typically require some level of sustained hydrology as part of their design and would require additional engineering of soils, such as clay liners, to accomplish this. In addition, many of these IMPs may present mosquito breeding hazards as a result of the presence of prolonged standing water and are not recommended for use at the site. In addition, the Chesapeake Stormwater Network's June 2009 *Technical Bulletin No. 1: Stormwater Design Guidelines for Karst Terrain in the Chesapeake Bay Watershed – Version 2.0* discourages the use of wet ponds and extended detention ponds and prohibits the use of wet swales in karst regions. In the Technical Bulletin, constructed wetlands are determined to be adequate for use in karst regions, but as discussed above and in the bulletin, liners would be required. The Technical Bulletin also indicates that, as a general rule, a stormwater system in karst terrain should avoid large contributing areas, deep excavations, or pools of standing water. These and other recommendations in the Technical Bulletin have been considered during the IMP selection process in this study.

The treatment train components further described in this section (in addition to the detail provided in Table 11-3) include dry wells, vegetative practices (dry swales, filter strips), bioretention basins, oil/sediment separators, and sub-surface infiltration systems. While some of these IMPs are also used in more traditional stormwater management they can provide important functions in low impact development projects with constraints related to siting and geology.

Dry Wells

Dry wells are a basic variation of the underground trench and, under the proposed LID plan, are intended to accept only rooftop stormwater from residential or commercial building. As noted in Section 11.1.3.10, dry wells are a variation of downspout disconnection whereby roof runoff is directed away from the traditional stormwater piping system. The leader from the roof is extended into an underground dry well, which is situated a minimum of 10 ft away from the building foundation. Rooftop gutter screens are needed to trap any particles, leaves and other debris and must be regularly cleared.

Dry wells can effectively reduce the increase in postdevelopment runoff volume produced during small and moderate sized storms. These devices are not intended to provide much removal of coarse particulate pollutants; however, fine particulates and soluble pollutants are effectively removed after exfiltrating through the dry well and into the soil. Subsurface stormwater infiltration BMPs such as dry wells are approved for use in the *CNMI and Guam Stormwater Management Manual* (refer to the Case Studies in Section 4.4). For the proposed project, dry wells have been sized to capture roof runoff generated by the 80% storm event for a 5,000 ft^2 area (approximate). These precast concrete structures would be 9 ft in diameter and 4 ft deep. The dry well stone fill is typically 1.5 to 3.0 inches diameter.

Rain Barrels and Cisterns

In some cases, above-ground cisterns to store roof runoff for possible water reuse will also be incorporated into the plan. These structures will not contribute to either treatment or storage of runoff (they are assumed to be already full during storm events), and therefore are considered offline/side stream elements of the rooftop treatment train. Under the proposed cistern/drywell configuration, runoff from each section of roof would be intercepted by a cistern, with the overflow directed to an adjacent dry well. A typical cistern (6-ft high, with a diameter of 12-ft) would have a capacity of approximately 5,000 gallons. Based on HydroCAD modeling results, runoff from a 5,000 ft^2 section of roof during the 95% storm event would result in a discharge of approximately 6,000 gallons.

Dry Swales and Filter Strips

For the proposed project, dry swales would be employed to intercept and convey stormwater runoff to downstream IMPs such as bioretention and detention basins. Dry swales can also provide some level of treatment while conveying flows. Generally, the swales are 16-ft wide (top) and 2-ft deep. The swales would consist of mowed grass, with slopes designed to maintain runoff velocities at less than 1 ft per second (fps). To increase the level of treatment, these swales could be modified to include native grasses and sedges (with minimal mowing) and check dams for slowing flow within the channel. However, dry swales located within the 1,000 ft Wellhead Protection Area would be lined to prevent groundwater recharge.

Filter strips are similar in many respects to grassed swales except that they are designed to only accept overland sheet flow. For the proposed development, they would intercept runoff from adjacent paved areas, and overflowing dry wells (roof runoff). To function properly, filter strips must be equipped with some sort of level spreading device; be densely vegetated with a mix of erosion resistant plant species; and graded to a uniform and relatively low slope.

Porous Pavement

As a BMP, porous (or pervious) pavement is generally only feasible on sites with gentle slopes, permeable soils, and relatively deep water table. In the Study Area, porous pavement would be used for pedestrian walkways and low traffic volume roadways. It is assumed that these areas would provide a recharge function rather than pollutant removal. The advantages of including porous pavement where applicable include reduction or elimination of curb and gutters and downstream conveyance systems, and preservation of the natural water balance at the site. Maintenance requirements are similar to conventional pavement.

Bioretention Basins

Bioretention basins are landscaped depressions or shallow basins designed to store and treat on-site stormwater runoff from reasonably small upstream areas (generally less than 2 acres). These basins provide stormwater management, pollutant removal and landscaping/habitat improvement. When incorporated into site design, bioretention involves minimal cost other than proper soil modification, grading and planting native species of shrubs; grasses etc. The basins are 2.5 feet deep including a shallow temporary ponding area (typically about 6-inches deep); standing water infiltrates within 24-36 hours. The proposed bioretention basins have been sized to store runoff from the 95% storm, with an assumed infiltration rate of 3-inches per hour. Since bioretention areas require shallow ponding they are generally appropriate for karst regions.

Stormwater Oil/Sediment Separator

These devices (such as Stormceptor®) are water quality structures that take the place of a conventional manhole within a storm drain system, and that are designed to remove free oil (TPH) and up to 80% of TSS from stormwater. Typically, stormwater runoff flows through an inlet protection before being directed to the oil/sediment separator. The oil/sediment separators would be used treat runoff from high pollutant areas such as military vehicle parking lots and maintenance facilities, before discharging to aboveground or belowground BMPs.

These devices have a lower treatment chamber, and an upper bypass chamber. Stormwater flows into the by-pass chamber via the storm drain pipe. Low flows are diverted into the treatment chamber by a weir and drop pipe arrangement. The treatment chamber is always full of water. Water flows up through the outlet pipe based on the head at the inlet weir, and is discharged back into the bypass chamber downstream of the weir. The downstream section of the bypass chamber is connected to the outlet storm drainpipe. Free oils and other liquids lighter than water would rise in the treatment chamber and become entrapped beneath the fiberglass insert since the outlet pipe is submerged. Sediment would settle to the bottom of the chamber by gravity. The circular design of the treatment chamber is critical to prevent turbulent eddy currents and to promote settling. During high flow conditions, stormwater in the bypass chamber would flow over the weir and be conveyed to the outlet storm drain directly. Water that overflows the weir creates a backwater effect on the outlet pipe (head stabilization between the inlet drop pipe and outlet riser pipe) ensuring that excessive flow would not be forced into the treatment chamber, which could scour or resuspend the settled material.

Maintenance of these units is required, but is a routine procedure performed from the surface via a vacuum truck.

Subsurface Stormwater Infiltration System (including TSS Filter Chamber)

Increasingly, subsurface infiltration chambers are replacing conventional stormwater retention/detention systems; particularly in areas with limited open space dedicated to stormwater control. These chambers (such as Cultec®) are typically installed beneath parking areas to capitalize on use of space. Runoff is treated through a structural stormwater treatment system device (such as Stormceptor®), followed by flow through a subsurface TSS filter chamber for additional TSS removal, and then directed into a series of chambers via a header system. The chamber contact area is maximized by having an open bottom and perforated sidewalls. For the proposed project, these systems have been sized to provide detention and infiltration for the runoff generated by the 95% storm. Subsurface stormwater infiltration BMPs such as subsurface infiltration chambers are approved for use in the *CNMI and Guam Stormwater Management Manual* (refer to the Case Studies in Section 4). However, in order to avoid permitting requirements under the UIC program, these devices will 2/3 open and grated to the surface.

Green Roof Systems

Low building rooftops are recommended for consideration of green roof applications if protected from strong winds. These could include low building surrounded by taller buildings or low buildings in areas of low topography sheltered somewhat from prevailing typhoon winds. To assist in wind resistance, parapet designs and/or ballast systems may be employed to facilitate the use of more green roofs in the cantonment area. Several different green roof systems are commercially available. A green roof system developed by Live Roofs has been shown to withstand 110+ mph sustained wind bench test for approximately two hours with no loss of plants or soil. A green roof system developed by Hydrotech uses weighted ballasts around the edges of the green roof planting areas to assist in sustaining higher wind loads. None of the green roof systems investigated during this study have indicated that data was available for green roof use in areas with winds up to 170 mph. However, based on the final layout of buildings, building height, and topography, opportunities to use green roofs, at least on a small scale, should be available. Parapet designs should be included wherever possible to further guide damaging winds around the edges of rooftops. Green roof systems need to be custom-tailored to each building; therefore, a reputable green roof firm should be retained for the final design and installation.

Recommended plant species for green roofs at the Finegayan Main Cantonment Area need to be able to withstand sunny, dry periods as well as intense wind and rain from typhoon events. A mixture of species is recommended and should be generally be low-growing and suitable for survival in USDA hardiness zones 9 through 11, compatible with the general climate of Guam. Sedums, such as *Sedum ellacombianum, Sedum lydium, Sedum mexicanum, Sedum moranense,* and *Sedum spurium*, are low-growing and have moderate to very high drought tolerance. Sedums are typically well suited for green roofs due to their ability to withstand high temperatures and drought as well as high wind and rain events. Other plant species that could be used include: *Carex pansa*, a spreading lawn-like sedge, *Narcissus asturiensis*, *Phlox subulata*, and *Rosularia chrysantha*, among many others. Where applicable, species native to Guam should be used as part of the green roof species assemblage.

12.3.3 Treatment Train Pollutant Removal Efficiencies

As indicated above, individual IMPs were assessed for pollutant removal efficiency for each of the six pollutants of concern, as well as the other parameters listed in Section 12.3.1. IMPs were then grouped together in Table 12-1 and sequenced to create five general treatment train types to address six general categories of stormwater treatment anticipated at the Finegayan Main Cantonment Area:

- Treatment Train A: Rooftop Runoff
- Treatment Train B: Impervious Paved Areas with Insignificant Oil/Suspended Metals
- Treatment Train C: Impervious Paved Areas with Significant Oil/Suspended Metals, or Large Areas for Vehicle Parking
- Treatment Train D: Impervious Paved Roadways with Insignificant Oil/Suspended Metals

- Treatment Train E: Landscaping, Grass, and Recreation Areas

Identifying treatment trains strictly by land use is not the most effective means of addressing stormwater quality because most land use categories identified for the Finegayan Main Cantonment Area contain more than one source of stormwater. Each source of stormwater within a land use category needs to be evaluated for particular pollutants of concern and one of the five treatment trains identified in this study needs to be chosen accordingly and modified as necessary to effectively treat the WQ_v.

These five treatment trains are representative of the types to be used within the study area and are generally modeled after the five treatment trains identified in the *Low Impact Development Manual* (DON 2009). Variations of one or more of these five treatment trains may be needed under certain circumstances in order to adapt to a particular site constraint within a particular subbasin. Hence, the IMP sequences presented for each treatment train are flexible. Alternative IMP options could be substituted from the options provided in Table 11-3, as necessary.

Table 12-1 also provides the step-wise pollutant reduction efficiency for each pollutant of concern. The "Original Load" column for each treatment train analysis begins with the addition of 100 "units" of a particular pollutant for ease of relative comparison. These 100 units are then treated by the first IMP in the train, resulting in a percent reduction of a given value for the particular IMP employed. The remaining level of pollutants then enters the second IMP in the train and those pollutants are further reduced by the efficiency of that second IMP, with the resulting cumulative removal rate shown in the right-hand column "Cumulative % Removed". Pollutant reduction thus continues in a step-wise fashion through the remainder of the treatment train. A dashed line in the table within each treatment train indicates the point in the treatment train where the volume of the 95% storm is anticipated to be contained. Reduction values shown as N/A in the IMP table were calculated as 0.1% for these reduction efficiency calculations.

As designed, each treatment train will capture and treat all the runoff generated by the 95% storm event. Therefore, under this scenario, no wet weather flow will reach the downstream detention basin shown at the terminus of each of the six treatment trains. Although the detention basins and conveyances to these basins will provide some additional treatment, the purpose of the detention basins is to capture and infiltrate runoff from storms greater than the 95% event. Therefore, stepwise pollutant reduction calculations in Table 12-1 are only shown up to the point where the 95% storm event is captured and treated.

Figure 12-1 through Figure 12-5 provide schematic flow diagrams of each of the five treatment train types. These diagrams are modeled after those found in the *Low Impact Development Manual* (DON 2009). Each diagram shows both the specific recommended IMP (rectangular graphic) and the function that IMP provides (oval graphic) for each step in the treatment train. While this portion of the study focuses on stormwater quality and treatment of up to the 95% storm, all recommended IMPs for each treatment train are shown in the schematic flow diagrams, including detention basins at the terminus of each treatment train. Dashed lines in each figure indicate the point within each treatment train where the 95% and 2-year to 100-year storms are captured.

Table 12-1: Proposed LID IMP Representative Stormwater Treatment Trains and Associated Pollutant Removal Efficiencies for the Finegayan Main Cantonment Area, Guam

Treatment Train A: Rooftop Runoff			Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓
Purpose	**IMP**	**Total Suspended Solids Removal Efficiency [TSS (%)]**	100	0	**Total Phosphorus Removal Effivciency [TP (%)]**	100	0	**Total Nitrogen Removal Efficiency [TN (%)]**	100	0	**Metals Removal Efficiency (%)**	100	0	**Bacteria Removal Efficiency (%)**	100	0	**Hydrocarbons Removal Efficiency (%)**	100	0
Recharge	Drywell	80%	20.0	80.0%	0.1%	99.9	0.1%	0.1%	99.9	0.1%	0.1%	99.9	0.1%	0.1%	99.9	0.1%	0.1%	99.9	0.1%
Pre-Treatment	Filter Strip	28%	14.4	85.6%	20.0%	79.9	20.1%	20.0%	79.9	20.1%	40.0%	59.9	40.1%	0.1%	99.8	0.2%	0.1%	99.8	0.2%
Conveyance	Dry Swale	81%	2.7	97.3%	34%	52.7	47.3%	84%	12.8	87.2%	70%	18.0	82.0%	0.1%	99.7	0.3%	62%	37.9	62.1%
Water Quality and Recharge	Bioretention Basin	80%	0.5	97.3%	51%	25.8	74.1%	33%	8.6	91.4%	62%	6.8	93.2%	70.0%	29.9	70.1%	81%	7.2	92.8%
Conveyance	Dry Swale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Storage	Detention Basin (Dry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total % Removal at 95% Storm=		**97.3%**	Total % Removal at 95% Storm=		**74.1%**	Total % Removal at 95% Storm=		**91.4%**	Total % Removal at 95% Storm=		**93.2%**	Total % Removal at 95% Storm=		**70.1%**	Total % Removal at 95% Storm=		**92.8%**

Treatment Train B: Impervious Paved Areas with Insignificant Oil/Suspended Metals			Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓
Purpose	**IMP**	**Total Suspended Solids Removal Efficiency [TSS (%)]**	100	0	**Total Phosphorus Removal Effivciency [TP (%)]**	100	0	**Total Nitrogen Removal Efficiency [TN (%)]**	100	0	**Metals Removal Efficiency (%)**	100	0	**Bacteria Removal Efficiency (%)**	100	0	**Hydrocarbons Removal Efficiency (%)**	100	0
Pre-Treatment (TSS, minor oil)	Filter Strip	28%	72.0	28.0%	20%	80.0	20.0%	20%	80.0	20.0%	40%	60.0	40.0%	0.1%	99.9	0.1%	0.1%	99.9	0.1%
Pre-Treatment (TSS, minor oil) and Conveyance	Dry Swale	81%	13.7	86.3%	34%	52.8	47.2%	84%	12.8	87.2%	70%	18.0	82.0%	0%	99.8	0.2%	62%	38.0	62.0%
Water Quality and Recharge	Bioretention Basin	80%	2.7	97.3%	51%	25.9	74.1%	33%	8.6	91.4%	62%	6.8	93.2%	70.0%	29.9	70.1%	81%	7.2	92.8%
Conveyance	Dry Swale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Storage	Detention Basin (Dry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total % Removal at 95% Storm=		**97.3%**	Total % Removal at 95% Storm=		**74.1%**	Total % Removal at 95% Storm=		**91.4%**	Total % Removal at 95% Storm=		**93.2%**	Total % Removal at 95% Storm=		**70.1%**	Total % Removal at 95% Storm=		**92.8%**

Note: Reduction values shown as N/A in Table 11.2 were calculated as %0.1 for these reduction efficiency calculations. Stepwise pollutant removal efficiency calculations are included for IMPs in each treatment train to the point where the 95% storm is captured. Stormwater flows greater than the 95% storm continue through the remainder of each treatment train, terminating at a dry detention basin. While IMPs downgradient of the 95% storm capture point contribute to pollutant removal to varying degrees, these further calculations are not included in this table since this table primarily addresses the capture and treatment of the 95% storm.

Note: – · – · – · – indicates the point in the treatment train where the 95% storm is anticipated to be contained.

Table 12-1 (Cont.): Proposed LID IMP Representative Stormwater Treatment Trains and Associated Pollutant Removal Efficiencies for the Finegayan Main Cantonment Area, Guam

Treatment Train C: Impervious Paved Areas with Significant Oil/Suspended Metals or Large Areas for Vehicle Parking			Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓
Purpose	**IMP**	**Total Suspended Solids Removal Efficiency [TSS (%)]**	100	0	**Total Phosphorus Removal Effivciency [TP (%)]**	100	0	**Total Nitrogen Removal Efficiency [TN (%)]**	100	0	**Metals Removal Efficiency (%)**	100	0	**Bacteria Removal Efficiency (%)**	100	0	**Hydrocarbons Removal Efficiency (%)**	100	0
Pre-Treatment (Oil, Metal, TSS)	Proprietary Oil, Metal, TSS Separator (OWS) such as Stormcepter®	80%	20.0	80.0%	0.1%	99.9	0.1%	0.1%	99.9	0.1%	80.0%	20.0	80.0%	0.1%	99.9	0.1%	93%	7.0	93.0%
Pre-Treatment (TSS)	Proprietary Subsurface TSS Filter Chamber (e.g. CULTEC® Stormfilter)	77%	4.6	95.4%	0.1%	99.8	0.2%	0.1%	99.8	0.2%	0.1%	20.0	80.0%	0.1%	99.8	0.2%	0.1%	7.0	93.0%
Recharge	Proprietary Subsurface Infiltration Device (e.g. CULTEC®)	0.1%	4.6	95.4%	0.1%	99.7	0.3%	0.1%	99.7	0.3%	0.1%	20.0	80.0%	0.1%	99.7	0.3%	0.1%	7.0	93.0%
Conveyance	Dry Swale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Storage	Detention Basin (Dry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total % Removal at 95% Storm=		**95.4%**	Total % Removal at 95% Storm=		**0.3%**	Total % Removal at 95% Storm=		**0.3%**	Total % Removal at 95% Storm=		**80.0%**	Total % Removal at 95% Storm=		**0.3%**	Total % Removal at 95% Storm=		**93.0%**

Treatment Train D: Impervious Paved Roadways with Insignificant Oil/Suspended Metals			Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓
Purpose	**IMP**	**Total Suspended Solids Removal Efficiency [TSS (%)]**	100	0	**Total Phosphorus Removal Effivciency [TP (%)]**	100	0	**Total Nitrogen Removal Efficiency [TN (%)]**	100	0	**Metals Removal Efficiency (%)**	100	0	**Bacteria Removal Efficiency (%)**	100	0	**Hydrocarbons Removal Efficiency (%)**	100	0
Pre-Treatment (TSS, minor oil) and Conveyance	Dry Swale	81%	19.0	81.0%	34%	66.0	34.0%	84%	16.0	84.0%	70%	30.0	70.0%	0%	99.9	0.1%	62%	38.0	62.0%
Water Quality and Recharge	Bioretention Basin/Swale	86%	2.7	97.3%	59%	27.1	72.9%	38%	9.9	90.1%	69%	9.3	90.7%	37%	62.9	37.1%	84%	6.1	93.9%
Conveyance	Dry Swale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Storage	Detention Basin (Dry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total % Removal at 95% Storm=		**97.3%**	Total % Removal at 95% Storm=		**72.9%**	Total % Removal at 95% Storm=		**90.1%**	Total % Removal at 95% Storm=		**90.7%**	Total % Removal at 95% Storm=		**37.1%**	Total % Removal at 95% Storm=		**93.9%**

Note: Reduction values shown as N/A in Table 11.2 were calculated as %0.1 for these reduction efficiency calculations. Stepwise pollutant removal efficiency calculations are included for IMPs in each treatment train to the point where the 95% storm is captured. Stormwater flows greater than the 95% storm continue through the remainder of each treatment train, terminating at a dry detention basin. While IMPs downgradient of the 95% storm capture point contribute to pollutant removal to varying degrees, these further calculations are not included in this table since this table primarily addresses the capture and treatment of the 95% storm.

Note: — · — · — · — indicates the point in the treatment train where the 95% storm is anticipated to be contained.

Table 12-1 (Cont.): Proposed LID IMP Representative Stormwater Treatment Trains and Associated Pollutant Removal Efficiencies for the Finegayan Main Cantonment Area, Guam

Treatment Train E: Landscaping, Grass, and Recreation Areas			Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓		Original Load ↓	Cumulative % Removed ↓
<u>Purpose</u>	**<u>IMP</u>**	**Total Suspended Solids Removal Efficiency [TSS (%)]**	100	0	**Total Phosphorus Removal Effivciency [TP (%)]**	100	0	**Total Nitrogen Removal Efficiency [TN (%)]**	100	0	**Metals Removal Efficiency (%)**	100	0	**Bacteria Removal Efficiency (%)**	100	0	**Hydrocarbons Removal Efficiency (%)**	100	0
Pre-Treatment (TSS)	Filter Strip (where required)	28%	72.0	28.0%	20%	80.0	20.0%	20%	80.0	20.0%	40%	60.0	40.0%	0.1%	99.9	0.1%	0.1%	99.9	0.1%
Pre-Treatment (TSS) and Conveyance	Dry Swale	81%	13.7	86.3%	34%	52.8	47.2%	84%	12.8	87.2%	70%	18.0	82.0%	0%	99.8	0.2%	62%	38.0	62.0%
Water Quality (nutrients) and Recharge	Bioretention Basin	80%	2.7	97.3%	51%	25.9	74.1%	33%	8.6	91.4%	62%	6.8	93.2%	70.0%	29.9	70.1%	81%	7.2	92.8%
Conveyance	Dry Swale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Storage	Detention Basin (Dry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total % Removal at 95% Storm=		**97.3%**	Total % Removal at 95% Storm=		**74.1%**	Total % Removal at 95% Storm=		**91.4%**	Total % Removal at 95% Storm=		**93.2%**	Total % Removal at 95% Storm=		**70.1%**	Total % Removal at 95% Storm=		**92.8%**

Note: Reduction values shown as N/A in Table 11.2 were calculated as %0.1 for these reduction efficiency calculations. Stepwise pollutant removal efficiency calculations are included for IMPs in each treatment train to the point where the 95% storm is captured. Stormwater flows greater than the 95% storm continue through the remainder of each treatment train, terminating at a dry detention basin. While IMPs downgradient of the 95% storm capture point contribute to pollutant removal to varying degrees, these further calculations are not included in this table since this table primarily addresses the capture and treatment of the 95% storm.

Note: — · — · — · — indicates the point in the treatment train where the 95% storm is anticipated to be contained.

12.4 IMP LAYOUTS

Based on the treatment train options developed for this project, and presented in Table 12-1, IMP layouts for each of the representative subbasins were developed. Figure 12-6 presents the entire project study area, indicating where each of the five subbasins analyzed is located. In addition, the individual subbasins are presented in Figure 12-7 through Figure 12-11, Each representative subbasin includes stormwater flow paths for both the 95% storm, and runoff from storms exceeding the 95% event. As indicated on these figures, stormwater within each subbasin is directed to detention basins sized to capture runoff from storms ranging between the 2-year and the 100-year event (the size of an individual detention basin is governed by open-space restrictions within each subbasin). An alternative plan for siting these detention basins has been developed and is presented in Appendix B. However, since NAVFAC has not yet reviewed the revised detention basin layout, the five representative subbasins (Figure 12-7 through Figure 12-11) contain the detention basin locations developed for the circa March 2010 Revised Draft Report. HydroCAD modeling results for examples of the treatment train layouts are included in Appendix D. Within each subbasin, all runoff generated by the 95% storm event receives treatment before infiltration. For each of the five subbasins, a layout in GIS format and a brief description of the proposed stormwater management scenario is presented. The layouts also depict pollutant stormwater hotspot land uses, if any, present in each subbasin (see discussion in Section 3).

The notional site grading presented in this study is conceptual. During final design, the site would be refined to accommodate the proposed stormwater BMPs. As noted on each subbasin figure, elevation for the preliminary notional grading is presented in meters and feet, while the elevation for BMPs is given in ft. Finally, four of the five basins selected contain areas designated for future "Smart Growth"; these areas were not used for siting potential IMP layouts.

12.4.1 Subbasin D

Subbasin D is representative of a comparatively low development area. Characterized by relatively large area of open landscaped terrain (approximately 51%), Subbasin D includes five housing complexes (each approximately 29,000 ft^2), three privately owned vehicle (POV) parking areas, and a large area designated for smart growth (approximately 4.4 acres).

As presented in Figure 12-7 (at end of section), roof runoff from each of the five buildings within the subbasin flows to a series of cisterns, and adjacent dry wells sized to capture the 80% storm. The results of HydroCAD modeling indicate that each dry well would empty completely within approximately 10 hours (based on an exfiltration rate of approximately 5-inches per hour). Overflow discharge from these sub surface structures would travel overland via filter strips to an adjacent dry swale. This runoff is then diverted via dry swale to one of five bioretention basins sized to capture the 95% storm event before overflowing (Treatment Train A). The available storage of the bioretention basins proposed for Subbasin D ranges from 4,000 cubic feet (ft^3) (BB-4 and BB-5) to 9,200 ft^3 (BB-1, BB-2, and BB-3).

Two approaches to manage runoff from the POV parking areas were assessed. The first alternative assumes that runoff from these areas would be directed to filter strips before discharging to dry swales and then to wet ponds located immediately downstream (Treatment Train B). Peak runoff from the POV areas during the 95% storm is estimated to be approximately 0.3 cfs. The second (and preferred) alternative would be to install subsurface infiltration chamber devices underneath the parking areas to capture and infiltrate the runoff from these impervious areas. This alternative would require that the parking area be sloped in such a way that runoff is directed to an oil/sediment separator installed upstream of the infiltration device. The oil/sediment separators would be equipped with inlet protectors to intercept any floatable material. These subsurface systems have been sized to capture runoff from the 95% storm (Treatment Train C). In the event of larger storms (greater than the 95th percentile) the subsurface systems would overflow to the detention basin located in the northwest corner of Subbasin D (DB-2).

Based on hydrologic soil group (HSG) classification for the site, the grassed areas within Subbasin D have been assigned a runoff coefficient (CN) value of 39 (>75% grass cover, HSG A). There is predicted to be no runoff from these grassed areas during the 95% storm event. Any runoff from these areas during larger storm events would flow to shallow contoured depressions or dry swales. Runoff from the paved roadways within Subbasin D (associated with POV Areas 1, 2, and 3), and the porous pavement walkways, would discharge to a bordering grassed swale (Treatment Train D and #, respectively). Runoff from the Subbasin D perimeter roadway would be directed to a vegetated swale/ drainage system. Ultimately, runoff from Subbasin D would discharge to a large detention basin located in the northwest corner of the subbasin.

12.4.2 Subbasin H

As indicated on Figure 12-8, this subbasin is dominated by two large areas designated for smart growth (16.6 acres, 47% of the total area). Under post-construction conditions, 56% of the remaining subbasin area is proposed to be impervious. Roof runoff from Building B-1 would be directed to cisterns with overflow to adjacent dry wells (sized for the 80% storm), with the overflow from these structures intercepted by a dry swale before discharging to the adjacent bioretention basin (BB-1) (Treatment Train A). By contrast, runoff from the large parking area (POV 1, approximately 1 acre) located in the southern portion of Subbasin H would be directed to one of two stormwater oil/sediment separators sized to treat a peak flow of 0.5 cfs and then to a subsurface infiltration system, sized to capture the 95% storm (Treatment Train C). Any runoff from the 0.6-acre open paged area located north of Buildings B-1 and B-2, as well as a 0.3 acre portion of the subbasin access road (Treatment Train D), would flow over a filter strip before discharging to a dry swale, and then to bioretention basin BB-1. The available storage of the bioretention basins proposed for Subbasin H is 5,400 ft^3. Overflow from BB-1, resulting from storms larger than the 95th percentile event, would ultimately discharge via grassed swale to the detention basin currently located in the northeast corner of the smart growth area (DB-1).

Roof runoff from Building B-3, and the adjacent paved areas, would ultimately discharge to the bioretention basin located just to the north (BB-2) (Treatment Train A and B, respectively). As shown on Figure 12-8, stormwater runoff from the three parking areas located on either side of Building B-3 (POV 2, 3, and 4), would be directed to stormwater oil/sediment separators (sized to treat a peak flows ranging from 0.1 to 0.3 cfs) and then to subsurface infiltration systems, sized to capture the 95% storm (Treatment Train C). Similarly, roof runoff from Building B-4 as well as the paved re-use area surrounding the building would be directed to a subsurface infiltration system, also sized for the 95% storm. Overflow from these IMPs, resulting from storms larger than the 95th percentile event, would ultimately discharge to one of the two detention basins currently located within the smart growth area (DB-1 or DB-2).

12.4.3 Subbasin E

The most significant feature of Subbasin E is the approximately 13 acre area of open space (including two sink holes) in the northwest section of the subbasin. The stormwater management objective within this subbasin is to protect this open space from the effects of upstream stormwater runoff, while at the same time providing opportunity for aboveground stormwater storage and treatment. To that end, runoff from the up-gradient parking areas POV 1, and POV 2 and POV 3 will discharge to subsurface infiltration systems (Treatment Train C). The parking areas would be configured to direct wet weather flow to oil/particle separators before discharging to the subsurface systems. These systems have been sized for the 95% storm event. Overflow volumes resulting from larger storm events will discharge either to detention basin DB-3 (POV 1), or DB-1 (POV 2 and

POV 3). As indicated on Figure 12-9, roof runoff from Buildings B-1, B-2, B-3 and B-4 would follow the typical treatment train, with overflow from the building dry wells discharging to adjacent bioretention basins BB-1, BB-2, B-3, and B-4, respectively (Treatment Train A). These bioretention basins have been sized to detain runoff generated by the 95% storm. Overflow from larger storms would discharge via grassed swale to one of the three detention basins located within Subbasin E. Stormwater runoff from the approximately 2.4 acre paved pedestrian area (porous pavement) that extends roughly north-south between POV-2/POV-3 and Buildings B-3 and B-4, would travel via sheet flow to a dry swale before discharging to the detention basin located east of B-4 (Treatment Train D). Although the peak flow from this area during the 95% storm is only approximately 1.2 cfs, the dry swale would include check dams spaced approximately 150 ft apart to allow infiltration of this runoff. Under the 95% storm event, no runoff would discharge to the detention basin. Similarly, runoff from the east-west access road just north of POVs 6 – 9 would discharge via dry swale to BB-4 (Treatment Train D).

Roof runoff from Buildings B-5 and B-6, located in the western portion of the subbasin, would discharge to the adjacent bioretention basin (BB-5). Each of the remaining six POV parking areas would discharge to subsurface infiltration systems, following pre-treatment via oil/particle separators. Each system has been sized for the 95% storm event; however, there is ample area under the POV areas to install additional units that would allow the capture of much larger storms.

12.4.4 Subbasin BB

The proposed layout for Sub-basin BB presents a higher degree of development than the previous three basins. Not considering the two areas designated for future smart growth (6.4 acres), 79% of the remaining subbasin area is impervious, including two areas with vehicle grease and wash racks.

Aboveground IMPs have been employed, where possible, to provide better opportunity for evapotranspiration of stormwater runoff. For example, bioretention basins located adjacent to Buildings B-3, B-7, and B-10 will intercept and treat roof runoff from these structures up to the 95% storm (Treatment Train A). Basin BB-2 has also been sized to accept runoff from the paved pedestrian area east of Building B-7, and the access road west of B-7 (Treatment Train D).

As indicated on Figure 12-10, stormwater runoff from the remaining eight buildings and the pavement surrounding them, would also be directed to subsurface infiltration chambers (Treatment Train C). Within Subbasin BB, these subsurface infiltration devices have been sized to capture and infiltrate runoff from the 95% storm. Stormwater oil/sediment separators sized to provide treatment for peak flows resulting from the 95% storm would be installed upstream of each subsurface chamber layout. Overflow volumes from storms greater than the 95% event will discharge to one of the detention basins located within Subbasin BB. It is assumed that future design of the two vehicle maintenance areas (south of Building 2 and Buildings 5 and 6) would include secondary containment and/or sumps to capture runoff for subsequent treatment.

12.4.5 Subbasin U

The final representative subbasin is approximately 88% impervious, with three small areas designated for smart growth located along the eastern perimeter, and the southeast and southwest corners of the basin (0.8, 1.12, and 0.28 acres, respectively). With the exception of these three small areas, Subbasin U offers little opportunity for aboveground stormwater management. Although not included in the recommended treatment train for roof runoff (due to high wind loading constraints), installation of green roof systems on selected low-rise buildings within this subbasin might be considered. As indicated on Figure 12-11 (Note 1), the proposed method of stormwater management/treatment for the remaining area of Subbasin U is subsurface infiltration (Treatment Train C). These devices have been sized for the 95% storm, and would require the installation of stormwater oil/sediment separators sized upstream of each subsurface chamber layout. Overflow volumes from storms greater than the 95% event will discharge to the large detention basins located along the western boundary of Subbasin U (DB-1). Runoff from the Subbasin U perimeter roadway would be diverted to a dry swale.

12.4.6 Subbasin L (Area 5) Non-Residential Areas

The stormwater management objectives for nonresidential facilities within Subbasin L (Figure 12-6) are similar in scope to those presented for the Main Cantonment: capture and treatment of runoff from the 95% storm event; incorporate (where possible) aboveground BMPs. By way of illustration, the example of a large community facility (hospital) has been selected to demonstrate a potential approaches (treatment trains) for managing stormwater within a commercial area. Such a facility would typically have a considerable footprint, including the hospital structure itself, ancillary buildings such as a dedicated power plant and maintenance building, and a parking area.

To achieve the project objectives, several measures should be considered during the planning phase of the design, including maintaining as much native vegetation as possible throughout the site development, and reducing the overall facility footprint as much as possible by incorporating features such as dedicated parking structures as opposed to a large adjacent parking area typical for facilities such as hospitals.

Roof Runoff

It is recommended that the roof design for commercial facilities within Subbasin L (such as hospitals, schools, base maintenance garage etc.) consider green roof technology to the extent practicable. Green roofs would provide peak flow attenuation, as well as an opportunity for evapotranspiration and slightly reducing downstream storage requirements. However, as noted in Section 11, due to the high potential for damaging winds on Guam, this IMP is not recommended. Roof runoff would overflow first to a cistern, followed by subsurface infiltration (dry wells) and then to an adjacent bioretention area (Treatment Train A). Runoff from storms greater than the 95% event would discharge to a downstream detention basin. Roof runoff is also considered the best (cleanest) water supply for cisterns and an alternative to green roofs. Generally, the two strategies are not employed together.

Pavement Runoff

Based on the assumption that vehicle parking for the example facility would be generally restricted to a dedicated structure, the paved area surrounding the hospital could be reduced significantly. Runoff from this smaller paved area (e.g., handicapped parking, ambulance and delivery access, etc) could be directed via sheet flow to a filter strip/dry swale combination and then discharge to either a wet pond or bioretention basin sized for the 95% storm (Treatment Train B). Walkways and paved pedestrian areas would receive similar treatment (Treatment Train D), although in these cases porous pavement could be considered. If a traditional (larger) parking area is selected, runoff could be directed either to a subsurface infiltration system (Treatment Train C) or to the larger downstream detention basin via grassed swale (or some other conveyance) (Treatment Train B).

12.4.7 Subbasin L (Area 5) Residential Areas

Development of the residential section of Subbasin L would provide an opportunity to implement some of the basic subdivision and infrastructure design features of LID:

- Planning site layout and grading to natural land contours;
- Conserving open space;

- Residential cluster development; and
- Decreasing impervious surfaces.

Incorporating the overall residential site layout, and grading to natural land contours, can result in retaining a greater percentage of the land's natural hydrology (and reducing grading costs). Contours that function as natural filtration basins can be retained or enhanced for water quality and quantity, and incorporated into the landscaping design. A cluster housing development allows the same number of houses on a site as conventional zoning; however, constructing houses on smaller lots is more likely to allow preservation of large areas of a site as open space where houses can never be built. The layout for a clustered housing development can be arranged so that the steep slopes, natural drainageways, and areas of prime vegetation are designated as open space. By clustering lots closer together and facing them on open spaces, shorter roads (and less pavement) are required; smaller, narrower lots also help reduce the need for pavement in driveways and walks. Reducing roadway surfaces can retain more permeable land area; for example, pavement needs can be reduced by using longer, undulating roads that create more available lot frontage, instead of wide shorter streets with numerous intersections.

On a household level, it is recommended that the stormwater management plan essentially follow Treatment Train A and B, including the following elements: rain barrel/cistern collection systems; filter strips; vegetated swales (dry and wet); communal wet pond/bioretention area within a downstream open space. Rain barrels are low-cost retention devices placed below roof downspouts to collect stormwater runoff. Although rain barrels offer no primary pollutant removal benefit, they act as quantity controls and can help reduce the cumulative effects of stormwater on downstream systems. For example, one 42-gallon rain barrel can provide storage for 0.5 inch of runoff from a rooftop measuring 133 ft^2. This provides opportunities to re-use captured rainwater for secondary household applications such as toilet flushing or yard irrigation. Water overflowing from the rain barrel would flow via a dry grassed swale to a road side vegetated wet swale (rain garden) which in turn would be hydraulically connected to downstream swales running along individual lot-lines. Higher volume flows from this system would discharge to a larger wet pond or detention basin located within a communal open space area. Runoff from other impervious areas such as driveways and walkways would flow over a filter strip or grassed/vegetated area before discharging to the roadside wet swale.

12.5 COMPARISON OF FUTURE LOADING ESTIMATES WITH AND WITHOUT RECOMMENDED CONTROLS

The effect of implementation of the IMP treatment trains proposed for the five representative subbasins was assessed for the following three pollutants: TSS, TP, and TN (i.e. the parameters assessed in the non-point source pollution model; see Section 10). For this assessment, the modeled future land use pollutant loads presented in Section 10 for each subbasin were used for the pre-treatment annual loads (see “Annual Load” column in Table 12-2 through Table 12-4). The loads were estimated using the Simple Method, which is described in Section 10.1.1. As shown in Table 12-2through Table 12-4, these loads were broken out into pervious and impervious categories(using land use acres derived from detailed GIS data developed for the Draft GJMMP), and the land use acreage treated by a particular IMP treatment train was calculated using the HydroCAD model.

Capture discounts (i.e. the percentage of annual rainfall captured by a stormwater control) were applied to account for the share of the load assumed to reach the IMPs. Since no IMPs were specifically designated to treat pervious surfaces, a capture discount of 0.0 was used for these areas. For impervious surfaces, a capture discount of 0.95 was used since all proposed treatment trains are sized to treat up to the 95% storm. Application of these discount factors resulted in the estimated loads treated by the proposed IMPs (see "Captured Load" column in Table 12-2 through Table 12-4).

Then, the estimated IMP treatment train reduction efficiencies identified in Table 12-1 were applied to determine the amount of pollutant loads removed from the various land use categories. As shown in Table 12-2 through Table 12-4, this process resulted in estimated TSS reductions of 83.9% to 90.3%, TP reductions of 9.4% to 50.8%, and TN reductions of 11.2% to 62.7% for the representative subbasins. The lower end of these reduction percentage ranges for TP and TN generally reflect subbasins with large impervious paved areas (such as Subbasins U and BB), where treatment trains were tailored to achieve higher reductions in POCs deemed more critical for this type of land use, such as TSS, metals, and hydrocarbons.

A comparison of existing conditions pollutant loads to future conditions with treatment annual loads is also provided in Table 12-2 through Table 12-4. The Navy has established a goal of no net increase in stormwater volume and sediment or nutrient loading from major construction projects. TSS loads for all representative subbasins decrease compared to future conditions with treatment, while TP and TN loads generally show increases. The increases in nutrient loads are largely due to the pristine native vegetation/forest conditions of much of the existing project site and the associated low nutrient loading rates compared to developed lands, and the focus on achieving higher reductions in POCs deemed more critical for large impervious paved areas, as discussed above.

12.6 DESCRIPTION OF PROPOSED STORMWATER DETENTION BASINS

Detention basins contemplated in this report are generally 2 to 3 meters deep. This depth includes a freeboard amount of 0.5 meter. Side slope gradients of the detention basins have been planned at 2:1. In non-residential areas these basin geometrics are acceptable. However, in residential areas (outside the scope of this report) a shallower, broader detention basin with side slopes laid back to 4:1 or 5:1 would be warranted so to allow the "walk out" ability of young children entrapped in a detention basin. In all instances detention basins should be fenced off with access gates and warning signs depicting intermittent flooding. Detention basin lining would be of an engineered soil that allows sufficient infiltration. A typical detention basin is depicted in Figure 9-1 (Detention Basin Detail).

12.7 STORMWATER DETENTION BASIN INTERACTION WITH PROPOSED IMPS

The stormwater BMP/IMP layouts proposed for the five representative subbasins have been sized to capture and treat runoff from the 95% storm event (2.2 inches/24-hours). Infiltrating the runoff volume from this storm event will have a negligible effect on determining the size of a detention basin capable of storing runoff from a 50-year storm (approximately 20 in/24 hours).

Table 12-2: Estimated Total Suspended Solids Reduction from Proposed Treatment Trains

Sub-basin	Land Use Category	Acres[a]	Load Per Acre (lbs)[b]	Annual Load (lbs)	Captured Load (lbs)[c]	Treatment Train Reduction Efficiency	Load Removed (lbs)	Net Load (lbs)
D	Residential (Pervious)	14.1	21.3	300.7	0.0	—	0	300.7
	Residential (Impervious)	8.6						
	Treatment Train A	3.4	405.4	1,372.3	1,303.6	99.5%	1,297.1	75.1
	Treatment Train B	0.9	405.4	352.7	335.0	97.3%	326.0	26.7
	Treatment Train C	2.3	405.4	920.2	874.1	95.4%	833.9	86.2
	Treatment Train D	2.1	405.4	855.3	812.5	96.2%	790.6	64.7
	Roadway (Pervious)	0.9	32.0	28.9	0.0	—	0	28.9
	Roadway (Impervious)	1.5						
	Treatment Train D	1.5	608.0	942.0	894.9	97.3%	870.7	71.3
	Urban Open (Pervious)	4.4	14.9	65.8	0.0	—	0	65.8
	Urban Open (Impervious)	0.0	283.7	0.0	0.0	—	0	0.0
	Total Future Annual Load			4,837.8	Total Reduced Load			719.5
	% Reduction to Future Annual Load Due to Treatment Train							84.9%
	Existing Conditions Annual Load[c]			2,664.90	% Change to Existing conditions			-73.0%
E	Commercial/Ops (Pervious)	15.9	16.0	254.3	0.0	—	0	254.3
	Commercial/Ops (Impervious)	18.5						
	Treatment Train A	4.6	304.0	1,393.2	1,323.6	99.5%	1,316.9	76.3
	Treatment Train B	0.2	304.0	48.6	46.2	97.3%	45.0	3.7
	Treatment Train C	9.6	304.0	2,912.5	2,766.8	95.4%	2,639.6	272.9
	Treatment Train D	4.2	304.0	1,276.9	1,213.0	97.3%	1,180.3	96.6
	Roadway (Pervious)	1.8	32.0	57.9	0.0	—	0	57.9
	Roadway (Impervious)	5.7						
	Treatment Train D	5.7	608.0	3,445.8	3,273.5	97.3%	3,185.1	260.7
	Urban Open (Pervious)	16.0	14.9	238.9	0.0	—	0	238.9
	Urban Open (Impervious)	0.0	283.7	0.0	0.0	—	0	0.0
	Total Annual Load			9,628.0	Total Reduced Load			1,261.2
	% Reduction to Annual Load							86.9%
	Existing Conditions Annual Load[d]			5,326.00	% Change to Existing conditions			-76.3%
H	Commercial/Ops (Pervious)	6.5	16.0	103.7	0.0	—	0	103.7
	Commercial/Ops (Impervious)	7.1						
	Treatment Train A	0.9	304.0	271.3	257.7	99.5%	256.5	14.9
	Treatment Train B	0.6	304.0	185.4	176.2	97.3%	171.4	14.0
	Treatment Train C	3.9	304.0	1,194.8	1,135.0	95.4%	1,082.8	112.0
	Treatment Train D	1.7	304.0	516.8	491.0	97.3%	477.7	39.1
	Roadway (Pervious)	1.3	32.0	41.7	0.0	—	0	41.7
	Roadway (Impervious)	3.2						
	Treatment Train D	3.2	608.0	1,918.5	1,822.6	97.3%	1,773.4	145.1
	Urban Open (Pervious)	17.0	14.9	253.3	0.0	—	0	253.3
	Urban Open (Impervious)	0.0	283.7	0.0	0.0	—	0	0.0
	Total Future Annual Load			4,485.6	Total Reduced Load			723.8
	% Reduction to Annual Load Due to Treatment Trains							83.9%
	Existing Conditions Annual Load[d]			3,055.20	% Change to Existing conditions			-76.3%

Sub-basin	Land Use Category	Acres[a]	Load Per Acre (lbs)[b]	Annual Load (lbs)	Captured Load (lbs)[c]	Treatment Train Reduction Efficiency	Load Removed (lbs)	Net Load (lbs)
U	Industrial (Pervious)	2.0	25.6	52.2	0.0	—	0	52.2
	Industrial (Impervious)	58.0						
	Treatment Train C	58.0	486.4	28,196.7	26,786.9	95.4%	25,554.7	2,642.0
	Roadway (Pervious)	3.3	32.0	104.5	0.0	—	0	104.5
	Roadway (Impervious)	7.1						
	Treatment Train D	7.1	608.0	4,317.9	4,102.0	97.3%	3,991.3	326.7
	Urban Open (Pervious)	3.4	14.9	51.4	0.0	—	0	51.4
	Urban Open (Impervious)	0.0	283.7	0.0	0.0	—	0	0.0
	Total Future Annual Load			32,722.6	Total Reduced Load			3,176.7
	% Reduction to Future Annual Load Due to Treatment Trains							90.3%
BB	Commercial/Ops (Pervious)	3.3	16.0	53.0	0.0	—	0	53.0
	Commercial/Ops (Impervious)	8.2						
	Treatment Train A	1.1	304.0	339.4	322.4	99.5%	320.8	18.6
	Treatment Train B	0.2	304.0	57.8	54.9	97.3%	53.4	4.4
	Treatment Train C	5.5	304.0	1,672.1	1,588.5	95.4%	1,515.4	156.7
	Treatment Train D	1.4	304.0	431.7	410.1	97.3%	399.0	32.7
	Industrial (Pervious)	1.8	25.6	46.1	0.0	—	0	46.1
	Industrial (Impervious)	16.2						
	Treatment Train A	0.4	486.4	188.6	179.2	99.5%	178.3	10.3
	Treatment Train C	15.2	486.4	7,379.1	7,010.1	95.4%	6,687.6	691.4
	Treatment Train D	0.6	486.4	291.9	277.3	96.2%	266.7	25.1
	Roadway (Pervious)	1.5	32.0	47.4	0.0	—	0	47.4
	Roadway (Impervious)	4.5						
	Treatment Train D	4.5	608.0	2,754.0	2,616.3	97.3%	2,545.6	208.3
	Urban Open (Pervious)	7.8	14.9	116.6	0.0	—	0	116.6
	Urban Open (Impervious)	0.0	283.7	0.0	0.0	—	0	0.0
	Total Future Annual Load			13,377.6	Total Reduced Load			1,407.6
	% Reduction to Annual Load Due to Treatment Trains							89.5%
	Existing Conditions Annual Load[d]			3,920.40	% Change to Existing conditions			-64.1%

[a] Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO and NAVFAC 2009).

[b] Loads per acre calculated using the Simple Method (Schueler 1987).

[c] For pervious surfaces, a capture discount of 0.0 was used. For impervious surfaces, a capture discount of 0.95 was used since it was assumed that all impervious surfaces are treated up to the 95% storm event.

[d] Annual load derived from existing land use acres, as reported in Appendix B.

Table 12-3: Estimated Total Phosphorus Reduction from Proposed Treatment Trains

Sub-Basin	Land Use Category	Acres[a]	Load Per Acre (lbs)[b]	Annual Load (lbs)	Captured Load (lbs)[c]	Treatment Train Reduction Efficiency	Load Removed (lbs)	Net Load (lbs)
D	Residential (Pervious)	14.1	0.1	1.2	0.0	—	0	1.2
	Residential (Impervious)	8.6						
	Treatment Train A	3.4	1.6	5.5	5.2	74.2%	3.9	1.6
	Treatment Train B	0.9	1.6	1.4	1.3	74.1%	1.0	0.4
	Treatment Train C	2.3	1.6	3.7	3.5	0.3%	0.0	3.7
	Treatment Train D	2.1	1.6	3.4	3.3	67.7%	2.2	1.2
	Roadway (Pervious)	0.9	0.1	0.1	0.0	—	0	0.1
	Roadway (Impervious)	1.5						
	Treatment Train D	1.5	2.0	3.1	3.0	72.9%	2.2	1.0
	Urban Open (Pervious)	4.4	0.0	0.1	0.0	—	0	0.1
	Urban Open (Impervious)	0.0	0.4	0.0	0.0	—	0	0.0
	Total Annual Load			18.5	Total Reduced Load			9.1
	% Reduction to Annual Load Due to Treatment Trains							50./%
	Existing Conditions Annual Load[d]			4.10	% Change to Existing conditions			122.4%
E	Commercial/Ops (Pervious)	15.9	0.0	0.7	0.0	—	0	0.7
	Commercial/Ops (Impervious)	18.5						
	Treatment Train A	4.6	0.8	3.7	3.5	74.2%	2.6	1.1
	Treatment Train B	0.2	0.8	0.1	0.1	74.1%	0.1	0.0
	Treatment Train C	9.6	0.8	7.8	7.4	0.3%	0.0	7.7
	Treatment Train D	4.2	0.8	3.4	3.2	72.9%	2.4	1.0
	Roadway (Pervious)	1.8	0.1	0.2	0.0	—	0	0.2
	Roadway (Impervious)	5.7						
	Treatment Train D	5.7	2.0	11.5	10.9	72.9%	8.0	3.5
	Urban Open (Pervious)	16.0	0.0	0.3	0.0	—	0	0.3
	Urban Open (Impervious)	0.0	0.4	0.0	0.0	—	0	0.0
	Total Annual Load			27.7	Total Reduced Load			14.7
	% Reduction to Annual Load Due to Treatment Trains							47.1%
	Existing Conditions Annual Load[d]			8.50	% Change to Existing conditions			72.6%
H	Commercial/Ops (Pervious)	6.5	0.0	0.3	0.0	—	0	0.3
	Commercial/Ops (Impervious)	7.1						
	Treatment Train A	0.9	0.8	0.7	0.7	74.2%	0.5	0.2
	Treatment Train B	0.6	0.8	0.5	0.5	74.1%	0.3	0.1
	Treatment Train C	3.9	0.8	3.2	3.0	0.3%	0.0	3.2
	Treatment Train D	1.7	0.8	1.4	1.3	72.9%	1.0	0.4
	Roadway (Pervious)	1.3	0.1	0.1	0.0	—	0	0.1
	Roadway (Impervious)	3.2						
	Treatment Train D	3.2	2.0	6.4	6.1	72.9%	4.4	2.0
	Urban Open (Pervious)	17.0	0.0	0.4	0.0	—	0	0.4
	Urban Open (Impervious)	0.0	0.4	0.0	0.0	—	0	0.0
	Total Annual Load			13.0	Total Reduced Load			6.8
	% Reduction to Annual Load Due to Treatment Trains							47.7%
	Existing Conditions Annual Load[d]			6.10	% Change to Existing conditions			9.9%

Sub-Basin	Land Use Category	Acres[a]	Load Per Acre (lbs)[b]	Annual Load (lbs)	Captured Load (lbs)[c]	Treatment Train Reduction Efficiency	Load Removed (lbs)	Net Load (lbs)
U	Industrial (Pervious)	2.0	0.1	0.2	0.0	—	0	0.2
	Industrial (Impervious)	58.0						
	Treatment Train C	58.0	1.6	94.0	89.3	0.3%	0.3	93.7
	Roadway (Pervious)	3.3	0.1	0.3	0.0	—	0	0.3
	Roadway (Impervious)	7.1						
	Treatment Train D	7.1	2.0	14.4	13.7	72.9%	10.0	4.4
	Urban Open (Pervious)	3.4	0.0	0.1	0.0	—	0	0.1
	Urban Open (Impervious)	0.0	0.4	0.0	0.0	—	0	0.0
	Total Annual Load			109.0	Total Reduced Load			98.7
	% Reduction to Annual Load Due to Treatment Trains							9.4%
	Existing Conditions Annual Load[d]			6.9	% Change to Existing conditions			1,331.0%
BB	Commercial/Ops (Pervious)	3.3	0.0	0.1	0.0	—	0	0.1
	Commercial/Ops (Impervious)	8.2						
	Treatment Train A	1.1	0.8	0.9	0.9	74.2%	0.6	0.3
	Treatment Train B	0.2	0.8	0.2	0.1	74.1%	0.1	0.0
	Treatment Train C	5.5	0.8	4.5	4.2	0.3%	0.0	4.4
	Treatment Train E	1.4	0.8	1.2	1.1	67.7%	0.7	0.4
	Industrial (Pervious)	1.8	0.1	0.2	0.0	—	0	0.2
	Industrial (Impervious)	16.2						
	Treatment Train A	0.4	1.6	0.6	0.6	74.2%	0.4	0.2
	Treatment Train B	15.2	1.6	24.6	23.4	0.3%	0.1	24.5
	Treatment Train C	0.6	1.6	1.0	0.9	67.7%	0.6	0.3
	Treatment Train E	1.5	0.1	0.2	0.0	—	0	0.2
	Roadway (Pervious)	4.5						
	Roadway (Impervious)	4.5	2.0	9.2	8.7	72.9%	6.4	2.8
	Treatment Train D	7.8	0.0	0.2	0.0	—	0	0.2
	Urban Open (Pervious)	0.0	0.4	0.0	0.0	—	0	0.0
	Urban Open (Impervious)	3.3	0.0	0.1	0.0	—	0	0.1
	Total Annual Load			42.7	Total Reduced Load			33.79
	% Reduction to Annual Load Due to Treatment Trains							21.1%
	Existing Conditions Annual Load[d]			6.1	% Change to Existing conditions			450.3%

[a] Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO and NAVFAC 2009).

[b] Loads per acre calculated using the Simple Method (Schueler 1987).

[c] For pervious surfaces, a capture discount of 0.0 was used. For impervious surfaces, a capture discount of 0.95 was used since it was assumed that all impervious surfaces are treated up to the 95% storm event.

[d] Annual load derived from existing land use acres, as reported in Appendix B.

Table 12-4: Estimated Total Nitrogen Reduction from Proposed Treatment Trains

Sub-Basin	Land Use Category	Acres[a]	Load Per Acre (lbs)[b]	Annual Load (lbs)	Captured Load (lbs)[c]	Treatment Train Reduction Efficiency	Load Removed (lbs)	Net Load (lbs)
D	Residential (Pervious)	14.1	0.5	6.6	0.0	—	0	6.6
	Residential (Impervious)	8.6						
	Treatment Train A	3.4	8.9	30.2	28.7	91.4%	26.2	4.0
	Treatment Train B	0.9	8.9	7.8	7.4	91.4%	6.7	1.0
	Treatment Train C	2.3	8.9	20.2	19.2	0.3%	0.1	20.2
	Treatment Train D	2.1	8.9	18.8	17.9	90.1%	16.1	2.7
	Roadway (Pervious)	0.9	0.6	0.6	0.0	—	0	0.6
	Roadway (Impervious)	1.5						
	Treatment Train D	1.5	12.2	18.8	17.9	90.1%	16.1	2.7
	Urban Open (Pervious)	4.4	0.2	0.9	0.0	—	0	0.9
	Urban Open (Impervious)	0.0	4.1	0.0	0.0	—	0	0.0
	Total Annual Load			104.0	Total Reduced Load			38.9
	% Reduction to Annual Load Due to Treatment Trains							62.6%
	Existing Conditions Annual Load[d]			29.6	% Change to Existing conditions			30.9%
E	Commercial/Ops (Pervious)	15.9	0.4	6.8	0.0	—	0	6.8
	Commercial/Ops (Impervious)	18.5						
	Treatment Train A	4.6	8.1	37.2	35.3	91.4%	32.3	4.9
	Treatment Train B	0.2	8.1	1.3	1.2	91.4%	1.1	0.2
	Treatment Train C	9.6	8.1	77.7	73.8	0.3%	0.2	77.4
	Treatment Train D	4.2	8.1	34.0	32.3	90.1%	29.1	4.9
	Roadway (Pervious)	1.8	0.6	1.2	0.0	—	0	1.2
	Roadway (Impervious)	5.7						
	Treatment Train D	5.7	12.2	68.9	65.5	90.1%	59.0	9.9
	Urban Open (Pervious)	16.0	0.2	3.4	0.0	—	0	3.4
	Urban Open (Impervious)	0.0	4.1	0.0	0.0	—	0	0.0
	Total Annual Load			230.4	Total Reduced Load			108.7
	% Reduction to Annual Load Due to Treatment Trains							52.8%
	Existing Conditions Annual Load[d]			60.30	% Change to Existing conditions			80.3%
H	Commercial/Ops (Pervious)	6.5	0.4	2.8	0.0	—	0	2.8
	Commercial/Ops (Impervious)	7.1						
	Treatment Train A	0.9	8.1	7.2	6.9	91.4%	6.3	1.0
	Treatment Train B	0.6	8.1	4.9	4.7	91.4%	4.3	0.7
	Treatment Train C	3.9	8.1	31.9	30.3	0.3%	0.1	31.8
	Treatment Train D	1.7	8.1	13.8	13.1	90.1%	11.7	2.0
	Roadway (Pervious)	1.3	0.6	0.8	0.0	—	0	0.8
	Roadway (Impervious)	3.2						
	Treatment Train D	3.2	12.2	38.4	36.5	90.1%	32.8	5.5
	Urban Open (Pervious)	17.0	0.2	3.6	0.0	—	0	3.6
	Urban Open (Impervious)	0.0	4.1	0.0	0.0	—	0	0.0
	Total Annual Load			103.4	Total Reduced Load			48.1
	% Reduction to Annual Load							53.5%
	Existing Conditions Annual Load[d]			52.20	% Change to Existing conditions			-7.8%

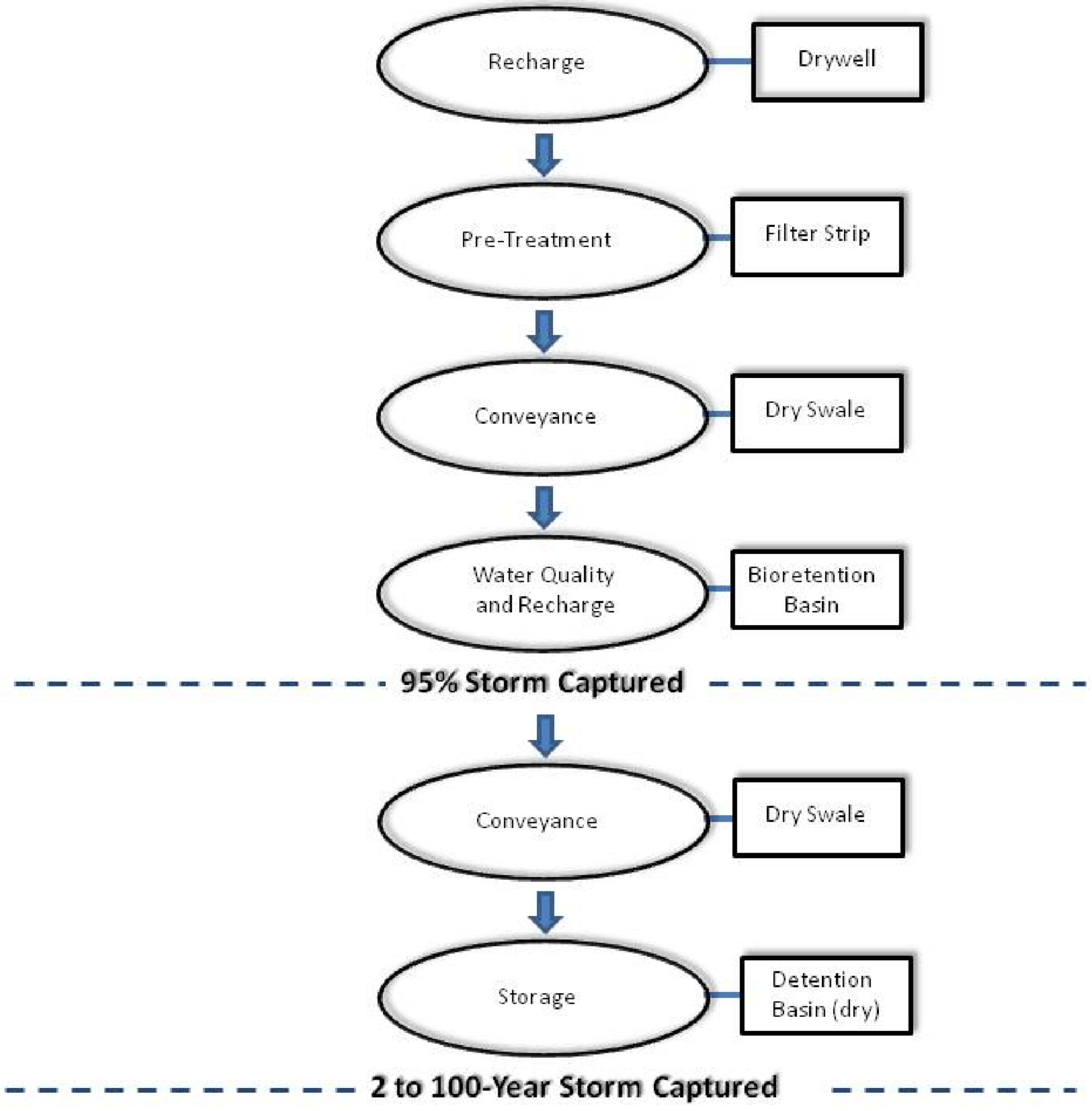
Sub-Basin	**Land Use Category**	**Acres[a]**	**Load Per Acre (lbs)[b]**	**Annual Load (lbs)**	**Captured Load (lbs)[c]**	**Treatment Train Reduction Efficiency**	**Load Removed (lbs)**	**Net Load (lbs)**
U	Industrial (Pervious)	2.0	0.5	1.1	0.0	—	0	1.1
	Industrial (Impervious)	58.0						
	Treatment Train C	58.0	10.1	587.4	558.1	0.3%	1.7	585.8
	Roadway (Pervious)	3.3	0.6	2.1	0.0	—	0	2.1
	Roadway (Impervious)	7.1						
	Treatment Train D	7.1	12.2	86.4	82.0	90.1%	73.9	12.4
	Urban Open (Pervious)	3.4	0.2	0.7	0.0	—	0	0.7
	Urban Open (Impervious)	0.0	4.1	0.0	0.0	—	0	0.0
	Total Annual Load			677.7	Total Reduced Load			602.1
	% Reduction to Annual Load Due to Treatment Trains							11.2%
	Existing Conditions Annual Load[d]			6.10	% Change to Existing conditions			9.9%
BB	Commercial/Ops (Pervious)	3.3	0.4	1.4	0	—	0	1.4
	Commercial/Ops (Impervious)	8.2						
	Treatment Train A	1.1	8.1	9.1	8.6	91.4%	7.9	1.2
	Treatment Train B	0.2	8.1	1.5	1.5	91.4%	1.3	0.2
	Treatment Train C	5.5	8.1	44.6	42.4	0.3%	0.1	44.5
	Treatment Train D	1.4	8.1	11.5	10.9	90.1%	9.9	1.7
	Industrial (Pervious)	1.8	0.5	1.0	0.0	—	0	1.0
	Industrial (Impervious)	16.2						
	Treatment Train A	0.4	10.1	3.9	3.7	91.4%	3.4	0.5
	Treatment Train C	15.2	10.1	153.7	146.0	0.3%	0.4	153.3
	Treatment Train D	0.6	10.1	6.1	5.8	90.1%	47.1	7.9
	Roadway (Pervious)	1.5	0.6	0.9	0.0	—	0	0.9
	Roadway (Impervious)	4.5						
	Treatment Train D	4.5	12.2	55.1	52.3	90.1%	47.1	7.9
	Urban Open (Pervious)	7.8	0.2	1.7	0.0	—	0	1.7
	Urban Open (Impervious)	0.0	4.1	0.0	0.0	—	0	0.0
	Total Annual Load			290.5	Total Reduced Load			215.1
	% Reduction to Annual Load Due to Treatment Trains							25.9%
	Existing Conditions Annual Load[d]			43.60	% Change to Existing conditions			393.4

[a] Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO and NAVFAC 2009).

[b] Loads per acre calculated using the Simple Method (Schueler 1987).

[c] For pervious surfaces, a capture discount of 0.0 was used. For impervious surfaces, a capture discount of 0.95 was used since it was assumed that all impervious surfaces are treated up to the 95% storm event.

[d] Annual load derived from existing land use acres, as reported in Appendix B.

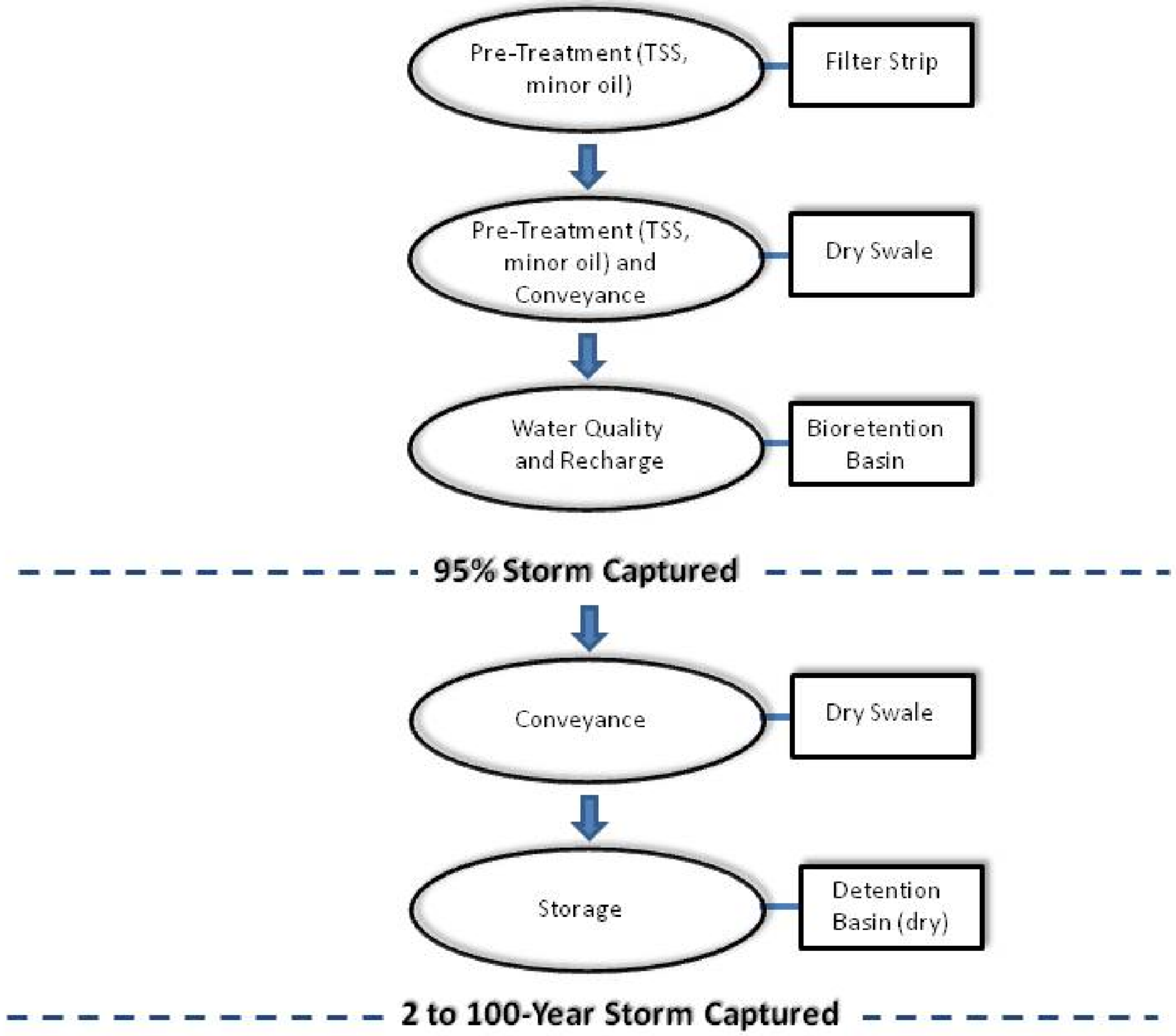


NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Treatment Train A: Rooftop Runoff

GIS FILE: Fig12-1.mxd

DATE: 04/23/2010

Figure 12-1



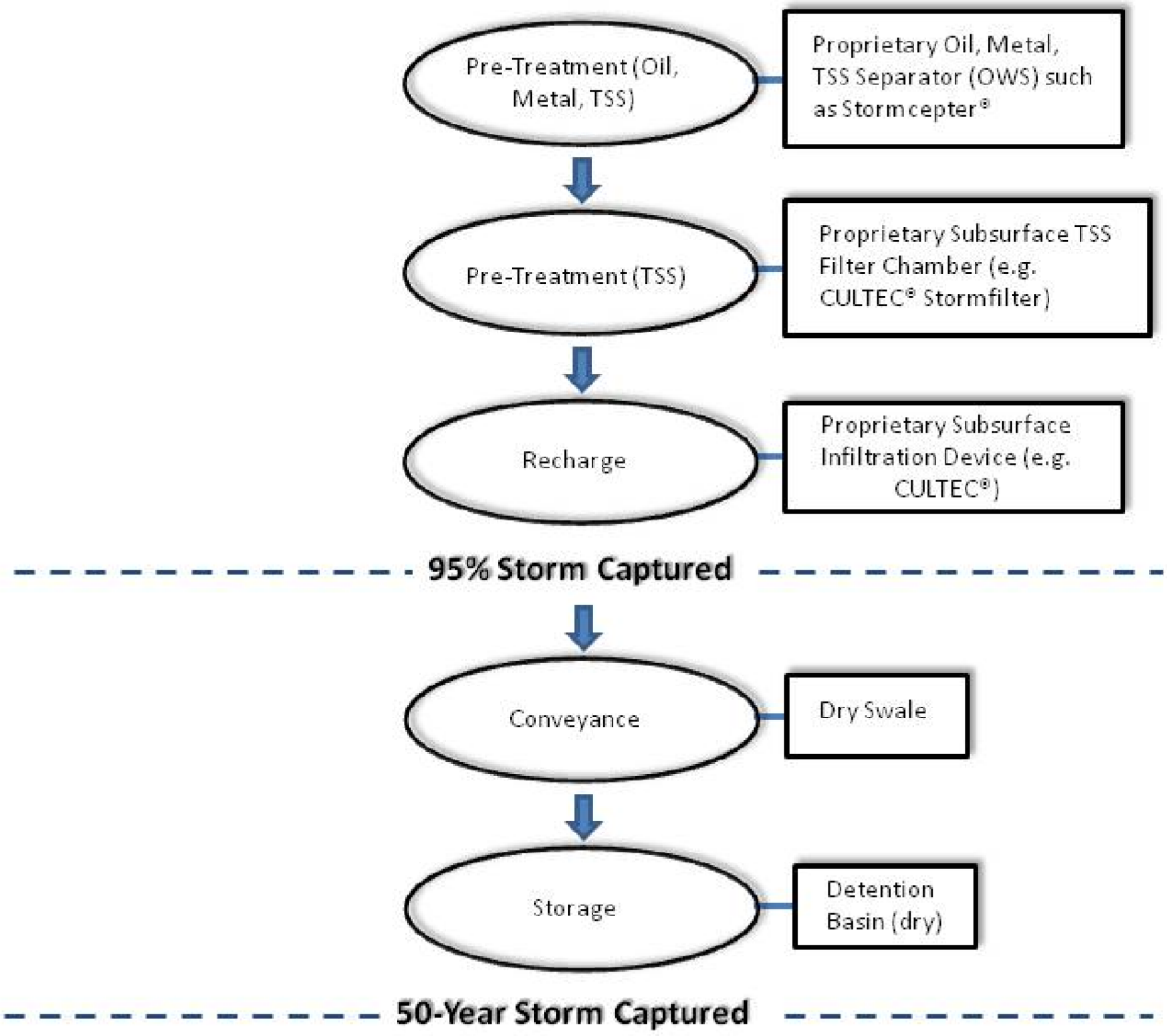
AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Treatment Train B: Impervious Paved Areas with
Insignificant Oil/Suspended Metals

GIS FILE: Fig12-2.mxd

DATE: 04/23/2010

Figure 12-2

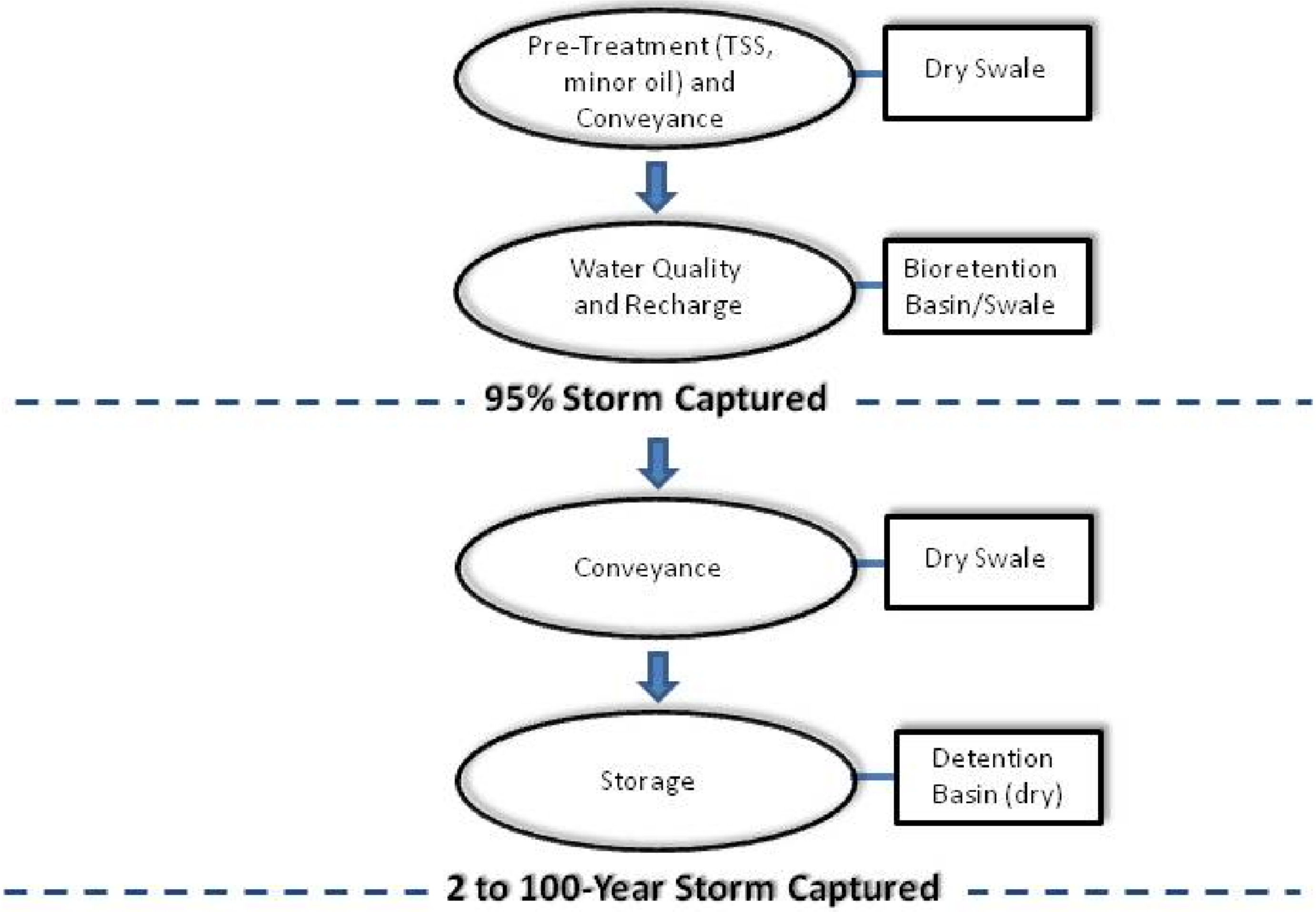


NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Treatment Train C: Impervious Paved Areas
with Significant Metals or Large Areas for Vehicle Parking

GIS FILE: Fig12-3_IndexMap.mxd

DATE: 03/04/2010

Figure 12-3



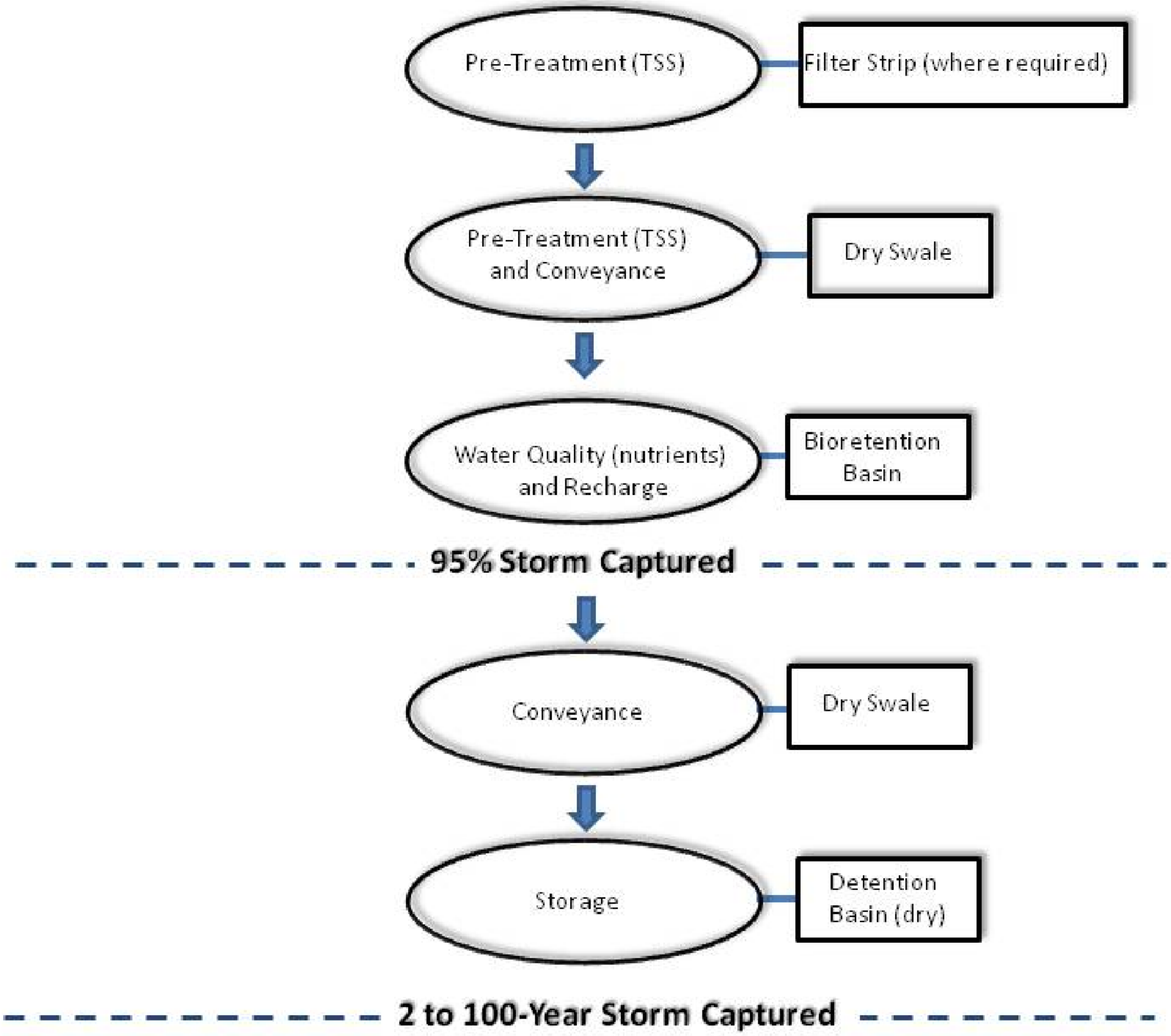
AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Treatment Train D: Impervious Paved Roadways
with Insignificant Oil/Suspended Metals

GIS FILE: Fig12-4.mxd

DATE: 04/23/2010

Figure 12-4



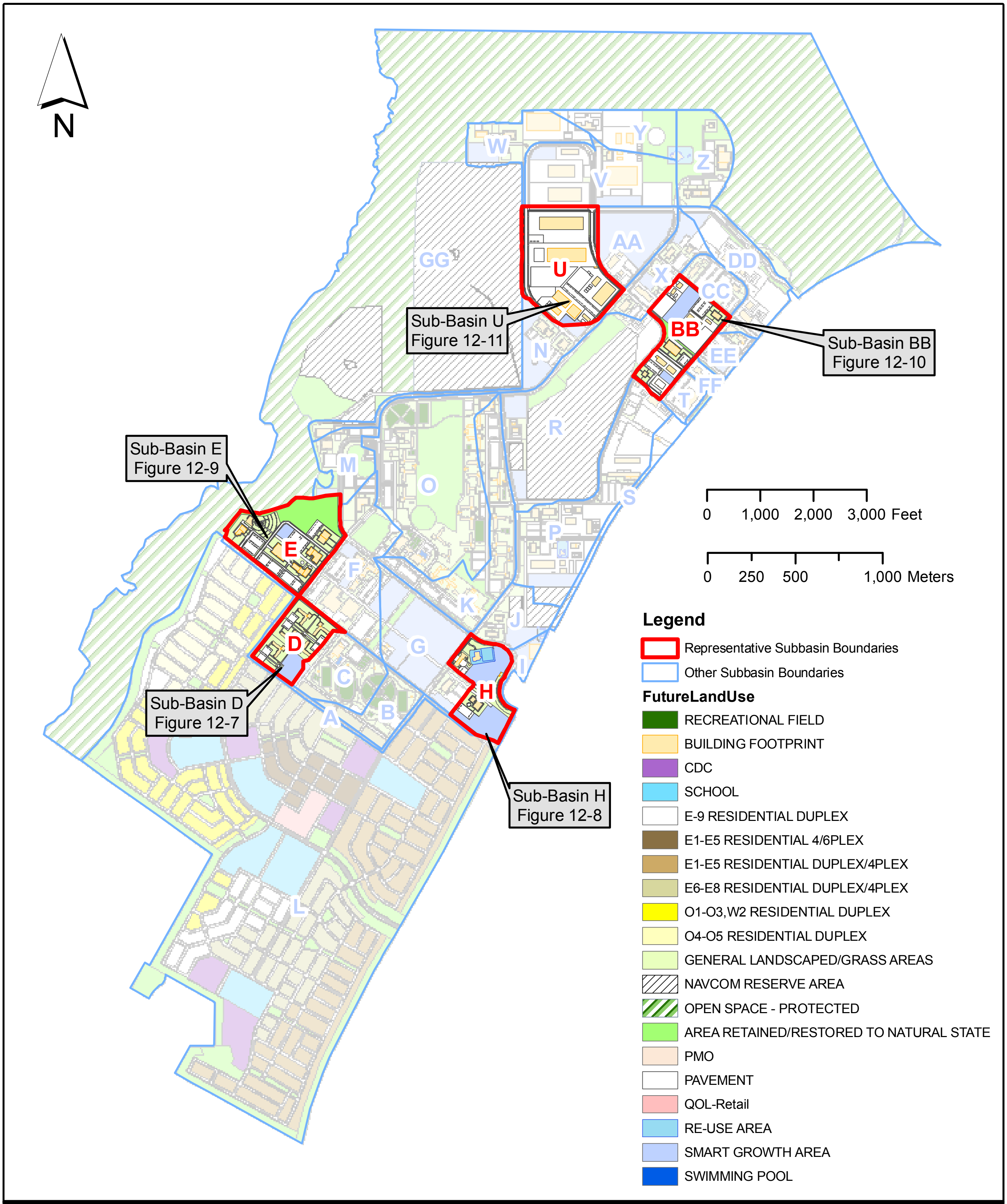
AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Treatment Train E: Landscaping, Grass, and Recreation Areas

GIS FILE: Fig12-5.mxd

DATE: 04/23/2010

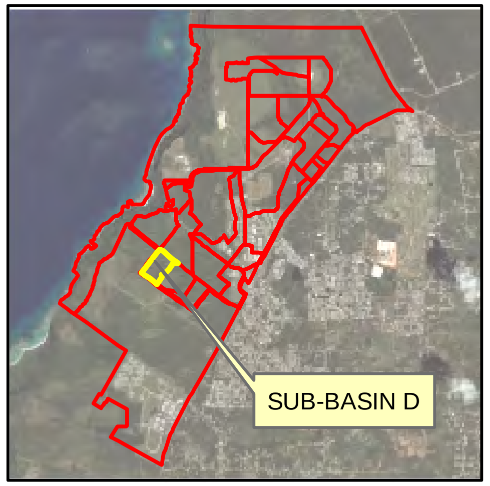
Figure 12-5



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Index Map

GIS FILE: Fig12-6_IndexMap.mxd
SCALE: AS NOTED
DATE: 04/27/2010
Figure 12-6



LOCATION MAP

Legend

- 🟥 Subbasin D Boundary
- ⊗ Cistern
- Headwall
- → 95% Storm Flow Direction
- - - → >95% Overflow Direction
- ○ Pond Riser
- ○ Stormwater Oil/Sediment Separator
- Dry Swale
- Bioretention Basin Elevation (feet)
- ○ Drywell
- ☐ Subsurface Infiltration System
- ▨ Detention Basins
- 138 (453) Notational Grading Contours Elevation in meters (feet)

Future Land Use

- 🟫 Building Footprints
- ⬜ Driveways/Parking
- 🟩 Landscaped Area
- ⬛ Roads
- ▨ Sidewalks
- 🟦 Smart Growth Area

0 60 120 240 Feet

0 25 50 100 Meters

AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study

REPRESENTATIVE BMP/LID LAYOUT FOR
SUBBASIN D

Figure 12-7

GIS FILE: Fig12-7_SubbasinDv2.mxd

SCALE: AS NOTED

DATE: 04/27/2010

AECOM

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Guam Drainage & Low Impact Development Study

REPRESENTATIVE BMP/LID LAYOUT FOR SUBBASIN H

Figure 12-8

GIS FILE: Fig12-8_SubbasinHv2.mxd

SCALE: AS NOTED

DATE: 04/27/2010

LOCATION MAP

N

Legend

🟥	Subbasin E Boundary
⊗	Cistern
⌣	Headwall
→	95% Storm Flow Direction
- - →	>95% Overflow Direction
▫	Catch Basin
○	Pond Riser
○	Stormwater Oil/Sediment Separator
┄	Dry Swale
┄┆┄	Dry Swale with Check Dam
—	Bioretention Basin Elevation (feet)
◌	Drywell
⬚	Subsurface Infiltration Basins
▨	Detention Basins
138 (453)	Notational Grading Contours Elevation in meters (feet)

Future Land Use

🟫	Building Footprints
⬛	Driveways/Parking
🟩	Landscaped Area
🟩	Open Space Area
⬛	Roads
▒	Sidewalks/Open Paved Areas
▦	Smart Growth Area

Note:
Cisterns shown are representative; number and location to be determined during final design.

AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study

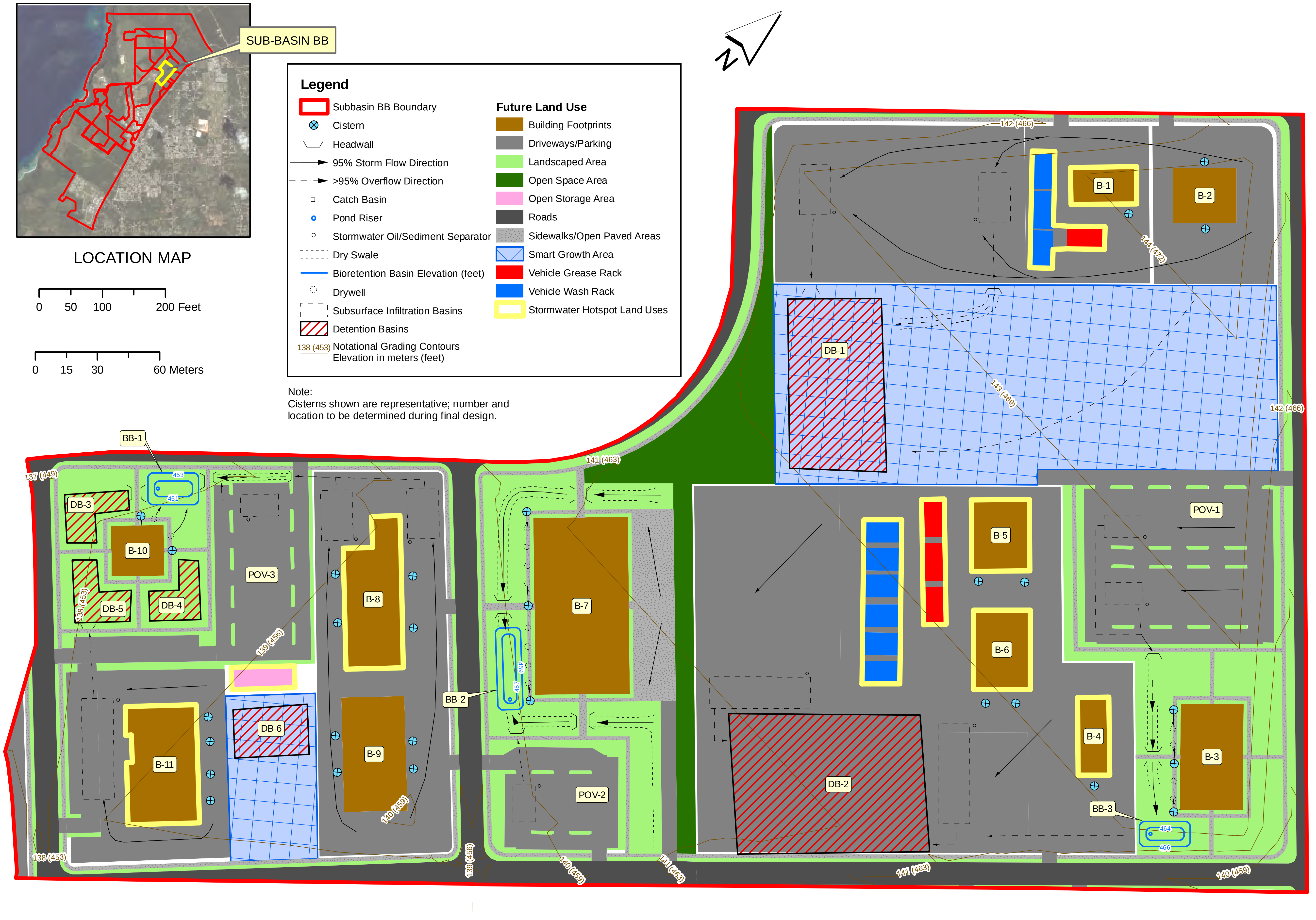
REPRESENTATIVE BMP/LID LAYOUT FOR SUBBASIN E

Figure 12-9

GIS FILE: Fig12-9_SubbasinEv2.mxd

SCALE: AS NOTED

DATE: 04/27/2010



Note:
Cisterns shown are representative; number and location to be determined during final design.

AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study

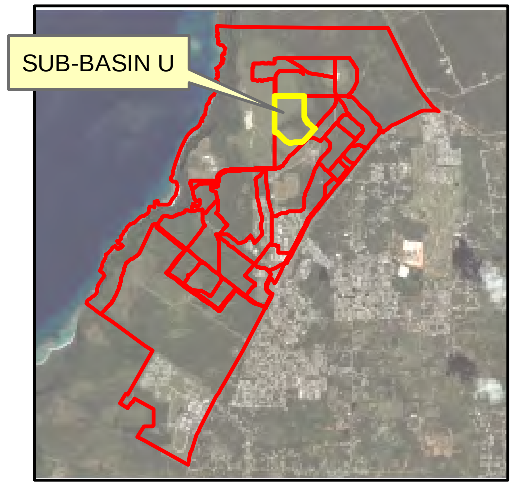
REPRESENTATIVE BMP/LID LAYOUT FOR SUBBASIN BB

Figure 12-10

GIS FILE:Fig12-10_SubbasinBBv2.mxd

SCALE: AS NOTED

DATE: 04/27/2010



LOCATION MAP

Legend

- 🟥 Subbasin U Boundary
- ● Cistern
- → 95% Storm Flow Direction
- ○ Stormwater Oil/Sediment Separator
- ☐ Subsurface Infiltration Basins
- ▨ Detention Basin
- 138 (453) Notational Grading Contours Elevation in meters (feet)

Future Land Use

- ■ Building Footprints
- ■ Driveways/Parking
- 🟩 Landscaped Area
- 🟩 NAVCOM Reserved
- ■ Open Storage Area
- ■ Roads
- ■ Sidewalks
- ▨ Smart Growth Area
- 🟥 Vehicle Grease Rack
- 🟦 Vehicle Wash Rack
- ☐ Stormwater Hotspot Land Uses

Notes:
1. All stormwater runoff from the 95% storm, within this subbasin, will be captured via subsurface infiltration systems (Treatment Train C). Overflow from these systems (>95% storm) will be directed to detention basin (DB-1).

2. Cisterns shown are representative; number and location to be determined during final design.

AECOM

NAVFAC Pacific
Guam Drainage & Low Impact Development Study

REPRESENTATIVE BMP/LID LAYOUT FOR
SUBBASIN U

Figure 12-11

GIS FILE: Fig 12-11_SubbasinUv2.mxd

SCALE: AS NOTED

DATE: 04/27/2010

13. IMP Construction Cost

13.1 APPROACH

Preliminary cost estimates were derived for the following seven types of IMP:

- Dry wells
- Dry swales
- Oil/sediment separators
- Green roofs
- Porous pavement
- Bioretention basins
- Subsurface infiltration systems

For the purpose of cost estimating, existing site conditions were assumed to be undeveloped vegetated forest. The existing ground was assumed to be hard limestone. A 10% contingency was also added to all cost estimates. Maintenance costs are excluded. See Section 11.1 for maintenance considerations.

13.2 COST DATA

Cost data were obtained from multiple sources, including material vendors, product manufacturers, Guam construction companies, and cost estimating resource manuals. The following sources contributed to the preliminary cost estimates:

- Smithbridge Guam, Inc.
- Rocky Mountain Precast, Guam
- Hawaiian Rock Products, Guam
- Kaikor Construction, Hawaii
- Tremco Roofing and Building Maintenance
- Group 70 International
- Indigo Piping (material supplier)
- International Waste Technology (material supplier)
- Cultec, Inc. (manufacturer)
- Imbrium Systems, Inc. (manufacturer)
- Naval Facilities Engineering Command Cost Data Book, 2002

13.3 DRY WELL

Dry wells shall be precast concrete units, 9 feet diameter by 4 feet deep. The units are assumed to be constructed on island by a local precast company, delivered to the site by truck, and assembled during installation. Rocky Mountain Precast Company located on Guam was contacted to provide a rough cost estimate for the precast dry well assembly. It was suggested by the precast representative that installation cost would be similar to that of installing precast manhole units.

The preliminary construction cost estimate is $18,000 per unit (Table 13-1). Costs include site preparation, excavation, drain rock fill, and miscellaneous construction cost. It was suggested by the precast representative that costs can be reduced by constructing a square dry well section vs. a circular section.

Table 13-1: Preliminary Cost Estimate for Dry Well

	Quantity		Engineer's Estimate	
Item	**Unit**	**Qty**	**$/U**	**Total**
Mobilization / demobilization	LS	1	$ 1,700.00	$ 1,700
Clear and grub	SF	400	$ 0.50	$ 200
Excavation	CY	30	$ 180.00	$ 5,400
Drain rock / structural backfill	CY	18	$ 150.00	$ 2,700
Geotextile filter fabric	LS	1	$ 500.00	$ 500
Pre-cast dry well unit	LS	1	$ 8,000.00	$ 8,000
Subtotal				$ 16,600
Contingencies (@ 10%)				$ 1,660
Total Construction Cost				$ 18,260
			Rounded	**$ 18,000**

CY	cubic yard
LS	lump sum

13.4 DRY SWALES

Typical dry swales shall be 16-ft wide and 2-ft deep measured along the invert. For estimating purposes, a typical length was assumed to be 1,000 linear ft.

The preliminary construction cost estimate is $205 per linear ft of dry swale (Table 13-2). Costs include site preparation, excavation, grass hydro-seeding, and miscellaneous construction cost.

Table 13-2: Preliminary Cost Estimate for Dry Swales

	Quantity		Engineer's Estimate	
Item	**Unit**	**Qty**	**$/U**	**Total**
Mobilization / demobilization	LS	1	$ 19,500.00	$ 19,500.00
Clear and grub	ft^2	16,000	$ 0.50	$ 8,000.00
Excavation / embankment	CY	593	$ 180.00	$ 106,740.00
Grass hydro-seeding (with establishment period)	ft^2	16,000	$ 5.00	$ 80,000.00
Subtotal				$ 186,740.00
Contingencies (@ 10%)				$ 18,674.00
Total Construction Cost				$ 205,414.00
Cost per linear Foot				$ 205.41
			Rounded	**$ 205**

13.5 OIL/SEDIMENT SEPARATORS

For this cost estimate, oil/sediment separators were assumed to be pre-fabricated Stormceptor 6,000 gallon inline unit. A Stormceptor representative was contacted to provide rough cost estimates per unit with shipping costs. The units would be manufactured in U.S. mainland, and shipped to Guam via ocean vessel through Port of Seattle, Washington.

The preliminary construction cost estimate is $66,000 per unit, installed, including site preparation, excavation, structural backfill, and miscellaneous construction items (Table 13-3). It was suggested by the manufacturer's representative that shipping costs are highly variable depending on the unit size and quantity.

Table 13-3: Preliminary Cost Estimate for Oil and Grit Separators

	Quantity		Engineer's Estimate	
Item	**Unit**	**Qty**	**$/U**	**Total**
Mobilization / demobilization	LS	1	$ 5,500	$ 5,500
Clear and grub	LS	1	$ 1,000	$ 1,000
Excavation	CY	15	$ 180	$ 2,700
Granular base course	CY	4	$ 150	$ 600
Pre-fab treatment unit (Stormceptor)	LS	1	$ 31,000	$ 31,000
Shipping for treatment unit (FOB Guam)	LS	1	$ 18,000	$ 18,000
Structural backfill	CY	10	$ 150	$ 1,500
Subtotal				$ 60,300
Contingencies (@ 10%)				$ 6,030
Total Construction Cost				$ 66,330
			Rounded	**$ 66,000**

13.6 GREEN ROOF

Green roof systems were assumed to be installed over concrete deck surfaces. A Sustainable Technology Specialists from Tremco Roofing and Building Maintenance (Tremco) was contacted to assist with this cost estimate. Tremco has constructed green systems on Guam.

The preliminary construction cost estimate for the recommended green roof system is $40 per square foot, installed, including a 20-year warranty on all system components. The system consists of sedum plants, five inch growing medium, subsurface irrigation system, electronic leak detection system, and waterproof membranes.

13.7 POROUS PAVEMENT

Porous pavements were assumed to be constructed from asphaltic porous pavement with a 2 inch bonder layer and a 2 inch wear layer. Construction costs are similar to that of standard asphalt pavement. The preliminary cost estimate for porous pavement is $60 per square yard, including site preparation and excavation, and porous pavement layers (Table 13-4).

Table 13-4: Preliminary Cost Estimate for Porous Pavement

	Quantity		Engineer's Estimate	
Item	**Unit**	**Qty**	**$/U**	**Total**
Mobilization / demobilization	LS	1	$ 2,500.00	$ 2,500.00
Clear and grub	ft^2	4,500	$ 0.50	$ 2,250.00
Excavation	CY	55	$ 180.00	$ 9,900.00
2" binder and 2" wear layer	SY	500	$ 25.00	$ 12,500.00
Subtotal				$ 27,150.00
Contingencies (@ 10%)				$ 2,715.00
Total Construction Cost				$ 29,865.00
Cost per Square Yard				$ 59.73
			Rounded	**$ 60.00**

SY square yard

13.8 BIORETENTION BASINS

Bioretention ponds were assumed to have a surface area of 5,000 ft^2 and an average depth of 2.5 ft. The total volume was assumed to be 12,500 ft^3. Assuming that the proposed ponds are located on level ground, the excavation quantities would be for the full storage volume.

The preliminary cost estimate for bioretention basin construction is $14 per ft^3 of retention volume, about $980,000 for 19,200 ft^3 (Table 13-5). The cost includes site preparation, excavation and embankment, and landscaping. It should be noted that it would be cost effective to locate basins within natural depressions in the Study Area when feasible. This reduces excavation quantities through hard limestone.

Table 13-5: Preliminary Cost Estimate for Bioretention Basins

	Quantity		Engineer's Estimate	
Item	**Unit**	**Qty**	**$/U**	**Total**
Mobilization / demobilization	LS	1	$ 16,300.00	$ 16,300.00
Clear and grub	ft^2	5,000	$ 0.50	$ 2,500.00
Excavation / embankment	CY	500	$ 180.00	$ 90,000.00
Inlet structure (GRP)	LS	1	$ 10,000.00	$ 10,000.00
Spillway (riprap)	LS	1	$ 10,000.00	$ 10,000.00
Landscaping	ft^2	5,000	$ 10.00	$ 50,000.00
Subtotal				$ 160,000.00
Contingencies (@ 10%)				$ 16,000.00
Total Construction Cost				$ 176,000.00
Cost per Cubic Foot				$ 14.08
			Rounded	**$ 14.00**

13.9 SUBSURFACE INFILTRATION SYSTEMS

Subsurface infiltration systems shall be constructed using proprietary systems such as Cultec Recharger 330. This system is comprised of prefabricated units assembled on site. The pieces are manufactured in U.S. mainland. A Cultec supplier was contacted to provide rough cost estimates for materials shipped to the Study Area material. For the purpose of this cost estimate, the retention volume is assumed to be 10,000 ft^3.

The preliminary construction cost estimate is $26 per ft^3 of retention volume, about $260,000 for a 10,000- ft^3 system (Table 13-6). This includes site preparation, excavation, prefabricated storage units, drainage fill material, and miscellaneous construction items.

Table 13-6: Preliminary Cost Estimate for Subsurface Infiltration Systems

	Quantity		**Engineer's Estimate**	
Item	**Unit**	**Qty**	**$/U**	**Total**
Mobilization / demobilization	LS	1	$ 21,600	$ 21,600
Clear and grub	SF	5,200	$ 0.50	$ 2,600
Excavation	CY	741	$ 180	$ 133,380
Pre-fab storage units (Cultect 330XLHD)	EA	126	$ 150	$ 18,900
Geotextile filter fabric	SY	1,295	$ 5.00	$ 6,475
Drain rock / structural backfill	CY	367	$ 150	$ 55,000
Subtotal				
Total Construction Cost				$ 23,796
Contingencies (@ 10%)				$ 261,751
Cost per Cubic Foot				$ 26.18
			Rounded	**$ 26.00**

EA each

13.10 CONSTRUCTION COST IMPACTS

The budgetary level IMP unit costs developed herein reflect estimated construction costs currently on Guam. With the anticipated relocation of military forces to the island, an increase in construction activity resulting from multiple projects ongoing at the same time may limit the resources available to construction contractors. The following are some resources that may be impacted and should be evaluated when developing future detailed construction cost estimates:

- Limited local manpower; especially experienced skilled labor fields
- Material shortages (e.g., cement, aggregates, concrete, etc.) and material transit time issues
- Only limestone available on island; basaltic material needs to be imported
- Limited port storage for containers and staging of equipment and materials
- Limited heavy construction equipment on island
- Time and cost to bring in contractor heavy equipment from off island
- Maintenance of heavy equipment; specifically limited skilled labor and spare parts required for maintenance of hydraulic systems
- Fuel demand; specifically the availability of diesel fuel needed for construction equipment
- Stricter security measures and access issues
- Coordination of multiple contractors working simultaneously

14. Basis of Design

This section contains the Basis of Design for the main tasks and analyses conducted for the Comprehensive Drainage and Low Impact Development Implementation Study, Finegayan Main Cantonment Area, Guam.

14.1 PREDEVELOPMENT AND POSTDEVELOPMENT STORMWATER RUNOFF MODELING

14.1.1 Standards and References

Design of predevelopment and postdevelopment stormwater runoff modeling would be guided by the following:

- FLO-2D, Version 2007.06
- Guam Storm Drainage Manual, September 1980
- “Draft Guam Joint Military Master Plan,” November 18, 2009
- USGS NED 30m DEM
- ROAD0001-MCF-001-C-SP-Topo.dwg- Existing Topography
- Master grading 3D Exploded.dwg- Master Grading Plan
- ROAD0001-MCF-001-C-SP-Exist.dwg- Existing Conditions
- GJMMP_SITE DEVELOPMENT PLAN_18SEP09.dwg- Site Development Plan
- “Urban Hydrology for Small Watersheds,” USDA Technical Release 55, June 1986
- “Guide for Selecting Manning’s Roughness Coefficients for Natural Channels and Flood plains,” USGS Water-supply Paper 2339
- Rainfall Frequency Intensity- Finegayan Main Cantonment Area
- "Rainfall Climatology for Saipan: Distribution, Return-periods, El Nino, Tropical Cyclones, and Long-term Variations," Water and Environment Research Institute, University of Guam , Technincal Report No. 103, Page 20, December 2004
- EPA’s Section 438 Technical Guidance
- USGS Historic Hydraulic Conditions, Rain Gage Dededo, Guam, October 1, 1988 to December 2, 2008
- “NOAA Atlas 14 Precipitation- Frequency Atlas for the United States,” Volume 5 Version 2.0- Selected Pacific Islands, Silver Spring, Maryland, 2009

14.1.2 Predevelopment and Postdevelopment Stormwater Runoff Modeling

1. Scope
    a. Determine stormwater runoff characteristics (Rates, Volumes, Durations, Overland Flow Patterns) and infiltration for the predevelopment and postdevelopment state for each of the following storm events:
        - 1-year and 2-year 24-hour storm events
        - 10-, 25-, 50-, 100-, and 500-year recurrence event storms

- 80% (0.8-inch), 90% (1.5-inch), and 95% annual exceedances

1) Identified adequate model extents, contributing subbasins, and boundary conditions

2) Applied topographic data

3) Assigned infiltration rates using the SCS curve number method based on land use

    i) Open Space; TR-55; Open Space (HSG A, Good Condition) =39

    ii) Woods; TR-55; Woods (HSG A, Good Condition) =30

    iii) Impervious; TR-55; Paved parking lots, roofs, driveways (HSG A) =98

    iv) Gravel Road; TR-55; Streets and roads (HSG A, Gravel) =76

    v) Housing Area;

    Buildings and Open Space within Housing Area: 24% Impervious, CN 98; 76% Open Space, CN 39; Total Combined= 53 (excluding roads)

    Roads within Housing Area: Impervious =98

    Percentages calculated base on: Housing Facility Footprint requirement (524,441 sm, Guam Joint Military Master Plan - Draft) and Total Housing Facility Area (2,149,535 sm, Site Development Plan CADD - Housing Facility Layer)

4) Assigned manning's roughness coefficients

    i) Open space; Silty Sand (D50= 0.5), minor floodplain irregularity, minor obstruction, small vegetation = 0.032

    ii) Woods; Silty Sand (D50= 0.5), minor floodplain irregularity, minor obstruction, extreme vegetation =0.177

    iii) Impervious; Concrete, minor floodplain irregularity, minor obstruction =0.035

    iv) Gravel Road; Gravel, minor floodplain irregularity, minor obstruction =0.017

    v) Housing Area;

    Buildings and Open Space within Housing Area: 24% Impervious, n 0.017; 76% Open Space, n 0.032; Total Combined= 0.028

    Roads within Housing Area: Impervious =0.017

Percentages calculated base on: Housing Facility Footprint requirement (524,441sm, Guam Joint Military Master Plan - Draft) and Total Housing Facility Area (2,149,535 sm, Site Development Plan CADD - Housing Facility Layer)

5) Assigned elements containing structures as completely blocked cells

6) Applied appropriate rainfall depth and temporal distribution for each of the storm events analyzed

b. Evaluate offsite runoff into the area of interest for each of the storm events.

1) Applied cross sections around the area of interest

2) Developed hydrographs from cross section output files

c. Determine if ocean discharge occurs from the area of interest for each of the storm events; quantify.

1) Assigned outflow elements at the coastal boundary

2) Developed hydrographs from outflow element output files

d. Characterize stormwater and groundwater relationships in terms of infiltration rates and percolation time.

14.2 NOTATIONAL GRADING AND DETENTION BASIN FACILITIES

14.2.1 Standards and References

Design of the grading and drainage improvements would be guided by the following:

- *Guam Joint Military Master Plan, NEPA Alternative 2*. September 18, 2009
- UFC 3-230-17FA (2004) – *Drainage other than Airfields*.
- *Guam Storm Drainage Manual*. U.S. Army Corps of Engineers, Honolulu District, (1980).
- *CNMI and Guam Stormwater Management Manual*. October 2006
- Department of the Navy – Strategic Forward Basing Initiatives Guam, Marianas Islands, *Low Impact Development Manual* (Draft dated April 2009).

14.2.2 Notional Grading

1. Scope

a. Prepare notional mass grading plan over the proposed MCB Finegayan site for all areas except NAVC parcels, OS parcels, OS-P parcels, and family housing areas. Notional Grading Plan to be used to determine postdevelopment hydrology for the LID & Drainage study and is not necessarily indicative of a final grading solution for the site. Design for the Notional Grading Plan includes and is based on the following:

1) Minimized cuts & fills wherever possible

2) Locate new low points of drainage at or near existing low points of drainage wherever possible

3) Protection of existing domestic water wellheads and surrounding area wherever possible

4) Maximum slope gradient of 2:1

5) "Developable" land areas graded at 1% minimum to 4% maximum

6) Minor road slopes (less than a few meters in height) are appropriate for placement on NAVC, OS and OS-P parcels

7) Major slopes (greater than a few meters in height) are not appropriate for placement on NAVC, OS and OS-P parcels and should be placed within developable land parcels.

14.2.3 Detention Basin Facilities

2. Scope

   a. Prepare notional detention basin sizing based on postdevelopment hydrology and Notional Grading Plan. Intent for notional detention basin sizing and siting is to convey to planning team approximate dimensions and locations of detention basins. Design for notional detention basins includes and is based on the following:

      1) Storage of a full 2-year to 100-year, 24-hour-duration storm event

      2) Maximum depth to bottom of detention basin is 3 meters.

      3) Notional detention basins do not include effects of evapotranspiration, infiltration prior to basins within the treatment trains, or microstorage within treatment trains. As such, notional detention basins are conservatively sized and represent a worst-case sizing analysis.

      4) Side slopes of detention basins are designed at a 2:1 maximum slope gradient for detention basins in nonfamily housing areas.

      5) Side slopes of detention basins should be designed at a 4:1 or 5:1 maximum slope gradient for detention basins in family housing areas.

      6) All detention basin facilities should be fenced appropriately. Gates for maintenance access should be provided. Signage warning of intermittent flooding should be provided around the perimeter of the detention basins.

14.3 ASSESS AND RECOMMEND BEST MANAGEMENT PRACTICES (BMPS) AND INTEGRATED MANAGEMENT PRACTICES (IMPS)

14.3.1 Standards and References

- *CNMI and Guam Stormwater Management Manual*. Commonwealth of the Northern Mariana Islands and the Territory of Guam, Final version October 2006
- *Low Impact Development Manual*. Department of the Navy – Strategic Forward Basing Initiatives Guam, Marianas Islands, Department of the Navy, draft version July 2009
- *Massachusetts Stormwater Handbook*. Massachusetts Department of Environmental Protection, February 2008
- *Ventura Countywide Stormwater Quality Management Program*. Ventura County, California,website: http://www.vcstormwater.org/publications.html#publications_program last updated: December 2009, accessed December 2009 and January 2010
- *Knox County Stormwater Manual.* Knox County Stormwater Management Division website: http://www.knoxcounty.org/stormwater/proposed_stormwater_ordinance.php webpage accessed January 2010

14.3.2 Assess Efficacy of Strategies for Removal of Pollutants

1. Scope

   a. Assess efficacy of individual BMPs/IMPs for removal of pollutants of concern and provide documentation of treatment train efficacies of BMP/IMP groupings for each contaminant of concern. This is accomplished via multistep process:

      1) Identify target pollutants of concern for the Finegayan Main Cantonment Area based on available literature review.

      2) Compile extensive list of available BMP/IMP options from a variety of sources to create a palette of options to be considered as part of the study.

      3) Compile and compare individual pollutant removal efficiencies for each BMP/IMP as available.

      4) Determine site constraints and opportunities for use of individual BMP/IMP options.

      5) Based on pollutants to be treated, individual BMP/IMP efficiency data, and site constraints and opportunities, select specific BMPs/IMPs and group into effective "treatment trains".

      6) Calculate step-wise pollutant reduction efficiencies for each pollutant of concern for each treatment train option.

14.3.3 Recommendation of BMPs and IMPs

2. Scope

a. Recommend BMPs and IMPs best suited for Northern Guam environment in conjunction with site design elements.

    1) Compare step-wise efficiencies of BMP/IMP trains for particular pollutants and add/remove BMPs/IMPs as necessary to achieve target removal rates.

    2) Choose treatment trains that satisfy target removal efficiencies including considerations of site constraints, feasibility, and maintenance considerations, among other factors.

14.4 SUSTAINABILITY PLAN

14.4.1 Design and Planning

- Treat stormwater as close to its origin as possible by distributing small-scale IMPs throughout the site.
- Cluster development to reduce impervious surface and site compaction.
- Grade to encourage sheet flow and increases the amount of time stormwater flows over the site.
- Minimize curb and gutter infrastructure.
- Integrate stormwater controls into the design as both flood control and site amenities.
- Reduce potable water and energy demands by collecting and reusing rooftop runoff.
- Minimize impervious surfaces by reducing roadway width and length and parking areas.
- Preserve native forest cover and natural drainage patterns to the maximum extent practicable.
- Preserve sinkholes or other areas of high infiltration capacity or those areas with the highest quality ecological functions.
- In order to protect IMPs from damage such as vegetation scour and erosion, allow for a high-flow bypass (up to the 50 ARI storm) around treatment systems.
- Velocity within swales and other conveyance mechanisms should be less than 1 fps for a 1.5-inch rain event.
- Velocity within bioretention basins and other treatment systems should not exceed 6.5 fps for flood events (50 ARI storm)
- Limit soil compaction during construction by:
    - Identifying depressional areas or other areas of high infiltration capacity or those areas with the highest quality ecological functions and cordon or limit disturbance in these areas.
    - Consolidating activities such as staging and parking in already-disturbed areas that have low functional potential. Consolidate activities such as staging and parking in already-disturbed areas that have low functional potential.
    - Designating a single access route into impacted areas. Prior to start of construction, fence off protected areas and sign each area clearly. If saving individual trees, protect the root system from compaction.

- Provide pretreatment for runoff from areas with significant pollutant loading (such as Regime C, D, and E) through an oil/sediment separator or oil/water separator, sedimentation basin, grass filter strip, and/or dry swale.
- For flat sites (grades less than 4–5%), capture and treat stormwater using microscale IMPs distributed through out of the development utilizing areas such as streetscape rights-of-way, plazas, and landscape areas.
- For steep sites (grades greater than 4–5%), convey stormwater to larger "end-of-line" solutions such as bioretention basin, infiltration basin, and detention basin.
- Use native plant species in vegetated systems, unless other species are determined to be necessary due to growth form and habit and are known to be noninvasive in Guam.
- Implement mosquito management activities including:
  - Removing trash and other debris, especially at outlet structures;
  - Maintaining and cleaning out temporary erosion and sediment control traps and basins; and
  - Avoiding small isolated pools or ponding areas.

14.4.2 Maintenance and Education

- Develop reliable, long-term maintenance programs with clear and enforceable guidelines.
- Educate building owner/operators, local staff, and others as needed on proper operation and maintenance of practices, and protection of all surface waters.

14.5 ASSESS NONPOINT SOURCE POLLUTANT LOADS

14.5.1 Standards and References

Non-point source (i.e. stormwater) pollutant loads estimates would be guided by the following:

- Caraco, D. 2002. *The Watershed Treatment Model Version 3.1*. Center for Watershed Protection, Ellicott City, MD. March 2002.
- Joint Guam Program Office and Naval Facilities Engineering Command (JGPO and NAVFAC). 2009. *Draft Guam Joint Military Master Plan*. November 18, 2009.
- Schueler, T. R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Publ. No. 87703. Washington: Metropolitan Washington Council of Governments.
- United States Department of Agriculture (USDA). 2005. *Land Vegetation United States Marine Corps Shapefile*. USDA Forest Service Region 5 State and Private Forestry, Forest Health Protection. June 2005.
- Environmental Protection Agency, United States (EPA). 1983. *Results of the Nationwide Urban Runoff Program: Volume 1 - Final Report*. Washington: Water Planning Division. December.

14.5.2 Assessment of Existing and Future Non-Point Source Pollutant Loads

1. Scope
   a. Assess site contamination for the NCTS Finegayan Study Area due to stormwater runoff utilizing available existing land use data and the most current future land use

plan. Intent for existing and future nonpoint source pollutant loading assessment is to provide an estimate of potential pollutant load increases due to proposed future land use changes within the Study Area. The pollutant loading assessment is based on the following:

1) The Simple Method (Schueler 1987) was selected as the appropriate approach for estimating stormwater pollutant loads. The Simple Method estimates stormwater pollutant loads by: (1) estimating runoff volumes using runoff coefficients for the land uses within the watershed to convert rainfall data into runoff volumes; and (2) estimating pollutant loads using runoff volumes and pollutant event mean concentrations (EMCs). The following formula is used:

$$L = 0.226*R*C*A$$

Where:

L = Annual load (lbs)
R = Annual runoff (inches)
C = Pollutant concentration (mg/l)
A = Area (acres)
0.226 = A conversion factor

2) Existing land use acreage was estimated using a detailed vegetation map prepared by the USDA in 2005 for the island of Guam, selected polyline features within a personal geodatabase obtained from the Navy, and recent aerial photographs. Default impervious cover/land use relationships developed by the Center for Watershed Protection were used for existing conditions.

3) Future land use acreage was derived from GIS data and housing facility footprint requirements developed for the Draft Guam Joint Military Master Plan (dated November 19, 2009). Land use categories (with the exception of forest areas) were further divided and defined as 100% impervious (for example, paved areas or buildings) or 100% pervious (for example, landscaped areas) using available detailed GIS data.

4) An annual rainfall value of 94.4 inches was used for the Study Area. The source of this value is Anderson AFB data recorded between 1952 and 1995, derived from National Climatic Data Center Cooperative Stations.

5) It was assumed there is no runoff up to the 95% storm (2.2 inches) for existing conditions, and a value of 0.05 was used for the fraction of rainfall events that produce runoff. For future conditions, accounting for proposed development, it was assumed there is no runoff up to the 80% storm (0.8 inches), and a value of 0.2 was used for the fraction of rainfall events that produce runoff.

6) The pollutant load assessment was limited to the following pollutants of concern due to data limitations: TSS, TP, and TN.

7) Default pollutant concentrations for various land use categories were used from the following sources: The Watershed Treatment Model Version 3.1 (Caraco

2002) and Results of the Nationwide Urban Runoff Program: Volume 1 (EPA 1983).

14.5.3 Assess Reduction of Nonpoint Source Pollutant Loads Due to Application of Recommended Treatment Trains

1. Scope

   a. Compare future nonpoint source pollutant loads with and without application of recommended IMP treatment trains. Intent for comparison is to provide an estimate of potential pollutant load reductions due to implementation of proposed stormwater management practices for the five representative subbasins in the Study Area. The pollutant loading reduction assessment is based on the following:

      1) The Simple Method (Schueler 1987) was selected as the appropriate approach for estimating stormwater pollutant loads (see additional detail for the Simple Method above).

      2) Future pollutant loads were broken out into pervious and impervious categories, and the land use acreage treated by a particular IMP treatment train was calculated using the HydroCAD model developed for the study.

      3) Since no IMPs were specifically designated to treat pervious surfaces, a capture discount of 0.0 was used for these areas. For impervious surfaces, a capture discount of 0.95 was used since all proposed treatment trains are sized to treat up to the 95% storm.

      4) IMP treatment train reduction efficiencies identified by the effort conducted under heading 15.3 above were used for this assessment.

14.6 SIZING AND LAYOUT OF TREATMENT TRAINS

14.6.1 Standards and References

Sizing and layout of treatment trains would be guided by the following:

- Applied Microcomputer Systems (AMS). 2006. *HydroCAD Stormwater Modeling System*. Version 8.
- *CNMI and Guam Stormwater Management Manual*. October 2006.
- Schueler, T. R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Publ. No. 87703. Washington: Metropolitan Washington Council of Governments.
- Department of the Navy – Strategic Forward Basing Initiatives Guam, Marianas Islands, *Low Impact Development Manual*. (Draft dated April 2009).

14.6.2 Sizing and Layout of Treatment Trains

1. Scope

   a. Develop a conceptual layout of potential site specific BMPs and IMPs in conjunction with the proposed development plan and notional grading plan.

Coordinate with previous task regarding development of stormwater treatment train options. Design of site specific BMPs and IMPs is based on the following:

1) Stormwater treatment train requirements and conceptual layouts were based on five representative subbasins in the Study Area.
2) Runoff simulated using HydroCAD Version 8 stormwater modeling software.
3) Based on the results of rainfall analysis, the 95th percentile rainfall depth of 2.2 inches (24-hour duration) was used in the HydroCAD stormwater runoff analysis. HydroCAD modeling employed the same CN values for open space (39) and impervious areas (98) as used for the FLO-2D modeling.
4) Provide storage and treatment for all runoff generated by the 95% storm event (2.2 inches in 24 hours).
5) BMP Treatment Train Components:
   - *Dry Wells.* Sized to capture roof runoff generated by the 80% storm event for a 5,000 ft^2 area (approximate). These pre-cast concrete structures would be 8 ft in diameter and 4 ft deep. The dry well stone fill is typically 1.5 to 3.0 inches in diameter. Assumed exfiltration rate of 5-inches/hour.
   - *Vegetative Practices.* Dry swales employed to intercept and convey stormwater runoff to downstream BMPs (detention basins). Generally, the swales are 16 ft wide (top) and 2 ft deep.
   - *Porous Pavement.* Porous asphalt cement pavement to be used in non-vehicular areas only.
   - *Bioretention Basins.* Sized to capture runoff from the 95% storm from areas less than 2 acres. Maximum depth of 2.5 ft with temporary ponding area 6-inches deep. Side slopes of 4:1; exfiltration rate of 3-inches/hour
   - *Stormwater Oil/Sediment Separator.* Structural stormwater treatment system device to provide pretreatment before discharge to subsurface, or aboveground, infiltration system. Units required to treat runoff from 95% storm; range of peak runoff rates is between 0.25 cfs and 2.1 cfs.
   - *Subsurface Stormwater Infiltration System.* Must be lo*cated downstream of oil/sediment separator* device. For the proposed project, these systems have been sized to provide detention and infiltration for the runoff generated by the 95% storm only.
   - *Green Roof System.* Green roof should be of *extensive* design, with maximum of 6 inches soil depth, planted with low maintenance, drought tolerant, low-growing plants.

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Appendix A
Stormwater Guidance Materials

Appendix A.1
Pre-Development Stormwater Runoff Modeling Results

Table A.1: Conflict Table

Finegayan Grading and Basin Conflicts

Conflict Number[1]	Sub Area	Detention Basin and Grading Conflicts with GJMMP	Resolutions (1)	Resolutions (2)	Resolutions (3)
C1	W	*Conflicts with interior parcel slope*	Rotate bulidings out of proposed slope	Regrade PMO area to include one larger slope	Relocate PMO area to eliminte Interior Parcel Slopes
C2	W	*Conflicts with CRSP Warehouse*	Relocate building out of low point of area	Revise Notional Grading to change low point	Reduce Basin size and drain to Wildlife Refuge
C3	Y	*In conflict with ORG Parking*	Relocate parking out of low point of subarea	Revise grading to relocate low point	Eliminate or reduce basin footprint and drain north to wildlife refuge
C4	X	*In Well Head Protection Zone and building conflict*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required.	Relocate Building to high point of parcel	Revise Notional Grading plan to relocate Basin
C5	V	*Conflicts with open storage area*	Rotate Buildings 90 degrees and create area for basin	Regrade to drain parcel to north	Reduce basin size and drain overflow to open space
C6	R' North	*In Well Head Protection Zone*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required.	Pipe flow to western NACCOM area or abondon well	Well located at low point of Notional Grading plan revise grading plan to reloacte Well
C7	U	*Conflicts with storage area*	Rotate buildings; provide area for detention Basin	Revise Notional grading to drain toward smart growth (detention) area to east and culvert to basin	Drain to NAVCOM reserve area
C8	AA	*In conflict with BLDG and Parking*	Locate this layout out of the low point of this area	Revise Notional Grading plan to revise low point	-
C9	O' West	*GoJ1 Street Flow Basin in Conflict with Building*	Relocate Building	Relocate basin to side of building	Pipe flow to detention basin14.20 to the East
C10	DD	*In conflict with Parking*	Provid area for detention basin in middle of drainage area "DD"	Create swale for Area "DD" that drains to secondary overflow swale at the eastern edge of the site	-
C11	DD	*In conflict with Parking*	Create area for detention basin	Overflow to Route 3 overflow swale	Create area for detention basin, and overflow to route3 overflow swale
C12	T	*In conflict with GJMMP (Building and Operational area)*	Relocate building to high point of parcel	Revise Grading to change low point of parcel and relocate Basin	Shift Building North and reduce basin size to just the operational Area
C13	BB	*In conflict with GJMMP*	Relocate building and parking area to higher ground	Locate building within WHP zone to leave basins out of protection zone	-
C14	R' South	*GoJ1 Street Flow Basin in WHP zone*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required.	Revise Low point of street to discharge flow away from Well Head	-
C15	BB	*In Well Head Protection Zone and conflicts with Building*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required. Revise location of building to higher ground	Edge of WHP zone consult with Guam EPA	Revise Notional Grading Plan to change low point
C16	O' Open Space	*Recreational Field located out of graded area*	Relocate field	Extend Grading to include this area	Adjust field location and extend grading to cover field
C17	K' North	*Building DWY's and parking lots encroaching into slope*	Include buffer zones to reduce dwy slopes	Revise grading to reduce dwy slope	Include buffer zone off slope and revise grading to reduce dwy slopes
C18	P	*In conflict with Organational parking area*	Create detention basin area at midpoint of area "P"	Reduce basin footprint and discharge overflow to secondary overflow swale	Create area for basin and reduce footprint size and overflow to overflow swale
C19	K' North	*GoJ1 Street Flow Basin in WHP zone*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required. Revise location of building to higher ground	Pipe flow downstream away from Well Head most likely to BEQ open space	-
C20	F	*Conflict with parade ground*	Reduce Parade ground area	Flow to basin 13.37 and overflow into wildlife refuge	Reduce basin footprint, ad dry wells dowstream and culvert to basin 13.37
C21	O' Open Space	*Buildings located outside graded area*	Relocate buildings	Regrade to include buildings	Relocate and regrade

---

[1] Conflict numbers coorespond to Detention Basin Map

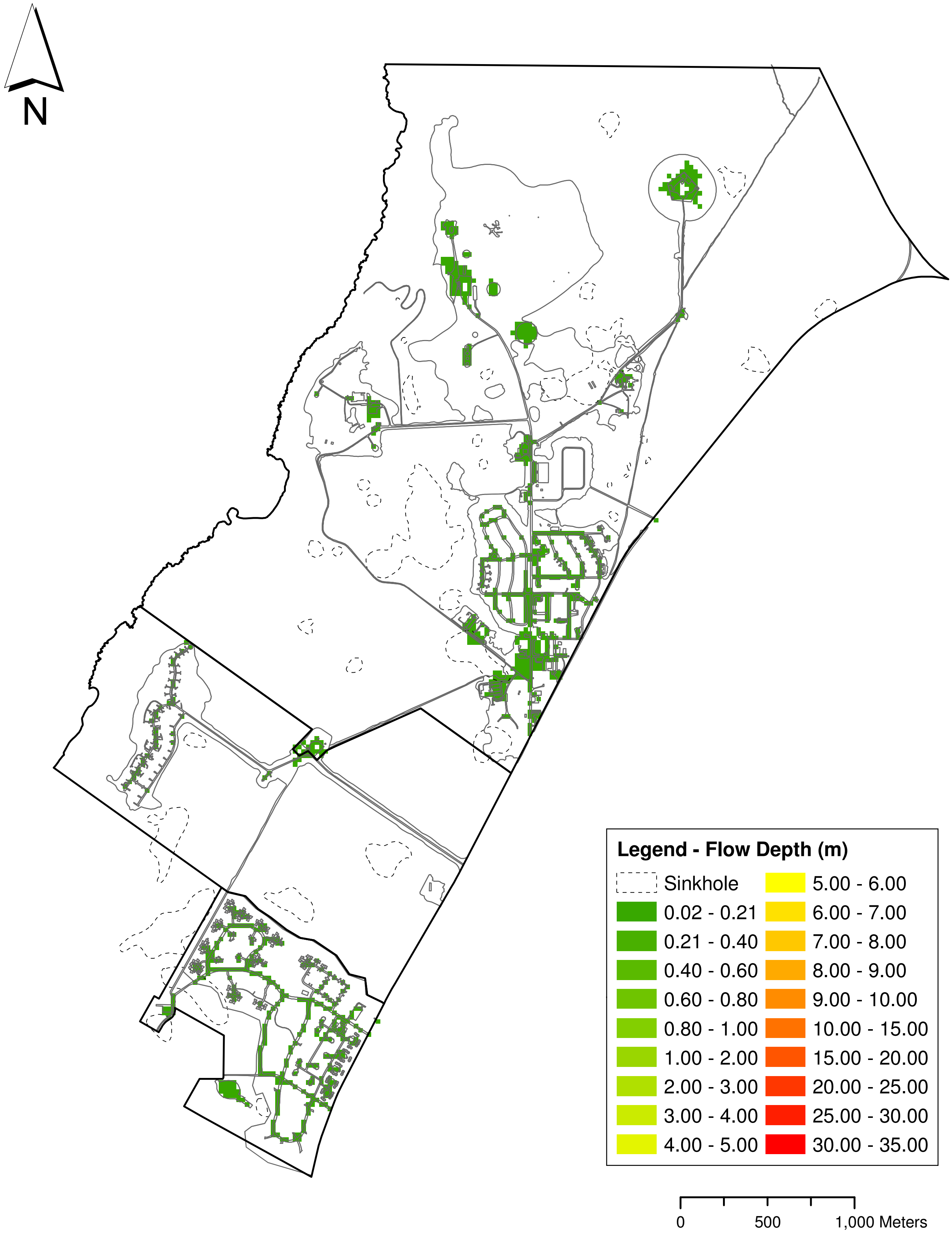
Conflict Table

Finegayan Grading and Basin Conflicts

Conflict Number[1]	Sub Area	Detention Basin and Grading Conflicts with GJMMP	Resolutions (1)	Resolutions (2)	Resolutions (3)
C22	O' Open Space	*Building located outside graded area*	Relocate building	Regrade to include building	Relocate and regrade
C23	G	*Basin at high point of Parcel*	Include micro storage around buildings to west to eliminate basin	Increase the size of Basin 16.44 and adjust BLDG to eliminate basin	Increase 16.44 and 16.45 and include micro storage around BLDG to eliminate Basin
C24	Z	*Basin inside well head protection zones*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required. Revise location of building to higher ground	Revised Notional Grading plan to Drain toward the North away from Well Head	-
C25	Z	*Basin inside well head protection zones*	Det basin can not be cost effectively moved and additional attention to LID strategies and treatment trains are required. Revise location of building to higher ground	Basin located very close to well, reduce infiltration through basin and channel water away from well	Revise Notional Grading plan
C26	J	*In conflict with Parking and BLDG*	Relocate Welcome Center / This is a natural low spot	Relocate low point to east	-
C27	K' North	*Basins inside well head protection zones*	Relocate Drainage basins on West side of buildings to increase distance from wells	-	-

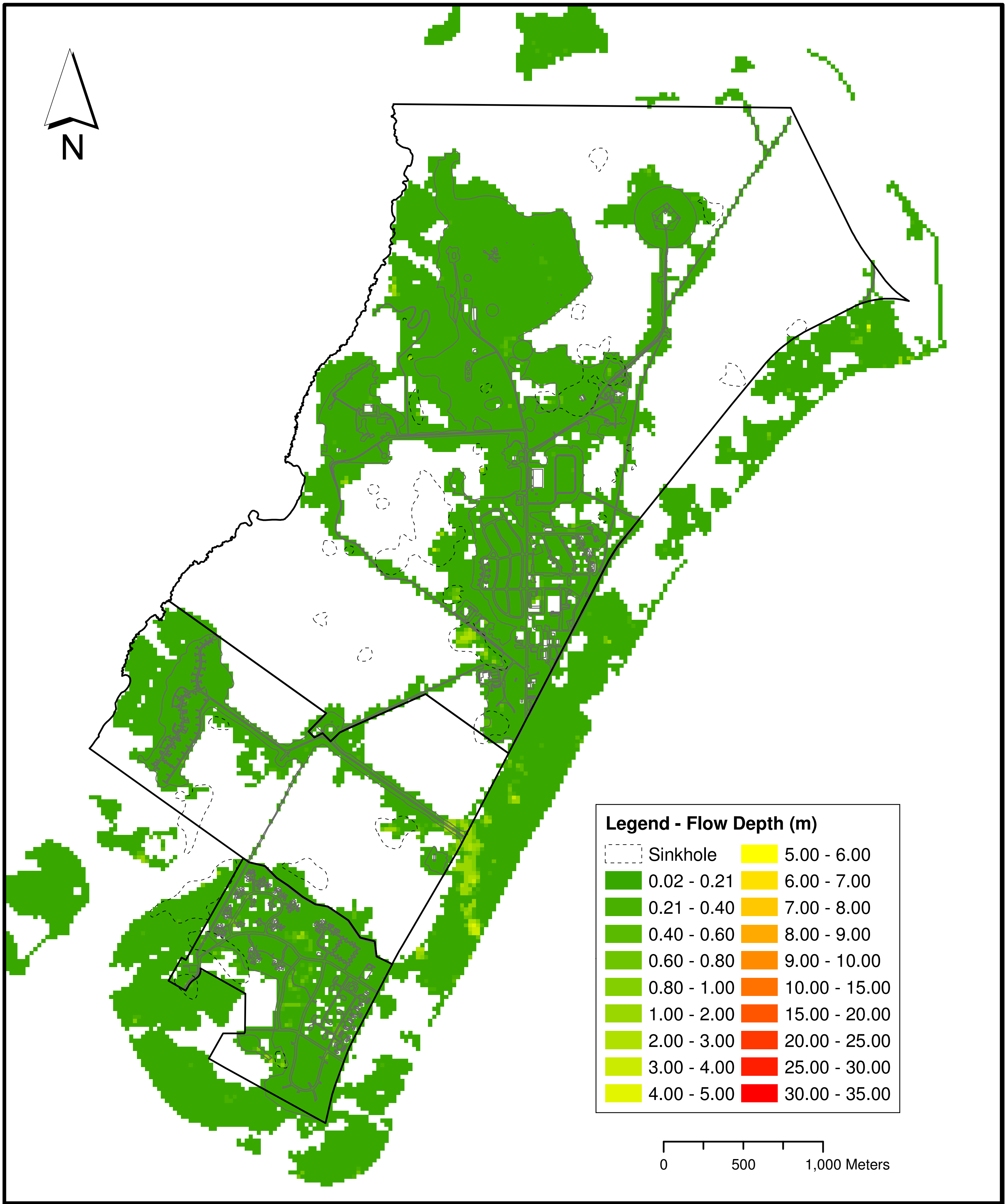
---

[1] Conflict numbers coorespond to Detention Basin Map



NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 1 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 1



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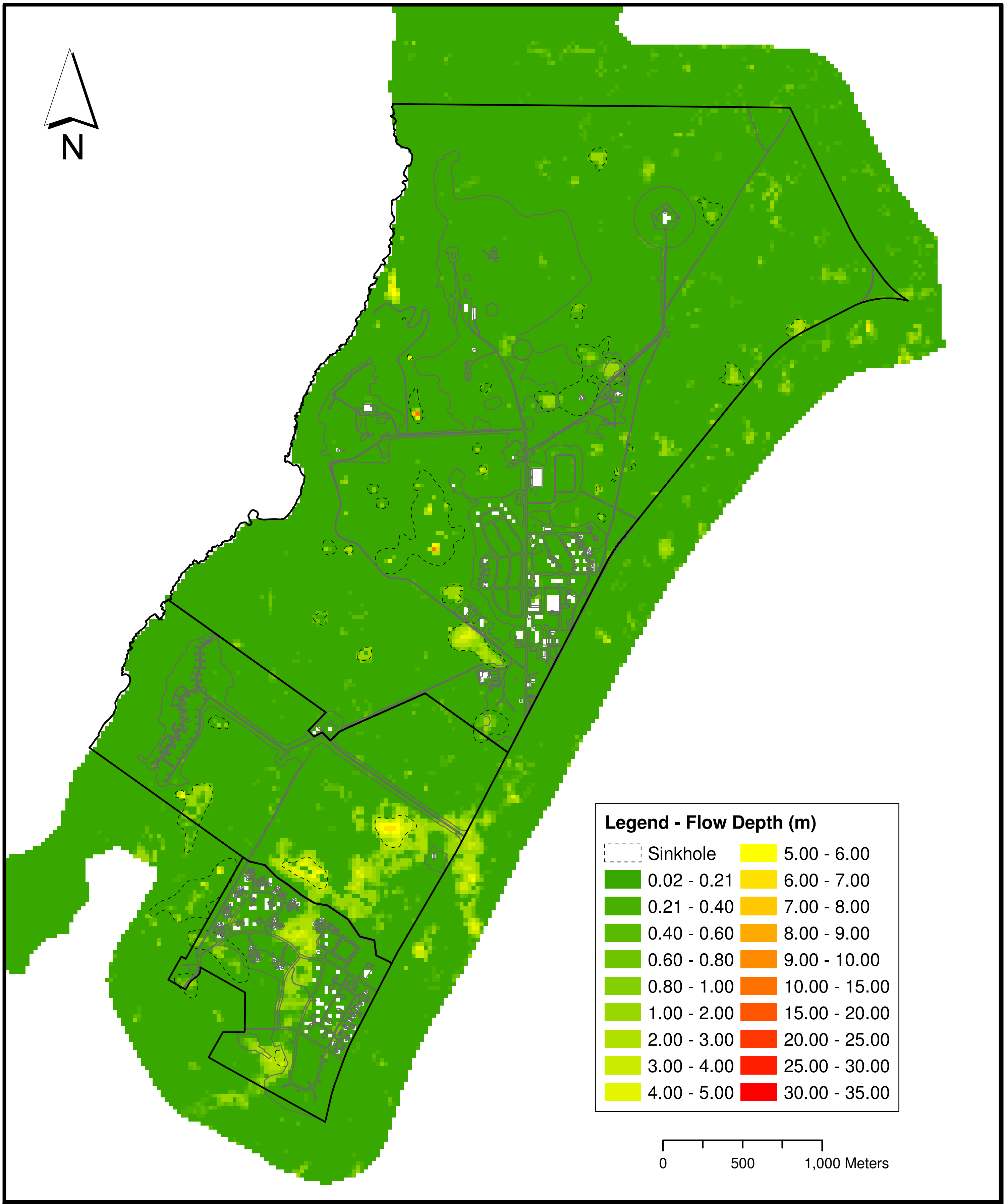
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 2 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 2



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NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 10 Year

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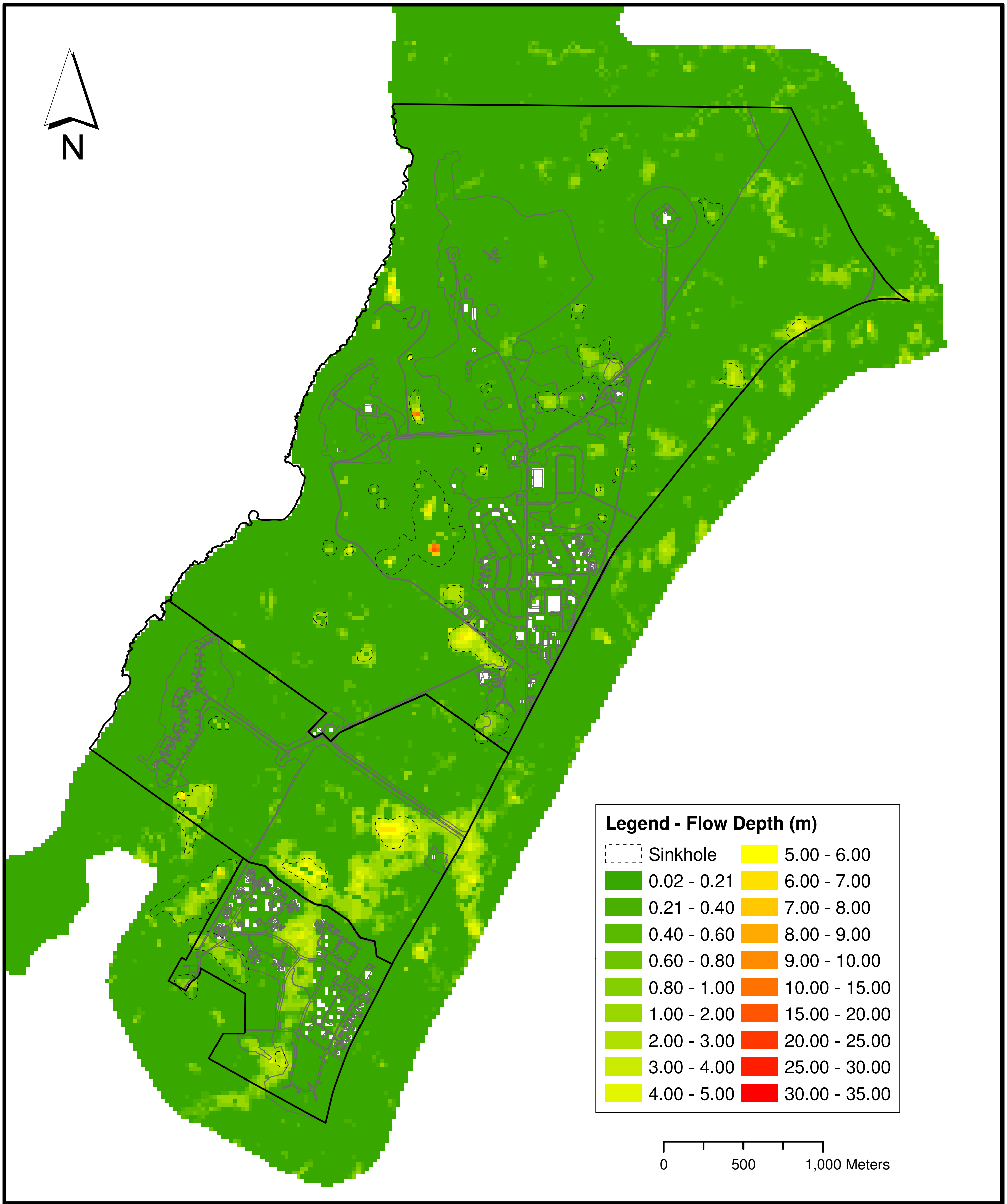
DATE: 02/24/2010

Figure 3



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NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 25 Year

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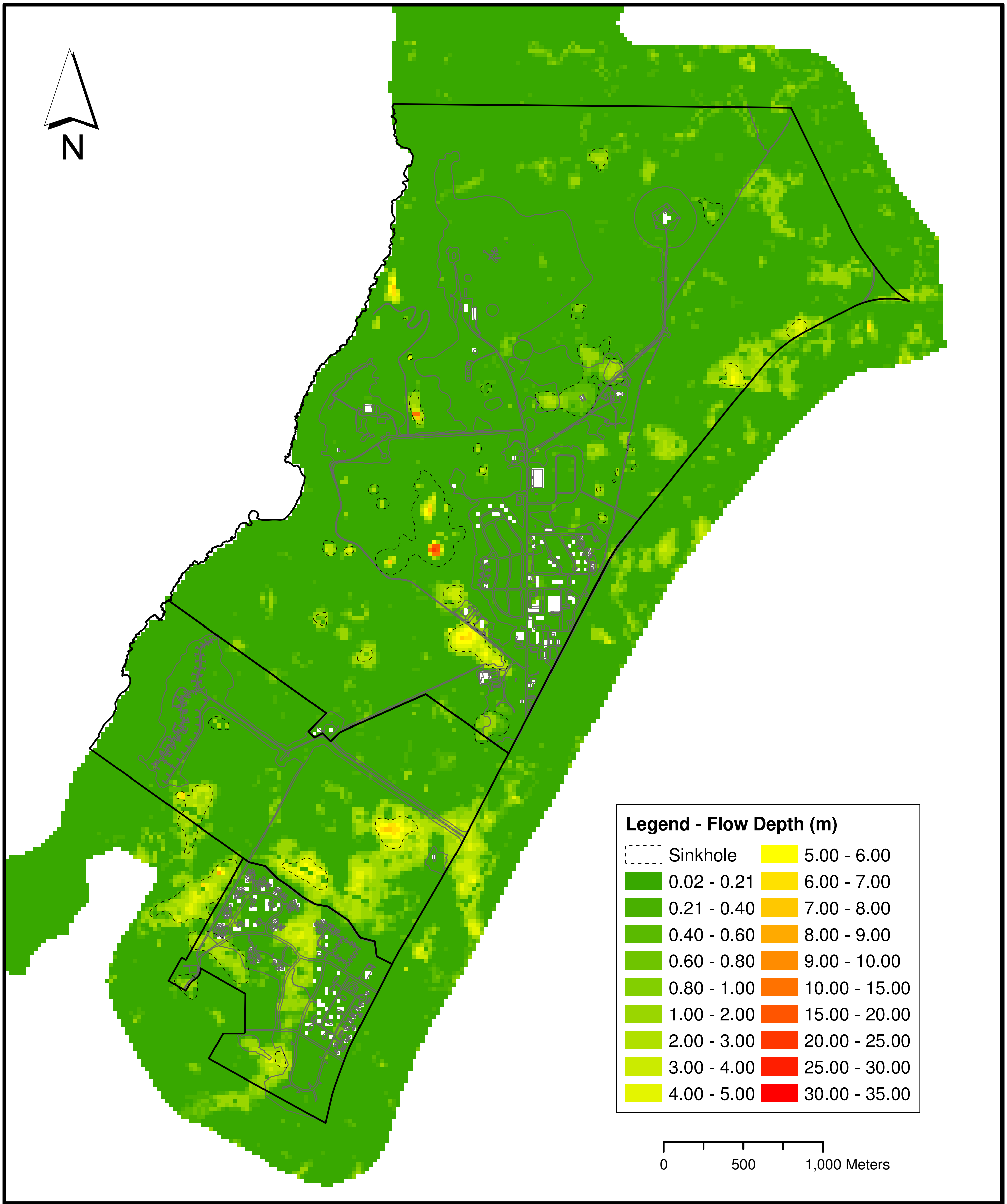
SCALE: AS NOTED

DATE: 02/24/2010

Figure 4



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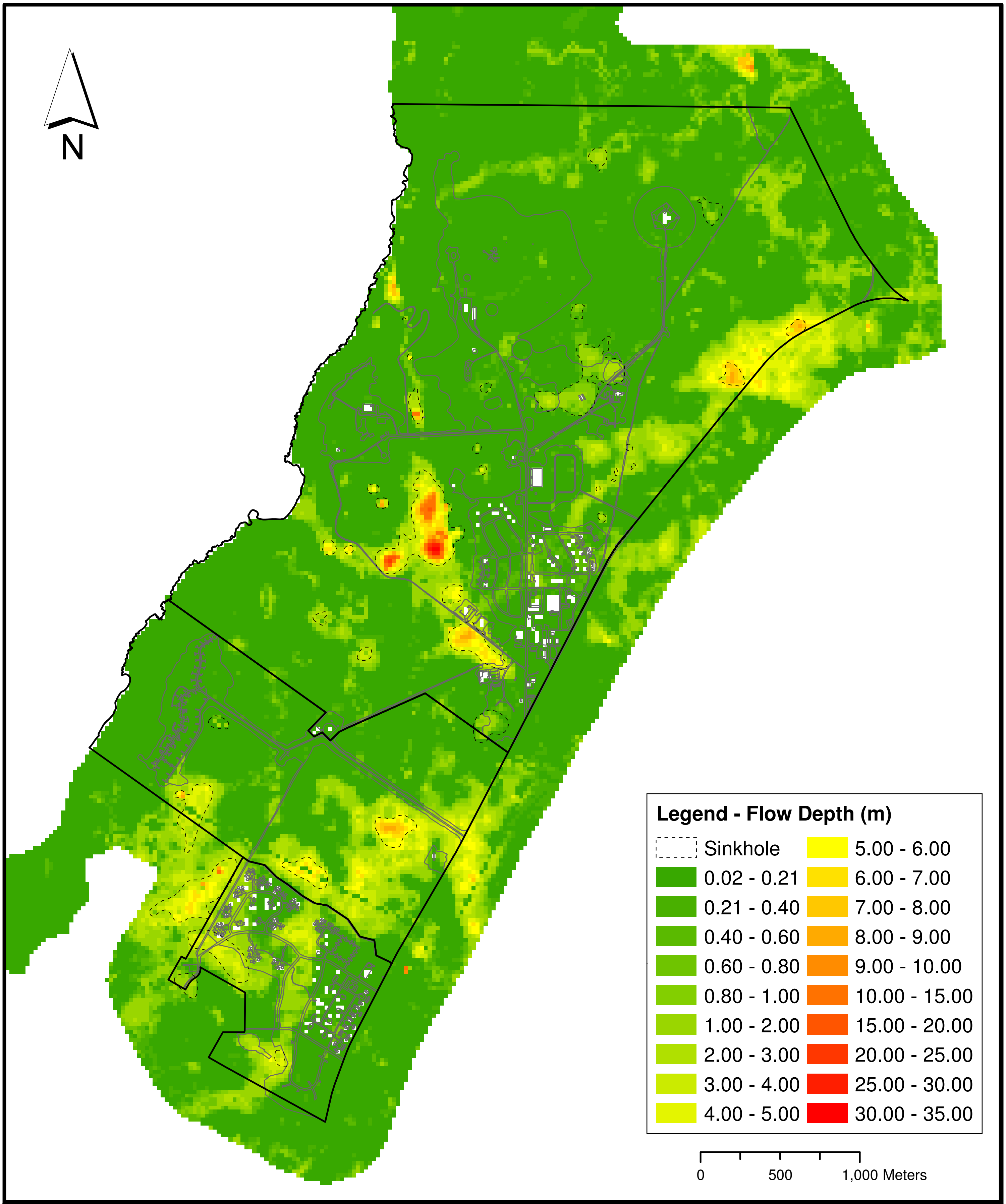
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 50 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 5



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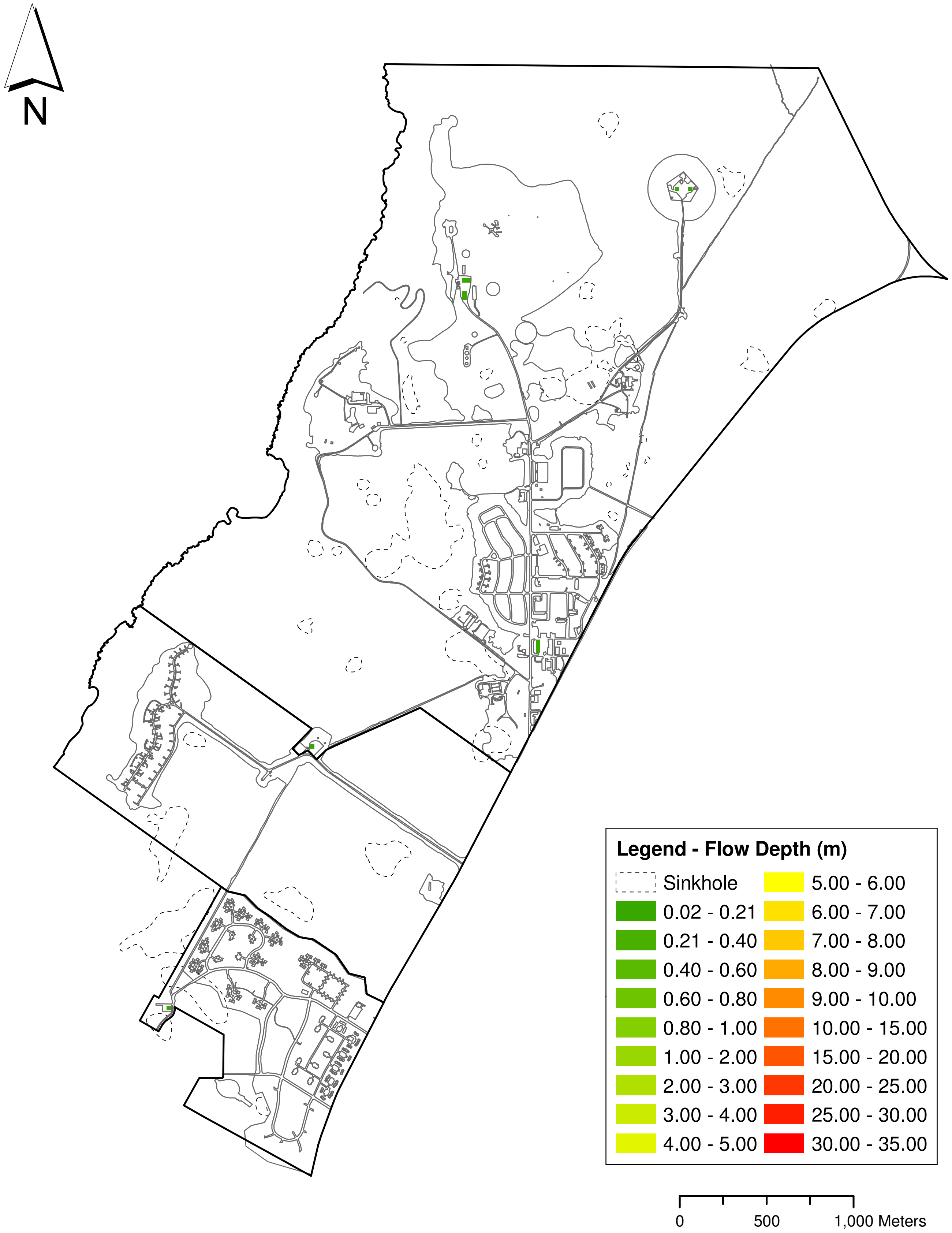
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Max Flow Depth - 500 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 6



NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 80 Percent

GIS FILE:
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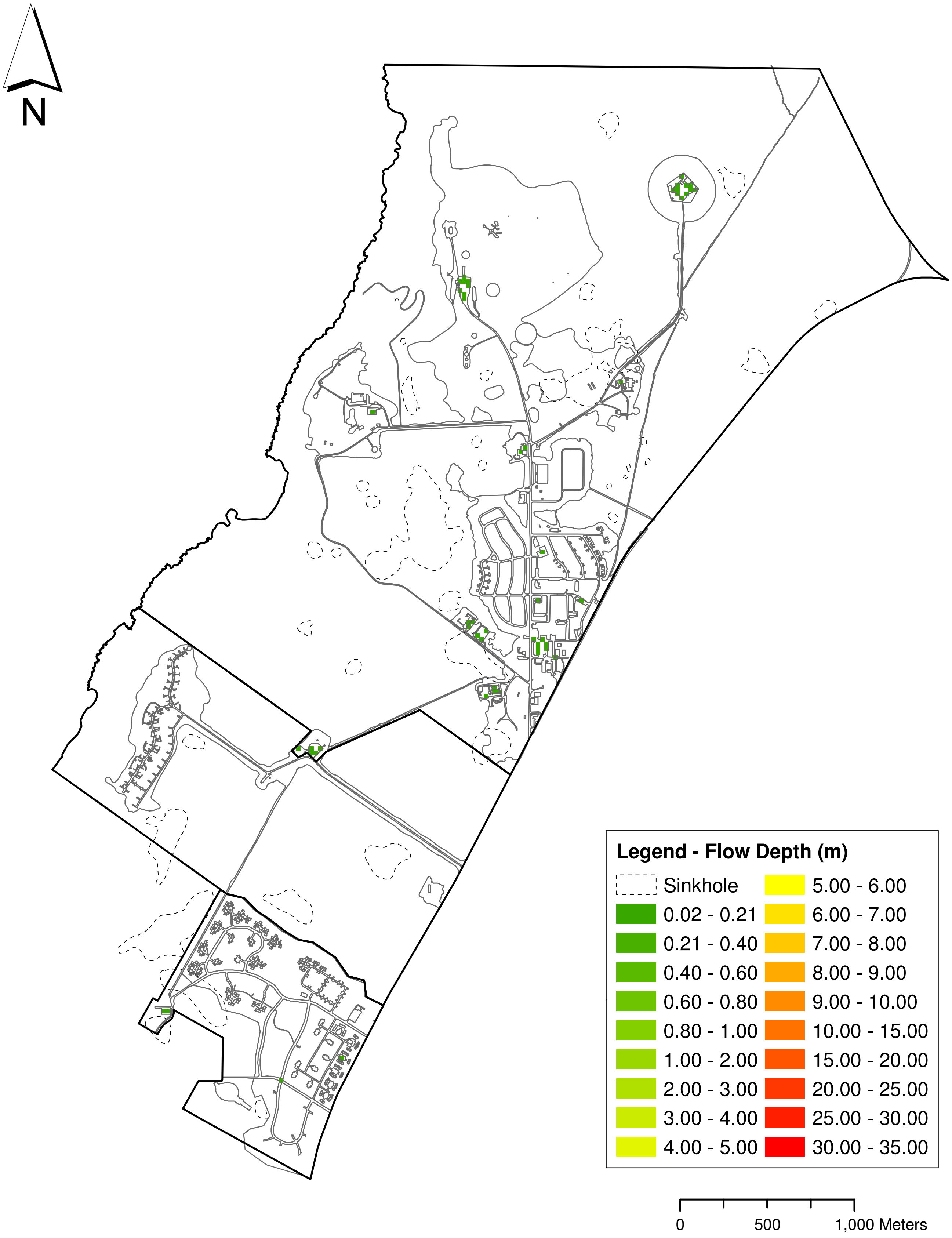
DATE: 02/24/2010
Figure 7



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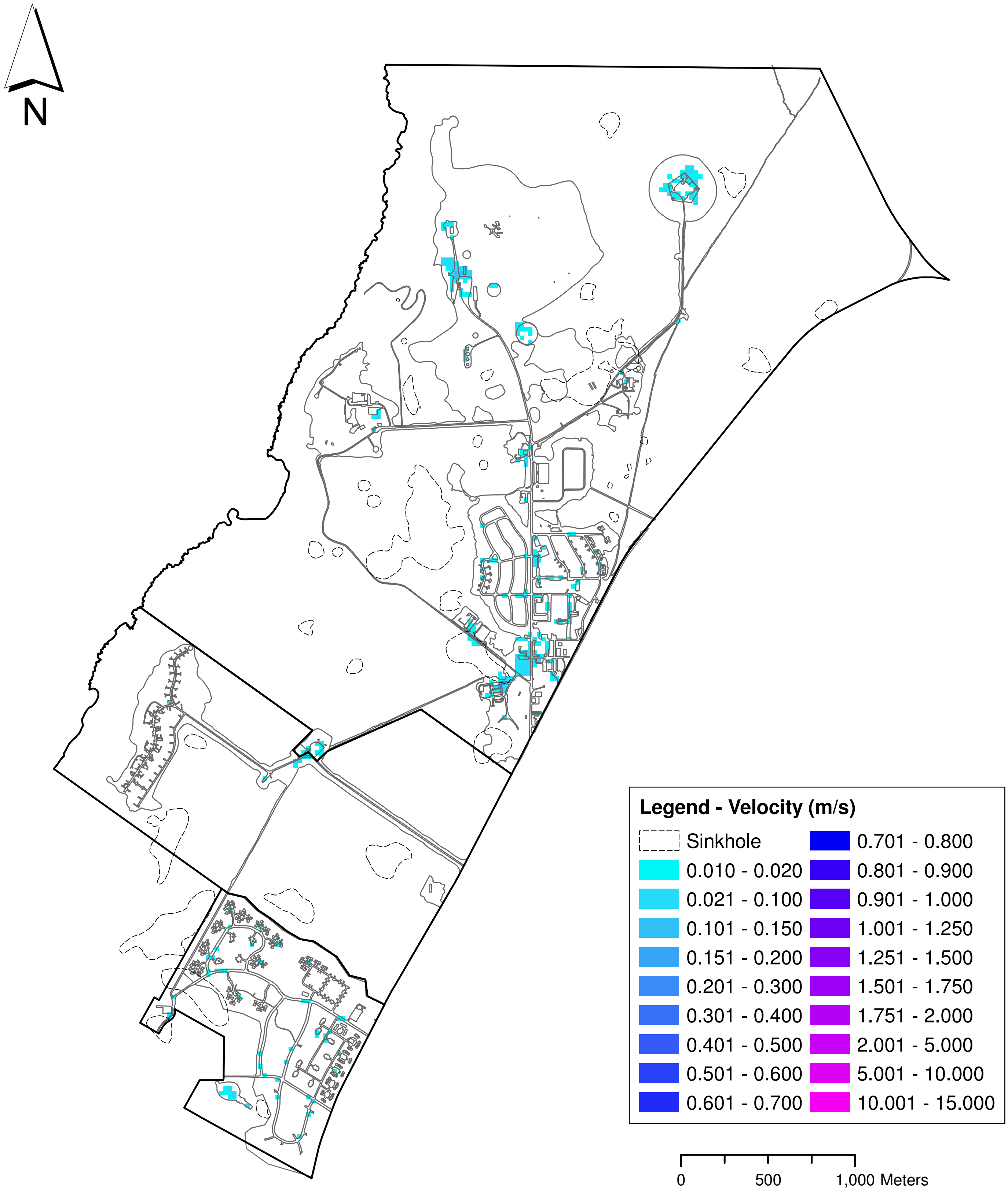
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Flow Depth - 90 Percent

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 8



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NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 1 Year

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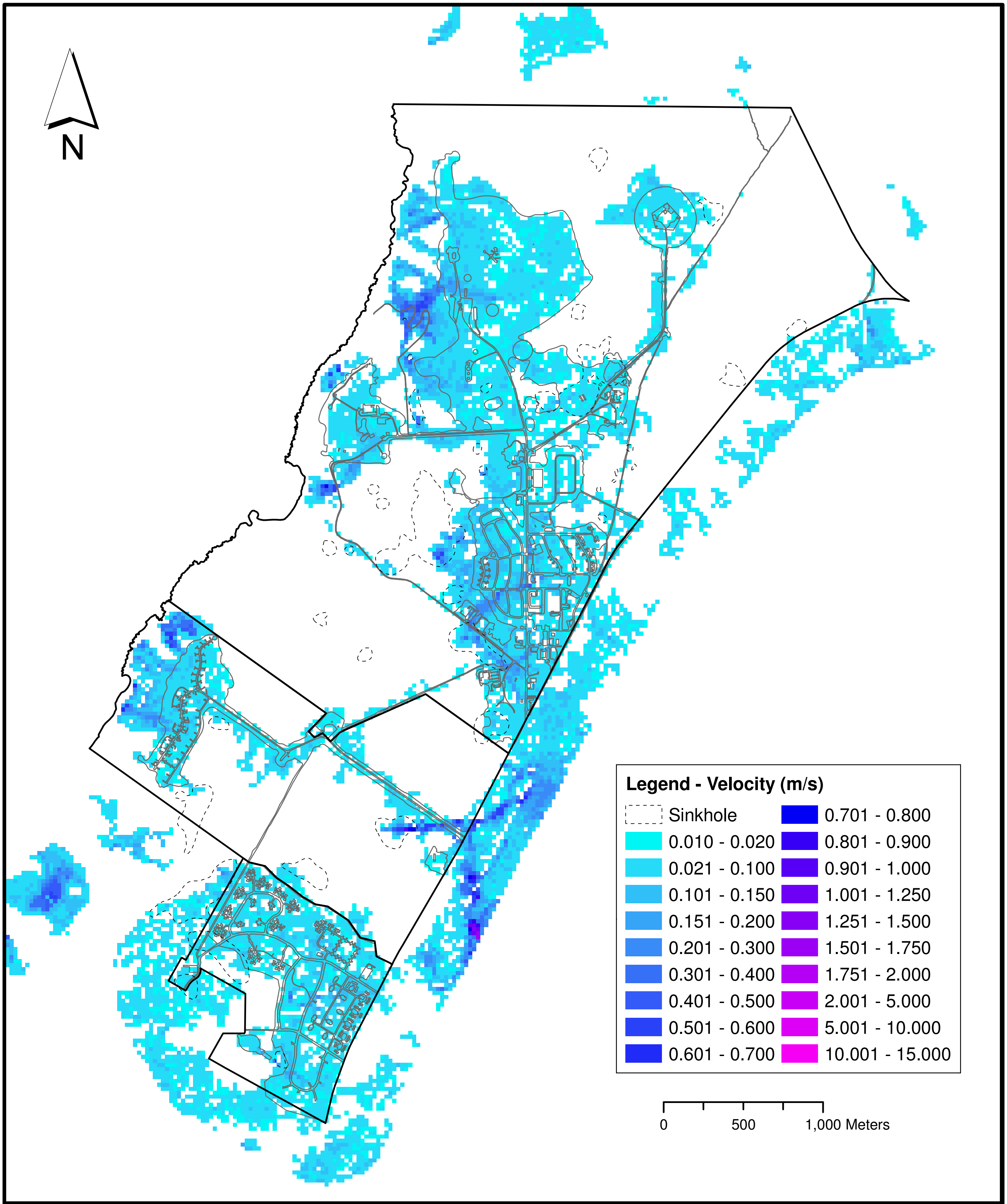
DATE: 02/24/2010

Figure 9



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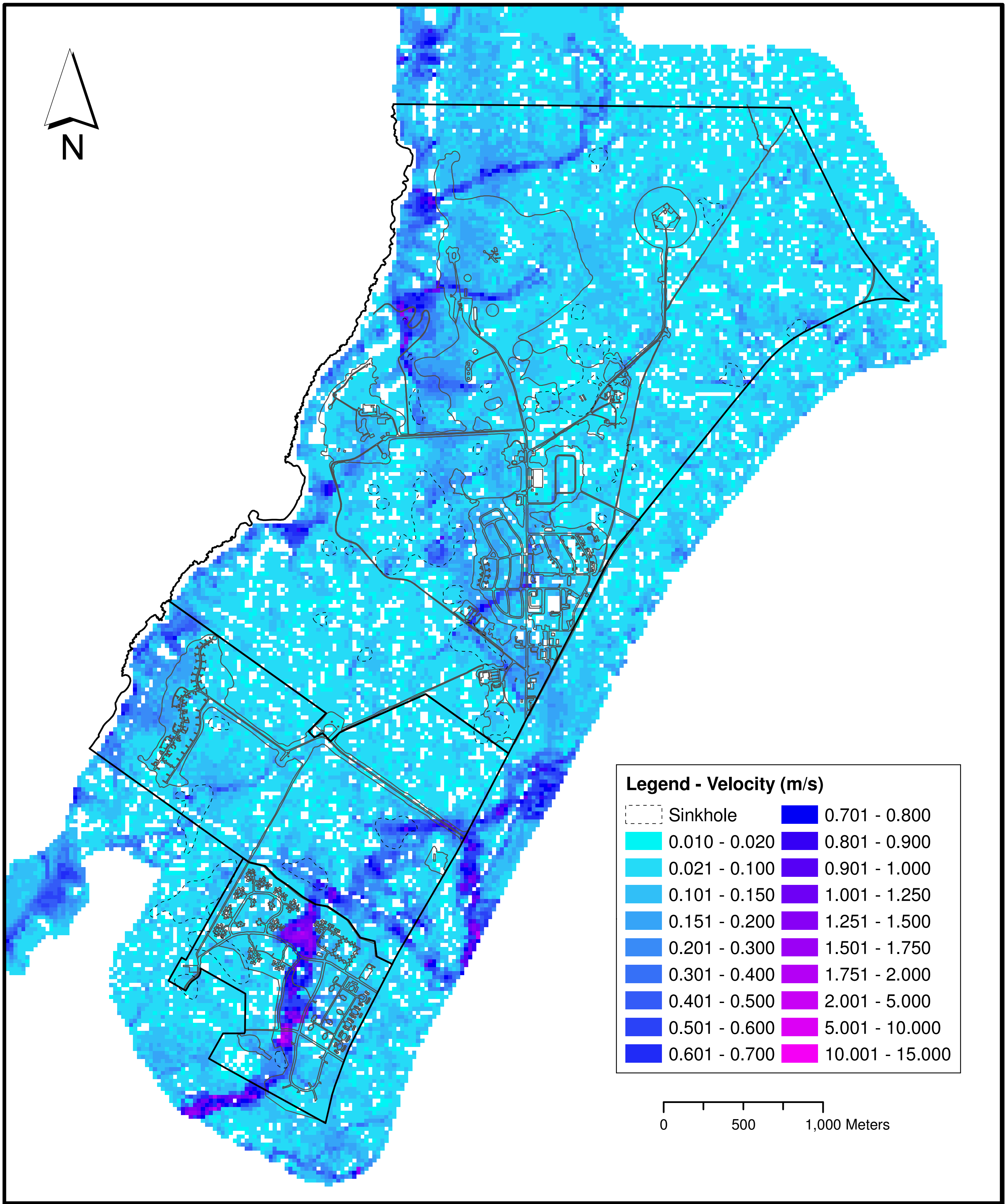
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 2 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 10



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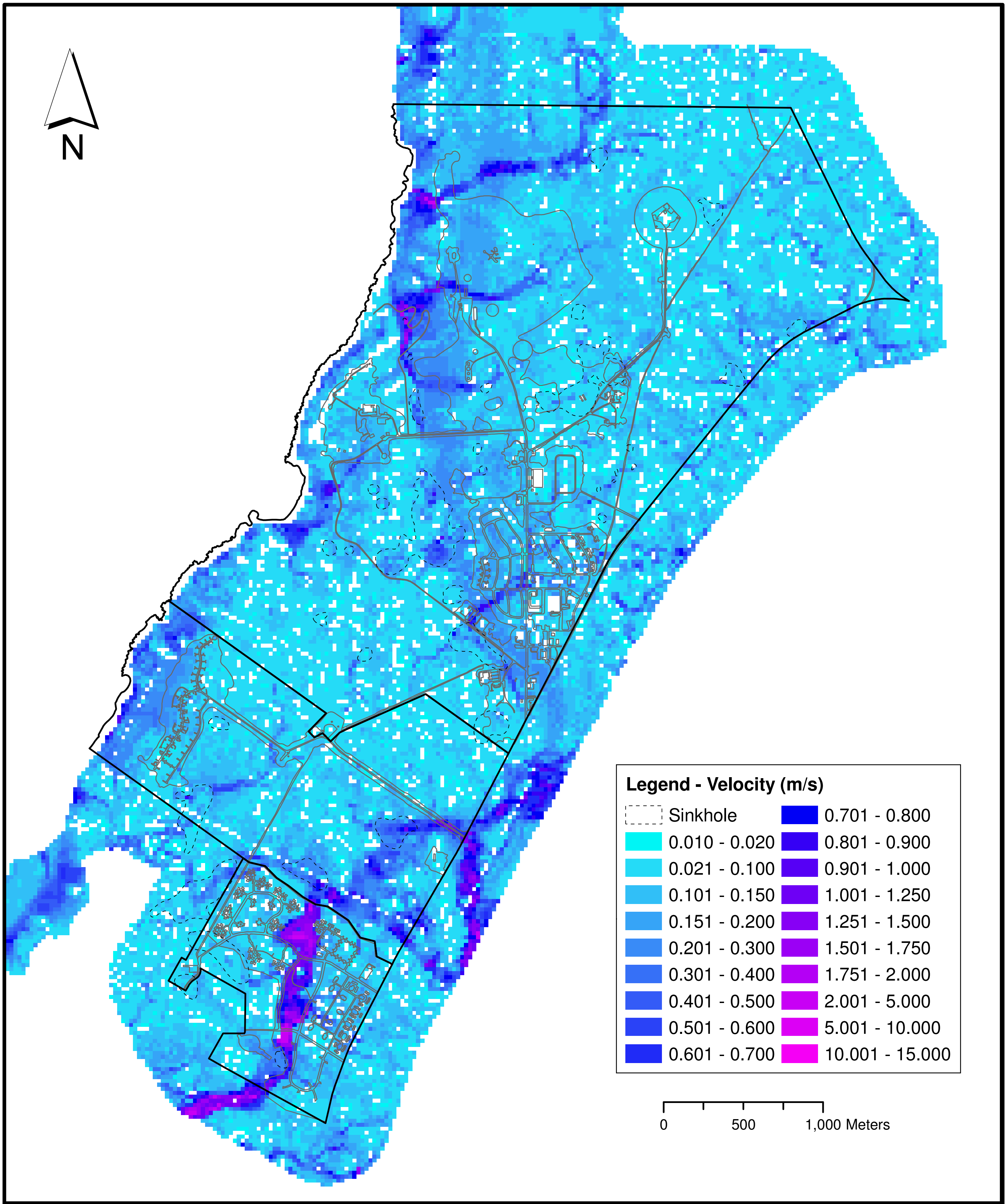
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 10 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

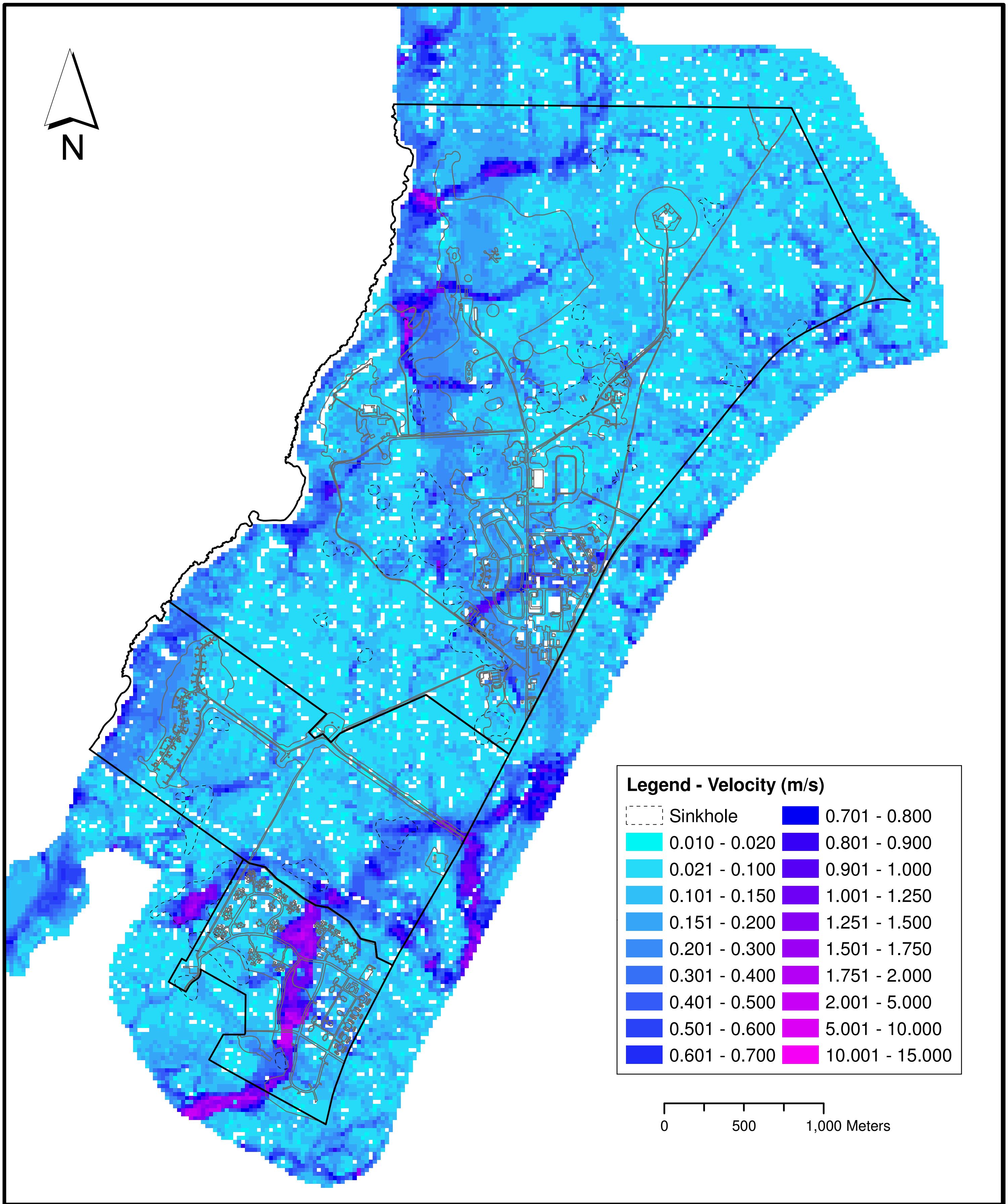
Figure 11



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 25 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 12



NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 50 Year

GIS FILE:

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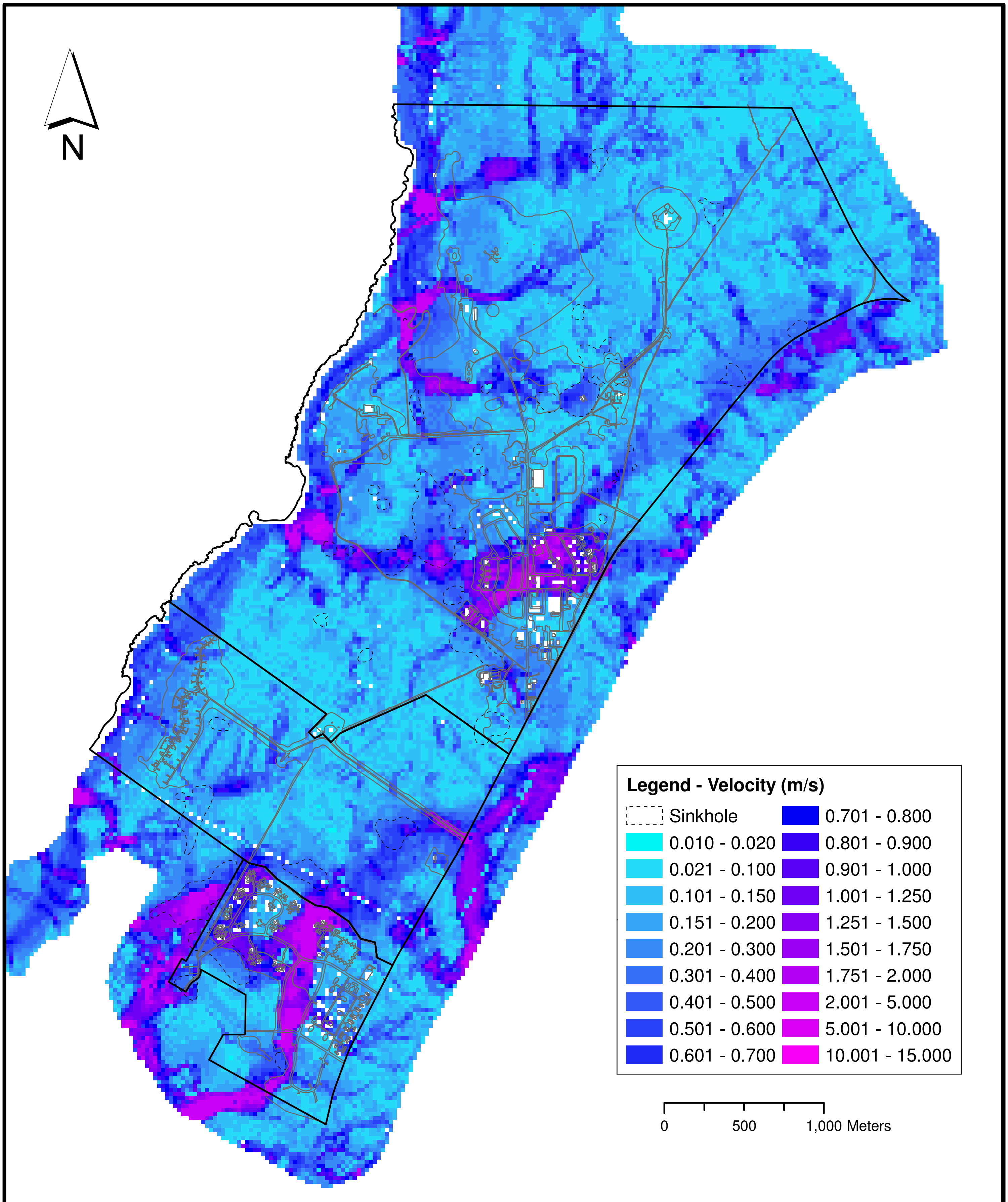
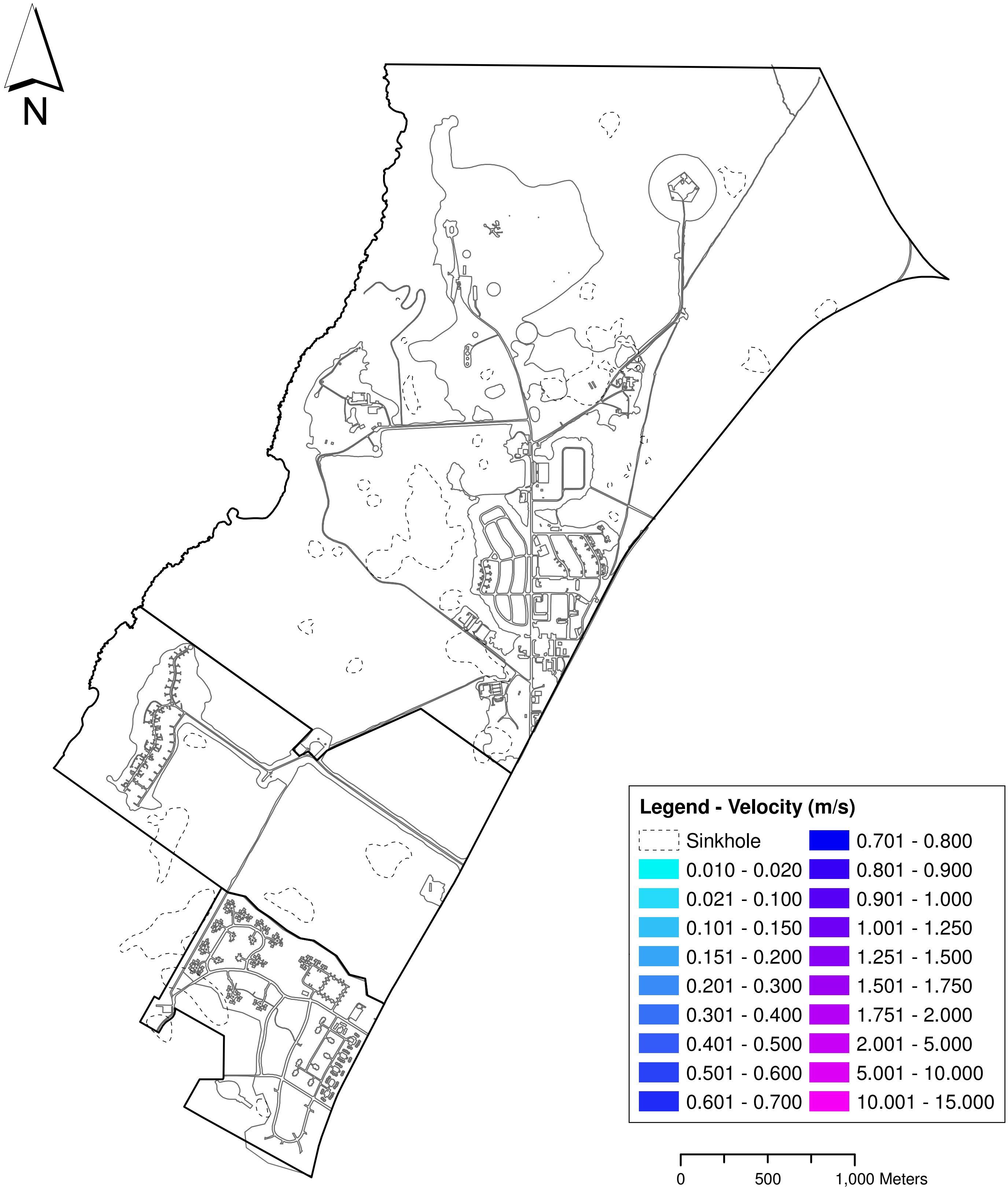
DATE: 02/24/2010

Figure 13



NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 500 Year

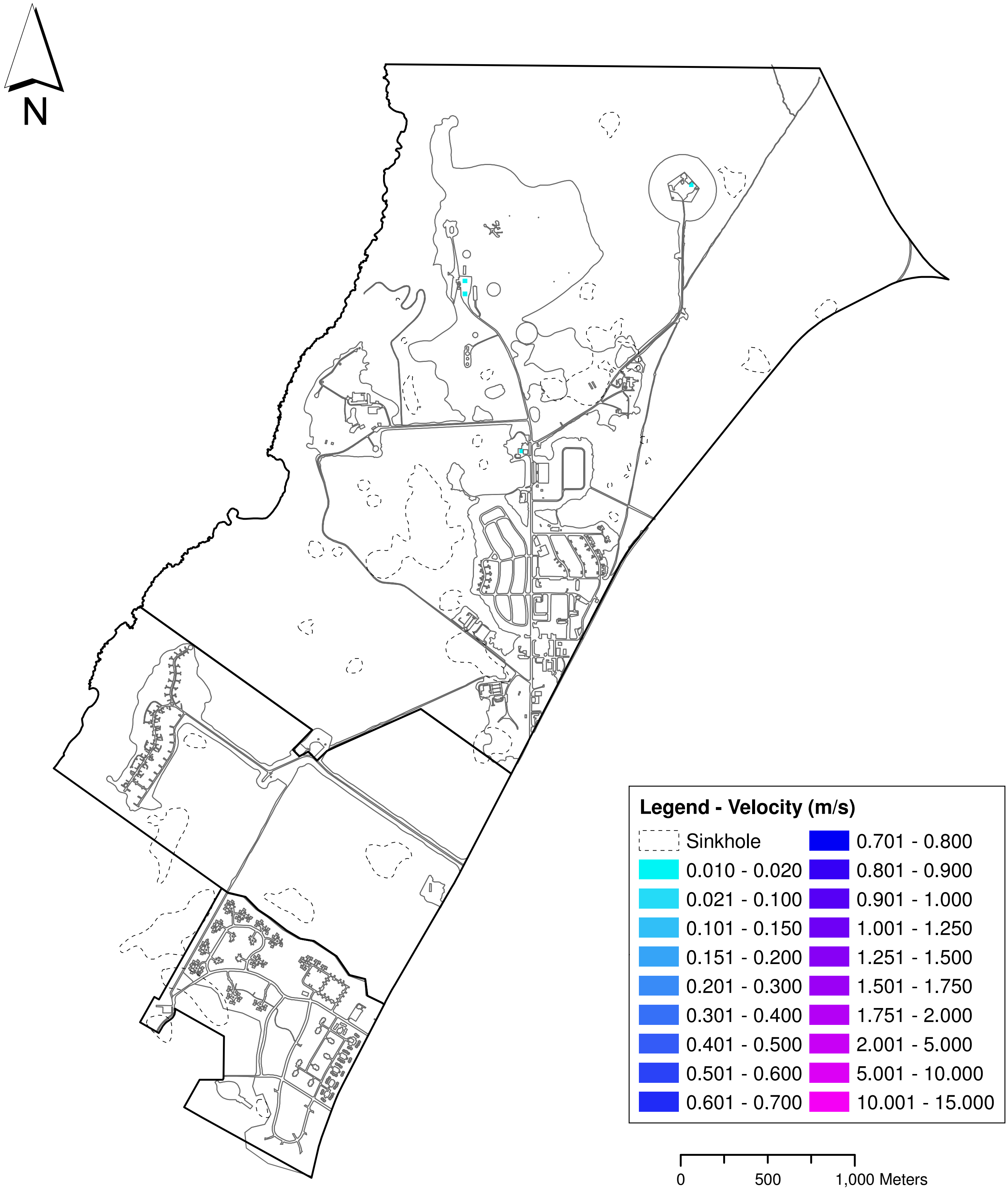
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 14



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 80 Percent

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 15



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NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Pre-Development Velocity - 90 Percent

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 16

Appendix A.2
Tables from Technical Report 55 Manual

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

---

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Appendix A.3
Rainfall Frequency Intensity

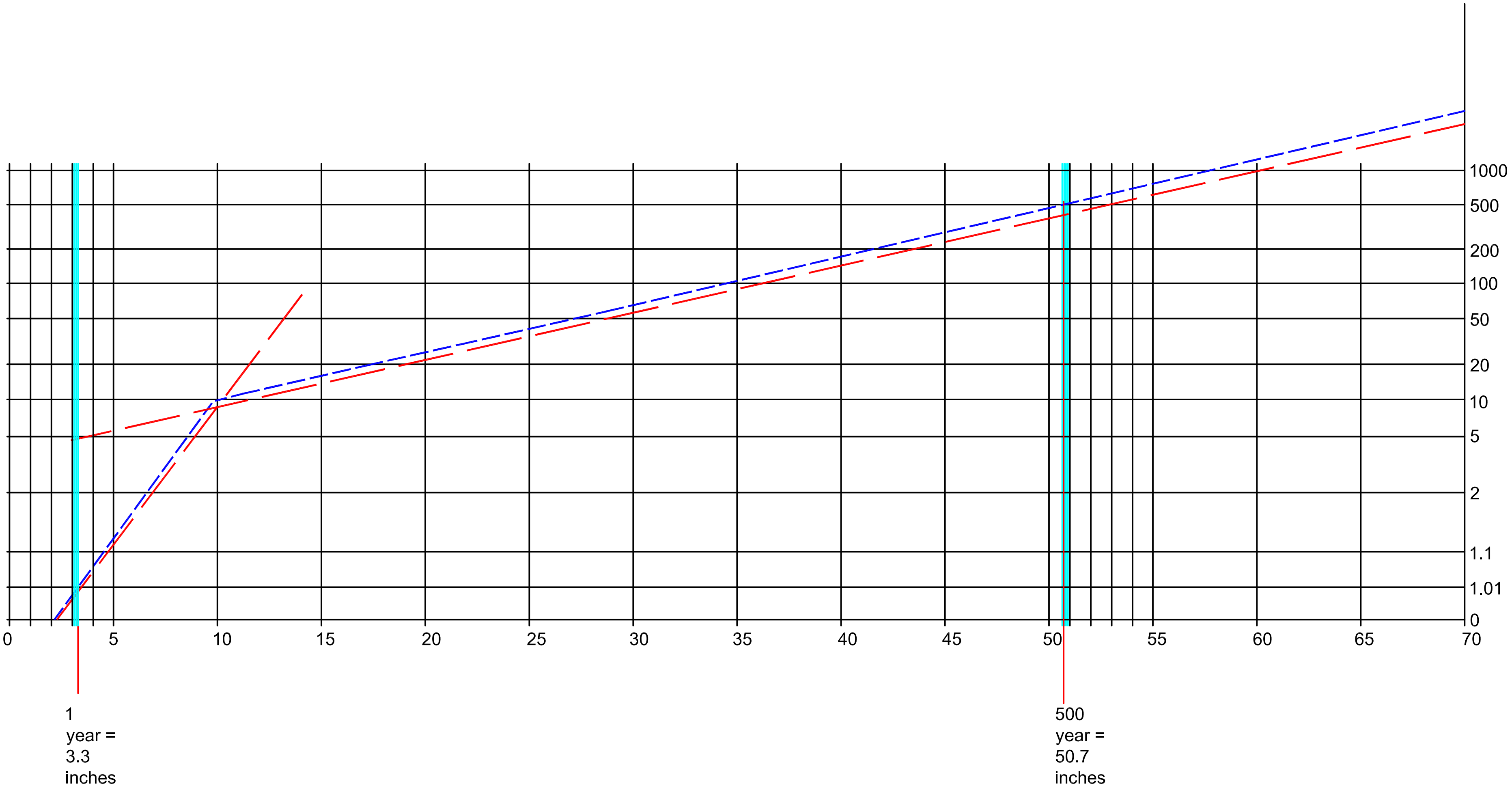
Rainfall Frequency Intensity - Finegayan Main Contonment Area

Recurrance Interval	Exceedance Frequency	Rainfall Depth (in) by Duration			
		5-min	1-hour	6-hour	24-hour
1-year	100%	0.5	1.1	2.1	**3.3**
2-year	50%	0.5	2.2	4.3	**8.0**
10-year	10%	0.8	3.4	6.6	**13.1**
20-year	*5%*	*0.9*	*4.1*	*7.9*	*15.9*
25-year	4%	1.0	4.2	8.2	**16.8**
50-year	*2%*	*1.1*	*4.6*	*9.5*	*20.5*
100-year	1%	1.2	5.3	10.2	**22.6**
500-year		2.2	9.7	19.3	**50.7**

ref: Guam Storm Drainage Manual, September 1980

Rainfall frequency intensity maps		pgs V-13 to V-47
6-hour:	$0.756\,(24\text{-hour})^{0.812}$	pg V-9
1-hour:	0.5 x 6-hour	pg V-11
5-min:	0.23 x 1-hour	pg V-51

1-year, 500-year recurrance intervals interolated from "Rainfall Climatology for Saipan: Distribution, Return-periods, El Nino, Tropical Cyclones, and Long-term Variations," Water and Environment Research Institute, University of Guam, Techinical Report No. 103, Page 20, December 2004



1000
500
200
100
50
20
10
5
2
1.1
1.01
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
1
year =
3.3
inches
500
year =
50.7
inches

Appendix A.4
Section 438 Technical Guidance

- Fewer square yards of sidewalks
- Reduced land purchases for stormwater control structures

In addition, other benefits were achieved through the use of GI/LID such as more beneficial uses of land previously dedicated to stormwater devices, increased livability and higher property values.

There are many different combinations of practices that can be employed at particular sites to achieve pre-development hydrology. In selecting the appropriate set of practices to be used at the site, project sponsors should consider a broad range of factors, including cost-effectiveness of particular combinations of practices as applied to the site, as well as the potential for ancillary cost savings or community benefits (e.g., elimination or reduction of infrastructure costs, or the creation of attractive green spaces). EPA encourages project sponsors to include these factors in the planning and design phases of their projects so as to maximize triple bottom-line (economic, environmental, and social) results.

E. CALCULATING THE 95TH PERCENTILE RAINFALL EVENT

A long period of precipitation records, i.e., a minimum of 10 years of data, is needed to determine the 95th percentile rainfall event for a location. Thirty years or more of monitoring data are desirable to conduct an unbiased statistical analysis. The National Climatic Data Center (NCDC) provides long-term precipitation data for many locations of the United States. You can download climate data from their Web site (www.ncdc.noaa.gov) or by ordering compact discs (NOTE: The NCDC charges a fee for access to their precipitation data). Local airports, universities, water treatment plants, or other facilities might also maintain long-term precipitation records. Data reporting formats can vary based on the data sources. In general, each record should include the following basic information:

- Location (monitoring station)
- Recording time (usually the starting time of a time-step)
- Total precipitation depth during the time-step

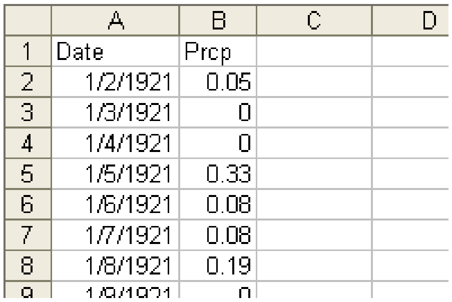
In addition to the above information, a status flag is sometimes included to indicate data monitoring errors or anomalies. Typical NCDC flags include A (end accumulation), M (missing data), D (deleted data), or I (incomplete data). If there are no flags, the record has passed the quality control as prescribed by the NCDC and has been determined to be a valid data point.

There are several data processing steps to determine the 95th percentile rainfall event using a spreadsheet. These steps are summarized below:

1. Obtain a long-term 24-hr precipitation data set for a location of interest (i.e., from the NCDC website).

2. Import the data into a spreadsheet. In MS Excel [Data / Import External Data / Import Data]

3. Rearrange all of the daily precipitation records into one column if the original data set has multiple columns of daily precipitation records.

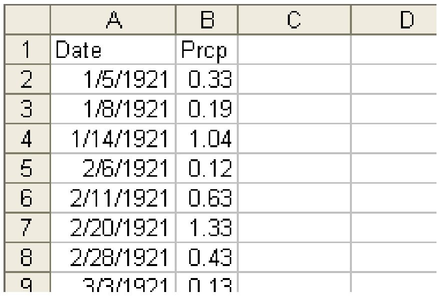


	A	B	C	D
1	Date	Prcp		
2	1/2/1921	0.05		
3	1/3/1921	0		
4	1/4/1921	0		
5	1/5/1921	0.33		
6	1/6/1921	0.08		
7	1/7/1921	0.08		
8	1/8/1921	0.19		

4. Review the records to identify if there are early periods with a large number of flagged data points (e.g., erroneous data points). Select a long period of good recording data that represents, ideally, 30 years or more of data. Remove all of the extra data (if not using the entire dataset).

5. Remove all flagged data points (i.e., erroneous data points) from the selected data set for further analysis.

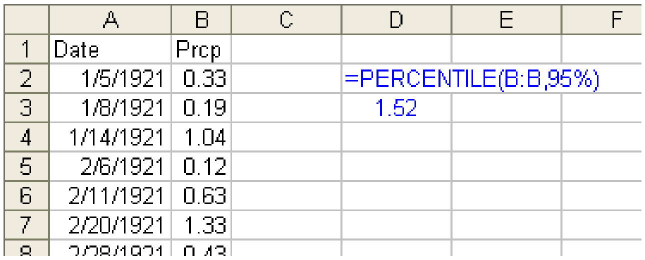
6. Remove small rainfall events (typically less than 0.1 inches), which may not contribute to rainfall runoff. These small events are categorized as depressional storage, which, in general, does not produce runoff from most sites.



	A	B	C	D
1	Date	Prcp		
2	1/5/1921	0.33		
3	1/8/1921	0.19		
4	1/14/1921	1.04		
5	2/6/1921	0.12		
6	2/11/1921	0.63		
7	2/20/1921	1.33		
8	2/28/1921	0.43		

Note: Steps 4 through 6 can be processed by applying data sort, delete and re-sort spreadsheet functions. In MS Excel [Data / Sort]

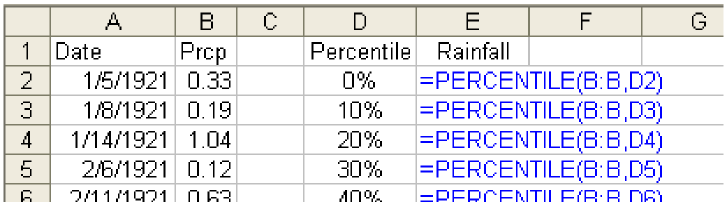
7. Calculate the 95th percentile rainfall amount by applying the PERCENTILE spreadsheet function at a cell. In MS Excel [=PERCENTILE(precipitation data range,95%)]



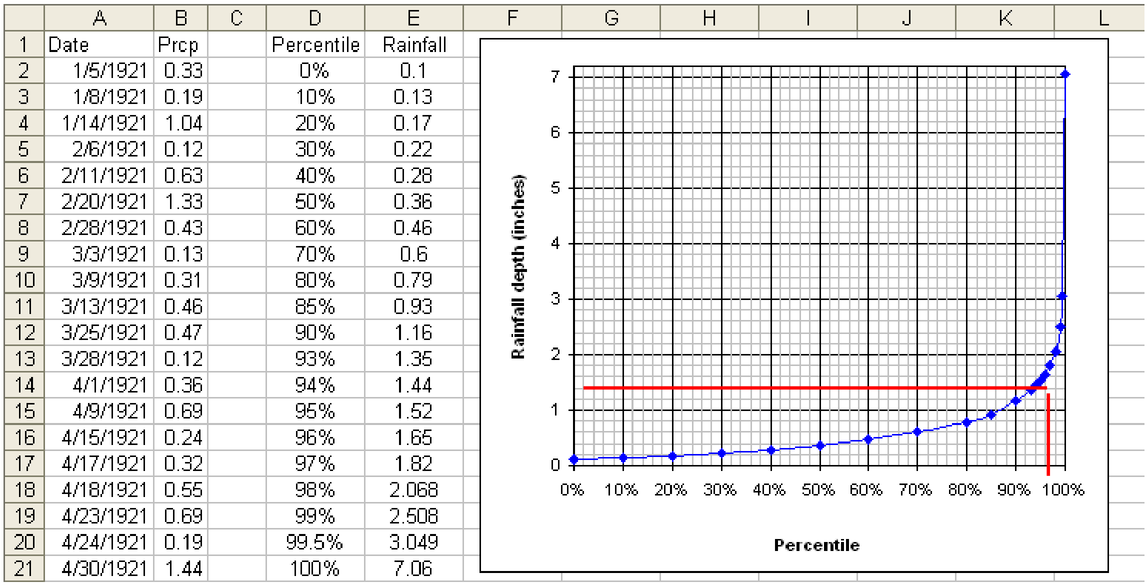
	A	B	C	D	E	F
1	Date	Prcp				
2	1/5/1921	0.33		=PERCENTILE(B:B,95%)		
3	1/8/1921	0.19		1.52		
4	1/14/1921	1.04				
5	2/6/1921	0.12				
6	2/11/1921	0.63				
7	2/20/1921	1.33				

Note: The PERCENTILE function returns the nth percentile of value in the entire precipitation data range. This function can be used to determine the 95th percentile storm event that captures all but the largest 5% of storms.

8. The 95th percentile was calculated in the previous step. However, if the user would like to see this information represented graphically and get a relative sense of where individual storm percentiles fall in terms of rainfall depths, the following methodology can be used. Derive a table showing percentile versus rainfall depth to draw a curve as shown below. The PERCENTILE spreadsheet function can be used for each selected percent. It is recommended to include at least 6 points between 0% and 100% (several points should be between 80% and 100% to draw an accurate curve).



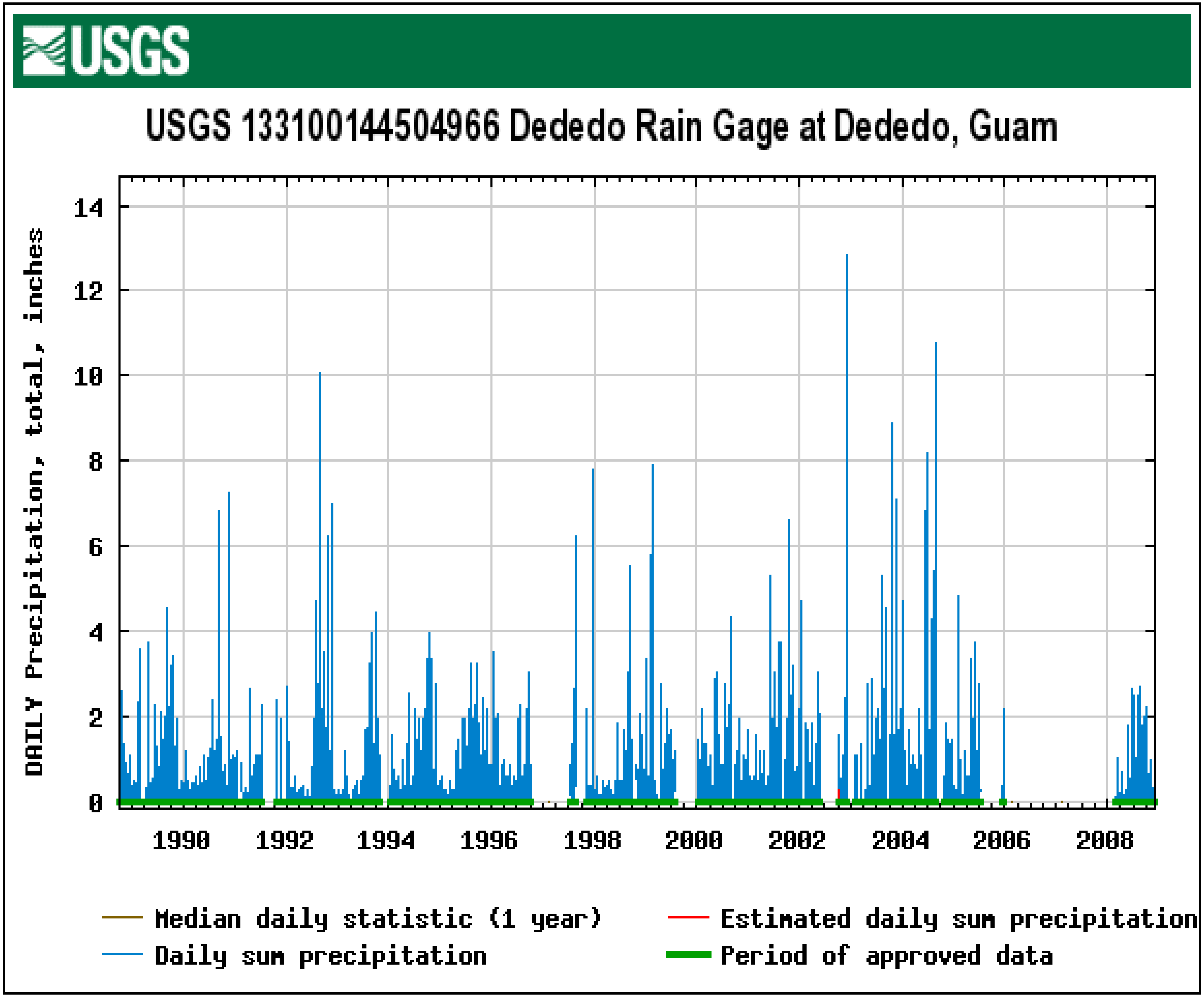
	A	B	C	D	E	F	G
1	Date	Prcp		Percentile	Rainfall		
2	1/5/1921	0.33		0%	=PERCENTILE(B:B,D2)		
3	1/8/1921	0.19		10%	=PERCENTILE(B:B,D3)		
4	1/14/1921	1.04		20%	=PERCENTILE(B:B,D4)		
5	2/6/1921	0.12		30%	=PERCENTILE(B:B,D5)		
6	2/11/1921	0.63		40%	=PERCENTILE(B:B,D6)		



	A	B	C	D	E
1	Date	Prcp		Percentile	Rainfall
2	1/5/1921	0.33		0%	0.1
3	1/8/1921	0.19		10%	0.13
4	1/14/1921	1.04		20%	0.17
5	2/6/1921	0.12		30%	0.22
6	2/11/1921	0.63		40%	0.28
7	2/20/1921	1.33		50%	0.36
8	2/28/1921	0.43		60%	0.46
9	3/3/1921	0.13		70%	0.6
10	3/9/1921	0.31		80%	0.79
11	3/13/1921	0.46		85%	0.93
12	3/25/1921	0.47		90%	1.16
13	3/28/1921	0.12		93%	1.35
14	4/1/1921	0.36		94%	1.44
15	4/9/1921	0.69		95%	1.52
16	4/15/1921	0.24		96%	1.65
17	4/17/1921	0.32		97%	1.82
18	4/18/1921	0.55		98%	2.068
19	4/23/1921	0.69		99%	2.508
20	4/24/1921	0.19		99.5%	3.049
21	4/30/1921	1.44		100%	7.06

Use the spreadsheet software to create of plot of rainfall depth versus percentile, as shown above. The 95th percentile storm event should correlate to the rainfall depth calculated in step 7, however the graph can be used to calculate rainfall depths at other percentiles (e.g., 50%, 90%).

Appendix A.5
Rain Gage


USGS
USGS 133100144504966 Dededo Rain Gage at Dededo, Guam
DAILY Precipitation, total, inches
14
12
10
8
6
4
2
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Median daily statistic (1 year)
Estimated daily sum precipitation
Daily sum precipitation
Period of approved data

Appendix A.6

NOAA Atlas 14, Volume 5, Appendix A.1

Appendix A.1 Temporal distributions of heavy precipitation

1. Introduction

Temporal distributions of heavy precipitation are provided for use with precipitation frequency estimates from NOAA Atlas 14 Volume 5 for 6-hour, 12-hour, 24-hour, and 96-hour durations. The temporal distributions are expressed in probability terms as cumulative percentages of precipitation totals at various time steps. The precipitation cases used to derive the temporal distributions were defined in the similar fashion as those for estimating precipitation frequencies for consistency. To provide detailed information on the varying temporal distributions, separate temporal distributions were derived for four precipitation cases defined by the duration quartile in which the greatest percentage of the total precipitation occurred.

2. Methodology and results

The methodology used to produce the temporal distributions is similar to the one developed by Huff (1967) except in the definition of precipitation cases. Because of that, temporal distribution curves may be different from corresponding temporal distribution curves obtained from the analysis of single storms. In accordance with the way a precipitation case (“event”) was defined for the precipitation frequency analysis, a precipitation case for temporal distribution analysis was computed as the total accumulation over a specific duration (6-, 12-, 24-, or 96-hours). As a result, the accumulation may contain parts of one or more storms. Also, a precipitation case was defined to start with precipitation but not necessarily to end with precipitation resulting in potentially more front-loaded cases when compared with distributions derived from the single storm approach. To eliminate potential biases, a constraint was imposed to exclude cases with a continuous dry period that lasted for more than 20% of the duration. This restriction produced a less variant sample. Table A.1.1 shows the number of precipitation cases used to derive the temporal distributions for each duration. By imposing the restriction on continuous dry period, the number of cases available for temporal distribution analysis decreased with duration because long, continuous precipitation events occurred less frequently than continuous short-duration events.

For each precipitation case, precipitation accumulation was converted into a percentage of the total precipitation amount at one hour time increments. All cases for a specific duration were then combined and probabilities of occurrence of precipitation totals were computed at each hour. The temporal distribution curves for nine deciles (10% to 90%) were smoothed using linear programming method (Bonta and Rao, 1988) and plotted in a same graph. Figure A.1.1 shows temporal distribution curves for the four selected durations; time steps were converted into percentages of durations for easier comparison.

The cases were further divided into four categories by the quartile in which the greatest percentage of the total precipitation occurred. Table A.1.1 shows the numbers and proportion of precipitation cases used to derive the temporal distributions in each quartile. Unlike the cases of 12-, 24-, and 96-hour durations in which the number of data points can be equally divided by four, the cases of 6-hour duration contain only six data points and they cannot be evenly distributed into four quartiles. Therefore, in this analysis, for 6-hour duration, the first quartile contains precipitation cases where the most precipitation occurred in the first hour, the second quartile contains precipitation cases where the most precipitation occurred in the second and third hours, the third quartile contains precipitation cases where the most precipitation occurred in the fourth hour, and the fourth quartile contains precipitation cases where the most precipitation occurred in the fifth and sixth hours. This uneven distribution affects the number of cases contained in each quartile for the 6-hour duration. Figures A.1.2 through A.1.5 show the temporal distribution curves for four quartile cases for 6-hour, 12-hour, 24-hour and 96-hour durations, respectively.

Table A.1.1. Number of all precipitation cases and number (and percent) of cases in each quartile for selected durations.

Duration (hours)	All cases	First-quartile cases	Second-quartile cases	Third-quartile cases	Fourth-quartile cases
6	363	25 (7%)	179 (49%)	45 (12%)	114 (32%)
12	298	60 (20%)	70 (24%)	111 (37%)	57 (19%)
24	205	31 (15%)	57 (28%)	71 (35%)	46 (22%)
96	176	39 (22%)	38 (22%)	43 (24%)	56 (32%)

Temporal distribution data are also available in a tabular form at PFDS web page (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_temporal.html). For 6-hour, 12-hour and 24-hour durations, temporal distribution data are provided in 0.5-hour increments and for 96-hour duration in hourly increments.

3. Interpretation

Figure A.1.1 shows the temporal distribution curves of all precipitation cases for the 6-, 12-, 24-, and 96-hour durations for the project area. Time steps were converted into percentages of total durations for easier comparison. Figures A.1.2 through A.1.5 show temporal distribution curves for first-, second-, third-, and fourth-quartile cases for 6-hour, 12-hour, 24-hour and 96-hour durations, respectively. First-quartile plots show temporal distribution curves for cases where the greatest percentage of the total precipitation fell during the first quarter of the duration (e.g., the first 3 hours of a 12-hour duration). The second, third, and fourth quartile plots are similarly for cases where the most precipitation fell in the second, third, or fourth quarter of the duration.

The temporal distribution curves represent the averages of many cases and illustrate the temporal distribution patterns with 10% to 90% occurrence probabilities in 10% increments. For example, the 10% curve in any figure indicates that 10% of the corresponding precipitation cases had distributions that fell above and to the left of the curve. Similarly, 10% of the cases had temporal distribution falling to the right and below the 90% curve. The 50% curve represents the median temporal distribution.

The following is an example of how to interpret the results using a figure in upper left panel in Figure A.1.4 and information from Table A.1.1 for 24-hour first-quartile cases.

- Of the total of 205 24-hour cases, 31 (15%) of them were first-quartile.
- In 10% of the first-quartile cases, 50% of the total precipitation fell by 4.8 hours and 90% of the total precipitation fell by 15.5 hours.
- A median case of this type will drop half of the precipitation (50% on the y-axis) in approximately 8 hours.
- In 90% of the cases, 50% of the total precipitation fell by 12.5 hours and 90% of precipitation fell by 22.8 hours.

Temporal distribution curves are presented in order to show the range of possibilities. Care should be taken in the interpretation and use of temporal distribution curves. For example, the use of different temporal distribution data in hydrologic models may result in very different peak flow estimates. Therefore, they should be selected and used in a way to reflect users' objectives.

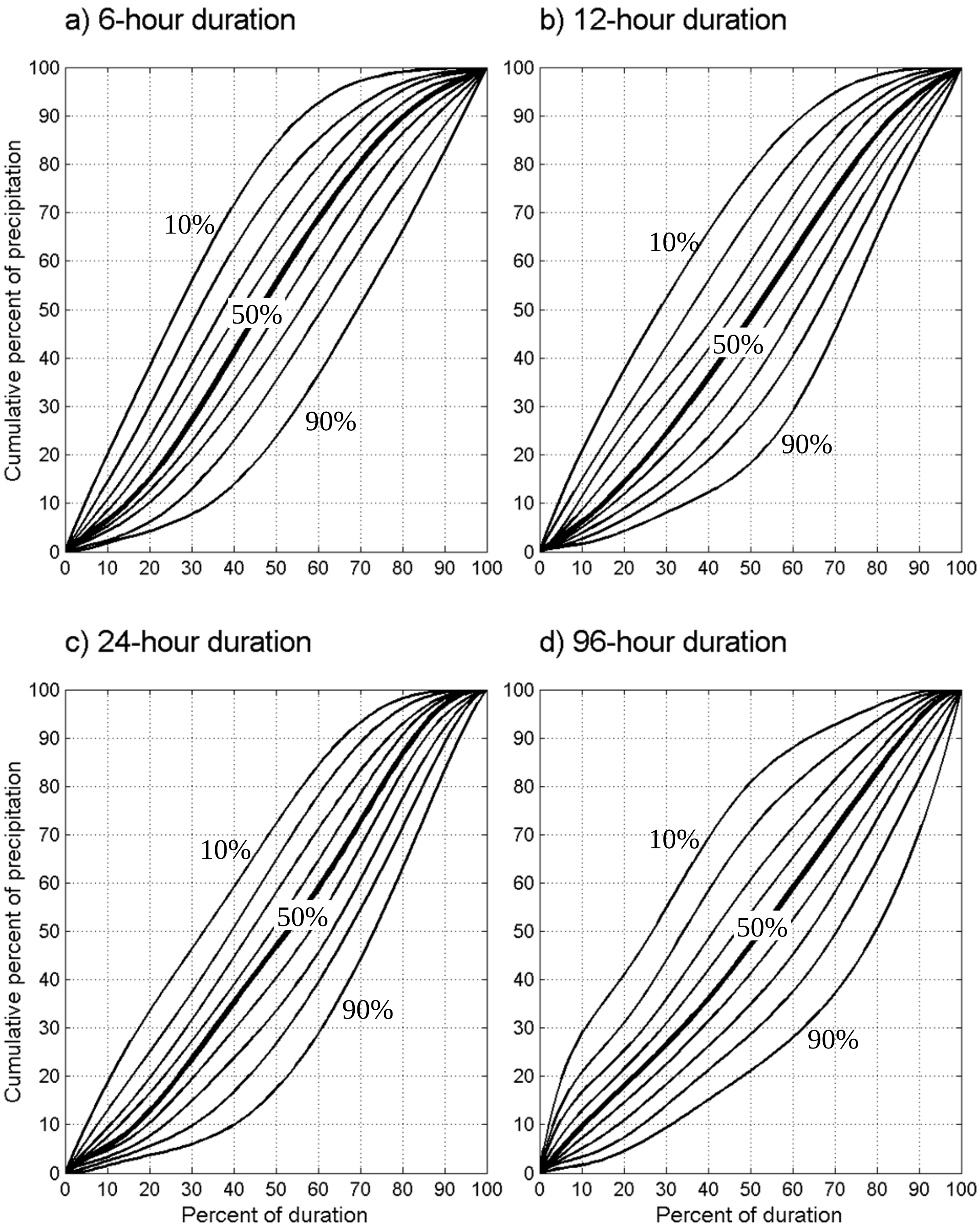


Figure A.1.1. Temporal distribution curves for all cases for: a) 6-hour, b) 12-hour, c) 24-hour, and d) 96-hour durations.

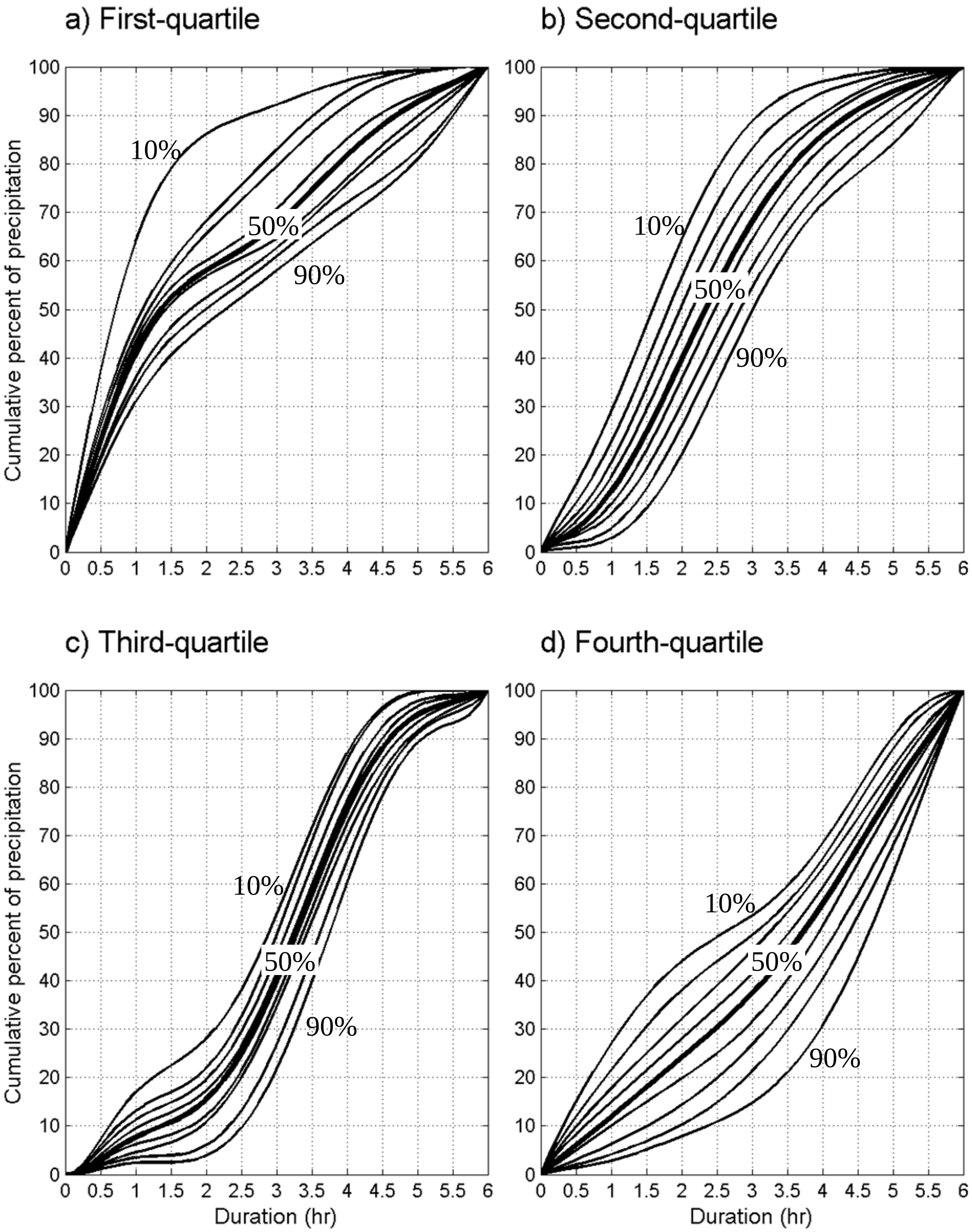


Figure A.1.2. 6-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

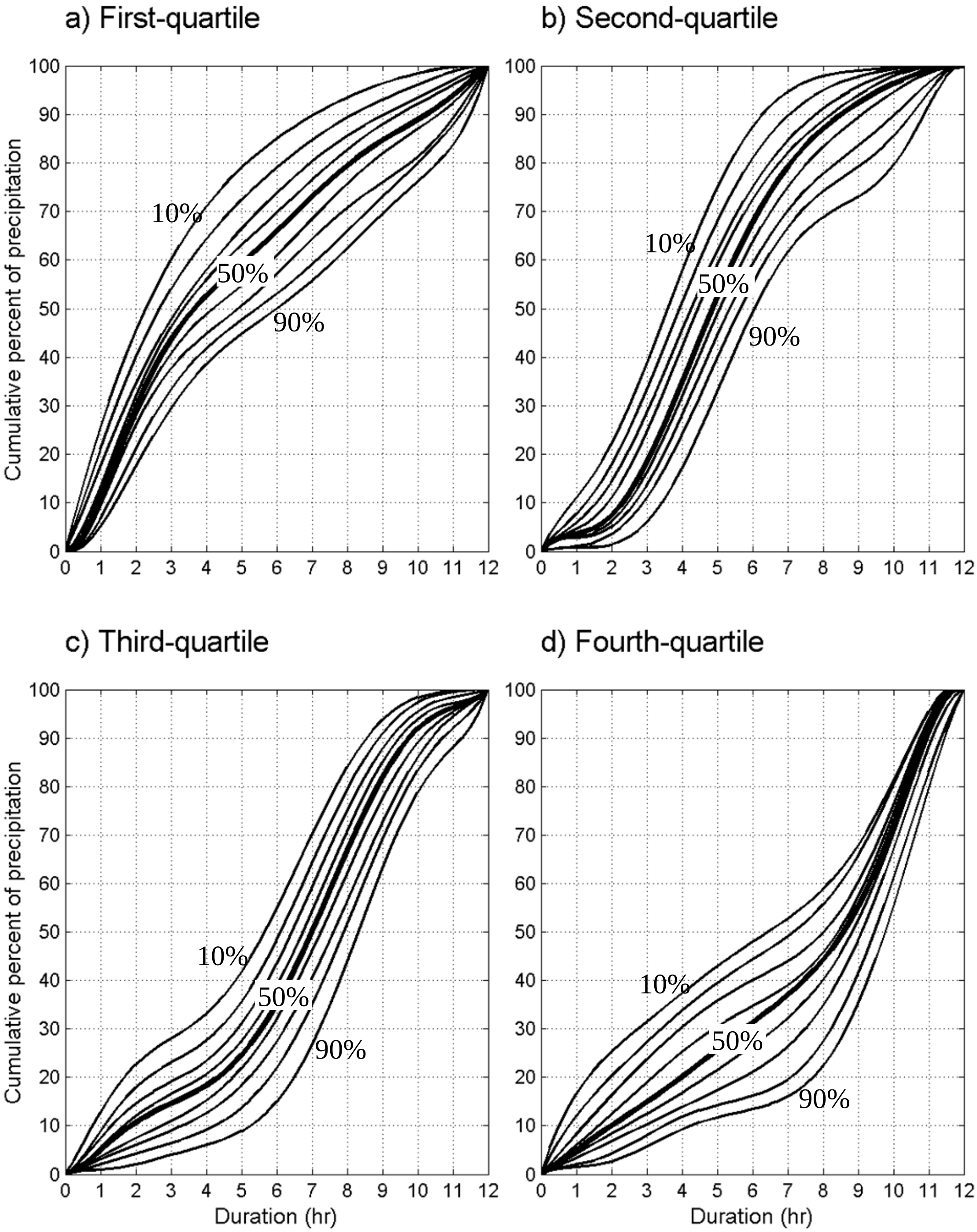
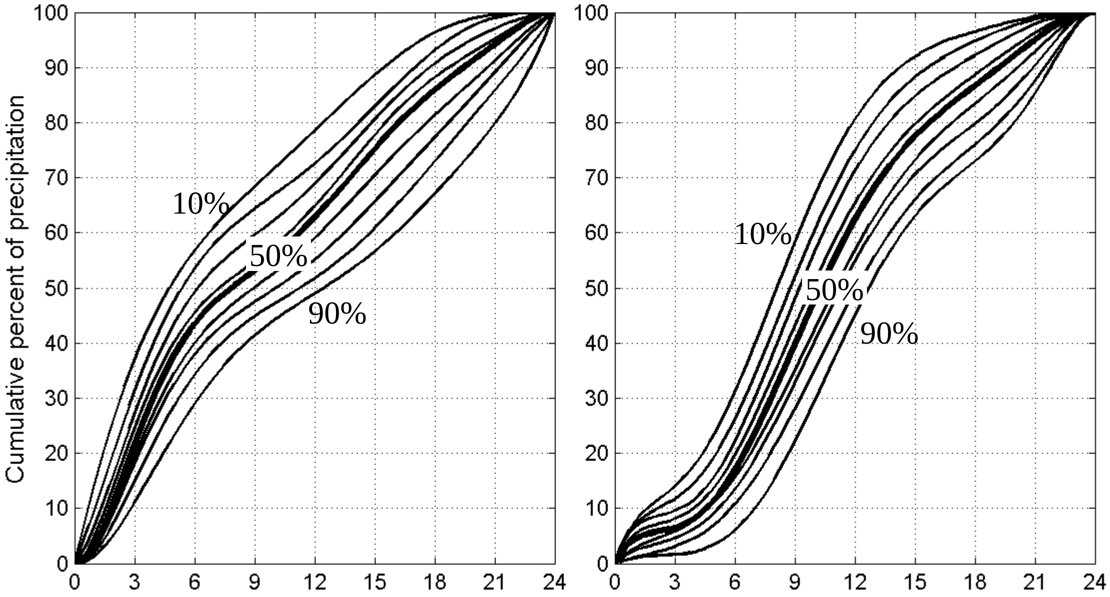
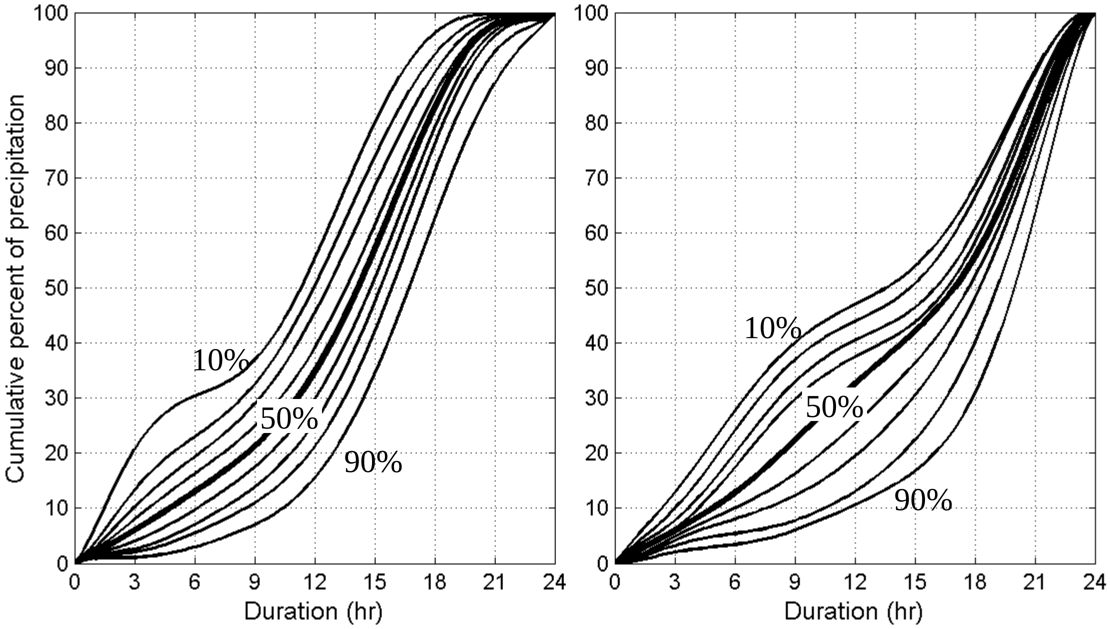


Figure A.1.3. 12-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.



a) First-quartile

b) Second-quartile



c) Third-quartile

d) Fourth-quartile

Figure A.1.4. 24-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

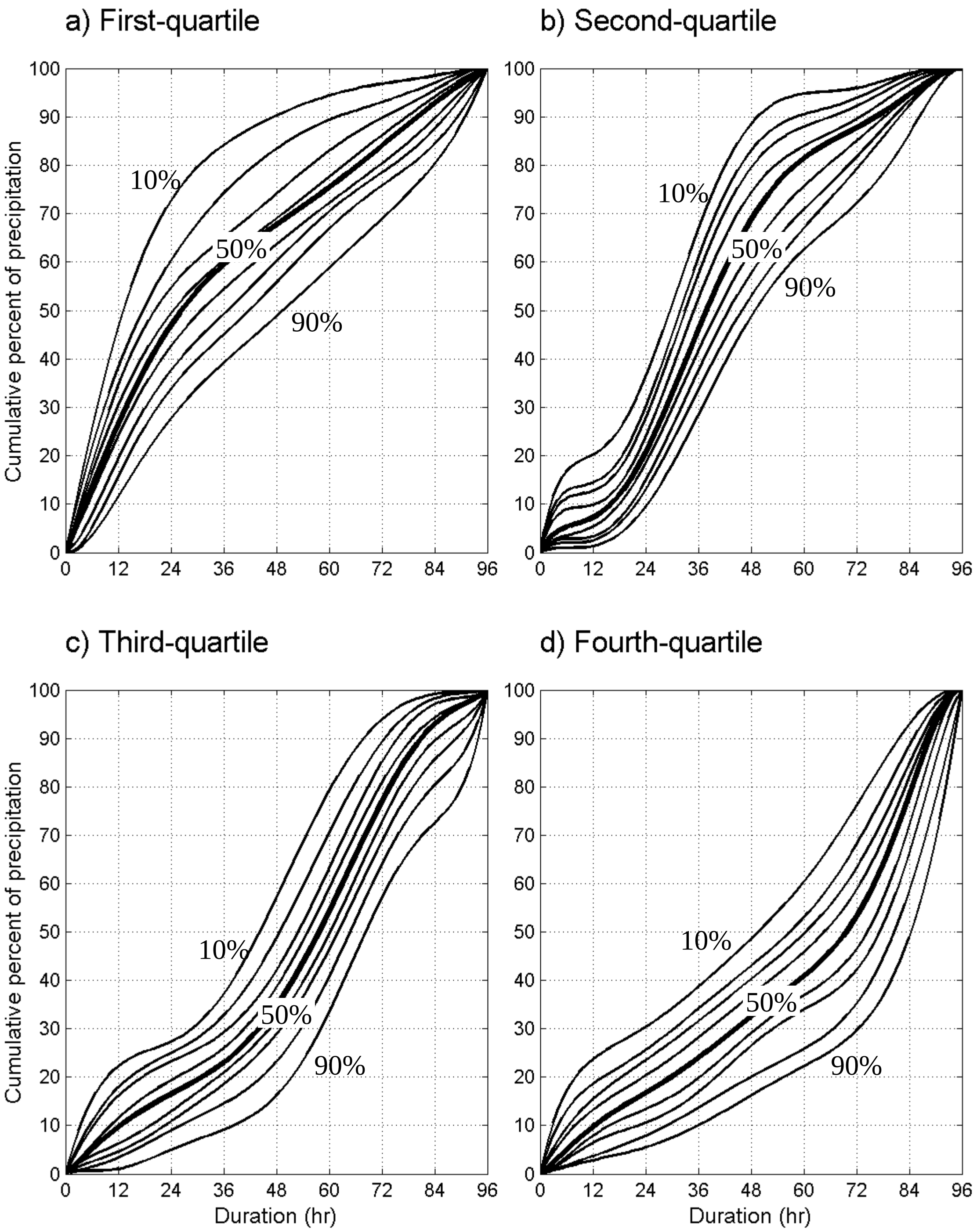
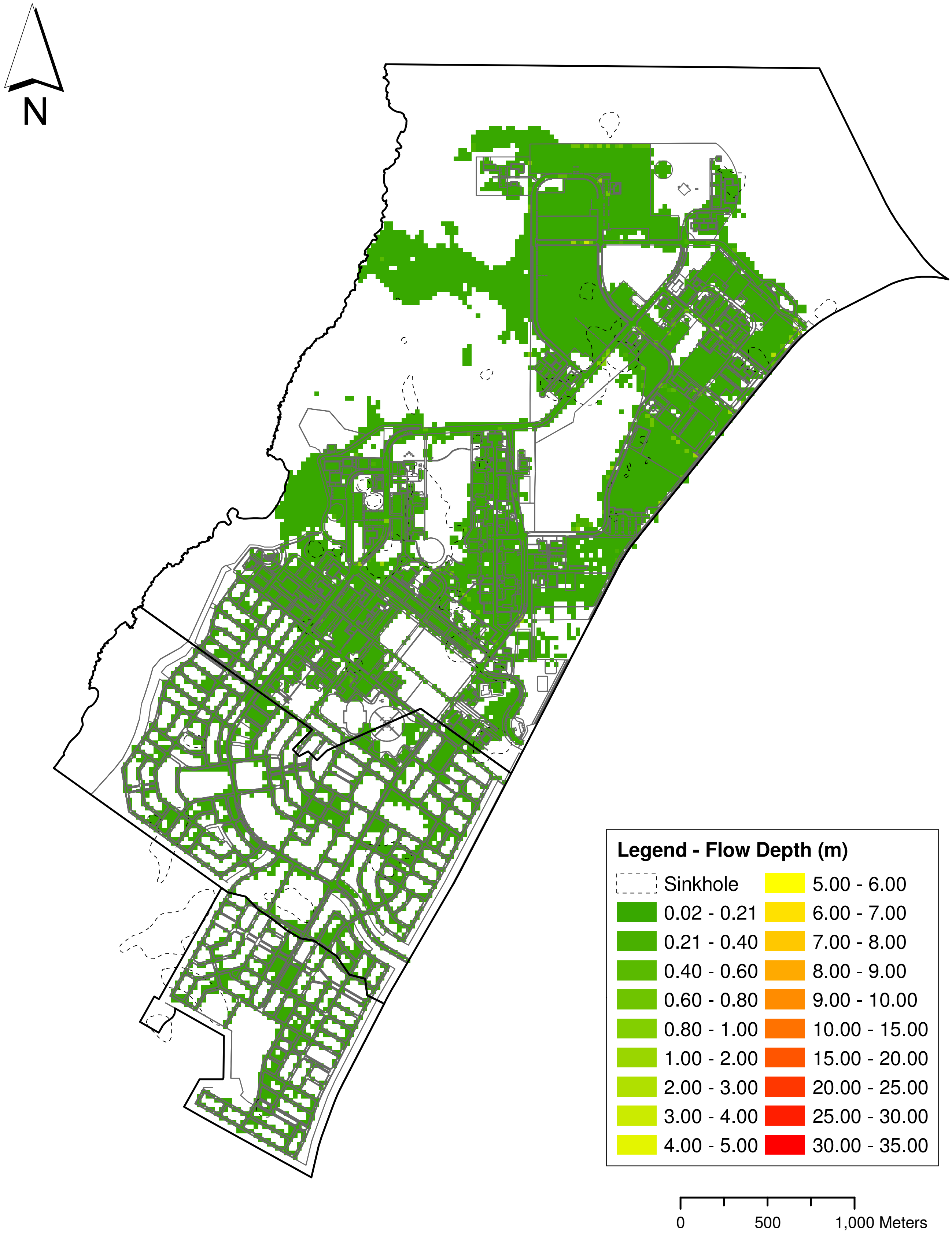


Figure A.1.5. 96-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

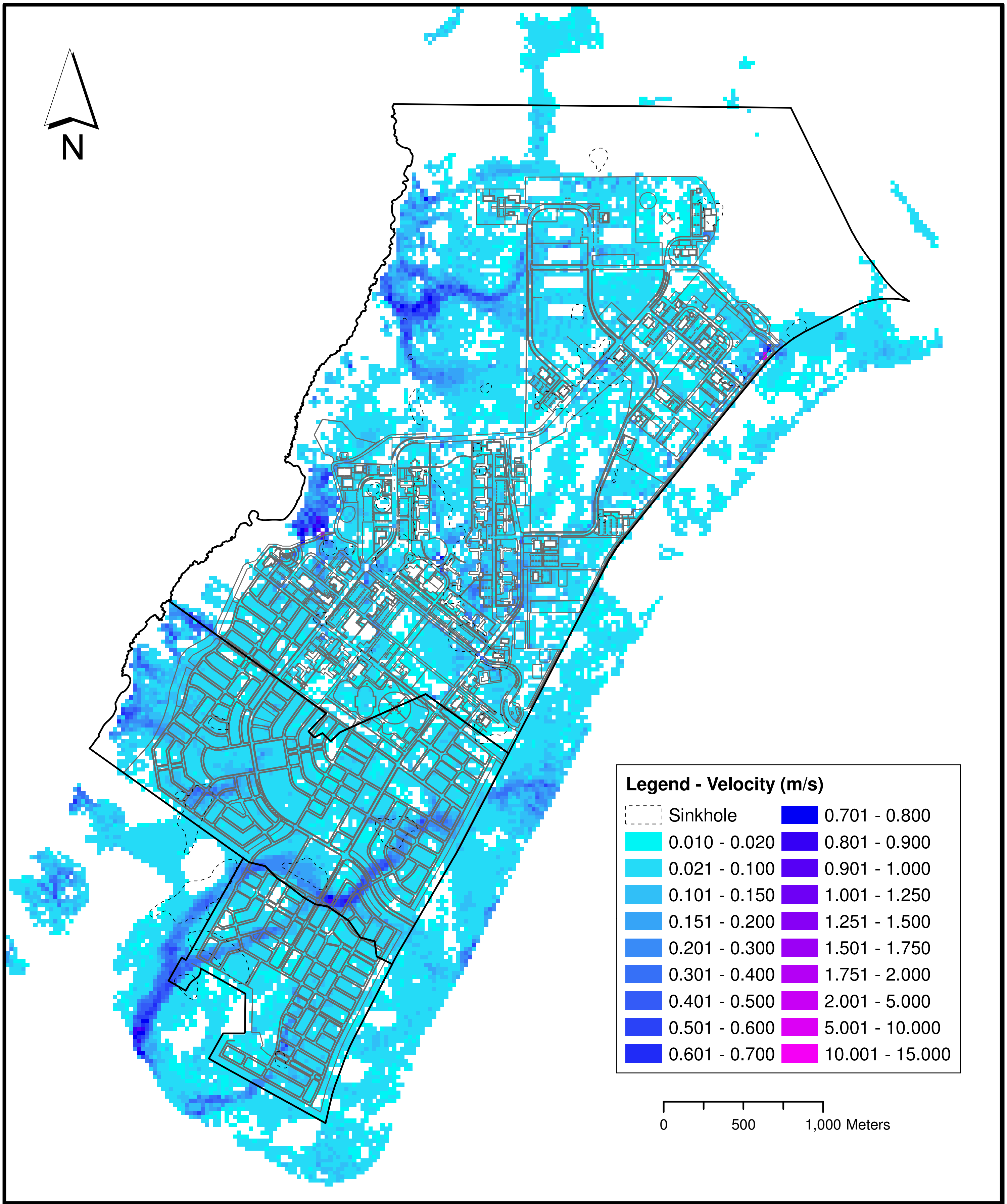
Appendix A.7
Post-Development Stormwater Runoff Modeling Results



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 1 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 1



AECOM

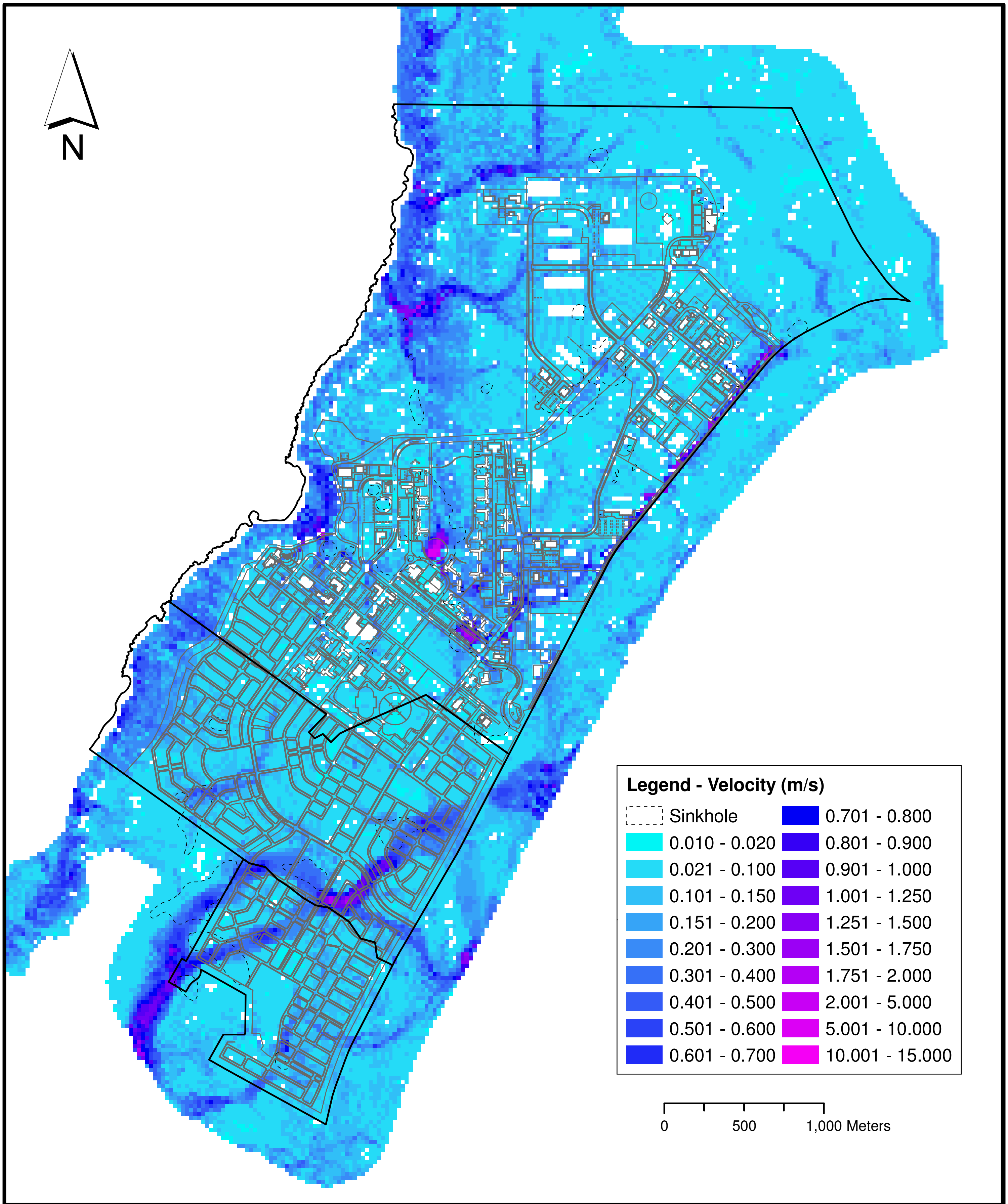
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Max Velocity - 2 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

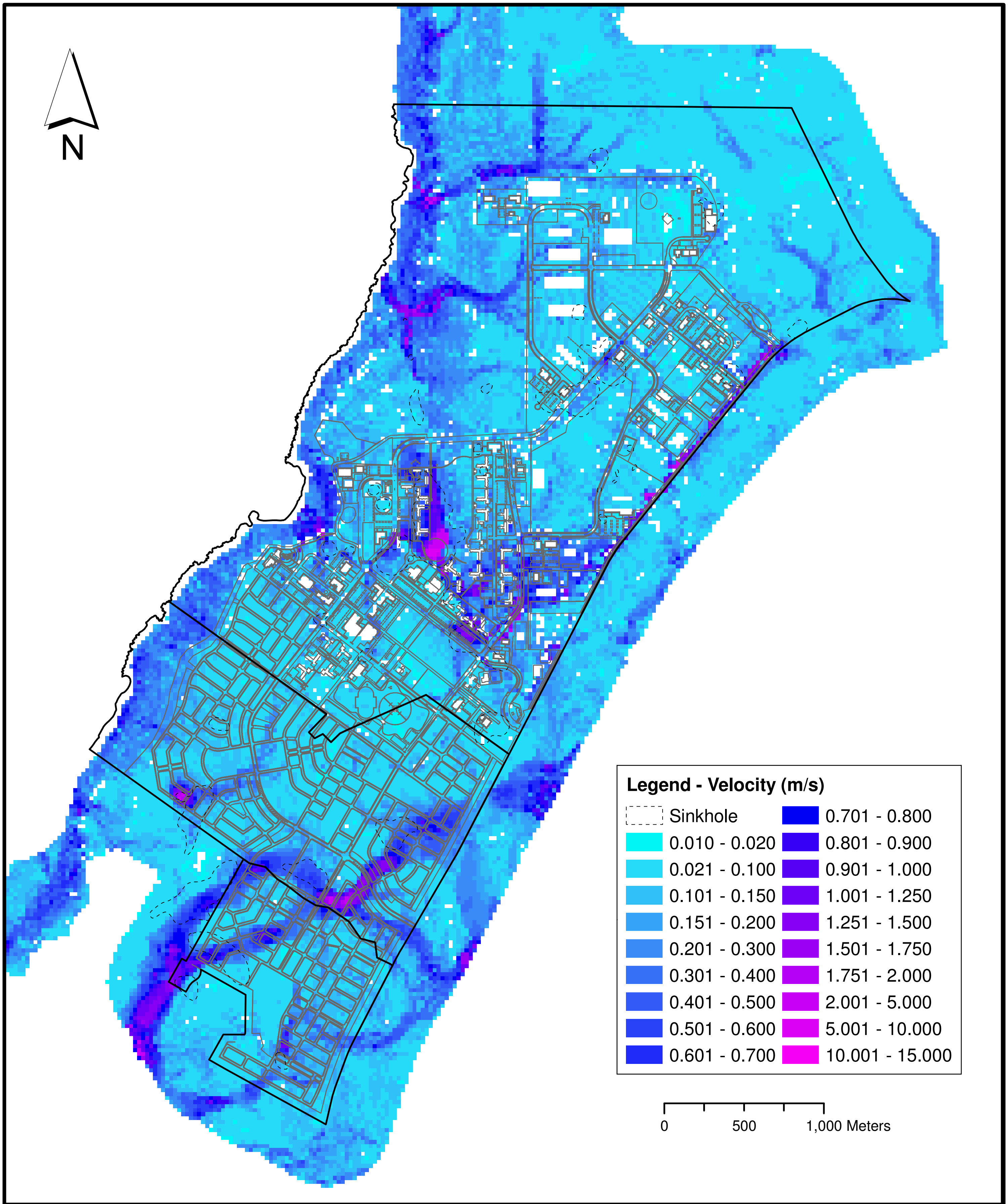
Figure 10



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 10 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 11



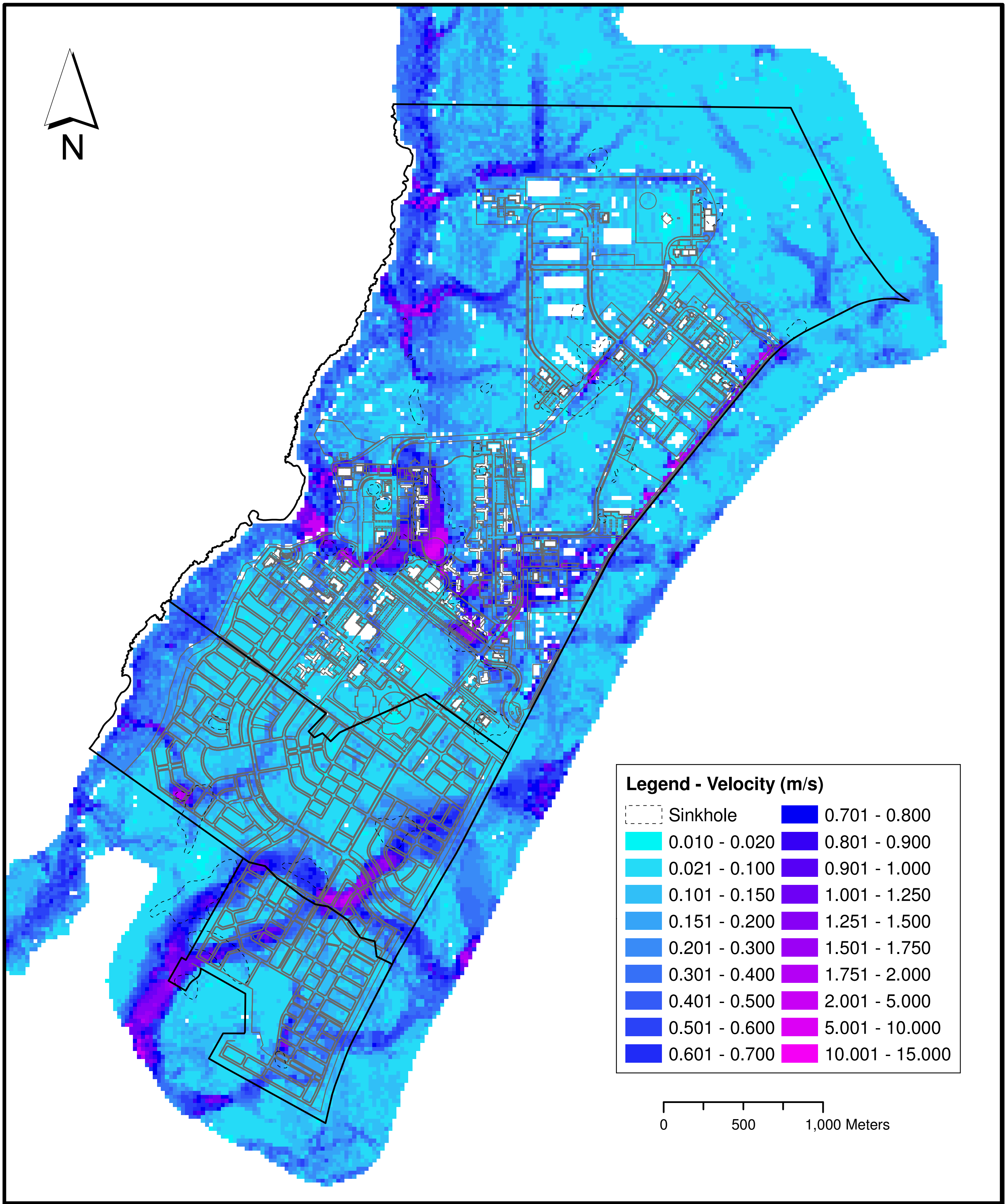
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 25 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 12



AECOM

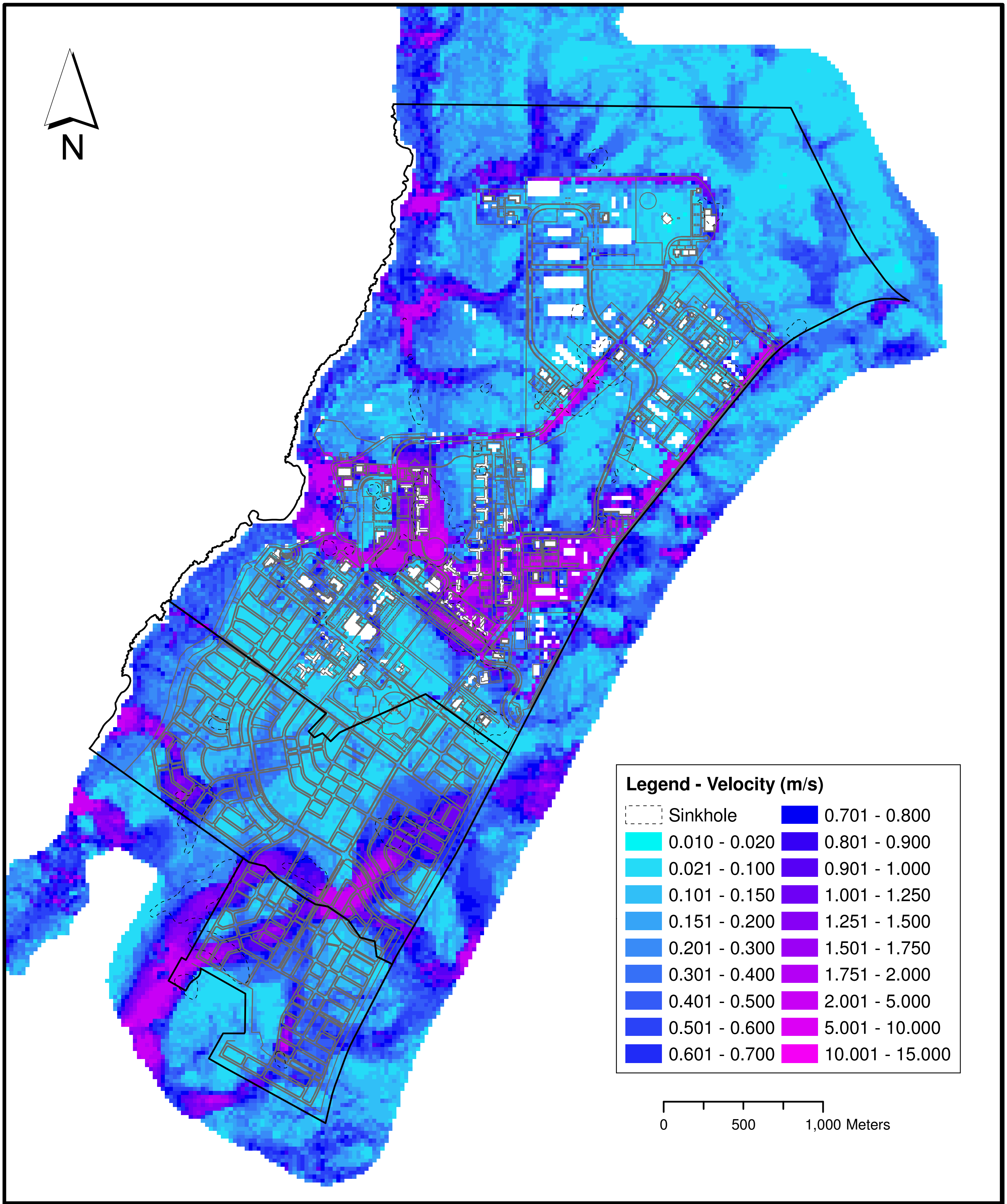
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 50 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 13



AECOM

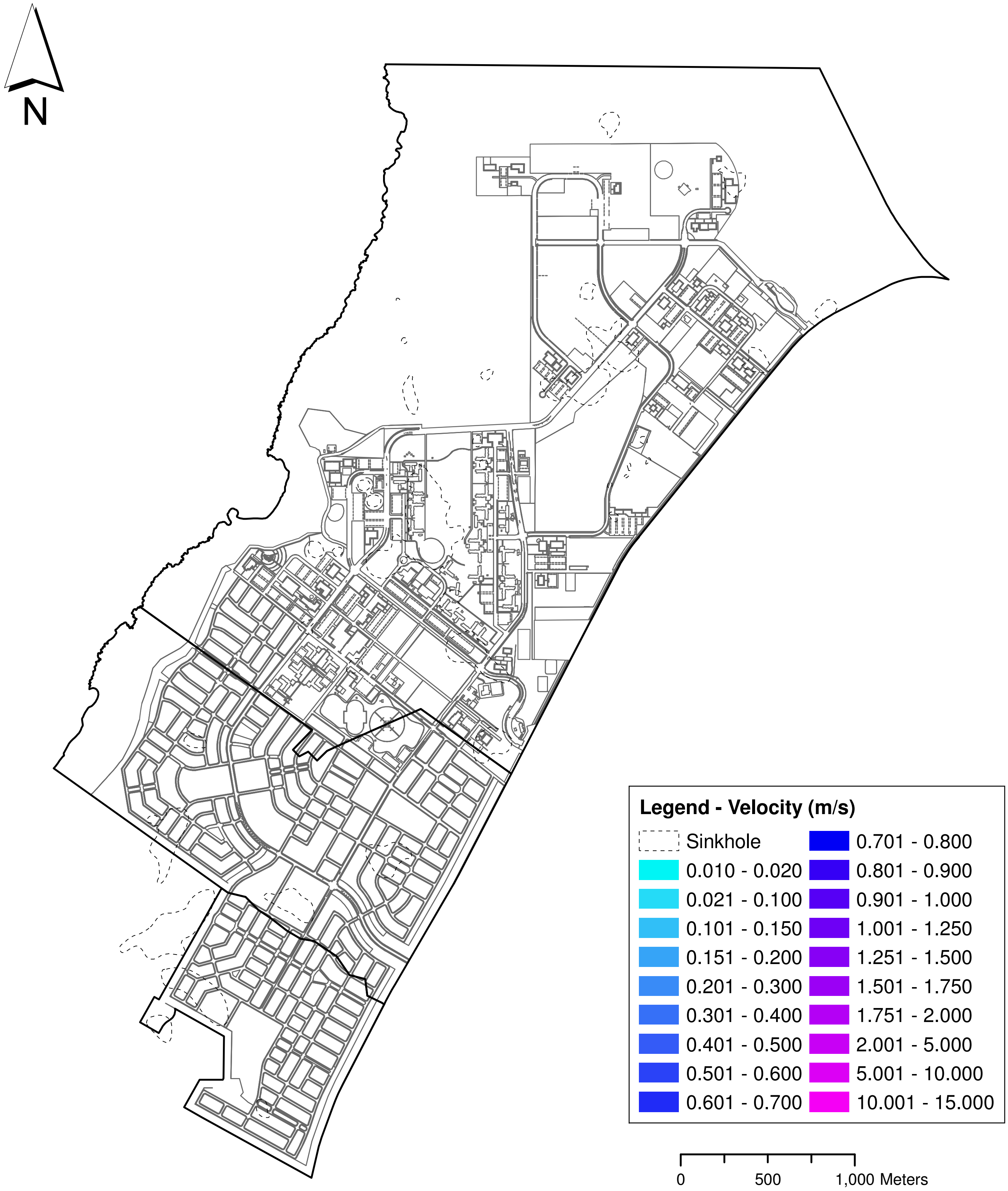
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 500 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

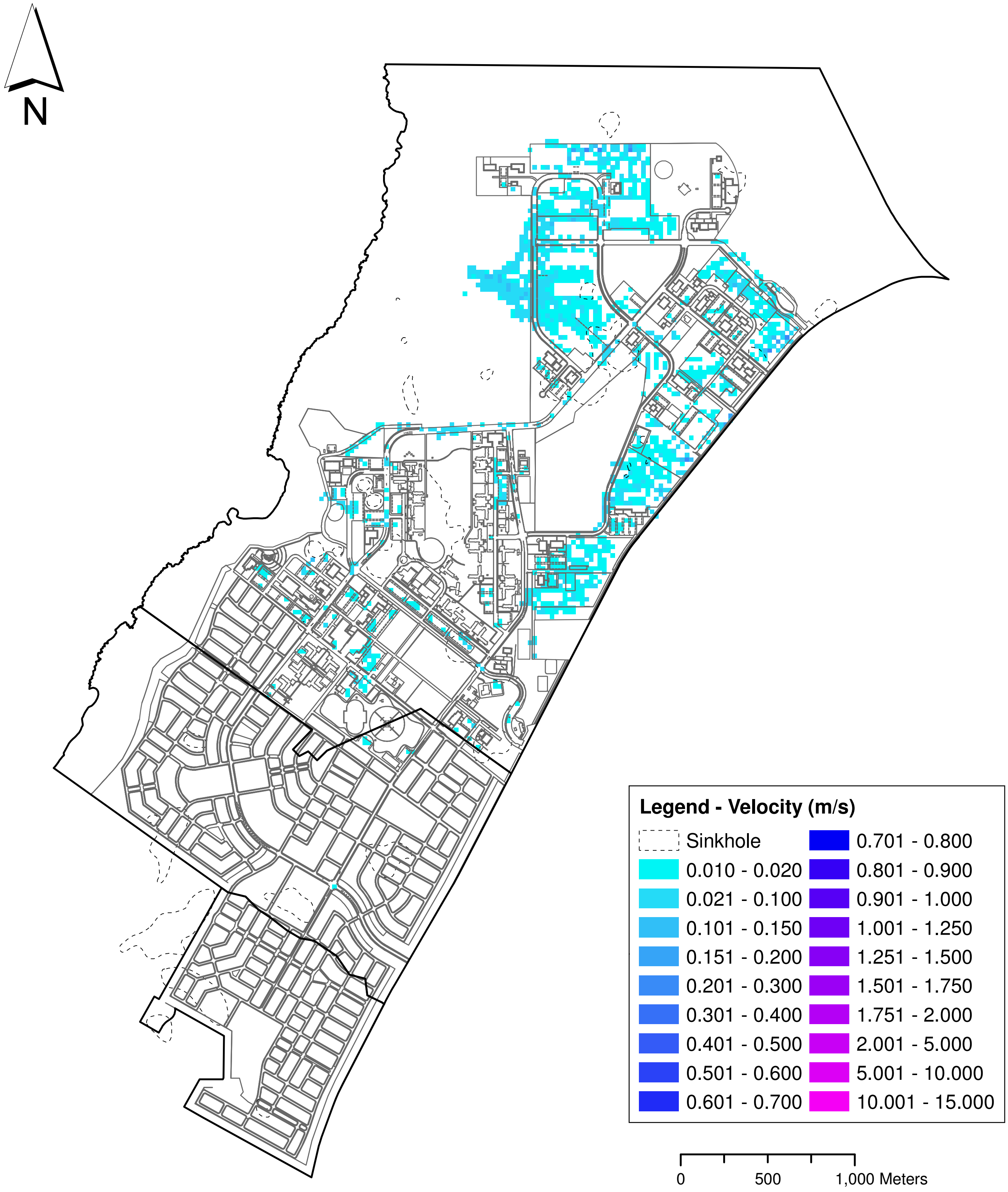
Figure 14



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 80 Percent

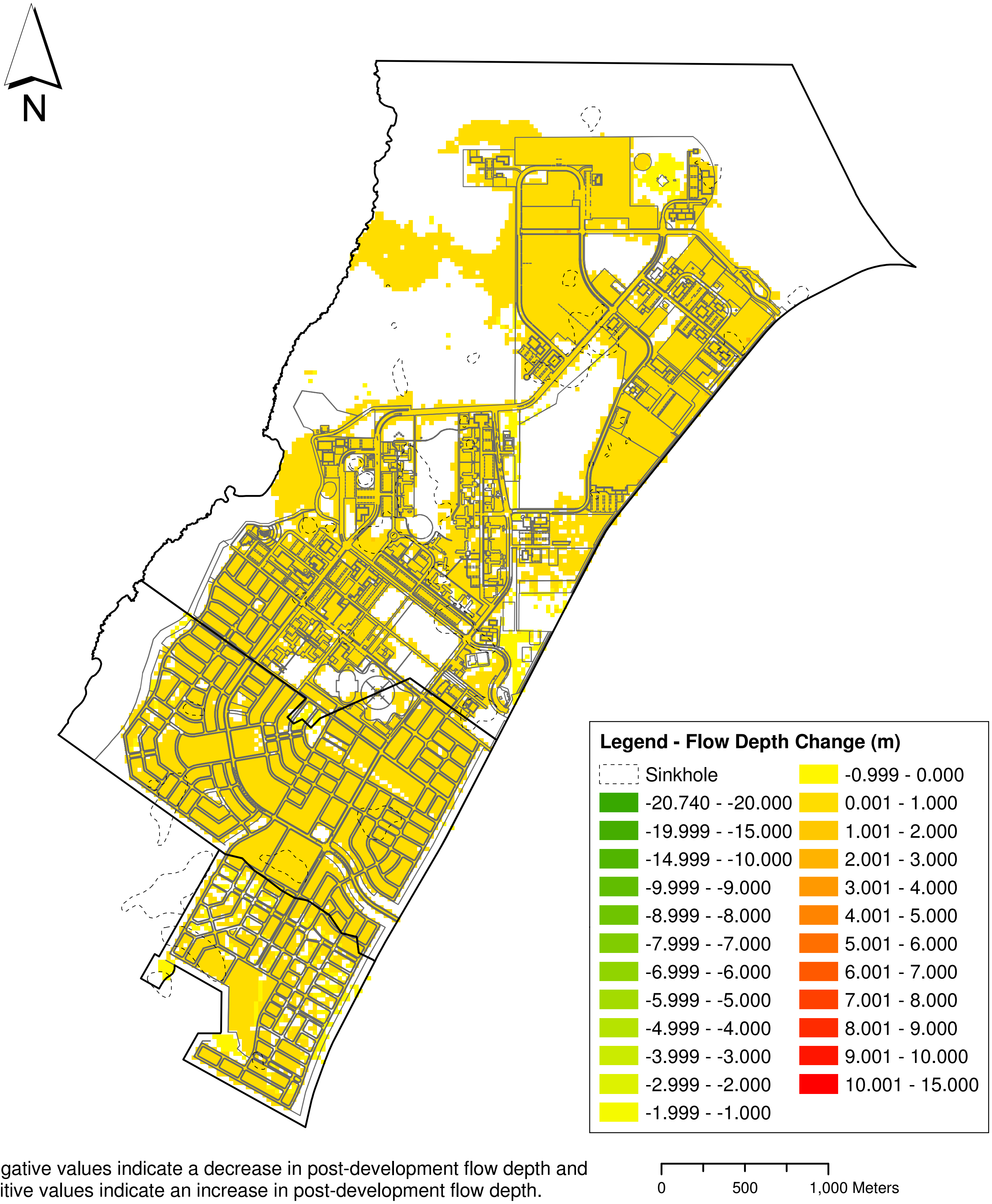
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 15



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 90 Percent

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 16

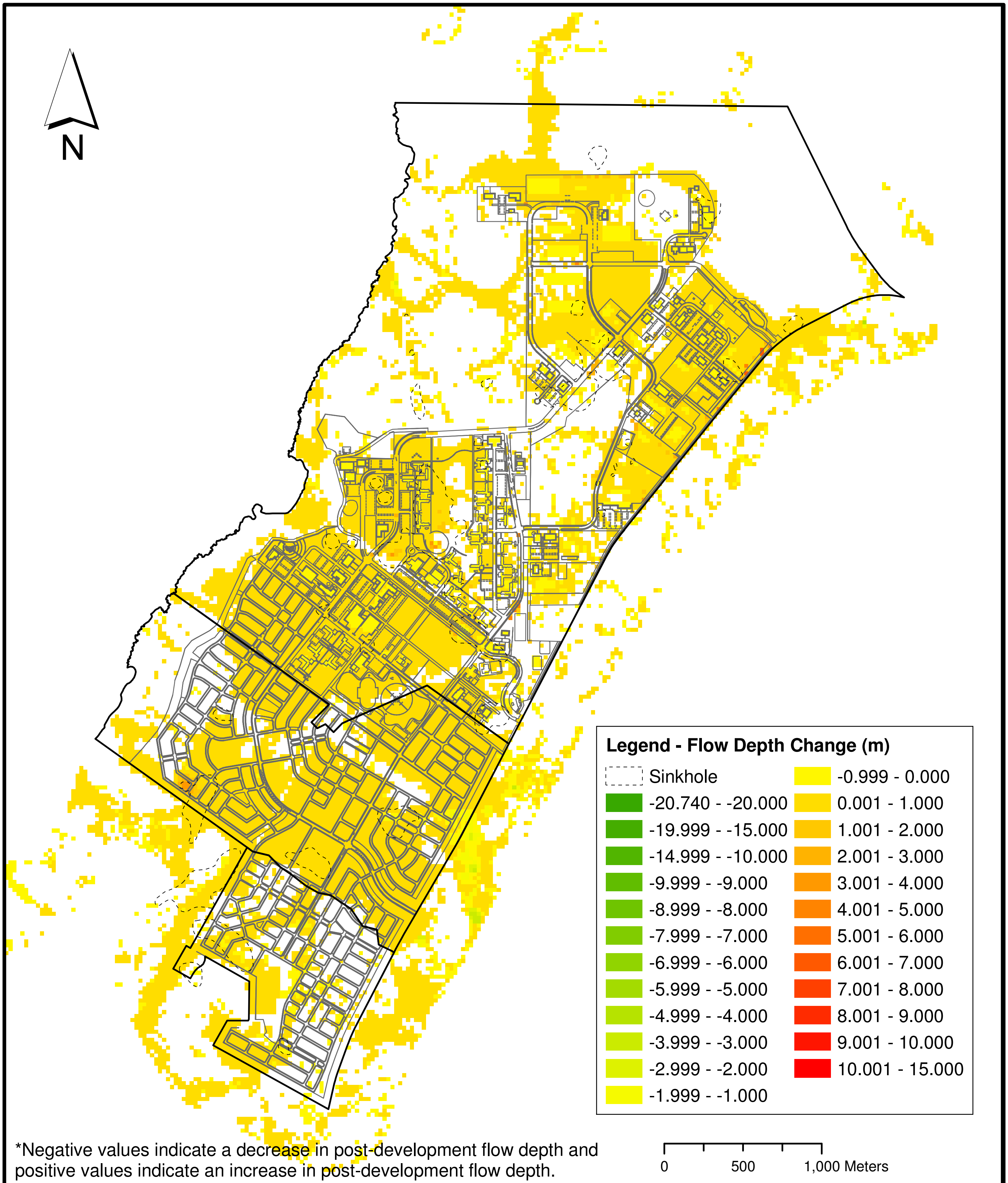


*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
1 Year Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 17



*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

AECOM

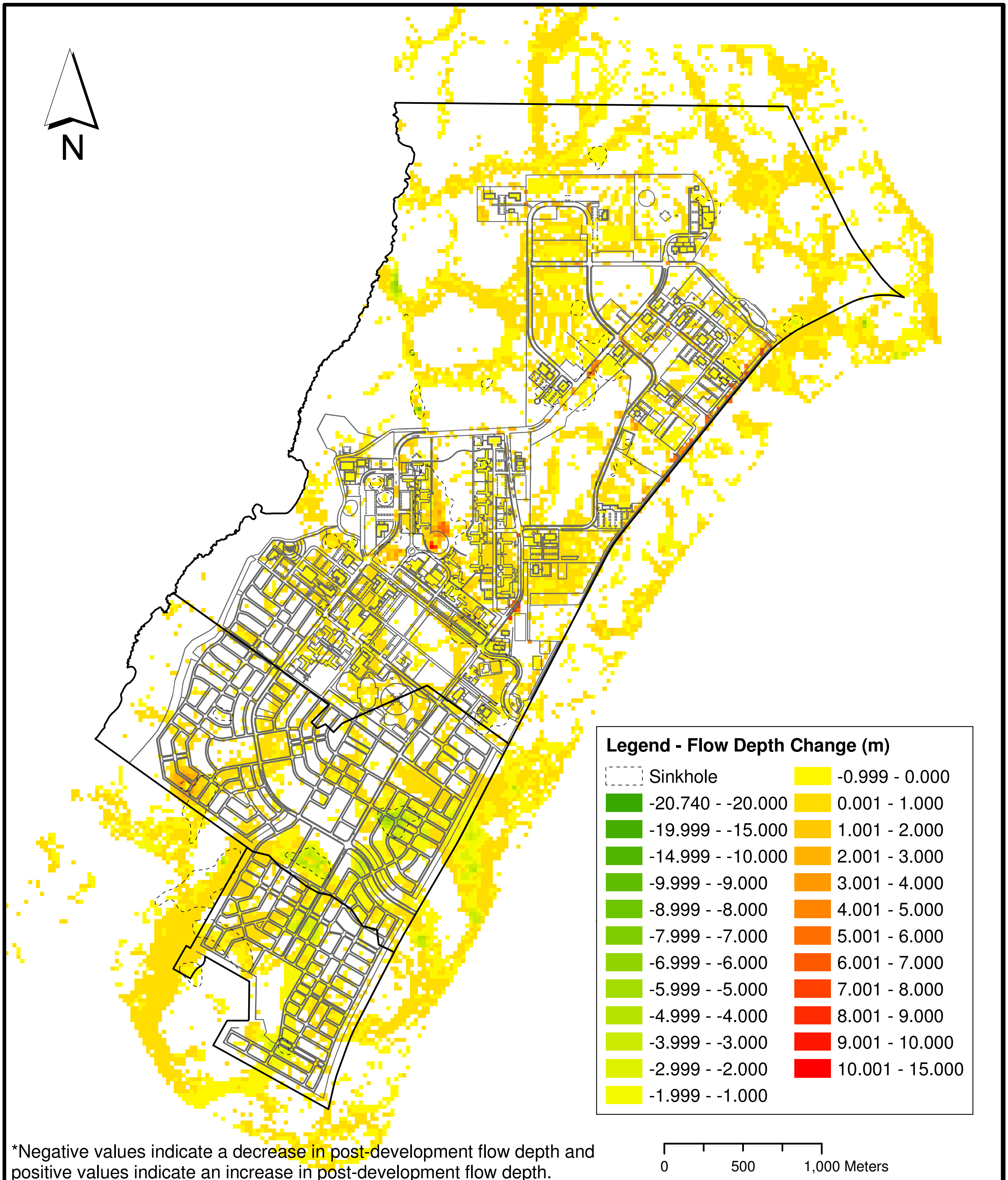
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
2 Year Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 18



*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

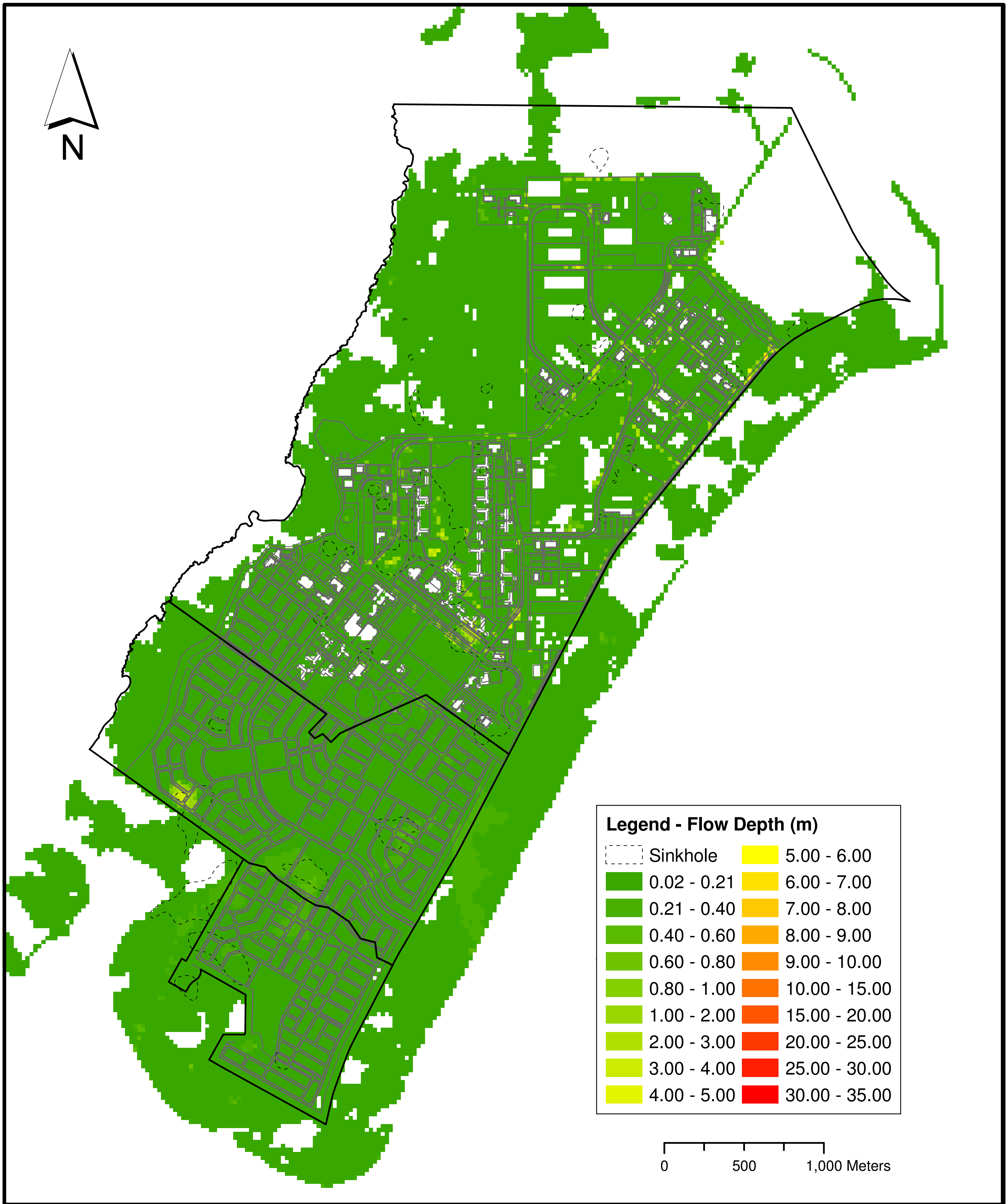
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
10 Year Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 19



AECOM

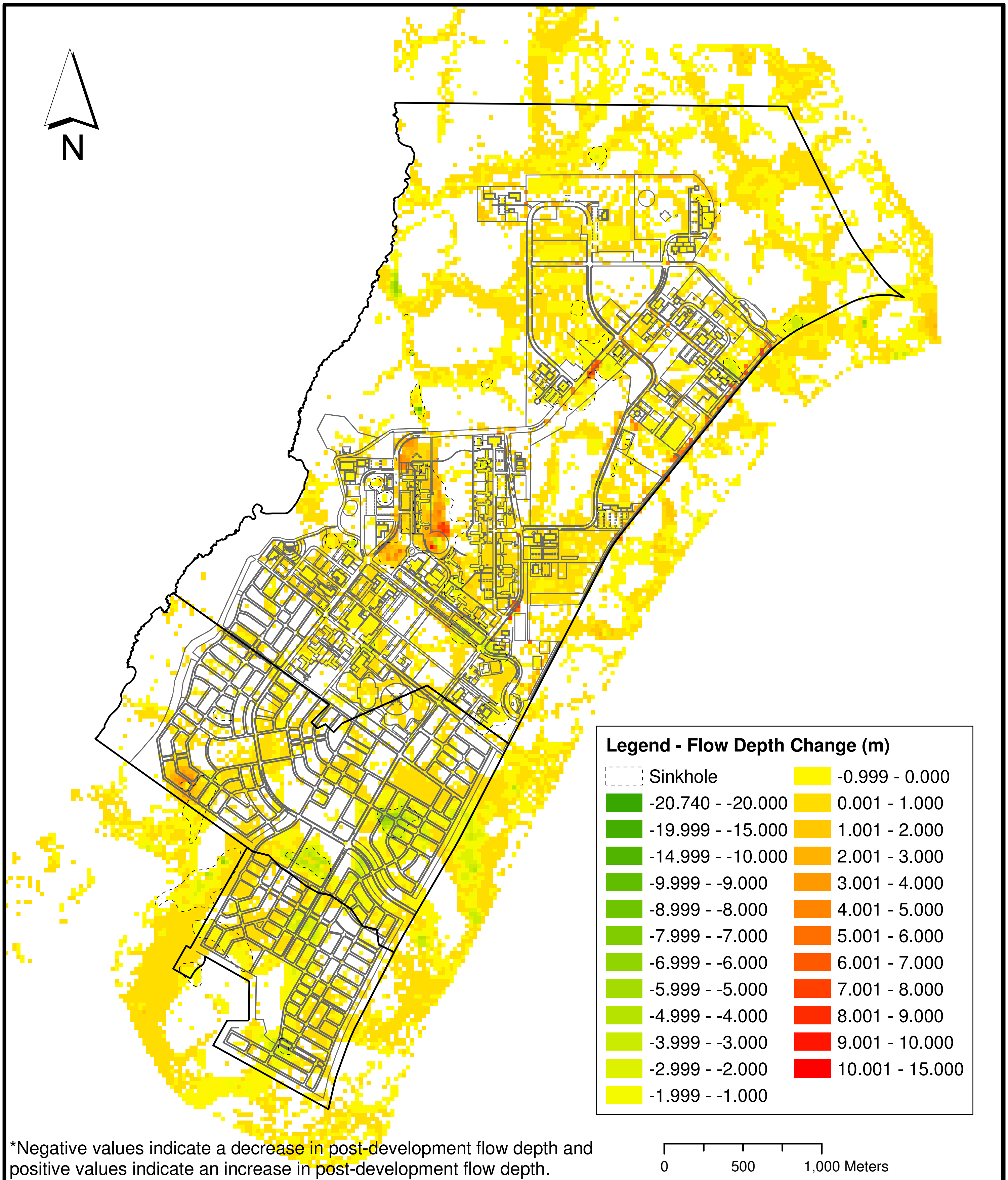
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 2 Year

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 2



*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

AECOM

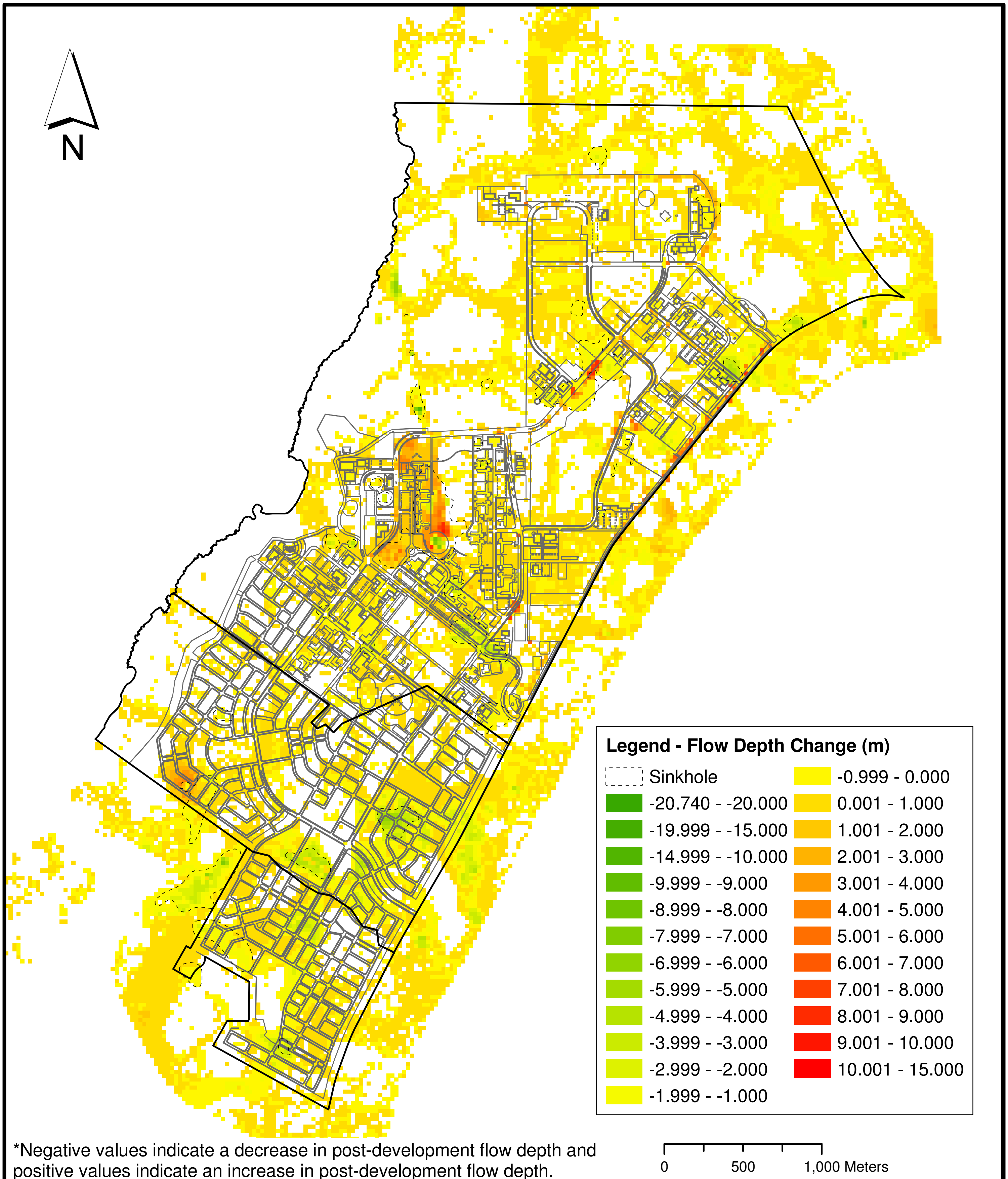
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
25 Year Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 20

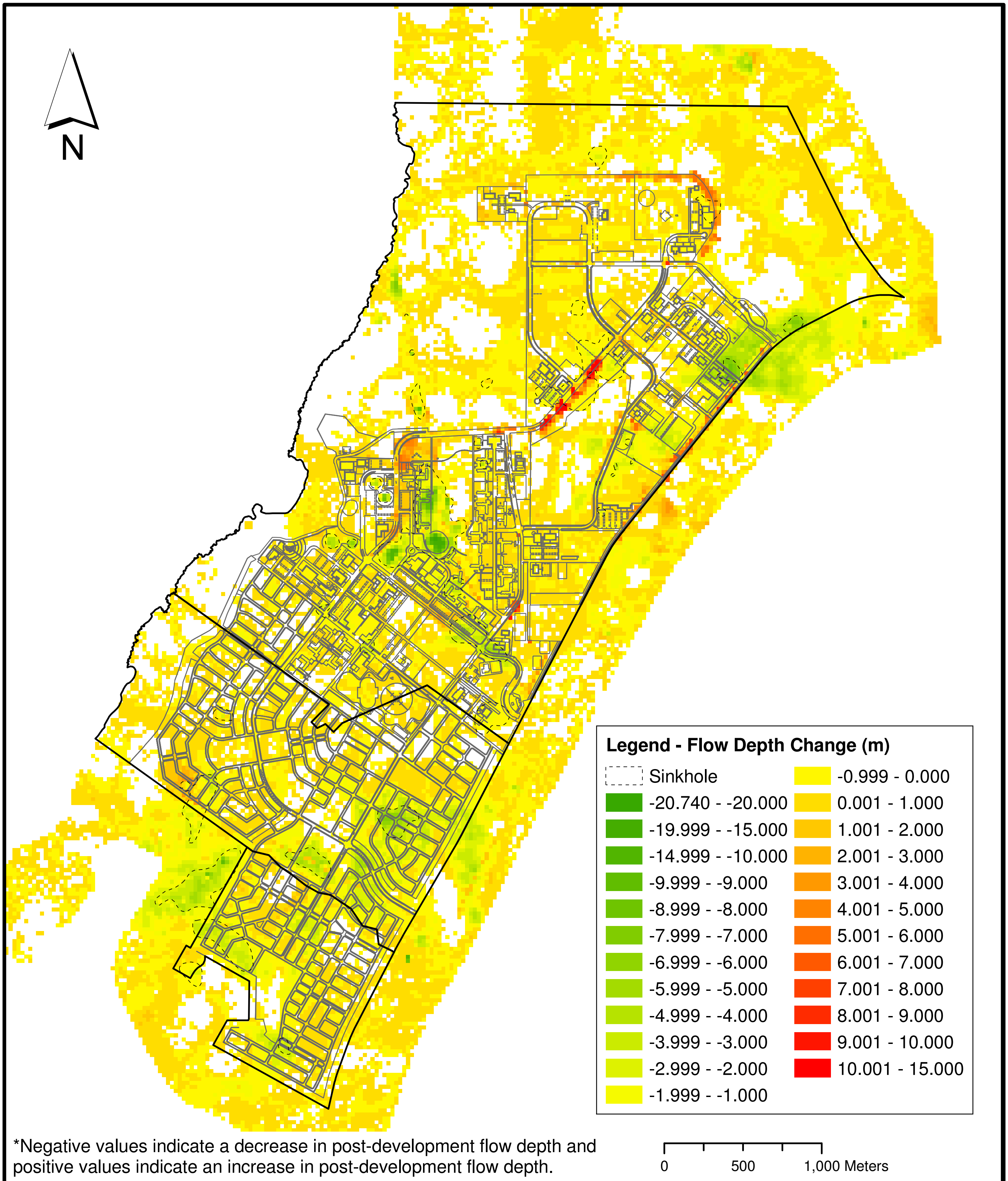


*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
50 Year Storm Flow Depth Change
(change = post-development – pre-development)

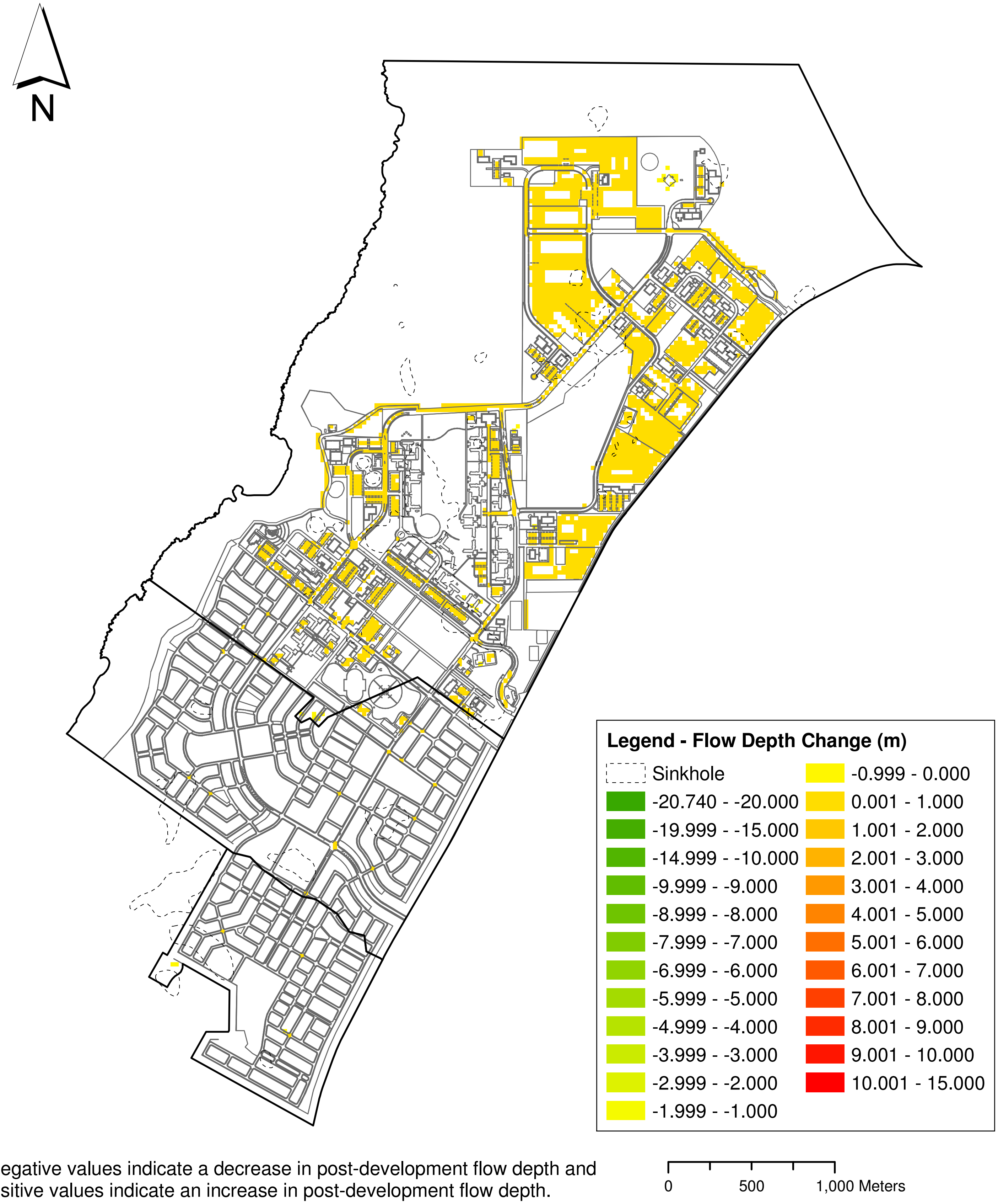
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 21



*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
500 Year Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 22

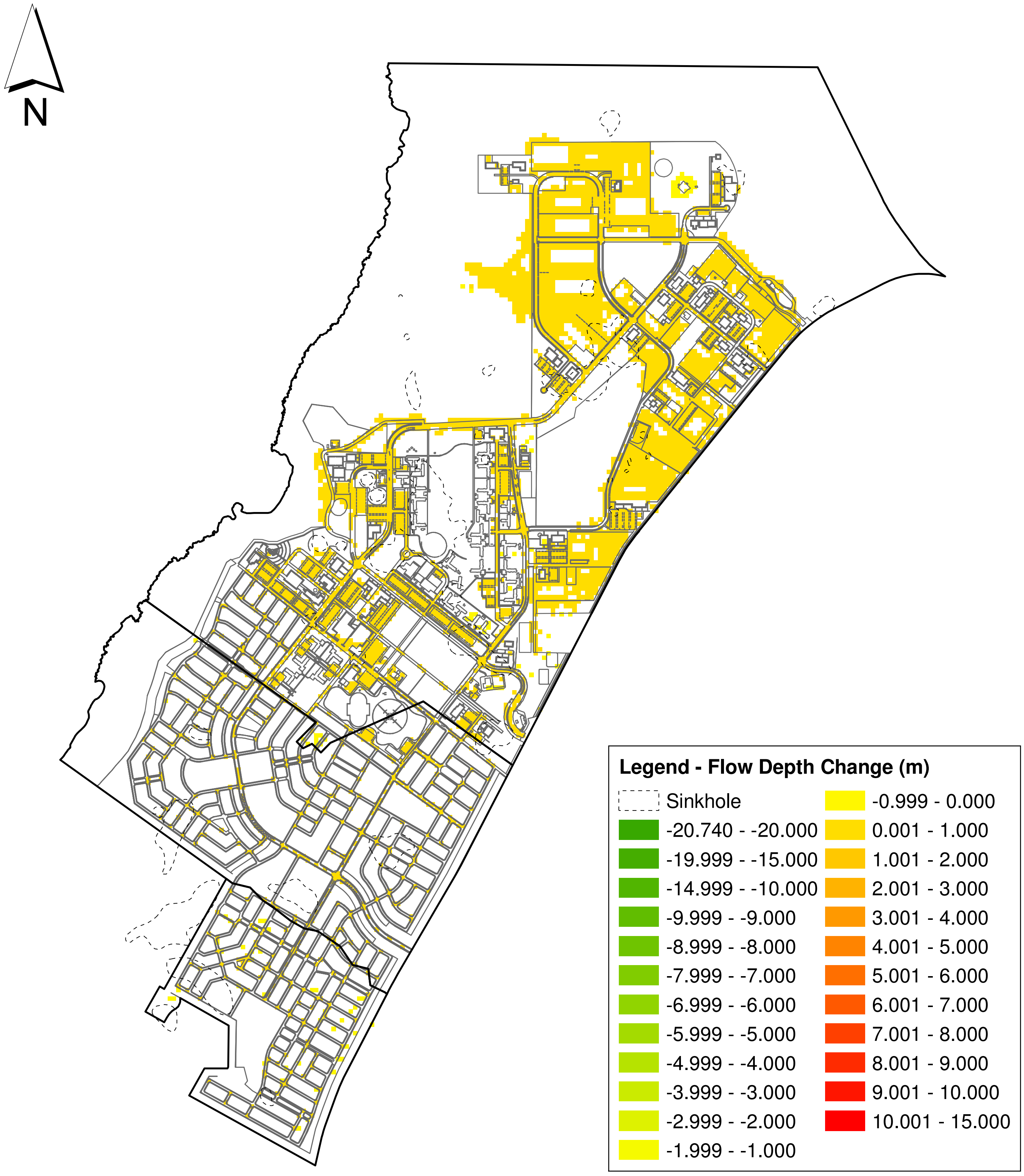


*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
80 Percent Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 23



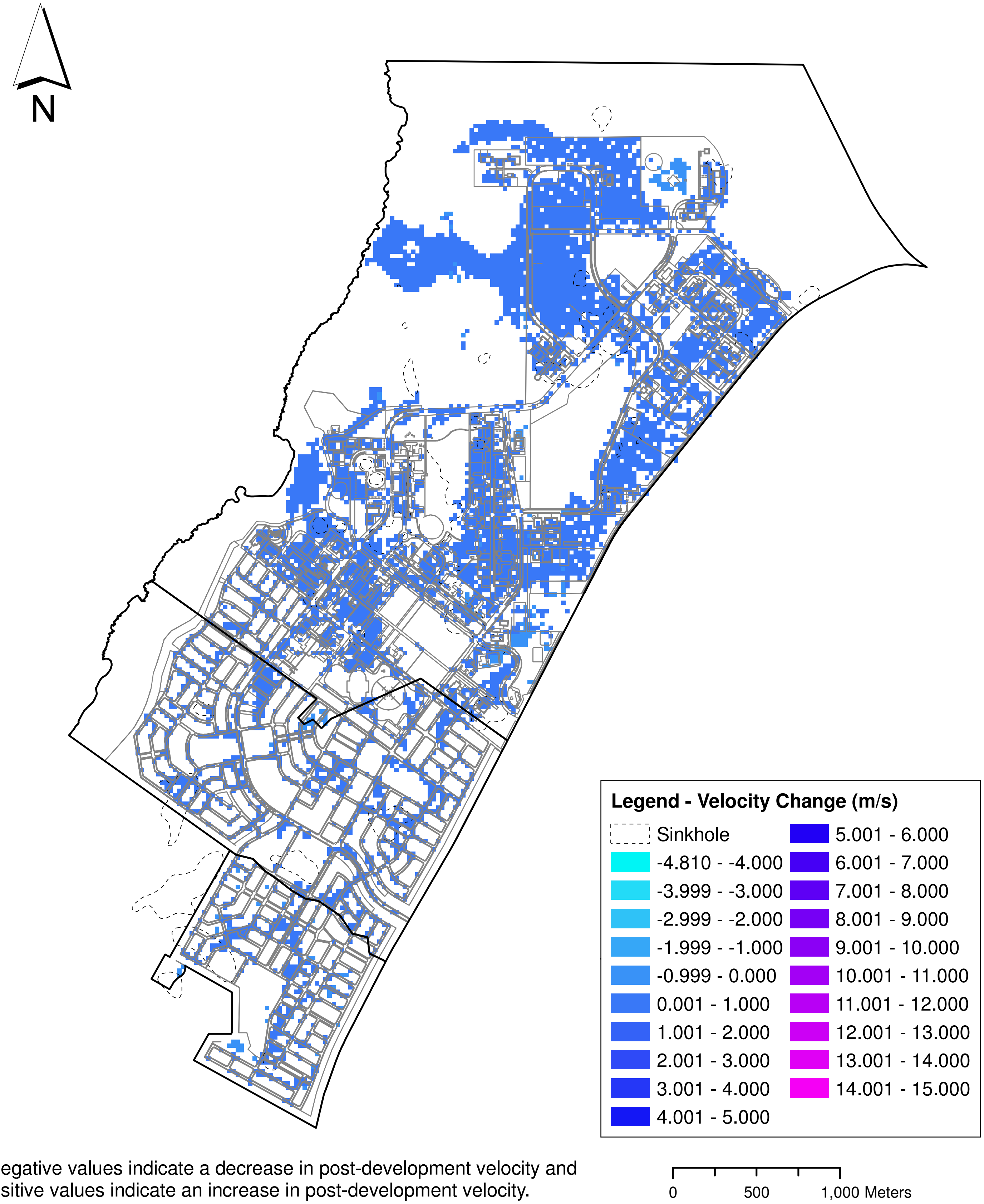
*Negative values indicate a decrease in post-development flow depth and positive values indicate an increase in post-development flow depth.

0 500 1,000 Meters

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
90 Percent Storm Flow Depth Change
(change = post-development – pre-development)

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 24



*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

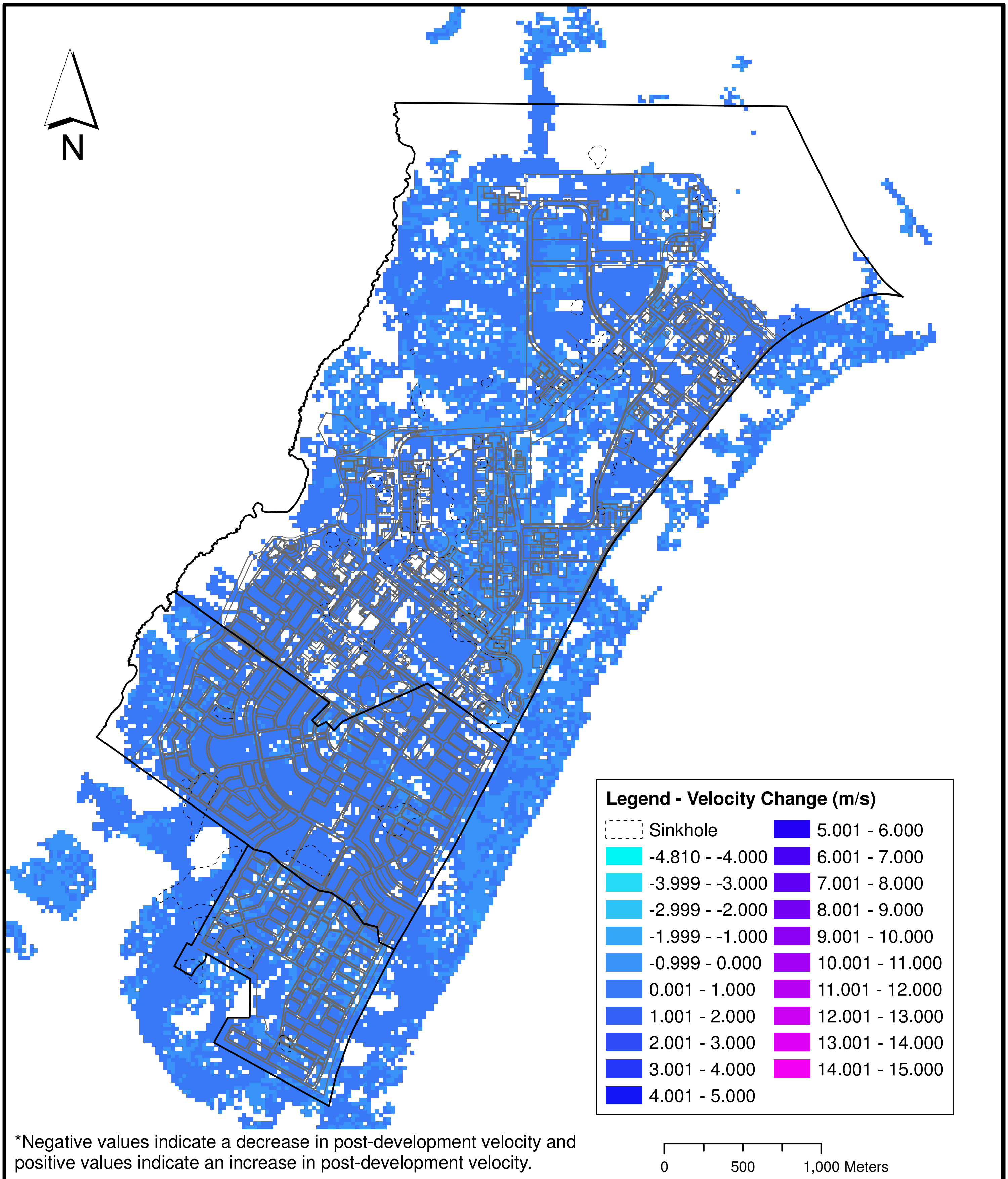
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
1 Year Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 25

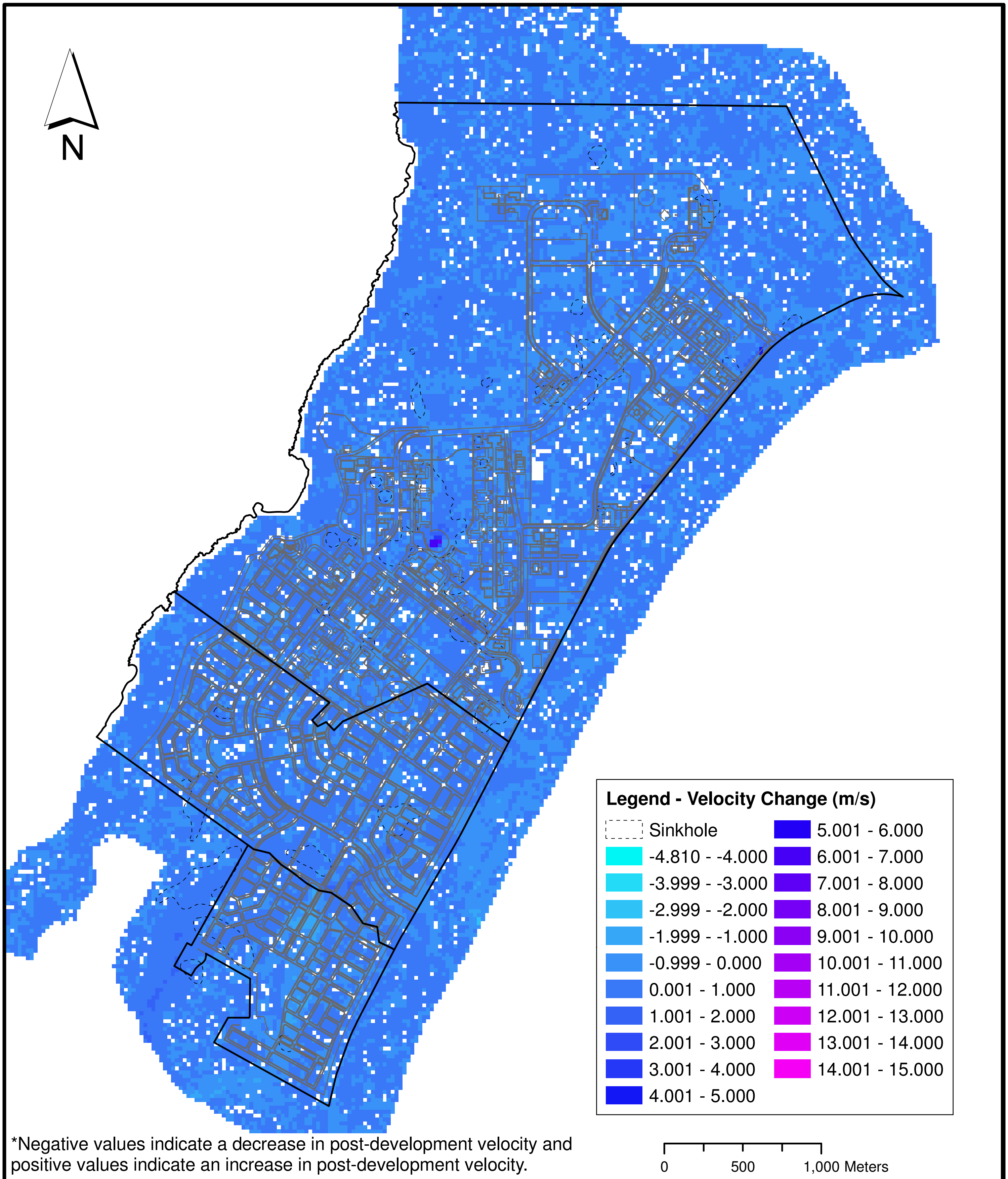


*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
2 Year Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 26

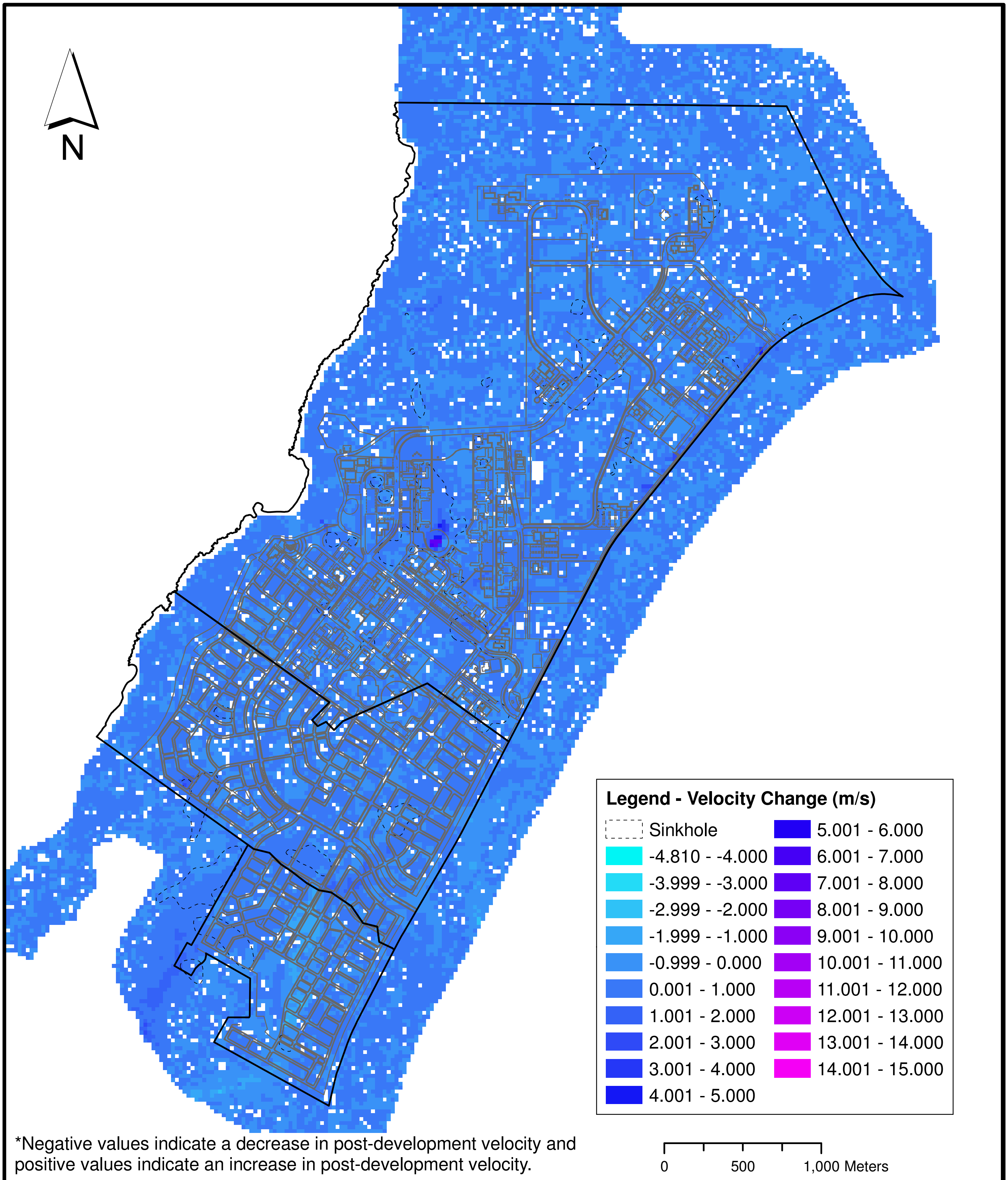


*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
10 Year Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 27



*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

AECOM

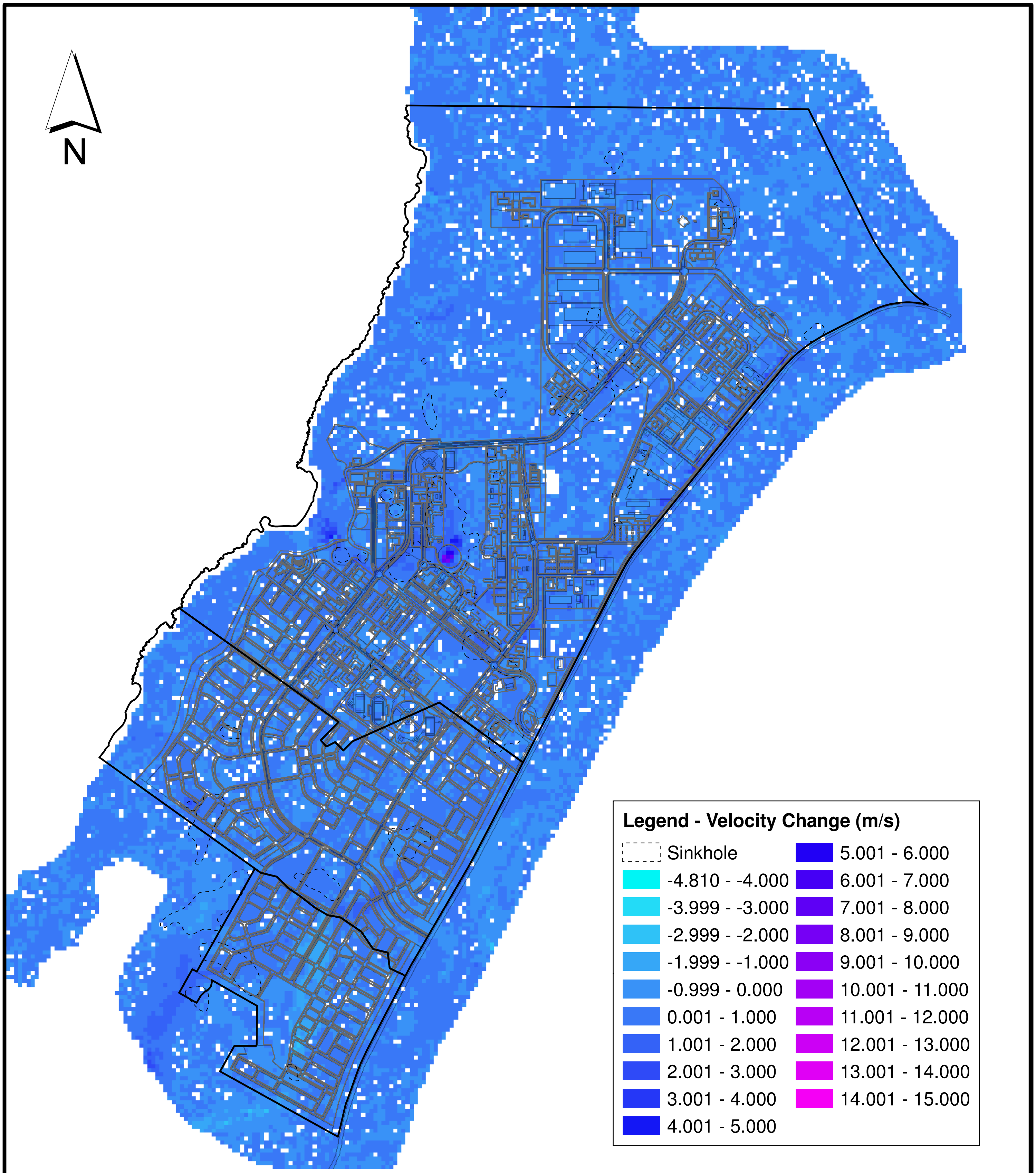
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
25 Year Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

Figure 28



*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

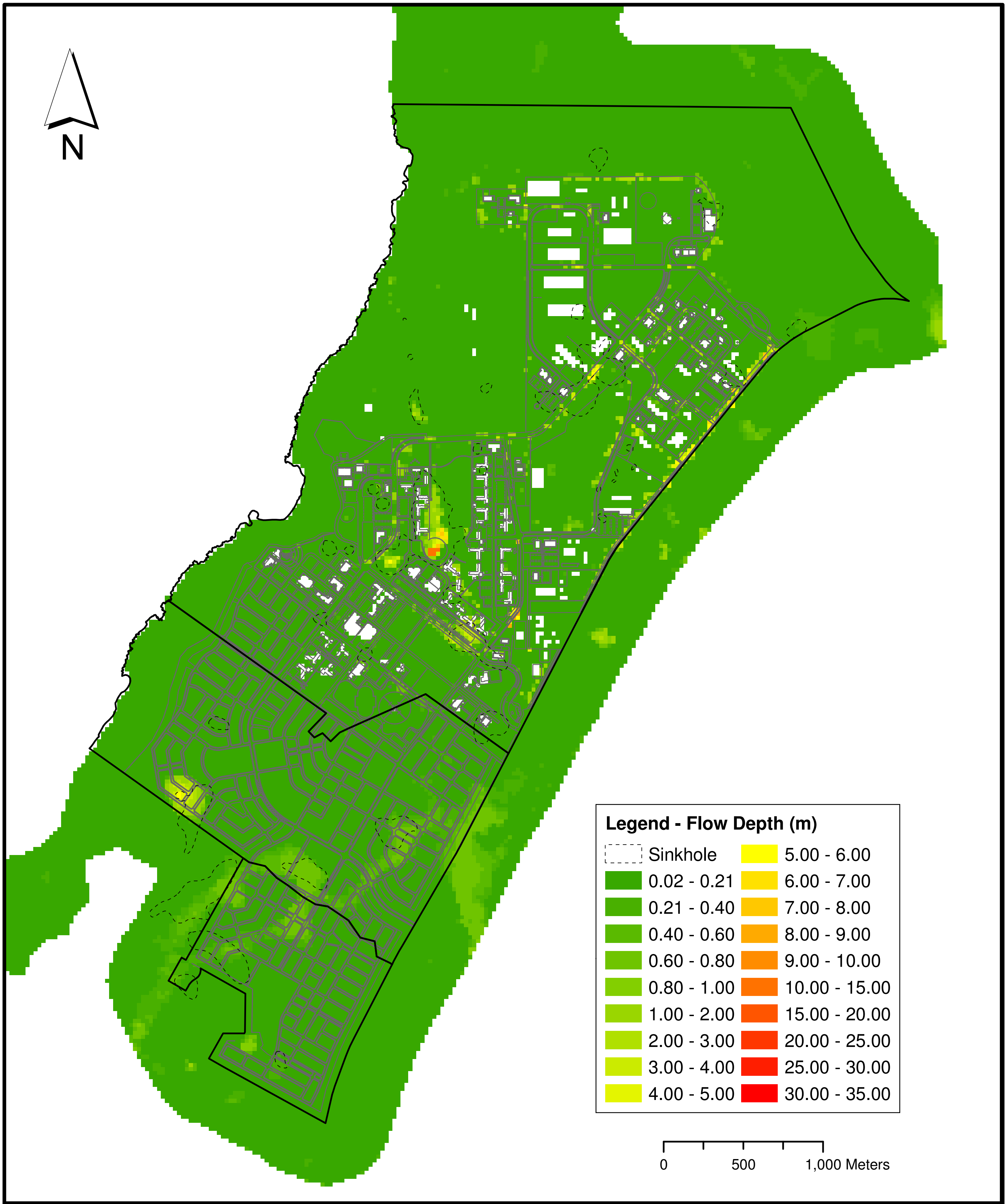
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
50 Year Storm Velocity Change
(change = post-development – pre-development)

GIS FILE:

SCALE: AS NOTED

DATE: 02/24/2010

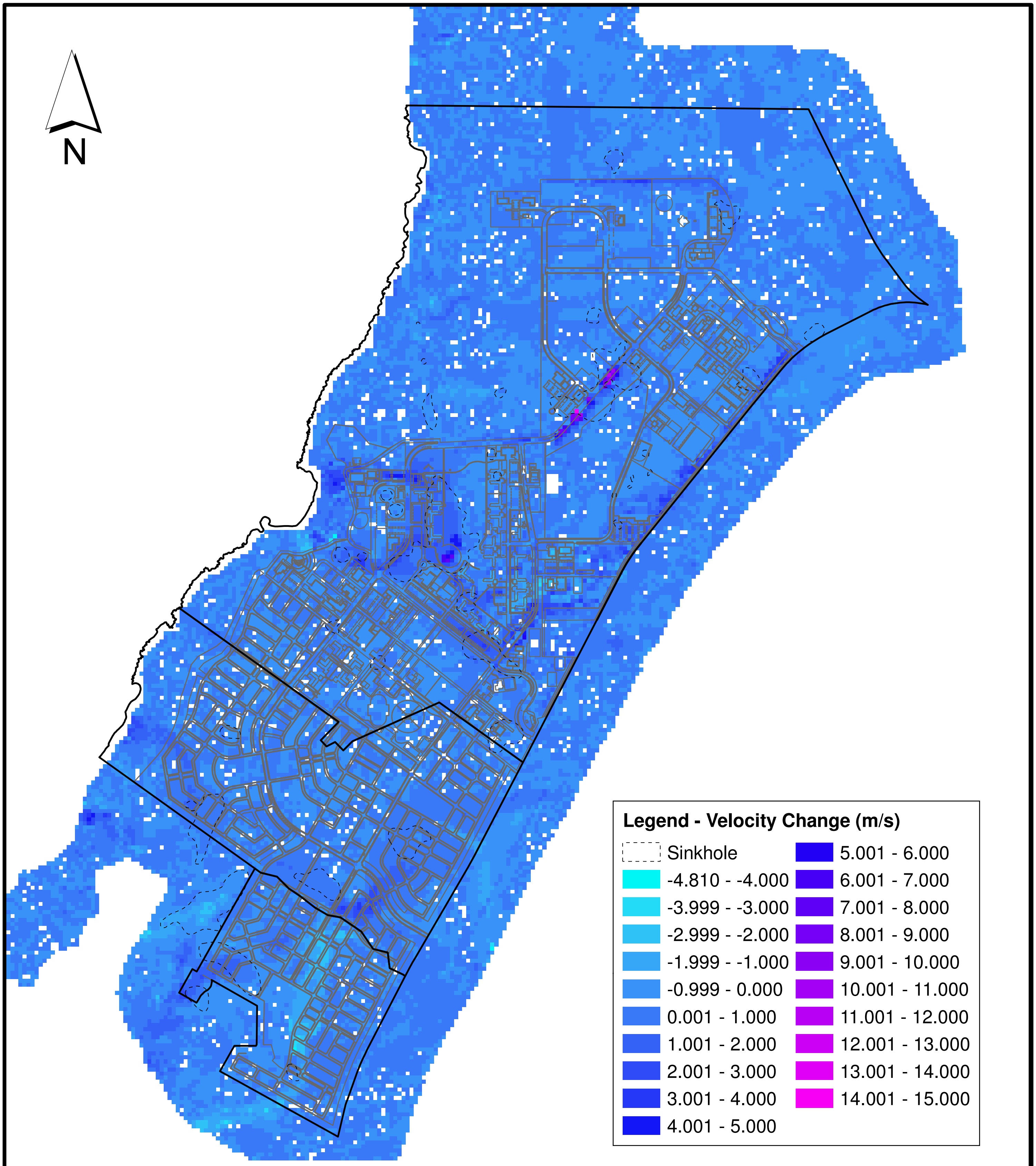
Figure 29



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 10 Year

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 3

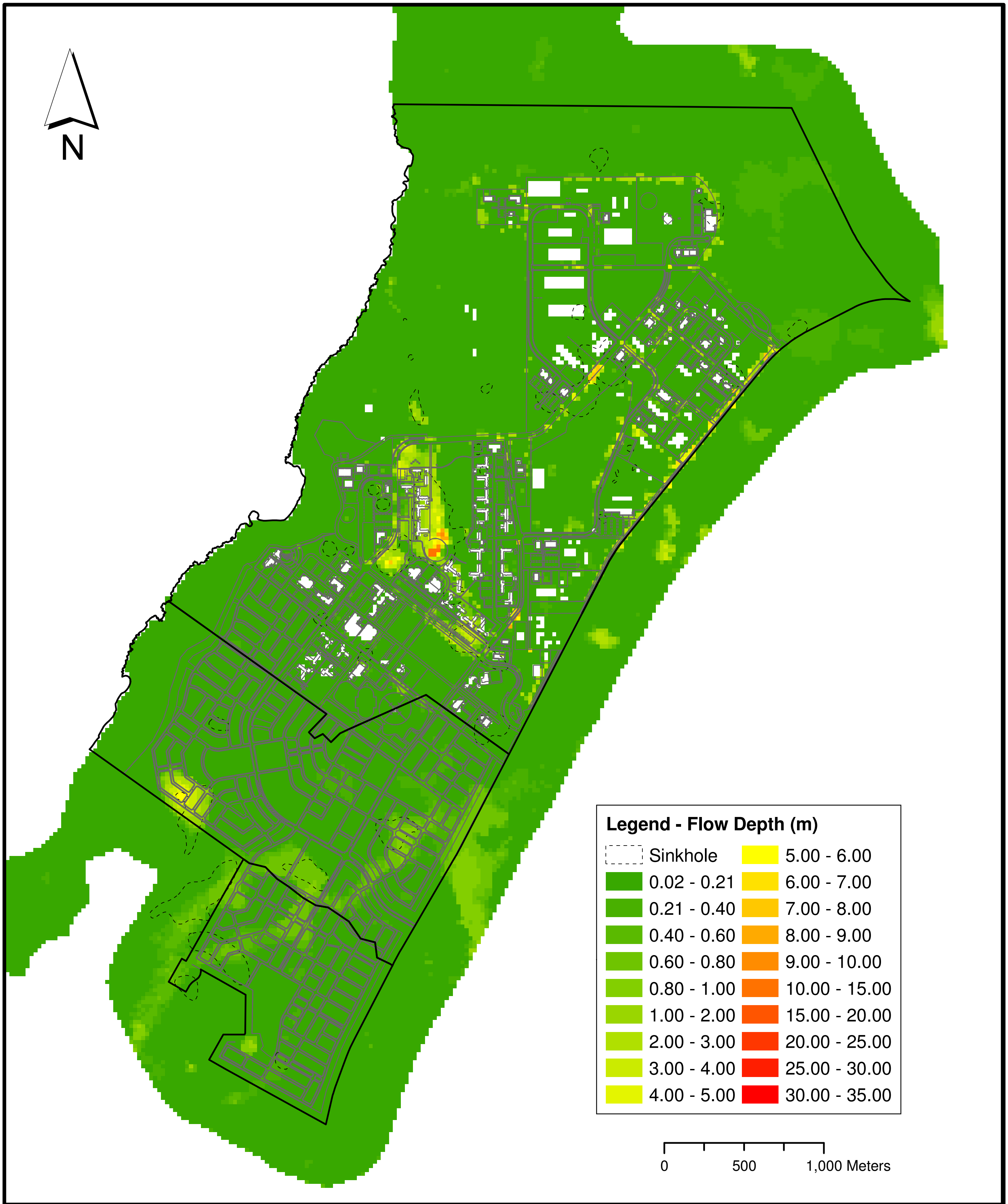


*Negative values indicate a decrease in post-development velocity and positive values indicate an increase in post-development velocity.

AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
500 Year Storm Velocity Change
(change = post-development – pre-development)

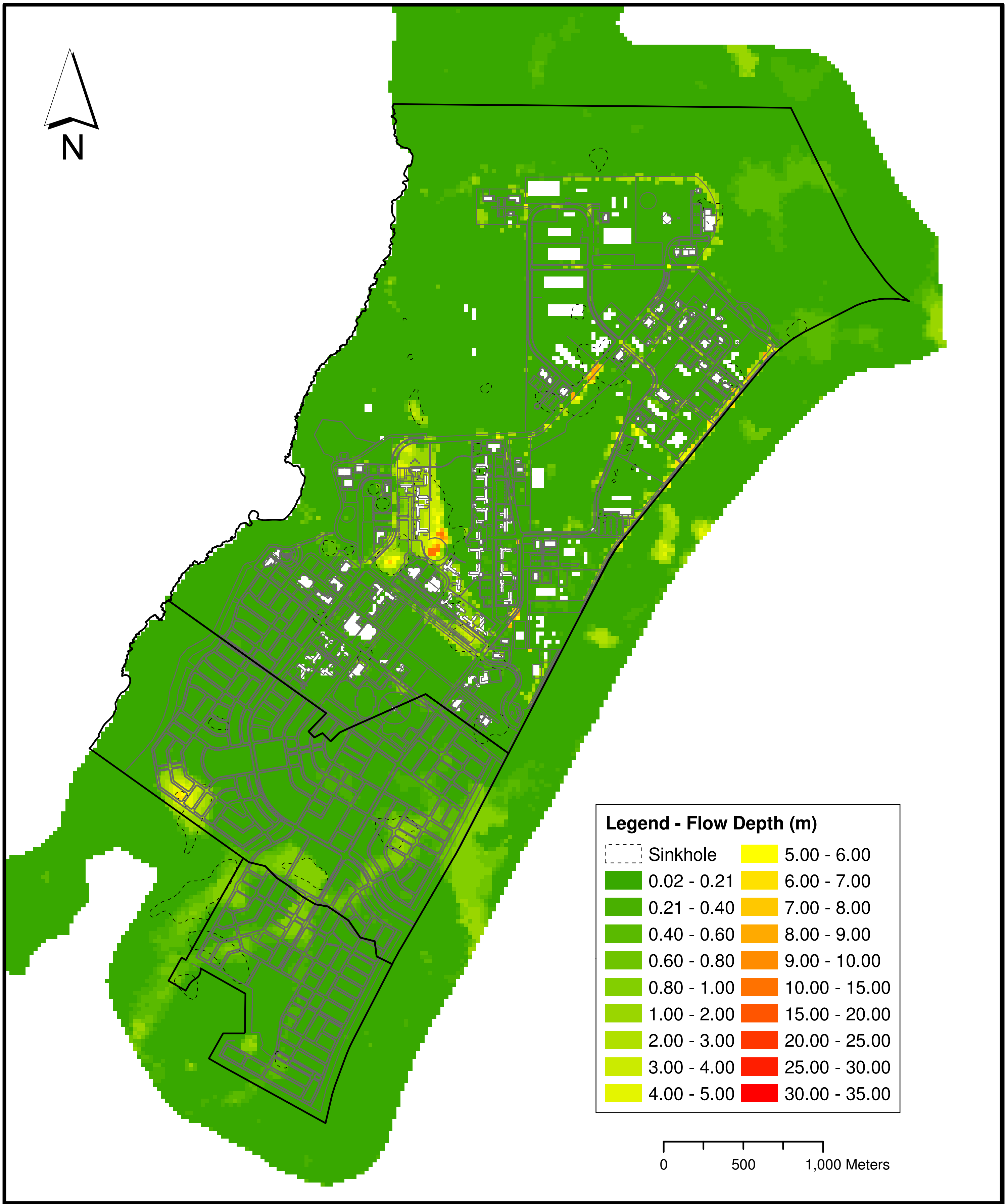
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 30



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 25 Year

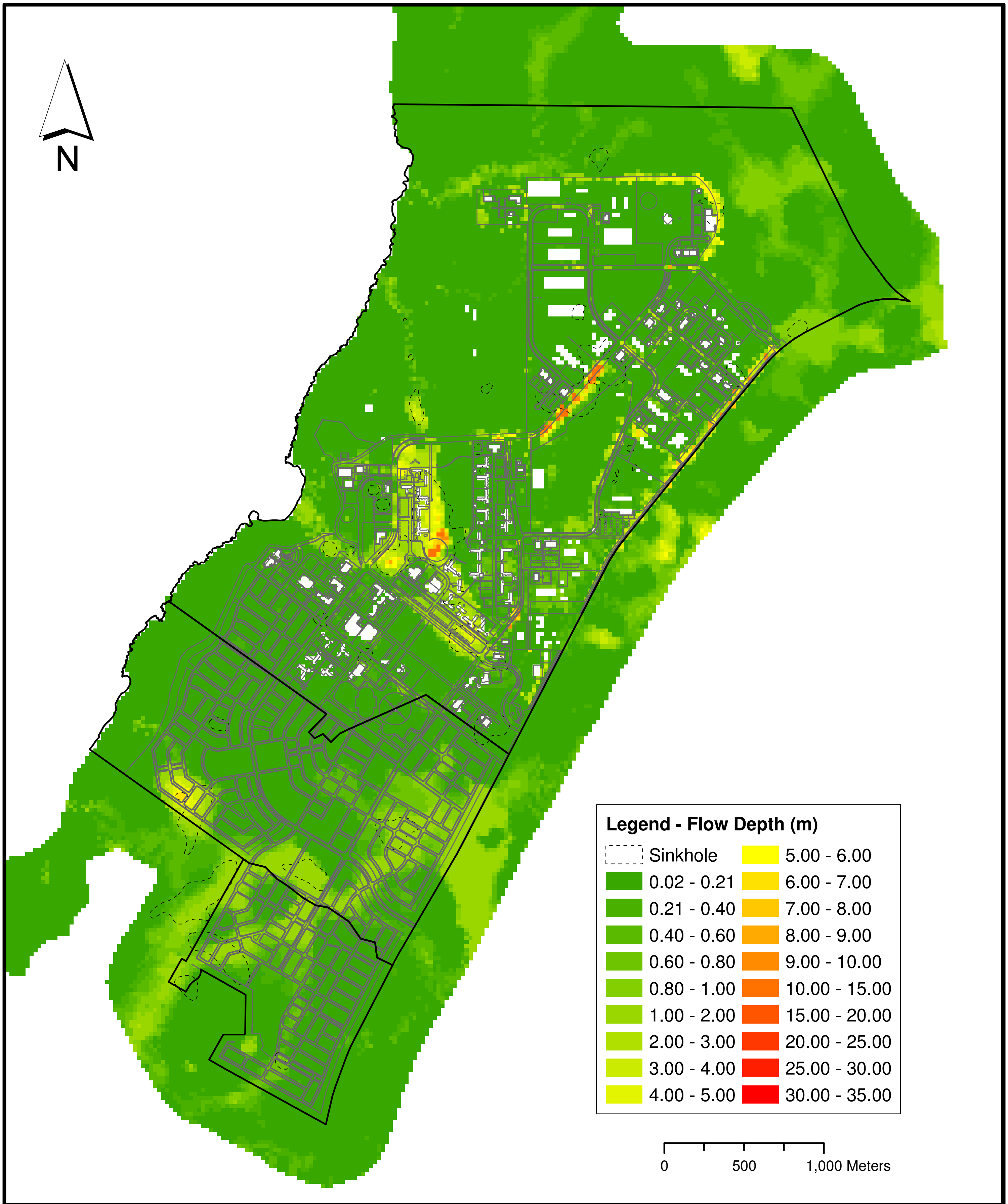
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 4



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 50 Year

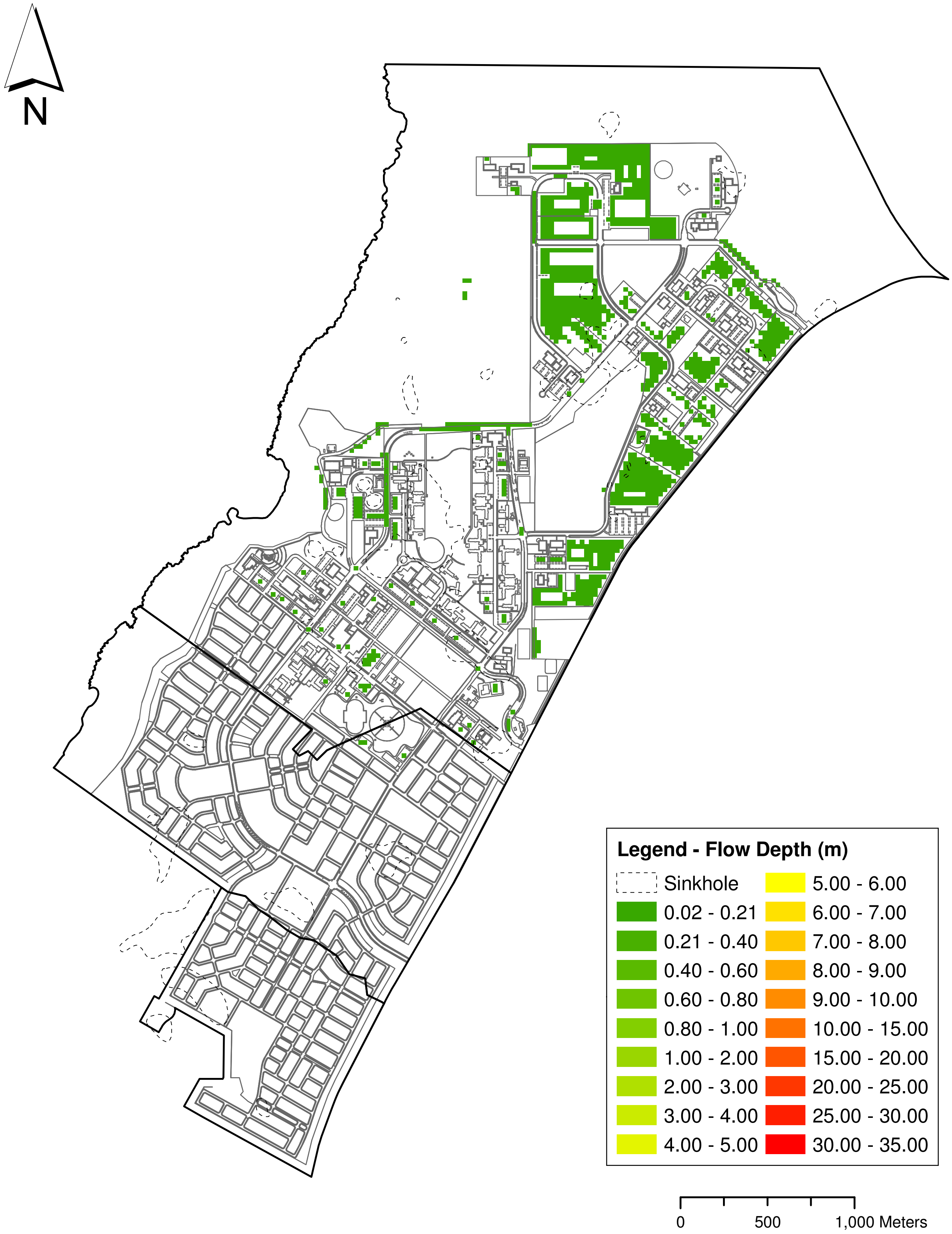
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 5



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 500 Year

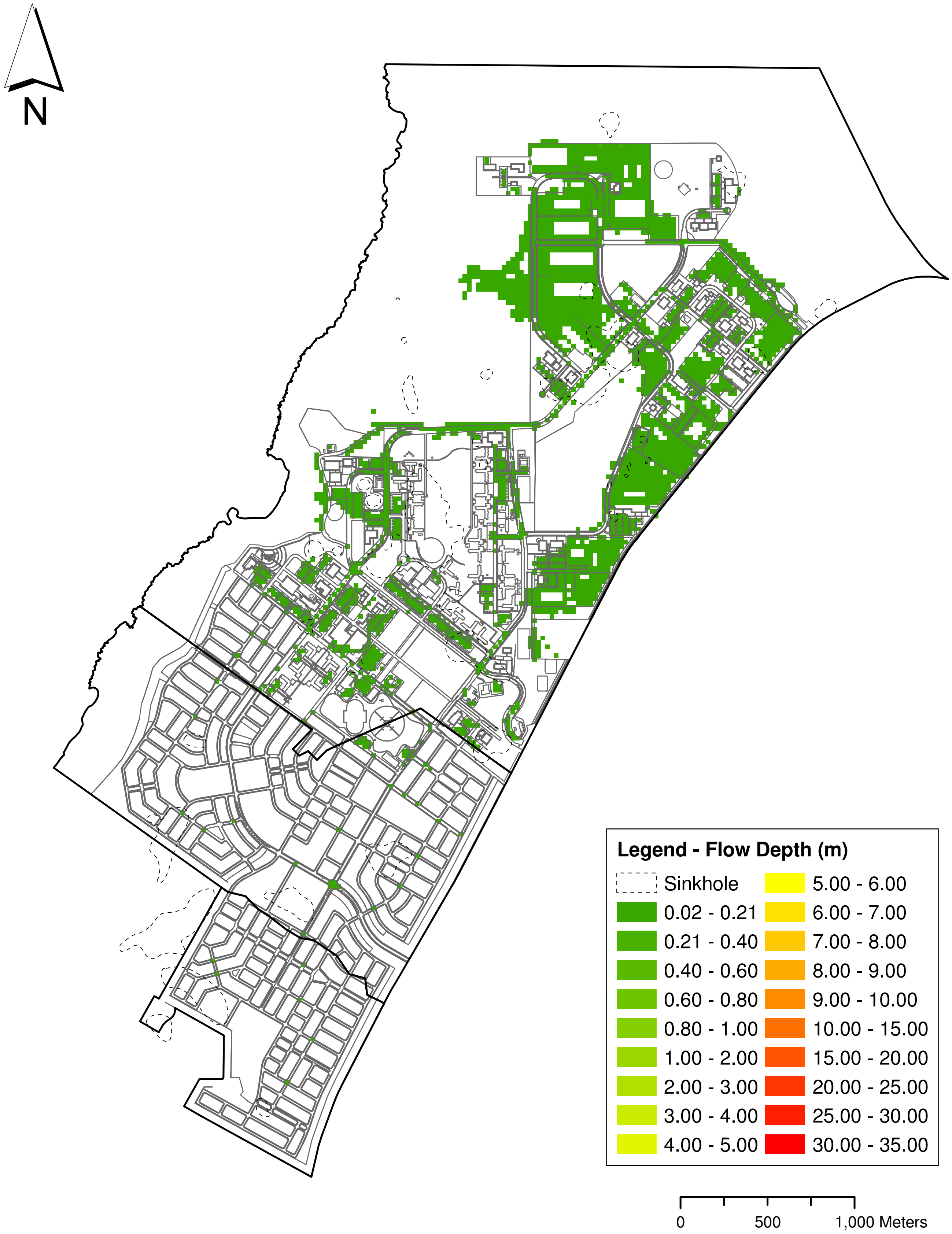
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 6



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 80 Percent

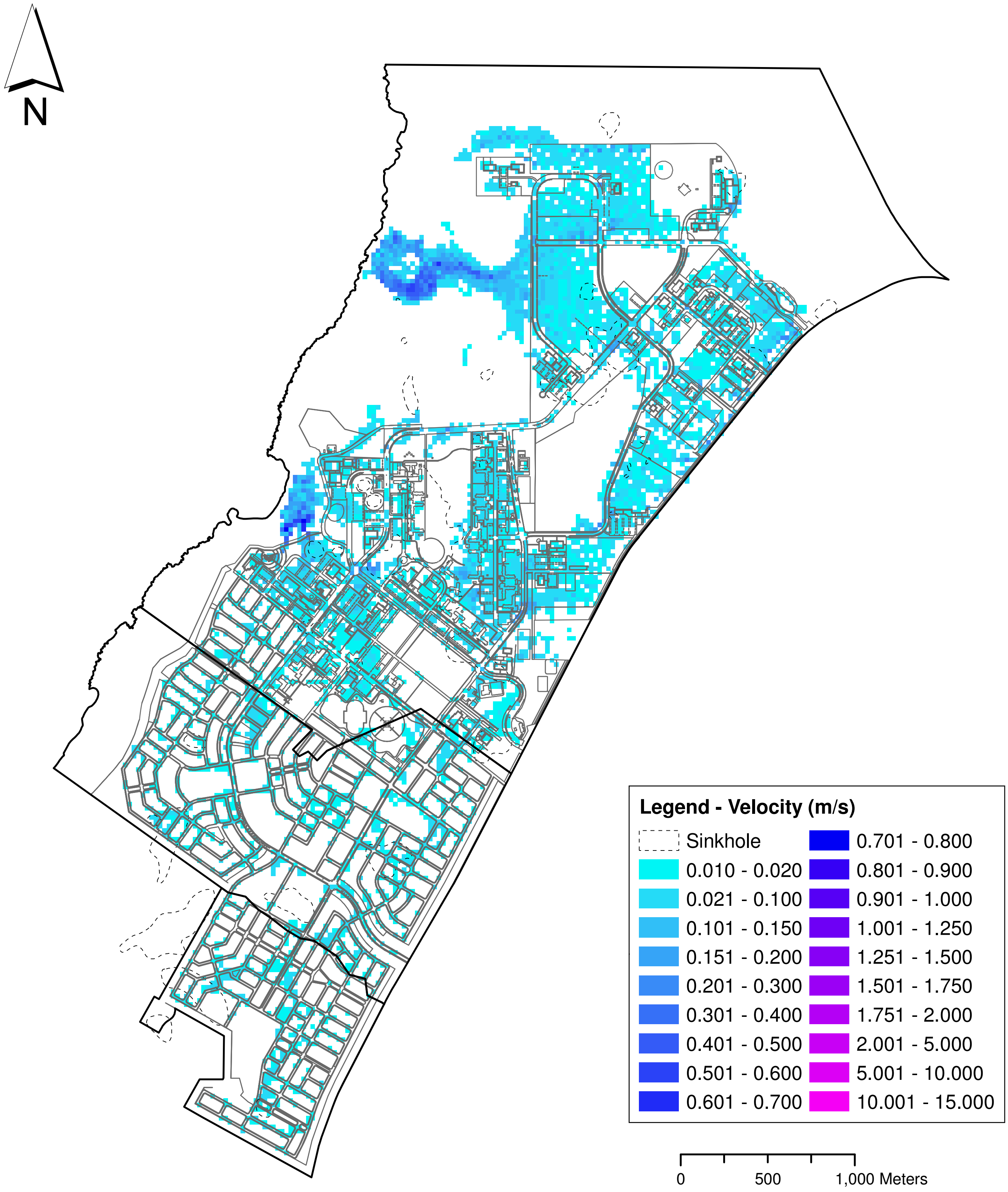
GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 7



AECOM

NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Flow Depth - 90 Percent

GIS FILE:	SCALE: AS NOTED	DATE: 02/24/2010	Figure 8



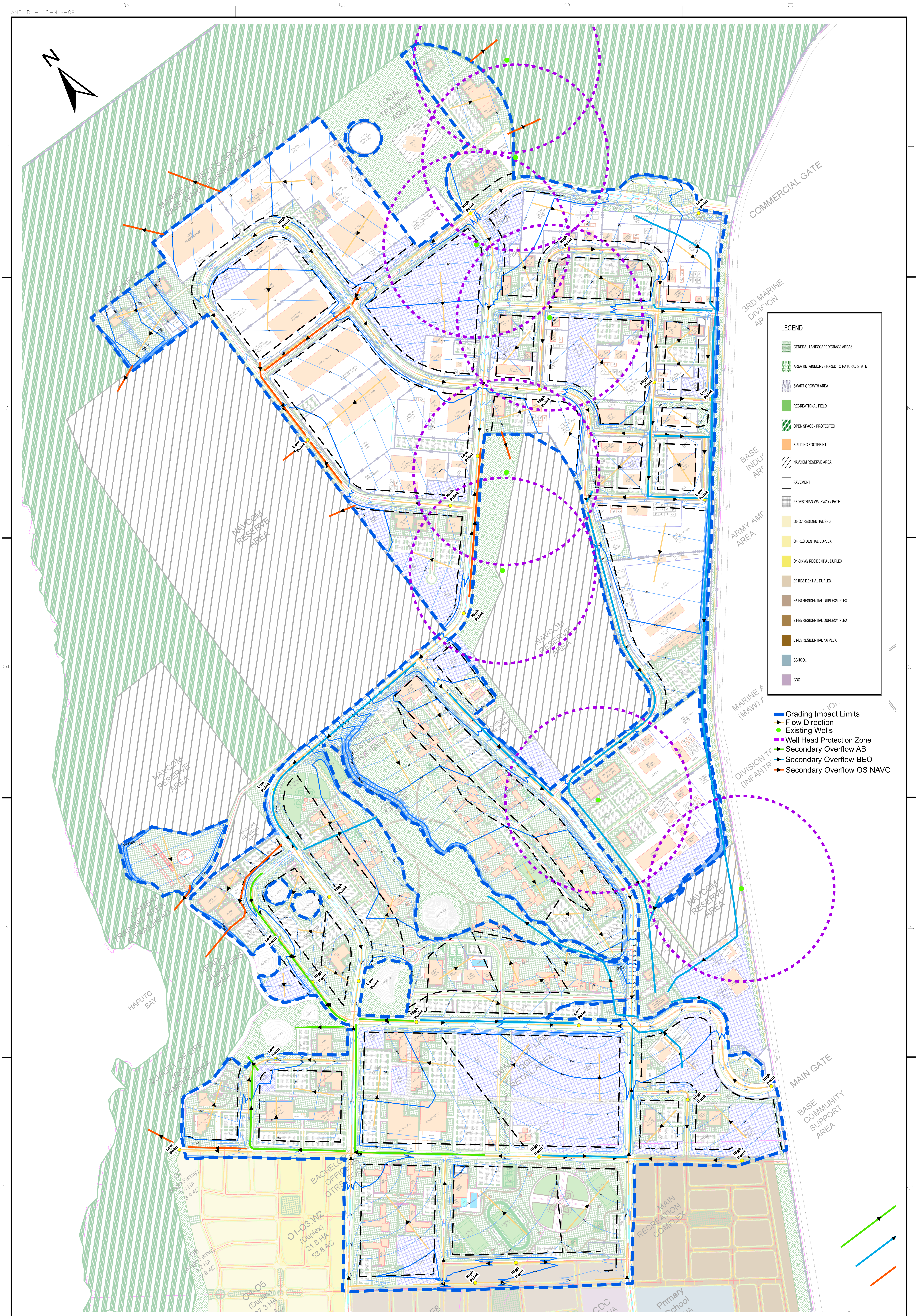
NAVFAC Pacific
Guam Drainage and Low Impact Development Study
Post-Development Velocity - 1 Year

GIS FILE:
SCALE: AS NOTED
DATE: 02/24/2010
Figure 9

Appendix B
Grading Plans

Appendix B.1
Notional Grading Plan

ANSI D - 18-Nov-09



SCALE:
DATE:
PROJ CHECK:
DEPT CHECK:
DRAWN BY:
DESIGNED BY:
CAD DWG FILE:
PROJECT NO:

Notional Grading Plan
Appendix B.1

AECOM

HUITT-ZOLLARS

MARK	DATE	MADE BY	CHECKED	DESCRIPTION

REVISIONS

Appendix B.2
Detention Basin Map

AECOM

HUITT-ZOLLARS
APRIL 28, 2010

APPENDIX B.2

FINEGAYAN
STORMWATER DETENTION BASIN MAP

Appendix B.3
Conflict Table

Conflict Table

Finegayan Grading and Basin Conflicts

Conflict Number[1]	Detention Basin and Grading Conflicts with GJMMP	Resolutions (1)	Resolutions (2)	Resolutions (3)
C1	*Conflicts with interior parcel slope*	**Rotate bulidings out of proposed slope**	**Regrade PMO area to include one larger slope**	**Relocate PMO area to eliminte Interior Parcel Slopes**
C2	*Conflicts with CRSP Warehouse*	**Relocate building out of low point of area**	**Revise Notional Grading to change low point**	**Reduce Basin size and drain to Wildlife Refuge**
C3	*In conflict with ORG Parking*	**Relocate parking out of low point of subarea**	**Revise grading to relocate low point**	**Eliminate or reduce basin footprint and drain north to wildlife refuge**
C5	*Conflicts with open storage area*	**Rotate Buildings 90 degrees and create area for basin**	**Regrade to drain parcel to north**	**Reduce basin size and drain overflow to open space**
C7	*Conflicts with BLDG and storage area*	**Rotate buildings; provide area for detention Basin**	**Revise Notional grading to drain toward smart growth (detention) area to east and culvert to basin**	**Drain to NAVCOM reserve area**
C8	*In conflict with BLDG and Parking*	**Locate this layout out of the low point of this area**	**Revise Notional Grading plan to revise low point**	-
C10	*In conflict with BLDG and Parking*	**Provid area for detention basin in middle of drainage area "DD"**	**Create swale for Area "DD" that drains to one larger detention basin at the eastern edge of the site**	**Add dry wells downstream of basin to reduce the size of basins, and swale to "Route 3 overflow swale"**
C11	*In conflict with Parking*	**Create area for detention basin**	**Overflow to Route 3 overflow swale**	**Create area for detention basin, and overflow to route3 overflow swale**
C13	*In conflict with Parking*	**Relocate parking and buildings out of low basin area**	**Revise grading to drain towards the north to utilize the location of the Smart Growth area**	**Create high point in middle of parcel and drain to two separate detention basins to the North and South**
C16	*Recreational Field located out of graded area*	**Relocate field**	**Extend Grading to include this area**	**Adjust field location and extend grading to cover field**
C17	*Building DWY's and parking lots encroaching into slope*	**Include buffer zones to reduce dwy slopes**	**Revise grading to reduce dwy slope**	**Include buffer zone off slope and revise grading to reduce dwy slopes**
C18	*In conflict with Organational parking area*	**Create detention basin area at midpoint of area "P"**	**Reduce basin footprint and discharge overflow to secondary overflow swale**	**Create area for basin and reduce footprint size and overflow to overflow swale**
C20	*Conflict with parade ground*	**Reduce Parade ground area**	**Flow to basin 13.37 and overflow into wildlife refuge**	**Reduce basin footprint, ad dry wells dowstream and culvert to basin 13.37**
C21	*Buildings located outside graded area*	**Relocate buildings**	**Regrade to include buildings**	**Relocate and regrade**
C22	*Building located outside graded area*	**Relocate building**	**Regrade to include building**	**Relocate and regrade**
C23	*Basin at high point of Parcel*	**Include micro storage around buildings to west to eliminate basin**	**Increase the size of Basin 16.44 and adjust BLDG to eliminate basin**	**Increase 16.44 and 16.45 and include micro storage around BLDG to eliminate Basin**
C26	*In conflict with Parking and BLDG*	**Relocate Welcome Center / This is a natural low spot**	**Relocate low point to east**	-
Well Heads	*Basins and underground storage facilities within well head buffer zone*	**Abandon well**	**Adjust locations of basins outside of well buffer zone**	-

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[1] Conflict numbers coorespond to Detention Basin MQ:\10138001\DOCS\H AND H\CALCS\Conflict Table.xls

Appendix B.4
Detention Basis Summary Table

Appendix B.4.1

Finegayan Detention Basin Sizing Data for 100yr Rainfall Event

(1) **Sub Area ID**	(2) **Drainage Area (ha)**	(3) **100yr Storm Volume REQ'D per Sub Area (m^3)**	(4) **Detention Basin Volume Provided (m^3)**	(5) **Secondary Overflow Volume (m^3)**	**Comments**
Recreation Disposal Area					
B	10.54	22,871	5,216	17,655	**Secondary Overflow detained within REC area; REC area detention basins designed at 5:1 slopes with 2m depth. Area outlined in map shall be designed to hold 0.3m water depth. No Secondary Overflow from REC area**
C	15.42	35,616	10,135	25,481	
(6) **REC Disposal Capacity @ 0.3m depth**	**-**	-	**46,775**	-	
Totals		***58,487***	***62,126***		
A Street B Street Disposal Area					
D	11.97	23,525	17,630	5,895	**63% *[101,019/159,641]* of 100yr storm detained within Detention basins and 3m depth disposal area. The remaining 37% is discharged to Open Space and Ocean**
E	23.44	45,700	11,704	33,996	
F	27.43	68,199	21,954	46,245	
M	11.10	22,216	5,901	16,315	
(6) **"A', 'B' Street Disposal Capacity @ 3m**	**-**	-	**43,830**	-	
Totals		***159,641***	***101,019***		
BEQ Disposal Area					
BB	17.60	60,677	27,548	33,129	
CC	7.09	16,907	9,738	7,169	
DD	18.82	51,585	22,446	29,139	
EE	5.29	10,244	9,304	940	
A	5.49	17,885	0	17,885	**This area is all street flow**
AA	15.34	40,400	10,935	29,465	
FF	2.67	5,514	6,273	0	
G	25.50	59,546	48,324	11,222	
H	14.19	31,815	25,090	6,725	
I	3.50	7,787	5,889	1,898	
J	10.87	22,768	18,972	3,796	
K	28.82	70,008	-	-	
K' North BEQ	17.30	42,021	15,492	26,529	
K' South	11.52	27,982	9,723	18,259	
O	58.10	87,069		87,069	
O' West BEQ	17.63	26,422	22,050	4,372	
O' East BEQ	18.28	27,396	35,244	0	
O' South BEQ	6.55	9,816	7,185	2,631	
O' Open Space	15.64	23,439	285,547	0	**Ultimate Overflow Disposal Area**
P	39.88	106,903	60,618	46,285	
S	5.67	16,451	0	16,451	**Drainage provided within sub area P**
T	4.31	10,669	13,536	0	
X	12.63	30,538	14,250	16,288	
(6) **BEQ Disposal Capacity**	-	-	**285,547**	-	
Totals		***646,766***	***648,164***		**100% of the 100yr Storm is detained in both the Detention basins and the BEQ disposal area, which is outlined in Detention Basin Map) Water surface elevation used for storage calculation is 104.5**
Drains to Open Space or NAVC					
N	15.15	33,211	19,095	14,116	**43% of 100yr discharged to open space and NAVC**
R	57.08	147,491	-	-	
R' North	4.42	11,427	5,436	5,991	**52% of 100yr discharged to NAVC**
R' NAVC	52.66	136,064	-	-	**Undeveloped No storage provided**
U	29.98	79,341	31,347	47,994	**49% of 100yr discharged to open space and NAVC**
V	29.02	71,264	50,400	20,864	
W	14.16	31,792	10,131	21,661	
Y	13.14	30,702	8,268	22,434	
Z	15.69	28,023	23,667	4,356	
Totals		***569,316***	***148,344***		

(1) Note Subareas include 1 or more detention basins. For individual basin values see Table A.3
(2) Drainage area
(3) 100yr Storage required for each studied area
(4) Volume of Storage provided per Graphic on Detention Basin Map
(5) Secondary Overflow calculation based on difference of required volume minus Design Volume
(6) Disposal area Boundary is color coded on Detention Basin Map

Appendix B.4.2

4/28/20102:34 PM

Finegayan Detention Basin Summary

	Total Storm Volume Calculations			Detention Basin Information		
Sub Area ID	25yr Storm Volume	50yr Storm Volume	(1) 100yr Storm Volume	Basin ID (Land Use Plan # . Basin #)	Detention Basin Area (m^2)	(2) Detention Basin Volume(m^3)
A	12,827.02	15,356.18	17,885.35	-	-	-
AA	29,113.04	34,756.65	40,400.27	4.8	3,645	10,935
B	14,721.66	15,356.18	17,885.35	19.67	2,607	5,214
BB	43,826.76	52,252.03	60,677.29	7.13	10,203	30,609
				8.14	1,901	5,703
C	23,475.74	29,545.76	35,615.78	19.52	2,045	5,083
				19.55	2,526	5,052
CC	11,971.65	14,439.30	16,906.96	7.10	10,821	32,463
D	15,946.48	19,735.65	23,524.83	18.51	7,004	17,922
DD	37,673.06	44,629.07	51,585.07	7.9	5,022	15,066
E	31,090.15	38,395.31	45,700.48	15.40	3,994	11,982
				15.42	611	1,222
EE	7,108.83	8,676.24	10,243.65	7.15	3,646	10,938
F	47,893.24	58,046.19	68,199.14	13.55	1,967	5,901
				16.44	4,326	12,978
				16.45	2,992	8,976
				16.46	2,049	6,147
FF	3,802.69	4,658.54	5,514.38	7.16	1,612	4,836
G	42,600.19	51,072.91	59,545.63	16.47	6,455	19,365
				16.56	4,955	14,865
				17.57	2,649	7,947
H	22,405.55	27,110.51	31,815.47	17.48	4,659	11,719
				17.58	4,457	13,371
I	5,650.09	6,718.59	7,787.09	17.49	1,963	5,889
J	16,164.31	19,465.97	22,767.63	17.62	6,323	18,969
K	47,999.68	59,003.93	70,008.17	-	-	-
K' North BEQ	28,799.81	35,402.36	42,004.90	14.21	1,360	2,720
				14.28	4,159	12,477
				14.30	2,227	4,454
K' South BEQ	19,199.87	23,601.57	28,003.27	14.27	1,412	4,236
				14.33	1,829	5,487
				14.34	2,835	8,505
M	15,417.37	18,816.72	22,216.06	-	-	-
N	23,579.10	28,395.27	33,211.45	4.11	6,365	19,095
O	56,044.15	71,556.45	87,068.76	-	-	-
O' West BEQ	17,003.79	21,710.23	26,416.66	14.20	4,587	13,761
				14.23	1,420	4,260
				14.24	1,343	4,029
O' East BEQ	17,631.49	22,511.66	27,391.83	14.22	9,706	29,118
				14.25	2,042	6,126
O' South BEQ	6,316.18	8,064.41	9,812.65	14.26	2,395	7,185
O' Open Space	15,092.69	19,270.15	23,447.62	-		-
P	76,480.77	91,691.97	106,903.16	9.65	4,326	12,978
				11.36	15,880	47,640

(1) 100yr Storm event chosen as Basis of Design

(2) All Storm volume beyond detention basin capacity is routed to ultimate disposal areas depicted in Detention Basin Map

Finegayan Detention Basin Summary

	Total Storm Volume Calculations			Detention Basin Information		
Sub Area ID	**25yr Storm Volume**	**50yr Storm Volume**	(1) **100yr Storm Volume**	**Basin ID (Land Use Plan # . Basin #)**	**Detention Basin Area (m^2)**	(2) **Detention Basin Volume(m^3)**
R	104,437.10	125,964.20	**147,491.29**	-		-
R' North	21,409.61	25,822.66	**30,235.72**	**6.12**	1,812	**5,436**
R' NAVC	83,027.50	100,141.54	**117,255.58**	-	-	-
S	12,039.38	14,245.07	**16,450.77**	-	-	-
T	7,871.43	9,270.38	**10,669.33**	**8.64**	4,512	**13,536**
U	58,185.01	68,762.97	**79,340.93**	**4.66**	10,499	**31,497**
V	50,726.74	60,995.27	**71,263.81**	**2.2**	4,584	**13,752**
				2.3	12,216	**36,648**
W	22,389.04	27,090.53	**31,792.03**	**1.1**	3,377	**10,131**
				2.63	30,440	**91,320**
X	21,737.24	26,137.47	**30,537.71**	**6.10**	4,750	**14,250**
Y	21,797.15	26,249.36	**30,701.57**	**4.4**	2,756	**8,268**
Z	18,471.26	23,247.29	**28,023.32**	**5.5**	5,324	**15,972**
				5.7	2,565	**7,695**

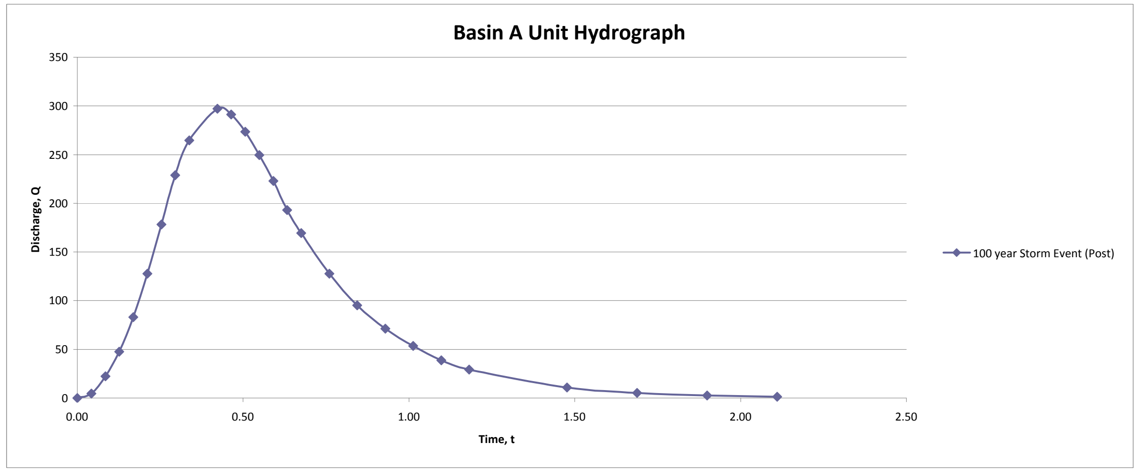
(1) 100yr Storm event chosen as Basis of Design
(2) All Storm volume beyond detention basin capacity is routed to ultimate disposal areas depicted in Detention Basin Map

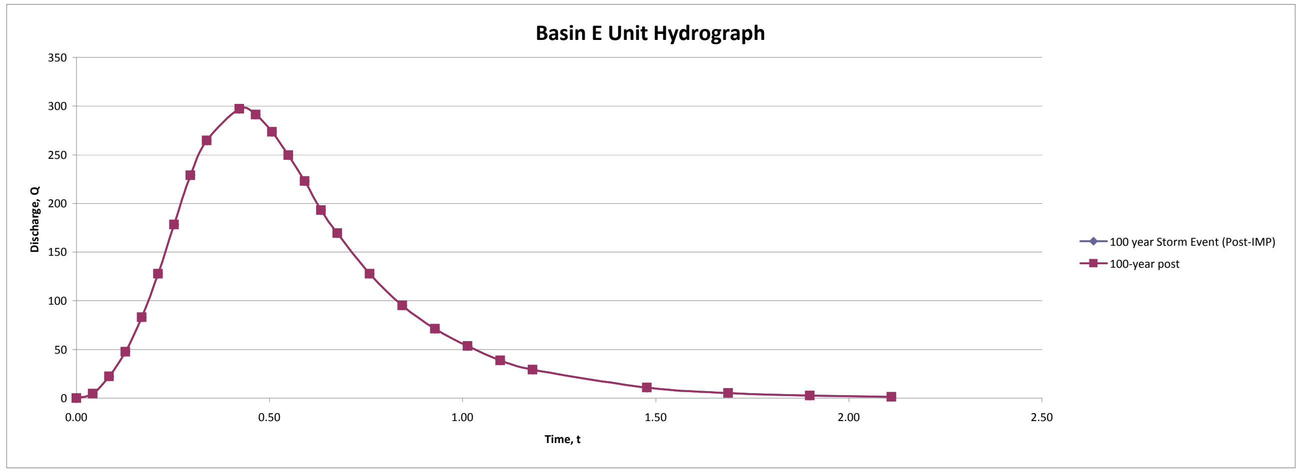
Appendix B.5
Storm Events Summary

The following data represents hydrographs for the studied areas of the Finegayan site. Using curve numbers calculated from the proposed land use of the GJMMP and the Notional Grading Plan hydrographs were produced for the 25-year and 100-year storm events. Using these hydrographs a representative volume for each sub area was calculated so that detention basins could be located and sized to store all or a portion of the volume of water produced by the storm. A 50-year runoff volume was calculated by interpolation of the 25-year and 100-year calculated runoff volumes. This 50yr runoff volume data was also added to the Detention Basin Summary Table (Appendix B.4.2) as a reference. Also provided within; are the 25-year and 100-year hydrographs that incorporate BMP's and IMP's. BMP and IMP hydrographs were not used in sizing of detention basins and is not expected to alter calculations significantly if considered.

100yr (post)			
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.457360557
0.20	0.08	0.075	22.28680279
0.30	0.13	0.16	47.54517928
0.40	0.17	0.28	83.20406374
0.50	0.21	0.43	127.7776693
0.60	0.25	0.6	178.2944223
0.70	0.30	0.77	228.8111753
0.80	0.34	0.89	264.4700597
1.00	0.42	1	297.1573705
1.10	0.46	0.98	291.2142231
1.20	0.51	0.92	273.3847809
1.30	0.55	0.84	249.6121912
1.40	0.59	0.75	222.8680279
1.50	0.63	0.65	193.1522908
1.60	0.68	0.57	169.3797012
1.80	0.76	0.43	127.7776693
2.00	0.84	0.32	95.09035856
2.20	0.93	0.24	71.31776892
2.40	1.01	0.18	53.48832669
2.60	1.10	0.13	38.63045816
2.80	1.18	0.098	29.12142231
3.50	1.48	0.036	10.69766534
4.00	1.69	0.018	5.348832669
4.50	1.90	0.009	2.674416334
5.00	2.11	0.004	1.188629482

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.495	Tc	0.495	Tc	0.495	Tc	0.495	Tc	0.495	Tc	0.495
Tp	0.422	Tp	0.422	Tp	0.422	Tp	0.422	Tp	0.422	Tp	0.422
A (sq miles)	0.021199	A (sq miles)	0.021199	A (sq miles)	0.021199	A (sq miles)	0.021199	A (sq miles)	0.021199	A (sq miles)	0.021199
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	83	CN	83	CN	83	CN	83	CN	83	CN	83
S	2.048192771	S	2.048193	S	2.048193	S	2.048193	S	2.04819277	S	2.048192771
Q (1-yr)	1.691626521	Q (2-yr)	5.97741	Q (10-yr)	10.9268	Q (25-yr)	14.56969	Q (100-yr)	20.3152439	Q (500-yr)	48.3223217
Ia	0.409638554	Ia	0.409639	Ia	0.409639	Ia	0.409639	Ia	0.40963855	Ia	0.409638554
Ia/P (1-yr)	0.124132895	Ia/P (2-yr)	0.051205	Ia/P (10-yr)	0.03127	Ia/P (25-yr)	0.024383	Ia/P (100-yr)	0.0181256	Ia/P (500-yr)	0.008079656
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	690	qu from chart	690	qu from chart	690	qu from chart	690	qu from chart	690	qu from chart	690
Qp (1-yr) =	24.74394552	Qp (2-yr) =	87.43342	Qp (10-yr) =	159.8297	Qp (25-yr) =	213.1153	Qp (100-yr) =	297.15737	Qp (500-yr) =	706.8255795





25yr (post)			
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	1.311501357
0.20	0.08	0.075	6.557506784
0.30	0.13	0.16	13.9893478
0.40	0.17	0.28	24.48135866
0.50	0.21	0.43	37.59637223
0.60	0.25	0.6	52.46005427
0.70	0.30	0.77	67.32373631
0.80	0.34	0.89	77.81574716
1.00	0.42	1	87.43342378
1.10	0.46	0.98	85.6847553
1.20	0.51	0.92	80.43874988
1.30	0.55	0.84	73.44407598
1.40	0.59	0.75	65.57506784
1.50	0.63	0.65	56.83172546
1.60	0.68	0.57	49.83705155
1.80	0.76	0.43	37.59637223
2.00	0.84	0.32	27.97869561
2.20	0.93	0.24	20.98402171
2.40	1.01	0.18	15.73801628
2.60	1.10	0.13	11.36634509
2.80	1.18	0.098	8.56847553
3.50	1.48	0.036	3.147603256
4.00	1.69	0.018	1.573801628
4.50	1.90	0.009	0.786900814
5.00	2.11	0.004	0.349733695

100yr (pre)			
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.39744595
0.20	0.08	0.075	11.98722975
0.30	0.13	0.16	25.5727568
0.40	0.17	0.28	44.75232441
0.50	0.21	0.43	68.72678391
0.60	0.25	0.6	95.89783801
0.70	0.30	0.77	123.0688921
0.80	0.34	0.89	142.2484597
1.00	0.42	1	159.82973
1.10	0.46	0.98	156.6331354
1.20	0.51	0.92	147.0433516
1.30	0.55	0.84	134.2569732
1.40	0.59	0.75	119.8722975
1.50	0.63	0.65	103.8893245
1.60	0.68	0.57	91.10294611
1.80	0.76	0.43	68.72678391
2.00	0.84	0.32	51.14551361
2.20	0.93	0.24	38.3591352
2.40	1.01	0.18	28.7693514
2.60	1.10	0.13	20.7778649
2.80	1.18	0.098	15.66331354
3.50	1.48	0.036	5.753870281
4.00	1.69	0.018	2.87693514
4.50	1.90	0.009	1.43846757
5.00	2.11	0.004	0.63931892

25yr (post w/BMP)			
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	3.19673
0.20	0.08	0.075	15.98365
0.30	0.13	0.16	34.09845
0.40	0.17	0.28	59.67229
0.50	0.21	0.43	91.63959
0.60	0.25	0.6	127.8692
0.70	0.30	0.77	164.0988
0.80	0.34	0.89	189.6726
1.00	0.42	1	213.1153
1.10	0.46	0.98	208.853
1.20	0.51	0.92	196.0661
1.30	0.55	0.84	179.0169
1.40	0.59	0.75	159.8365
1.50	0.63	0.65	138.525
1.60	0.68	0.57	121.4757
1.80	0.76	0.43	91.63959
2.00	0.84	0.32	68.1969
2.20	0.93	0.24	51.14768
2.40	1.01	0.18	38.36076
2.60	1.10	0.13	27.70499
2.80	1.18	0.098	20.8853
3.50	1.48	0.036	7.672151
4.00	1.69	0.018	3.836076
4.50	1.90	0.009	1.918038
5.00	2.11	0.004	0.852461

100yr (post w/IMP)			
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.457361
0.20	0.08	0.075	22.2868
0.30	0.13	0.16	47.54518
0.40	0.17	0.28	83.20406
0.50	0.21	0.43	127.7777
0.60	0.25	0.6	178.2944
0.70	0.30	0.77	228.8112
0.80	0.34	0.89	264.4701
1.00	0.42	1	297.1574
1.10	0.46	0.98	291.2142
1.20	0.51	0.92	273.3848
1.30	0.55	0.84	249.6122
1.40	0.59	0.75	222.868
1.50	0.63	0.65	193.1523
1.60	0.68	0.57	169.3797
1.80	0.76	0.43	127.7777
2.00	0.84	0.32	95.09036
2.20	0.93	0.24	71.31777
2.40	1.01	0.18	53.48833
2.60	1.10	0.13	38.63046
2.80	1.18	0.098	29.12142
3.50	1.48	0.036	10.69767
4.00	1.69	0.018	5.348833
4.50	1.90	0.009	2.674416
5.00	2.11	0.004	1.188629

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.130191819
0.20	0.07	0.075	5.650959095
0.30	0.10	0.16	12.0553794
0.40	0.13	0.28	21.09691396
0.50	0.17	0.43	32.39883215
0.60	0.20	0.6	45.20767276
0.70	0.24	0.77	58.01651338
0.80	0.27	0.89	67.05804793
1.00	0.34	1	75.34612127
1.10	0.37	0.98	73.83919885
1.20	0.40	0.92	69.31843157
1.30	0.44	0.84	63.29074187
1.40	0.47	0.75	56.50959095
1.50	0.50	0.65	48.97497883
1.60	0.54	0.57	42.94728913
1.80	0.61	0.43	32.39883215
2.00	0.67	0.32	24.11075881
2.20	0.74	0.24	18.08306911
2.40	0.81	0.18	13.56230183
2.60	0.87	0.13	9.794995766
2.80	0.94	0.098	7.383919885
3.50	1.18	0.036	2.712460366
4.00	1.34	0.018	1.356230183
4.50	1.51	0.009	0.678115091
5.00	1.68	0.004	0.301384485

Duration, D	0.25
Tc	0.352
Tp	0.3362
A (sq miles)	0.059240374
P (1-yr)	3.3
CN	85
S	1.764705882
Q (1-yr)	1.843291474
Ia	0.352941176
Ia/P (1-yr)	0.106951872
use Ia/P min	0.1
qu from chart	690
Qp (1-yr) =	75.34612127

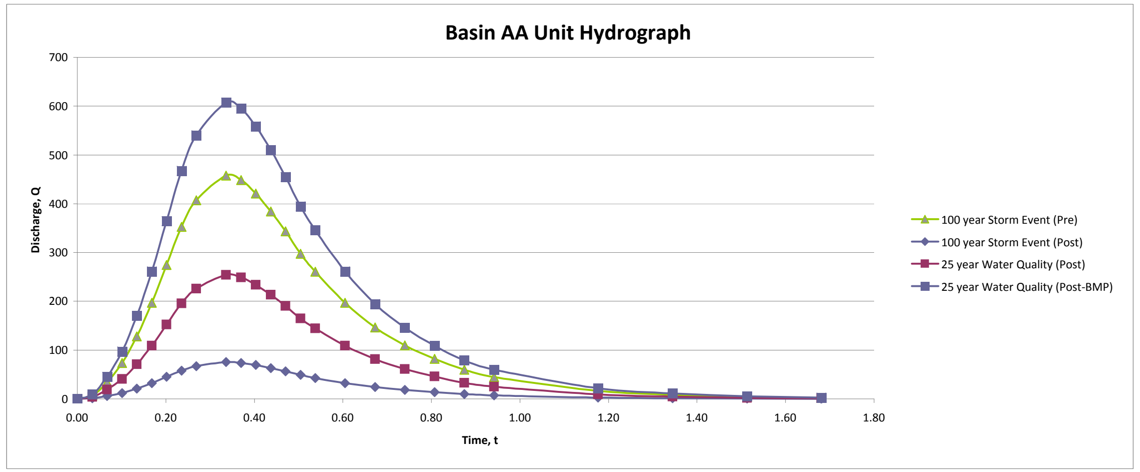
Duration, D	0.25
Tc	0.352
Tp	0.3362
A (sq miles)	0.05924
P (2-yr)	8
CN	85
S	1.764706
Q (2-yr)	6.213235
Ia	0.352941
Ia/P (2-yr)	0.044118
use Ia/P min	0.1
qu from chart	690
Qp (2-yr) =	253.9713

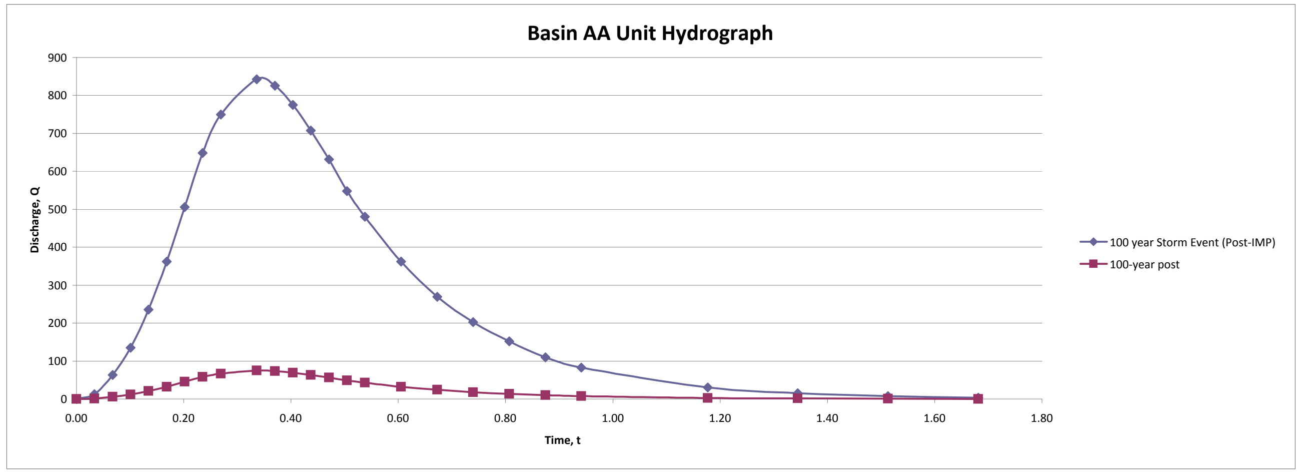
Duration, D	0.25
Tc	0.352
Tp	0.3362
A (sq miles)	0.05924
P (10-yr)	13.1
CN	85
S	1.764706
Q (10-yr)	11.19695
Ia	0.352941
Ia/P (10-yr)	0.026942
use Ia/P min	0.1
qu from chart	690
Qp (10-yr) =	457.685

Duration, D	0.25
Tc	0.352
Tp	0.3362
A (sq miles)	0.05924
P (25-yr)	16.8
CN	85
S	1.764706
Q (25-yr)	14.85335
Ia	0.352941
Ia/P (25-yr)	0.021008
use Ia/P min	0.1
qu from chart	690
Qp (25-yr) =	607.1435

Duration, D	0.25
Tc	0.352
Tp	0.3362
A (sq miles)	0.05924037
P (100-yr)	22.6
CN	85
S	1.76470588
Q (100-yr)	20.6120472
Ia	0.35294118
Ia/P (100-yr)	0.01561687
use Ia/P min	0.1
qu from chart	690
Qp (100-yr) =	842.535121

Duration, D	0.25
Tc	0.352
Tp	0.3362
A (sq miles)	0.059240374
P (500-yr)	50.7
CN	85
S	1.764705882
Q (500-yr)	48.64211271
Ia	0.352941176
Ia/P (500-yr)	0.006961364
use Ia/P min	0.1
qu from chart	690
Qp (500-yr) =	1988.288111





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	3.809569891
0.20	0.07	0.075	19.04784946
0.30	0.10	0.16	40.63541217
0.40	0.13	0.28	71.1119713
0.50	0.17	0.43	109.2076702
0.60	0.20	0.6	152.3827956
0.70	0.24	0.77	195.5579211
0.80	0.27	0.89	226.0344802
1.00	0.34	1	253.9713261
1.10	0.37	0.98	248.8918996
1.20	0.40	0.92	233.65362
1.30	0.44	0.84	213.3359139
1.40	0.47	0.75	190.4784946
1.50	0.50	0.65	165.0813619
1.60	0.54	0.57	144.7636559
1.80	0.61	0.43	109.2076702
2.00	0.67	0.32	81.27082434
2.20	0.74	0.24	60.95311826
2.40	0.81	0.18	45.71483869
2.60	0.87	0.13	33.01627239
2.80	0.94	0.098	24.88918996
3.50	1.18	0.036	9.142967739
4.00	1.34	0.018	4.571483869
4.50	1.51	0.009	2.285741935
5.00	1.68	0.004	1.015885304

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	6.865274344
0.20	0.07	0.075	34.32637172
0.30	0.10	0.16	73.22959301
0.40	0.13	0.28	128.1517878
0.50	0.17	0.43	196.8045312
0.60	0.20	0.6	274.6109738
0.70	0.24	0.77	352.4174163
0.80	0.27	0.89	407.3396111
1.00	0.34	1	457.6849563
1.10	0.37	0.98	448.5312572
1.20	0.40	0.92	421.0701598
1.30	0.44	0.84	384.4553633
1.40	0.47	0.75	343.2637172
1.50	0.50	0.65	297.4952216
1.60	0.54	0.57	260.8804251
1.80	0.61	0.43	196.8045312
2.00	0.67	0.32	146.459186
2.20	0.74	0.24	109.8443895
2.40	0.81	0.18	82.38329213
2.60	0.87	0.13	59.49904432
2.80	0.94	0.098	44.85312572
3.50	1.18	0.036	16.47665843
4.00	1.34	0.018	8.238329213
4.50	1.51	0.009	4.119164607
5.00	1.68	0.004	1.830739825

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	9.107152
0.20	0.07	0.075	45.53576
0.30	0.10	0.16	97.14296
0.40	0.13	0.28	170.0002
0.50	0.17	0.43	261.0717
0.60	0.20	0.6	364.2861
0.70	0.24	0.77	467.5005
0.80	0.27	0.89	540.3577
1.00	0.34	1	607.1435
1.10	0.37	0.98	595.0006
1.20	0.40	0.92	558.572
1.30	0.44	0.84	510.0005
1.40	0.47	0.75	455.3576
1.50	0.50	0.65	394.6433
1.60	0.54	0.57	346.0718
1.80	0.61	0.43	261.0717
2.00	0.67	0.32	194.2859
2.20	0.74	0.24	145.7144
2.40	0.81	0.18	109.2858
2.60	0.87	0.13	78.92865
2.80	0.94	0.098	59.50006
3.50	1.18	0.036	21.85717
4.00	1.34	0.018	10.92858
4.50	1.51	0.009	5.464291
5.00	1.68	0.004	2.428574

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	12.63803
0.20	0.07	0.075	63.19013
0.30	0.10	0.16	134.8056
0.40	0.13	0.28	235.9098
0.50	0.17	0.43	362.2901
0.60	0.20	0.6	505.5211
0.70	0.24	0.77	648.752
0.80	0.27	0.89	749.8563
1.00	0.34	1	842.5351
1.10	0.37	0.98	825.6844
1.20	0.40	0.92	775.1323
1.30	0.44	0.84	707.7295
1.40	0.47	0.75	631.9013
1.50	0.50	0.65	547.6478
1.60	0.54	0.57	480.245
1.80	0.61	0.43	362.2901
2.00	0.67	0.32	269.6112
2.20	0.74	0.24	202.2084
2.40	0.81	0.18	151.6563
2.60	0.87	0.13	109.5296
2.80	0.94	0.098	82.56844
3.50	1.18	0.036	30.33126
4.00	1.34	0.018	15.16563
4.50	1.51	0.009	7.582816
5.00	1.68	0.004	3.37014

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	0.083355292
0.20	0.08	0.075	0.416776461
0.30	0.12	0.16	0.889123117
0.40	0.16	0.28	1.555965455
0.50	0.20	0.43	2.389518377
0.60	0.24	0.6	3.334211689
0.70	0.28	0.77	4.278905
0.80	0.32	0.89	4.945747338
1.00	0.40	1	5.557019481
1.10	0.44	0.98	5.445879091
1.20	0.48	0.92	5.112457922
1.30	0.52	0.84	4.667896364
1.40	0.56	0.75	4.167764611
1.50	0.60	0.65	3.612062663
1.60	0.64	0.57	3.167501104
1.80	0.72	0.43	2.389518377
2.00	0.79	0.32	1.778246234
2.20	0.87	0.24	1.333684675
2.40	0.95	0.18	1.000263507
2.60	1.03	0.13	0.722412533
2.80	1.11	0.098	0.544587909
3.50	1.39	0.036	0.200052701
4.00	1.59	0.018	0.100026351
4.50	1.79	0.009	0.050013175
5.00	1.99	0.004	0.022228078

Duration, D	0.25
Tc	0.454
Tp	0.3974
A (sq miles)	0.040711286
P (1-yr)	3.3
CN	52
S	9.230769231
Q (1-yr)	0.197823559
Ia	1.846153846
Ia/P (1-yr)	0.559440559
use Ia/P min	0.1
qu from chart	690
Qp (1-yr) =	5.557019481

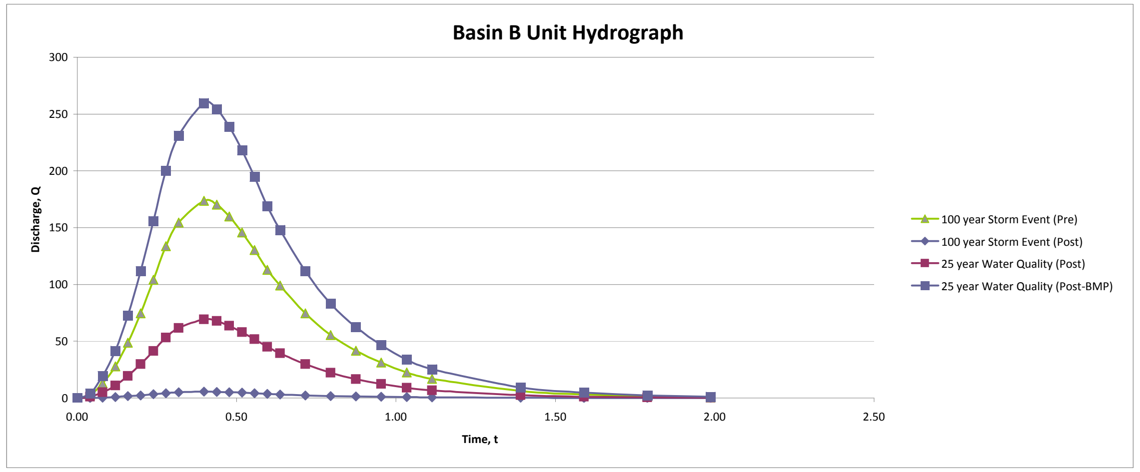
Duration, D	0.25
Tc	0.454
Tp	0.3974
A (sq miles)	0.040711
P (2-yr)	8
CN	52
S	9.230769
Q (2-yr)	2.461538
Ia	1.846154
Ia/P (2-yr)	0.230769
use Ia/P min	0.1
qu from chart	690
Qp (2-yr) =	69.14655

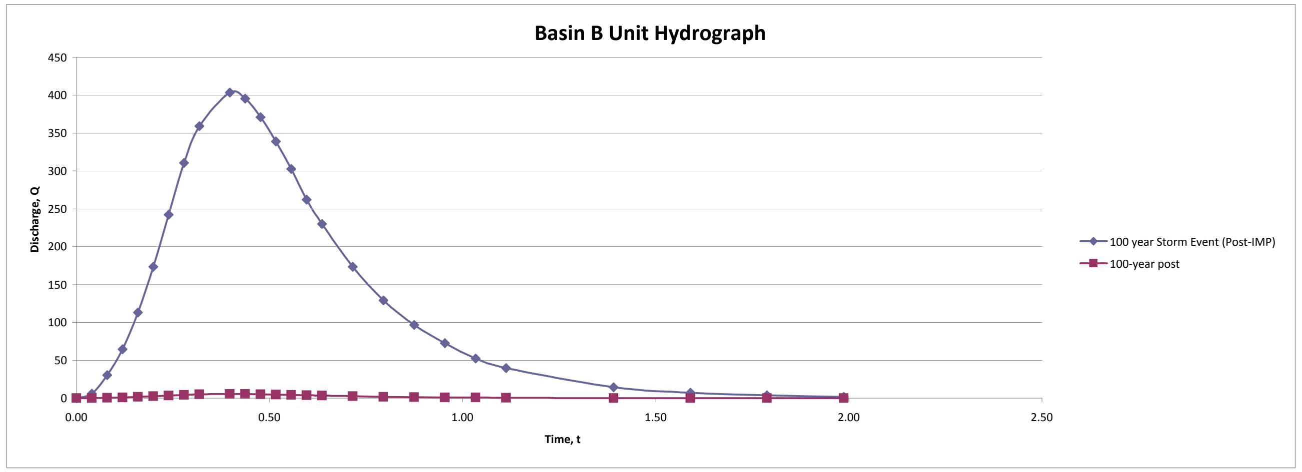
Duration, D	0.25
Tc	0.454
Tp	0.3974
A (sq miles)	0.040711
P (10-yr)	13.1
CN	52
S	9.230769
Q (10-yr)	6.182642
Ia	1.846154
Ia/P (10-yr)	0.140928
use Ia/P min	0.1
qu from chart	690
Qp (10-yr) =	173.6753

Duration, D	0.25
Tc	0.454
Tp	0.3974
A (sq miles)	0.040711
P (25-yr)	16.8
CN	52
S	9.230769
Q (25-yr)	9.246271
Ia	1.846154
Ia/P (25-yr)	0.10989
use Ia/P min	0.1
qu from chart	690
Qp (25-yr) =	259.735

Duration, D	0.25
Tc	0.454
Tp	0.3974
A (sq miles)	0.04071129
P (100-yr)	22.6
CN	52
S	9.23076923
Q (100-yr)	14.3647709
Ia	1.84615385
Ia/P (100-yr)	0.08168822
use Ia/P min	0.1
qu from chart	690
Qp (100-yr) =	403.517721

Duration, D	0.25
Tc	0.454
Tp	0.3974
A (sq miles)	0.040711286
P (500-yr)	50.7
CN	52
S	9.230769231
Q (500-yr)	41.09002475
Ia	1.846153846
Ia/P (500-yr)	0.036413291
use Ia/P min	0.1
qu from chart	690
Qp (500-yr) =	1154.251139





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	1.037198295
0.20	0.08	0.075	5.185991473
0.30	0.12	0.16	11.06344848
0.40	0.16	0.28	19.36103483
0.50	0.20	0.43	29.73301778
0.60	0.24	0.6	41.48793179
0.70	0.28	0.77	53.24284579
0.80	0.32	0.89	61.54043215
1.00	0.40	1	69.14655298
1.10	0.44	0.98	67.76362192
1.20	0.48	0.92	63.61482874
1.30	0.52	0.84	58.0831045
1.40	0.56	0.75	51.85991473
1.50	0.60	0.65	44.94525943
1.60	0.64	0.57	39.4135352
1.80	0.72	0.43	29.73301778
2.00	0.79	0.32	22.12689695
2.20	0.87	0.24	16.59517271
2.40	0.95	0.18	12.44637954
2.60	1.03	0.13	8.989051887
2.80	1.11	0.098	6.776362192
3.50	1.39	0.036	2.489275907
4.00	1.59	0.018	1.244637954
4.50	1.79	0.009	0.622318977
5.00	1.99	0.004	0.276586212

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.605129408
0.20	0.08	0.075	13.02564704
0.30	0.12	0.16	27.78804702
0.40	0.16	0.28	48.62908229
0.50	0.20	0.43	74.68037638
0.60	0.24	0.6	104.2051763
0.70	0.28	0.77	133.7299763
0.80	0.32	0.89	154.5710116
1.00	0.40	1	173.6752939
1.10	0.44	0.98	170.201788
1.20	0.48	0.92	159.7812704
1.30	0.52	0.84	145.8872469
1.40	0.56	0.75	130.2564704
1.50	0.60	0.65	112.888941
1.60	0.64	0.57	98.99491752
1.80	0.72	0.43	74.68037638
2.00	0.79	0.32	55.57609405
2.20	0.87	0.24	41.68207054
2.40	0.95	0.18	31.2615529
2.60	1.03	0.13	22.57778821
2.80	1.11	0.098	17.0201788
3.50	1.39	0.036	6.25231058
4.00	1.59	0.018	3.12615529
4.50	1.79	0.009	1.563077645
5.00	1.99	0.004	0.694701176

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	3.896026
0.20	0.08	0.075	19.48013
0.30	0.12	0.16	41.55761
0.40	0.16	0.28	72.72581
0.50	0.20	0.43	111.6861
0.60	0.24	0.6	155.841
0.70	0.28	0.77	199.996
0.80	0.32	0.89	231.1642
1.00	0.40	1	259.735
1.10	0.44	0.98	254.5403
1.20	0.48	0.92	238.9562
1.30	0.52	0.84	218.1774
1.40	0.56	0.75	194.8013
1.50	0.60	0.65	168.8278
1.60	0.64	0.57	148.049
1.80	0.72	0.43	111.6861
2.00	0.79	0.32	83.11521
2.20	0.87	0.24	62.33641
2.40	0.95	0.18	46.75231
2.60	1.03	0.13	33.76556
2.80	1.11	0.098	25.45403
3.50	1.39	0.036	9.350461
4.00	1.59	0.018	4.675231
4.50	1.79	0.009	2.337615
5.00	1.99	0.004	1.03894

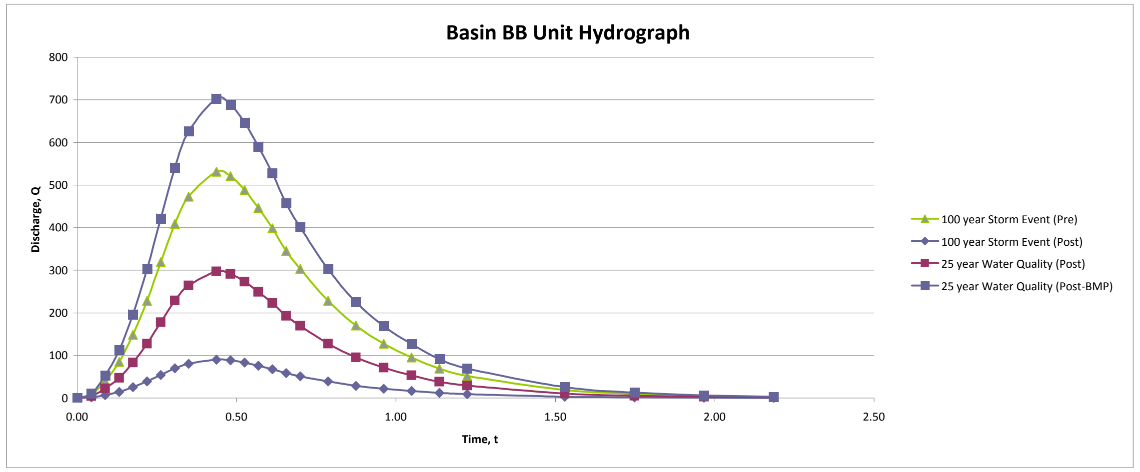
100yr (post w/IMP)

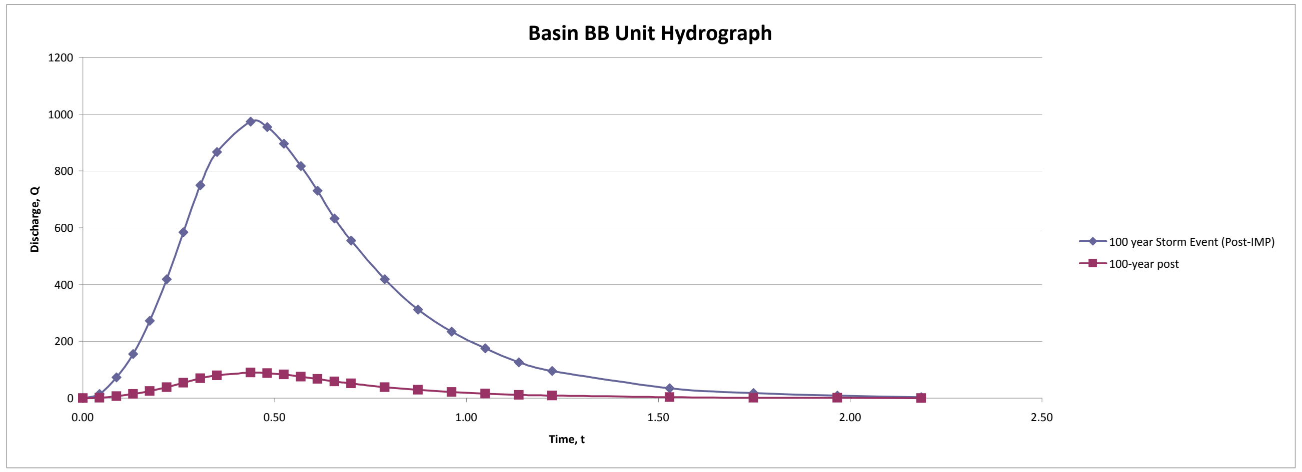
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	6.052766
0.20	0.08	0.075	30.26383
0.30	0.12	0.16	64.56284
0.40	0.16	0.28	112.985
0.50	0.20	0.43	173.5126
0.60	0.24	0.6	242.1106
0.70	0.28	0.77	310.7086
0.80	0.32	0.89	359.1308
1.00	0.40	1	403.5177
1.10	0.44	0.98	395.4474
1.20	0.48	0.92	371.2363
1.30	0.52	0.84	338.9549
1.40	0.56	0.75	302.6383
1.50	0.60	0.65	262.2865
1.60	0.64	0.57	230.0051
1.80	0.72	0.43	173.5126
2.00	0.79	0.32	129.1257
2.20	0.87	0.24	96.84425
2.40	0.95	0.18	72.63319
2.60	1.03	0.13	52.4573
2.80	1.11	0.098	39.54474
3.50	1.39	0.036	14.52664
4.00	1.59	0.018	7.263319
4.50	1.79	0.009	3.631659
5.00	1.99	0.004	1.614071

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	1.352358205
0.20	0.09	0.075	6.761791027
0.30	0.13	0.16	14.42515419
0.40	0.17	0.28	25.24401983
0.50	0.22	0.43	38.76760189
0.60	0.26	0.6	54.09432821
0.70	0.31	0.77	69.42105454
0.80	0.35	0.89	80.23992019
1.00	0.44	1	90.15721369
1.10	0.48	0.98	88.35406942
1.20	0.52	0.92	82.9446366
1.30	0.57	0.84	75.7320595
1.40	0.61	0.75	67.61791027
1.50	0.66	0.65	58.6021889
1.60	0.70	0.57	51.3896118
1.80	0.79	0.43	38.76760189
2.00	0.87	0.32	28.85030838
2.20	0.96	0.24	21.63773129
2.40	1.05	0.18	16.22829846
2.60	1.14	0.13	11.72043778
2.80	1.22	0.098	8.835406942
3.50	1.53	0.036	3.245659693
4.00	1.75	0.018	1.622829846
4.50	1.97	0.009	0.811414923
5.00	2.19	0.004	0.360628855

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.52	Tc	0.52	Tc	0.52	Tc	0.52	Tc	0.52	Tc	0.52
Tp	0.437	Tp	0.437	Tp	0.437	Tp	0.437	Tp	0.437	Tp	0.437
A (sq miles)	0.06797114	A (sq miles)	0.067971	A (sq miles)	0.067971	A (sq miles)	0.067971	A (sq miles)	0.06797114	A (sq miles)	0.06797114
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	86	CN	86	CN	86	CN	86	CN	86	CN	86
S	1.627906977	S	1.627907	S	1.627907	S	1.627907	S	1.62790698	S	1.627906977
Q (1-yr)	1.922325111	Q (2-yr)	6.331395	Q (10-yr)	11.33052	Q (25-yr)	14.99291	Q (100-yr)	20.7573829	Q (500-yr)	48.79747245
Ia	0.325581395	Ia	0.325581	Ia	0.325581	Ia	0.325581	Ia	0.3255814	Ia	0.325581395
Ia/P (1-yr)	0.098661029	Ia/P (2-yr)	0.040698	Ia/P (10-yr)	0.024854	Ia/P (25-yr)	0.01938	Ia/P (100-yr)	0.01440626	Ia/P (500-yr)	0.006421724
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	690	qu from chart	690	qu from chart	690	qu from chart	690	qu from chart	690	qu from chart	690
Qp (1-yr) =	90.15721369	Qp (2-yr) =	296.943	Qp (10-yr) =	531.4021	Qp (25-yr) =	703.1686	Qp (100-yr) =	973.52305	Qp (500-yr) =	2288.605671





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.454144827
0.20	0.09	0.075	22.27072414
0.30	0.13	0.16	47.51087816
0.40	0.17	0.28	83.14403678
0.50	0.22	0.43	127.6854851
0.60	0.26	0.6	178.1657931
0.70	0.31	0.77	228.6461011
0.80	0.35	0.89	264.2792598
1.00	0.44	1	296.9429885
1.10	0.48	0.98	291.0041287
1.20	0.52	0.92	273.1875494
1.30	0.57	0.84	249.4321103
1.40	0.61	0.75	222.7072414
1.50	0.66	0.65	193.0129425
1.60	0.70	0.57	169.2575034
1.80	0.79	0.43	127.6854851
2.00	0.87	0.32	95.02175632
2.20	0.96	0.24	71.26631724
2.40	1.05	0.18	53.44973793
2.60	1.14	0.13	38.6025885
2.80	1.22	0.098	29.10041287
3.50	1.53	0.036	10.68994759
4.00	1.75	0.018	5.344973793
4.50	1.97	0.009	2.672486896
5.00	2.19	0.004	1.187771954

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	7.971032204
0.20	0.09	0.075	39.85516102
0.30	0.13	0.16	85.0243435
0.40	0.17	0.28	148.7926011
0.50	0.22	0.43	228.5029232
0.60	0.26	0.6	318.8412881
0.70	0.31	0.77	409.1796531
0.80	0.35	0.89	472.9479107
1.00	0.44	1	531.4021469
1.10	0.48	0.98	520.774104
1.20	0.52	0.92	488.8899751
1.30	0.57	0.84	446.3778034
1.40	0.61	0.75	398.5516102
1.50	0.66	0.65	345.4113955
1.60	0.70	0.57	302.8992237
1.80	0.79	0.43	228.5029232
2.00	0.87	0.32	170.048687
2.20	0.96	0.24	127.5365153
2.40	1.05	0.18	95.65238644
2.60	1.14	0.13	69.0822791
2.80	1.22	0.098	52.0774104
3.50	1.53	0.036	19.13047729
4.00	1.75	0.018	9.565238644
4.50	1.97	0.009	4.782619322
5.00	2.19	0.004	2.125608588

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	10.54753
0.20	0.09	0.075	52.73764
0.30	0.13	0.16	112.507
0.40	0.17	0.28	196.8872
0.50	0.22	0.43	302.3625
0.60	0.26	0.6	421.9012
0.70	0.31	0.77	541.4398
0.80	0.35	0.89	625.82
1.00	0.44	1	703.1686
1.10	0.48	0.98	689.1052
1.20	0.52	0.92	646.9151
1.30	0.57	0.84	590.6616
1.40	0.61	0.75	527.3764
1.50	0.66	0.65	457.0596
1.60	0.70	0.57	400.8061
1.80	0.79	0.43	302.3625
2.00	0.87	0.32	225.0139
2.20	0.96	0.24	168.7605
2.40	1.05	0.18	126.5703
2.60	1.14	0.13	91.41192
2.80	1.22	0.098	68.91052
3.50	1.53	0.036	25.31407
4.00	1.75	0.018	12.65703
4.50	1.97	0.009	6.328517
5.00	2.19	0.004	2.812674

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	14.60285
0.20	0.09	0.075	73.01423
0.30	0.13	0.16	155.7637
0.40	0.17	0.28	272.5865
0.50	0.22	0.43	418.6149
0.60	0.26	0.6	584.1138
0.70	0.31	0.77	749.6127
0.80	0.35	0.89	866.4355
1.00	0.44	1	973.523
1.10	0.48	0.98	954.0526
1.20	0.52	0.92	895.6412
1.30	0.57	0.84	817.7594
1.40	0.61	0.75	730.1423
1.50	0.66	0.65	632.79
1.60	0.70	0.57	554.9081
1.80	0.79	0.43	418.6149
2.00	0.87	0.32	311.5274
2.20	0.96	0.24	233.6455
2.40	1.05	0.18	175.2341
2.60	1.14	0.13	126.558
2.80	1.22	0.098	95.40526
3.50	1.53	0.036	35.04683
4.00	1.75	0.018	17.52341
4.50	1.97	0.009	8.761707
5.00	2.19	0.004	3.894092

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	0.211734963
0.20	0.08	0.075	1.058674815
0.30	0.12	0.16	2.258506272
0.40	0.16	0.28	3.952385977
0.50	0.20	0.43	6.069735607
0.60	0.23	0.6	8.469398522
0.70	0.27	0.77	10.86906144
0.80	0.31	0.89	12.56294114
1.00	0.39	1	14.1156642
1.10	0.43	0.98	13.83335092
1.20	0.47	0.92	12.98641107
1.30	0.51	0.84	11.85715793
1.40	0.55	0.75	10.58674815
1.50	0.59	0.65	9.175181732
1.60	0.63	0.57	8.045928596
1.80	0.70	0.43	6.069735607
2.00	0.78	0.32	4.517012545
2.20	0.86	0.24	3.387759409
2.40	0.94	0.18	2.540819556
2.60	1.02	0.13	1.835036346
2.80	1.10	0.098	1.383335092
3.50	1.37	0.036	0.508163911
4.00	1.57	0.018	0.254081956
4.50	1.76	0.009	0.127040978
5.00	1.96	0.004	0.056462657

Duration, D	0.25
Tc	0.444
Tp	0.3914
A (sq miles)	0.059520813
P (1-yr)	3.3
CN	57
S	7.543859649
Q (1-yr)	0.343703037
Ia	1.50877193
Ia/P (1-yr)	0.457203615
use Ia/P min	0.1
qu from chart	690
Qp (1-yr) =	14.1156642

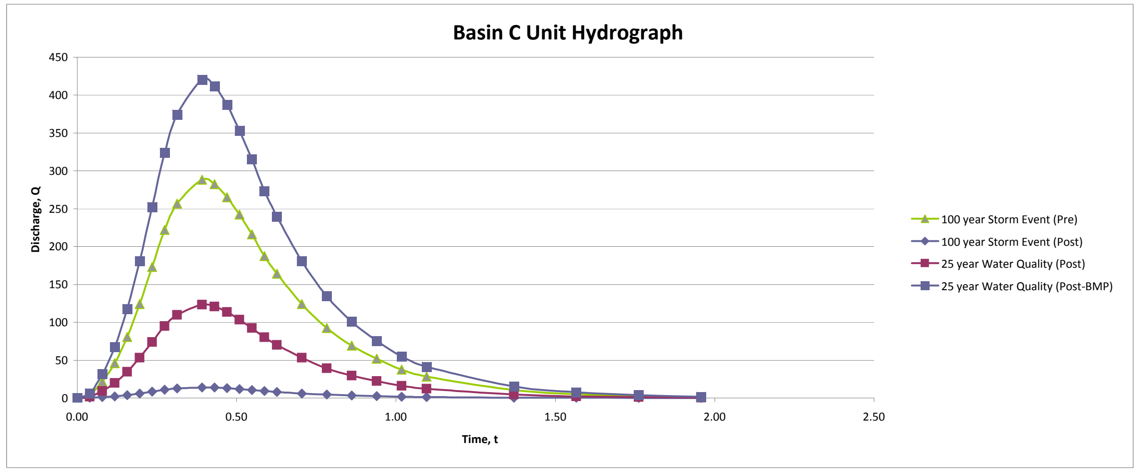
Duration, D	0.25
Tc	0.444
Tp	0.3914
A (sq miles)	0.059521
P (2-yr)	8
CN	57
S	7.54386
Q (2-yr)	3.002193
Ia	1.508772
Ia/P (2-yr)	0.188596
use Ia/P min	0.1
qu from chart	690
Qp (2-yr) =	123.2981

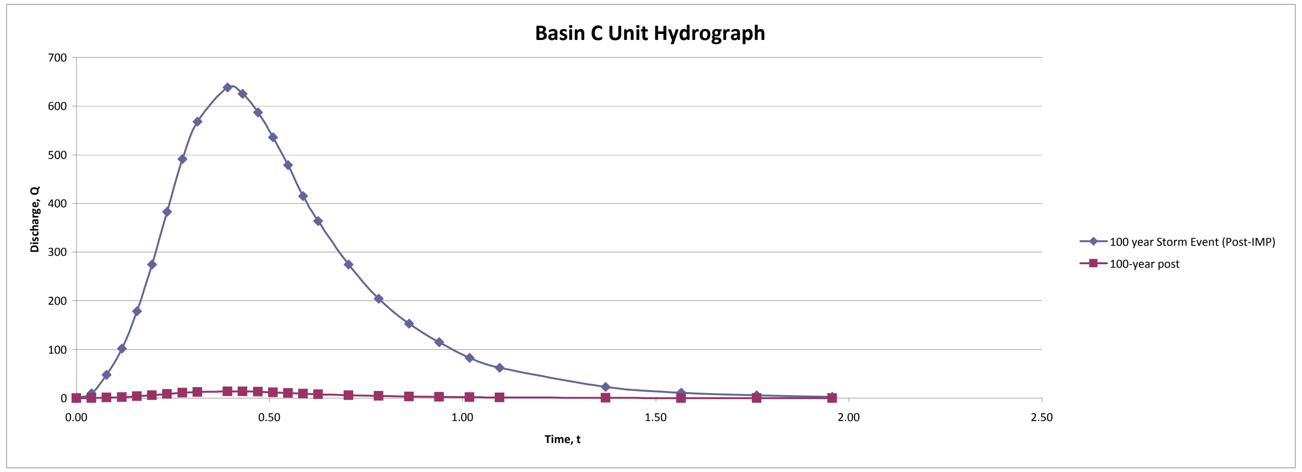
Duration, D	0.25
Tc	0.444
Tp	0.3914
A (sq miles)	0.059521
P (10-yr)	13.1
CN	57
S	7.54386
Q (10-yr)	7.021476
Ia	1.508772
Ia/P (10-yr)	0.115173
use Ia/P min	0.1
qu from chart	690
Qp (10-yr) =	288.3676

Duration, D	0.25
Tc	0.444
Tp	0.3914
A (sq miles)	0.059521
P (25-yr)	16.8
CN	57
S	7.54386
Q (25-yr)	10.23958
Ia	1.508772
Ia/P (25-yr)	0.089808
use Ia/P min	0.1
qu from chart	690
Qp (25-yr) =	420.5329

Duration, D	0.25
Tc	0.444
Tp	0.3914
A (sq miles)	0.05952081
P (100-yr)	22.6
CN	57
S	7.54385965
Q (100-yr)	15.534784
Ia	1.50877193
Ia/P (100-yr)	0.06675982
use Ia/P min	0.1
qu from chart	690
Qp (100-yr) =	638.003655

Duration, D	0.25
Tc	0.444
Tp	0.3914
A (sq miles)	0.059520813
P (500-yr)	50.7
CN	57
S	7.543859649
Q (500-yr)	42.65044819
Ia	1.50877193
Ia/P (500-yr)	0.029758815
use Ia/P min	0.1
qu from chart	690
Qp (500-yr) =	1751.626666





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	1.849472224
0.20	0.08	0.075	9.24736112
0.30	0.12	0.16	19.72770372
0.40	0.16	0.28	34.52348152
0.50	0.20	0.43	53.01820376
0.60	0.23	0.6	73.97888896
0.70	0.27	0.77	94.93957417
0.80	0.31	0.89	109.735352
1.00	0.39	1	123.2981483
1.10	0.43	0.98	120.8321853
1.20	0.47	0.92	113.4342964
1.30	0.51	0.84	103.5704445
1.40	0.55	0.75	92.4736112
1.50	0.59	0.65	80.14379638
1.60	0.63	0.57	70.27994451
1.80	0.70	0.43	53.01820376
2.00	0.78	0.32	39.45540745
2.20	0.86	0.24	29.59155559
2.40	0.94	0.18	22.19366669
2.60	1.02	0.13	16.02875928
2.80	1.10	0.098	12.08321853
3.50	1.37	0.036	4.438733338
4.00	1.57	0.018	2.219366669
4.50	1.76	0.009	1.109683334
5.00	1.96	0.004	0.493192593

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.32551331
0.20	0.08	0.075	21.62756655
0.30	0.12	0.16	46.13880864
0.40	0.16	0.28	80.74291511
0.50	0.20	0.43	123.9980482
0.60	0.23	0.6	173.0205324
0.70	0.27	0.77	222.0430166
0.80	0.31	0.89	256.647123
1.00	0.39	1	288.367554
1.10	0.43	0.98	282.6002029
1.20	0.47	0.92	265.2981497
1.30	0.51	0.84	242.2287453
1.40	0.55	0.75	216.2756655
1.50	0.59	0.65	187.4389101
1.60	0.63	0.57	164.3695058
1.80	0.70	0.43	123.9980482
2.00	0.78	0.32	92.27761727
2.20	0.86	0.24	69.20821295
2.40	0.94	0.18	51.90615971
2.60	1.02	0.13	37.48778202
2.80	1.10	0.098	28.26002029
3.50	1.37	0.036	10.38123194
4.00	1.57	0.018	5.190615971
4.50	1.76	0.009	2.595307986
5.00	1.96	0.004	1.153470216

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	6.307994
0.20	0.08	0.075	31.53997
0.30	0.12	0.16	67.28527
0.40	0.16	0.28	117.7492
0.50	0.20	0.43	180.8292
0.60	0.23	0.6	252.3198
0.70	0.27	0.77	323.8103
0.80	0.31	0.89	374.2743
1.00	0.39	1	420.5329
1.10	0.43	0.98	412.1223
1.20	0.47	0.92	386.8903
1.30	0.51	0.84	353.2477
1.40	0.55	0.75	315.3997
1.50	0.59	0.65	273.3464
1.60	0.63	0.57	239.7038
1.80	0.70	0.43	180.8292
2.00	0.78	0.32	134.5705
2.20	0.86	0.24	100.9279
2.40	0.94	0.18	75.69593
2.60	1.02	0.13	54.66928
2.80	1.10	0.098	41.21223
3.50	1.37	0.036	15.13919
4.00	1.57	0.018	7.569593
4.50	1.76	0.009	3.784796
5.00	1.96	0.004	1.682132

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	9.570055
0.20	0.08	0.075	47.85027
0.30	0.12	0.16	102.0806
0.40	0.16	0.28	178.641
0.50	0.20	0.43	274.3416
0.60	0.23	0.6	382.8022
0.70	0.27	0.77	491.2628
0.80	0.31	0.89	567.8233
1.00	0.39	1	638.0037
1.10	0.43	0.98	625.2436
1.20	0.47	0.92	586.9634
1.30	0.51	0.84	535.9231
1.40	0.55	0.75	478.5027
1.50	0.59	0.65	414.7024
1.60	0.63	0.57	363.6621
1.80	0.70	0.43	274.3416
2.00	0.78	0.32	204.1612
2.20	0.86	0.24	153.1209
2.40	0.94	0.18	114.8407
2.60	1.02	0.13	82.94048
2.80	1.10	0.098	62.52436
3.50	1.37	0.036	22.96813
4.00	1.57	0.018	11.48407
4.50	1.76	0.009	5.742033
5.00	1.96	0.004	2.552015

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	0.3045158
0.20	0.07	0.075	1.522579002
0.30	0.11	0.16	3.248168538
0.40	0.15	0.28	5.684294942
0.50	0.19	0.43	8.729452947
0.60	0.22	0.6	12.18063202
0.70	0.26	0.77	15.63181109
0.80	0.30	0.89	18.06793749
1.00	0.37	1	20.30105336
1.10	0.41	0.98	19.8950323
1.20	0.45	0.92	18.6769691
1.30	0.48	0.84	17.05288483
1.40	0.52	0.75	15.22579002
1.50	0.56	0.65	13.19568469
1.60	0.60	0.57	11.57160042
1.80	0.67	0.43	8.729452947
2.00	0.74	0.32	6.496337077
2.20	0.82	0.24	4.872252807
2.40	0.89	0.18	3.654189606
2.60	0.97	0.13	2.639136937
2.80	1.04	0.098	1.98950323
3.50	1.30	0.036	0.730837921
4.00	1.49	0.018	0.365418961
4.50	1.67	0.009	0.18270948
5.00	1.86	0.004	0.081204213

Duration, D	0.25
Tc	0.412
Tp	0.3722
A (sq miles)	0.0274
P (1-yr)	3.3
CN	78
S	2.820512821
Q (1-yr)	1.347117012
Ia	0.564102564
Ia/P (1-yr)	0.170940171
use Ia/P min	0.1
qu from chart	550
Qp (1-yr) =	20.30105336

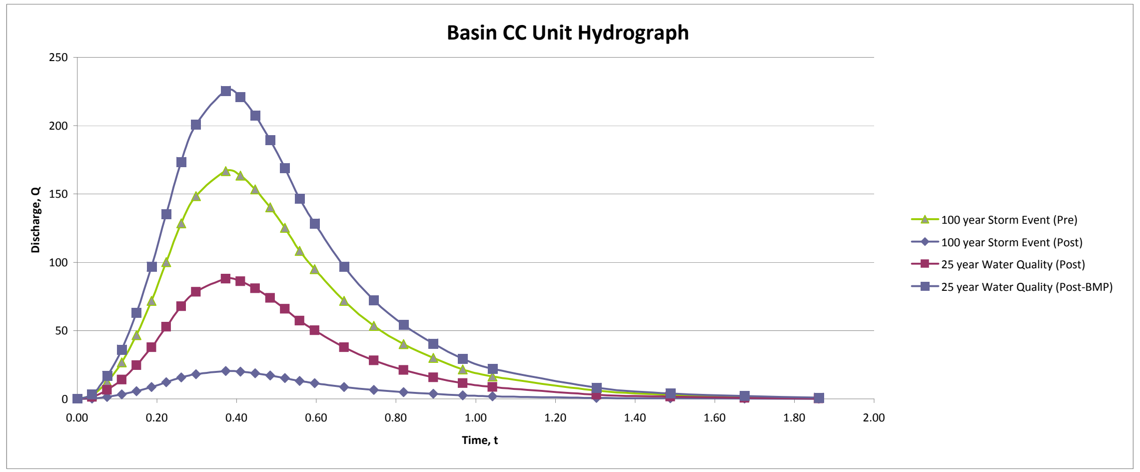
Duration, D	0.25
Tc	0.412
Tp	0.3722
A (sq miles)	0.0274
P (2-yr)	8
CN	78
S	2.820513
Q (2-yr)	5.391026
Ia	0.564103
Ia/P (2-yr)	0.070513
use Ia/P min	0.1
qu from chart	595
Qp (2-yr) =	87.88989

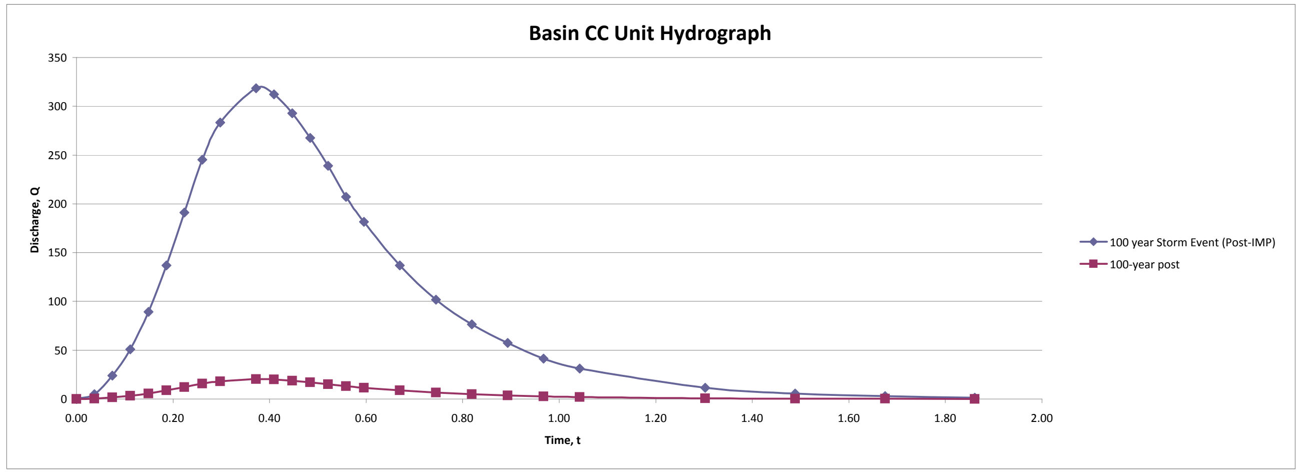
Duration, D	0.25
Tc	0.412
Tp	0.3722
A (sq miles)	0.0274
P (10-yr)	13.1
CN	78
S	2.820513
Q (10-yr)	10.23343
Ia	0.564103
Ia/P (10-yr)	0.043061
use Ia/P min	0.1
qu from chart	595
Qp (10-yr) =	166.8356

Duration, D	0.25
Tc	0.412
Tp	0.3722
A (sq miles)	0.0274
P (25-yr)	16.8
CN	78
S	2.820513
Q (25-yr)	13.83284
Ia	0.564103
Ia/P (25-yr)	0.033578
use Ia/P min	0.1
qu from chart	595
Qp (25-yr) =	225.5169

Duration, D	0.25
Tc	0.412
Tp	0.3722
A (sq miles)	0.0274
P (100-yr)	22.6
CN	78
S	2.82051282
Q (100-yr)	19.5354346
Ia	0.56410256
Ia/P (100-yr)	0.02496029
use Ia/P min	0.1
qu from chart	595
Qp (100-yr) =	318.48619

Duration, D	0.25
Tc	0.412
Tp	0.3722
A (sq miles)	0.0274
P (500-yr)	50.7
CN	78
S	2.820512821
Q (500-yr)	47.46560803
Ia	0.564102564
Ia/P (500-yr)	0.011126283
use Ia/P min	0.1
qu from chart	595
Qp (500-yr) =	773.8318077





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	1.318348365
0.20	0.07	0.075	6.591741827
0.30	0.11	0.16	14.06238256
0.40	0.15	0.28	24.60916949
0.50	0.19	0.43	37.79265314
0.60	0.22	0.6	52.73393462
0.70	0.26	0.77	67.67521609
0.80	0.30	0.89	78.22200301
1.00	0.37	1	87.88989103
1.10	0.41	0.98	86.13209321
1.20	0.45	0.92	80.85869974
1.30	0.48	0.84	73.82750846
1.40	0.52	0.75	65.91741827
1.50	0.56	0.65	57.12842917
1.60	0.60	0.57	50.09723788
1.80	0.67	0.43	37.79265314
2.00	0.74	0.32	28.12476513
2.20	0.82	0.24	21.09357385
2.40	0.89	0.18	15.82018038
2.60	0.97	0.13	11.42568583
2.80	1.04	0.098	8.613209321
3.50	1.30	0.036	3.164036077
4.00	1.49	0.018	1.582018038
4.50	1.67	0.009	0.791009019
5.00	1.86	0.004	0.351559564

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.502533743
0.20	0.07	0.075	12.51266872
0.30	0.11	0.16	26.69369326
0.40	0.15	0.28	46.7139632
0.50	0.19	0.43	71.73930063
0.60	0.22	0.6	100.1013497
0.70	0.26	0.77	128.4633988
0.80	0.30	0.89	148.4836688
1.00	0.37	1	166.8355829
1.10	0.41	0.98	163.4988712
1.20	0.45	0.92	153.4887362
1.30	0.48	0.84	140.1418896
1.40	0.52	0.75	125.1266872
1.50	0.56	0.65	108.4431289
1.60	0.60	0.57	95.09628224
1.80	0.67	0.43	71.73930063
2.00	0.74	0.32	53.38738652
2.20	0.82	0.24	40.04053989
2.40	0.89	0.18	30.03040492
2.60	0.97	0.13	21.68862577
2.80	1.04	0.098	16.34988712
3.50	1.30	0.036	6.006080983
4.00	1.49	0.018	3.003040492
4.50	1.67	0.009	1.501520246
5.00	1.86	0.004	0.667342331

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	3.382753
0.20	0.07	0.075	16.91377
0.30	0.11	0.16	36.0827
0.40	0.15	0.28	63.14472
0.50	0.19	0.43	96.97225
0.60	0.22	0.6	135.3101
0.70	0.26	0.77	173.648
0.80	0.30	0.89	200.71
1.00	0.37	1	225.5169
1.10	0.41	0.98	221.0065
1.20	0.45	0.92	207.4755
1.30	0.48	0.84	189.4342
1.40	0.52	0.75	169.1377
1.50	0.56	0.65	146.586
1.60	0.60	0.57	128.5446
1.80	0.67	0.43	96.97225
2.00	0.74	0.32	72.1654
2.20	0.82	0.24	54.12405
2.40	0.89	0.18	40.59304
2.60	0.97	0.13	29.31719
2.80	1.04	0.098	22.10065
3.50	1.30	0.036	8.118607
4.00	1.49	0.018	4.059304
4.50	1.67	0.009	2.029652
5.00	1.86	0.004	0.902067

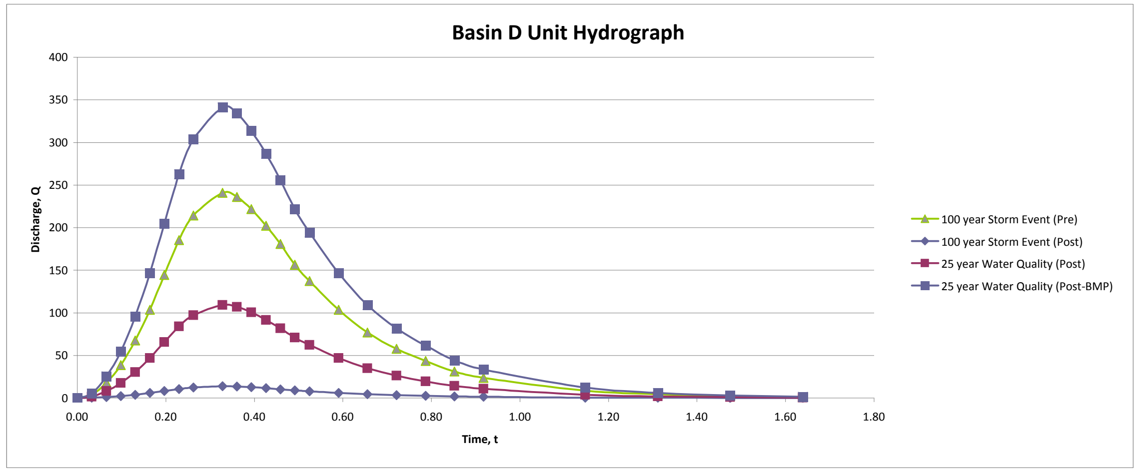
100yr (post w/IMP)

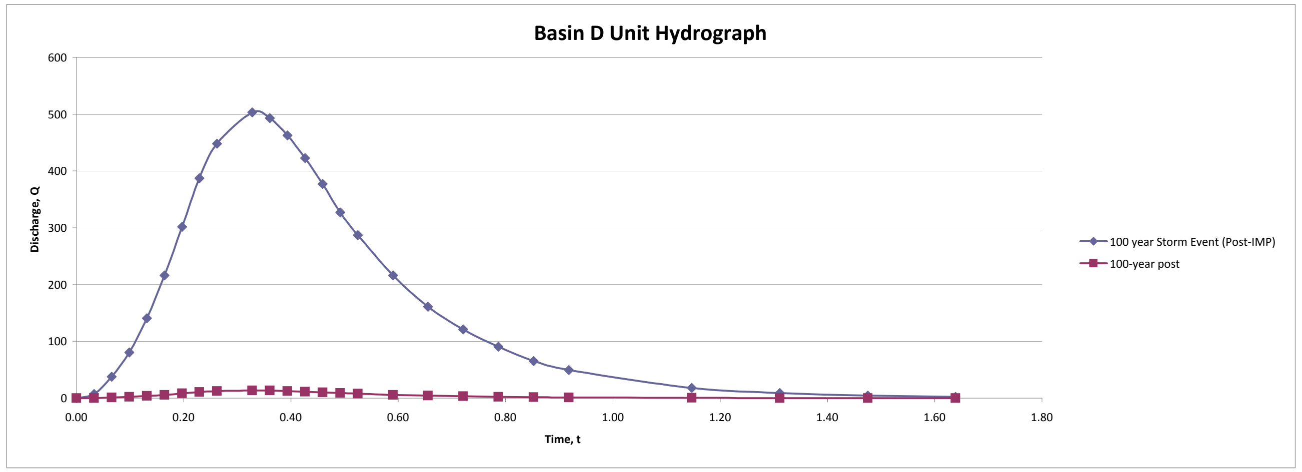
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.777293
0.20	0.07	0.075	23.88646
0.30	0.11	0.16	50.95779
0.40	0.15	0.28	89.17613
0.50	0.19	0.43	136.9491
0.60	0.22	0.6	191.0917
0.70	0.26	0.77	245.2344
0.80	0.30	0.89	283.4527
1.00	0.37	1	318.4862
1.10	0.41	0.98	312.1165
1.20	0.45	0.92	293.0073
1.30	0.48	0.84	267.5284
1.40	0.52	0.75	238.8646
1.50	0.56	0.65	207.016
1.60	0.60	0.57	181.5371
1.80	0.67	0.43	136.9491
2.00	0.74	0.32	101.9156
2.20	0.82	0.24	76.43669
2.40	0.89	0.18	57.32751
2.60	0.97	0.13	41.4032
2.80	1.04	0.098	31.21165
3.50	1.30	0.036	11.4655
4.00	1.49	0.018	5.732751
4.50	1.67	0.009	2.866376
5.00	1.86	0.004	1.273945

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.20594594
0.20	0.07	0.075	1.0297297
0.30	0.10	0.16	2.196756692
0.40	0.13	0.28	3.844324212
0.50	0.16	0.43	5.903783611
0.60	0.20	0.6	8.237837596
0.70	0.23	0.77	10.57189158
0.80	0.26	0.89	12.2194591
1.00	0.33	1	13.72972933
1.10	0.36	0.98	13.45513474
1.20	0.39	0.92	12.63135098
1.30	0.43	0.84	11.53297263
1.40	0.46	0.75	10.297297
1.50	0.49	0.65	8.924324063
1.60	0.52	0.57	7.825945716
1.80	0.59	0.43	5.903783611
2.00	0.66	0.32	4.393513385
2.20	0.72	0.24	3.295135038
2.40	0.79	0.18	2.471351279
2.60	0.85	0.13	1.784864813
2.80	0.92	0.098	1.345513474
3.50	1.15	0.036	0.494270256
4.00	1.31	0.018	0.247135128
4.50	1.48	0.009	0.123567564
5.00	1.64	0.004	0.054918917

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.338	Tc	0.338	Tc	0.338	Tc	0.338	Tc	0.338	Tc	0.338
Tp	0.3278	Tp	0.3278	Tp	0.3278	Tp	0.3278	Tp	0.3278	Tp	0.3278
A (sq miles)	0.0462	A (sq miles)	0.0462	A (sq miles)	0.0462	A (sq miles)	0.0462	A (sq miles)	0.0462	A (sq miles)	0.0462
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	64	CN	64	CN	64	CN	64	CN	64	CN	64
S	5.625	S	5.625	S	5.625	S	5.625	S	5.625	S	5.625
Q (1-yr)	0.606490385	Q (2-yr)	3.78125	Q (10-yr)	8.147763	Q (25-yr)	11.53548	Q (100-yr)	17.0175507	Q (500-yr)	44.52319973
Ia	1.125	Ia	1.125	Ia	1.125	Ia	1.125	Ia	1.125	Ia	1.125
Ia/P (1-yr)	0.340909091	Ia/P (2-yr)	0.140625	Ia/P (10-yr)	0.085878	Ia/P (25-yr)	0.066964	Ia/P (100-yr)	0.04977876	Ia/P (500-yr)	0.022189349
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	490	qu from chart	625	qu from chart	640	qu from chart	640	qu from chart	640	qu from chart	640
Qp (1-yr) =	13.72972933	Qp (2-yr) =	109.1836	Qp (10-yr) =	240.9131	Qp (25-yr) =	341.0809	Qp (100-yr) =	503.17494	Qp (500-yr) =	1316.46197





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.637753906
0.20	0.07	0.075	8.188769531
0.30	0.10	0.16	17.469375
0.40	0.13	0.28	30.57140625
0.50	0.16	0.43	46.94894531
0.60	0.20	0.6	65.51015625
0.70	0.23	0.77	84.07136719
0.80	0.26	0.89	97.17339844
1.00	0.33	1	109.1835938
1.10	0.36	0.98	106.9999219
1.20	0.39	0.92	100.4489063
1.30	0.43	0.84	91.71421875
1.40	0.46	0.75	81.88769531
1.50	0.49	0.65	70.96933594
1.60	0.52	0.57	62.23464844
1.80	0.59	0.43	46.94894531
2.00	0.66	0.32	34.93875
2.20	0.72	0.24	26.2040625
2.40	0.79	0.18	19.65304688
2.60	0.85	0.13	14.19386719
2.80	0.92	0.098	10.69999219
3.50	1.15	0.036	3.930609375
4.00	1.31	0.018	1.965304688
4.50	1.48	0.009	0.982652344
5.00	1.64	0.004	0.436734375

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	3.61369575
0.20	0.07	0.075	18.06847875
0.30	0.10	0.16	38.546088
0.40	0.13	0.28	67.455654
0.50	0.16	0.43	103.5926115
0.60	0.20	0.6	144.54783
0.70	0.23	0.77	185.5030485
0.80	0.26	0.89	214.4126145
1.00	0.33	1	240.91305
1.10	0.36	0.98	236.094789
1.20	0.39	0.92	221.640006
1.30	0.43	0.84	202.366962
1.40	0.46	0.75	180.6847875
1.50	0.49	0.65	156.5934825
1.60	0.52	0.57	137.3204385
1.80	0.59	0.43	103.5926115
2.00	0.66	0.32	77.092176
2.20	0.72	0.24	57.819132
2.40	0.79	0.18	43.364349
2.60	0.85	0.13	31.3186965
2.80	0.92	0.098	23.6094789
3.50	1.15	0.036	8.6728698
4.00	1.31	0.018	4.3364349
4.50	1.48	0.009	2.16821745
5.00	1.64	0.004	0.9636522

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	5.116214
0.20	0.07	0.075	25.58107
0.30	0.10	0.16	54.57295
0.40	0.13	0.28	95.50266
0.50	0.16	0.43	146.6648
0.60	0.20	0.6	204.6486
0.70	0.23	0.77	262.6323
0.80	0.26	0.89	303.562
1.00	0.33	1	341.0809
1.10	0.36	0.98	334.2593
1.20	0.39	0.92	313.7945
1.30	0.43	0.84	286.508
1.40	0.46	0.75	255.8107
1.50	0.49	0.65	221.7026
1.60	0.52	0.57	194.4161
1.80	0.59	0.43	146.6648
2.00	0.66	0.32	109.1459
2.20	0.72	0.24	81.85942
2.40	0.79	0.18	61.39457
2.60	0.85	0.13	44.34052
2.80	0.92	0.098	33.42593
3.50	1.15	0.036	12.27891
4.00	1.31	0.018	6.139457
4.50	1.48	0.009	3.069728
5.00	1.64	0.004	1.364324

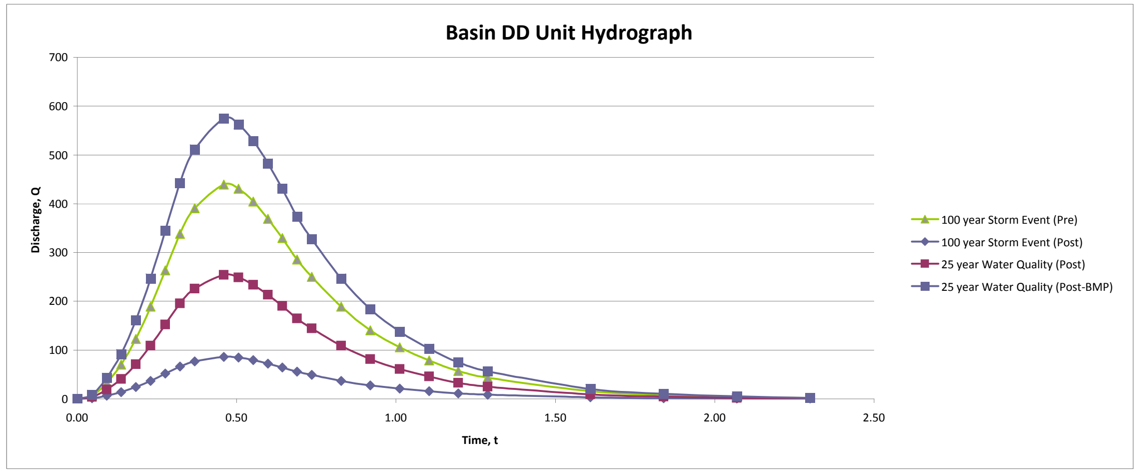
100yr (post w/IMP)

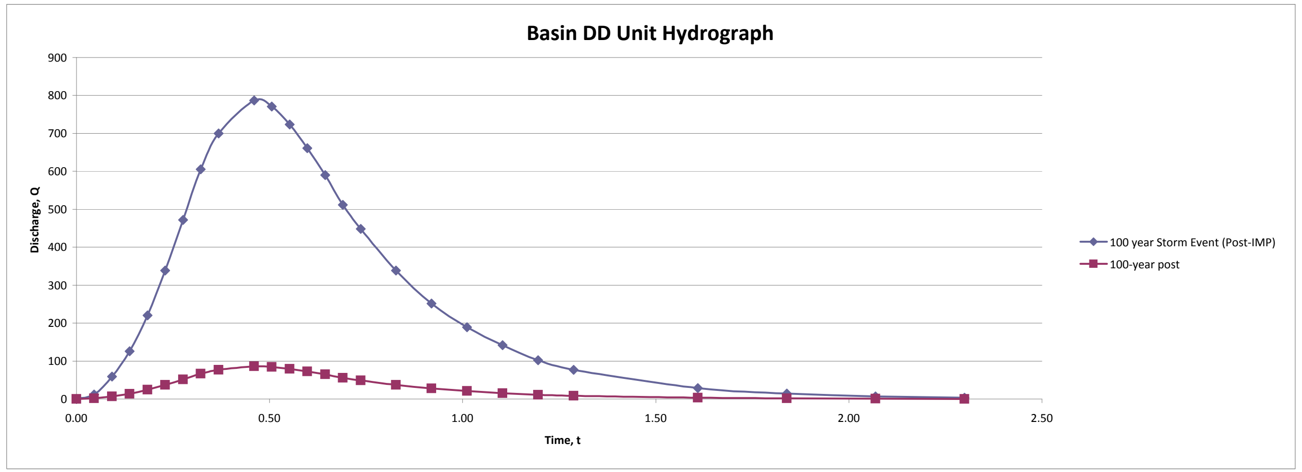
Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	7.547624
0.20	0.07	0.075	37.73812
0.30	0.10	0.16	80.50799
0.40	0.13	0.28	140.889
0.50	0.16	0.43	216.3652
0.60	0.20	0.6	301.905
0.70	0.23	0.77	387.4447
0.80	0.26	0.89	447.8257
1.00	0.33	1	503.1749
1.10	0.36	0.98	493.1114
1.20	0.39	0.92	462.9209
1.30	0.43	0.84	422.6669
1.40	0.46	0.75	377.3812
1.50	0.49	0.65	327.0637
1.60	0.52	0.57	286.8097
1.80	0.59	0.43	216.3652
2.00	0.66	0.32	161.016
2.20	0.72	0.24	120.762
2.40	0.79	0.18	90.57149
2.60	0.85	0.13	65.41274
2.80	0.92	0.098	49.31114
3.50	1.15	0.036	18.1143
4.00	1.31	0.018	9.057149
4.50	1.48	0.009	4.528574
5.00	1.64	0.004	2.0127

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	1.293619596
0.20	0.09	0.075	6.468097979
0.30	0.14	0.16	13.79860902
0.40	0.18	0.28	24.14756579
0.50	0.23	0.43	37.08376174
0.60	0.28	0.6	51.74478383
0.70	0.32	0.77	66.40580591
0.80	0.37	0.89	76.75476268
1.00	0.46	1	86.24130638
1.10	0.51	0.98	84.51648025
1.20	0.55	0.92	79.34200187
1.30	0.60	0.84	72.44269736
1.40	0.64	0.75	64.68097979
1.50	0.69	0.65	56.05684915
1.60	0.74	0.57	49.15754464
1.80	0.83	0.43	37.08376174
2.00	0.92	0.32	27.59721804
2.20	1.01	0.24	20.69791353
2.40	1.10	0.18	15.52343515
2.60	1.20	0.13	11.21136983
2.80	1.29	0.098	8.451648025
3.50	1.61	0.036	3.10468703
4.00	1.84	0.018	1.552343515
4.50	2.07	0.009	0.776171757
5.00	2.30	0.004	0.344965226

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.558	Tc	0.558	Tc	0.558	Tc	0.558	Tc	0.558	Tc	0.558
Tp	0.4598	Tp	0.4598	Tp	0.4598	Tp	0.4598	Tp	0.4598	Tp	0.4598
A (sq miles)	0.0726	A (sq miles)	0.0726	A (sq miles)	0.0726	A (sq miles)	0.0726	A (sq miles)	0.0726	A (sq miles)	0.0726
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	91	CN	91	CN	91	CN	91	CN	91	CN	91
S	0.989010989	S	0.989011	S	0.989011	S	0.989011	S	0.98901099	S	0.989010989
Q (1-yr)	2.352270856	Q (2-yr)	6.924451	Q (10-yr)	11.9836	Q (25-yr)	15.66879	Q (100-yr)	21.4550035	Q (500-yr)	49.53218312
Ia	0.197802198	Ia	0.197802	Ia	0.197802	Ia	0.197802	Ia	0.1978022	Ia	0.197802198
Ia/P (1-yr)	0.05994006	Ia/P (2-yr)	0.024725	Ia/P (10-yr)	0.015099	Ia/P (25-yr)	0.011774	Ia/P (100-yr)	0.00875231	Ia/P (500-yr)	0.003901424
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	505	qu from chart	505	qu from chart	505	qu from chart	505	qu from chart	505	qu from chart	505
Qp (1-yr) =	86.24130638	Qp (2-yr) =	253.8711	Qp (10-yr) =	439.3548	Qp (25-yr) =	574.4649	Qp (100-yr) =	786.604793	Qp (500-yr) =	1815.99843





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	3.808066957
0.20	0.09	0.075	19.04033479
0.30	0.14	0.16	40.61938088
0.40	0.18	0.28	71.08391654
0.50	0.23	0.43	109.1645861
0.60	0.28	0.6	152.3226783
0.70	0.32	0.77	195.4807705
0.80	0.37	0.89	225.9453061
1.00	0.46	1	253.8711305
1.10	0.51	0.98	248.7937079
1.20	0.55	0.92	233.5614401
1.30	0.60	0.84	213.2517496
1.40	0.64	0.75	190.4033479
1.50	0.69	0.65	165.0162348
1.60	0.74	0.57	144.7065444
1.80	0.83	0.43	109.1645861
2.00	0.92	0.32	81.23876176
2.20	1.01	0.24	60.92907132
2.40	1.10	0.18	45.69680349
2.60	1.20	0.13	33.00324696
2.80	1.29	0.098	24.87937079
3.50	1.61	0.036	9.139360698
4.00	1.84	0.018	4.569680349
4.50	2.07	0.009	2.284840174
5.00	2.30	0.004	1.015484522

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	6.590321633
0.20	0.09	0.075	32.95160816
0.30	0.14	0.16	70.29676408
0.40	0.18	0.28	123.0193371
0.50	0.23	0.43	188.9225535
0.60	0.28	0.6	263.6128653
0.70	0.32	0.77	338.3031771
0.80	0.37	0.89	391.0257502
1.00	0.46	1	439.3547755
1.10	0.51	0.98	430.56768
1.20	0.55	0.92	404.2063935
1.30	0.60	0.84	369.0580114
1.40	0.64	0.75	329.5160816
1.50	0.69	0.65	285.5806041
1.60	0.74	0.57	250.432222
1.80	0.83	0.43	188.9225535
2.00	0.92	0.32	140.5935282
2.20	1.01	0.24	105.4451461
2.40	1.10	0.18	79.08385959
2.60	1.20	0.13	57.11612082
2.80	1.29	0.098	43.056768
3.50	1.61	0.036	15.81677192
4.00	1.84	0.018	7.908385959
4.50	2.07	0.009	3.95419298
5.00	2.30	0.004	1.757419102

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	8.616973
0.20	0.09	0.075	43.08487
0.30	0.14	0.16	91.91438
0.40	0.18	0.28	160.8502
0.50	0.23	0.43	247.0199
0.60	0.28	0.6	344.6789
0.70	0.32	0.77	442.338
0.80	0.37	0.89	511.2737
1.00	0.46	1	574.4649
1.10	0.51	0.98	562.9756
1.20	0.55	0.92	528.5077
1.30	0.60	0.84	482.5505
1.40	0.64	0.75	430.8487
1.50	0.69	0.65	373.4022
1.60	0.74	0.57	327.445
1.80	0.83	0.43	247.0199
2.00	0.92	0.32	183.8288
2.20	1.01	0.24	137.8716
2.40	1.10	0.18	103.4037
2.60	1.20	0.13	74.68043
2.80	1.29	0.098	56.29756
3.50	1.61	0.036	20.68074
4.00	1.84	0.018	10.34037
4.50	2.07	0.009	5.170184
5.00	2.30	0.004	2.29786

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	11.79907
0.20	0.09	0.075	58.99536
0.30	0.14	0.16	125.8568
0.40	0.18	0.28	220.2493
0.50	0.23	0.43	338.2401
0.60	0.28	0.6	471.9629
0.70	0.32	0.77	605.6857
0.80	0.37	0.89	700.0783
1.00	0.46	1	786.6048
1.10	0.51	0.98	770.8727
1.20	0.55	0.92	723.6764
1.30	0.60	0.84	660.748
1.40	0.64	0.75	589.9536
1.50	0.69	0.65	511.2931
1.60	0.74	0.57	448.3647
1.80	0.83	0.43	338.2401
2.00	0.92	0.32	251.7135
2.20	1.01	0.24	188.7852
2.40	1.10	0.18	141.5889
2.60	1.20	0.13	102.2586
2.80	1.29	0.098	77.08727
3.50	1.61	0.036	28.31777
4.00	1.84	0.018	14.15889
4.50	2.07	0.009	7.079443
5.00	2.30	0.004	3.146419

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.471791011
0.20	0.06	0.075	2.358955054
0.30	0.09	0.16	5.032437449
0.40	0.12	0.28	8.806765536
0.50	0.16	0.43	13.52467564
0.60	0.19	0.6	18.87164043
0.70	0.22	0.77	24.21860522
0.80	0.25	0.89	27.99293331
1.00	0.31	1	31.45273406
1.10	0.34	0.98	30.82367937
1.20	0.37	0.92	28.93651533
1.30	0.41	0.84	26.42029661
1.40	0.44	0.75	23.58955054
1.50	0.47	0.65	20.44427714
1.60	0.50	0.57	17.92805841
1.80	0.56	0.43	13.52467564
2.00	0.62	0.32	10.0648749
2.20	0.69	0.24	7.548656173
2.40	0.75	0.18	5.66149213
2.60	0.81	0.13	4.088855427
2.80	0.87	0.098	3.082367937
3.50	1.09	0.036	1.132298426
4.00	1.25	0.018	0.566149213
4.50	1.40	0.009	0.283074606
5.00	1.56	0.004	0.125810936

Duration, D	0.25
Tc	0.311
Tp	0.3116
A (sq miles)	0.0905
P (1-yr)	3.3
CN	65
S	5.384615385
Q (1-yr)	0.649614996
Ia	1.076923077
Ia/P (1-yr)	0.326340326
use Ia/P min	0.1
qu from chart	535
Qp (1-yr) =	31.45273406

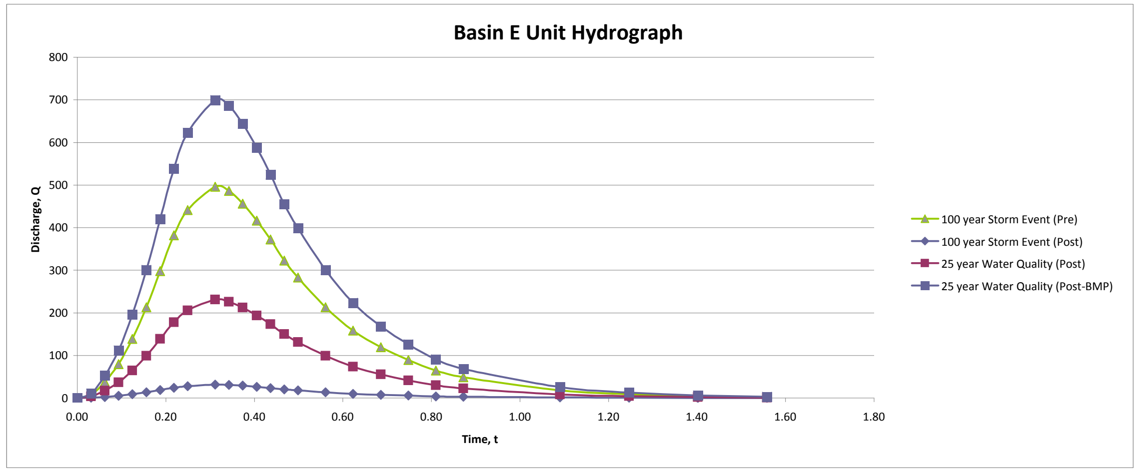
Duration, D	0.25
Tc	0.311
Tp	0.3116
A (sq miles)	0.0905
P (2-yr)	8
CN	65
S	5.384615
Q (2-yr)	3.894231
Ia	1.076923
Ia/P (2-yr)	0.134615
use Ia/P min	0.1
qu from chart	655
Qp (2-yr) =	230.8403

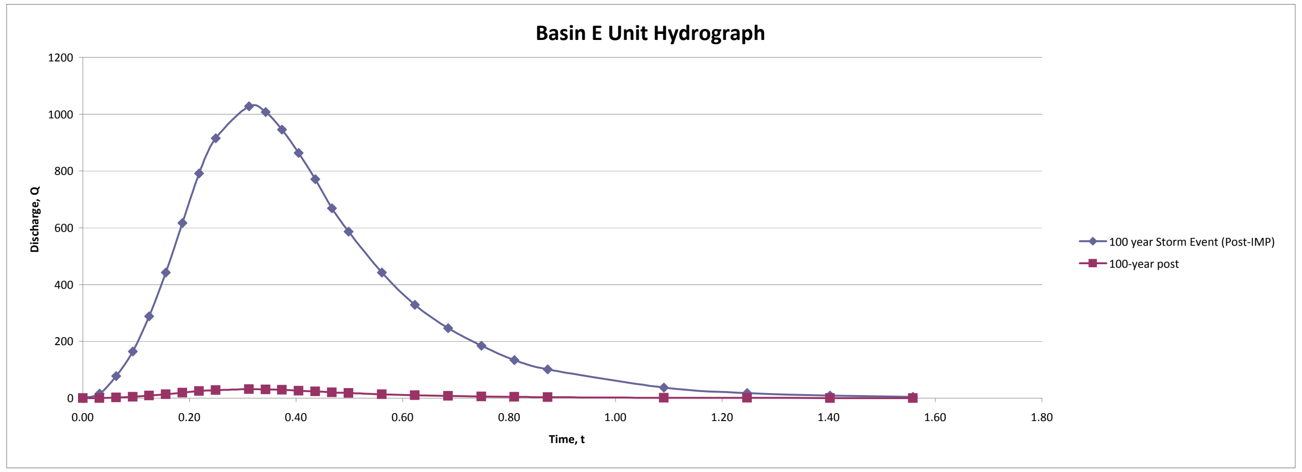
Duration, D	0.25
Tc	0.311
Tp	0.3116
A (sq miles)	0.0905
P (10-yr)	13.1
CN	65
S	5.384615
Q (10-yr)	8.304052
Ia	1.076923
Ia/P (10-yr)	0.082208
use Ia/P min	0.1
qu from chart	660
Qp (10-yr) =	496.001

Duration, D	0.25
Tc	0.311
Tp	0.3116
A (sq miles)	0.0905
P (25-yr)	16.8
CN	65
S	5.384615
Q (25-yr)	11.71209
Ia	1.076923
Ia/P (25-yr)	0.064103
use Ia/P min	0.1
qu from chart	660
Qp (25-yr) =	699.563

Duration, D	0.25
Tc	0.311
Tp	0.3116
A (sq miles)	0.0905
P (100-yr)	22.6
CN	65
S	5.38461538
Q (100-yr)	17.2160004
Ia	1.07692308
Ia/P (100-yr)	0.04765146
use Ia/P min	0.1
qu from chart	660
Qp (100-yr) =	1028.3117

Duration, D	0.25
Tc	0.311
Tp	0.3116
A (sq miles)	0.0905
P (500-yr)	50.7
CN	65
S	5.384615385
Q (500-yr)	44.76555296
Ia	1.076923077
Ia/P (500-yr)	0.021241086
use Ia/P min	0.1
qu from chart	660
Qp (500-yr) =	2673.846478





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	3.462603966
0.20	0.06	0.075	17.31301983
0.30	0.09	0.16	36.93444231
0.40	0.12	0.28	64.63527404
0.50	0.16	0.43	99.2613137
0.60	0.19	0.6	138.5041587
0.70	0.22	0.77	177.7470036
0.80	0.25	0.89	205.4478353
1.00	0.31	1	230.8402644
1.10	0.34	0.98	226.2234591
1.20	0.37	0.92	212.3730433
1.30	0.41	0.84	193.9058221
1.40	0.44	0.75	173.1301983
1.50	0.47	0.65	150.0461719
1.60	0.50	0.57	131.5789507
1.80	0.56	0.43	99.2613137
2.00	0.62	0.32	73.86888462
2.20	0.69	0.24	55.40166346
2.40	0.75	0.18	41.5512476
2.60	0.81	0.13	30.00923438
2.80	0.87	0.098	22.62234591
3.50	1.09	0.036	8.310249519
4.00	1.25	0.018	4.15512476
4.50	1.40	0.009	2.07756238
5.00	1.56	0.004	0.923361058

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	7.440015213
0.20	0.06	0.075	37.20007607
0.30	0.09	0.16	79.36016227
0.40	0.12	0.28	138.880284
0.50	0.16	0.43	213.2804361
0.60	0.19	0.6	297.6006085
0.70	0.22	0.77	381.9207809
0.80	0.25	0.89	441.4409026
1.00	0.31	1	496.0010142
1.10	0.34	0.98	486.0809939
1.20	0.37	0.92	456.3209331
1.30	0.41	0.84	416.6408519
1.40	0.44	0.75	372.0007607
1.50	0.47	0.65	322.4006592
1.60	0.50	0.57	282.7205781
1.80	0.56	0.43	213.2804361
2.00	0.62	0.32	158.7203245
2.20	0.69	0.24	119.0402434
2.40	0.75	0.18	89.28018256
2.60	0.81	0.13	64.48013185
2.80	0.87	0.098	48.60809939
3.50	1.09	0.036	17.85603651
4.00	1.25	0.018	8.928018256
4.50	1.40	0.009	4.464009128
5.00	1.56	0.004	1.984004057

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	10.49345
0.20	0.06	0.075	52.46723
0.30	0.09	0.16	111.9301
0.40	0.12	0.28	195.8776
0.50	0.16	0.43	300.8121
0.60	0.19	0.6	419.7378
0.70	0.22	0.77	538.6635
0.80	0.25	0.89	622.6111
1.00	0.31	1	699.563
1.10	0.34	0.98	685.5718
1.20	0.37	0.92	643.598
1.30	0.41	0.84	587.6329
1.40	0.44	0.75	524.6723
1.50	0.47	0.65	454.716
1.60	0.50	0.57	398.7509
1.80	0.56	0.43	300.8121
2.00	0.62	0.32	223.8602
2.20	0.69	0.24	167.8951
2.40	0.75	0.18	125.9213
2.60	0.81	0.13	90.94319
2.80	0.87	0.098	68.55718
3.50	1.09	0.036	25.18427
4.00	1.25	0.018	12.59213
4.50	1.40	0.009	6.296067
5.00	1.56	0.004	2.798252

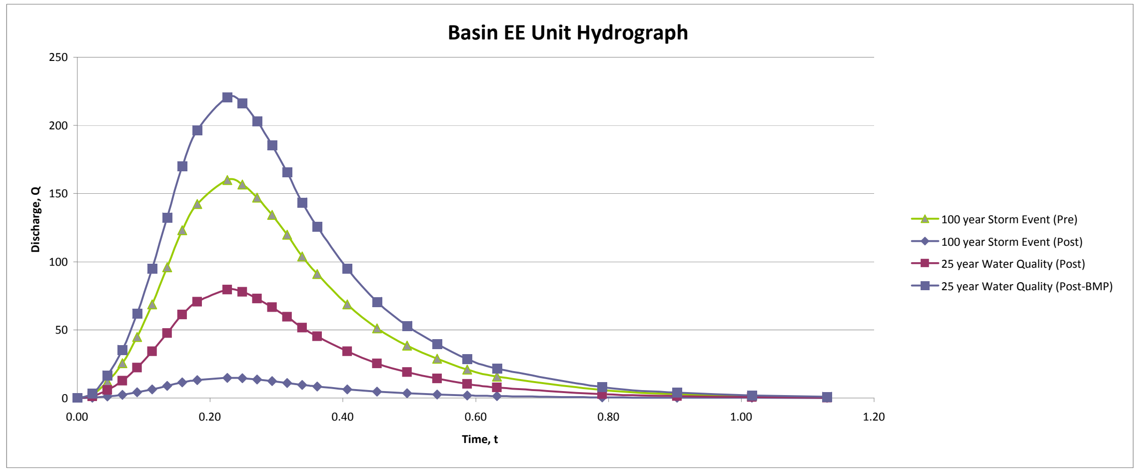
100yr (post w/IMP)

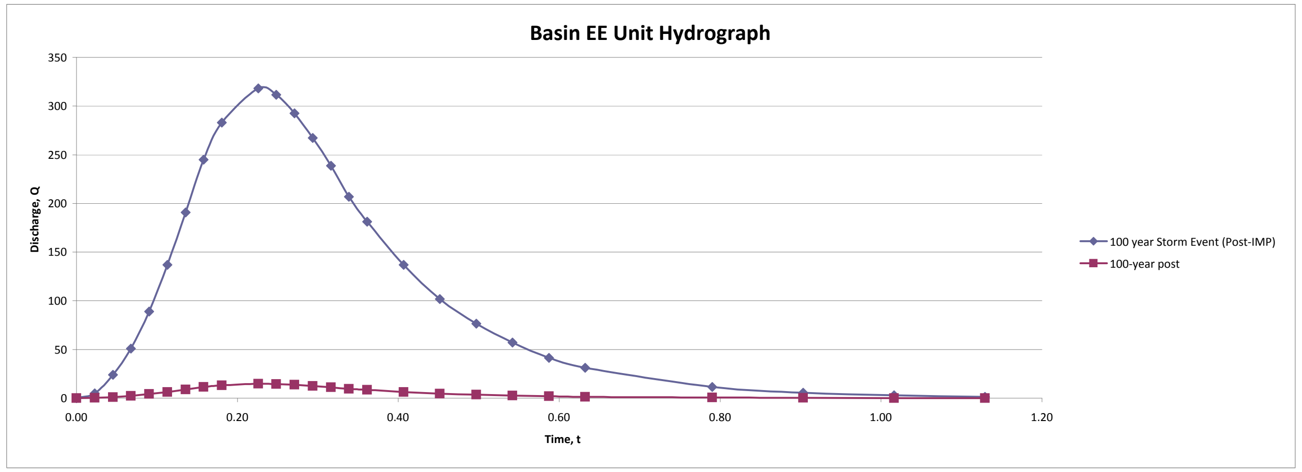
Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	15.42468
0.20	0.06	0.075	77.12338
0.30	0.09	0.16	164.5299
0.40	0.12	0.28	287.9273
0.50	0.16	0.43	442.174
0.60	0.19	0.6	616.987
0.70	0.22	0.77	791.8
0.80	0.25	0.89	915.1974
1.00	0.31	1	1028.312
1.10	0.34	0.98	1007.745
1.20	0.37	0.92	946.0468
1.30	0.41	0.84	863.7818
1.40	0.44	0.75	771.2338
1.50	0.47	0.65	668.4026
1.60	0.50	0.57	586.1377
1.80	0.56	0.43	442.174
2.00	0.62	0.32	329.0597
2.20	0.69	0.24	246.7948
2.40	0.75	0.18	185.0961
2.60	0.81	0.13	133.6805
2.80	0.87	0.098	100.7745
3.50	1.09	0.036	37.01922
4.00	1.25	0.018	18.50961
4.50	1.40	0.009	9.254805
5.00	1.56	0.004	4.113247

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	0.222640408
0.20	0.05	0.075	1.113202041
0.30	0.07	0.16	2.37483102
0.40	0.09	0.28	4.155954285
0.50	0.11	0.43	6.382358366
0.60	0.14	0.6	8.905616324
0.70	0.16	0.77	11.42887428
0.80	0.18	0.89	13.20999755
1.00	0.23	1	14.84269387
1.10	0.25	0.98	14.54584
1.20	0.27	0.92	13.65527836
1.30	0.29	0.84	12.46786285
1.40	0.32	0.75	11.13202041
1.50	0.34	0.65	9.647751018
1.60	0.36	0.57	8.460335508
1.80	0.41	0.43	6.382358366
2.00	0.45	0.32	4.74966204
2.20	0.50	0.24	3.56224653
2.40	0.54	0.18	2.671684897
2.60	0.59	0.13	1.929550204
2.80	0.63	0.098	1.454584
3.50	0.79	0.036	0.534336979
4.00	0.90	0.018	0.26716849
4.50	1.02	0.009	0.133584245
5.00	1.13	0.004	0.059370775

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.168	Tc	0.168	Tc	0.168	Tc	0.168	Tc	0.168	Tc	0.168
Tp	0.2258	Tp	0.2258	Tp	0.2258	Tp	0.2258	Tp	0.2258	Tp	0.2258
A (sq miles)	0.0204	A (sq miles)	0.0204	A (sq miles)	0.0204	A (sq miles)	0.0204	A (sq miles)	0.0204	A (sq miles)	0.0204
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	71	CN	71	CN	71	CN	71	CN	71	CN	71
S	4.084507042	S	4.084507	S	4.084507	S	4.084507	S	4.08450704	S	4.084507042
Q (1-yr)	0.938816817	Q (2-yr)	4.579225	Q (10-yr)	9.217873	Q (25-yr)	12.72994	Q (100-yr)	18.3435371	Q (500-yr)	46.1077251
Ia	0.816901408	Ia	0.816901	Ia	0.816901	Ia	0.816901	Ia	0.81690141	Ia	0.816901408
Ia/P (1-yr)	0.247545881	Ia/P (2-yr)	0.102113	Ia/P (10-yr)	0.062359	Ia/P (25-yr)	0.048625	Ia/P (100-yr)	0.03614608	Ia/P (500-yr)	0.016112454
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	775	qu from chart	850	qu from chart	850	qu from chart	850	qu from chart	850	qu from chart	850
Qp (1-yr) =	14.84269387	Qp (2-yr) =	79.40377	Qp (10-yr) =	159.8379	Qp (25-yr) =	220.7372	Qp (100-yr) =	318.076934	Qp (500-yr) =	799.5079533





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	1.191056514
0.20	0.05	0.075	5.95528257
0.30	0.07	0.16	12.70460282
0.40	0.09	0.28	22.23305493
0.50	0.11	0.43	34.14362007
0.60	0.14	0.6	47.64226056
0.70	0.16	0.77	61.14090106
0.80	0.18	0.89	70.66935317
1.00	0.23	1	79.40376761
1.10	0.25	0.98	77.81569225
1.20	0.27	0.92	73.0514662
1.30	0.29	0.84	66.69916479
1.40	0.32	0.75	59.5528257
1.50	0.34	0.65	51.61244894
1.60	0.36	0.57	45.26014754
1.80	0.41	0.43	34.14362007
2.00	0.45	0.32	25.40920563
2.20	0.50	0.24	19.05690423
2.40	0.54	0.18	14.29267817
2.60	0.59	0.13	10.32248979
2.80	0.63	0.098	7.781569225
3.50	0.79	0.036	2.858535634
4.00	0.90	0.018	1.429267817
4.50	1.02	0.009	0.714633908
5.00	1.13	0.004	0.31761507

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	2.397568783
0.20	0.05	0.075	11.98784391
0.30	0.07	0.16	25.57406701
0.40	0.09	0.28	44.75461728
0.50	0.11	0.43	68.7303051
0.60	0.14	0.6	95.9027513
0.70	0.16	0.77	123.0751975
0.80	0.18	0.89	142.2557478
1.00	0.23	1	159.8379188
1.10	0.25	0.98	156.6411605
1.20	0.27	0.92	147.0508853
1.30	0.29	0.84	134.2638518
1.40	0.32	0.75	119.8784391
1.50	0.34	0.65	103.8946472
1.60	0.36	0.57	91.10761374
1.80	0.41	0.43	68.7303051
2.00	0.45	0.32	51.14813403
2.20	0.50	0.24	38.36110052
2.40	0.54	0.18	28.77082539
2.60	0.59	0.13	20.77892945
2.80	0.63	0.098	15.66411605
3.50	0.79	0.036	5.754165078
4.00	0.90	0.018	2.877082539
4.50	1.02	0.009	1.43854127
5.00	1.13	0.004	0.639351675

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	3.311058
0.20	0.05	0.075	16.55529
0.30	0.07	0.16	35.31795
0.40	0.09	0.28	61.80641
0.50	0.11	0.43	94.91699
0.60	0.14	0.6	132.4423
0.70	0.16	0.77	169.9676
0.80	0.18	0.89	196.4561
1.00	0.23	1	220.7372
1.10	0.25	0.98	216.3224
1.20	0.27	0.92	203.0782
1.30	0.29	0.84	185.4192
1.40	0.32	0.75	165.5529
1.50	0.34	0.65	143.4792
1.60	0.36	0.57	125.8202
1.80	0.41	0.43	94.91699
2.00	0.45	0.32	70.6359
2.20	0.50	0.24	52.97692
2.40	0.54	0.18	39.73269
2.60	0.59	0.13	28.69583
2.80	0.63	0.098	21.63224
3.50	0.79	0.036	7.946539
4.00	0.90	0.018	3.973269
4.50	1.02	0.009	1.986635
5.00	1.13	0.004	0.882949

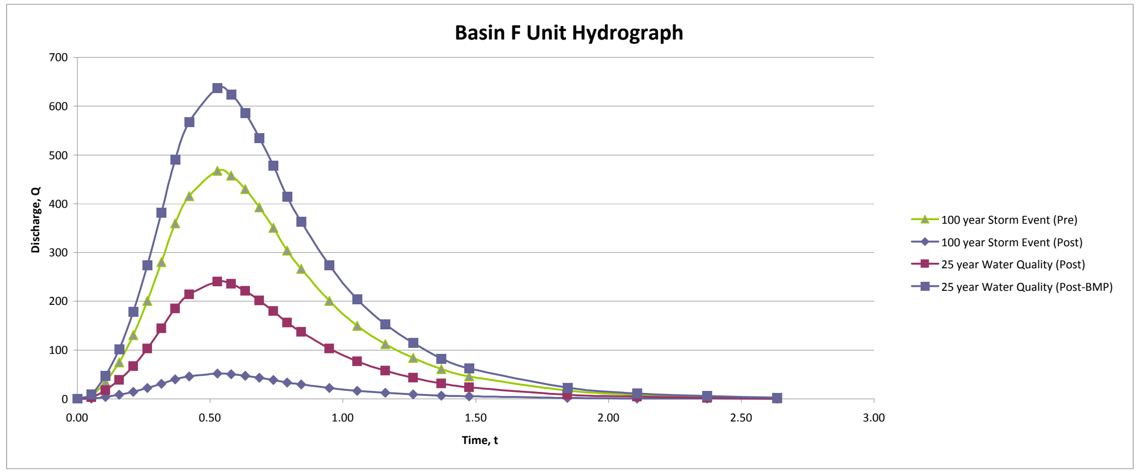
100yr (post w/IMP)

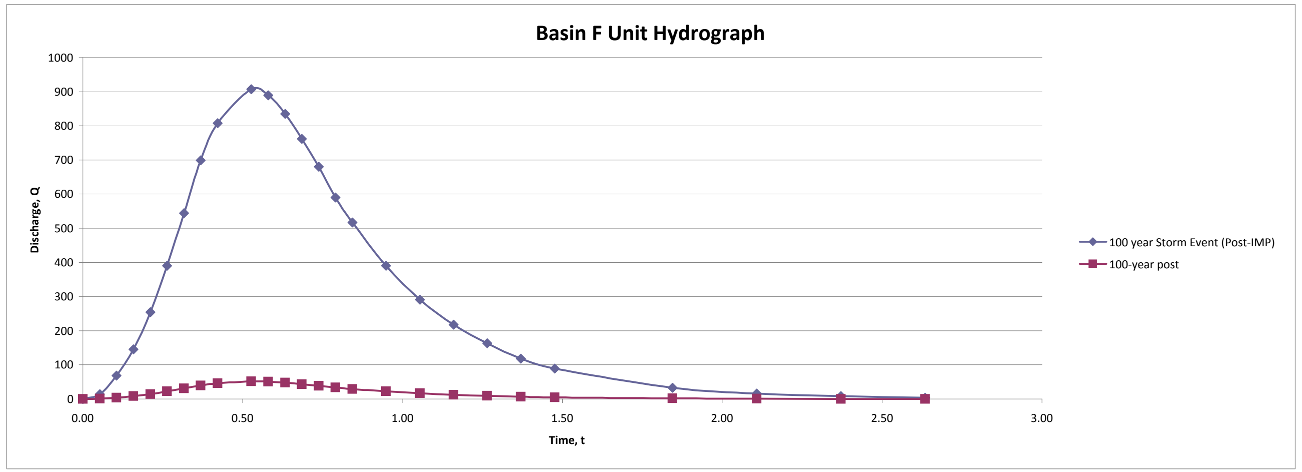
Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	4.771154
0.20	0.05	0.075	23.85577
0.30	0.07	0.16	50.89231
0.40	0.09	0.28	89.06154
0.50	0.11	0.43	136.7731
0.60	0.14	0.6	190.8462
0.70	0.16	0.77	244.9192
0.80	0.18	0.89	283.0885
1.00	0.23	1	318.0769
1.10	0.25	0.98	311.7154
1.20	0.27	0.92	292.6308
1.30	0.29	0.84	267.1846
1.40	0.32	0.75	238.5577
1.50	0.34	0.65	206.75
1.60	0.36	0.57	181.3039
1.80	0.41	0.43	136.7731
2.00	0.45	0.32	101.7846
2.20	0.50	0.24	76.33846
2.40	0.54	0.18	57.25385
2.60	0.59	0.13	41.35
2.80	0.63	0.098	31.17154
3.50	0.79	0.036	11.45077
4.00	0.90	0.018	5.725385
4.50	1.02	0.009	2.862692
5.00	1.13	0.004	1.272308

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	0.775383235
0.20	0.11	0.075	3.876916173
0.30	0.16	0.16	8.270754503
0.40	0.21	0.28	14.47382038
0.50	0.26	0.43	22.22765273
0.60	0.32	0.6	31.01532939
0.70	0.37	0.77	39.80300604
0.80	0.42	0.89	46.00607192
1.00	0.53	1	51.69221564
1.10	0.58	0.98	50.65837133
1.20	0.63	0.92	47.55683839
1.30	0.69	0.84	43.42146114
1.40	0.74	0.75	38.76916173
1.50	0.79	0.65	33.59994017
1.60	0.84	0.57	29.46456292
1.80	0.95	0.43	22.22765273
2.00	1.05	0.32	16.54150901
2.20	1.16	0.24	12.40613175
2.40	1.26	0.18	9.304598816
2.60	1.37	0.13	6.719988034
2.80	1.48	0.098	5.065837133
3.50	1.84	0.036	1.860919763
4.00	2.11	0.018	0.930459882
4.50	2.37	0.009	0.465229941
5.00	2.64	0.004	0.206768863

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.67	Tc	0.67	Tc	0.67	Tc	0.67	Tc	0.67	Tc	0.67
Tp	0.527	Tp	0.527	Tp	0.527	Tp	0.527	Tp	0.527	Tp	0.527
A (sq miles)	0.1059	A (sq miles)	0.1059	A (sq miles)	0.1059	A (sq miles)	0.1059	A (sq miles)	0.1059	A (sq miles)	0.1059
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	75	CN	75	CN	75	CN	75	CN	75	CN	75
S	3.333333333	S	3.333333	S	3.333333	S	3.333333	S	3.33333333	S	3.333333333
Q (1-yr)	1.162197393	Q (2-yr)	5.041667	Q (10-yr)	9.804722	Q (25-yr)	13.37078	Q (100-yr)	19.0397537	Q (500-yr)	46.90820321
Ia	0.666666667	Ia	0.666667	Ia	0.666667	Ia	0.666667	Ia	0.66666667	Ia	0.666666667
Ia/P (1-yr)	0.202020202	Ia/P (2-yr)	0.083333	Ia/P (10-yr)	0.050891	Ia/P (25-yr)	0.039683	Ia/P (100-yr)	0.02949853	Ia/P (500-yr)	0.013149244
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	420	qu from chart	450	qu from chart	450	qu from chart	450	qu from chart	450	qu from chart	450
Qp (1-yr) =	51.69221564	Qp (2-yr) =	240.2606	Qp (10-yr) =	467.244	Qp (25-yr) =	637.1843	Qp (100-yr) =	907.339464	Qp (500-yr) =	2235.410424





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	3.603909375
0.20	0.11	0.075	18.01954688
0.30	0.16	0.16	38.4417
0.40	0.21	0.28	67.272975
0.50	0.26	0.43	103.3120688
0.60	0.32	0.6	144.156375
0.70	0.37	0.77	185.0006813
0.80	0.42	0.89	213.8319563
1.00	0.53	1	240.260625
1.10	0.58	0.98	235.4554125
1.20	0.63	0.92	221.039775
1.30	0.69	0.84	201.818925
1.40	0.74	0.75	180.1954688
1.50	0.79	0.65	156.1694063
1.60	0.84	0.57	136.9485563
1.80	0.95	0.43	103.3120688
2.00	1.05	0.32	76.8834
2.20	1.16	0.24	57.66255
2.40	1.26	0.18	43.2469125
2.60	1.37	0.13	31.23388125
2.80	1.48	0.098	23.54554125
3.50	1.84	0.036	8.6493825
4.00	2.11	0.018	4.32469125
4.50	2.37	0.009	2.162345625
5.00	2.64	0.004	0.9610425

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	7.008660143
0.20	0.11	0.075	35.04330071
0.30	0.16	0.16	74.75904152
0.40	0.21	0.28	130.8283227
0.50	0.26	0.43	200.9149241
0.60	0.32	0.6	280.3464057
0.70	0.37	0.77	359.7778873
0.80	0.42	0.89	415.8471685
1.00	0.53	1	467.2440095
1.10	0.58	0.98	457.8991293
1.20	0.63	0.92	429.8644888
1.30	0.69	0.84	392.484968
1.40	0.74	0.75	350.4330071
1.50	0.79	0.65	303.7086062
1.60	0.84	0.57	266.3290854
1.80	0.95	0.43	200.9149241
2.00	1.05	0.32	149.518083
2.20	1.16	0.24	112.1385623
2.40	1.26	0.18	84.10392171
2.60	1.37	0.13	60.74172124
2.80	1.48	0.098	45.78991293
3.50	1.84	0.036	16.82078434
4.00	2.11	0.018	8.410392171
4.50	2.37	0.009	4.205196086
5.00	2.64	0.004	1.868976038

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	9.557765
0.20	0.11	0.075	47.78883
0.30	0.16	0.16	101.9495
0.40	0.21	0.28	178.4116
0.50	0.26	0.43	273.9893
0.60	0.32	0.6	382.3106
0.70	0.37	0.77	490.6319
0.80	0.42	0.89	567.0941
1.00	0.53	1	637.1843
1.10	0.58	0.98	624.4407
1.20	0.63	0.92	586.2096
1.30	0.69	0.84	535.2348
1.40	0.74	0.75	477.8883
1.50	0.79	0.65	414.1698
1.60	0.84	0.57	363.1951
1.80	0.95	0.43	273.9893
2.00	1.05	0.32	203.899
2.20	1.16	0.24	152.9242
2.40	1.26	0.18	114.6932
2.60	1.37	0.13	82.83396
2.80	1.48	0.098	62.44407
3.50	1.84	0.036	22.93864
4.00	2.11	0.018	11.46932
4.50	2.37	0.009	5.734659
5.00	2.64	0.004	2.548737

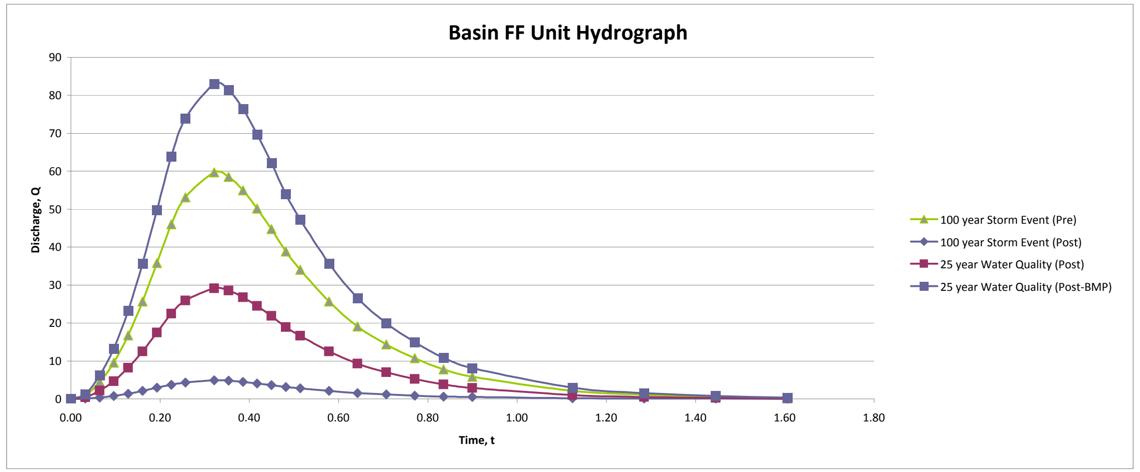
100yr (post w/IMP)

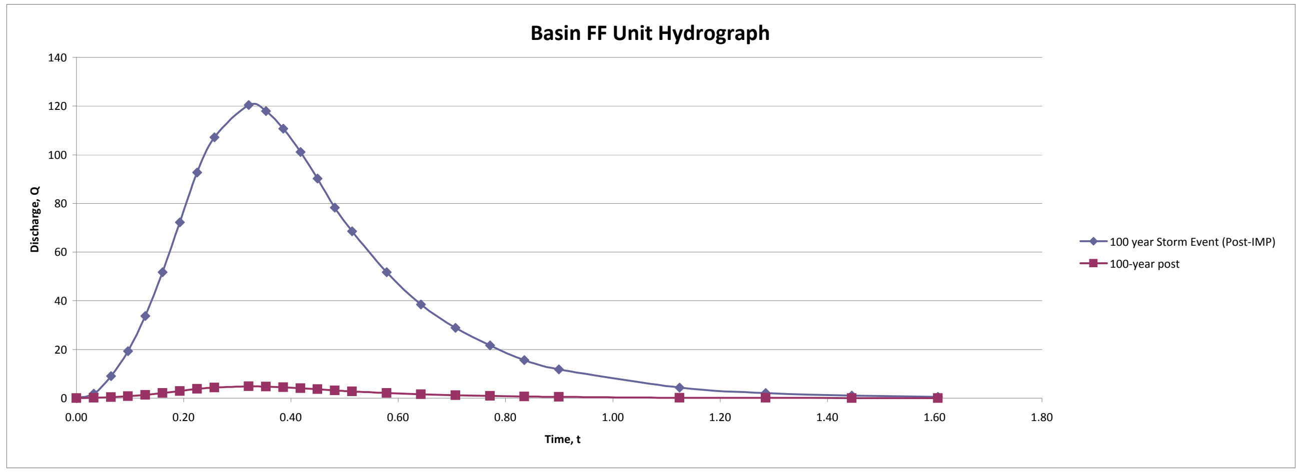
Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	13.61009
0.20	0.11	0.075	68.05046
0.30	0.16	0.16	145.1743
0.40	0.21	0.28	254.0551
0.50	0.26	0.43	390.156
0.60	0.32	0.6	544.4037
0.70	0.37	0.77	698.6514
0.80	0.42	0.89	807.5321
1.00	0.53	1	907.3395
1.10	0.58	0.98	889.1927
1.20	0.63	0.92	834.7523
1.30	0.69	0.84	762.1652
1.40	0.74	0.75	680.5046
1.50	0.79	0.65	589.7707
1.60	0.84	0.57	517.1835
1.80	0.95	0.43	390.156
2.00	1.05	0.32	290.3486
2.20	1.16	0.24	217.7615
2.40	1.26	0.18	163.3211
2.60	1.37	0.13	117.9541
2.80	1.48	0.098	88.91927
3.50	1.84	0.036	32.66422
4.00	2.11	0.018	16.33211
4.50	2.37	0.009	8.166055
5.00	2.64	0.004	3.629358

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.073019643
0.20	0.06	0.075	0.365098216
0.30	0.10	0.16	0.778876194
0.40	0.13	0.28	1.363033339
0.50	0.16	0.43	2.093229771
0.60	0.19	0.6	2.920785726
0.70	0.22	0.77	3.748341682
0.80	0.26	0.89	4.332498827
1.00	0.32	1	4.867976211
1.10	0.35	0.98	4.770616686
1.20	0.39	0.92	4.478538114
1.30	0.42	0.84	4.089100017
1.40	0.45	0.75	3.650982158
1.50	0.48	0.65	3.164184537
1.60	0.51	0.57	2.77474644
1.80	0.58	0.43	2.093229771
2.00	0.64	0.32	1.557752387
2.20	0.71	0.24	1.168314291
2.40	0.77	0.18	0.876235718
2.60	0.84	0.13	0.632836907
2.80	0.90	0.098	0.477061669
3.50	1.12	0.036	0.175247144
4.00	1.28	0.018	0.087623572
4.50	1.45	0.009	0.043811786
5.00	1.61	0.004	0.019471905

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.327	Tc	0.327	Tc	0.327	Tc	0.327	Tc	0.327	Tc	0.327
Tp	0.3212	Tp	0.3212	Tp	0.3212	Tp	0.3212	Tp	0.3212	Tp	0.3212
A (sq miles)	0.0103	A (sq miles)	0.0103	A (sq miles)	0.0103	A (sq miles)	0.0103	A (sq miles)	0.0103	A (sq miles)	0.0103
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	69	CN	69	CN	69	CN	69	CN	69	CN	69
S	4.492753623	S	4.492754	S	4.492754	S	4.492754	S	4.49275362	S	4.492753623
Q (1-yr)	0.836493893	Q (2-yr)	4.349638	Q (10-yr)	8.917788	Q (25-yr)	12.39843	Q (100-yr)	17.9792797	Q (500-yr)	45.68046343
Ia	0.898550725	Ia	0.898551	Ia	0.898551	Ia	0.898551	Ia	0.89855072	Ia	0.898550725
Ia/P (1-yr)	0.272288098	Ia/P (2-yr)	0.112319	Ia/P (10-yr)	0.068592	Ia/P (25-yr)	0.053485	Ia/P (100-yr)	0.03975888	Ia/P (500-yr)	0.017722894
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	565	qu from chart	650	qu from chart	650	qu from chart	650	qu from chart	650	qu from chart	650
Qp (1-yr) =	4.867976211	Qp (2-yr) =	29.12082	Qp (10-yr) =	59.70459	Qp (25-yr) =	83.00749	Qp (100-yr) =	120.371278	Qp (500-yr) =	305.8307027





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.436812364
0.20	0.06	0.075	2.184061821
0.30	0.10	0.16	4.659331884
0.40	0.13	0.28	8.153830797
0.50	0.16	0.43	12.52195444
0.60	0.19	0.6	17.47249457
0.70	0.22	0.77	22.42303469
0.80	0.26	0.89	25.91753361
1.00	0.32	1	29.12082428
1.10	0.35	0.98	28.53840779
1.20	0.39	0.92	26.79115833
1.30	0.42	0.84	24.46149239
1.40	0.45	0.75	21.84061821
1.50	0.48	0.65	18.92853578
1.60	0.51	0.57	16.59886984
1.80	0.58	0.43	12.52195444
2.00	0.64	0.32	9.318663768
2.20	0.71	0.24	6.988997826
2.40	0.77	0.18	5.24174837
2.60	0.84	0.13	3.785707156
2.80	0.90	0.098	2.853840779
3.50	1.12	0.036	1.048349674
4.00	1.28	0.018	0.524174837
4.50	1.45	0.009	0.262087418
5.00	1.61	0.004	0.116483297

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.895568873
0.20	0.06	0.075	4.477844364
0.30	0.10	0.16	9.552734643
0.40	0.13	0.28	16.71728563
0.50	0.16	0.43	25.67297435
0.60	0.19	0.6	35.82275491
0.70	0.22	0.77	45.97253547
0.80	0.26	0.89	53.13708645
1.00	0.32	1	59.70459152
1.10	0.35	0.98	58.51049969
1.20	0.39	0.92	54.9282242
1.30	0.42	0.84	50.15185688
1.40	0.45	0.75	44.77844364
1.50	0.48	0.65	38.80798449
1.60	0.51	0.57	34.03161717
1.80	0.58	0.43	25.67297435
2.00	0.64	0.32	19.10546929
2.20	0.71	0.24	14.32910196
2.40	0.77	0.18	10.74682647
2.60	0.84	0.13	7.761596897
2.80	0.90	0.098	5.851049969
3.50	1.12	0.036	2.149365295
4.00	1.28	0.018	1.074682647
4.50	1.45	0.009	0.537341324
5.00	1.61	0.004	0.238818366

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.245112
0.20	0.06	0.075	6.225561
0.30	0.10	0.16	13.2812
0.40	0.13	0.28	23.2421
0.50	0.16	0.43	35.69322
0.60	0.19	0.6	49.80449
0.70	0.22	0.77	63.91576
0.80	0.26	0.89	73.87666
1.00	0.32	1	83.00749
1.10	0.35	0.98	81.34734
1.20	0.39	0.92	76.36689
1.30	0.42	0.84	69.72629
1.40	0.45	0.75	62.25561
1.50	0.48	0.65	53.95487
1.60	0.51	0.57	47.31427
1.80	0.58	0.43	35.69322
2.00	0.64	0.32	26.5624
2.20	0.71	0.24	19.9218
2.40	0.77	0.18	14.94135
2.60	0.84	0.13	10.79097
2.80	0.90	0.098	8.134734
3.50	1.12	0.036	2.98827
4.00	1.28	0.018	1.494135
4.50	1.45	0.009	0.747067
5.00	1.61	0.004	0.33203

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.805569
0.20	0.06	0.075	9.027846
0.30	0.10	0.16	19.2594
0.40	0.13	0.28	33.70396
0.50	0.16	0.43	51.75965
0.60	0.19	0.6	72.22277
0.70	0.22	0.77	92.68588
0.80	0.26	0.89	107.1304
1.00	0.32	1	120.3713
1.10	0.35	0.98	117.9639
1.20	0.39	0.92	110.7416
1.30	0.42	0.84	101.1119
1.40	0.45	0.75	90.27846
1.50	0.48	0.65	78.24133
1.60	0.51	0.57	68.61163
1.80	0.58	0.43	51.75965
2.00	0.64	0.32	38.51881
2.20	0.71	0.24	28.88911
2.40	0.77	0.18	21.66683
2.60	0.84	0.13	15.64827
2.80	0.90	0.098	11.79639
3.50	1.12	0.036	4.333366
4.00	1.28	0.018	2.166683
4.50	1.45	0.009	1.083341
5.00	1.61	0.004	0.481485

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.387293491
0.20	0.07	0.075	6.936467453
0.30	0.10	0.16	14.79779723
0.40	0.14	0.28	25.89614516
0.50	0.17	0.43	39.76908007
0.60	0.21	0.6	55.49173963
0.70	0.24	0.77	71.21439919
0.80	0.28	0.89	82.31274711
1.00	0.34	1	92.48623271
1.10	0.38	0.98	90.63650806
1.20	0.41	0.92	85.0873341
1.30	0.45	0.84	77.68843548
1.40	0.48	0.75	69.36467453
1.50	0.52	0.65	60.11605126
1.60	0.55	0.57	52.71715265
1.80	0.62	0.43	39.76908007
2.00	0.69	0.32	29.59559447
2.20	0.76	0.24	22.19669585
2.40	0.83	0.18	16.64752189
2.60	0.90	0.13	12.02321025
2.80	0.96	0.098	9.063650806
3.50	1.21	0.036	3.329504378
4.00	1.38	0.018	1.664752189
4.50	1.55	0.009	0.832376094
5.00	1.72	0.004	0.369944931

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0985
P (1-yr)	3.3
CN	82
S	2.195121951
Q (1-yr)	1.618873319
Ia	0.43902439
Ia/P (1-yr)	0.133037694
use Ia/P min	0.1
qu from chart	580
Qp (1-yr) =	92.48623271

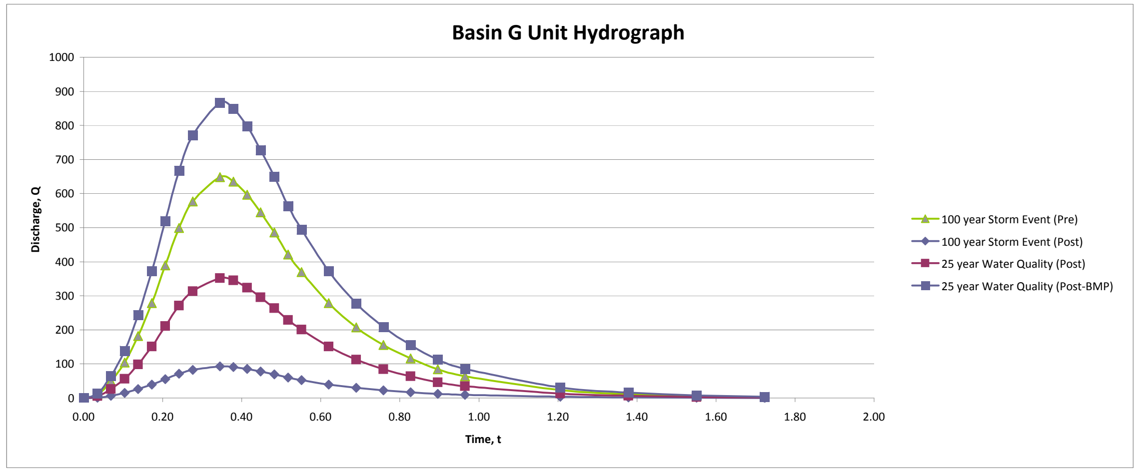
Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0985
P (2-yr)	8
CN	82
S	2.195122
Q (2-yr)	5.859756
Ia	0.439024
Ia/P (2-yr)	0.054878
use Ia/P min	0.1
qu from chart	610
Qp (2-yr) =	352.0834

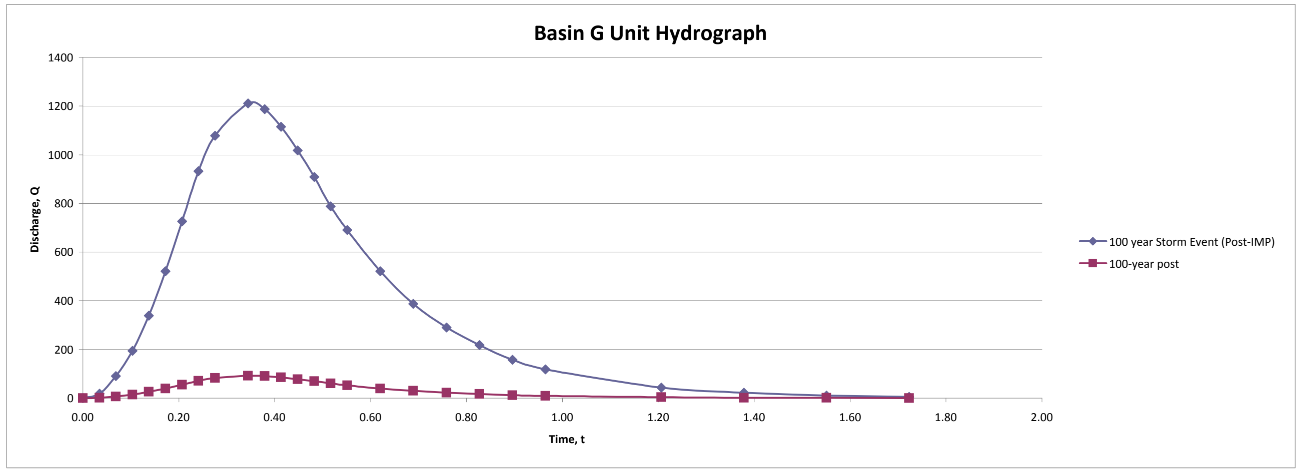
Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0985
P (10-yr)	13.1
CN	82
S	2.195122
Q (10-yr)	10.7902
Ia	0.439024
Ia/P (10-yr)	0.033513
use Ia/P min	0.1
qu from chart	610
Qp (10-yr) =	648.3293

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0985
P (25-yr)	16.8
CN	82
S	2.195122
Q (25-yr)	14.42553
Ia	0.439024
Ia/P (25-yr)	0.026132
use Ia/P min	0.1
qu from chart	610
Qp (25-yr) =	866.7579

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0985
P (100-yr)	22.6
CN	82
S	2.19512195
Q (100-yr)	20.1636916
Ia	0.43902439
Ia/P (100-yr)	0.01942586
use Ia/P min	0.1
qu from chart	610
Qp (100-yr) =	1211.53541

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0985
P (500-yr)	50.7
CN	82
S	2.195121951
Q (500-yr)	48.15771258
Ia	0.43902439
Ia/P (500-yr)	0.008659258
use Ia/P min	0.1
qu from chart	610
Qp (500-yr) =	2893.55616





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	5.281251677
0.20	0.07	0.075	26.40625838
0.30	0.10	0.16	56.33335122
0.40	0.14	0.28	98.58336463
0.50	0.17	0.43	151.3958814
0.60	0.21	0.6	211.2500671
0.70	0.24	0.77	271.1042527
0.80	0.28	0.89	313.3542662
1.00	0.34	1	352.0834451
1.10	0.38	0.98	345.0417762
1.20	0.41	0.92	323.9167695
1.30	0.45	0.84	295.7500939
1.40	0.48	0.75	264.0625838
1.50	0.52	0.65	228.8542393
1.60	0.55	0.57	200.6875637
1.80	0.62	0.43	151.3958814
2.00	0.69	0.32	112.6667024
2.20	0.76	0.24	84.50002683
2.40	0.83	0.18	63.37502012
2.60	0.90	0.13	45.77084787
2.80	0.96	0.098	34.50417762
3.50	1.21	0.036	12.67500402
4.00	1.38	0.018	6.337502012
4.50	1.55	0.009	3.168751006
5.00	1.72	0.004	1.40833378

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	9.724939901
0.20	0.07	0.075	48.6246995
0.30	0.10	0.16	103.7326923
0.40	0.14	0.28	181.5322115
0.50	0.17	0.43	278.7816105
0.60	0.21	0.6	388.997596
0.70	0.24	0.77	499.2135816
0.80	0.28	0.89	577.0131008
1.00	0.34	1	648.3293267
1.10	0.38	0.98	635.3627402
1.20	0.41	0.92	596.4629806
1.30	0.45	0.84	544.5966344
1.40	0.48	0.75	486.246995
1.50	0.52	0.65	421.4140624
1.60	0.55	0.57	369.5477162
1.80	0.62	0.43	278.7816105
2.00	0.69	0.32	207.4653845
2.20	0.76	0.24	155.5990384
2.40	0.83	0.18	116.6992788
2.60	0.90	0.13	84.28281247
2.80	0.96	0.098	63.53627402
3.50	1.21	0.036	23.33985576
4.00	1.38	0.018	11.66992788
4.50	1.55	0.009	5.83496394
5.00	1.72	0.004	2.593317307

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	13.00137
0.20	0.07	0.075	65.00684
0.30	0.10	0.16	138.6813
0.40	0.14	0.28	242.6922
0.50	0.17	0.43	372.7059
0.60	0.21	0.6	520.0547
0.70	0.24	0.77	667.4036
0.80	0.28	0.89	771.4145
1.00	0.34	1	866.7579
1.10	0.38	0.98	849.4227
1.20	0.41	0.92	797.4173
1.30	0.45	0.84	728.0766
1.40	0.48	0.75	650.0684
1.50	0.52	0.65	563.3926
1.60	0.55	0.57	494.052
1.80	0.62	0.43	372.7059
2.00	0.69	0.32	277.3625
2.20	0.76	0.24	208.0219
2.40	0.83	0.18	156.0164
2.60	0.90	0.13	112.6785
2.80	0.96	0.098	84.94227
3.50	1.21	0.036	31.20328
4.00	1.38	0.018	15.60164
4.50	1.55	0.009	7.800821
5.00	1.72	0.004	3.467032

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	18.17303
0.20	0.07	0.075	90.86516
0.30	0.10	0.16	193.8457
0.40	0.14	0.28	339.2299
0.50	0.17	0.43	520.9602
0.60	0.21	0.6	726.9212
0.70	0.24	0.77	932.8823
0.80	0.28	0.89	1078.267
1.00	0.34	1	1211.535
1.10	0.38	0.98	1187.305
1.20	0.41	0.92	1114.613
1.30	0.45	0.84	1017.69
1.40	0.48	0.75	908.6516
1.50	0.52	0.65	787.498
1.60	0.55	0.57	690.5752
1.80	0.62	0.43	520.9602
2.00	0.69	0.32	387.6913
2.20	0.76	0.24	290.7685
2.40	0.83	0.18	218.0764
2.60	0.90	0.13	157.4996
2.80	0.96	0.098	118.7305
3.50	1.21	0.036	43.61527
4.00	1.38	0.018	21.80764
4.50	1.55	0.009	10.90382
5.00	1.72	0.004	4.846142

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.567590297
0.20	0.07	0.075	2.837951483
0.30	0.10	0.16	6.054296496
0.40	0.14	0.28	10.59501887
0.50	0.17	0.43	16.27092183
0.60	0.21	0.6	22.70361186
0.70	0.24	0.77	29.13630189
0.80	0.28	0.89	33.67702426
1.00	0.34	1	37.8393531
1.10	0.38	0.98	37.08256604
1.20	0.41	0.92	34.81220485
1.30	0.45	0.84	31.78505661
1.40	0.48	0.75	28.37951483
1.50	0.52	0.65	24.59557952
1.60	0.55	0.57	21.56843127
1.80	0.62	0.43	16.27092183
2.00	0.69	0.32	12.10859299
2.20	0.76	0.24	9.081444745
2.40	0.83	0.18	6.811083558
2.60	0.90	0.13	4.919115903
2.80	0.96	0.098	3.708256604
3.50	1.21	0.036	1.362216712
4.00	1.38	0.018	0.681108356
4.50	1.55	0.009	0.340554178
5.00	1.72	0.004	0.151357412

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0548
P (1-yr)	3.3
CN	76
S	3.157894737
Q (1-yr)	1.222122379
Ia	0.631578947
Ia/P (1-yr)	0.19138756
use Ia/P min	0.1
qu from chart	565
Qp (1-yr) =	37.8393531

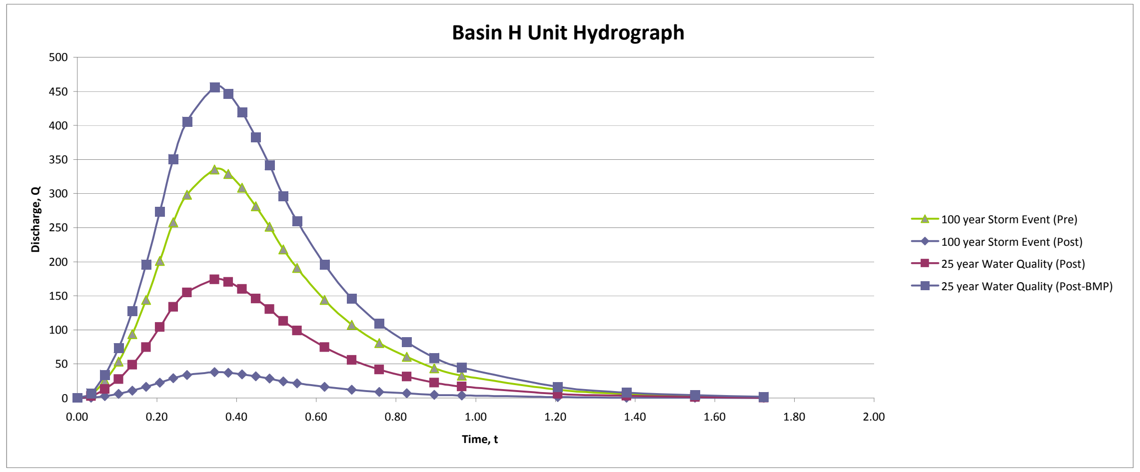
Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0548
P (2-yr)	8
CN	76
S	3.157895
Q (2-yr)	5.157895
Ia	0.631579
Ia/P (2-yr)	0.078947
use Ia/P min	0.1
qu from chart	615
Qp (2-yr) =	173.8314

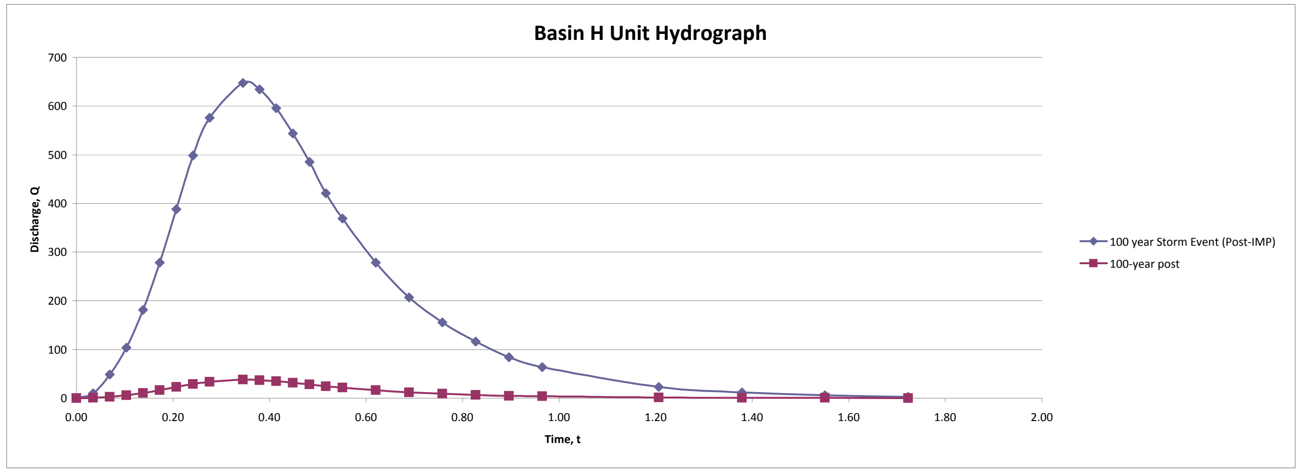
Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0548
P (10-yr)	13.1
CN	76
S	3.157895
Q (10-yr)	9.9487
Ia	0.631579
Ia/P (10-yr)	0.048212
use Ia/P min	0.1
qu from chart	615
Qp (10-yr) =	335.2911

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0548
P (25-yr)	16.8
CN	76
S	3.157895
Q (25-yr)	13.52652
Ia	0.631579
Ia/P (25-yr)	0.037594
use Ia/P min	0.1
qu from chart	615
Qp (25-yr) =	455.8709

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0548
P (100-yr)	22.6
CN	76
S	3.15789474
Q (100-yr)	19.207413
Ia	0.63157895
Ia/P (100-yr)	0.02794597
use Ia/P min	0.1
qu from chart	615
Qp (100-yr) =	647.328232

Duration, D	0.25
Tc	0.366
Tp	0.3446
A (sq miles)	0.0548
P (500-yr)	50.7
CN	76
S	3.157894737
Q (500-yr)	47.09788287
Ia	0.631578947
Ia/P (500-yr)	0.012457178
use Ia/P min	0.1
qu from chart	615
Qp (500-yr) =	1587.292849





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	2.607470526
0.20	0.07	0.075	13.03735263
0.30	0.10	0.16	27.81301895
0.40	0.14	0.28	48.67278316
0.50	0.17	0.43	74.74748842
0.60	0.21	0.6	104.2988211
0.70	0.24	0.77	133.8501537
0.80	0.28	0.89	154.7099179
1.00	0.34	1	173.8313684
1.10	0.38	0.98	170.3547411
1.20	0.41	0.92	159.9248589
1.30	0.45	0.84	146.0183495
1.40	0.48	0.75	130.3735263
1.50	0.52	0.65	112.9903895
1.60	0.55	0.57	99.08388
1.80	0.62	0.43	74.74748842
2.00	0.69	0.32	55.62603789
2.20	0.76	0.24	41.71952842
2.40	0.83	0.18	31.28964632
2.60	0.90	0.13	22.59807789
2.80	0.96	0.098	17.03547411
3.50	1.21	0.036	6.257929263
4.00	1.38	0.018	3.128964632
4.50	1.55	0.009	1.564482316
5.00	1.72	0.004	0.695325474

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	5.02936617
0.20	0.07	0.075	25.14683085
0.30	0.10	0.16	53.64657248
0.40	0.14	0.28	93.88150185
0.50	0.17	0.43	144.1751635
0.60	0.21	0.6	201.1746468
0.70	0.24	0.77	258.1741301
0.80	0.28	0.89	298.4090594
1.00	0.34	1	335.291078
1.10	0.38	0.98	328.5852565
1.20	0.41	0.92	308.4677918
1.30	0.45	0.84	281.6445055
1.40	0.48	0.75	251.4683085
1.50	0.52	0.65	217.9392007
1.60	0.55	0.57	191.1159145
1.80	0.62	0.43	144.1751635
2.00	0.69	0.32	107.293145
2.20	0.76	0.24	80.46985872
2.40	0.83	0.18	60.35239404
2.60	0.90	0.13	43.58784014
2.80	0.96	0.098	32.85852565
3.50	1.21	0.036	12.07047881
4.00	1.38	0.018	6.035239404
4.50	1.55	0.009	3.017619702
5.00	1.72	0.004	1.341164312

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	6.838063
0.20	0.07	0.075	34.19031
0.30	0.10	0.16	72.93934
0.40	0.14	0.28	127.6438
0.50	0.17	0.43	196.0245
0.60	0.21	0.6	273.5225
0.70	0.24	0.77	351.0206
0.80	0.28	0.89	405.7251
1.00	0.34	1	455.8709
1.10	0.38	0.98	446.7534
1.20	0.41	0.92	419.4012
1.30	0.45	0.84	382.9315
1.40	0.48	0.75	341.9031
1.50	0.52	0.65	296.3161
1.60	0.55	0.57	259.8464
1.80	0.62	0.43	196.0245
2.00	0.69	0.32	145.8787
2.20	0.76	0.24	109.409
2.40	0.83	0.18	82.05675
2.60	0.90	0.13	59.26321
2.80	0.96	0.098	44.67534
3.50	1.21	0.036	16.41135
4.00	1.38	0.018	8.205675
4.50	1.55	0.009	4.102838
5.00	1.72	0.004	1.823483

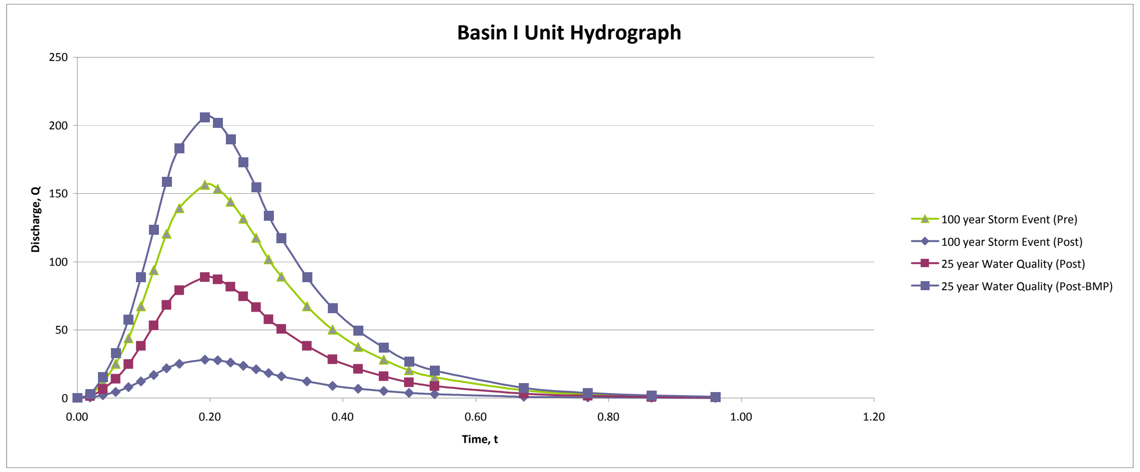
100yr (post w/IMP)

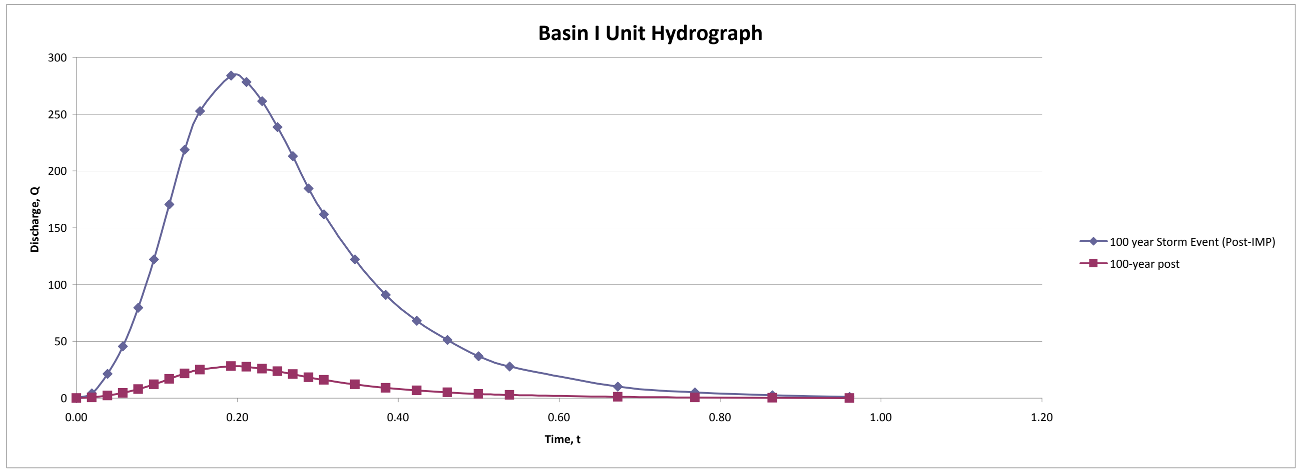
Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	9.709923
0.20	0.07	0.075	48.54962
0.30	0.10	0.16	103.5725
0.40	0.14	0.28	181.2519
0.50	0.17	0.43	278.3511
0.60	0.21	0.6	388.3969
0.70	0.24	0.77	498.4427
0.80	0.28	0.89	576.1221
1.00	0.34	1	647.3282
1.10	0.38	0.98	634.3817
1.20	0.41	0.92	595.542
1.30	0.45	0.84	543.7557
1.40	0.48	0.75	485.4962
1.50	0.52	0.65	420.7634
1.60	0.55	0.57	368.9771
1.80	0.62	0.43	278.3511
2.00	0.69	0.32	207.145
2.20	0.76	0.24	155.3588
2.40	0.83	0.18	116.5191
2.60	0.90	0.13	84.15267
2.80	0.96	0.098	63.43817
3.50	1.21	0.036	23.30382
4.00	1.38	0.018	11.65191
4.50	1.55	0.009	5.825954
5.00	1.72	0.004	2.589313

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.112	Tc	0.112	Tc	0.112	Tc	0.112	Tc	0.112	Tc	0.112
Tp	0.1922	Tp	0.1922	Tp	0.1922	Tp	0.1922	Tp	0.1922	Tp	0.1922
A (sq miles)	0.0135	A (sq miles)	0.0135	A (sq miles)	0.0135	A (sq miles)	0.0135	A (sq miles)	0.0135	A (sq miles)	0.0135
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	88	CN	88	CN	88	CN	88	CN	88	CN	88
S	1.363636364	S	1.363636	S	1.363636	S	1.363636	S	1.36363636	S	1.363636364
Q (1-yr)	2.087125918	Q (2-yr)	6.568182	Q (10-yr)	11.59467	Q (25-yr)	15.26757	Q (100-yr)	21.0421266	Q (500-yr)	49.09954043
Ia	0.272727273	Ia	0.272727	Ia	0.272727	Ia	0.272727	Ia	0.27272727	Ia	0.272727273
Ia/P (1-yr)	0.082644628	Ia/P (2-yr)	0.034091	Ia/P (10-yr)	0.020819	Ia/P (25-yr)	0.016234	Ia/P (100-yr)	0.01206758	Ia/P (500-yr)	0.005379236
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	1000	qu from chart	1000	qu from chart	1000	qu from chart	1000	qu from chart	1000	qu from chart	1000
Qp (1-yr) =	28.17619989	Qp (2-yr) =	88.67045	Qp (10-yr) =	156.5281	Qp (25-yr) =	206.1122	Qp (100-yr) =	284.068709	Qp (500-yr) =	662.8437958

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	0.422642998
0.20	0.04	0.075	2.113214992
0.30	0.06	0.16	4.508191982
0.40	0.08	0.28	7.889335968
0.50	0.10	0.43	12.11576595
0.60	0.12	0.6	16.90571993
0.70	0.13	0.77	21.69567391
0.80	0.15	0.89	25.0768179
1.00	0.19	1	28.17619989
1.10	0.21	0.98	27.61267589
1.20	0.23	0.92	25.9221039
1.30	0.25	0.84	23.66800791
1.40	0.27	0.75	21.13214992
1.50	0.29	0.65	18.31452993
1.60	0.31	0.57	16.06043394
1.80	0.35	0.43	12.11576595
2.00	0.38	0.32	9.016383964
2.20	0.42	0.24	6.762287973
2.40	0.46	0.18	5.07171598
2.60	0.50	0.13	3.662905985
2.80	0.54	0.098	2.761267589
3.50	0.67	0.036	1.014343196
4.00	0.77	0.018	0.507171598
4.50	0.86	0.009	0.253585799
5.00	0.96	0.004	0.1127048





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	1.330056818
0.20	0.04	0.075	6.650284091
0.30	0.06	0.16	14.18727273
0.40	0.08	0.28	24.82772727
0.50	0.10	0.43	38.12829545
0.60	0.12	0.6	53.20227273
0.70	0.13	0.77	68.27625
0.80	0.15	0.89	78.91670455
1.00	0.19	1	88.67045455
1.10	0.21	0.98	86.89704545
1.20	0.23	0.92	81.57681818
1.30	0.25	0.84	74.48318182
1.40	0.27	0.75	66.50284091
1.50	0.29	0.65	57.63579545
1.60	0.31	0.57	50.54215909
1.80	0.35	0.43	38.12829545
2.00	0.38	0.32	28.37454545
2.20	0.42	0.24	21.28090909
2.40	0.46	0.18	15.96068182
2.60	0.50	0.13	11.52715909
2.80	0.54	0.098	8.689704545
3.50	0.67	0.036	3.192136364
4.00	0.77	0.018	1.596068182
4.50	0.86	0.009	0.798034091
5.00	0.96	0.004	0.354681818

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	2.347920928
0.20	0.04	0.075	11.73960464
0.30	0.06	0.16	25.0444899
0.40	0.08	0.28	43.82785732
0.50	0.10	0.43	67.30706659
0.60	0.12	0.6	93.91683711
0.70	0.13	0.77	120.5266076
0.80	0.15	0.89	139.309975
1.00	0.19	1	156.5280618
1.10	0.21	0.98	153.3975006
1.20	0.23	0.92	144.0058169
1.30	0.25	0.84	131.483572
1.40	0.27	0.75	117.3960464
1.50	0.29	0.65	101.7432402
1.60	0.31	0.57	89.22099525
1.80	0.35	0.43	67.30706659
2.00	0.38	0.32	50.08897979
2.20	0.42	0.24	37.56673484
2.40	0.46	0.18	28.17505113
2.60	0.50	0.13	20.34864804
2.80	0.54	0.098	15.33975006
3.50	0.67	0.036	5.635010227
4.00	0.77	0.018	2.817505113
4.50	0.86	0.009	1.408752557
5.00	0.96	0.004	0.626112247

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	3.091683
0.20	0.04	0.075	15.45842
0.30	0.06	0.16	32.97796
0.40	0.08	0.28	57.71142
0.50	0.10	0.43	88.62826
0.60	0.12	0.6	123.6673
0.70	0.13	0.77	158.7064
0.80	0.15	0.89	183.4399
1.00	0.19	1	206.1122
1.10	0.21	0.98	201.99
1.20	0.23	0.92	189.6232
1.30	0.25	0.84	173.1343
1.40	0.27	0.75	154.5842
1.50	0.29	0.65	133.9729
1.60	0.31	0.57	117.484
1.80	0.35	0.43	88.62826
2.00	0.38	0.32	65.95591
2.20	0.42	0.24	49.46693
2.40	0.46	0.18	37.1002
2.60	0.50	0.13	26.79459
2.80	0.54	0.098	20.199
3.50	0.67	0.036	7.42004
4.00	0.77	0.018	3.71002
4.50	0.86	0.009	1.85501
5.00	0.96	0.004	0.824449

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	4.261031
0.20	0.04	0.075	21.30515
0.30	0.06	0.16	45.45099
0.40	0.08	0.28	79.53924
0.50	0.10	0.43	122.1495
0.60	0.12	0.6	170.4412
0.70	0.13	0.77	218.7329
0.80	0.15	0.89	252.8212
1.00	0.19	1	284.0687
1.10	0.21	0.98	278.3873
1.20	0.23	0.92	261.3432
1.30	0.25	0.84	238.6177
1.40	0.27	0.75	213.0515
1.50	0.29	0.65	184.6447
1.60	0.31	0.57	161.9192
1.80	0.35	0.43	122.1495
2.00	0.38	0.32	90.90199
2.20	0.42	0.24	68.17649
2.40	0.46	0.18	51.13237
2.60	0.50	0.13	36.92893
2.80	0.54	0.098	27.83873
3.50	0.67	0.036	10.22647
4.00	0.77	0.018	5.113237
4.50	0.86	0.009	2.556618
5.00	0.96	0.004	1.136275

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	0.689539649
0.20	0.05	0.075	3.447698243
0.30	0.07	0.16	7.355089586
0.40	0.10	0.28	12.87140677
0.50	0.12	0.43	19.76680326
0.60	0.15	0.6	27.58158595
0.70	0.17	0.77	35.39636863
0.80	0.20	0.89	40.91268582
1.00	0.25	1	45.96930991
1.10	0.27	0.98	45.04992371
1.20	0.30	0.92	42.29176512
1.30	0.32	0.84	38.61422032
1.40	0.35	0.75	34.47698243
1.50	0.37	0.65	29.88005144
1.60	0.40	0.57	26.20250665
1.80	0.45	0.43	19.76680326
2.00	0.49	0.32	14.71017917
2.20	0.54	0.24	11.03263438
2.40	0.59	0.18	8.274475784
2.60	0.64	0.13	5.976010288
2.80	0.69	0.098	4.504992371
3.50	0.87	0.036	1.654895157
4.00	0.99	0.018	0.827447578
4.50	1.11	0.009	0.413723789
5.00	1.24	0.004	0.18387724

Duration, D	0.25
Tc	0.204
Tp	0.2474
A (sq miles)	0.042
P (1-yr)	3.3
CN	79
S	2.658227848
Q (1-yr)	1.412267586
Ia	0.53164557
Ia/P (1-yr)	0.161104718
use Ia/P min	0.1
qu from chart	775
Qp (1-yr) =	45.96930991

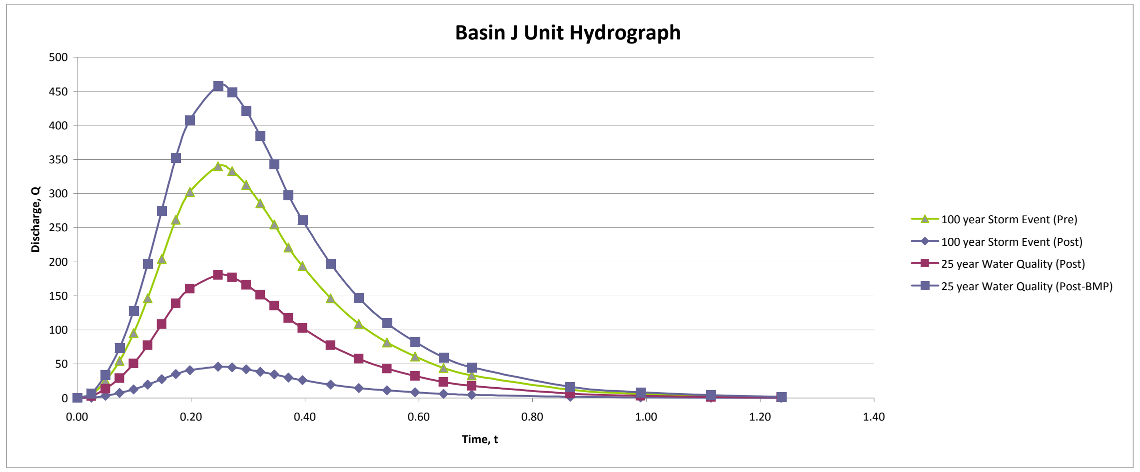
Duration, D	0.25
Tc	0.204
Tp	0.2474
A (sq miles)	0.042
P (2-yr)	8
CN	79
S	2.658228
Q (2-yr)	5.507911
Ia	0.531646
Ia/P (2-yr)	0.066456
use Ia/P min	0.1
qu from chart	780
Qp (2-yr) =	180.4392

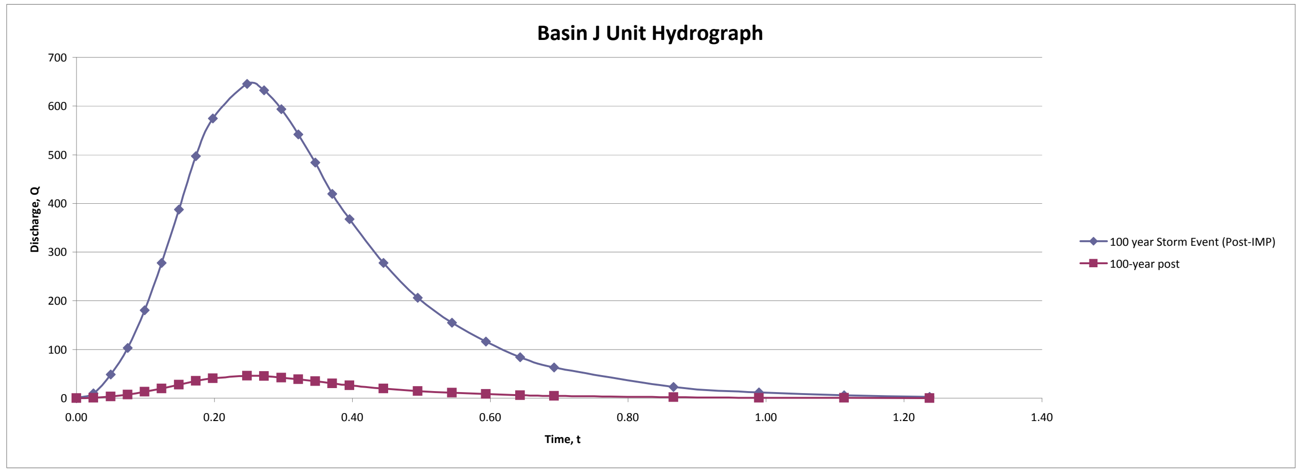
Duration, D	0.25
Tc	0.204
Tp	0.2474
A (sq miles)	0.042
P (10-yr)	13.1
CN	79
S	2.658228
Q (10-yr)	10.37419
Ia	0.531646
Ia/P (10-yr)	0.040584
use Ia/P min	0.1
qu from chart	780
Qp (10-yr) =	339.8586

Duration, D	0.25
Tc	0.204
Tp	0.2474
A (sq miles)	0.042
P (25-yr)	16.8
CN	79
S	2.658228
Q (25-yr)	13.98347
Ia	0.531646
Ia/P (25-yr)	0.031646
use Ia/P min	0.1
qu from chart	780
Qp (25-yr) =	458.0986

Duration, D	0.25
Tc	0.204
Tp	0.2474
A (sq miles)	0.042
P (100-yr)	22.6
CN	79
S	2.65822785
Q (100-yr)	19.695899
Ia	0.53164557
Ia/P (100-yr)	0.02352414
use Ia/P min	0.1
qu from chart	780
Qp (100-yr) =	645.237651

Duration, D	0.25
Tc	0.204
Tp	0.2474
A (sq miles)	0.042
P (500-yr)	50.7
CN	79
S	2.658227848
Q (500-yr)	47.64388832
Ia	0.53164557
Ia/P (500-yr)	0.010486106
use Ia/P min	0.1
qu from chart	780
Qp (500-yr) =	1560.813781





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	2.706587658
0.20	0.05	0.075	13.53293829
0.30	0.07	0.16	28.87026835
0.40	0.10	0.28	50.52296962
0.50	0.12	0.43	77.5888462
0.60	0.15	0.6	108.2635063
0.70	0.17	0.77	138.9381665
0.80	0.20	0.89	160.5908677
1.00	0.25	1	180.4391772
1.10	0.27	0.98	176.8303937
1.20	0.30	0.92	166.004043
1.30	0.32	0.84	151.5689089
1.40	0.35	0.75	135.3293829
1.50	0.37	0.65	117.2854652
1.60	0.40	0.57	102.850331
1.80	0.45	0.43	77.5888462
2.00	0.49	0.32	57.74053671
2.20	0.54	0.24	43.30540253
2.40	0.59	0.18	32.4790519
2.60	0.64	0.13	23.45709304
2.80	0.69	0.098	17.68303937
3.50	0.87	0.036	6.49581038
4.00	0.99	0.018	3.24790519
4.50	1.11	0.009	1.623952595
5.00	1.24	0.004	0.721756709

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	5.097879402
0.20	0.05	0.075	25.48939701
0.30	0.07	0.16	54.37738029
0.40	0.10	0.28	95.1604155
0.50	0.12	0.43	146.1392095
0.60	0.15	0.6	203.9151761
0.70	0.17	0.77	261.6911426
0.80	0.20	0.89	302.4741778
1.00	0.25	1	339.8586268
1.10	0.27	0.98	333.0614543
1.20	0.30	0.92	312.6699367
1.30	0.32	0.84	285.4812465
1.40	0.35	0.75	254.8939701
1.50	0.37	0.65	220.9081074
1.60	0.40	0.57	193.7194173
1.80	0.45	0.43	146.1392095
2.00	0.49	0.32	108.7547606
2.20	0.54	0.24	81.56607043
2.40	0.59	0.18	61.17455282
2.60	0.64	0.13	44.18162148
2.80	0.69	0.098	33.30614543
3.50	0.87	0.036	12.23491056
4.00	0.99	0.018	6.117455282
4.50	1.11	0.009	3.058727641
5.00	1.24	0.004	1.359434507

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	6.871479
0.20	0.05	0.075	34.35739
0.30	0.07	0.16	73.29577
0.40	0.10	0.28	128.2676
0.50	0.12	0.43	196.9824
0.60	0.15	0.6	274.8591
0.70	0.17	0.77	352.7359
0.80	0.20	0.89	407.7077
1.00	0.25	1	458.0986
1.10	0.27	0.98	448.9366
1.20	0.30	0.92	421.4507
1.30	0.32	0.84	384.8028
1.40	0.35	0.75	343.5739
1.50	0.37	0.65	297.7641
1.60	0.40	0.57	261.1162
1.80	0.45	0.43	196.9824
2.00	0.49	0.32	146.5915
2.20	0.54	0.24	109.9437
2.40	0.59	0.18	82.45774
2.60	0.64	0.13	59.55282
2.80	0.69	0.098	44.89366
3.50	0.87	0.036	16.49155
4.00	0.99	0.018	8.245774
4.50	1.11	0.009	4.122887
5.00	1.24	0.004	1.832394

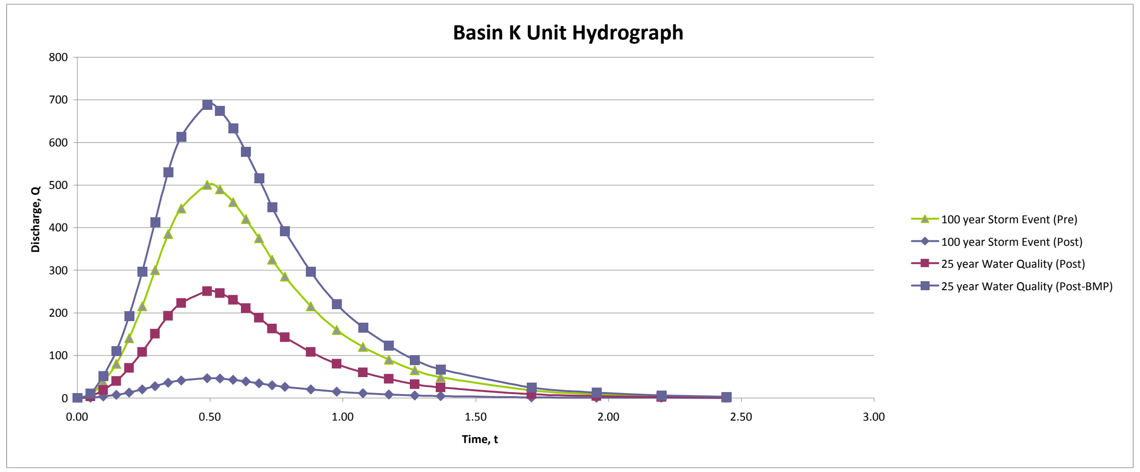
100yr (post w/IMP)

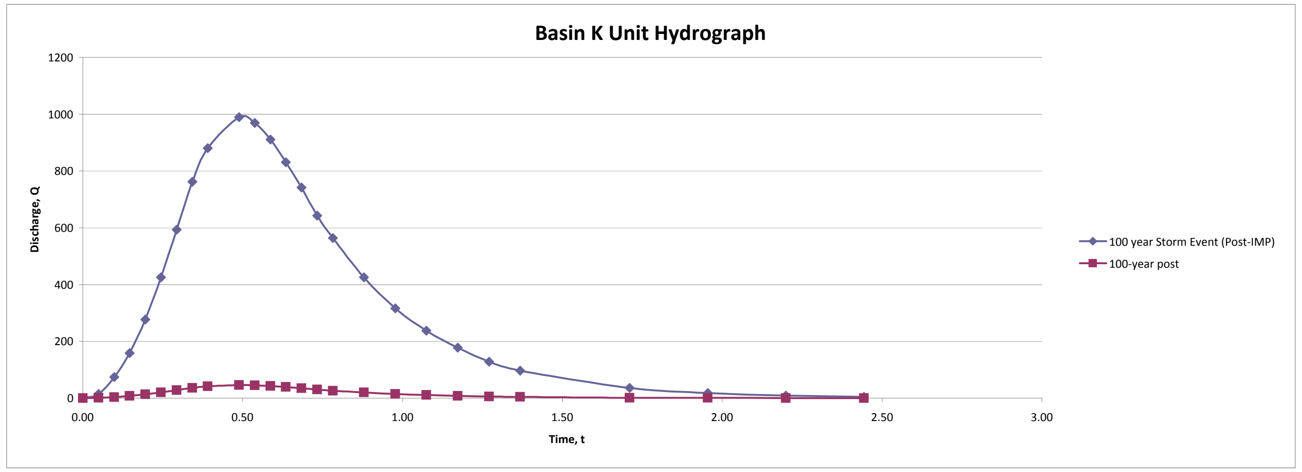
Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	9.678565
0.20	0.05	0.075	48.39282
0.30	0.07	0.16	103.238
0.40	0.10	0.28	180.6665
0.50	0.12	0.43	277.4522
0.60	0.15	0.6	387.1426
0.70	0.17	0.77	496.833
0.80	0.20	0.89	574.2615
1.00	0.25	1	645.2377
1.10	0.27	0.98	632.3329
1.20	0.30	0.92	593.6186
1.30	0.32	0.84	541.9996
1.40	0.35	0.75	483.9282
1.50	0.37	0.65	419.4045
1.60	0.40	0.57	367.7855
1.80	0.45	0.43	277.4522
2.00	0.49	0.32	206.476
2.20	0.54	0.24	154.857
2.40	0.59	0.18	116.1428
2.60	0.64	0.13	83.88089
2.80	0.69	0.098	63.23329
3.50	0.87	0.036	23.22856
4.00	0.99	0.018	11.61428
4.50	1.11	0.009	5.807139
5.00	1.24	0.004	2.580951

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	0.695775458
0.20	0.10	0.075	3.478877288
0.30	0.15	0.16	7.42160488
0.40	0.20	0.28	12.98780854
0.50	0.24	0.43	19.94556312
0.60	0.29	0.6	27.8310183
0.70	0.34	0.77	35.71647349
0.80	0.39	0.89	41.28267715
1.00	0.49	1	46.3850305
1.10	0.54	0.98	45.45732989
1.20	0.59	0.92	42.67422806
1.30	0.64	0.84	38.96342562
1.40	0.68	0.75	34.78877288
1.50	0.73	0.65	30.15026983
1.60	0.78	0.57	26.43946739
1.80	0.88	0.43	19.94556312
2.00	0.98	0.32	14.84320976
2.20	1.07	0.24	11.13240732
2.40	1.17	0.18	8.34930549
2.60	1.27	0.13	6.030053965
2.80	1.37	0.098	4.545732989
3.50	1.71	0.036	1.669861098
4.00	1.95	0.018	0.834930549
4.50	2.20	0.009	0.417465275
5.00	2.44	0.004	0.185540122

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.606	Tc	0.606	Tc	0.606	Tc	0.606	Tc	0.606	Tc	0.606
Tp	0.4886	Tp	0.4886	Tp	0.4886	Tp	0.4886	Tp	0.4886	Tp	0.4886
A (sq miles)	0.1113	A (sq miles)	0.1113	A (sq miles)	0.1113	A (sq miles)	0.1113	A (sq miles)	0.1113	A (sq miles)	0.1113
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	72	CN	72	CN	72	CN	72	CN	72	CN	72
S	3.888888889	S	3.888889	S	3.888889	S	3.888889	S	3.88888889	S	3.888888889
Q (1-yr)	0.992278067	Q (2-yr)	4.694444	Q (10-yr)	9.36624	Q (25-yr)	12.89288	Q (100-yr)	18.5215404	Q (500-yr)	46.31438043
Ia	0.777777778	Ia	0.777778	Ia	0.777778	Ia	0.777778	Ia	0.77777778	Ia	0.777777778
Ia/P (1-yr)	0.235690236	Ia/P (2-yr)	0.097222	Ia/P (10-yr)	0.059372	Ia/P (25-yr)	0.046296	Ia/P (100-yr)	0.03441495	Ia/P (500-yr)	0.015340785
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	420	qu from chart	480	qu from chart	480	qu from chart	480	qu from chart	480	qu from chart	480
Qp (1-yr) =	46.3850305	Qp (2-yr) =	250.796	Qp (10-yr) =	500.382	Qp (25-yr) =	688.7893	Qp (100-yr) =	989.494773	Qp (500-yr) =	2474.29946





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	3.76194
0.20	0.10	0.075	18.8097
0.30	0.15	0.16	40.12736
0.40	0.20	0.28	70.22288
0.50	0.24	0.43	107.84228
0.60	0.29	0.6	150.4776
0.70	0.34	0.77	193.11292
0.80	0.39	0.89	223.20844
1.00	0.49	1	250.796
1.10	0.54	0.98	245.78008
1.20	0.59	0.92	230.73232
1.30	0.64	0.84	210.66864
1.40	0.68	0.75	188.097
1.50	0.73	0.65	163.0174
1.60	0.78	0.57	142.95372
1.80	0.88	0.43	107.84228
2.00	0.98	0.32	80.25472
2.20	1.07	0.24	60.19104
2.40	1.17	0.18	45.14328
2.60	1.27	0.13	32.60348
2.80	1.37	0.098	24.578008
3.50	1.71	0.036	9.028656
4.00	1.95	0.018	4.514328
4.50	2.20	0.009	2.257164
5.00	2.44	0.004	1.003184

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	7.505730243
0.20	0.10	0.075	37.52865121
0.30	0.15	0.16	80.06112259
0.40	0.20	0.28	140.1069645
0.50	0.24	0.43	215.164267
0.60	0.29	0.6	300.2292097
0.70	0.34	0.77	385.2941525
0.80	0.39	0.89	445.3399944
1.00	0.49	1	500.3820162
1.10	0.54	0.98	490.3743759
1.20	0.59	0.92	460.3514549
1.30	0.64	0.84	420.3208936
1.40	0.68	0.75	375.2865121
1.50	0.73	0.65	325.2483105
1.60	0.78	0.57	285.2177492
1.80	0.88	0.43	215.164267
2.00	0.98	0.32	160.1222452
2.20	1.07	0.24	120.0916839
2.40	1.17	0.18	90.06876291
2.60	1.27	0.13	65.0496621
2.80	1.37	0.098	49.03743759
3.50	1.71	0.036	18.01375258
4.00	1.95	0.018	9.006876291
4.50	2.20	0.009	4.503438146
5.00	2.44	0.004	2.001528065

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	10.33184
0.20	0.10	0.075	51.6592
0.30	0.15	0.16	110.2063
0.40	0.20	0.28	192.861
0.50	0.24	0.43	296.1794
0.60	0.29	0.6	413.2736
0.70	0.34	0.77	530.3678
0.80	0.39	0.89	613.0225
1.00	0.49	1	688.7893
1.10	0.54	0.98	675.0135
1.20	0.59	0.92	633.6862
1.30	0.64	0.84	578.583
1.40	0.68	0.75	516.592
1.50	0.73	0.65	447.7131
1.60	0.78	0.57	392.6099
1.80	0.88	0.43	296.1794
2.00	0.98	0.32	220.4126
2.20	1.07	0.24	165.3094
2.40	1.17	0.18	123.9821
2.60	1.27	0.13	89.54261
2.80	1.37	0.098	67.50135
3.50	1.71	0.036	24.79642
4.00	1.95	0.018	12.39821
4.50	2.20	0.009	6.199104
5.00	2.44	0.004	2.755157

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.05	0.015	14.84242
0.20	0.10	0.075	74.21211
0.30	0.15	0.16	158.3192
0.40	0.20	0.28	277.0585
0.50	0.24	0.43	425.4828
0.60	0.29	0.6	593.6969
0.70	0.34	0.77	761.911
0.80	0.39	0.89	880.6503
1.00	0.49	1	989.4948
1.10	0.54	0.98	969.7049
1.20	0.59	0.92	910.3352
1.30	0.64	0.84	831.1756
1.40	0.68	0.75	742.1211
1.50	0.73	0.65	643.1716
1.60	0.78	0.57	564.012
1.80	0.88	0.43	425.4828
2.00	0.98	0.32	316.6383
2.20	1.07	0.24	237.4787
2.40	1.17	0.18	178.1091
2.60	1.27	0.13	128.6343
2.80	1.37	0.098	96.97049
3.50	1.71	0.036	35.62181
4.00	1.95	0.018	17.81091
4.50	2.20	0.009	8.905453
5.00	2.44	0.004	3.957979

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	0.436972287
0.20	0.05	0.075	2.184861437
0.30	0.07	0.16	4.661037732
0.40	0.10	0.28	8.156816031
0.50	0.12	0.43	12.52653891
0.60	0.15	0.6	17.4788915
0.70	0.17	0.77	22.43124409
0.80	0.20	0.89	25.92702239
1.00	0.25	1	29.13148583
1.10	0.27	0.98	28.54885611
1.20	0.30	0.92	26.80096696
1.30	0.32	0.84	24.47044809
1.40	0.35	0.75	21.84861437
1.50	0.37	0.65	18.93546579
1.60	0.40	0.57	16.60494692
1.80	0.45	0.43	12.52653891
2.00	0.50	0.32	9.322075464
2.20	0.55	0.24	6.991556598
2.40	0.60	0.18	5.243667449
2.60	0.64	0.13	3.787093157
2.80	0.69	0.098	2.854885611
3.50	0.87	0.036	1.04873349
4.00	0.99	0.018	0.524366745
4.50	1.12	0.009	0.262183372
5.00	1.24	0.004	0.116525943

Duration, D	0.25
Tc	0.205
Tp	0.248
A (sq miles)	0.0428
P (1-yr)	3.3
CN	71
S	4.084507042
Q (1-yr)	0.938816817
Ia	0.816901408
Ia/P (1-yr)	0.247545881
use Ia/P min	0.1
qu from chart	725
Qp (1-yr) =	29.13148583

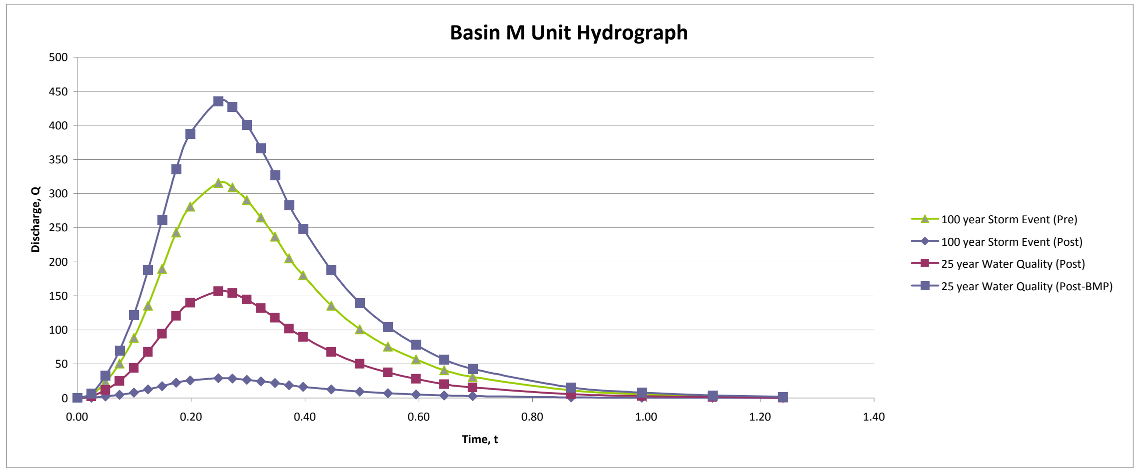
Duration, D	0.25
Tc	0.205
Tp	0.248
A (sq miles)	0.0428
P (2-yr)	8
CN	71
S	4.084507
Q (2-yr)	4.579225
Ia	0.816901
Ia/P (2-yr)	0.102113
use Ia/P min	0.1
qu from chart	800
Qp (2-yr) =	156.7927

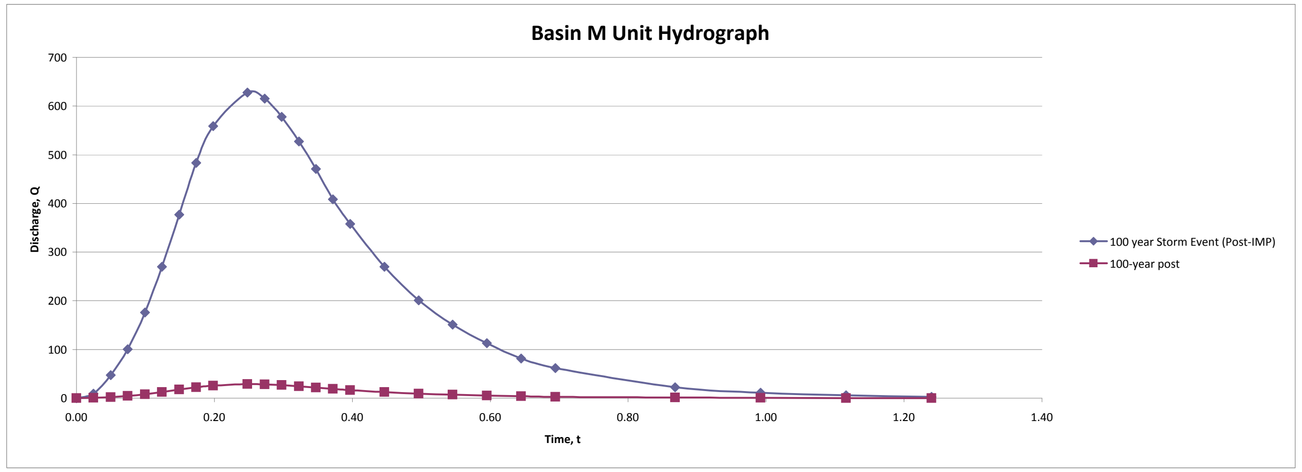
Duration, D	0.25
Tc	0.205
Tp	0.248
A (sq miles)	0.0428
P (10-yr)	13.1
CN	71
S	4.084507
Q (10-yr)	9.217873
Ia	0.816901
Ia/P (10-yr)	0.062359
use Ia/P min	0.1
qu from chart	800
Qp (10-yr) =	315.62

Duration, D	0.25
Tc	0.205
Tp	0.248
A (sq miles)	0.0428
P (25-yr)	16.8
CN	71
S	4.084507
Q (25-yr)	12.72994
Ia	0.816901
Ia/P (25-yr)	0.048625
use Ia/P min	0.1
qu from chart	800
Qp (25-yr) =	435.8732

Duration, D	0.25
Tc	0.205
Tp	0.248
A (sq miles)	0.0428
P (100-yr)	22.6
CN	71
S	4.08450704
Q (100-yr)	18.3435371
Ia	0.81690141
Ia/P (100-yr)	0.03614608
use Ia/P min	0.1
qu from chart	800
Qp (100-yr) =	628.082711

Duration, D	0.25
Tc	0.205
Tp	0.248
A (sq miles)	0.0428
P (500-yr)	50.7
CN	71
S	4.084507042
Q (500-yr)	46.1077251
Ia	0.816901408
Ia/P (500-yr)	0.016112454
use Ia/P min	0.1
qu from chart	800
Qp (500-yr) =	1578.728508





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	2.351890141
0.20	0.05	0.075	11.7594507
0.30	0.07	0.16	25.08682817
0.40	0.10	0.28	43.9019493
0.50	0.12	0.43	67.4208507
0.60	0.15	0.6	94.07560563
0.70	0.17	0.77	120.7303606
0.80	0.20	0.89	139.5454817
1.00	0.25	1	156.7926761
1.10	0.27	0.98	153.6568225
1.20	0.30	0.92	144.249262
1.30	0.32	0.84	131.7058479
1.40	0.35	0.75	117.594507
1.50	0.37	0.65	101.9152394
1.60	0.40	0.57	89.37182535
1.80	0.45	0.43	67.4208507
2.00	0.50	0.32	50.17365634
2.20	0.55	0.24	37.63024225
2.40	0.60	0.18	28.22268169
2.60	0.64	0.13	20.38304789
2.80	0.69	0.098	15.36568225
3.50	0.87	0.036	5.644536338
4.00	0.99	0.018	2.822268169
4.50	1.12	0.009	1.411134085
5.00	1.24	0.004	0.627170704

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	4.734299603
0.20	0.05	0.075	23.67149802
0.30	0.07	0.16	50.49919577
0.40	0.10	0.28	88.37359259
0.50	0.12	0.43	135.7165886
0.60	0.15	0.6	189.3719841
0.70	0.17	0.77	243.0273796
0.80	0.20	0.89	280.9017764
1.00	0.25	1	315.6199735
1.10	0.27	0.98	309.3075741
1.20	0.30	0.92	290.3703757
1.30	0.32	0.84	265.1207778
1.40	0.35	0.75	236.7149802
1.50	0.37	0.65	205.1529828
1.60	0.40	0.57	179.9033849
1.80	0.45	0.43	135.7165886
2.00	0.50	0.32	100.9983915
2.20	0.55	0.24	75.74879365
2.40	0.60	0.18	56.81159524
2.60	0.64	0.13	41.03059656
2.80	0.69	0.098	30.93075741
3.50	0.87	0.036	11.36231905
4.00	0.99	0.018	5.681159524
4.50	1.12	0.009	2.840579762
5.00	1.24	0.004	1.262479894

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	6.538098
0.20	0.05	0.075	32.69049
0.30	0.07	0.16	69.73971
0.40	0.10	0.28	122.0445
0.50	0.12	0.43	187.4255
0.60	0.15	0.6	261.5239
0.70	0.17	0.77	335.6224
0.80	0.20	0.89	387.9271
1.00	0.25	1	435.8732
1.10	0.27	0.98	427.1557
1.20	0.30	0.92	401.0033
1.30	0.32	0.84	366.1335
1.40	0.35	0.75	326.9049
1.50	0.37	0.65	283.3176
1.60	0.40	0.57	248.4477
1.80	0.45	0.43	187.4255
2.00	0.50	0.32	139.4794
2.20	0.55	0.24	104.6096
2.40	0.60	0.18	78.45717
2.60	0.64	0.13	56.66351
2.80	0.69	0.098	42.71557
3.50	0.87	0.036	15.69143
4.00	0.99	0.018	7.845717
4.50	1.12	0.009	3.922859
5.00	1.24	0.004	1.743493

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	9.421241
0.20	0.05	0.075	47.1062
0.30	0.07	0.16	100.4932
0.40	0.10	0.28	175.8632
0.50	0.12	0.43	270.0756
0.60	0.15	0.6	376.8496
0.70	0.17	0.77	483.6237
0.80	0.20	0.89	558.9936
1.00	0.25	1	628.0827
1.10	0.27	0.98	615.5211
1.20	0.30	0.92	577.8361
1.30	0.32	0.84	527.5895
1.40	0.35	0.75	471.062
1.50	0.37	0.65	408.2538
1.60	0.40	0.57	358.0071
1.80	0.45	0.43	270.0756
2.00	0.50	0.32	200.9865
2.20	0.55	0.24	150.7399
2.40	0.60	0.18	113.0549
2.60	0.64	0.13	81.65075
2.80	0.69	0.098	61.55211
3.50	0.87	0.036	22.61098
4.00	0.99	0.018	11.30549
4.50	1.12	0.009	5.652744
5.00	1.24	0.004	2.512331

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.805522124
0.20	0.06	0.075	4.027610621
0.30	0.09	0.16	8.59223599
0.40	0.12	0.28	15.03641298
0.50	0.15	0.43	23.09163422
0.60	0.18	0.6	32.22088496
0.70	0.21	0.77	41.3501357
0.80	0.24	0.89	47.7943127
1.00	0.30	1	53.70147494
1.10	0.33	0.98	52.62744544
1.20	0.36	0.92	49.40535695
1.30	0.39	0.84	45.10923895
1.40	0.42	0.75	40.27610621
1.50	0.45	0.65	34.90595871
1.60	0.48	0.57	30.60984072
1.80	0.53	0.43	23.09163422
2.00	0.59	0.32	17.18447198
2.20	0.65	0.24	12.88835399
2.40	0.71	0.18	9.666265489
2.60	0.77	0.13	6.981191742
2.80	0.83	0.098	5.262744544
3.50	1.04	0.036	1.933253098
4.00	1.19	0.018	0.966626549
4.50	1.34	0.009	0.483313274
5.00	1.49	0.004	0.2148059

Duration, D	0.25
Tc	0.287
Tp	0.2972
A (sq miles)	0.0585
P (1-yr)	3.3
CN	79
S	2.658227848
Q (1-yr)	1.412267586
Ia	0.53164557
Ia/P (1-yr)	0.161104718
use Ia/P min	0.1
qu from chart	650
Qp (1-yr) =	53.70147494

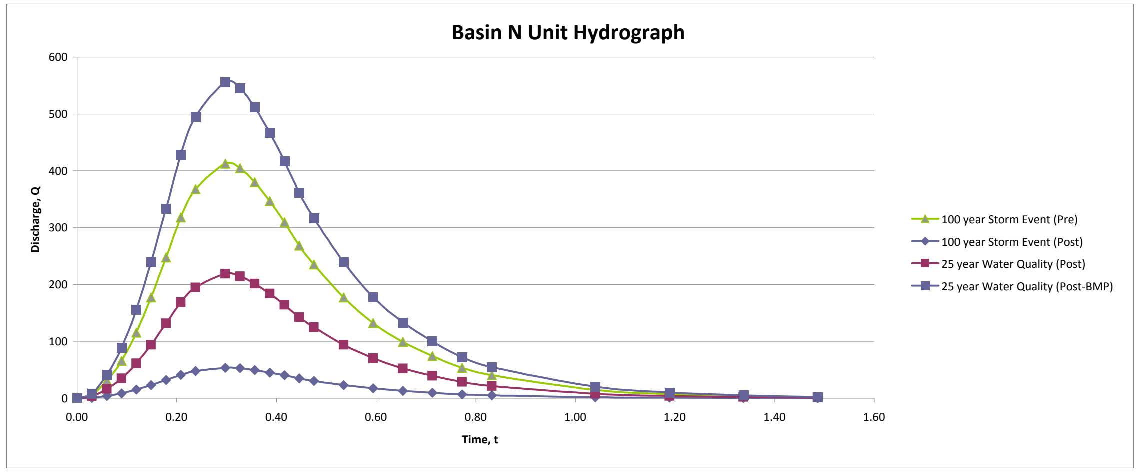
Duration, D	0.25
Tc	0.287
Tp	0.2972
A (sq miles)	0.0585
P (2-yr)	8
CN	79
S	2.658228
Q (2-yr)	5.507911
Ia	0.531646
Ia/P (2-yr)	0.066456
use Ia/P min	0.1
qu from chart	680
Qp (2-yr) =	219.1047

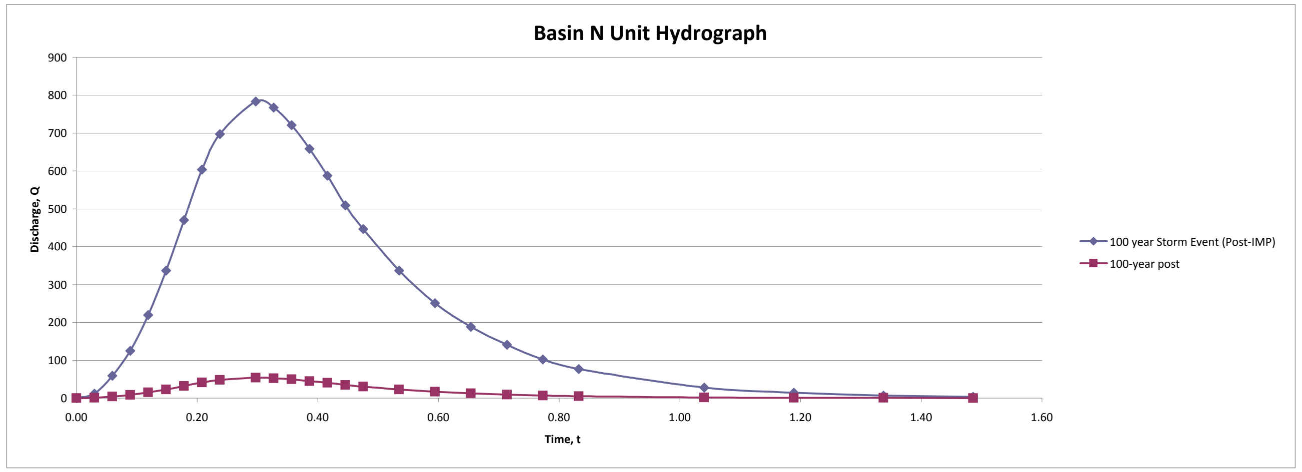
Duration, D	0.25
Tc	0.287
Tp	0.2972
A (sq miles)	0.0585
P (10-yr)	13.1
CN	79
S	2.658228
Q (10-yr)	10.37419
Ia	0.531646
Ia/P (10-yr)	0.040584
use Ia/P min	0.1
qu from chart	680
Qp (10-yr) =	412.6855

Duration, D	0.25
Tc	0.287
Tp	0.2972
A (sq miles)	0.0585
P (25-yr)	16.8
CN	79
S	2.658228
Q (25-yr)	13.98347
Ia	0.531646
Ia/P (25-yr)	0.031646
use Ia/P min	0.1
qu from chart	680
Qp (25-yr) =	556.2626

Duration, D	0.25
Tc	0.287
Tp	0.2972
A (sq miles)	0.0585
P (100-yr)	22.6
CN	79
S	2.65822785
Q (100-yr)	19.695899
Ia	0.53164557
Ia/P (100-yr)	0.02352414
use Ia/P min	0.1
qu from chart	680
Qp (100-yr) =	783.502862

Duration, D	0.25
Tc	0.287
Tp	0.2972
A (sq miles)	0.0585
P (500-yr)	50.7
CN	79
S	2.658227848
Q (500-yr)	47.64388832
Ia	0.53164557
Ia/P (500-yr)	0.010486106
use Ia/P min	0.1
qu from chart	680
Qp (500-yr) =	1895.273877





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	3.286570728
0.20	0.06	0.075	16.43285364
0.30	0.09	0.16	35.05675443
0.40	0.12	0.28	61.34932025
0.50	0.15	0.43	94.21502753
0.60	0.18	0.6	131.4628291
0.70	0.21	0.77	168.7106307
0.80	0.24	0.89	195.0031965
1.00	0.30	1	219.1047152
1.10	0.33	0.98	214.7226209
1.20	0.36	0.92	201.576338
1.30	0.39	0.84	184.0479608
1.40	0.42	0.75	164.3285364
1.50	0.45	0.65	142.4180649
1.60	0.48	0.57	124.8896877
1.80	0.53	0.43	94.21502753
2.00	0.59	0.32	70.11350886
2.20	0.65	0.24	52.58513165
2.40	0.71	0.18	39.43884873
2.60	0.77	0.13	28.48361297
2.80	0.83	0.098	21.47226209
3.50	1.04	0.036	7.887769747
4.00	1.19	0.018	3.943884873
4.50	1.34	0.009	1.971942437
5.00	1.49	0.004	0.876418861

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	6.190282131
0.20	0.06	0.075	30.95141065
0.30	0.09	0.16	66.02967606
0.40	0.12	0.28	115.5519331
0.50	0.15	0.43	177.4547544
0.60	0.18	0.6	247.6112852
0.70	0.21	0.77	317.7678161
0.80	0.24	0.89	367.2900731
1.00	0.30	1	412.6854754
1.10	0.33	0.98	404.4317659
1.20	0.36	0.92	379.6706374
1.30	0.39	0.84	346.6557993
1.40	0.42	0.75	309.5141065
1.50	0.45	0.65	268.245559
1.60	0.48	0.57	235.230721
1.80	0.53	0.43	177.4547544
2.00	0.59	0.32	132.0593521
2.20	0.65	0.24	99.04451409
2.40	0.71	0.18	74.28338557
2.60	0.77	0.13	53.6491118
2.80	0.83	0.098	40.44317659
3.50	1.04	0.036	14.85667711
4.00	1.19	0.018	7.428338557
4.50	1.34	0.009	3.714169279
5.00	1.49	0.004	1.650741902

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	8.343938
0.20	0.06	0.075	41.71969
0.30	0.09	0.16	89.00201
0.40	0.12	0.28	155.7535
0.50	0.15	0.43	239.1929
0.60	0.18	0.6	333.7575
0.70	0.21	0.77	428.3222
0.80	0.24	0.89	495.0737
1.00	0.30	1	556.2626
1.10	0.33	0.98	545.1373
1.20	0.36	0.92	511.7616
1.30	0.39	0.84	467.2606
1.40	0.42	0.75	417.1969
1.50	0.45	0.65	361.5707
1.60	0.48	0.57	317.0697
1.80	0.53	0.43	239.1929
2.00	0.59	0.32	178.004
2.20	0.65	0.24	133.503
2.40	0.71	0.18	100.1273
2.60	0.77	0.13	72.31413
2.80	0.83	0.098	54.51373
3.50	1.04	0.036	20.02545
4.00	1.19	0.018	10.01273
4.50	1.34	0.009	5.006363
5.00	1.49	0.004	2.22505

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	11.75254
0.20	0.06	0.075	58.76271
0.30	0.09	0.16	125.3605
0.40	0.12	0.28	219.3808
0.50	0.15	0.43	336.9062
0.60	0.18	0.6	470.1017
0.70	0.21	0.77	603.2972
0.80	0.24	0.89	697.3175
1.00	0.30	1	783.5029
1.10	0.33	0.98	767.8328
1.20	0.36	0.92	720.8226
1.30	0.39	0.84	658.1424
1.40	0.42	0.75	587.6271
1.50	0.45	0.65	509.2769
1.60	0.48	0.57	446.5966
1.80	0.53	0.43	336.9062
2.00	0.59	0.32	250.7209
2.20	0.65	0.24	188.0407
2.40	0.71	0.18	141.0305
2.60	0.77	0.13	101.8554
2.80	0.83	0.098	76.78328
3.50	1.04	0.036	28.2061
4.00	1.19	0.018	14.10305
4.50	1.34	0.009	7.051526
5.00	1.49	0.004	3.134011

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	0.279542493
0.20	0.04	0.075	1.397712463
0.30	0.07	0.16	2.981786588
0.40	0.09	0.28	5.218126529
0.50	0.11	0.43	8.013551455
0.60	0.13	0.6	11.1816997
0.70	0.16	0.77	14.34984795
0.80	0.18	0.89	16.58618789
1.00	0.22	1	18.63616617
1.10	0.24	0.98	18.26344285
1.20	0.27	0.92	17.14527288
1.30	0.29	0.84	15.65437959
1.40	0.31	0.75	13.97712463
1.50	0.33	0.65	12.11350801
1.60	0.35	0.57	10.62261472
1.80	0.40	0.43	8.013551455
2.00	0.44	0.32	5.963573176
2.20	0.49	0.24	4.472679882
2.40	0.53	0.18	3.354509911
2.60	0.58	0.13	2.422701603
2.80	0.62	0.098	1.826344285
3.50	0.78	0.036	0.670901982
4.00	0.89	0.018	0.335450991
4.50	1.00	0.009	0.167725496
5.00	1.11	0.004	0.074544665

Duration, D	0.25
Tc	0.161
Tp	0.2216
A (sq miles)	0.2243
P (1-yr)	3.3
CN	52
S	9.230769231
Q (1-yr)	0.197823559
Ia	1.846153846
Ia/P (1-yr)	0.559440559
use Ia/P min	0.1
qu from chart	420
Qp (1-yr) =	18.63616617

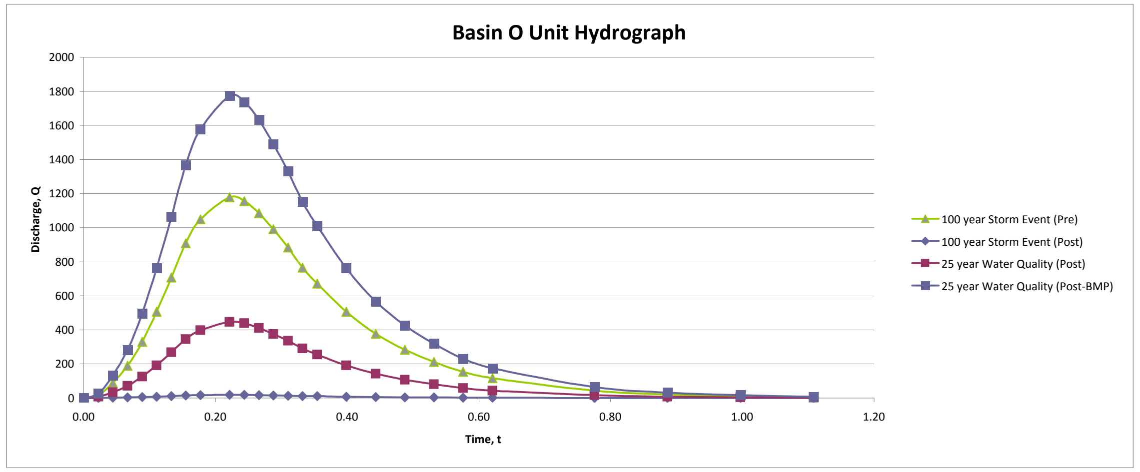
Duration, D	0.25
Tc	0.161
Tp	0.2216
A (sq miles)	0.2243
P (2-yr)	8
CN	52
S	9.230769
Q (2-yr)	2.461538
Ia	1.846154
Ia/P (2-yr)	0.230769
use Ia/P min	0.1
qu from chart	810
Qp (2-yr) =	447.2197

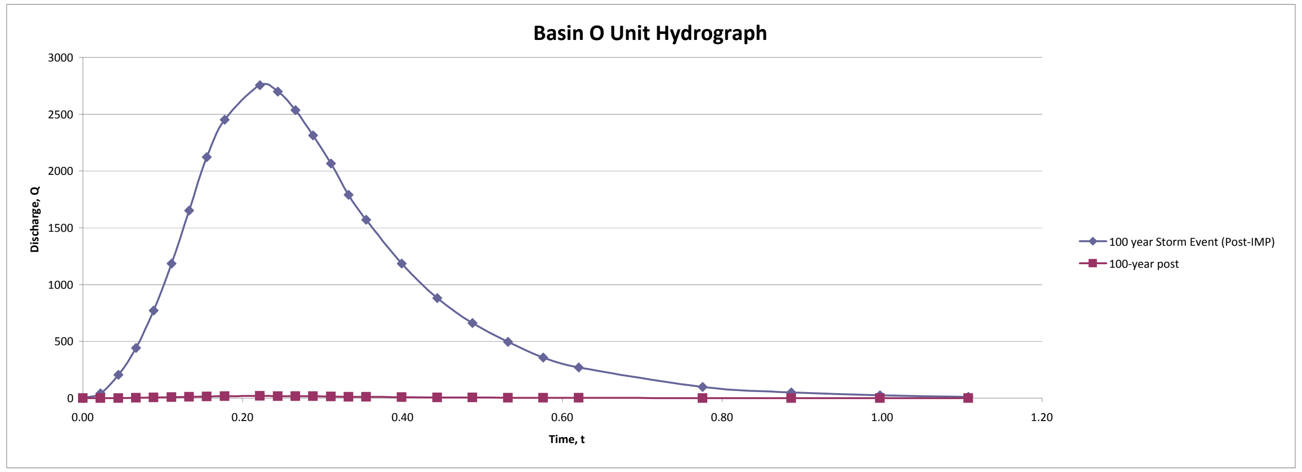
Duration, D	0.25
Tc	0.161
Tp	0.2216
A (sq miles)	0.2243
P (10-yr)	13.1
CN	52
S	9.230769
Q (10-yr)	6.182642
Ia	1.846154
Ia/P (10-yr)	0.140928
use Ia/P min	0.1
qu from chart	850
Qp (10-yr) =	1178.752

Duration, D	0.25
Tc	0.161
Tp	0.2216
A (sq miles)	0.2243
P (25-yr)	16.8
CN	52
S	9.230769
Q (25-yr)	9.246271
Ia	1.846154
Ia/P (25-yr)	0.10989
use Ia/P min	0.1
qu from chart	855
Qp (25-yr) =	1773.218

Duration, D	0.25
Tc	0.161
Tp	0.2216
A (sq miles)	0.2243
P (100-yr)	22.6
CN	52
S	9.23076923
Q (100-yr)	14.3647709
Ia	1.84615385
Ia/P (100-yr)	0.08168822
use Ia/P min	0.1
qu from chart	855
Qp (100-yr) =	2754.82548

Duration, D	0.25
Tc	0.161
Tp	0.2216
A (sq miles)	0.2243
P (500-yr)	50.7
CN	52
S	9.230769231
Q (500-yr)	41.09002475
Ia	1.846153846
Ia/P (500-yr)	0.036413291
use Ia/P min	0.1
qu from chart	855
Qp (500-yr) =	7880.101132





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	6.708295385
0.20	0.04	0.075	33.54147692
0.30	0.07	0.16	71.55515077
0.40	0.09	0.28	125.2215138
0.50	0.11	0.43	192.3044677
0.60	0.13	0.6	268.3318154
0.70	0.16	0.77	344.3591631
0.80	0.18	0.89	398.0255262
1.00	0.22	1	447.2196923
1.10	0.24	0.98	438.2752985
1.20	0.27	0.92	411.4421169
1.30	0.29	0.84	375.6645415
1.40	0.31	0.75	335.4147692
1.50	0.33	0.65	290.6928
1.60	0.35	0.57	254.9152246
1.80	0.40	0.43	192.3044677
2.00	0.44	0.32	143.1103015
2.20	0.49	0.24	107.3327262
2.40	0.53	0.18	80.49954462
2.60	0.58	0.13	58.13856
2.80	0.62	0.098	43.82752985
3.50	0.78	0.036	16.09990892
4.00	0.89	0.018	8.049954462
4.50	1.00	0.009	4.024977231
5.00	1.11	0.004	1.788878769

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	17.68127553
0.20	0.04	0.075	88.40637765
0.30	0.07	0.16	188.6002723
0.40	0.09	0.28	330.0504765
0.50	0.11	0.43	506.8632318
0.60	0.13	0.6	707.2510212
0.70	0.16	0.77	907.6388105
0.80	0.18	0.89	1049.089015
1.00	0.22	1	1178.751702
1.10	0.24	0.98	1155.176668
1.20	0.27	0.92	1084.451566
1.30	0.29	0.84	990.1514296
1.40	0.31	0.75	884.0637765
1.50	0.33	0.65	766.1886063
1.60	0.35	0.57	671.8884701
1.80	0.40	0.43	506.8632318
2.00	0.44	0.32	377.2005446
2.20	0.49	0.24	282.9004085
2.40	0.53	0.18	212.1753063
2.60	0.58	0.13	153.2377213
2.80	0.62	0.098	115.5176668
3.50	0.78	0.036	42.43506127
4.00	0.89	0.018	21.21753063
4.50	1.00	0.009	10.60876532
5.00	1.11	0.004	4.715006808

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	26.59826
0.20	0.04	0.075	132.9913
0.30	0.07	0.16	283.7148
0.40	0.09	0.28	496.5009
0.50	0.11	0.43	762.4835
0.60	0.13	0.6	1063.931
0.70	0.16	0.77	1365.378
0.80	0.18	0.89	1578.164
1.00	0.22	1	1773.218
1.10	0.24	0.98	1737.753
1.20	0.27	0.92	1631.36
1.30	0.29	0.84	1489.503
1.40	0.31	0.75	1329.913
1.50	0.33	0.65	1152.591
1.60	0.35	0.57	1010.734
1.80	0.40	0.43	762.4835
2.00	0.44	0.32	567.4296
2.20	0.49	0.24	425.5722
2.40	0.53	0.18	319.1792
2.60	0.58	0.13	230.5183
2.80	0.62	0.098	173.7753
3.50	0.78	0.036	63.83583
4.00	0.89	0.018	31.91792
4.50	1.00	0.009	15.95896
5.00	1.11	0.004	7.09287

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.02	0.015	41.32238
0.20	0.04	0.075	206.6119
0.30	0.07	0.16	440.7721
0.40	0.09	0.28	771.3511
0.50	0.11	0.43	1184.575
0.60	0.13	0.6	1652.895
0.70	0.16	0.77	2121.216
0.80	0.18	0.89	2451.795
1.00	0.22	1	2754.825
1.10	0.24	0.98	2699.729
1.20	0.27	0.92	2534.439
1.30	0.29	0.84	2314.053
1.40	0.31	0.75	2066.119
1.50	0.33	0.65	1790.637
1.60	0.35	0.57	1570.251
1.80	0.40	0.43	1184.575
2.00	0.44	0.32	881.5442
2.20	0.49	0.24	661.1581
2.40	0.53	0.18	495.8686
2.60	0.58	0.13	358.1273
2.80	0.62	0.098	269.9729
3.50	0.78	0.036	99.17372
4.00	0.89	0.018	49.58686
4.50	1.00	0.009	24.79343
5.00	1.11	0.004	11.0193

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	1.495838947
0.20	0.12	0.075	7.479194734
0.30	0.18	0.16	15.95561543
0.40	0.24	0.28	27.92232701
0.50	0.30	0.43	42.88071647
0.60	0.36	0.6	59.83355787
0.70	0.42	0.77	76.78639927
0.80	0.48	0.89	88.75311084
1.00	0.60	1	99.72259645
1.10	0.66	0.98	97.72814452
1.20	0.72	0.92	91.74478873
1.30	0.77	0.84	83.76698102
1.40	0.83	0.75	74.79194734
1.50	0.89	0.65	64.81968769
1.60	0.95	0.57	56.84187998
1.80	1.07	0.43	42.88071647
2.00	1.19	0.32	31.91123086
2.20	1.31	0.24	23.93342315
2.40	1.43	0.18	17.95006736
2.60	1.55	0.13	12.96393754
2.80	1.67	0.098	9.772814452
3.50	2.09	0.036	3.590013472
4.00	2.38	0.018	1.795006736
4.50	2.68	0.009	0.897503368
5.00	2.98	0.004	0.398890386

Duration, D	0.25
Tc	0.785
Tp	0.596
A (sq miles)	0.154
P (1-yr)	3.3
CN	82
S	2.195121951
Q (1-yr)	1.618873319
Ia	0.43902439
Ia/P (1-yr)	0.133037694
use Ia/P min	0.1
qu from chart	400
Qp (1-yr) =	99.72259645

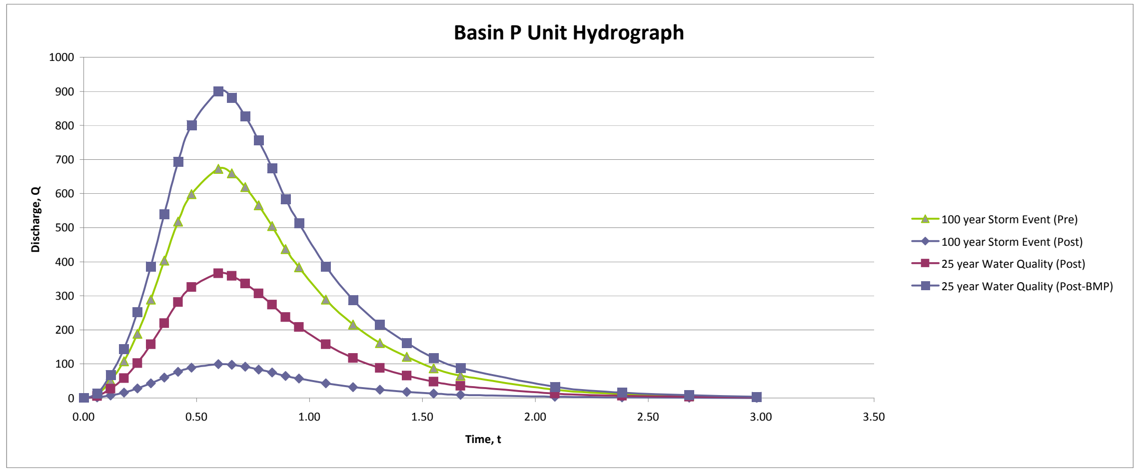
Duration, D	0.25
Tc	0.785
Tp	0.596
A (sq miles)	0.154
P (2-yr)	8
CN	82
S	2.195122
Q (2-yr)	5.859756
Ia	0.439024
Ia/P (2-yr)	0.054878
use Ia/P min	0.1
qu from chart	405
Qp (2-yr) =	365.473

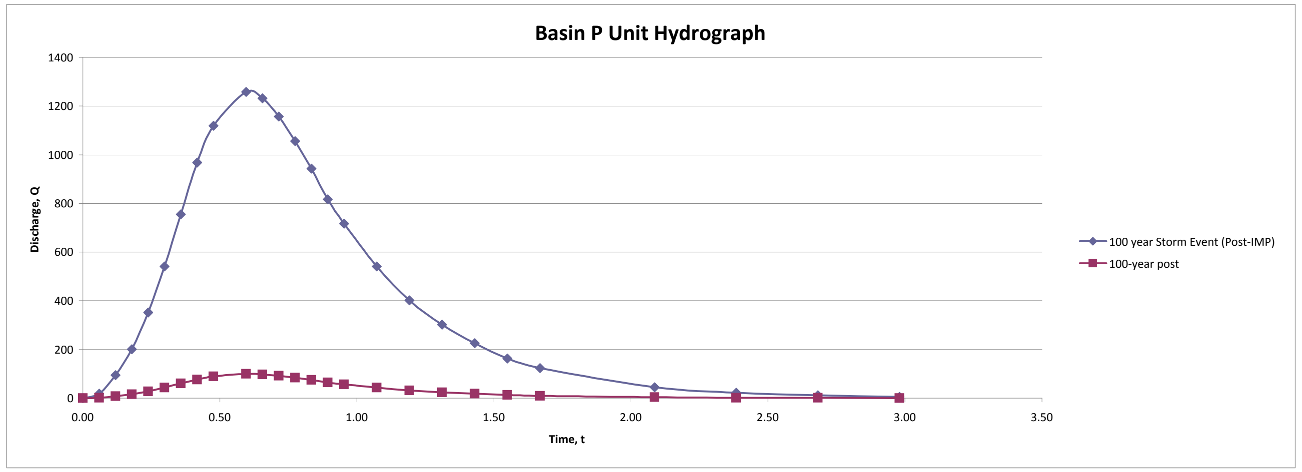
Duration, D	0.25
Tc	0.785
Tp	0.596
A (sq miles)	0.154
P (10-yr)	13.1
CN	82
S	2.195122
Q (10-yr)	10.7902
Ia	0.439024
Ia/P (10-yr)	0.033513
use Ia/P min	0.1
qu from chart	405
Qp (10-yr) =	672.9849

Duration, D	0.25
Tc	0.785
Tp	0.596
A (sq miles)	0.154
P (25-yr)	16.8
CN	82
S	2.195122
Q (25-yr)	14.42553
Ia	0.439024
Ia/P (25-yr)	0.026132
use Ia/P min	0.1
qu from chart	405
Qp (25-yr) =	899.7202

Duration, D	0.25
Tc	0.785
Tp	0.596
A (sq miles)	0.154
P (100-yr)	22.6
CN	82
S	2.19512195
Q (100-yr)	20.1636916
Ia	0.43902439
Ia/P (100-yr)	0.01942586
use Ia/P min	0.1
qu from chart	405
Qp (100-yr) =	1257.60945

Duration, D	0.25
Tc	0.785
Tp	0.596
A (sq miles)	0.154
P (500-yr)	50.7
CN	82
S	2.195121951
Q (500-yr)	48.15771258
Ia	0.43902439
Ia/P (500-yr)	0.008659258
use Ia/P min	0.1
qu from chart	405
Qp (500-yr) =	3003.596533





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	5.482094817
0.20	0.12	0.075	27.41047409
0.30	0.18	0.16	58.47567805
0.40	0.24	0.28	102.3324366
0.50	0.30	0.43	157.1533848
0.60	0.36	0.6	219.2837927
0.70	0.42	0.77	281.4142006
0.80	0.48	0.89	325.2709591
1.00	0.60	1	365.4729878
1.10	0.66	0.98	358.163528
1.20	0.72	0.92	336.2351488
1.30	0.77	0.84	306.9973098
1.40	0.83	0.75	274.1047409
1.50	0.89	0.65	237.5574421
1.60	0.95	0.57	208.319603
1.80	1.07	0.43	157.1533848
2.00	1.19	0.32	116.9513561
2.20	1.31	0.24	87.71351707
2.40	1.43	0.18	65.7851378
2.60	1.55	0.13	47.51148841
2.80	1.67	0.098	35.8163528
3.50	2.09	0.036	13.15702756
4.00	2.38	0.018	6.57851378
4.50	2.68	0.009	3.28925689
5.00	2.98	0.004	1.461891951

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	10.0947741
0.20	0.12	0.075	50.47387048
0.30	0.18	0.16	107.6775904
0.40	0.24	0.28	188.4357831
0.50	0.30	0.43	289.3835241
0.60	0.36	0.6	403.7909639
0.70	0.42	0.77	518.1984036
0.80	0.48	0.89	598.9565964
1.00	0.60	1	672.9849398
1.10	0.66	0.98	659.525241
1.20	0.72	0.92	619.1461446
1.30	0.77	0.84	565.3073494
1.40	0.83	0.75	504.7387048
1.50	0.89	0.65	437.4402109
1.60	0.95	0.57	383.6014157
1.80	1.07	0.43	289.3835241
2.00	1.19	0.32	215.3551807
2.20	1.31	0.24	161.5163855
2.40	1.43	0.18	121.1372892
2.60	1.55	0.13	87.48804217
2.80	1.67	0.098	65.9525241
3.50	2.09	0.036	24.22745783
4.00	2.38	0.018	12.11372892
4.50	2.68	0.009	6.056864458
5.00	2.98	0.004	2.691939759

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	13.4958
0.20	0.12	0.075	67.47902
0.30	0.18	0.16	143.9552
0.40	0.24	0.28	251.9217
0.50	0.30	0.43	386.8797
0.60	0.36	0.6	539.8321
0.70	0.42	0.77	692.7846
0.80	0.48	0.89	800.751
1.00	0.60	1	899.7202
1.10	0.66	0.98	881.7258
1.20	0.72	0.92	827.7426
1.30	0.77	0.84	755.765
1.40	0.83	0.75	674.7902
1.50	0.89	0.65	584.8182
1.60	0.95	0.57	512.8405
1.80	1.07	0.43	386.8797
2.00	1.19	0.32	287.9105
2.20	1.31	0.24	215.9329
2.40	1.43	0.18	161.9496
2.60	1.55	0.13	116.9636
2.80	1.67	0.098	88.17258
3.50	2.09	0.036	32.38993
4.00	2.38	0.018	16.19496
4.50	2.68	0.009	8.097482
5.00	2.98	0.004	3.598881

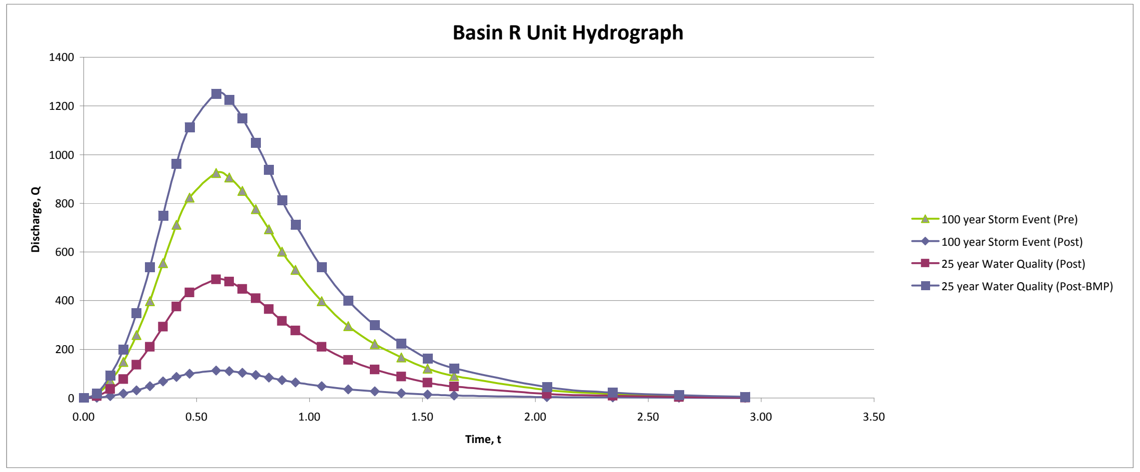
100yr (post w/IMP)

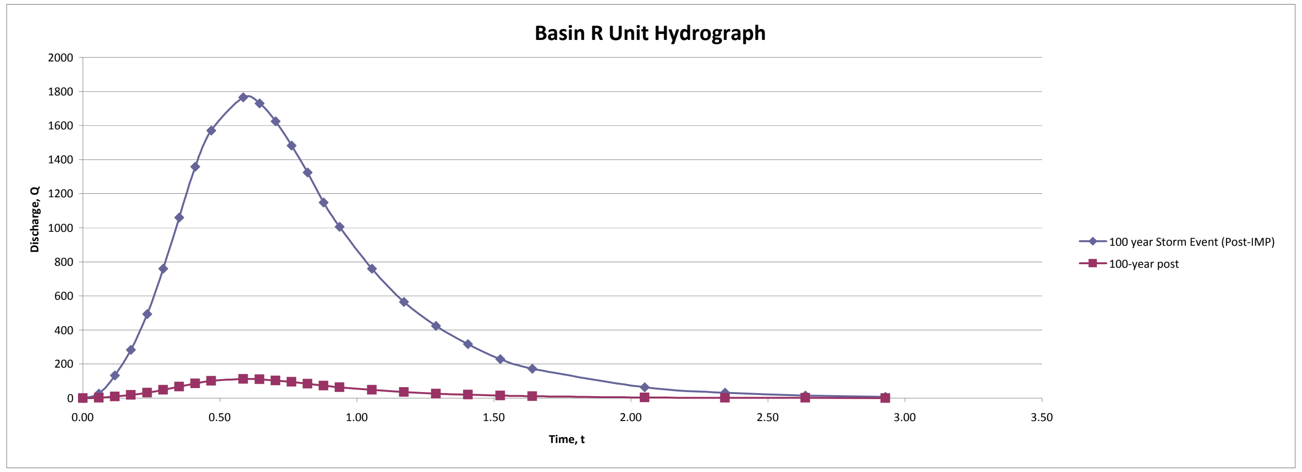
Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	18.86414
0.20	0.12	0.075	94.32071
0.30	0.18	0.16	201.2175
0.40	0.24	0.28	352.1306
0.50	0.30	0.43	540.7721
0.60	0.36	0.6	754.5657
0.70	0.42	0.77	968.3593
0.80	0.48	0.89	1119.272
1.00	0.60	1	1257.609
1.10	0.66	0.98	1232.457
1.20	0.72	0.92	1157.001
1.30	0.77	0.84	1056.392
1.40	0.83	0.75	943.2071
1.50	0.89	0.65	817.4461
1.60	0.95	0.57	716.8374
1.80	1.07	0.43	540.7721
2.00	1.19	0.32	402.435
2.20	1.31	0.24	301.8263
2.40	1.43	0.18	226.3697
2.60	1.55	0.13	163.4892
2.80	1.67	0.098	123.2457
3.50	2.09	0.036	45.27394
4.00	2.38	0.018	22.63697
4.50	2.68	0.009	11.31849
5.00	2.98	0.004	5.030438

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	1.692356159
0.20	0.12	0.075	8.461780797
0.30	0.18	0.16	18.05179903
0.40	0.23	0.28	31.59064831
0.50	0.29	0.43	48.5142099
0.60	0.35	0.6	67.69424637
0.70	0.41	0.77	86.87428284
0.80	0.47	0.89	100.4131321
1.00	0.59	1	112.823744
1.10	0.64	0.98	110.5672691
1.20	0.70	0.92	103.7978444
1.30	0.76	0.84	94.77194492
1.40	0.82	0.75	84.61780797
1.50	0.88	0.65	73.33543357
1.60	0.94	0.57	64.30953405
1.80	1.05	0.43	48.5142099
2.00	1.17	0.32	36.10359807
2.20	1.29	0.24	27.07769855
2.40	1.41	0.18	20.30827391
2.60	1.52	0.13	14.66708671
2.80	1.64	0.098	11.05672691
3.50	2.05	0.036	4.061654782
4.00	2.34	0.018	2.030827391
4.50	2.64	0.009	1.015413696
5.00	2.93	0.004	0.451294976

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.768	Tc	0.768	Tc	0.768	Tc	0.768	Tc	0.768	Tc	0.768
Tp	0.5858	Tp	0.5858	Tp	0.5858	Tp	0.5858	Tp	0.5858	Tp	0.5858
A (sq miles)	0.2204	A (sq miles)	0.2204	A (sq miles)	0.2204	A (sq miles)	0.2204	A (sq miles)	0.2204	A (sq miles)	0.2204
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	78	CN	78	CN	78	CN	78	CN	78	CN	78
S	2.820512821	S	2.820513	S	2.820513	S	2.820513	S	2.82051282	S	2.820512821
Q (1-yr)	1.347117012	Q (2-yr)	5.391026	Q (10-yr)	10.23343	Q (25-yr)	13.83284	Q (100-yr)	19.5354346	Q (500-yr)	47.46560803
Ia	0.564102564	Ia	0.564103	Ia	0.564103	Ia	0.564103	Ia	0.56410256	Ia	0.564102564
Ia/P (1-yr)	0.170940171	Ia/P (2-yr)	0.070513	Ia/P (10-yr)	0.043061	Ia/P (25-yr)	0.033578	Ia/P (100-yr)	0.02496029	Ia/P (500-yr)	0.011126283
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	380	qu from chart	410	qu from chart	410	qu from chart	410	qu from chart	410	qu from chart	410
Qp (1-yr) =	112.823744	Qp (2-yr) =	487.1546	Qp (10-yr) =	924.7335	Qp (25-yr) =	1249.991	Qp (100-yr) =	1765.30001	Qp (500-yr) =	4289.182204





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	7.307319615
0.20	0.12	0.075	36.53659808
0.30	0.18	0.16	77.94474256
0.40	0.23	0.28	136.4032995
0.50	0.29	0.43	209.4764956
0.60	0.35	0.6	292.2927846
0.70	0.41	0.77	375.1090736
0.80	0.47	0.89	433.5676305
1.00	0.59	1	487.154641
1.10	0.64	0.98	477.4115482
1.20	0.70	0.92	448.1822697
1.30	0.76	0.84	409.2098985
1.40	0.82	0.75	365.3659808
1.50	0.88	0.65	316.6505167
1.60	0.94	0.57	277.6781454
1.80	1.05	0.43	209.4764956
2.00	1.17	0.32	155.8894851
2.20	1.29	0.24	116.9171138
2.40	1.41	0.18	87.68783538
2.60	1.52	0.13	63.33010333
2.80	1.64	0.098	47.74115482
3.50	2.05	0.036	17.53756708
4.00	2.34	0.018	8.768783538
4.50	2.64	0.009	4.384391769
5.00	2.93	0.004	1.948618564

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	13.87100283
0.20	0.12	0.075	69.35501416
0.30	0.18	0.16	147.9573635
0.40	0.23	0.28	258.9253862
0.50	0.29	0.43	397.6354145
0.60	0.35	0.6	554.8401132
0.70	0.41	0.77	712.044812
0.80	0.47	0.89	823.0128346
1.00	0.59	1	924.7335221
1.10	0.64	0.98	906.2388516
1.20	0.70	0.92	850.7548403
1.30	0.76	0.84	776.7761585
1.40	0.82	0.75	693.5501416
1.50	0.88	0.65	601.0767893
1.60	0.94	0.57	527.0981076
1.80	1.05	0.43	397.6354145
2.00	1.17	0.32	295.9147271
2.20	1.29	0.24	221.9360453
2.40	1.41	0.18	166.452034
2.60	1.52	0.13	120.2153579
2.80	1.64	0.098	90.62388516
3.50	2.05	0.036	33.29040679
4.00	2.34	0.018	16.6452034
4.50	2.64	0.009	8.322601699
5.00	2.93	0.004	3.698934088

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	18.74987
0.20	0.12	0.075	93.74934
0.30	0.18	0.16	199.9986
0.40	0.23	0.28	349.9975
0.50	0.29	0.43	537.4962
0.60	0.35	0.6	749.9947
0.70	0.41	0.77	962.4932
0.80	0.47	0.89	1112.492
1.00	0.59	1	1249.991
1.10	0.64	0.98	1224.991
1.20	0.70	0.92	1149.992
1.30	0.76	0.84	1049.993
1.40	0.82	0.75	937.4934
1.50	0.88	0.65	812.4943
1.60	0.94	0.57	712.495
1.80	1.05	0.43	537.4962
2.00	1.17	0.32	399.9972
2.20	1.29	0.24	299.9979
2.40	1.41	0.18	224.9984
2.60	1.52	0.13	162.4989
2.80	1.64	0.098	122.4991
3.50	2.05	0.036	44.99968
4.00	2.34	0.018	22.49984
4.50	2.64	0.009	11.24992
5.00	2.93	0.004	4.999965

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.06	0.015	26.4795
0.20	0.12	0.075	132.3975
0.30	0.18	0.16	282.448
0.40	0.23	0.28	494.284
0.50	0.29	0.43	759.079
0.60	0.35	0.6	1059.18
0.70	0.41	0.77	1359.281
0.80	0.47	0.89	1571.117
1.00	0.59	1	1765.3
1.10	0.64	0.98	1729.994
1.20	0.70	0.92	1624.076
1.30	0.76	0.84	1482.852
1.40	0.82	0.75	1323.975
1.50	0.88	0.65	1147.445
1.60	0.94	0.57	1006.221
1.80	1.05	0.43	759.079
2.00	1.17	0.32	564.896
2.20	1.29	0.24	423.672
2.40	1.41	0.18	317.754
2.60	1.52	0.13	229.489
2.80	1.64	0.098	172.9994
3.50	2.05	0.036	63.5508
4.00	2.34	0.018	31.7754
4.50	2.64	0.009	15.8877
5.00	2.93	0.004	7.0612

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.07	0.015	0.285218808
0.20	0.14	0.075	1.426094039
0.30	0.21	0.16	3.042333951
0.40	0.27	0.28	5.324084413
0.50	0.34	0.43	8.176272492
0.60	0.41	0.6	11.40875231
0.70	0.48	0.77	14.64123214
0.80	0.55	0.89	16.9229826
1.00	0.69	1	19.01458719
1.10	0.76	0.98	18.63429545
1.20	0.82	0.92	17.49342022
1.30	0.89	0.84	15.97225324
1.40	0.96	0.75	14.26094039
1.50	1.03	0.65	12.35948167
1.60	1.10	0.57	10.8383147
1.80	1.24	0.43	8.176272492
2.00	1.37	0.32	6.084667901
2.20	1.51	0.24	4.563500926
2.40	1.65	0.18	3.422625694
2.60	1.79	0.13	2.471896335
2.80	1.92	0.098	1.863429545
3.50	2.41	0.036	0.684525139
4.00	2.75	0.018	0.342262569
4.50	3.09	0.009	0.171131285
5.00	3.44	0.004	0.076058349

Duration, D	0.25
Tc	0.937
Tp	0.6872
A (sq miles)	0.0219
P (1-yr)	3.3
CN	92
S	0.869565217
Q (1-yr)	2.445763353
Ia	0.173913043
Ia/P (1-yr)	0.052700922
use Ia/P min	0.1
qu from chart	355
Qp (1-yr) =	19.01458719

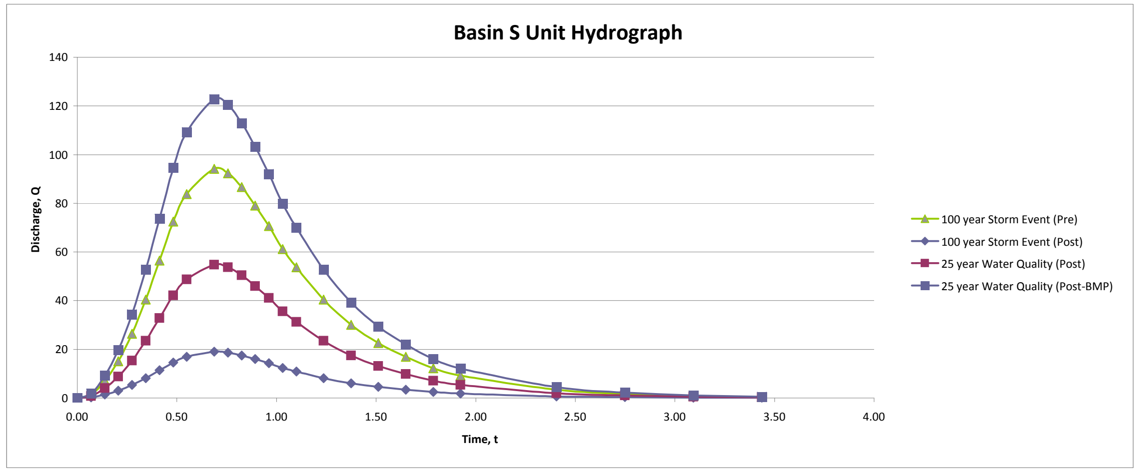
Duration, D	0.25
Tc	0.937
Tp	0.6872
A (sq miles)	0.0219
P (2-yr)	8
CN	92
S	0.869565
Q (2-yr)	7.043478
Ia	0.173913
Ia/P (2-yr)	0.021739
use Ia/P min	0.1
qu from chart	355
Qp (2-yr) =	54.75952

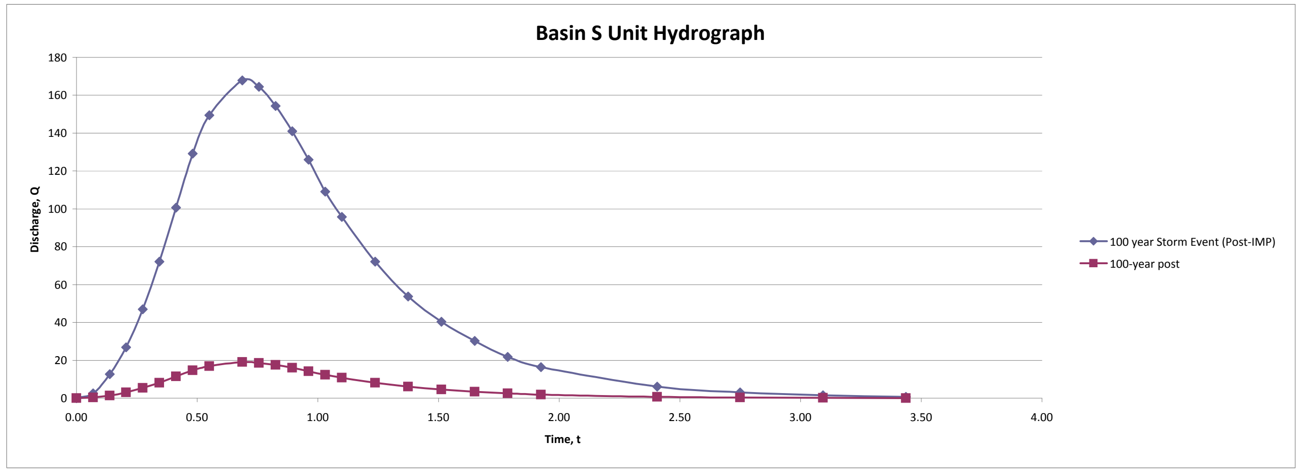
Duration, D	0.25
Tc	0.937
Tp	0.6872
A (sq miles)	0.0219
P (10-yr)	13.1
CN	92
S	0.869565
Q (10-yr)	12.11133
Ia	0.173913
Ia/P (10-yr)	0.013276
use Ia/P min	0.1
qu from chart	355
Qp (10-yr) =	94.15955

Duration, D	0.25
Tc	0.937
Tp	0.6872
A (sq miles)	0.0219
P (25-yr)	16.8
CN	92
S	0.869565
Q (25-yr)	15.79974
Ia	0.173913
Ia/P (25-yr)	0.010352
use Ia/P min	0.1
qu from chart	355
Qp (25-yr) =	122.8351

Duration, D	0.25
Tc	0.937
Tp	0.6872
A (sq miles)	0.0219
P (100-yr)	22.6
CN	92
S	0.86956522
Q (100-yr)	21.5889803
Ia	0.17391304
Ia/P (100-yr)	0.00769527
use Ia/P min	0.1
qu from chart	355
Qp (100-yr) =	167.843527

Duration, D	0.25
Tc	0.937
Tp	0.6872
A (sq miles)	0.0219
P (500-yr)	50.7
CN	92
S	0.869565217
Q (500-yr)	49.67123395
Ia	0.173913043
Ia/P (500-yr)	0.003430238
use Ia/P min	0.1
qu from chart	355
Qp (500-yr) =	386.1690083





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.07	0.015	0.821392826
0.20	0.14	0.075	4.10696413
0.30	0.21	0.16	8.761523478
0.40	0.27	0.28	15.33266609
0.50	0.34	0.43	23.54659435
0.60	0.41	0.6	32.85571304
0.70	0.48	0.77	42.16483174
0.80	0.55	0.89	48.73597435
1.00	0.69	1	54.75952174
1.10	0.76	0.98	53.6643313
1.20	0.82	0.92	50.37876
1.30	0.89	0.84	45.99799826
1.40	0.96	0.75	41.0696413
1.50	1.03	0.65	35.59368913
1.60	1.10	0.57	31.21292739
1.80	1.24	0.43	23.54659435
2.00	1.37	0.32	17.52304696
2.20	1.51	0.24	13.14228522
2.40	1.65	0.18	9.856713913
2.60	1.79	0.13	7.118737826
2.80	1.92	0.098	5.36643313
3.50	2.41	0.036	1.971342783
4.00	2.75	0.018	0.985671391
4.50	3.09	0.009	0.492835696
5.00	3.44	0.004	0.219038087

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.07	0.015	1.412393263
0.20	0.14	0.075	7.061966313
0.30	0.21	0.16	15.06552814
0.40	0.27	0.28	26.36467424
0.50	0.34	0.43	40.48860686
0.60	0.41	0.6	56.49573051
0.70	0.48	0.77	72.50285415
0.80	0.55	0.89	83.80200025
1.00	0.69	1	94.15955084
1.10	0.76	0.98	92.27635983
1.20	0.82	0.92	86.62678678
1.30	0.89	0.84	79.09402271
1.40	0.96	0.75	70.61966313
1.50	1.03	0.65	61.20370805
1.60	1.10	0.57	53.67094398
1.80	1.24	0.43	40.48860686
2.00	1.37	0.32	30.13105627
2.20	1.51	0.24	22.5982922
2.40	1.65	0.18	16.94871915
2.60	1.79	0.13	12.24074161
2.80	1.92	0.098	9.227635983
3.50	2.41	0.036	3.38974383
4.00	2.75	0.018	1.694871915
4.50	3.09	0.009	0.847435958
5.00	3.44	0.004	0.376638203

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.07	0.015	1.842526
0.20	0.14	0.075	9.212631
0.30	0.21	0.16	19.65361
0.40	0.27	0.28	34.39382
0.50	0.34	0.43	52.81909
0.60	0.41	0.6	73.70105
0.70	0.48	0.77	94.58301
0.80	0.55	0.89	109.3232
1.00	0.69	1	122.8351
1.10	0.76	0.98	120.3784
1.20	0.82	0.92	113.0083
1.30	0.89	0.84	103.1815
1.40	0.96	0.75	92.12631
1.50	1.03	0.65	79.8428
1.60	1.10	0.57	70.016
1.80	1.24	0.43	52.81909
2.00	1.37	0.32	39.30723
2.20	1.51	0.24	29.48042
2.40	1.65	0.18	22.11032
2.60	1.79	0.13	15.96856
2.80	1.92	0.098	12.03784
3.50	2.41	0.036	4.422063
4.00	2.75	0.018	2.211032
4.50	3.09	0.009	1.105516
5.00	3.44	0.004	0.49134

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.07	0.015	2.517653
0.20	0.14	0.075	12.58826
0.30	0.21	0.16	26.85496
0.40	0.27	0.28	46.99619
0.50	0.34	0.43	72.17272
0.60	0.41	0.6	100.7061
0.70	0.48	0.77	129.2395
0.80	0.55	0.89	149.3807
1.00	0.69	1	167.8435
1.10	0.76	0.98	164.4867
1.20	0.82	0.92	154.416
1.30	0.89	0.84	140.9886
1.40	0.96	0.75	125.8826
1.50	1.03	0.65	109.0983
1.60	1.10	0.57	95.67081
1.80	1.24	0.43	72.17272
2.00	1.37	0.32	53.70993
2.20	1.51	0.24	40.28245
2.40	1.65	0.18	30.21183
2.60	1.79	0.13	21.81966
2.80	1.92	0.098	16.44867
3.50	2.41	0.036	6.042367
4.00	2.75	0.018	3.021183
4.50	3.09	0.009	1.510592
5.00	3.44	0.004	0.671374

Duration, D	0.25
Tc	0.277
Tp	0.2912
A (sq miles)	0.0166
P (1-yr)	3.3
CN	96
S	0.416666667
Q (1-yr)	2.847782875
Ia	0.083333333
Ia/P (1-yr)	0.025252525
use Ia/P min	0.1
qu from chart	700
Qp (1-yr) =	33.091237

Duration, D	0.25
Tc	0.277
Tp	0.2912
A (sq miles)	0.0166
P (2-yr)	8
CN	96
S	0.416667
Q (2-yr)	7.520833
Ia	0.083333
Ia/P (2-yr)	0.010417
use Ia/P min	0.1
qu from chart	700
Qp (2-yr) =	87.39208

Duration, D	0.25
Tc	0.277
Tp	0.2912
A (sq miles)	0.0166
P (10-yr)	13.1
CN	96
S	0.416667
Q (10-yr)	12.61292
Ia	0.083333
Ia/P (10-yr)	0.006361
use Ia/P min	0.1
qu from chart	700
Qp (10-yr) =	146.5622

Duration, D	0.25
Tc	0.277
Tp	0.2912
A (sq miles)	0.0166
P (25-yr)	16.8
CN	96
S	0.416667
Q (25-yr)	16.31013
Ia	0.083333
Ia/P (25-yr)	0.00496
use Ia/P min	0.1
qu from chart	700
Qp (25-yr) =	189.5237

Duration, D	0.25
Tc	0.277
Tp	0.2912
A (sq miles)	0.0166
P (100-yr)	22.6
CN	96
S	0.41666667
Q (100-yr)	22.1075703
Ia	0.08333333
Ia/P (100-yr)	0.00368732
use Ia/P min	0.1
qu from chart	700
Qp (100-yr) =	256.889966

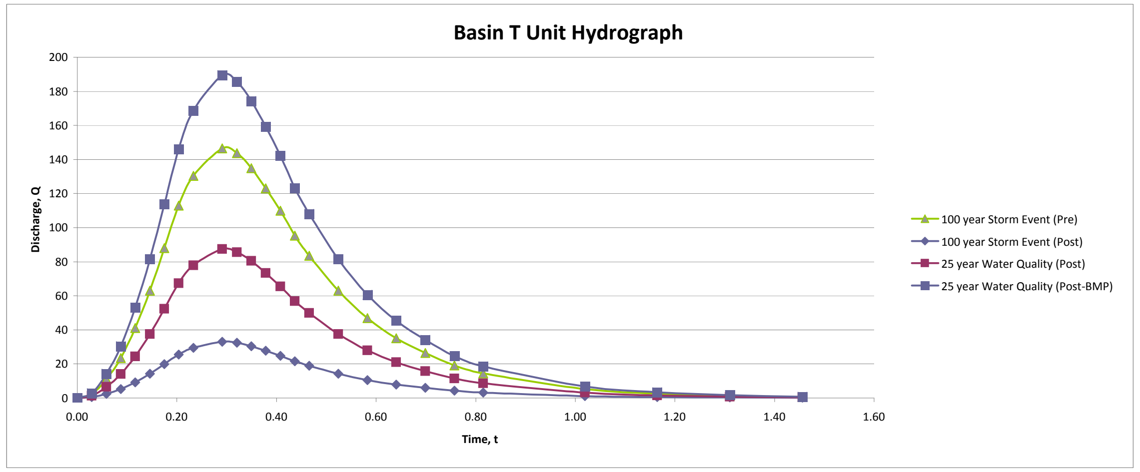
Duration, D	0.25
Tc	0.277
Tp	0.2912
A (sq miles)	0.0166
P (500-yr)	50.7
CN	96
S	0.416666667
Q (500-yr)	50.20340192
Ia	0.083333333
Ia/P (500-yr)	0.001643655
use Ia/P min	0.1
qu from chart	700
Qp (500-yr) =	583.3635303

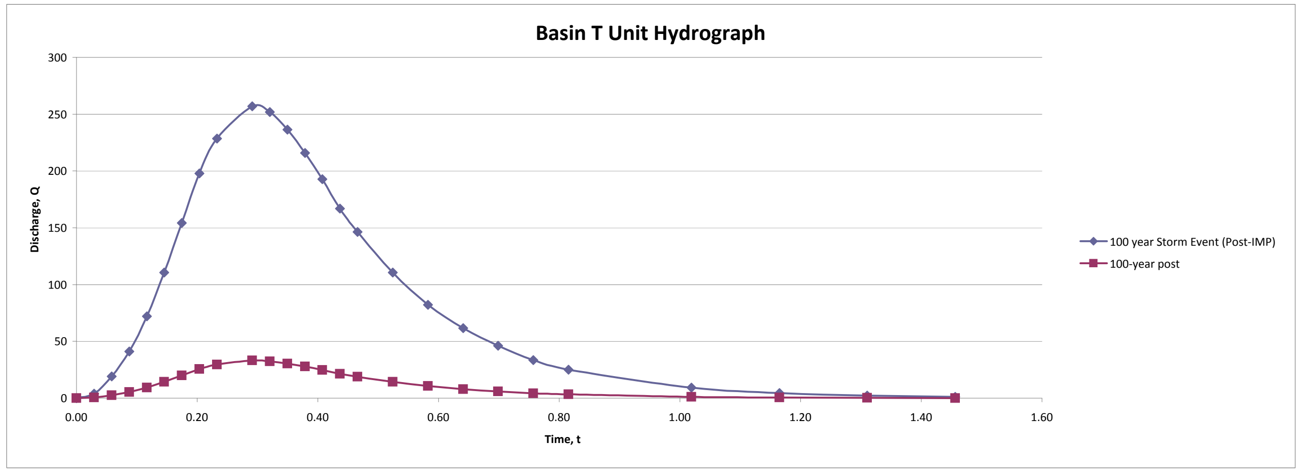
100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.496368555
0.20	0.06	0.075	2.481842775
0.30	0.09	0.16	5.29459792
0.40	0.12	0.28	9.265546361
0.50	0.15	0.43	14.22923191
0.60	0.17	0.6	19.8547422
0.70	0.20	0.77	25.48025249
0.80	0.23	0.89	29.45120093
1.00	0.29	1	33.091237
1.10	0.32	0.98	32.42941226
1.20	0.35	0.92	30.44393804
1.30	0.38	0.84	27.79663908
1.40	0.41	0.75	24.81842775
1.50	0.44	0.65	21.50930405
1.60	0.47	0.57	18.86200509
1.80	0.52	0.43	14.22923191
2.00	0.58	0.32	10.58919584
2.20	0.64	0.24	7.941896881
2.40	0.70	0.18	5.956422661
2.60	0.76	0.13	4.30186081
2.80	0.82	0.098	3.242941226
3.50	1.02	0.036	1.191284532
4.00	1.16	0.018	0.595642266
4.50	1.31	0.009	0.297821133
5.00	1.46	0.004	0.132364948

25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.31088125
0.20	0.06	0.075	6.55440625
0.30	0.09	0.16	13.98273333
0.40	0.12	0.28	24.46978333
0.50	0.15	0.43	37.57859583
0.60	0.17	0.6	52.43525
0.70	0.20	0.77	67.29190417
0.80	0.23	0.89	77.77895417
1.00	0.29	1	87.39208333
1.10	0.32	0.98	85.64424167
1.20	0.35	0.92	80.40071667
1.30	0.38	0.84	73.40935
1.40	0.41	0.75	65.5440625
1.50	0.44	0.65	56.80485417
1.60	0.47	0.57	49.8134875
1.80	0.52	0.43	37.57859583
2.00	0.58	0.32	27.96546667
2.20	0.64	0.24	20.9741
2.40	0.70	0.18	15.730575
2.60	0.76	0.13	11.36097083
2.80	0.82	0.098	8.564424167
3.50	1.02	0.036	3.146115
4.00	1.16	0.018	1.5730575
4.50	1.31	0.009	0.78652875
5.00	1.46	0.004	0.349568333





100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	2.198432636
0.20	0.06	0.075	10.99216318
0.30	0.09	0.16	23.44994812
0.40	0.12	0.28	41.03740921
0.50	0.15	0.43	63.02173558
0.60	0.17	0.6	87.93730546
0.70	0.20	0.77	112.8528753
0.80	0.23	0.89	130.4403364
1.00	0.29	1	146.5621758
1.10	0.32	0.98	143.6309322
1.20	0.35	0.92	134.8372017
1.30	0.38	0.84	123.1122276
1.40	0.41	0.75	109.9216318
1.50	0.44	0.65	95.26541425
1.60	0.47	0.57	83.54044019
1.80	0.52	0.43	63.02173558
2.00	0.58	0.32	46.89989624
2.20	0.64	0.24	35.17492218
2.40	0.70	0.18	26.38119164
2.60	0.76	0.13	19.05308285
2.80	0.82	0.098	14.36309322
3.50	1.02	0.036	5.276238328
4.00	1.16	0.018	2.638119164
4.50	1.31	0.009	1.319059582
5.00	1.46	0.004	0.586248703

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	2.842856
0.20	0.06	0.075	14.21428
0.30	0.09	0.16	30.3238
0.40	0.12	0.28	53.06665
0.50	0.15	0.43	81.49521
0.60	0.17	0.6	113.7142
0.70	0.20	0.77	145.9333
0.80	0.23	0.89	168.6761
1.00	0.29	1	189.5237
1.10	0.32	0.98	185.7333
1.20	0.35	0.92	174.3618
1.30	0.38	0.84	159.1999
1.40	0.41	0.75	142.1428
1.50	0.44	0.65	123.1904
1.60	0.47	0.57	108.0285
1.80	0.52	0.43	81.49521
2.00	0.58	0.32	60.6476
2.20	0.64	0.24	45.4857
2.40	0.70	0.18	34.11427
2.60	0.76	0.13	24.63809
2.80	0.82	0.098	18.57333
3.50	1.02	0.036	6.822855
4.00	1.16	0.018	3.411427
4.50	1.31	0.009	1.705714
5.00	1.46	0.004	0.758095

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	3.853349
0.20	0.06	0.075	19.26675
0.30	0.09	0.16	41.10239
0.40	0.12	0.28	71.92919
0.50	0.15	0.43	110.4627
0.60	0.17	0.6	154.134
0.70	0.20	0.77	197.8053
0.80	0.23	0.89	228.6321
1.00	0.29	1	256.89
1.10	0.32	0.98	251.7522
1.20	0.35	0.92	236.3388
1.30	0.38	0.84	215.7876
1.40	0.41	0.75	192.6675
1.50	0.44	0.65	166.9785
1.60	0.47	0.57	146.4273
1.80	0.52	0.43	110.4627
2.00	0.58	0.32	82.20479
2.20	0.64	0.24	61.65359
2.40	0.70	0.18	46.24019
2.60	0.76	0.13	33.3957
2.80	0.82	0.098	25.17522
3.50	1.02	0.036	9.248039
4.00	1.16	0.018	4.624019
4.50	1.31	0.009	2.31201
5.00	1.46	0.004	1.02756

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.64923141
0.20	0.07	0.075	13.24615705
0.30	0.11	0.16	28.25846837
0.40	0.15	0.28	49.45231964
0.50	0.18	0.43	75.94463374
0.60	0.22	0.6	105.9692564
0.70	0.26	0.77	135.993879
0.80	0.29	0.89	157.1877303
1.00	0.37	1	176.6154273
1.10	0.41	0.98	173.0831188
1.20	0.44	0.92	162.4861931
1.30	0.48	0.84	148.3569589
1.40	0.52	0.75	132.4615705
1.50	0.55	0.65	114.8000277
1.60	0.59	0.57	100.6707936
1.80	0.66	0.43	75.94463374
2.00	0.74	0.32	56.51693674
2.20	0.81	0.24	42.38770255
2.40	0.88	0.18	31.79077691
2.60	0.96	0.13	22.96000555
2.80	1.03	0.098	17.30831188
3.50	1.29	0.036	6.358155383
4.00	1.47	0.018	3.179077691
4.50	1.66	0.009	1.589538846
5.00	1.84	0.004	0.706461709

Duration, D	0.25
Tc	0.406
Tp	0.3686
A (sq miles)	0.1158
P (1-yr)	3.3
CN	93
S	0.752688172
Q (1-yr)	2.541960669
Ia	0.150537634
Ia/P (1-yr)	0.045617465
use Ia/P min	0.1
qu from chart	600
Qp (1-yr) =	176.6154273

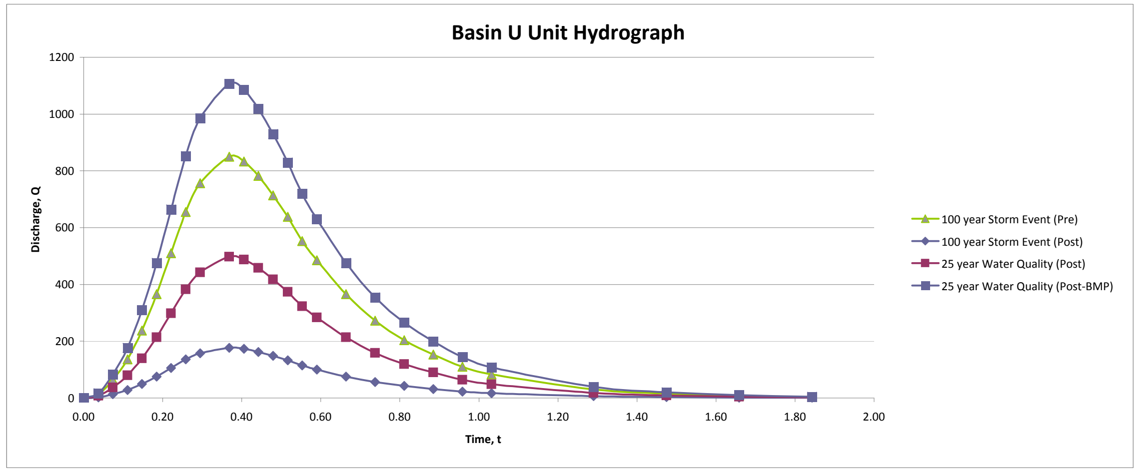
Duration, D	0.25
Tc	0.406
Tp	0.3686
A (sq miles)	0.1158
P (2-yr)	8
CN	93
S	0.752688
Q (2-yr)	7.162634
Ia	0.150538
Ia/P (2-yr)	0.018817
use Ia/P min	0.1
qu from chart	600
Qp (2-yr) =	497.6598

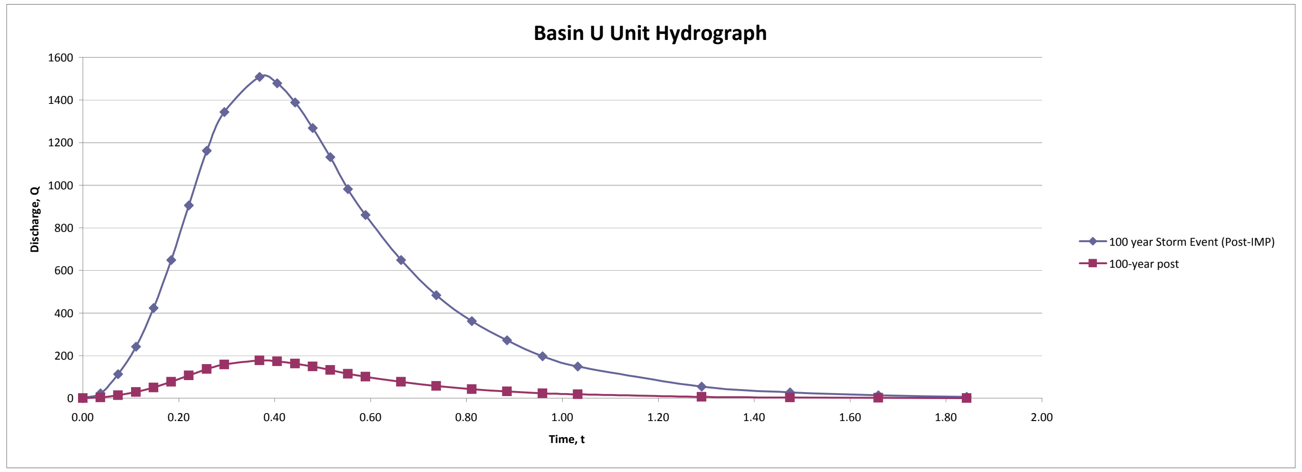
Duration, D	0.25
Tc	0.406
Tp	0.3686
A (sq miles)	0.1158
P (10-yr)	13.1
CN	93
S	0.752688
Q (10-yr)	12.23812
Ia	0.150538
Ia/P (10-yr)	0.011491
use Ia/P min	0.1
qu from chart	600
Qp (10-yr) =	850.3046

Duration, D	0.25
Tc	0.406
Tp	0.3686
A (sq miles)	0.1158
P (25-yr)	16.8
CN	93
S	0.752688
Q (25-yr)	15.92933
Ia	0.150538
Ia/P (25-yr)	0.008961
use Ia/P min	0.1
qu from chart	600
Qp (25-yr) =	1106.77

Duration, D	0.25
Tc	0.406
Tp	0.3686
A (sq miles)	0.1158
P (100-yr)	22.6
CN	93
S	0.75268817
Q (100-yr)	21.7211917
Ia	0.15053763
Ia/P (100-yr)	0.00666096
use Ia/P min	0.1
qu from chart	600
Qp (100-yr) =	1509.1884

Duration, D	0.25
Tc	0.406
Tp	0.3686
A (sq miles)	0.1158
P (500-yr)	50.7
CN	93
S	0.752688172
Q (500-yr)	49.80781739
Ia	0.150537634
Ia/P (500-yr)	0.002969184
use Ia/P min	0.1
qu from chart	600
Qp (500-yr) =	3460.647152





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	7.464897581
0.20	0.07	0.075	37.3244879
0.30	0.11	0.16	79.62557419
0.40	0.15	0.28	139.3447548
0.50	0.18	0.43	213.9937306
0.60	0.22	0.6	298.5959032
0.70	0.26	0.77	383.1980758
0.80	0.29	0.89	442.9172565
1.00	0.37	1	497.6598387
1.10	0.41	0.98	487.7066419
1.20	0.44	0.92	457.8470516
1.30	0.48	0.84	418.0342645
1.40	0.52	0.75	373.244879
1.50	0.55	0.65	323.4788952
1.60	0.59	0.57	283.6661081
1.80	0.66	0.43	213.9937306
2.00	0.74	0.32	159.2511484
2.20	0.81	0.24	119.4383613
2.40	0.88	0.18	89.57877097
2.60	0.96	0.13	64.69577903
2.80	1.03	0.098	48.77066419
3.50	1.29	0.036	17.91575419
4.00	1.47	0.018	8.957877097
4.50	1.66	0.009	4.478938548
5.00	1.84	0.004	1.990639355

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	12.75456965
0.20	0.07	0.075	63.77284827
0.30	0.11	0.16	136.048743
0.40	0.15	0.28	238.0853002
0.50	0.18	0.43	365.6309968
0.60	0.22	0.6	510.1827862
0.70	0.26	0.77	654.7345756
0.80	0.29	0.89	756.7711328
1.00	0.37	1	850.3046436
1.10	0.41	0.98	833.2985507
1.20	0.44	0.92	782.2802721
1.30	0.48	0.84	714.2559006
1.40	0.52	0.75	637.7284827
1.50	0.55	0.65	552.6980184
1.60	0.59	0.57	484.6736469
1.80	0.66	0.43	365.6309968
2.00	0.74	0.32	272.097486
2.20	0.81	0.24	204.0731145
2.40	0.88	0.18	153.0548359
2.60	0.96	0.13	110.5396037
2.80	1.03	0.098	83.32985507
3.50	1.29	0.036	30.61096717
4.00	1.47	0.018	15.30548359
4.50	1.66	0.009	7.652741793
5.00	1.84	0.004	3.401218574

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	16.60155
0.20	0.07	0.075	83.00774
0.30	0.11	0.16	177.0832
0.40	0.15	0.28	309.8956
0.50	0.18	0.43	475.911
0.60	0.22	0.6	664.0619
0.70	0.26	0.77	852.2128
0.80	0.29	0.89	985.0252
1.00	0.37	1	1106.77
1.10	0.41	0.98	1084.634
1.20	0.44	0.92	1018.228
1.30	0.48	0.84	929.6867
1.40	0.52	0.75	830.0774
1.50	0.55	0.65	719.4004
1.60	0.59	0.57	630.8588
1.80	0.66	0.43	475.911
2.00	0.74	0.32	354.1663
2.20	0.81	0.24	265.6248
2.40	0.88	0.18	199.2186
2.60	0.96	0.13	143.8801
2.80	1.03	0.098	108.4634
3.50	1.29	0.036	39.84371
4.00	1.47	0.018	19.92186
4.50	1.66	0.009	9.960929
5.00	1.84	0.004	4.427079

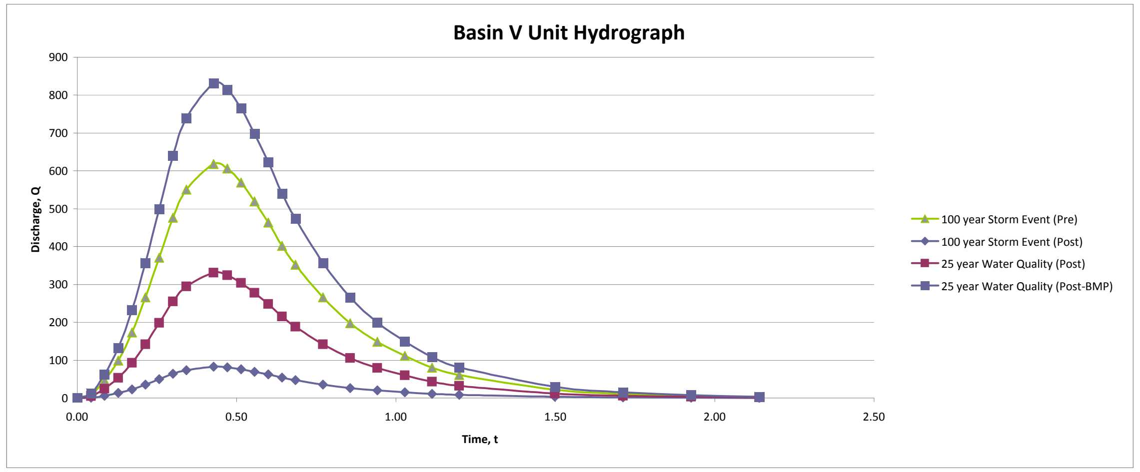
100yr (post w/IMP)

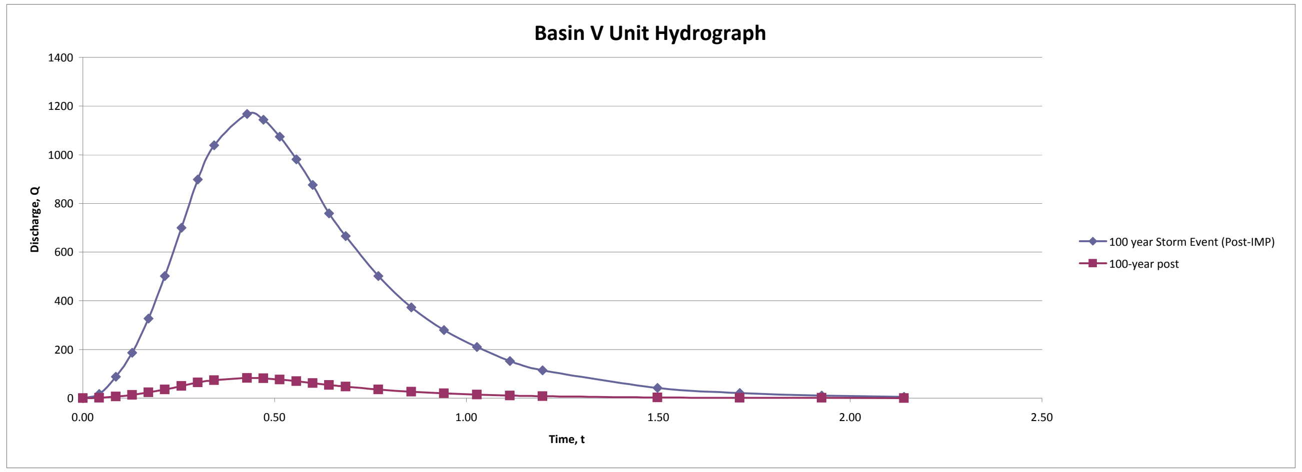
Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	22.63783
0.20	0.07	0.075	113.1891
0.30	0.11	0.16	241.4701
0.40	0.15	0.28	422.5728
0.50	0.18	0.43	648.951
0.60	0.22	0.6	905.513
0.70	0.26	0.77	1162.075
0.80	0.29	0.89	1343.178
1.00	0.37	1	1509.188
1.10	0.41	0.98	1479.005
1.20	0.44	0.92	1388.453
1.30	0.48	0.84	1267.718
1.40	0.52	0.75	1131.891
1.50	0.55	0.65	980.9725
1.60	0.59	0.57	860.2374
1.80	0.66	0.43	648.951
2.00	0.74	0.32	482.9403
2.20	0.81	0.24	362.2052
2.40	0.88	0.18	271.6539
2.60	0.96	0.13	196.1945
2.80	1.03	0.098	147.9005
3.50	1.29	0.036	54.33078
4.00	1.47	0.018	27.16539
4.50	1.66	0.009	13.5827
5.00	1.84	0.004	6.036754

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	1.242566038
0.20	0.09	0.075	6.212830189
0.30	0.13	0.16	13.25403774
0.40	0.17	0.28	23.19456604
0.50	0.21	0.43	35.62022642
0.60	0.26	0.6	49.70264151
0.70	0.30	0.77	63.7850566
0.80	0.34	0.89	73.72558491
1.00	0.43	1	82.83773585
1.10	0.47	0.98	81.18098113
1.20	0.51	0.92	76.21071698
1.30	0.56	0.84	69.58369811
1.40	0.60	0.75	62.12830189
1.50	0.64	0.65	53.8445283
1.60	0.68	0.57	47.21750943
1.80	0.77	0.43	35.62022642
2.00	0.86	0.32	26.50807547
2.20	0.94	0.24	19.8810566
2.40	1.03	0.18	14.91079245
2.60	1.11	0.13	10.76890566
2.80	1.20	0.098	8.118098113
3.50	1.50	0.036	2.982158491
4.00	1.71	0.018	1.491079245
4.50	1.93	0.009	0.745539623
5.00	2.14	0.004	0.331350943

Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25	Duration, D	0.25
Tc	0.505	Tc	0.505	Tc	0.505	Tc	0.505	Tc	0.505	Tc	0.505
Tp	0.428	Tp	0.428	Tp	0.428	Tp	0.428	Tp	0.428	Tp	0.428
A (sq miles)	0.112	A (sq miles)	0.112	A (sq miles)	0.112	A (sq miles)	0.112	A (sq miles)	0.112	A (sq miles)	0.112
P (1-yr)	3.3	P (2-yr)	8	P (10-yr)	13.1	P (25-yr)	16.8	P (100-yr)	22.6	P (500-yr)	50.7
CN	80	CN	80	CN	80	CN	80	CN	80	CN	80
S	2.5	S	2.5	S	2.5	S	2.5	S	2.5	S	2.5
Q (1-yr)	1.479245283	Q (2-yr)	5.625	Q (10-yr)	10.51391	Q (25-yr)	14.13245	Q (100-yr)	19.854065	Q (500-yr)	47.81859583
Ia	0.5	Ia	0.5	Ia	0.5	Ia	0.5	Ia	0.5	Ia	0.5
Ia/P (1-yr)	0.151515152	Ia/P (2-yr)	0.0625	Ia/P (10-yr)	0.038168	Ia/P (25-yr)	0.029762	Ia/P (100-yr)	0.02212389	Ia/P (500-yr)	0.009861933
use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1	use Ia/P min	0.1
qu from chart	500	qu from chart	525	qu from chart	525	qu from chart	525	qu from chart	525	qu from chart	525
Qp (1-yr) =	82.83773585	Qp (2-yr) =	330.75	Qp (10-yr) =	618.2177	Qp (25-yr) =	830.9879	Qp (100-yr) =	1167.41902	Qp (500-yr) =	2811.733435





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.96125
0.20	0.09	0.075	24.80625
0.30	0.13	0.16	52.92
0.40	0.17	0.28	92.61
0.50	0.21	0.43	142.2225
0.60	0.26	0.6	198.45
0.70	0.30	0.77	254.6775
0.80	0.34	0.89	294.3675
1.00	0.43	1	330.75
1.10	0.47	0.98	324.135
1.20	0.51	0.92	304.29
1.30	0.56	0.84	277.83
1.40	0.60	0.75	248.0625
1.50	0.64	0.65	214.9875
1.60	0.68	0.57	188.5275
1.80	0.77	0.43	142.2225
2.00	0.86	0.32	105.84
2.20	0.94	0.24	79.38
2.40	1.03	0.18	59.535
2.60	1.11	0.13	42.9975
2.80	1.20	0.098	32.4135
3.50	1.50	0.036	11.907
4.00	1.71	0.018	5.9535
4.50	1.93	0.009	2.97675
5.00	2.14	0.004	1.323

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	9.273266225
0.20	0.09	0.075	46.36633113
0.30	0.13	0.16	98.91483974
0.40	0.17	0.28	173.1009695
0.50	0.21	0.43	265.8336318
0.60	0.26	0.6	370.930649
0.70	0.30	0.77	476.0276662
0.80	0.34	0.89	550.213796
1.00	0.43	1	618.2177483
1.10	0.47	0.98	605.8533934
1.20	0.51	0.92	568.7603285
1.30	0.56	0.84	519.3029086
1.40	0.60	0.75	463.6633113
1.50	0.64	0.65	401.8415364
1.60	0.68	0.57	352.3841166
1.80	0.77	0.43	265.8336318
2.00	0.86	0.32	197.8296795
2.20	0.94	0.24	148.3722596
2.40	1.03	0.18	111.2791947
2.60	1.11	0.13	80.36830728
2.80	1.20	0.098	60.58533934
3.50	1.50	0.036	22.25583894
4.00	1.71	0.018	11.12791947
4.50	1.93	0.009	5.563959735
5.00	2.14	0.004	2.472870993

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	12.46482
0.20	0.09	0.075	62.32409
0.30	0.13	0.16	132.9581
0.40	0.17	0.28	232.6766
0.50	0.21	0.43	357.3248
0.60	0.26	0.6	498.5927
0.70	0.30	0.77	639.8607
0.80	0.34	0.89	739.5792
1.00	0.43	1	830.9879
1.10	0.47	0.98	814.3681
1.20	0.51	0.92	764.5088
1.30	0.56	0.84	698.0298
1.40	0.60	0.75	623.2409
1.50	0.64	0.65	540.1421
1.60	0.68	0.57	473.6631
1.80	0.77	0.43	357.3248
2.00	0.86	0.32	265.9161
2.20	0.94	0.24	199.4371
2.40	1.03	0.18	149.5778
2.60	1.11	0.13	108.0284
2.80	1.20	0.098	81.43681
3.50	1.50	0.036	29.91556
4.00	1.71	0.018	14.95778
4.50	1.93	0.009	7.478891
5.00	2.14	0.004	3.323951

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	17.51129
0.20	0.09	0.075	87.55643
0.30	0.13	0.16	186.787
0.40	0.17	0.28	326.8773
0.50	0.21	0.43	501.9902
0.60	0.26	0.6	700.4514
0.70	0.30	0.77	898.9126
0.80	0.34	0.89	1039.003
1.00	0.43	1	1167.419
1.10	0.47	0.98	1144.071
1.20	0.51	0.92	1074.026
1.30	0.56	0.84	980.632
1.40	0.60	0.75	875.5643
1.50	0.64	0.65	758.8224
1.60	0.68	0.57	665.4288
1.80	0.77	0.43	501.9902
2.00	0.86	0.32	373.5741
2.20	0.94	0.24	280.1806
2.40	1.03	0.18	210.1354
2.60	1.11	0.13	151.7645
2.80	1.20	0.098	114.4071
3.50	1.50	0.036	42.02708
4.00	1.71	0.018	21.01354
4.50	1.93	0.009	10.50677
5.00	2.14	0.004	4.669676

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	0.551513277
0.20	0.07	0.075	2.757566383
0.30	0.11	0.16	5.882808284
0.40	0.14	0.28	10.2949145
0.50	0.18	0.43	15.81004726
0.60	0.21	0.6	22.06053107
0.70	0.25	0.77	28.31101487
0.80	0.28	0.89	32.72312108
1.00	0.35	1	36.76755178
1.10	0.39	0.98	36.03220074
1.20	0.42	0.92	33.82614763
1.30	0.46	0.84	30.88474349
1.40	0.50	0.75	27.57566383
1.50	0.53	0.65	23.89890865
1.60	0.57	0.57	20.95750451
1.80	0.64	0.43	15.81004726
2.00	0.71	0.32	11.76561657
2.20	0.78	0.24	8.824212426
2.40	0.85	0.18	6.61815932
2.60	0.92	0.13	4.779781731
2.80	0.99	0.098	3.603220074
3.50	1.24	0.036	1.323631864
4.00	1.41	0.018	0.661815932
4.50	1.59	0.009	0.330907966
5.00	1.77	0.004	0.147070207

Duration, D	0.25
Tc	0.381
Tp	0.3536
A (sq miles)	0.0547
P (1-yr)	3.3
CN	76
S	3.157894737
Q (1-yr)	1.222122379
Ia	0.631578947
Ia/P (1-yr)	0.19138756
use Ia/P min	0.1
qu from chart	550
Qp (1-yr) =	36.76755178

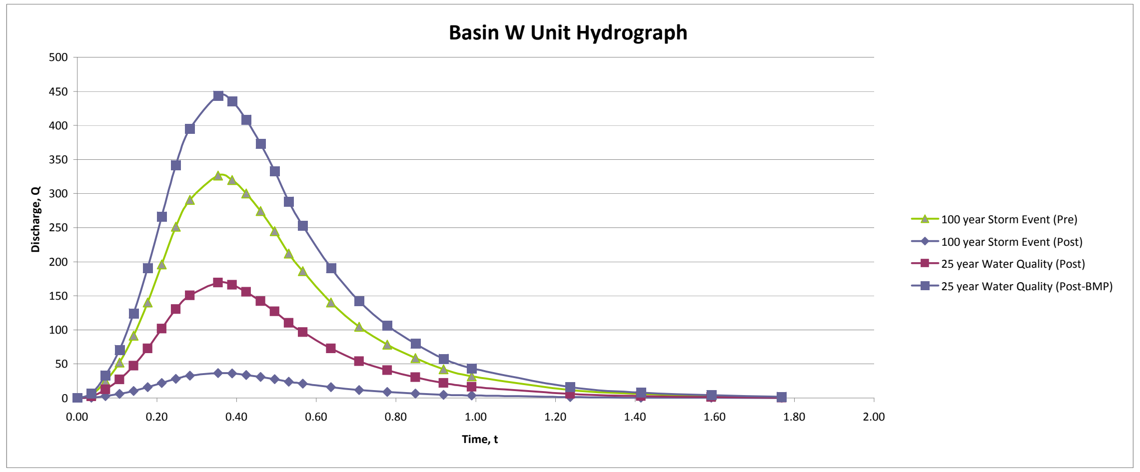
Duration, D	0.25
Tc	0.381
Tp	0.3536
A (sq miles)	0.0547
P (2-yr)	8
CN	76
S	3.157895
Q (2-yr)	5.157895
Ia	0.631579
Ia/P (2-yr)	0.078947
use Ia/P min	0.1
qu from chart	600
Qp (2-yr) =	169.2821

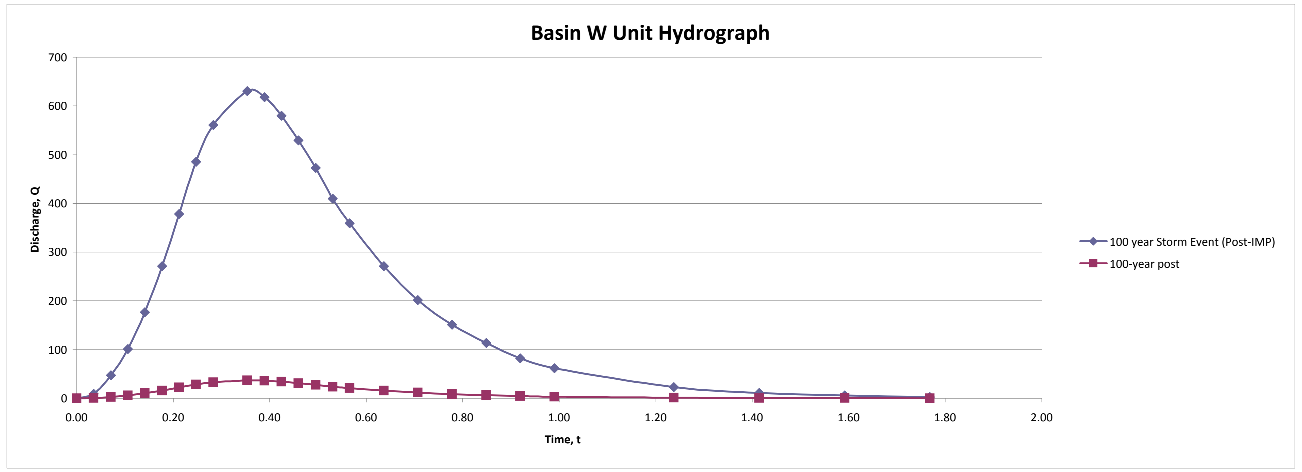
Duration, D	0.25
Tc	0.381
Tp	0.3536
A (sq miles)	0.0547
P (10-yr)	13.1
CN	76
S	3.157895
Q (10-yr)	9.9487
Ia	0.631579
Ia/P (10-yr)	0.048212
use Ia/P min	0.1
qu from chart	600
Qp (10-yr) =	326.5163

Duration, D	0.25
Tc	0.381
Tp	0.3536
A (sq miles)	0.0547
P (25-yr)	16.8
CN	76
S	3.157895
Q (25-yr)	13.52652
Ia	0.631579
Ia/P (25-yr)	0.037594
use Ia/P min	0.1
qu from chart	600
Qp (25-yr) =	443.9405

Duration, D	0.25
Tc	0.381
Tp	0.3536
A (sq miles)	0.0547
P (100-yr)	22.6
CN	76
S	3.15789474
Q (100-yr)	19.207413
Ia	0.63157895
Ia/P (100-yr)	0.02794597
use Ia/P min	0.1
qu from chart	600
Qp (100-yr) =	630.387293

Duration, D	0.25
Tc	0.381
Tp	0.3536
A (sq miles)	0.0547
P (500-yr)	50.7
CN	76
S	3.157894737
Q (500-yr)	47.09788287
Ia	0.631578947
Ia/P (500-yr)	0.012457178
use Ia/P min	0.1
qu from chart	600
Qp (500-yr) =	1545.752516





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.539231579
0.20	0.07	0.075	12.69615789
0.30	0.11	0.16	27.08513684
0.40	0.14	0.28	47.39898947
0.50	0.18	0.43	72.79130526
0.60	0.21	0.6	101.5692632
0.70	0.25	0.77	130.3472211
0.80	0.28	0.89	150.6610737
1.00	0.35	1	169.2821053
1.10	0.39	0.98	165.8964632
1.20	0.42	0.92	155.7395368
1.30	0.46	0.84	142.1969684
1.40	0.50	0.75	126.9615789
1.50	0.53	0.65	110.0333684
1.60	0.57	0.57	96.4908
1.80	0.64	0.43	72.79130526
2.00	0.71	0.32	54.17027368
2.20	0.78	0.24	40.62770526
2.40	0.85	0.18	30.47077895
2.60	0.92	0.13	22.00667368
2.80	0.99	0.098	16.58964632
3.50	1.24	0.036	6.094155789
4.00	1.41	0.018	3.047077895
4.50	1.59	0.009	1.523538947
5.00	1.77	0.004	0.677128421

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.897744873
0.20	0.07	0.075	24.48872436
0.30	0.11	0.16	52.24261198
0.40	0.14	0.28	91.42457096
0.50	0.18	0.43	140.4020197
0.60	0.21	0.6	195.9097949
0.70	0.25	0.77	251.4175701
0.80	0.28	0.89	290.5995291
1.00	0.35	1	326.5163249
1.10	0.39	0.98	319.9859984
1.20	0.42	0.92	300.3950189
1.30	0.46	0.84	274.2737129
1.40	0.50	0.75	244.8872436
1.50	0.53	0.65	212.2356112
1.60	0.57	0.57	186.1143052
1.80	0.64	0.43	140.4020197
2.00	0.71	0.32	104.485224
2.20	0.78	0.24	78.36391797
2.40	0.85	0.18	58.77293848
2.60	0.92	0.13	42.44712223
2.80	0.99	0.098	31.99859984
3.50	1.24	0.036	11.7545877
4.00	1.41	0.018	5.877293848
4.50	1.59	0.009	2.938646924
5.00	1.77	0.004	1.306065299

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	6.659107
0.20	0.07	0.075	33.29553
0.30	0.11	0.16	71.03047
0.40	0.14	0.28	124.3033
0.50	0.18	0.43	190.8944
0.60	0.21	0.6	266.3643
0.70	0.25	0.77	341.8342
0.80	0.28	0.89	395.107
1.00	0.35	1	443.9405
1.10	0.39	0.98	435.0616
1.20	0.42	0.92	408.4252
1.30	0.46	0.84	372.91
1.40	0.50	0.75	332.9553
1.50	0.53	0.65	288.5613
1.60	0.57	0.57	253.0461
1.80	0.64	0.43	190.8944
2.00	0.71	0.32	142.0609
2.20	0.78	0.24	106.5457
2.40	0.85	0.18	79.90928
2.60	0.92	0.13	57.71226
2.80	0.99	0.098	43.50616
3.50	1.24	0.036	15.98186
4.00	1.41	0.018	7.990928
4.50	1.59	0.009	3.995464
5.00	1.77	0.004	1.775762

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	9.455809
0.20	0.07	0.075	47.27905
0.30	0.11	0.16	100.862
0.40	0.14	0.28	176.5084
0.50	0.18	0.43	271.0665
0.60	0.21	0.6	378.2324
0.70	0.25	0.77	485.3982
0.80	0.28	0.89	561.0447
1.00	0.35	1	630.3873
1.10	0.39	0.98	617.7795
1.20	0.42	0.92	579.9563
1.30	0.46	0.84	529.5253
1.40	0.50	0.75	472.7905
1.50	0.53	0.65	409.7517
1.60	0.57	0.57	359.3208
1.80	0.64	0.43	271.0665
2.00	0.71	0.32	201.7239
2.20	0.78	0.24	151.293
2.40	0.85	0.18	113.4697
2.60	0.92	0.13	81.95035
2.80	0.99	0.098	61.77795
3.50	1.24	0.036	22.69394
4.00	1.41	0.018	11.34697
4.50	1.59	0.009	5.673486
5.00	1.77	0.004	2.521549

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	0.541403774
0.20	0.09	0.075	2.707018868
0.30	0.13	0.16	5.774973585
0.40	0.18	0.28	10.10620377
0.50	0.22	0.43	15.52024151
0.60	0.26	0.6	21.65615094
0.70	0.31	0.77	27.79206038
0.80	0.35	0.89	32.12329057
1.00	0.44	1	36.09358491
1.10	0.48	0.98	35.37171321
1.20	0.53	0.92	33.20609811
1.30	0.57	0.84	30.31861132
1.40	0.61	0.75	27.07018868
1.50	0.66	0.65	23.46083019
1.60	0.70	0.57	20.5733434
1.80	0.79	0.43	15.52024151
2.00	0.88	0.32	11.54994717
2.20	0.96	0.24	8.662460377
2.40	1.05	0.18	6.496845283
2.60	1.14	0.13	4.692166038
2.80	1.23	0.098	3.537171321
3.50	1.53	0.036	1.299369057
4.00	1.75	0.018	0.649684528
4.50	1.97	0.009	0.324842264
5.00	2.19	0.004	0.14437434

Duration, D	0.25
Tc	0.521
Tp	0.4376
A (sq miles)	0.0488
P (1-yr)	3.3
CN	80
S	2.5
Q (1-yr)	1.479245283
Ia	0.5
Ia/P (1-yr)	0.151515152
use Ia/P min	0.1
qu from chart	500
Qp (1-yr) =	36.09358491

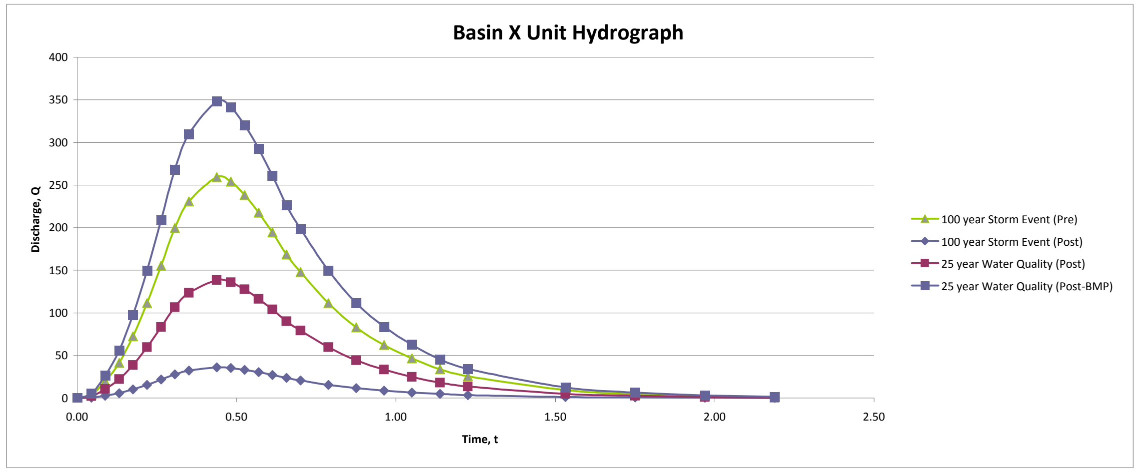
Duration, D	0.25
Tc	0.521
Tp	0.4376
A (sq miles)	0.0488
P (2-yr)	8
CN	80
S	2.5
Q (2-yr)	5.625
Ia	0.5
Ia/P (2-yr)	0.0625
use Ia/P min	0.1
qu from chart	505
Qp (2-yr) =	138.6225

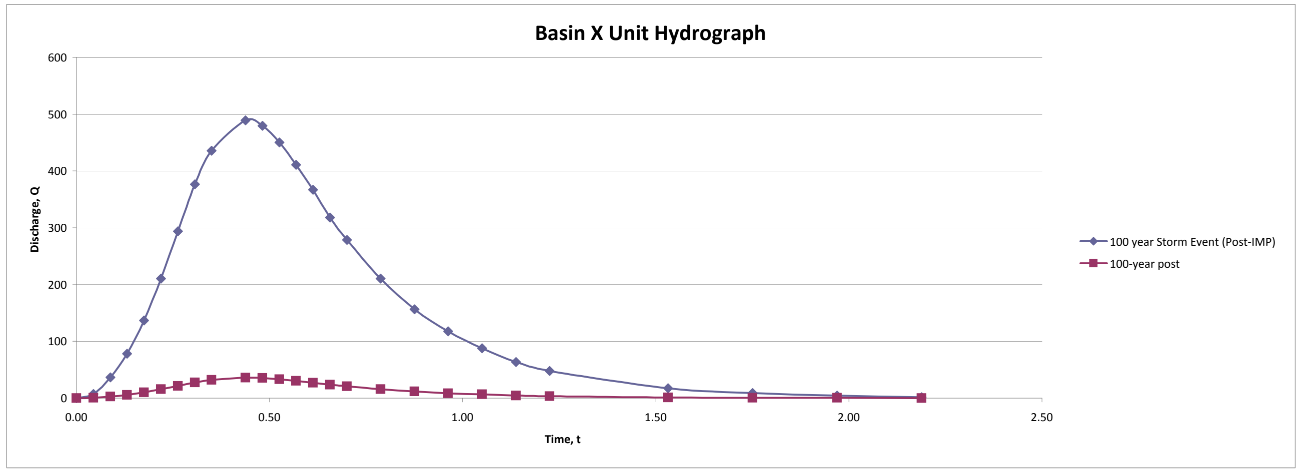
Duration, D	0.25
Tc	0.521
Tp	0.4376
A (sq miles)	0.0488
P (10-yr)	13.1
CN	80
S	2.5
Q (10-yr)	10.51391
Ia	0.5
Ia/P (10-yr)	0.038168
use Ia/P min	0.1
qu from chart	505
Qp (10-yr) =	259.1047

Duration, D	0.25
Tc	0.521
Tp	0.4376
A (sq miles)	0.0488
P (25-yr)	16.8
CN	80
S	2.5
Q (25-yr)	14.13245
Ia	0.5
Ia/P (25-yr)	0.029762
use Ia/P min	0.1
qu from chart	505
Qp (25-yr) =	348.28

Duration, D	0.25
Tc	0.521
Tp	0.4376
A (sq miles)	0.0488
P (100-yr)	22.6
CN	80
S	2.5
Q (100-yr)	19.854065
Ia	0.5
Ia/P (100-yr)	0.02212389
use Ia/P min	0.1
qu from chart	505
Qp (100-yr) =	489.283579

Duration, D	0.25
Tc	0.521
Tp	0.4376
A (sq miles)	0.0488
P (500-yr)	50.7
CN	80
S	2.5
Q (500-yr)	47.81859583
Ia	0.5
Ia/P (500-yr)	0.009861933
use Ia/P min	0.1
qu from chart	505
Qp (500-yr) =	1178.441476





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.0793375
0.20	0.09	0.075	10.3966875
0.30	0.13	0.16	22.1796
0.40	0.18	0.28	38.8143
0.50	0.22	0.43	59.607675
0.60	0.26	0.6	83.1735
0.70	0.31	0.77	106.739325
0.80	0.35	0.89	123.374025
1.00	0.44	1	138.6225
1.10	0.48	0.98	135.85005
1.20	0.53	0.92	127.5327
1.30	0.57	0.84	116.4429
1.40	0.61	0.75	103.966875
1.50	0.66	0.65	90.104625
1.60	0.70	0.57	79.014825
1.80	0.79	0.43	59.607675
2.00	0.88	0.32	44.3592
2.20	0.96	0.24	33.2694
2.40	1.05	0.18	24.95205
2.60	1.14	0.13	18.020925
2.80	1.23	0.098	13.585005
3.50	1.53	0.036	4.99041
4.00	1.75	0.018	2.495205
4.50	1.97	0.009	1.2476025
5.00	2.19	0.004	0.55449

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	3.886570967
0.20	0.09	0.075	19.43285483
0.30	0.13	0.16	41.45675698
0.40	0.18	0.28	72.54932472
0.50	0.22	0.43	111.4150344
0.60	0.26	0.6	155.4628387
0.70	0.31	0.77	199.510643
0.80	0.35	0.89	230.6032107
1.00	0.44	1	259.1047311
1.10	0.48	0.98	253.9226365
1.20	0.53	0.92	238.3763526
1.30	0.57	0.84	217.6479741
1.40	0.61	0.75	194.3285483
1.50	0.66	0.65	168.4180752
1.60	0.70	0.57	147.6896967
1.80	0.79	0.43	111.4150344
2.00	0.88	0.32	82.91351396
2.20	0.96	0.24	62.18513547
2.40	1.05	0.18	46.6388516
2.60	1.14	0.13	33.68361505
2.80	1.23	0.098	25.39226365
3.50	1.53	0.036	9.327770321
4.00	1.75	0.018	4.66388516
4.50	1.97	0.009	2.33194258
5.00	2.19	0.004	1.036418925

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	5.2242
0.20	0.09	0.075	26.121
0.30	0.13	0.16	55.7248
0.40	0.18	0.28	97.51841
0.50	0.22	0.43	149.7604
0.60	0.26	0.6	208.968
0.70	0.31	0.77	268.1756
0.80	0.35	0.89	309.9692
1.00	0.44	1	348.28
1.10	0.48	0.98	341.3144
1.20	0.53	0.92	320.4176
1.30	0.57	0.84	292.5552
1.40	0.61	0.75	261.21
1.50	0.66	0.65	226.382
1.60	0.70	0.57	198.5196
1.80	0.79	0.43	149.7604
2.00	0.88	0.32	111.4496
2.20	0.96	0.24	83.5872
2.40	1.05	0.18	62.6904
2.60	1.14	0.13	45.2764
2.80	1.23	0.098	34.13144
3.50	1.53	0.036	12.53808
4.00	1.75	0.018	6.26904
4.50	1.97	0.009	3.13452
5.00	2.19	0.004	1.39312

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	7.339254
0.20	0.09	0.075	36.69627
0.30	0.13	0.16	78.28537
0.40	0.18	0.28	136.9994
0.50	0.22	0.43	210.3919
0.60	0.26	0.6	293.5701
0.70	0.31	0.77	376.7484
0.80	0.35	0.89	435.4624
1.00	0.44	1	489.2836
1.10	0.48	0.98	479.4979
1.20	0.53	0.92	450.1409
1.30	0.57	0.84	410.9982
1.40	0.61	0.75	366.9627
1.50	0.66	0.65	318.0343
1.60	0.70	0.57	278.8916
1.80	0.79	0.43	210.3919
2.00	0.88	0.32	156.5707
2.20	0.96	0.24	117.4281
2.40	1.05	0.18	88.07104
2.60	1.14	0.13	63.60687
2.80	1.23	0.098	47.94979
3.50	1.53	0.036	17.61421
4.00	1.75	0.018	8.807104
4.50	1.97	0.009	4.403552
5.00	2.19	0.004	1.957134

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	0.558495339
0.20	0.08	0.075	2.792476697
0.30	0.12	0.16	5.95728362
0.40	0.16	0.28	10.42524634
0.50	0.21	0.43	16.01019973
0.60	0.25	0.6	22.33981358
0.70	0.29	0.77	28.66942742
0.80	0.33	0.89	33.13739014
1.00	0.41	1	37.23302263
1.10	0.45	0.98	36.48836217
1.20	0.49	0.92	34.25438082
1.30	0.53	0.84	31.27573901
1.40	0.57	0.75	27.92476697
1.50	0.62	0.65	24.20146471
1.60	0.66	0.57	21.2228229
1.80	0.74	0.43	16.01019973
2.00	0.82	0.32	11.91456724
2.20	0.90	0.24	8.93592543
2.40	0.99	0.18	6.701944073
2.60	1.07	0.13	4.840292941
2.80	1.15	0.098	3.648836217
3.50	1.44	0.036	1.340388815
4.00	1.64	0.018	0.670194407
4.50	1.85	0.009	0.335097204
5.00	2.05	0.004	0.148932091

Duration, D	0.25
Tc	0.476
Tp	0.4106
A (sq miles)	0.0507
P (1-yr)	3.3
CN	79
S	2.658227848
Q (1-yr)	1.412267586
Ia	0.53164557
Ia/P (1-yr)	0.161104718
use Ia/P min	0.1
qu from chart	520
Qp (1-yr) =	37.23302263

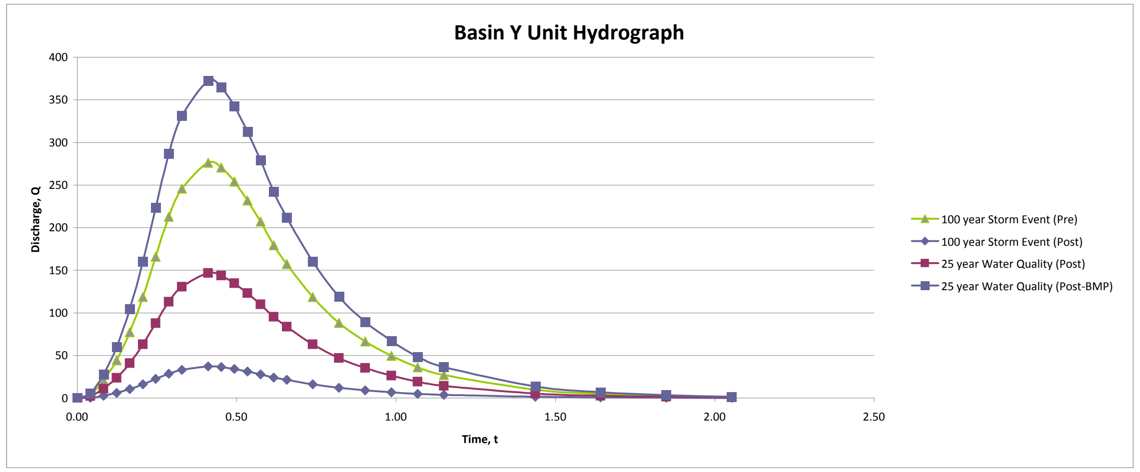
Duration, D	0.25
Tc	0.476
Tp	0.4106
A (sq miles)	0.0507
P (2-yr)	8
CN	79
S	2.658228
Q (2-yr)	5.507911
Ia	0.531646
Ia/P (2-yr)	0.066456
use Ia/P min	0.1
qu from chart	525
Qp (2-yr) =	146.6068

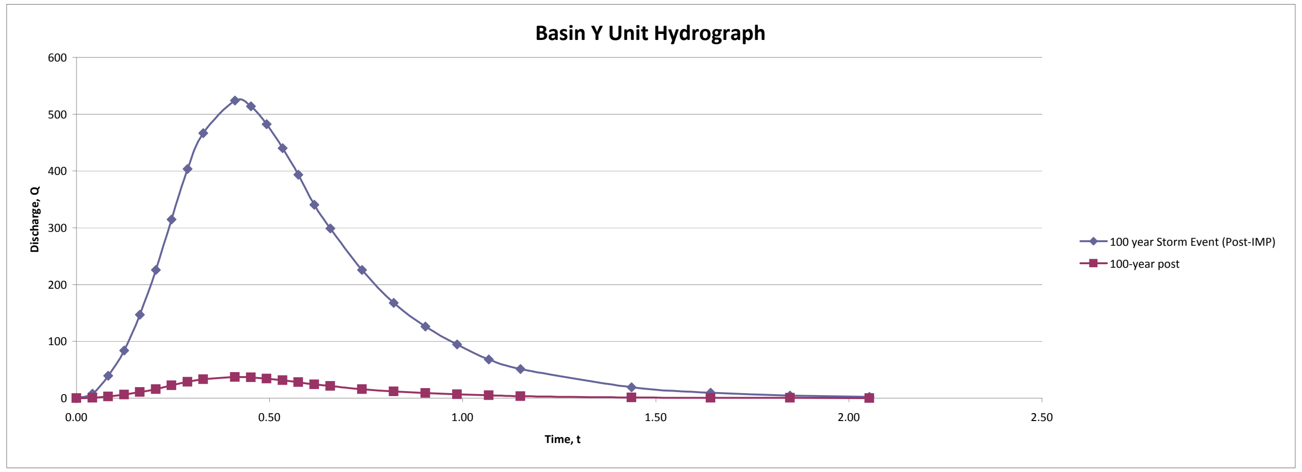
Duration, D	0.25
Tc	0.476
Tp	0.4106
A (sq miles)	0.0507
P (10-yr)	13.1
CN	79
S	2.658228
Q (10-yr)	10.37419
Ia	0.531646
Ia/P (10-yr)	0.040584
use Ia/P min	0.1
qu from chart	525
Qp (10-yr) =	276.1351

Duration, D	0.25
Tc	0.476
Tp	0.4106
A (sq miles)	0.0507
P (25-yr)	16.8
CN	79
S	2.658228
Q (25-yr)	13.98347
Ia	0.531646
Ia/P (25-yr)	0.031646
use Ia/P min	0.1
qu from chart	525
Qp (25-yr) =	372.2051

Duration, D	0.25
Tc	0.476
Tp	0.4106
A (sq miles)	0.0507
P (100-yr)	22.6
CN	79
S	2.65822785
Q (100-yr)	19.695899
Ia	0.53164557
Ia/P (100-yr)	0.02352414
use Ia/P min	0.1
qu from chart	525
Qp (100-yr) =	524.255592

Duration, D	0.25
Tc	0.476
Tp	0.4106
A (sq miles)	0.0507
P (500-yr)	50.7
CN	79
S	2.658227848
Q (500-yr)	47.64388832
Ia	0.53164557
Ia/P (500-yr)	0.010486106
use Ia/P min	0.1
qu from chart	525
Qp (500-yr) =	1268.161197





25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	2.199102472
0.20	0.08	0.075	10.99551236
0.30	0.12	0.16	23.45709304
0.40	0.16	0.28	41.04991282
0.50	0.21	0.43	63.04093754
0.60	0.25	0.6	87.96409889
0.70	0.29	0.77	112.8872602
0.80	0.33	0.89	130.48008
1.00	0.41	1	146.6068315
1.10	0.45	0.98	143.6746949
1.20	0.49	0.92	134.878285
1.30	0.53	0.84	123.1497384
1.40	0.57	0.75	109.9551236
1.50	0.62	0.65	95.29444047
1.60	0.66	0.57	83.56589395
1.80	0.74	0.43	63.04093754
2.00	0.82	0.32	46.91418608
2.20	0.90	0.24	35.18563956
2.40	0.99	0.18	26.38922967
2.60	1.07	0.13	19.05888809
2.80	1.15	0.098	14.36746949
3.50	1.44	0.036	5.277845934
4.00	1.64	0.018	2.638922967
4.50	1.85	0.009	1.319461483
5.00	2.05	0.004	0.586427326

100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	4.142027014
0.20	0.08	0.075	20.71013507
0.30	0.12	0.16	44.18162148
0.40	0.16	0.28	77.3178376
0.50	0.21	0.43	118.7381077
0.60	0.25	0.6	165.6810806
0.70	0.29	0.77	212.6240534
0.80	0.33	0.89	245.7602695
1.00	0.41	1	276.1351343
1.10	0.45	0.98	270.6124316
1.20	0.49	0.92	254.0443235
1.30	0.53	0.84	231.9535128
1.40	0.57	0.75	207.1013507
1.50	0.62	0.65	179.4878373
1.60	0.66	0.57	157.3970265
1.80	0.74	0.43	118.7381077
2.00	0.82	0.32	88.36324297
2.20	0.90	0.24	66.27243223
2.40	0.99	0.18	49.70432417
2.60	1.07	0.13	35.89756746
2.80	1.15	0.098	27.06124316
3.50	1.44	0.036	9.940864834
4.00	1.64	0.018	4.970432417
4.50	1.85	0.009	2.485216208
5.00	2.05	0.004	1.104540537

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	5.583076
0.20	0.08	0.075	27.91538
0.30	0.12	0.16	59.55282
0.40	0.16	0.28	104.2174
0.50	0.21	0.43	160.0482
0.60	0.25	0.6	223.3231
0.70	0.29	0.77	286.5979
0.80	0.33	0.89	331.2625
1.00	0.41	1	372.2051
1.10	0.45	0.98	364.761
1.20	0.49	0.92	342.4287
1.30	0.53	0.84	312.6523
1.40	0.57	0.75	279.1538
1.50	0.62	0.65	241.9333
1.60	0.66	0.57	212.1569
1.80	0.74	0.43	160.0482
2.00	0.82	0.32	119.1056
2.20	0.90	0.24	89.32922
2.40	0.99	0.18	66.99692
2.60	1.07	0.13	48.38666
2.80	1.15	0.098	36.4761
3.50	1.44	0.036	13.39938
4.00	1.64	0.018	6.699692
4.50	1.85	0.009	3.349846
5.00	2.05	0.004	1.48882

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.04	0.015	7.863834
0.20	0.08	0.075	39.31917
0.30	0.12	0.16	83.88089
0.40	0.16	0.28	146.7916
0.50	0.21	0.43	225.4299
0.60	0.25	0.6	314.5534
0.70	0.29	0.77	403.6768
0.80	0.33	0.89	466.5875
1.00	0.41	1	524.2556
1.10	0.45	0.98	513.7705
1.20	0.49	0.92	482.3151
1.30	0.53	0.84	440.3747
1.40	0.57	0.75	393.1917
1.50	0.62	0.65	340.7661
1.60	0.66	0.57	298.8257
1.80	0.74	0.43	225.4299
2.00	0.82	0.32	167.7618
2.20	0.90	0.24	125.8213
2.40	0.99	0.18	94.36601
2.60	1.07	0.13	68.15323
2.80	1.15	0.098	51.37705
3.50	1.44	0.036	18.8732
4.00	1.64	0.018	9.436601
4.50	1.85	0.009	4.7183
5.00	2.05	0.004	2.097022

100yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	0.117159773
0.20	0.06	0.075	0.585798864
0.30	0.09	0.16	1.249704242
0.40	0.12	0.28	2.186982424
0.50	0.15	0.43	3.358580151
0.60	0.19	0.6	4.686390909
0.70	0.22	0.77	6.014201666
0.80	0.25	0.89	6.951479848
1.00	0.31	1	7.810651515
1.10	0.34	0.98	7.654438485
1.20	0.37	0.92	7.185799394
1.30	0.40	0.84	6.560947272
1.40	0.43	0.75	5.857988636
1.50	0.46	0.65	5.076923485
1.60	0.49	0.57	4.452071363
1.80	0.56	0.43	3.358580151
2.00	0.62	0.32	2.499408485
2.20	0.68	0.24	1.874556364
2.40	0.74	0.18	1.405917273
2.60	0.80	0.13	1.015384697
2.80	0.87	0.098	0.765443848
3.50	1.08	0.036	0.281183455
4.00	1.24	0.018	0.140591727
4.50	1.39	0.009	0.070295864
5.00	1.55	0.004	0.031242606

Duration, D	0.25
Tc	0.307
Tp	0.3092
A (sq miles)	0.0606
P (1-yr)	3.3
CN	57
S	7.543859649
Q (1-yr)	0.343703037
Ia	1.50877193
Ia/P (1-yr)	0.457203615
use Ia/P min	0.1
qu from chart	375
Qp (1-yr) =	7.810651515

Duration, D	0.25
Tc	0.307
Tp	0.3092
A (sq miles)	0.0606
P (2-yr)	8
CN	57
S	7.54386
Q (2-yr)	3.002193
Ia	1.508772
Ia/P (2-yr)	0.188596
use Ia/P min	0.1
qu from chart	615
Qp (2-yr) =	111.8887

Duration, D	0.25
Tc	0.307
Tp	0.3092
A (sq miles)	0.0606
P (10-yr)	13.1
CN	57
S	7.54386
Q (10-yr)	7.021476
Ia	1.508772
Ia/P (10-yr)	0.115173
use Ia/P min	0.1
qu from chart	670
Qp (10-yr) =	285.086

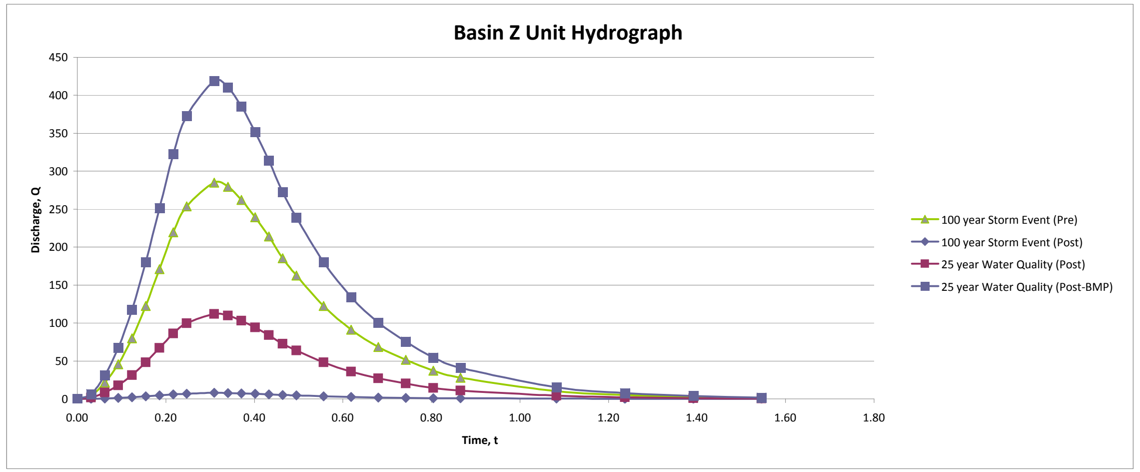
Duration, D	0.25
Tc	0.307
Tp	0.3092
A (sq miles)	0.0606
P (25-yr)	16.8
CN	57
S	7.54386
Q (25-yr)	10.23958
Ia	1.508772
Ia/P (25-yr)	0.089808
use Ia/P min	0.1
qu from chart	675
Qp (25-yr) =	418.8499

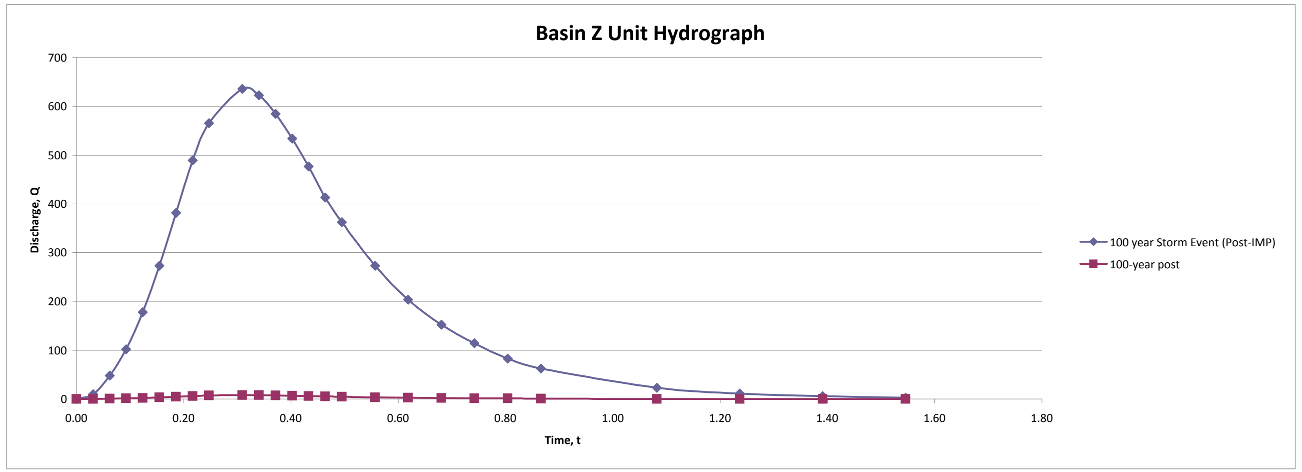
Duration, D	0.25
Tc	0.307
Tp	0.3092
A (sq miles)	0.0606
P (100-yr)	22.6
CN	57
S	7.54385965
Q (100-yr)	15.534784
Ia	1.50877193
Ia/P (100-yr)	0.06675982
use Ia/P min	0.1
qu from chart	675
Qp (100-yr) =	635.450338

Duration, D	0.25
Tc	0.307
Tp	0.3092
A (sq miles)	0.0606
P (500-yr)	50.7
CN	57
S	7.543859649
Q (500-yr)	42.65044819
Ia	1.50877193
Ia/P (500-yr)	0.029758815
use Ia/P min	0.1
qu from chart	675
Qp (500-yr) =	1744.616583

25yr (post)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	1.678330954
0.20	0.06	0.075	8.39165477
0.30	0.09	0.16	17.90219684
0.40	0.12	0.28	31.32884447
0.50	0.15	0.43	48.11215401
0.60	0.19	0.6	67.13323816
0.70	0.22	0.77	86.1543223
0.80	0.25	0.89	99.58096993
1.00	0.31	1	111.8887303
1.10	0.34	0.98	109.6509557
1.20	0.37	0.92	102.9376318
1.30	0.40	0.84	93.98653342
1.40	0.43	0.75	83.9165477
1.50	0.46	0.65	72.72767467
1.60	0.49	0.57	63.77657625
1.80	0.56	0.43	48.11215401
2.00	0.62	0.32	35.80439368
2.20	0.68	0.24	26.85329526
2.40	0.74	0.18	20.13997145
2.60	0.80	0.13	14.54553493
2.80	0.87	0.098	10.96509557
3.50	1.08	0.036	4.027994289
4.00	1.24	0.018	2.013997145
4.50	1.39	0.009	1.006998572
5.00	1.55	0.004	0.447554921





100yr (pre)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	4.276289815
0.20	0.06	0.075	21.38144907
0.30	0.09	0.16	45.61375802
0.40	0.12	0.28	79.82407654
0.50	0.15	0.43	122.5869747
0.60	0.19	0.6	171.0515926
0.70	0.22	0.77	219.5162105
0.80	0.25	0.89	253.726529
1.00	0.31	1	285.0859876
1.10	0.34	0.98	279.3842679
1.20	0.37	0.92	262.2791086
1.30	0.40	0.84	239.4722296
1.40	0.43	0.75	213.8144907
1.50	0.46	0.65	185.305892
1.60	0.49	0.57	162.499013
1.80	0.56	0.43	122.5869747
2.00	0.62	0.32	91.22751604
2.20	0.68	0.24	68.42063703
2.40	0.74	0.18	51.31547778
2.60	0.80	0.13	37.06117839
2.80	0.87	0.098	27.93842679
3.50	1.08	0.036	10.26309556
4.00	1.24	0.018	5.131547778
4.50	1.39	0.009	2.565773889
5.00	1.55	0.004	1.140343951

25yr (post w/BMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	6.282749
0.20	0.06	0.075	31.41374
0.30	0.09	0.16	67.01599
0.40	0.12	0.28	117.278
0.50	0.15	0.43	180.1055
0.60	0.19	0.6	251.31
0.70	0.22	0.77	322.5144
0.80	0.25	0.89	372.7764
1.00	0.31	1	418.8499
1.10	0.34	0.98	410.4729
1.20	0.37	0.92	385.3419
1.30	0.40	0.84	351.8339
1.40	0.43	0.75	314.1374
1.50	0.46	0.65	272.2525
1.60	0.49	0.57	238.7445
1.80	0.56	0.43	180.1055
2.00	0.62	0.32	134.032
2.20	0.68	0.24	100.524
2.40	0.74	0.18	75.39299
2.60	0.80	0.13	54.45049
2.80	0.87	0.098	41.04729
3.50	1.08	0.036	15.0786
4.00	1.24	0.018	7.539299
4.50	1.39	0.009	3.769649
5.00	1.55	0.004	1.6754

100yr (post w/IMP)

Time		Discharge	
0.00	0.00	0	0
0.10	0.03	0.015	9.531755
0.20	0.06	0.075	47.65878
0.30	0.09	0.16	101.6721
0.40	0.12	0.28	177.9261
0.50	0.15	0.43	273.2436
0.60	0.19	0.6	381.2702
0.70	0.22	0.77	489.2968
0.80	0.25	0.89	565.5508
1.00	0.31	1	635.4503
1.10	0.34	0.98	622.7413
1.20	0.37	0.92	584.6143
1.30	0.40	0.84	533.7783
1.40	0.43	0.75	476.5878
1.50	0.46	0.65	413.0427
1.60	0.49	0.57	362.2067
1.80	0.56	0.43	273.2436
2.00	0.62	0.32	203.3441
2.20	0.68	0.24	152.5081
2.40	0.74	0.18	114.3811
2.60	0.80	0.13	82.60854
2.80	0.87	0.098	62.27413
3.50	1.08	0.036	22.87621
4.00	1.24	0.018	11.43811
4.50	1.39	0.009	5.719053
5.00	1.55	0.004	2.541801

Basin Curve Number

BasinID	Area_AC	CN Value			Weighted CN
		98	77		
A	13.57	4.08	9.49		83
		98	39	81	
AA	37.91	11.25	1.09	25.57	85
		98	39		
B	26.06	5.80	20.26		52
		39	81	98	
BB	43.56	5.64	10.21	27.70	86
		98	77	39	
C	38.09	9.48	3.07	25.54	57
		81	39	98	
CC	17.51	1.48	5.44	10.59	78
		81	98	39	
D	29.57	7.80	7.22	14.55	64
		39	81	98	
DD	46.56	4.42	4.34	37.73	91
		81	39	98	
E	57.92	7.71	30.14	20.07	65
		81	98	39	
EE	13.09	2.15	5.50	5.42	71
		81	98	39	
F	67.79	10.22	34.65	22.92	75
		81	98	39	
FF	6.61	0.39	3.03	3.18	69
		81	98	39	
G	63.01	43.32	14.69	5	82
		81	98	39	
H	35.06	18.66	8.84	7.56	76
		81	98		
I	8.66	5.28	3.38		88
		39	81	98	
J	26.87	6.9	5.43	14.54	79
		81	39	98	
K	64.62	6.97	26.54	31.11	72
		81	39	98	
M	27.42	2.63	11.87	12.92	71
		81	98	39	
N	37.45	15.46	14.48	7.51	79
		81	98	39	
O	126.63	12.04	19.17	95.42	52
		81	39	98	
P	59.21	19.26	10.95	29.00	82
		39	81	98	
R	141.05	20.2	97.23	23.62	78
		98	39	81	

Basin Curve Number

2/3/201010:02 AM

BasinID	Area_AC	CN Value			Weighted CN
S	14.01	10.57	0.74	2.70	92
		81	39	98	
T	16.22	1.72	0.12	14.38	96
		81	39	98	
U	91.74	16.95	2.47	72.32	93
		81	39	89	
V	71.71	18.94	10.29	42.48	80
		81	98	39	
W	32.35	5.74	16.47	10.14	76
		81	39	98	
X	31.25	7.97	6.99	16.29	80
		81	39	98	
Y	32.48	2.23	9.95	20.3	79
		81	98	39	
Z	38.77	3.38	9.22	26.17	57

Basin Information

2/3/201010:03 AM

Basin ID	SHAPE_Area (m^2)	Area_Acres	Tc length (m)	Area_sq miles	Tc length (ft)	Tc high point	Tc low point	Weighted CN	Coeff, m	Tc (hours)
A	54977.3498	13.5674	541.3019	0.0212	1774.7602	109.0000	106.2000	83.0000	44681.7833	0.4949
AA	153633.2858	37.9138	615.4339	0.0592	2017.8162	150.0000	140.0000	85.0000	28663.0506	0.3516
B	105580.1664	26.0552	565.6478	0.0407	1854.5828	115.0000	111.0000	52.0000	39933.6825	0.4539
BB	176275.5487	43.5015	728.0194	0.0680	2386.9490	144.0000	138.0000	86.0000	47609.0029	0.5197
C	154360.5729	38.0933	555.1569	0.0595	1820.1866	115.0000	111.0000	57.0000	38827.8984	0.4442
CC	70955.3698	17.5105	663.1819	0.0274	2174.3669	148.0000	139.7000	78.0000	35193.3156	0.4118
D	119827.5574	29.5712	501.9199	0.0462	1645.6390	115.0000	109.0000	64.0000	27253.7469	0.3382
DD	188403.5751	46.4945	993.8610	0.0726	3258.5605	150.0000	137.3000	91.0000	52195.9529	0.5579
E	234685.9761	57.9161	604.5666	0.0905	1982.1855	109.0000	96.0000	65.0000	24476.2432	0.3114
EE	52954.2599	13.0681	275.8788	0.0204	904.5206	144.0000	137.9000	71.0000	11014.4481	0.1684
F	274683.0055	67.7867	1038.5439	0.1059	3405.0618	113.0000	104.0000	75.0000	66231.7522	0.6701
FF	26736.8978	6.5982	472.9789	0.0103	1550.7506	141.5000	136.0000	69.0000	26039.4371	0.3266
G	255328.0127	63.0102	536.9913	0.0985	1760.6271	109.0000	103.0000	82.0000	30159.5903	0.3657
H	142053.8689	35.0563	590.8167	0.0548	1937.1041	114.0000	106.0000	76.0000	30142.8589	0.3655
I	35075.7056	8.6560	227.7291	0.0135	746.6529	119.0000	109.0000	88.0000	6451.7596	0.1115
J	108886.1880	26.8711	498.9277	0.0420	1635.8285	128.0000	106.0000	79.0000	14105.7224	0.2037
K	288601.0954	71.2214	1433.5595	0.1113	4700.1950	136.8000	106.0000	72.0000	58062.8634	0.6055
M	111116.6300	27.4215	397.8155	0.0428	1304.3132	106.9000	96.0000	71.0000	14267.8849	0.2055
N	151746.9408	37.4483	775.4896	0.0585	2542.5888	140.0000	106.0000	79.0000	21987.4435	0.2867
O	581728.8674	143.5599	424.5192	0.2243	1391.8663	136.8000	112.0000	52.0000	10427.2652	0.1614
P	399330.0749	98.5472	1311.2520	0.1540	4299.1867	138.0000	126.0000	82.0000	81374.5949	0.7853
R	571573.4063	141.0537	1494.4022	0.2204	4899.6792	143.0000	124.2000	78.0000	79099.2826	0.7683
S	56784.5156	14.0134	1438.0035	0.0219	4714.7656	138.0000	128.0000	92.0000	102374.1163	0.9371
T	43108.0455	10.6383	277.7201	0.0166	910.5578	138.9000	137.2000	96.0000	21073.5067	0.2775
U	300209.6195	74.0862	673.4165	0.1158	2207.9230	143.0000	134.0000	93.0000	34582.3603	0.4063
V	290573.5693	71.7082	942.2946	0.1120	3089.4904	150.0000	136.0000	80.0000	45895.0939	0.5052
W	141778.2172	34.9882	770.8792	0.0547	2527.4729	144.0000	128.0000	76.0000	31766.5296	0.3806
X	126471.4690	31.2108	835.4893	0.0488	2739.3092	147.0000	138.0000	80.0000	47790.3617	0.5212
Y	131600.6121	32.4766	799.2450	0.0507	2620.4754	150.0000	140.0000	79.0000	42419.9486	0.4755
Z	157086.1838	38.7660	344.3299	0.0606	1128.9504	150.0000	147.5000	57.0000	23990.6654	0.3066

Storm Events Summary

BasinID	Q (cfs) 1 year, 24 hour	Q (cfs) 2 year, 24 hour	Q (cfs) 10 year, 24 hour	Q (cfs) 25 year, 24 hour	Q (cfs) 100 year, 24 hour	Q (cfs) 500 year, 24 hour
A	24.74	87.43	159.83	213.12	297.16	706.83
AA	75.35	253.97	457.69	607.14	842.54	1988.29
B	5.56	69.15	173.68	259.74	403.52	1154.25
BB	90.16	296.94	531.40	703.17	973.52	2288.61
C	14.12	123.30	288.37	420.53	638.00	1751.63
CC	20.30	87.89	166.84	225.52	318.49	773.83
D	13.73	109.18	240.91	341.08	503.18	1316.46
DD	86.24	253.87	439.36	574.47	786.61	1816.00
E	31.45	230.84	496.00	699.56	1028.31	2673.85
EE	14.84	79.40	159.84	220.74	318.08	799.51
F	51.69	240.26	467.24	637.18	907.34	2235.41
FF	4.87	29.12	59.71	83.01	120.37	305.83
G	92.49	352.08	648.33	866.76	1211.54	2893.56
H	37.84	173.83	335.29	455.87	647.33	1587.29
I	28.18	88.67	156.53	206.11	284.07	662.84
J	45.97	180.44	339.86	458.10	645.24	1560.81
K	46.39	250.80	500.38	688.79	989.50	2474.30
M	29.13	156.79	315.62	435.87	628.08	1578.73
N	53.70	219.11	412.69	556.26	783.50	1895.27
O	18.64	447.22	1178.75	1773.22	2754.83	7880.10
P	99.72	365.47	672.99	899.72	1257.61	3003.60
R	112.82	487.15	924.73	1249.99	1765.30	4289.18
S	19.02	54.76	94.16	122.84	167.84	386.17
T	33.09	87.39	146.56	189.52	256.89	583.36
U	176.62	497.66	850.31	1106.77	1509.19	3460.65
V	82.84	330.75	618.22	830.99	1167.42	2811.73
W	36.77	169.28	326.52	443.94	630.39	1545.75
X	36.09	138.62	259.11	348.28	489.28	1178.44
Y	37.23	146.61	276.14	372.21	524.26	1268.16
Z	7.81	111.89	285.09	418.85	635.45	1744.62

Appendix C
Detailed Non-Point Source Pollutant Loading Assessment Table

Table C-1: Existing Land Use Acreage Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]
A	Forest	13.35
	Urban Open	0.22
B	Forest	26.09
C	Forest	38.14
D	Forest	29.61
E	Forest	57.73
	Roadway	0.27
F	Forest	67.39
	Roadway	0.48
G	Forest	63.09
H	Commercial / Ops	3.92
	Forest	13.69
	Roadway	0.58
	Urban Open	16.92
I	Commercial / Ops	4.02
	Roadway	0.66
	Urban Open	3.99
J	Commercial / Ops	11.56
	Forest	4.64
	Industrial	5.12
	Residential	1.96
	Roadway	3.03
	Urban Open	0.59
K	Commercial / Ops	7.13
	Forest	36.06
	Residential	23.60
	Roadway	4.53
L[2]	Commercial / Ops	1.80
	Forest	684.35
	Residential	173.98
	Roadway	40.41
	Urban Open	18.15
M	Forest	27.13
	Roadway	0.33
N	Commercial / Ops	0.44
	Forest	10.12
	Roadway	0.20
	Urban Open	26.74
O	Forest	125.16
	Residential	15.75
	Roadway	2.84
P	Commercial / Ops	4.99
	Forest	39.91
	Industrial	14.41
	Residential	28.19
	Roadway	7.78

Sub-Basin	Land Use Category	Acres[1]
	Urban Open	3.38
R	Commercial / Ops	24.79
	Forest	54.86
	Residential	35.98
	Roadway	5.06
	Urban Open	20.36
S	Commercial / Ops	0.31
	Forest	9.30
	Industrial	1.52
	Residential	0.96
	Roadway	0.66
	Urban Open	1.26
T	Forest	10.65
U	Forest	33.00
	Urban Open	41.18
V	Commercial / Ops	6.68
	Forest	40.36
	Roadway	0.09
	Urban Open	24.67
W	Forest	20.51
	Urban Open	14.53
X	Forest	29.96
	Roadway	0.90
	Urban Open	0.39
Y	Commercial / Ops	8.52
	Forest	24.00
Z	Commercial / Ops	13.50
	Forest	25.31
AA	Forest	37.73
	Roadway	0.23
BB	Commercial / Ops	0.00
	Forest	43.56
CC	Forest	17.53
DD	Forest	46.56
EE	Forest	13.09
FF	Forest	6.61
GG[3]	Commercial / Ops	0.26
	Forest	864.96
	Roadway	4.03
	Urban Open	215.68

Notes:

1 Existing land use acres derived from a detailed vegetation map for the island of Guam (USDA, 2005), selected polyline features within a personal geodatabase obtained from the Navy, and recent aerial photographs.

2 Sub-Basin L comprises the “Family Housing Area”, which is referred to as Area 5 in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

3 Sub-Basin GG comprises land designated “Open Space – Protected” in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

Table C-2: Future Land Use Acreage by Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]
A	Residential	2.95
	Commercial / Ops	0.01
	Roadway	10.18
	Urban Open	0.49
B	Residential	5.39
	Roadway	3.99
	Urban Open	16.65
C	Residential	3.62
	Roadway	4.09
	Urban Open	30.43
D	Residential	22.73
	Roadway	2.45
	Urban Open	4.41
E	Commercial / Ops	34.42
	Roadway	7.48
	Urban Open	16.00
F	Residential	2.37
	Commercial / Ops	42.98
	Roadway	10.60
	Urban Open	11.94
G	Commercial / Ops	11.23
	Roadway	8.35
	Urban Open	43.54
H	Commercial / Ops	13.61
	Roadway	4.46
	Urban Open	16.96
I	Commercial / Ops	1.75
	Roadway	2.46
	Urban Open	4.45
J	Commercial / Ops	9.18
	Roadway	4.07
	Urban Open	13.69
K	Residential	50.10
	Roadway	16.42
	Urban Open	4.76
L[2]	Residential	553.81
	Roadway	229.36
	Urban Open	134.40
M	Commercial / Ops	16.13
	Roadway	3.62
	Urban Open	7.66
N	Commercial / Ops	3.78
	Roadway	10.58
	Industrial	9.70
	Urban Open	13.40

Sub-Basin	Land Use Category	Acres[1]
O	Residential	80.53
	Commercial / Ops	0.87
	Roadway	12.14
	Urban Open	50.06
P	Commercial / Ops	39.95
	Roadway	9.35
	Industrial	38.74
	Urban Open	10.26
R	Commercial / Ops	5.21
	Roadway	12.74
	Industrial	9.38
	Urban Open	112.78
S	Commercial / Ops	8.56
	Roadway	0.14
	Industrial	2.69
	Urban Open	2.64
T	Commercial / Ops	8.56
	Roadway	2.08
	Urban Open	0.00
U	Roadway	10.37
	Industrial	60.00
	Urban Open	3.44
V	Roadway	5.81
	Industrial	45.58
	Urban Open	19.95
W	Commercial / Ops	12.76
	Roadway	1.72
	Industrial	14.03
	Urban Open	6.43
X	Roadway	6.72
	Industrial	19.33
	Urban Open	5.17
Y	Industrial	19.68
	Urban Open	12.81
Z	Roadway	1.95
	Urban Open	36.86
AA	Roadway	6.49
	Industrial	6.80
	Urban Open	24.61
BB	Commercial / Ops	11.54
	Roadway	6.01
	Industrial	17.96
	Urban Open	7.81
CC	Roadway	2.90
	Industrial	14.62
DD	Roadway	9.45

Sub-Basin	Land Use Category	Acres[1]
	Industrial	30.91
	Urban Open	6.66
EE	Roadway	2.22
	Industrial	7.70
	Urban Open	3.17
FF	Commercial / Ops	3.00
	Roadway	0.94
	Urban Open	2.66
GG[3]	Commercial / Ops	0.19
	Roadway	6.68
	Industrial	0.74
	Urban Open	3.50
	Forest	807.13

Notes:

1 Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO / NAVFAC, 2009).

2 Sub-Basin L comprises the “Family Housing Area”, which is referred to as Area 5 in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

3 Sub-Basin GG comprises land designated “Open Space – Protected” in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

Table C-3: Future Land Use Percent Impervious Cover Presented by Sub-Basin

Basin ID	Future Condition	Condition Area (acres)	Assigned Percent Impervious	Area (acres)	Calculated Percent Impervious
A	Commercial/Ops	0.01	0%	0.01	0.0%
	Residential	2.95	0%	2.26	23.6%
			100%	0.70	
	Roadway	10.18	0%	3.02	70.4%
			100%	7.16	
	Urban Open	0.49	0%	0.49	0.0%
B	Residential	5.39	0%	4.10	24%
			100%	1.29	
	Roadway	3.99	0%	1.20	70.0%
			100%	2.79	
	Urban Open	16.65	0%	14.26	14.3%
			100%	2.39	
C	Residential	3.62	0%	2.85	21.4%
			100%	0.77	
	Roadway	4.09	0%	1.07	73.9%
			100%	3.02	
	Urban Open	30.43	0%	22.64	24.3%
			30%	0.28	
			40%	0.37	
			100%	7.15	
D	Residential	22.73	0%	14.10	38.0%
			100%	8.64	
	Roadway	2.45	0%	0.90	63.2%
			100%	1.55	
	Urban Open	4.41	0%	4.41	0.0%
E	Commercial/Ops	34.42	0%	15.89	53.8%
			100%	18.52	
	Roadway	7.48	0%	1.81	75.8%
			100%	5.67	
	Urban Open	16.00	0%	16.00	0.0%
F	Commercial/Ops	42.98	0%	13.43	68.8%
			100%	29.56	
	Residential	2.37	0%	1.44	39.4%
			100%	0.94	
	Roadway	10.60	0%	3.39	68.0%
			100%	7.21	
	Urban Open	11.94	0%	11.94	0.0%
G	Commercial/Ops	11.23	0%	2.87	74.5%
			100%	8.37	
	Roadway	8.35	0%	2.74	67.2%
			100%	5.61	
	Urban Open	43.54	0%	43.54	0.0%
H	Commercial/Ops	13.61	0%	6.48	52.4%
			100%	7.13	

Basin ID	**Future Condition**	**Condition Area (acres)**	**Assigned Percent Impervious**	**Area (acres)**	**Calculated Percent Impervious**
	Roadway	4.46	0%	1.30	70.8%
			100%	3.16	
	Urban Open	16.96	0%	16.96	0.0%
I	Commercial/Ops	1.75	0%	0.23	86.7%
			100%	1.52	
	Roadway	2.46	0%	0.60	75.7%
			100%	1.86	
	Urban Open	4.45	0%	4.45	0.0%
J	Commercial/Ops	9.18	0%	6.98	23.9%
			100%	2.19	
	Roadway	4.07	0%	1.23	69.8%
			100%	2.84	
	Urban Open	13.69	0%	13.69	0.0%
K	Residential	50.10	0%	26.90	46.3%
			100%	23.20	
	Roadway	16.42	0%	4.63	71.8%
			100%	11.79	
	Urban Open	4.76	0%	4.76	0.0%
L[1]	Residential	554	0%	420.89	24%
			100%	132.91	
	Roadway	229.36	0%	53.98	76.5%
			100%	175.37	
	Urban Open	134.40	0%	134.40	0.0%
M	Commercial/Ops	16.13	0%	6.81	57.7%
			100%	9.31	
	Roadway	3.62	0%	1.49	58.8%
			100%	2.13	
	Urban Open	7.66	0%	7.66	0.0%
N	Commercial/Ops	3.78	0%	1.80	52.5%
			100%	1.98	
	Industrial	9.70	0%	4.02	58.5%
			100%	5.68	
	Roadway	10.58	0%	3.40	67.8%
			100%	7.18	
	Urban Open	13.40	0%	13.40	0.0%
O	Commercial/Ops	0.87	0%	0.47	45.6%
			100%	0.40	
	Residential	80.53	0%	51.46	35.8%
			30%	0.28	
			100%	28.78	
	Roadway	12.14	0%	3.19	73.7%
			100%	8.95	
	Urban Open	50.06	0%	49.10	1.9%
			100%	0.96	
P	Commercial/Ops	39.95	0%	5.30	86.7%

Basin ID	**Future Condition**	**Condition Area (acres)**	**Assigned Percent Impervious**	**Area (acres)**	**Calculated Percent Impervious**
			100%	34.65	
	Industrial	38.74	0%	6.05	84.4%
			100%	32.69	
	Roadway	9.35	0%	2.64	71.7%
			100%	6.71	
	Urban Open	10.26	0%	10.26	0.0%
R	Commercial/Ops	5.21	0%	3.87	25.7%
			100%	1.34	
	Industrial	9.38	0%	1.92	79.5%
			100%	7.46	
	Roadway	12.74	0%	4.04	68.3%
			100%	8.70	
	Urban Open	112.78	0%	112.78	0.0%
S	Commercial/Ops	8.56	0%	0.72	91.5%
			100%	7.84	
	Industrial	2.69	0%	0.04	98.5%
			100%	2.65	
	Roadway	0.14	0%	0.04	72.7%
			100%	0.10	
	Urban Open	2.64	0%	2.64	0.0%
T	Commercial/Ops	8.56	0%	0.46	94.6%
			100%	8.10	
	Roadway	2.08	0%	0.41	80.4%
			100%	1.67	
	Urban Open	0.00	0%	0.00	0.0%
U	Industrial	60.00	0%	2.04	96.6%
			100%	57.97	
	Roadway	10.37	0%	3.27	68.5%
			100%	7.10	
	Urban Open	3.44	0%	3.44	0.0%
V	Industrial	45.58	0%	3.04	93.3%
			100%	42.54	
	Roadway	5.81	0%	1.54	73.5%
			100%	4.27	
	Urban Open	19.95	0%	14.14	29.1%
			100%	5.80	
W	Commercial/Ops	12.76	0%	9.07	28.9%
			100%	3.68	
	Industrial	14.03	0%	1.72	87.7%
			100%	12.30	
	Roadway	1.72	0%	0.66	61.7%
			100%	1.06	
	Urban Open	6.43	0%	6.43	0.0%
X	Industrial	19.33	0%	6.48	66.5%
			100%	12.85	

Basin ID	**Future Condition**	**Condition Area (acres)**	**Assigned Percent Impervious**	**Area (acres)**	**Calculated Percent Impervious**
	Roadway	6.72	0%	1.86	72.3%
			100%	4.86	
	Urban Open	5.17	0%	5.17	0.0%
Y	Industrial	19.68	0%	0.13	99.4%
			100%	19.56	
	Urban Open	12.81	0%	9.87	23.0%
			100%	2.94	
Z	Roadway	1.95	0%	0.52	73.2%
			100%	1.43	
	Urban Open	36.86	0%	24.97	32.3%
			100%	11.90	
AA	Industrial	6.80	0%	1.07	84.2%
			100%	5.73	
	Roadway	6.49	0%	2.19	66.3%
			100%	4.30	
	Urban Open	24.61	0%	24.61	0.0%
BB	Commercial/Ops	11.54	0%	3.31	71.3%
			100%	8.23	
	Industrial	17.96	0%	1.80	90.0%
			100%	16.16	
	Roadway	6.01	0%	1.48	75.3%
			100%	4.53	
	Urban Open	7.81	0%	7.81	0.0%
CC	Industrial	14.62	0%	5.67	61.2%
			100%	8.95	
	Roadway	2.90	0%	0.67	76.9%
			100%	2.23	
DD	Industrial	30.91	0%	2.37	92.3%
			100%	28.54	
	Roadway	9.45	0%	2.75	70.9%
			100%	6.70	
	Urban Open	6.66	0%	6.66	0.0%
EE	Industrial	7.70	0%	1.67	78.3%
			100%	6.03	
	Roadway	2.22	0%	0.44	80.2%
			100%	1.78	
	Urban Open	3.17	0%	3.17	0.0%
FF	Commercial/Ops	3.00	0%	0.10	96.8%
			100%	2.91	
	Roadway	0.94	0%	0.21	77.3%
			100%	0.72	
	Urban Open	2.66	0%	2.66	0.0%
GG[2]	Commercial/Ops	0.19	0%	0.17	9.7%
			100%	0.02	
	Forest	807.13	0%	807.13	0.0%

Basin ID	Future Condition	Condition Area (acres)	Assigned Percent Impervious	Area (acres)	Calculated Percent Impervious
			100%	0.00	
	Industrial	0.74	100%	0.74	100.0%
	Roadway	6.68	0%	3.96	40.7%
			100%	2.72	
	Urban Open	3.50	0%	266.68	1.3%
			100%	3.50	

Notes:

1 Sub-Basin L comprises the “Family Housing Area”, which is referred to as Area 5 in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

2 Sub-Basin GG comprises land designated “Open Space – Protected” in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

Table C-4: Annual Total Suspended Solids (TSS) Load for Existing Conditions Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
A	Forest	13.35	90.0	1,201.6
	Urban Open	0.22	39.1	8.7
	Subtotal			*1,210.3*
B	Forest	26.09	90.0	2,348.0
	Subtotal			*2,348.0*
C	Forest	38.14	90.0	3,432.9
	Subtotal			*3,432.9*
D	Forest	29.61	90.0	2,664.9
	Subtotal			*2,664.9*
E	Forest	57.73	90.0	5,195.4
	Roadway	0.27	492.8	130.6
	Subtotal			*5,326.0*
F	Forest	67.39	90.0	6,065.3
	Roadway	0.48	492.8	237.8
	Subtotal			*6,303.1*
G	Forest	63.09	90.0	5,678.3
	Subtotal			*5,678.3*
H	Commercial / Ops	3.92	223.4	875.7
	Forest	13.69	90.0	1,231.8
	Roadway	0.58	492.8	285.9
	Urban Open	16.92	39.1	661.8
	Subtotal			*3,055.2*
I	Commercial / Ops	4.02	223.4	896.9
	Roadway	0.66	492.8	326.3
	Urban Open	3.99	39.1	156.0
	Subtotal			*1,379.2*
J	Commercial / Ops	11.56	223.4	2,583.3
	Forest	4.64	90.0	417.8
	Industrial	5.12	269.8	1,380.6
	Residential	1.96	190.3	373.2
	Roadway	3.03	492.8	1,492.7
	Urban Open	0.59	39.1	23.2
	Subtotal			*6,270.8*
K	Commercial / Ops	7.13	223.4	1,592.1
	Forest	36.06	90.0	3,245.6
	Residential	23.60	190.3	4,490.8
	Roadway	4.53	492.8	2,230.5
	Subtotal			*11,559.0*
L[3]	Commercial / Ops	1.80	223.4	403.2
	Forest	684.35	90.0	61,591.5
	Residential	173.98	190.3	33,108.0
	Roadway	40.41	492.8	19,916.2
	Urban Open	18.15	39.1	710.3
	Subtotal			*115,729.1*
M	Forest	27.13	90.0	2,441.3
	Roadway	0.33	492.8	163.3

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
	Subtotal			*2,604.6*
N	Commercial / Ops	0.44	223.4	97.3
	Forest	10.12	90.0	911.0
	Roadway	0.20	492.8	99.3
	Urban Open	26.74	39.1	1,046.2
	Subtotal			*2,153.8*
O	Forest	125.16	90.0	11,264.4
	Residential	15.75	190.3	2,996.8
	Roadway	2.84	492.8	1,399.4
	Subtotal			*15,660.7*
P	Commercial / Ops	4.99	223.4	1,115.5
	Forest	39.91	90.0	3,592.2
	Industrial	14.41	269.8	3,888.6
	Residential	28.19	190.3	5,363.9
	Roadway	7.78	492.8	3,834.9
	Urban Open	3.38	39.1	132.2
	Subtotal			*17,927.3*
R	Commercial / Ops	24.79	223.4	5,537.6
	Forest	54.86	90.0	4,937.2
	Residential	35.98	190.3	6,846.3
	Roadway	5.06	492.8	2,493.6
	Urban Open	20.36	39.1	796.5
	Subtotal			*20,611.2*
S	Commercial / Ops	0.31	223.4	70.1
	Forest	9.30	90.0	836.9
	Industrial	1.52	269.8	409.2
	Residential	0.96	190.3	183.0
	Roadway	0.66	492.8	326.4
	Urban Open	1.26	39.1	49.5
	Subtotal			*1,875.1*
T	Forest	10.65	90.0	958.7
	Subtotal			*958.7*
U	Forest	33.00	90.0	2,970.1
	Urban Open	41.18	39.1	1,611.3
	Subtotal			*4,581.4*
V	Commercial / Ops	6.68	223.4	1,491.1
	Forest	40.36	90.0	3,632.4
	Roadway	0.09	492.8	46.5
	Urban Open	24.67	39.1	965.4
	Subtotal			*6,135.3*
W	Forest	20.51	90.0	1,845.7
	Urban Open	14.53	39.1	568.4
	Subtotal			*2,414.1*
X	Forest	29.96	90.0	2,696.2
	Roadway	0.90	492.8	442.9
	Urban Open	0.39	39.1	15.4
	Subtotal			*3,154.6*

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
Y	Commercial / Ops	8.52	223.4	1,903.4
	Forest	24.00	90.0	2,159.8
	Subtotal			*4,063.2*
Z	Commercial / Ops	13.50	223.4	3,016.3
	Forest	25.31	90.0	2,278.2
	Subtotal			*5,294.4*
AA	Forest	37.73	90.0	3,395.7
	Roadway	0.23	492.8	115.2
	Subtotal			*3,510.9*
BB	Commercial / Ops	0.00	223.4	0.2
	Forest	43.56	90.0	3,920.2
	Subtotal			*3,920.4*
CC	Forest	17.53	90.0	1,578.0
	Subtotal			*1,578.0*
DD	Forest	46.56	90.0	4,190.0
	Subtotal			*4,190.0*
EE	Forest	13.09	90.0	1,177.7
	Subtotal			*1,177.7*
FF	Forest	6.61	90.0	594.6
	Subtotal			*594.6*
GG[4]	Commercial / Ops	0.26	223.4	57.7
	Forest	864.96	90.0	77,846.0
	Roadway	4.03	492.8	1,987.9
	Urban Open	215.68	39.1	8,439.1
	Subtotal			*88,330.7*
TOTAL LOAD				*355,693.5*

Notes:

1 Existing land use acres derived from a detailed vegetation map for the island of Guam (USDA, 2005), selected polyline features within a personal geodatabase obtained from the Navy, and recent aerial photographs.

2 Loads per acre calculated using the Simple Method (Schueler, 1987).

3 Sub-Basin L comprises the “Family Housing Area”, which is referred to as Area 5 in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

4 Sub-Basin GG comprises land designated “Open Space – Protected” in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

5 To meet the Navy's goal of no net increase to sediment and nutrient loading, annual loads should not exceed these values in the developed condition to the extent practicable.

Table C-5: Annual Total Phosphorus (TP) Load for Existing Conditions Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
A	Forest	13.35	0.1	1.9
	Urban Open	0.22	0.1	0.0
	Subtotal			*1.9*
B	Forest	26.09	0.1	3.7
	Subtotal			*3.7*
C	Forest	38.14	0.1	5.3
	Subtotal			*5.3*
D	Forest	29.61	0.1	4.1
	Subtotal			*4.1*
E	Forest	57.73	0.1	8.1
	Roadway	0.27	1.6	0.4
	Subtotal			*8.5*
F	Forest	67.39	0.1	9.4
	Roadway	0.48	1.6	0.8
	Subtotal			*10.2*
G	Forest	63.09	0.1	8.8
	Subtotal			*8.8*
H	Commercial / Ops	3.92	0.6	2.3
	Forest	13.69	0.1	1.9
	Roadway	0.58	1.6	1.0
	Urban Open	16.92	0.1	0.9
	Subtotal			*6.1*
I	Commercial / Ops	4.02	0.6	2.4
	Roadway	0.66	1.6	1.1
	Urban Open	3.99	0.1	0.2
	Subtotal			*3.7*
J	Commercial / Ops	11.56	0.6	6.9
	Forest	4.64	0.1	0.6
	Industrial	5.12	0.9	4.6
	Residential	1.96	0.8	1.5
	Roadway	3.03	1.6	5.0
	Urban Open	0.59	0.1	0.0
	Subtotal			*18.6*
K	Commercial / Ops	7.13	0.6	4.2
	Forest	36.06	0.1	5.0
	Residential	23.60	0.8	18.0
	Roadway	4.53	1.6	7.4
	Subtotal			*34.7*
L[3]	Commercial / Ops	1.80	0.6	1.1
	Forest	684.35	0.1	95.8

Sub-Basin	**Land Use Category**	**Acres[1]**	**Load Per Acre (lbs)[2]**	**Annual Load (lbs)[5]**
	Residential	173.98	0.8	132.4
	Roadway	40.41	1.6	66.4
	Urban Open	18.15	0.1	1.0
	Subtotal			*296.7*
M	Forest	27.13	0.1	3.8
	Roadway	0.33	1.6	0.5
	Subtotal			*4.3*
N	Commercial / Ops	0.44	0.6	0.3
	Forest	10.12	0.1	1.4
	Roadway	0.20	1.6	0.3
	Urban Open	26.74	0.1	1.5
	Subtotal			*3.5*
O	Forest	125.16	0.1	17.5
	Residential	15.75	0.8	12.0
	Roadway	2.84	1.6	4.7
	Subtotal			*34.2*
P	Commercial / Ops	4.99	0.6	3.0
	Forest	39.91	0.1	5.6
	Industrial	14.41	0.9	13.0
	Residential	28.19	0.8	21.5
	Roadway	7.78	1.6	12.8
	Urban Open	3.38	0.1	0.2
	Subtotal			*56.0*
R	Commercial / Ops	24.79	0.6	14.8
	Forest	54.86	0.1	7.7
	Residential	35.98	0.8	27.4
	Roadway	5.06	1.6	8.3
	Urban Open	20.36	0.1	1.1
	Subtotal			*59.3*
S	Commercial / Ops	0.31	0.6	0.2
	Forest	9.30	0.1	1.3
	Industrial	1.52	0.9	1.4
	Residential	0.96	0.8	0.7
	Roadway	0.66	1.6	1.1
	Urban Open	1.26	0.1	0.1
	Subtotal			*4.7*
T	Forest	10.65	0.1	1.5
	Subtotal			*1.5*
U	Forest	33.00	0.1	4.6
	Urban Open	41.18	0.1	2.3
	Subtotal			*6.9*

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
V	Commercial / Ops	6.68	0.6	4.0
	Forest	40.36	0.1	5.7
	Roadway	0.09	1.6	0.2
	Urban Open	24.67	0.1	1.4
	Subtotal			*11.2*
W	Forest	20.51	0.1	2.9
	Urban Open	14.53	0.1	0.8
	Subtotal			*3.7*
X	Forest	29.96	0.1	4.2
	Roadway	0.90	1.6	1.5
	Urban Open	0.39	0.1	0.0
	Subtotal			*5.7*
Y	Commercial / Ops	8.52	0.6	5.1
	Forest	24.00	0.1	3.4
	Subtotal			*8.4*
Z	Commercial / Ops	13.50	0.6	8.0
	Forest	25.31	0.1	3.5
	Subtotal			*11.6*
AA	Forest	37.73	0.1	5.3
	Roadway	0.23	1.6	0.4
	Subtotal			*5.7*
BB	Commercial / Ops	0.00	0.6	0.0
	Forest	43.56	0.1	6.1
	Subtotal			*6.1*
CC	Forest	17.53	0.1	2.5
	Subtotal			*2.5*
DD	Forest	46.56	0.1	6.5
	Subtotal			*6.5*
EE	Forest	13.09	0.1	1.8
	Subtotal			*1.8*
FF	Forest	6.61	0.1	0.9
	Subtotal			*0.9*
GG[4]	Commercial / Ops	0.26	0.6	0.2
	Forest	864.96	0.1	121.1
	Roadway	4.03	1.6	6.6
	Urban Open	215.68	0.1	12.1
	Subtotal			*139.9*
TOTAL LOAD				*776.9*

Notes:

1. Existing land use acres derived from a detailed vegetation map for the island of Guam (USDA, 2005), selected polyline features within a personal geodatabase obtained from the Navy, and recent aerial photographs.
2. Loads per acre calculated using the Simple Method (Schueler, 1987).

3 Sub-Basin L comprises the "Family Housing Area", which is referred to as Area 5 in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

4 Sub-Basin GG comprises land designated "Open Space – Protected" in the Draft Guam Joint Military Master Plan (dated November 19, 2009).

5 To meet the Navy's goal of no net increase to sediment and nutrient loading, annual loads should not exceed these values in the developed condition to the extent practicable.

Table C-6: Annual Total Nitrogen (TN) Load for Existing Conditions Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
A	Forest	13.35	1.0	13.4
	Urban Open	0.22	0.6	0.1
	Subtotal			*13.5*
B	Forest	26.09	1.0	26.1
	Subtotal			*26.1*
C	Forest	38.14	1.0	38.1
	Subtotal			*38.1*
D	Forest	29.61	1.0	29.6
	Subtotal			*29.6*
E	Forest	57.73	1.0	57.7
	Roadway	0.27	9.9	2.6
	Subtotal			*60.3*
F	Forest	67.39	1.0	67.4
	Roadway	0.48	9.9	4.8
	Subtotal			*72.1*
G	Forest	63.09	1.0	63.1
	Subtotal			*63.1*
H	Commercial / Ops	3.92	6.0	23.4
	Forest	13.69	1.0	13.7
	Roadway	0.58	9.9	5.7
	Urban Open	16.92	0.6	9.5
	Subtotal			*52.2*
I	Commercial / Ops	4.02	6.0	23.9
	Roadway	0.66	9.9	6.5
	Urban Open	3.99	0.6	2.2
	Subtotal			*32.7*
J	Commercial / Ops	11.56	6.0	68.9
	Forest	4.64	1.0	4.6
	Industrial	5.12	5.6	28.8
	Residential	1.96	4.2	8.2
	Roadway	3.03	9.9	29.9
	Urban Open	0.59	0.6	0.3
	Subtotal			*140.7*
K	Commercial / Ops	7.13	6.0	42.5
	Forest	36.06	1.0	36.1
	Residential	23.60	4.2	98.8
	Roadway	4.53	9.9	44.6
	Subtotal			*221.9*
L[3]	Commercial / Ops	1.80	6.0	10.8
	Forest	684.35	1.0	684.4
	Residential	173.98	4.2	728.4
	Roadway	40.41	9.9	398.3
	Urban Open	18.15	0.6	10.1
	Subtotal			*1,831.9*

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
M	Forest	27.13	1.0	27.1
	Roadway	0.33	9.9	3.3
	Subtotal			*30.4*
N	Commercial / Ops	0.44	6.0	2.6
	Forest	10.12	1.0	10.1
	Roadway	0.20	9.9	2.0
	Urban Open	26.74	0.6	14.9
	Subtotal			*29.6*
O	Forest	125.16	1.0	125.2
	Residential	15.75	4.2	65.9
	Roadway	2.84	9.9	28.0
	Subtotal			*219.1*
P	Commercial / Ops	4.99	6.0	29.7
	Forest	39.91	1.0	39.9
	Industrial	14.41	5.6	81.0
	Residential	28.19	4.2	118.0
	Roadway	7.78	9.9	76.7
	Urban Open	3.38	0.6	1.9
	Subtotal			*347.3*
R	Commercial / Ops	24.79	6.0	147.7
	Forest	54.86	1.0	54.9
	Residential	35.98	4.2	150.6
	Roadway	5.06	9.9	49.9
	Urban Open	20.36	0.6	11.4
	Subtotal			*414.4*
S	Commercial / Ops	0.31	6.0	1.9
	Forest	9.30	1.0	9.3
	Industrial	1.52	5.6	8.5
	Residential	0.96	4.2	4.0
	Roadway	0.66	9.9	6.5
	Urban Open	1.26	0.6	0.7
	Subtotal			*31.0*
T	Forest	10.65	1.0	10.7
	Subtotal			*10.7*
U	Forest	33.00	1.0	33.0
	Urban Open	41.18	0.6	23.0
	Subtotal			*56.0*
V	Commercial / Ops	6.68	6.0	39.8
	Forest	40.36	1.0	40.4
	Roadway	0.09	9.9	0.9
	Urban Open	24.67	0.6	13.8
	Subtotal			*94.8*
W	Forest	20.51	1.0	20.5
	Urban Open	14.53	0.6	8.1
	Subtotal			*28.6*

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)[5]
X	Forest	29.96	1.0	30.0
	Roadway	0.90	9.9	8.9
	Urban Open	0.39	0.6	0.2
	Subtotal			*39.0*
Y	Commercial / Ops	8.52	6.0	50.8
	Forest	24.00	1.0	24.0
	Subtotal			*74.8*
Z	Commercial / Ops	13.50	6.0	80.4
	Forest	25.31	1.0	25.3
	Subtotal			*105.7*
AA	Forest	37.73	1.0	37.7
	Roadway	0.23	9.9	2.3
	Subtotal			*40.0*
BB	Commercial / Ops	0.00	6.0	0.0
	Forest	43.56	1.0	43.6
	Subtotal			*43.6*
CC	Forest	17.53	1.0	17.5
	Subtotal			*17.5*
DD	Forest	46.56	1.0	46.6
	Subtotal			*46.6*
EE	Forest	13.09	1.0	13.1
	Subtotal			*13.1*
FF	Forest	6.61	1.0	6.6
	Subtotal			*6.6*
GG[4]	Commercial / Ops	0.26	6.0	1.5
	Forest	864.96	1.0	865.0
	Roadway	4.03	9.9	39.8
	Urban Open	215.68	0.6	120.6
	Subtotal			*1,026.8*
TOTAL LOAD				*5,257.9*

Notes:

1. Existing land use acres derived from a detailed vegetation map for the island of Guam (USDA, 2005), selected polyline features within a personal geodatabase obtained from the Navy, and recent aerial photographs.
2. Loads per acre calculated using the Simple Method (Schueler, 1987).
3. Sub-Basin L comprises the “Family Housing Area”, which is referred to as Area 5 in the Draft Guam Joint Military Master Plan (dated November 19, 2009).
4. Sub-Basin GG comprises land designated “Open Space – Protected” in the Draft Guam Joint Military Master Plan (dated November 19, 2009).
5. To meet the Navy's goal of no net increase to sediment and nutrient loading, annual loads should not exceed these values in the developed condition to the extent practicable.

Table C-7: Annual Total Suspended Solids (TSS) Load for Future Conditions Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
A	Residential	2.95	111.9	330.3
	Commercial / Ops	0.01	16.0	0.2
	Roadway	10.18	437.3	4,452.2
	Urban Open	0.49	14.9	7.3
	Subtotal			*4,790.0*
B	Residential	5.39	113.5	611.9
	Roadway	3.99	435.2	1,735.6
	Urban Open	16.65	53.5	889.8
	Subtotal			*3,237.2*
C	Residential	3.62	103.5	374.6
	Roadway	4.09	457.9	1,871.6
	Urban Open	30.43	80.1	2,438.4
	Subtotal			*4,684.7*
D	Residential	22.73	167.2	3,801.1
	Roadway	2.45	395.8	970.9
	Urban Open	4.41	14.9	65.8
	Subtotal			*4,837.8*
E	Commercial / Ops	34.42	171.0	5,885.5
	Roadway	7.48	468.7	3,503.6
	Urban Open	16.00	14.9	238.9
	Subtotal			*9,628.0*
F	Residential	2.37	172.6	409.7
	Commercial / Ops	42.98	214.0	9,200.0
	Roadway	10.60	423.8	4,493.8
	Urban Open	11.94	14.9	178.4
	Subtotal			*14,281.9*
G	Commercial / Ops	11.23	230.5	2,589.1
	Roadway	8.35	418.9	3,496.9
	Urban Open	43.54	14.9	650.3
	Subtotal			*6,736.2*
H	Commercial / Ops	13.61	166.9	2,272.1
	Roadway	4.46	439.7	1,960.2
	Urban Open	16.96	14.9	253.3
	Subtotal			*4,485.6*
I	Commercial / Ops	1.75	265.7	464.7
	Roadway	2.46	468.1	1,151.6
	Urban Open	4.45	14.9	66.5
	Subtotal			*1,682.8*
J	Commercial / Ops	9.18	265.7	2,438.1
	Roadway	4.07	468.1	1,905.3
	Urban Open	13.69	14.9	204.5
	Subtotal			*4,547.9*
K	Residential	50.10	199.2	9,977.5
	Roadway	16.42	445.6	7,317.8
	Urban Open	4.76	14.9	71.0
	Subtotal			*17,366.4*

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
L	Residential	553.81	113.5	62,856.4
	Roadway	229.36	472.5	108,359.0
	Urban Open	134.40	14.9	2,007.2
	Subtotal			*173,222.6*
M	Commercial / Ops	16.13	182.3	2,940.3
	Roadway	3.62	370.9	1,342.5
	Urban Open	7.66	14.9	114.4
	Subtotal			*4,397.2*
N	Commercial / Ops	3.78	167.2	632.1
	Roadway	10.58	422.8	4,473.3
	Industrial	9.70	295.3	2,863.9
	Urban Open	13.40	14.9	200.2
	Subtotal			*8,169.4*
O	Residential	80.53	159.0	12,803.2
	Commercial / Ops	0.87	147.3	127.8
	Roadway	12.14	456.7	5,546.1
	Urban Open	50.06	20.1	1,006.6
	Subtotal			*19,483.6*
P	Commercial / Ops	39.95	265.8	10,620.1
	Roadway	9.35	445.2	4,163.3
	Industrial	38.74	414.4	16,055.2
	Urban Open	10.26	14.9	153.2
	Subtotal			*30,991.9*
R	Commercial / Ops	5.21	89.9	468.2
	Roadway	12.74	425.4	5,417.2
	Industrial	9.38	392.2	3,679.5
	Urban Open	112.78	14.9	1,684.2
	Subtotal			*11,249.1*
S	Commercial / Ops	8.56	279.6	2,393.7
	Roadway	0.14	450.8	62.1
	Industrial	2.69	479.3	1,289.9
	Urban Open	2.64	14.9	39.4
	Subtotal			*3,785.0*
T	Commercial / Ops	8.56	288.4	2,469.5
	Roadway	2.08	495.4	1,029.4
	Urban Open	0.00	14.9	0.0
	Subtotal			*3,498.9*
U	Roadway	10.37	426.6	4,422.4
	Industrial	60.00	470.8	28,248.8
	Urban Open	3.44	14.9	51.4
	Subtotal			*32,722.6*
V	Roadway	5.81	455.3	2,647.1
	Industrial	45.58	455.7	20,770.9
	Urban Open	19.95	93.1	1,858.1
	Subtotal			*25,276.1*
W	Commercial / Ops	12.76	99.2	1,264.9
	Roadway	1.72	387.6	666.2

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
	Industrial	14.03	429.8	6,029.3
	Urban Open	6.43	14.9	96.1
	Subtotal			*8,056.5*
X	Roadway	6.72	448.7	3,013.5
	Industrial	19.33	332.0	6,417.3
	Urban Open	5.17	14.9	77.1
	Subtotal			*9,508.0*
Y	Industrial	19.68	483.5	9,517.0
	Urban Open	12.81	76.7	982.2
	Subtotal			*10,499.2*
Z	Roadway	1.95	453.4	885.1
	Urban Open	36.86	101.7	3,748.2
	Subtotal			*4,633.3*
AA	Roadway	6.49	413.8	2,684.4
	Industrial	6.80	413.8	2,814.4
	Urban Open	24.61	14.9	367.6
	Subtotal			*5,866.4*
BB	Commercial / Ops	11.54	221.3	2,554.0
	Roadway	6.01	466.0	2,801.4
	Industrial	17.96	440.2	7,905.6
	Urban Open	7.81	14.9	116.6
	Subtotal			*13,377.6*
CC	Roadway	2.90	474.9	1,379.2
	Industrial	14.62	307.6	4,498.6
	Subtotal			*5,877.8*
DD	Roadway	9.45	440.4	4,160.6
	Industrial	30.91	451.1	13,942.1
	Urban Open	6.66	14.9	99.5
	Subtotal			*18,202.2*
EE	Roadway	2.22	494.1	1,095.7
	Industrial	7.70	386.5	2,975.2
	Urban Open	3.17	14.9	47.3
	Subtotal			*4,118.2*
FF	Commercial / Ops	3.00	294.7	884.9
	Roadway	0.94	477.3	447.6
	Urban Open	2.66	14.9	39.7
	Subtotal			*1,372.2*
GG	Commercial / Ops	0.19	43.9	8.4
	Roadway	6.68	266.5	1,781.2
	Industrial	0.74	486.4	360.8
	Urban Open	3.50	18.4	64.4
	Forest	807.13	90.0	72,641.9
	Subtotal			*74,856.8*
TOTAL LOAD				*545,443.4*

Notes:
1 Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO / NAVFAC, 2009).
2 Loads per acre calculated using the Simple Method (Schueler, 1987).

Table C-8: Annual Total Phosphorus (TP) Load for Future Conditions Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
A	Residential	2.95	0.45	1.3
	Commercial / Ops	0.01	0.04	0.0
	Roadway	10.18	1.46	14.8
	Urban Open	0.49	0.02	0.0
	Subtotal			*16.2*
B	Residential	5.39	0.45	2.4
	Roadway	3.99	1.45	5.8
	Urban Open	16.65	0.08	1.3
	Subtotal			*9.5*
C	Residential	3.62	0.41	1.5
	Roadway	4.09	1.53	6.2
	Urban Open	30.43	0.11	3.5
	Subtotal			*11.2*
D	Residential	22.73	0.67	15.2
	Roadway	2.45	1.32	3.2
	Urban Open	4.41	0.02	0.1
	Subtotal			*18.5*
E	Commercial / Ops	34.42	0.46	15.7
	Roadway	7.48	1.56	11.7
	Urban Open	16.00	0.02	0.3
	Subtotal			*27.7*
F	Residential	2.37	0.69	1.6
	Commercial / Ops	42.98	0.57	24.5
	Roadway	10.60	1.41	15.0
	Urban Open	11.94	0.02	0.3
	Subtotal			*41.4*
G	Commercial / Ops	11.23	0.61	6.9
	Roadway	8.35	1.40	11.7
	Urban Open	43.54	0.02	0.9
	Subtotal			*19.5*
H	Commercial / Ops	13.61	0.45	6.1
	Roadway	4.46	1.47	6.5
	Urban Open	16.96	0.02	0.4
	Subtotal			*13.0*
I	Commercial / Ops	1.75	0.71	1.2
	Roadway	2.46	1.56	3.8
	Urban Open	4.45	0.02	0.1
	Subtotal			*5.2*
J	Commercial / Ops	9.18	0.71	6.5
	Roadway	4.07	1.56	6.4
	Urban Open	13.69	0.02	0.3
	Subtotal			*13.1*
K	Residential	50.10	0.80	39.9
	Roadway	16.42	1.49	24.4

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
	Urban Open	4.76	0.02	0.1
	Subtotal			*64.4*
L	Residential	553.81	0.45	251.4
	Roadway	229.36	1.57	361.2
	Urban Open	134.40	0.02	2.9
	Subtotal			*615.5*
M	Commercial / Ops	16.13	0.49	7.8
	Roadway	3.62	1.24	4.5
	Urban Open	7.66	0.02	0.2
	Subtotal			*12.5*
N	Commercial / Ops	3.78	0.45	1.7
	Roadway	10.58	1.41	14.9
	Industrial	9.70	0.98	9.5
	Urban Open	13.40	0.02	0.3
	Subtotal			*26.4*
O	Residential	80.53	0.64	51.2
	Commercial / Ops	0.87	0.39	0.3
	Roadway	12.14	1.52	18.5
	Urban Open	50.06	0.03	1.4
	Subtotal			*71.5*
P	Commercial / Ops	39.95	0.71	28.3
	Roadway	9.35	1.48	13.9
	Industrial	38.74	1.38	53.5
	Urban Open	10.26	0.02	0.2
	Subtotal			*95.9*
R	Commercial / Ops	5.21	3.02	15.7
	Roadway	12.74	1.42	18.1
	Industrial	9.38	1.31	12.3
	Urban Open	112.78	0.02	2.4
	Subtotal			*48.4*
S	Commercial / Ops	8.56	0.75	6.4
	Roadway	0.14	1.50	0.2
	Industrial	2.69	1.60	4.3
	Urban Open	2.64	0.02	0.1
	Subtotal			*10.9*
T	Commercial / Ops	8.56	0.77	6.6
	Roadway	2.08	1.65	3.4
	Urban Open	0.00	0.02	0.0
	Subtotal			*10.0*
U	Roadway	10.37	1.42	14.7
	Industrial	60.00	1.57	94.2
	Urban Open	3.44	0.02	0.1
	Subtotal			*109.0*
V	Roadway	5.81	1.52	8.8
	Industrial	45.58	1.52	69.2

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
	Urban Open	19.95	0.13	2.7
	Subtotal			*80.7*
W	Commercial / Ops	12.76	0.26	3.4
	Roadway	1.72	1.29	2.2
	Industrial	14.03	1.43	20.1
	Urban Open	6.43	0.02	0.1
	Subtotal			*25.8*
X	Roadway	6.72	1.50	10.0
	Industrial	19.33	1.11	21.4
	Urban Open	5.17	0.02	0.1
	Subtotal			*31.5*
Y	Industrial	19.68	1.61	31.7
	Urban Open	12.81	0.11	1.4
	Subtotal			*33.1*
Z	Roadway	1.95	1.51	3.0
	Urban Open	36.86	0.15	5.4
	Subtotal			*8.3*
AA	Roadway	6.49	1.38	8.9
	Industrial	6.80	1.38	9.4
	Urban Open	24.61	0.02	0.5
	Subtotal			*18.9*
BB	Commercial / Ops	11.54	0.59	6.8
	Roadway	6.01	1.55	9.3
	Industrial	17.96	1.47	26.4
	Urban Open	7.81	0.02	0.2
	Subtotal			*42.7*
CC	Roadway	2.90	1.58	4.6
	Industrial	14.62	1.03	15.0
	Subtotal			*19.6*
DD	Roadway	9.45	1.47	13.9
	Industrial	30.91	1.50	46.5
	Urban Open	6.66	0.02	0.1
	Subtotal			*60.5*
EE	Roadway	2.22	1.65	3.7
	Industrial	7.70	1.29	9.9
	Urban Open	3.17	0.02	0.1
	Subtotal			*13.6*
FF	Commercial / Ops	3.00	0.79	2.4
	Roadway	0.94	1.59	1.5
	Urban Open	2.66	0.02	0.1
	Subtotal			*3.9*
GG	Commercial / Ops	0.19	0.12	0.0
	Roadway	6.68	0.89	5.9
	Industrial	0.74	1.62	1.2
	Urban Open	3.50	0.03	0.1

Sub-Basin	**Land Use Category**	**Acres**[1]	**Load Per Acre (lbs)**[2]	**Annual Load (lbs)**
	Forest	807.13	0.10	80.7
	Subtotal			*88.0*
TOTAL LOAD				*1,666.5*

Notes:
1 Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO / NAVFAC, 2009).
2 Loads per acre calculated using the Simple Method (Schueler, 1987).

Table C-9: Annual Total Nitrogen (TN) Load for Future Conditions Presented by Sub-Basin

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
A	Residential	2.95	2.46	7.3
	Commercial / Ops	0.01	0.43	0.0
	Roadway	10.18	8.75	89.0
	Urban Open	0.49	0.21	0.1
	Subtotal			*96.4*
B	Residential	5.39	2.50	13.5
	Roadway	3.99	8.70	34.7
	Urban Open	16.65	0.76	12.7
	Subtotal			*60.9*
C	Residential	3.62	2.28	8.2
	Roadway	4.09	9.16	37.4
	Urban Open	30.43	1.14	34.8
	Subtotal			*80.5*
D	Residential	22.73	3.68	83.6
	Roadway	2.45	7.92	19.4
	Urban Open	4.41	0.21	0.9
	Subtotal			*104.0*
E	Commercial / Ops	34.42	4.56	156.9
	Roadway	7.48	9.37	70.1
	Urban Open	16.00	0.21	3.4
	Subtotal			*230.4*
F	Residential	2.37	3.80	9.0
	Commercial / Ops	42.98	5.71	245.3
	Roadway	10.60	8.48	89.9
	Urban Open	11.94	0.21	2.5
	Subtotal			*346.8*
G	Commercial / Ops	11.23	6.15	69.0
	Roadway	8.35	8.38	69.9
	Urban Open	43.54	0.21	9.3
	Subtotal			*148.3*
H	Commercial / Ops	13.61	4.45	60.6
	Roadway	4.46	8.79	39.2
	Urban Open	16.96	0.21	3.6
	Subtotal			*103.4*
I	Commercial / Ops	1.75	7.09	12.4
	Roadway	2.46	9.36	23.0
	Urban Open	4.45	0.21	1.0
	Subtotal			*36.4*
J	Commercial / Ops	9.18	7.09	65.0
	Roadway	4.07	9.36	38.1
	Urban Open	13.69	0.21	2.9
	Subtotal			*106.0*
K	Residential	50.10	4.38	219.5
	Roadway	16.42	8.91	146.4

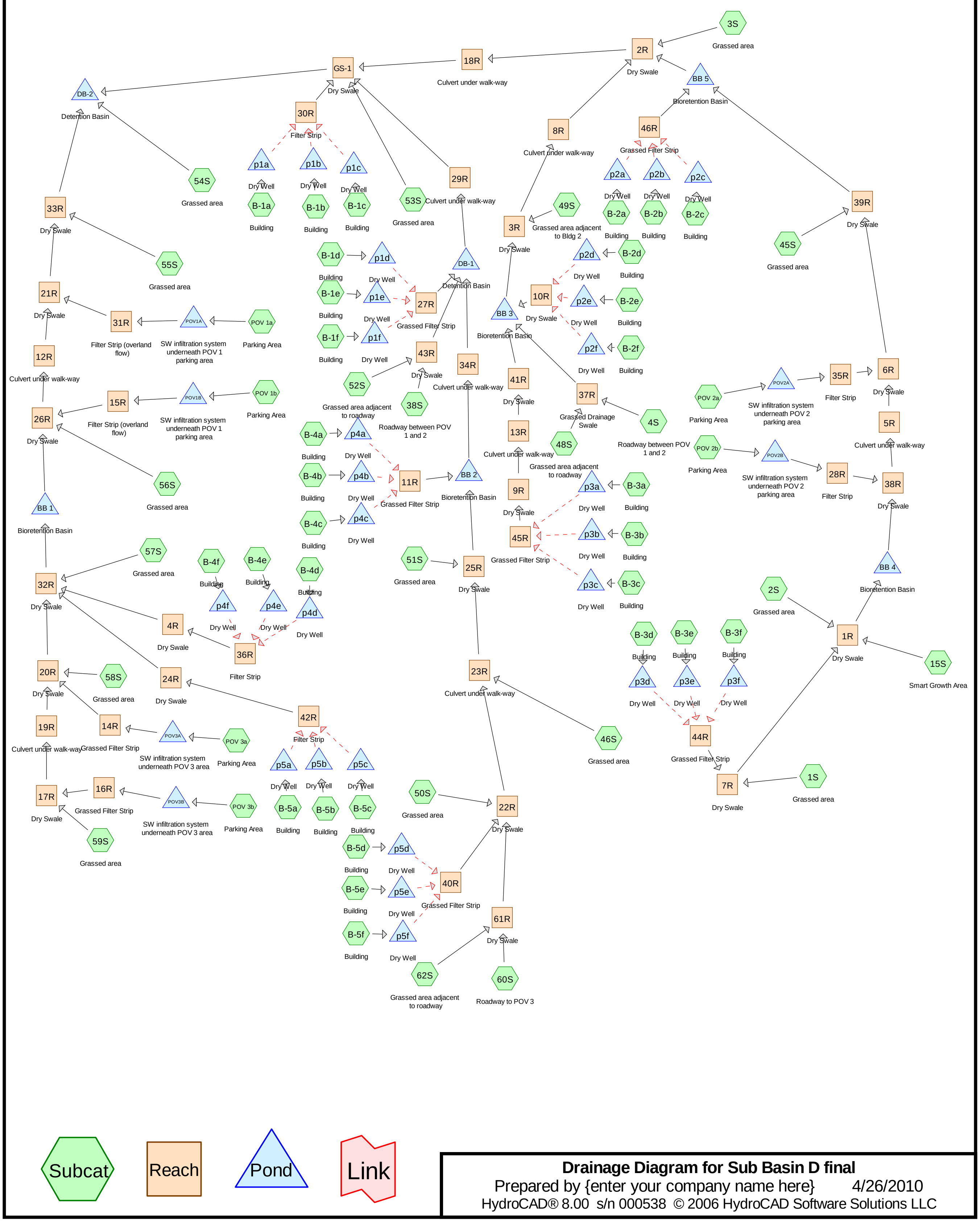
Sub-Basin	Land Use Category	Acres^1	Load Per Acre (lbs)^2	Annual Load (lbs)
	Urban Open	4.76	0.21	1.0
	Subtotal			*366.9*
L	Residential	553.81	2.50	1,382.8
	Roadway	229.36	9.45	2,167.2
	Urban Open	134.40	0.21	28.7
	Subtotal			*3,578.7*
M	Commercial / Ops	16.13	4.86	78.4
	Roadway	3.62	7.42	26.9
	Urban Open	7.66	0.21	1.6
	Subtotal			*106.9*
N	Commercial / Ops	3.78	4.46	16.9
	Roadway	10.58	8.46	89.5
	Industrial	9.70	6.15	59.7
	Urban Open	13.40	0.21	2.9
	Subtotal			*168.8*
O	Residential	80.53	3.50	281.7
	Commercial / Ops	0.87	3.93	3.4
	Roadway	12.14	9.13	110.9
	Urban Open	50.06	0.29	14.4
	Subtotal			*410.4*
P	Commercial / Ops	39.95	7.09	283.2
	Roadway	9.35	8.90	83.3
	Industrial	38.74	8.63	334.5
	Urban Open	10.26	0.21	2.2
	Subtotal			*703.1*
R	Commercial / Ops	5.21	30.17	157.1
	Roadway	12.74	8.51	108.3
	Industrial	9.38	8.17	76.7
	Urban Open	112.78	0.21	24.1
	Subtotal			*366.2*
S	Commercial / Ops	8.56	7.46	63.8
	Roadway	0.14	9.02	1.2
	Industrial	2.69	9.99	26.9
	Urban Open	2.64	0.21	0.6
	Subtotal			*92.5*
T	Commercial / Ops	8.56	7.69	65.9
	Roadway	2.08	9.91	20.6
	Urban Open	0.00	0.21	0.0
	Subtotal			*86.4*
U	Roadway	10.37	8.53	88.4
	Industrial	60.00	9.81	588.5
	Urban Open	3.44	0.21	0.7
	Subtotal			*677.7*
V	Roadway	5.81	9.11	52.9
	Industrial	45.58	9.49	432.7

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
	Urban Open	19.95	1.33	26.5
	Subtotal			*512.2*
W	Commercial / Ops	12.76	2.64	33.7
	Roadway	1.72	7.75	13.3
	Industrial	14.03	8.95	125.6
	Urban Open	6.43	0.21	1.4
	Subtotal			*174.0*
X	Roadway	6.72	8.97	60.3
	Industrial	19.33	6.92	133.7
	Urban Open	5.17	0.21	1.1
	Subtotal			*195.1*
Y	Industrial	19.68	10.07	198.3
	Urban Open	12.81	1.10	14.0
	Subtotal			*212.3*
Z	Roadway	1.95	9.07	17.7
	Urban Open	36.86	1.45	53.5
	Subtotal			*71.2*
AA	Roadway	6.49	8.28	53.7
	Industrial	6.80	8.62	58.6
	Urban Open	24.61	0.21	5.3
	Subtotal			*117.6*
BB	Commercial / Ops	11.54	5.90	68.1
	Roadway	6.01	9.32	56.0
	Industrial	17.96	9.17	164.7
	Urban Open	7.81	0.21	1.7
	Subtotal			*290.5*
CC	Roadway	2.90	9.50	27.6
	Industrial	14.62	29.02	424.4
	Subtotal			*452.0*
DD	Roadway	9.45	8.81	83.2
	Industrial	30.91	9.40	290.5
	Urban Open	6.66	0.21	1.4
	Subtotal			*375.1*
EE	Roadway	2.22	9.88	21.9
	Industrial	7.70	8.05	62.0
	Urban Open	3.17	0.21	0.7
	Subtotal			*84.6*
FF	Commercial / Ops	3.00	7.86	23.6
	Roadway	0.94	9.55	9.0
	Urban Open	2.66	0.21	0.6
	Subtotal			*33.1*
GG	Commercial / Ops	0.19	1.17	0.2
	Roadway	6.68	5.33	35.6
	Industrial	0.74	10.13	7.5
	Urban Open	3.50	0.26	0.9

Sub-Basin	Land Use Category	Acres[1]	Load Per Acre (lbs)[2]	Annual Load (lbs)
	Forest	807.13	0.50	403.6
	Subtotal			*447.9*
TOTAL LOAD				*10,836.4*

Notes:
1 Future land use acres derived from detailed GIS data developed for the Draft GJMMP (JGPO / NAVFAC, 2009).
2 Loads per acre calculated using the Simple Method (Schueler, 1987).

Appendix D
Draft HydroCAD Output



Drainage Diagram for Sub Basin D final
Prepared by {enter your company name here} 4/26/2010
HydroCAD® 8.00 s/n 000538 © 2006 HydroCAD Software Solutions LLC

Pond p4a: Dry Well

```
Inflow Area =       0.112 ac,  Inflow Depth =   1.97"    for  95 % event
Inflow      =       0.06 cfs @    7.81 hrs,  Volume=           0.018 af
Outflow     =       0.06 cfs @    7.82 hrs,  Volume=           0.018 af,  Atten= 0%,  Lag= 0.6 min
Discarded  =        0.01 cfs @    4.32 hrs,  Volume=           0.014 af
Secondary =         0.05 cfs @    7.82 hrs,  Volume=           0.004 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Peak Elev= 369.14' @ 7.82 hrs   Surf.Area= 64 sf   Storage= 80 cf

Plug-Flow detention time= 95.3 min calculated for 0.018 af (100% of inflow)
Center-of-Mass det. time= 95.3 min ( 768.2 - 672.9 )

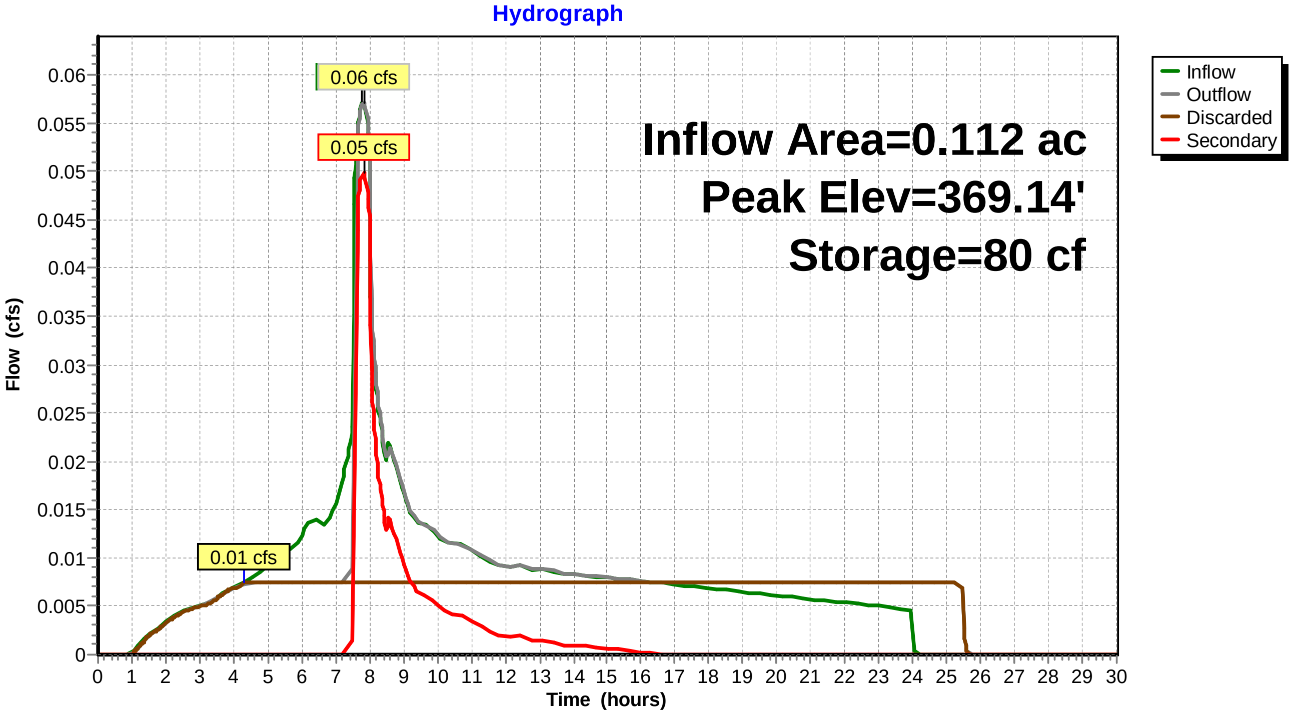
Volume       Invert     Avail.Storage   Storage Description
     #1      366.00'           102 cf   9.00'D x 4.00'H Infiltration Gallery
                                        254 cf Overall  x 40.0% Voids

Device   Routing          Invert   Outlet Devices
    #1   Secondary       369.00'   6.0"  x 40.0' long Overflow Culvert   Ke= 0.500
                                   Outlet Invert= 368.70'   S= 0.0075 '/'   Cc= 0.900
                                   n= 0.011  Concrete pipe, straight & clean
    #2   Discarded         0.00'   5.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.01 cfs @ 4.32 hrs  HW=366.04'   (Free Discharge)
↑—2=Exfiltration  (Exfiltration Controls 0.01 cfs)

Secondary OutFlow  Max=0.05 cfs @ 7.82 hrs  HW=369.14'   (Free Discharge)
↑—1=Overflow Culvert  (Barrel Controls 0.05 cfs @ 1.71 fps)
```

Pond p4a: Dry Well



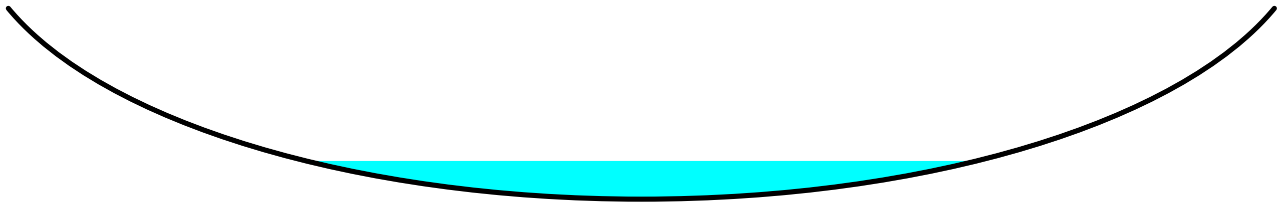
Reach 11R: Grassed Filter Strip

Inflow	=	0.15 cfs @	7.82 hrs,	Volume=	0.013 af
Outflow	=	0.13 cfs @	8.22 hrs,	Volume=	0.013 af, Atten= 16%, Lag= 24.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 0.05 fps, Min. Travel Time= 12.2 min
Avg. Velocity = 0.01 fps, Avg. Travel Time= 41.1 min

Peak Storage= 92 cf @ 8.01 hrs, Average Depth at Peak Storage= 0.05'
Bank-Full Depth= 0.25', Capacity at Bank-Full= 4.25 cfs

180.00' x 0.25' deep Parabolic Channel, n= 0.240 Sheet flow over Dense Grass
Length= 35.0'   Slope= 0.0057 '/'
Inlet Invert= 368.70', Outlet Invert= 368.50'



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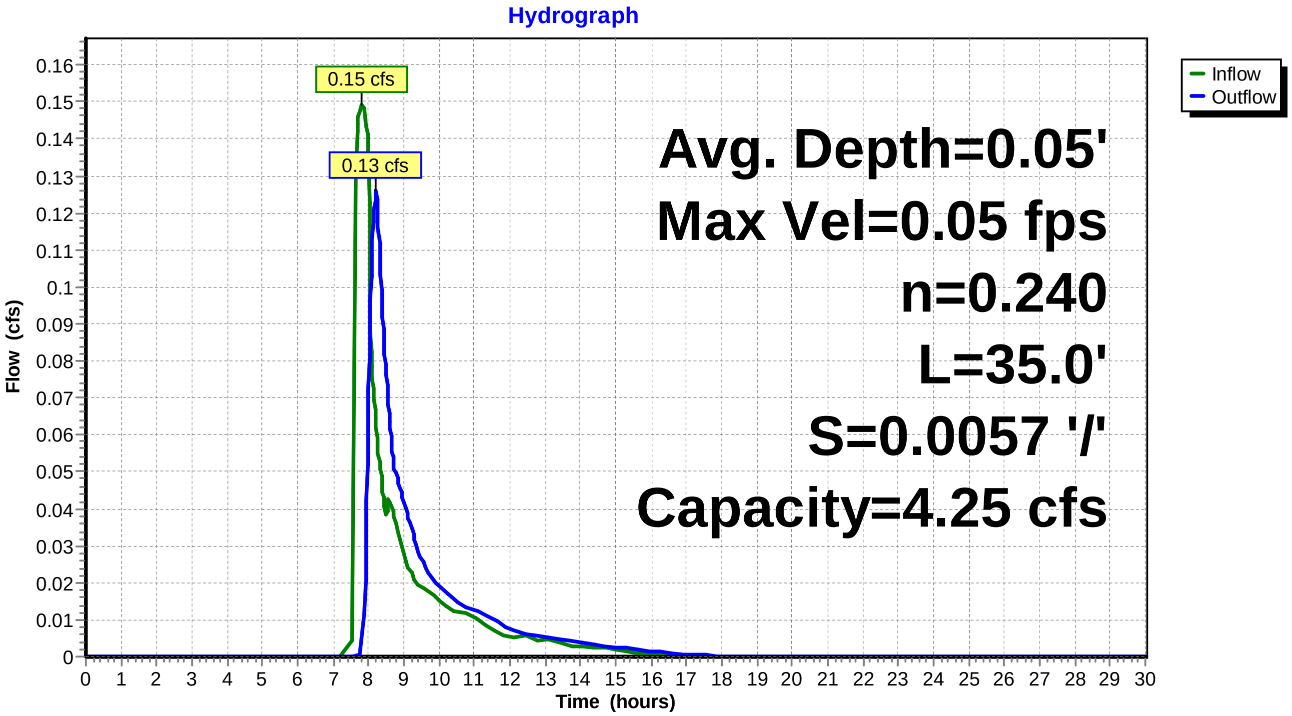
Reach 11R: Grassed Filter Strip



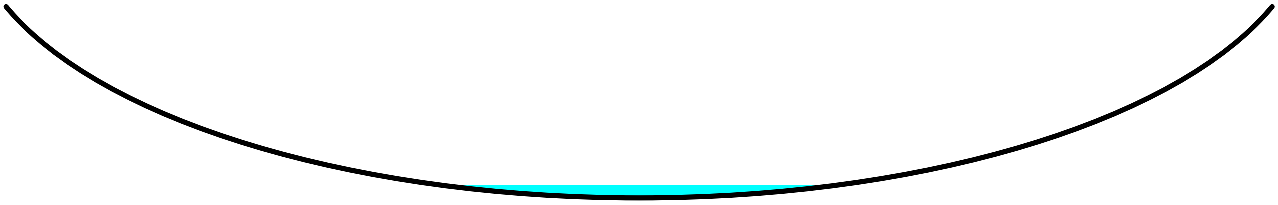
Reach 25R: Dry Swale

Inflow Area =	2.745 ac,	Inflow Depth = 0.17"	for 95 % event		
Inflow =	0.19 cfs @	8.36 hrs,	Volume=	0.039 af	
Outflow =	0.18 cfs @	8.52 hrs,	Volume=	0.039 af,	Atten= 4%, Lag= 9.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 0.52 fps, Min. Travel Time= 5.4 min
Avg. Velocity = 0.24 fps, Avg. Travel Time= 12.0 min

Peak Storage= 58 cf @ 8.42 hrs, Average Depth at Peak Storage= 0.13'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 67.62 cfs

16.00' x 2.00' deep Parabolic Channel, n= 0.030 Short grass
Length= 170.0' Slope= 0.0029 '/'
Inlet Invert= 368.50', Outlet Invert= 368.00'



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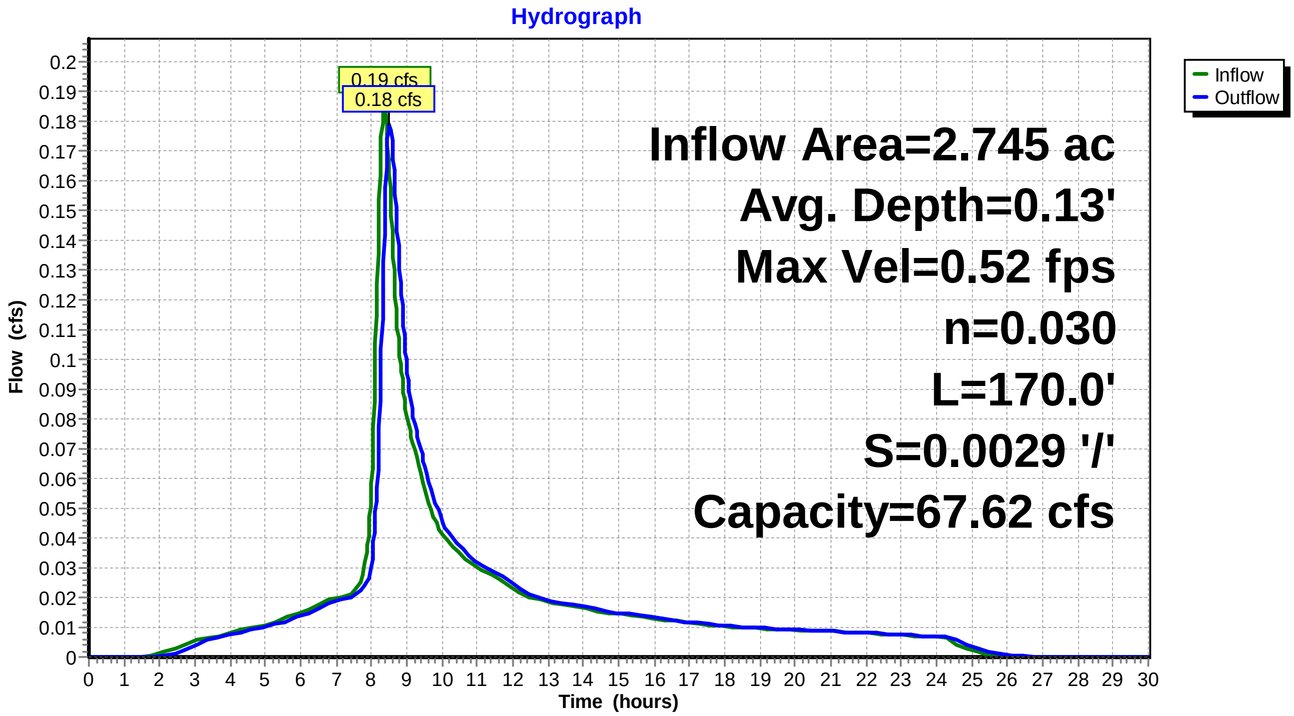
Reach 25R: Dry Swale



Pond BB 2: Bioretention Basin

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Inflow Area =        2.745 ac,  Inflow Depth =   0.23"    for  95 % event
Inflow      =       0.26 cfs @     8.47 hrs,  Volume=           0.052 af
Outflow     =       0.17 cfs @     8.83 hrs,  Volume=           0.052 af,  Atten= 33%,  Lag= 21.8 min
Discarded  =        0.17 cfs @     8.83 hrs,  Volume=           0.052 af
Primary     =       0.00 cfs @     0.00 hrs,  Volume=           0.000 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Peak Elev= 365.57' @ 8.83 hrs   Surf.Area= 2,467 sf   Storage= 179 cf

Plug-Flow detention time= 8.4 min calculated for 0.052 af (100% of inflow)
Center-of-Mass det. time= 8.4 min ( 669.9 - 661.5 )

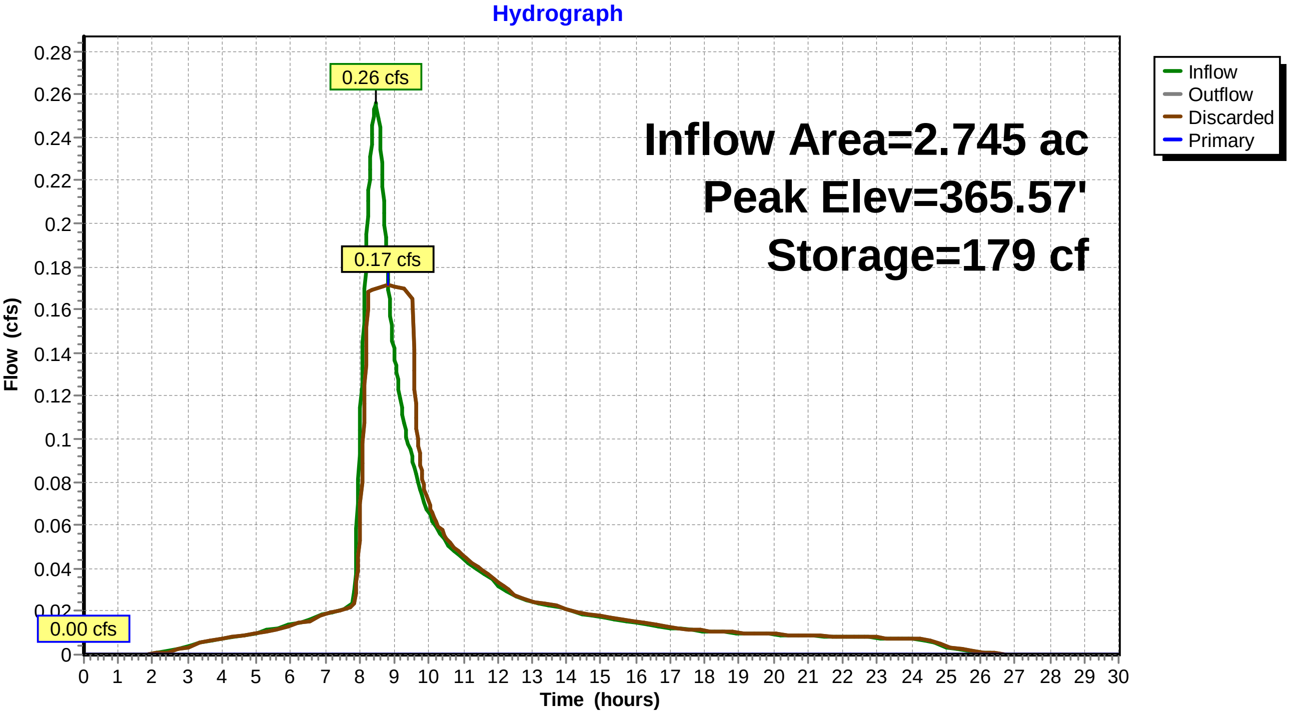
Volume       Invert     Avail.Storage    Storage Description
    #1       365.50'          9,169 cf   30.00'W x 80.00'L x 2.50'H Prismatoid  Z=4.1

Device   Routing           Invert   Outlet Devices
   #1    Primary          364.50'   12.0"  x 60.0' long Culvert Barrel
                                    CMP, projecting, no headwall,  Ke= 0.900
                                    Outlet Invert= 363.50'   S= 0.0167 '/'   Cc= 0.900
                                    n= 0.011  Concrete pipe, straight & clean
   #2    Device 1         366.00'   24.0" Horiz. Top of Riser     Limited to weir flow   C= 0.600
   #3    Primary          367.00'   6.0' long  x 1.0' breadth Broad-Crested Rectangular Weir
                                    Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00  2.50
                                    3.00
                                    Coef. (English)  2.69  2.72  2.75  2.85  2.98  3.08  3.20  3.28  3.31  3.30
                                    3.31  3.32
   #4    Discarded          0.00'   3.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.17 cfs @ 8.83 hrs  HW=365.57'   (Free Discharge)
└─4=Exfiltration  (Exfiltration Controls 0.17 cfs)

Primary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=365.50'   (Free Discharge)
├─1=Culvert Barrel  (Passes 0.00 cfs of 2.11 cfs potential flow)
│  └─2=Top of Riser  ( Controls 0.00 cfs)
└─3=Broad-Crested Rectangular Weir  ( Controls 0.00 cfs)
```

Pond BB 2: Bioretention Basin



Pond POV3: SW infiltration system underneath POV 3 area

Inflow Area = 0.974 ac, Inflow Depth = 1.97" for 95 % event
Inflow = 0.50 cfs @ 7.81 hrs, Volume= 0.160 af
Outflow = 0.14 cfs @ 7.12 hrs, Volume= 0.137 af, Atten= 71%, Lag= 0.0 min
Discarded = 0.14 cfs @ 7.12 hrs, Volume= 0.137 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Peak Elev= 372.15' @ 9.06 hrs Surf.Area= 1,208 sf Storage= 1,870 cf

Plug-Flow detention time= 204.7 min calculated for 0.137 af (86% of inflow)
Center-of-Mass det. time= 106.3 min (779.2 - 672.9)

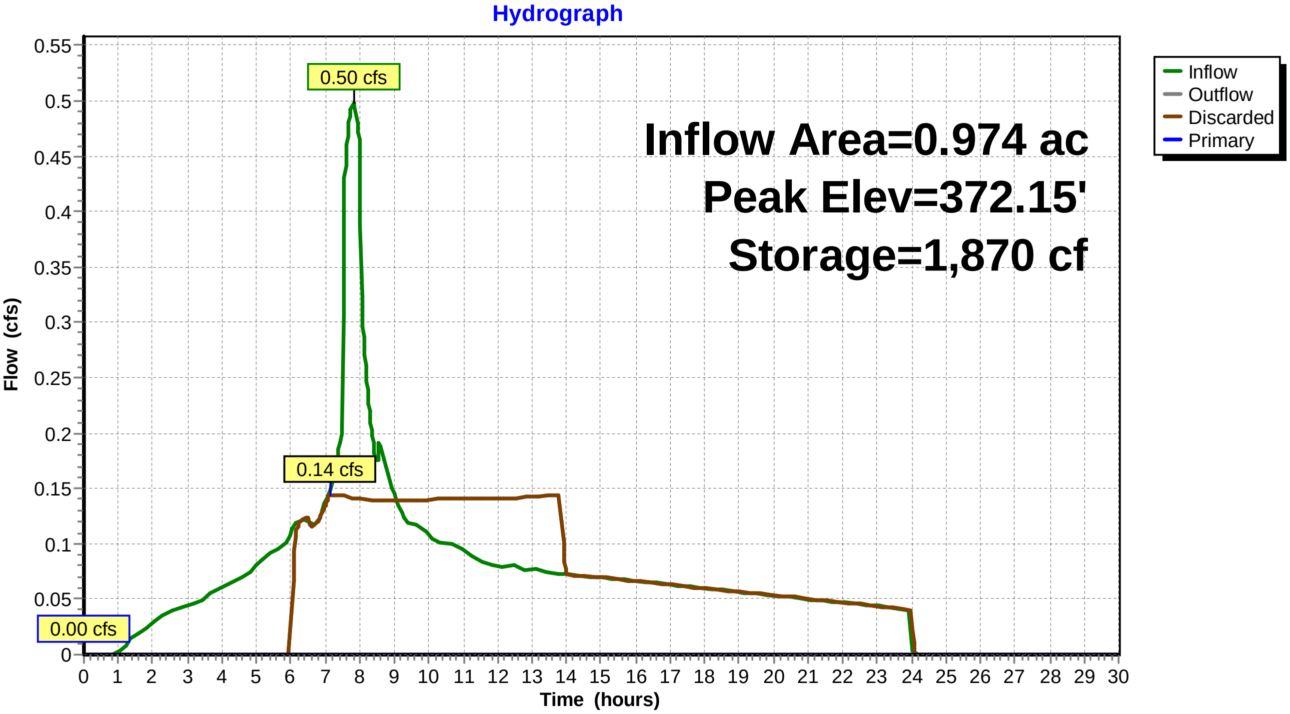
Volume	Invert	Avail.Storage	Storage Description
#1	371.70'	2,328 cf	**47.8"W x 30.0"H x 6.25'L Cultec R-330** x 50
#2	370.20'	2,388 cf	**25.65'W x 65.75'L x 3.54'H Excavation w/stone backfill** -Impervious 5,970 cf Overall x 40.0% Voids
		4,717 cf	Total Available Storage

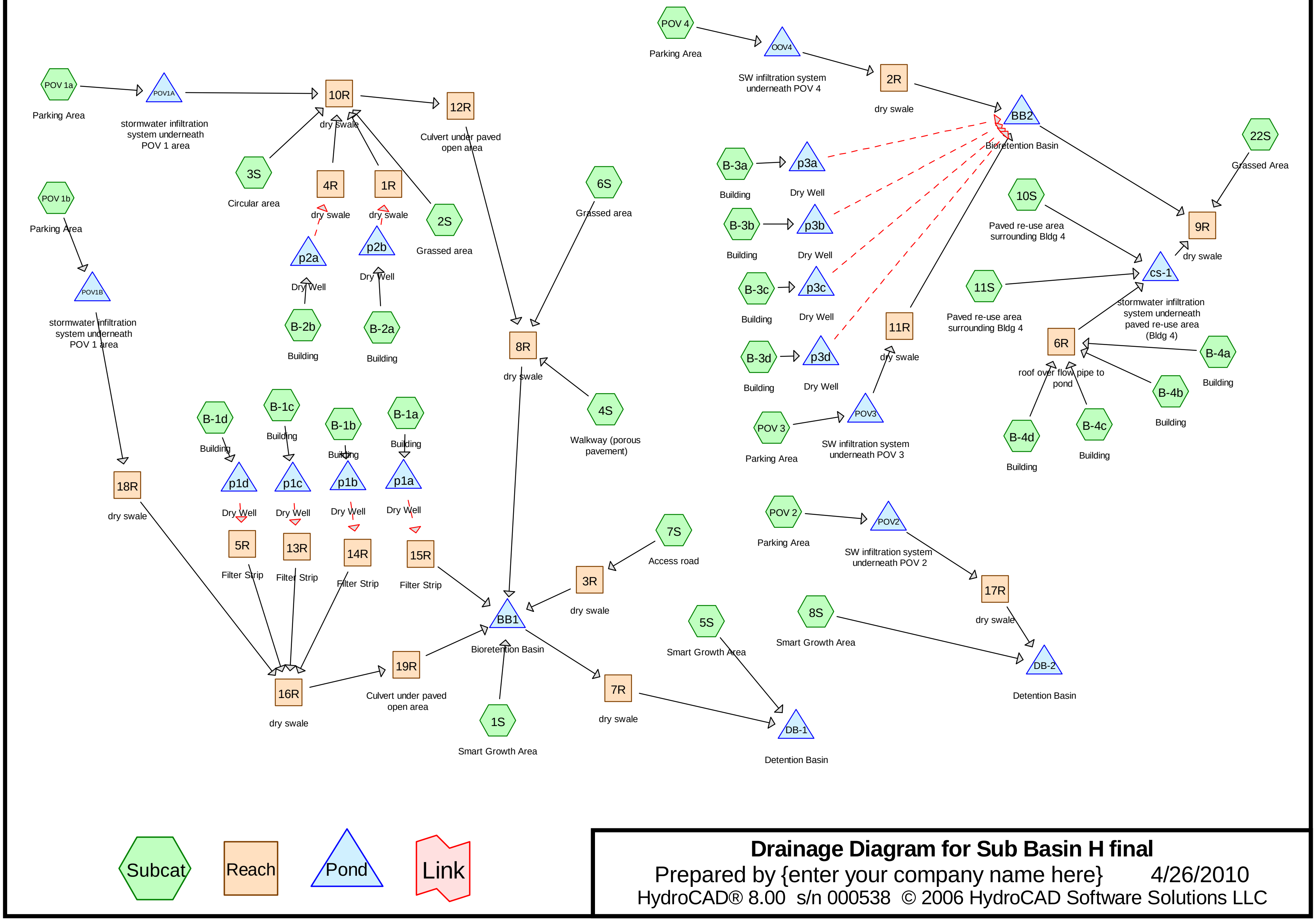
Device	Routing	Invert	Outlet Devices
#1	Primary	372.70'	**18.0" x 40.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 372.20' S= 0.0125 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Discarded	0.00'	**5.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.14 cfs @ 7.12 hrs HW=371.70' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.14 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=370.20' (Free Discharge)
↑—**1=Culvert** (Controls 0.00 cfs)

Pond POV3: SW infiltration system underneath POV 3 area





Drainage Diagram for Sub Basin H final
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Pond BB2: Bioretention Basin

```
Inflow Area =       0.519 ac,  Inflow Depth =   0.72"    for  95 % event
Inflow      =       0.25 cfs @    7.79 hrs,  Volume=          0.031 af
Outflow     =       0.10 cfs @    8.27 hrs,  Volume=          0.031 af,  Atten= 62%,  Lag= 28.6 min
Discarded   =       0.10 cfs @    8.27 hrs,  Volume=          0.031 af
Primary     =       0.00 cfs @    0.00 hrs,  Volume=          0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.03 hrs
Peak Elev= 351.75' @ 8.27 hrs   Surf.Area= 1,368 sf   Storage= 321 cf

Plug-Flow detention time= 26.9 min calculated for 0.031 af (100% of inflow)
Center-of-Mass det. time= 26.9 min ( 607.1 - 580.1 )

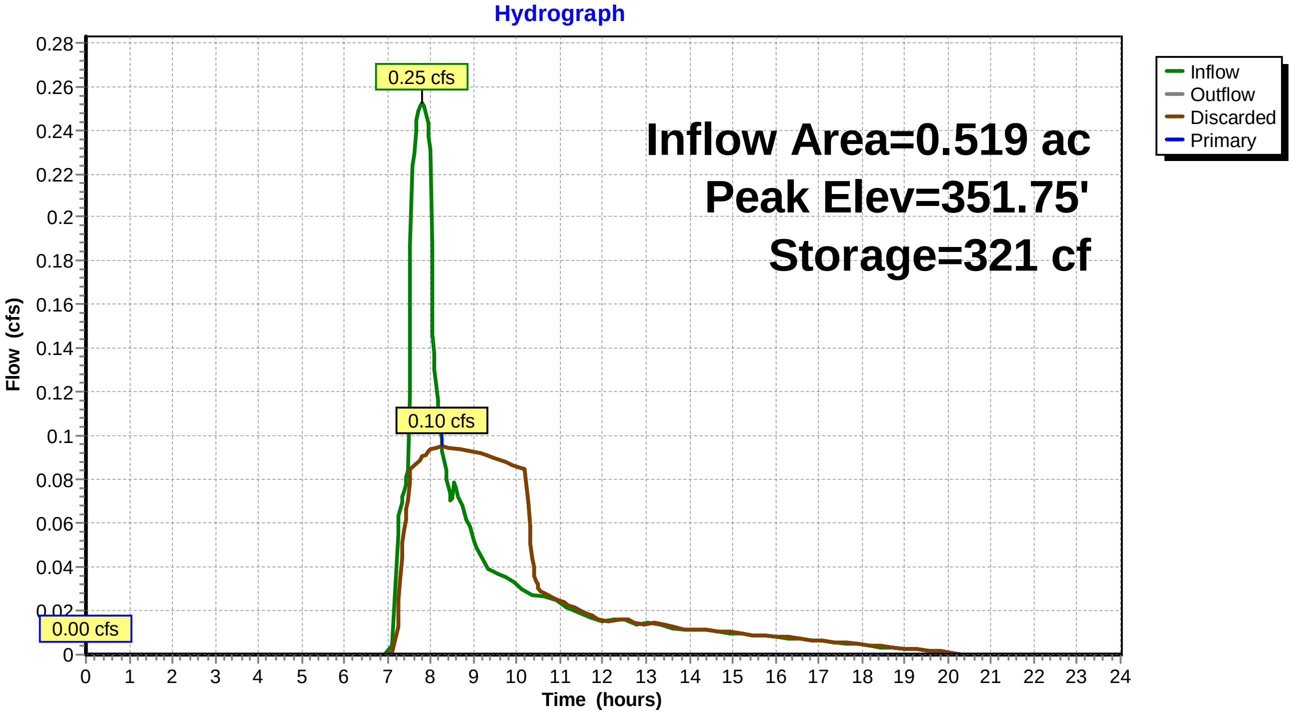
Volume      Invert    Avail.Storage   Storage Description
   #1      351.50'         5,400 cf   20.00'W x 60.00'L x 2.50'H Prismatoid  Z=4.1

Device  Routing          Invert   Outlet Devices
   #1   Primary         350.50'   12.0"  x 60.0' long Culvert Barrel
                                  CMP, projecting, no headwall,  Ke= 0.900
                                  Outlet Invert= 350.00'   S= 0.0083 '/'   Cc= 0.900
                                  n= 0.011  Concrete pipe, straight & clean
   #2   Device 1        352.00'   24.0" Horiz. Top of Riser     Limited to weir flow   C= 0.600
   #3   Primary         353.00'   6.0' long  x 1.0' breadth Broad-Crested Rectangular Weir
                                  Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00  2.50
                                  3.00
                                  Coef. (English)  2.69  2.72  2.75  2.85  2.98  3.08  3.20  3.28  3.31  3.30
                                  3.31  3.32
   #4   Discarded         0.00'   3.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.10 cfs @ 8.27 hrs  HW=351.75'   (Free Discharge)
└─4=Exfiltration  (Exfiltration Controls 0.10 cfs)

Primary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=351.50'   (Free Discharge)
├─1=Culvert Barrel  (Passes 0.00 cfs of 2.11 cfs potential flow)
│ └─2=Top of Riser  ( Controls 0.00 cfs)
└─3=Broad-Crested Rectangular Weir  ( Controls 0.00 cfs)
```

Pond BB2: Bioretention Basin



Pond cs-1: stormwater infiltration system underneath paved re-use area (Bldg 4)

Inflow Area = 2.799 ac, Inflow Depth =   1.97"   for 95 % event
Inflow = 1.43 cfs @ 7.79 hrs, Volume= 0.460 af
Outflow = 0.28 cfs @ 5.70 hrs, Volume= 0.446 af, Atten= 81%, Lag= 0.0 min
Discarded = 0.28 cfs @ 5.70 hrs, Volume= 0.446 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.03 hrs
Peak Elev= 352.44' @ 11.52 hrs   Surf.Area= 2,083 sf   Storage= 4,978 cf

Plug-Flow detention time= 209.3 min calculated for 0.446 af (97% of inflow)
Center-of-Mass det. time= 186.4 min (858.7 - 672.3)

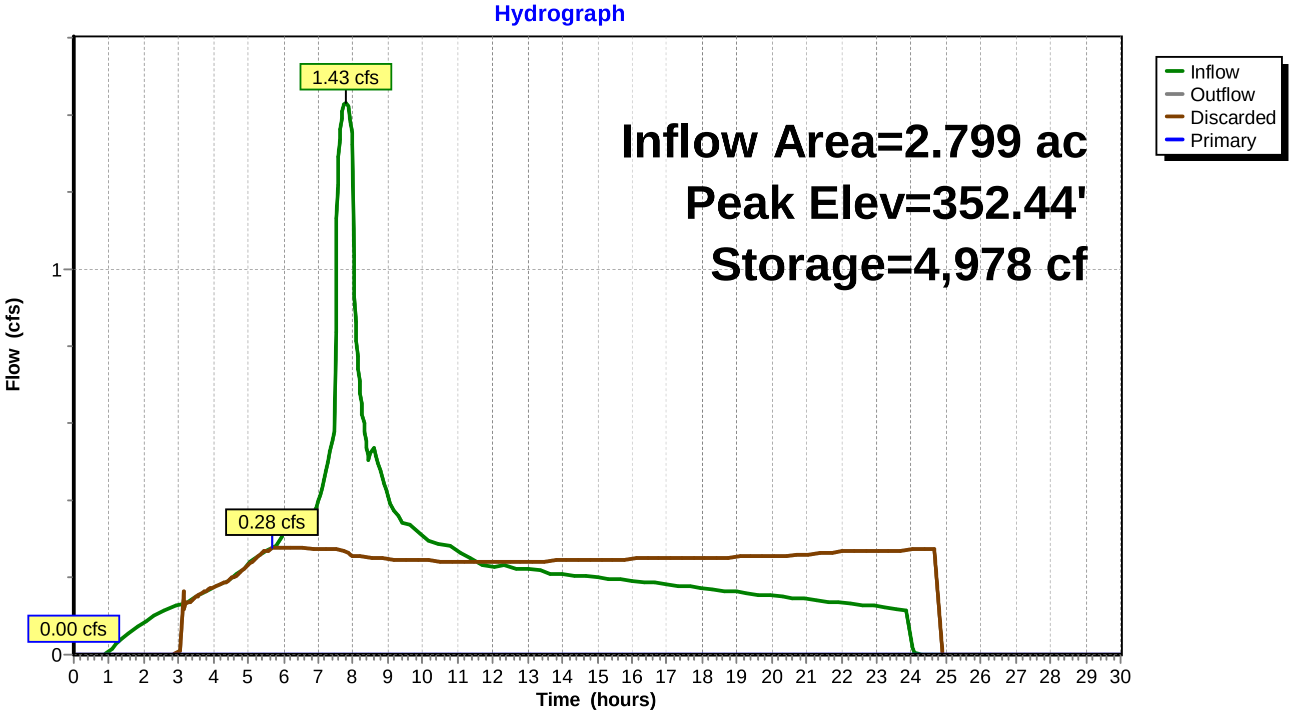
Volume	Invert	Avail.Storage	Storage Description
#1	351.20'	4,471 cf	**47.8"W x 30.0"H x 6.25'L Cultec R-330** x 96
#2	350.70'	4,448 cf	**40.14'W x 78.25'L x 3.54'H Excavation w/stone backfill** -Impervious 11,119 cf Overall x 40.0% Voids
		8,918 cf	Total Available Storage

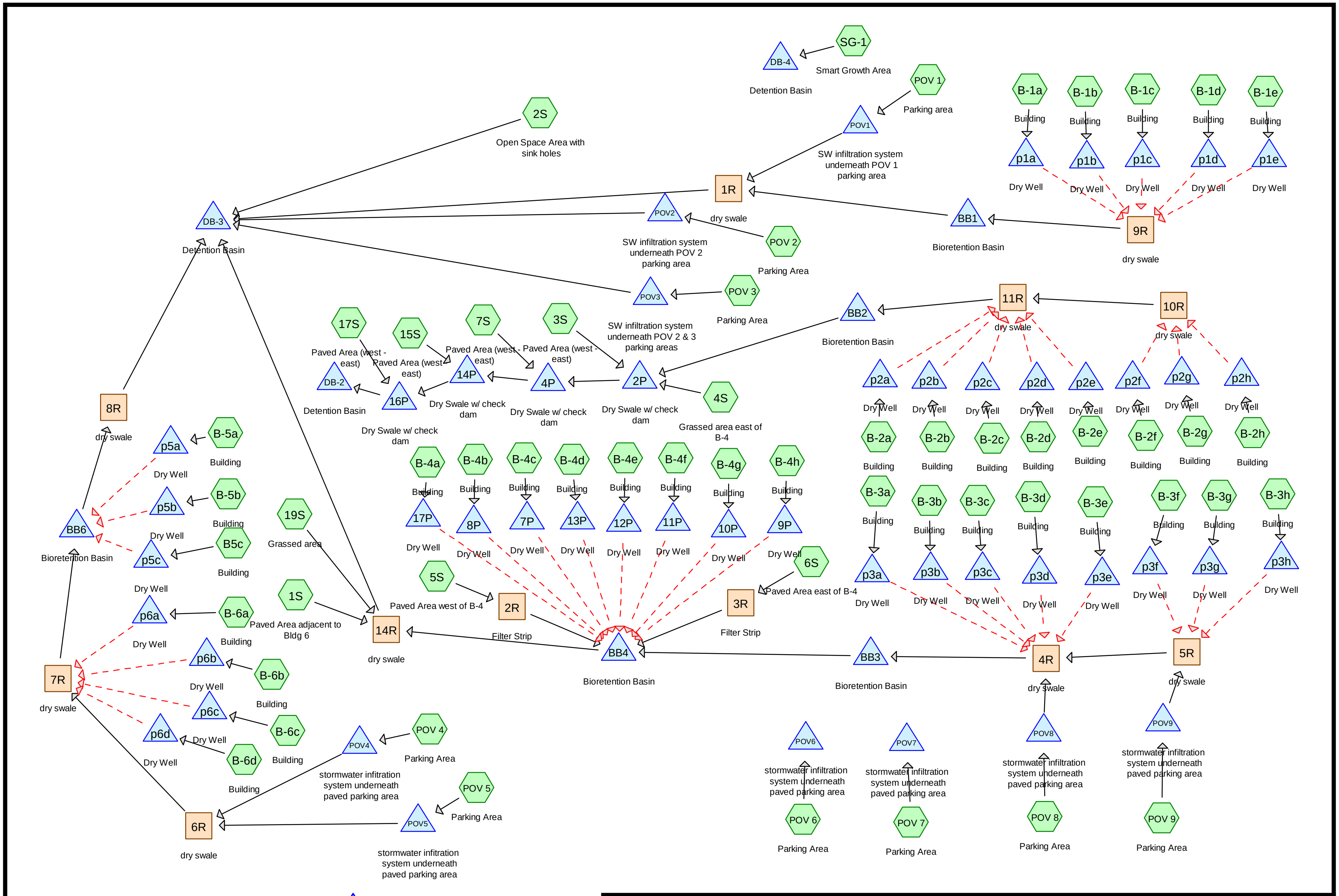
Device	Routing	Invert	Outlet Devices
#1	Primary	353.70'	**18.0" x 80.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 353.20' S= 0.0063 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Discarded	0.00'	**5.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.28 cfs @ 5.70 hrs HW=351.20'   (Free Discharge)
↑**2=Exfiltration** (Exfiltration Controls 0.28 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=350.70'   (Free Discharge)
↑**1=Culvert** (Controls 0.00 cfs)

Pond cs-1: stormwater infiltration system underneath paved re-use area (Bldg 4)





Drainage Diagram for Sub Basin E final

Prepared by {enter your company name here}   4/26/2010

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Pond BB1: Bioretention Basin

```
Inflow Area =        1.057 ac,  Inflow Depth =   0.48"    for  95 % event
Inflow      =       0.33 cfs @    7.84 hrs,  Volume=          0.042 af
Outflow     =       0.10 cfs @    8.44 hrs,  Volume=          0.042 af,  Atten= 69%,  Lag= 36.0 min
Discarded  =        0.10 cfs @    8.44 hrs,  Volume=          0.042 af
Primary     =       0.00 cfs @    0.00 hrs,  Volume=          0.000 af

Routing by Stor-Ind method, Time Span= 0.00-26.01 hrs, dt= 0.03 hrs
Peak Elev= 346.87' @ 8.44 hrs   Surf.Area= 1,453 sf   Storage= 493 cf

Plug-Flow detention time= 41.3 min calculated for 0.042 af (100% of inflow)
Center-of-Mass det. time= 41.2 min ( 630.3 - 589.1 )

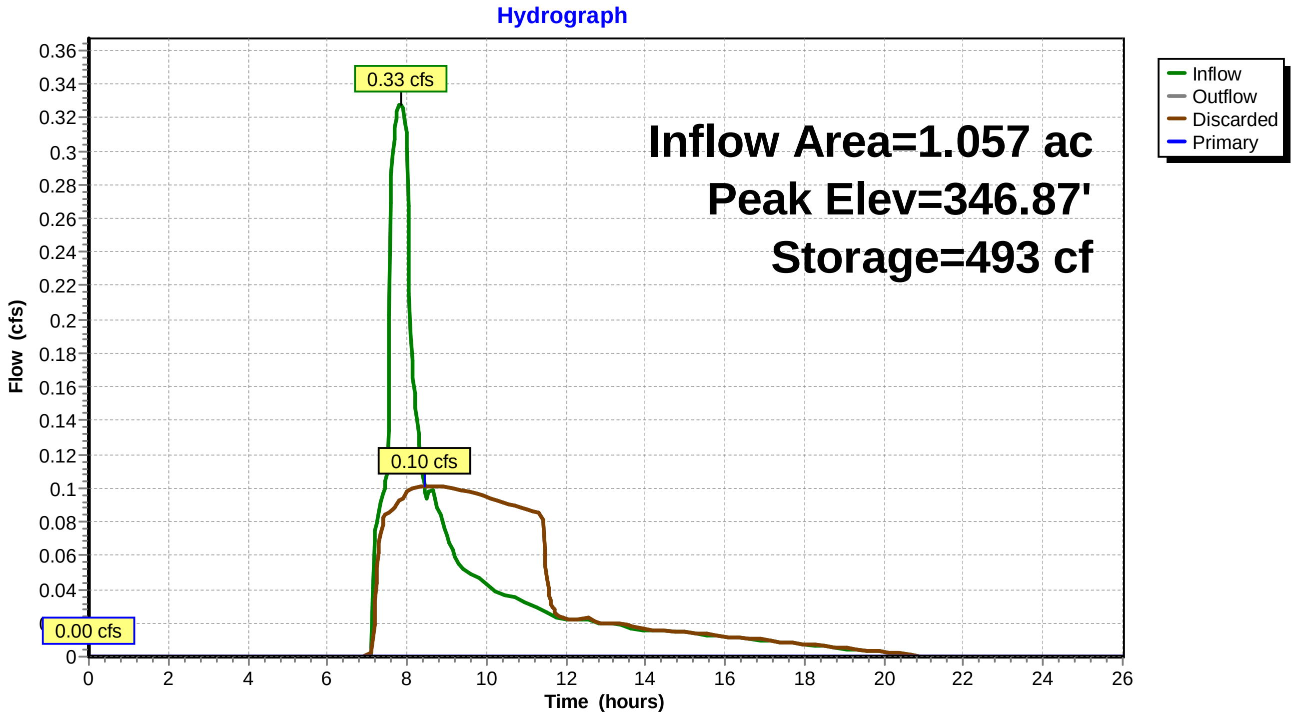
Volume         Invert      Avail.Storage    Storage Description
    #1        346.50'          5,400 cf     20.00'W x 60.00'L x 2.50'H Prismatoid  Z=4.1

Device    Routing            Invert    Outlet Devices
    #1    Primary           345.50'    12.0"  x 160.0' long Culvert Barrel
                                       CMP, projecting, no headwall,  Ke= 0.900
                                       Outlet Invert= 343.50'   S= 0.0125 '/'   Cc= 0.900
                                       n= 0.011  Concrete pipe, straight & clean
    #2    Device 1          347.00'    24.0" Horiz. Top of Riser     Limited to weir flow   C= 0.600
    #3    Primary           348.00'    6.0' long  x 1.0' breadth Broad-Crested Rectangular Weir
                                       Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00  2.50
                                       3.00
                                       Coef. (English)  2.69  2.72  2.75  2.85  2.98  3.08  3.20  3.28  3.31  3.30
                                       3.31  3.32
    #4    Discarded           0.00'    3.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.10 cfs @ 8.44 hrs  HW=346.87'   (Free Discharge)
↑
└─4=Exfiltration  (Exfiltration Controls 0.10 cfs)

Primary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=346.50'   (Free Discharge)
↑
├─1=Culvert Barrel  (Passes 0.00 cfs of 2.11 cfs potential flow)
│  ↑
│  └─2=Top of Riser  ( Controls 0.00 cfs)
└─3=Broad-Crested Rectangular Weir  ( Controls 0.00 cfs)
```

Pond BB1: Bioretention Basin



Pond 1P: SW infiltration system underneath POV 1 parking area

Inflow Area = 1.057 ac, Inflow Depth = 1.97" for 95 % event
Inflow = 0.52 cfs @ 8.05 hrs, Volume= 0.174 af
Outflow = 0.14 cfs @ 7.23 hrs, Volume= 0.166 af, Atten= 72%, Lag= 0.0 min
Discarded = 0.14 cfs @ 7.23 hrs, Volume= 0.166 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-26.01 hrs, dt= 0.03 hrs
Peak Elev= 341.74' @ 9.49 hrs Surf.Area= 1,197 sf Storage= 1,362 cf

Plug-Flow detention time= 98.5 min calculated for 0.166 af (96% of inflow)
Center-of-Mass det. time= 66.8 min (754.4 - 687.6)

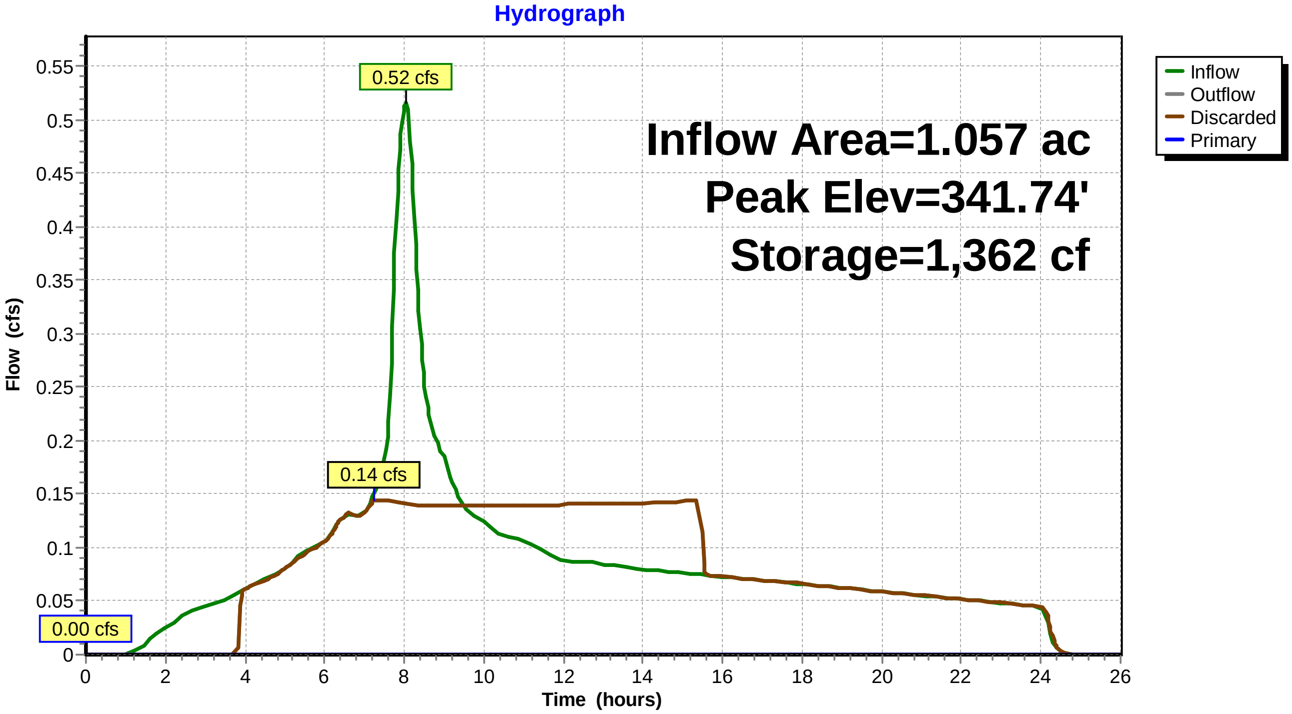
Volume	Invert	Avail.Storage	Storage Description
#1	341.20'	2,328 cf	**47.8"W x 30.0"H x 6.25'L Cultec R-330** x 50
#2	340.70'	2,388 cf	**25.65'W x 65.75'L x 3.54'H Excavation w/stone backfill** -Impervious 5,970 cf Overall x 40.0% Voids
		4,717 cf	Total Available Storage

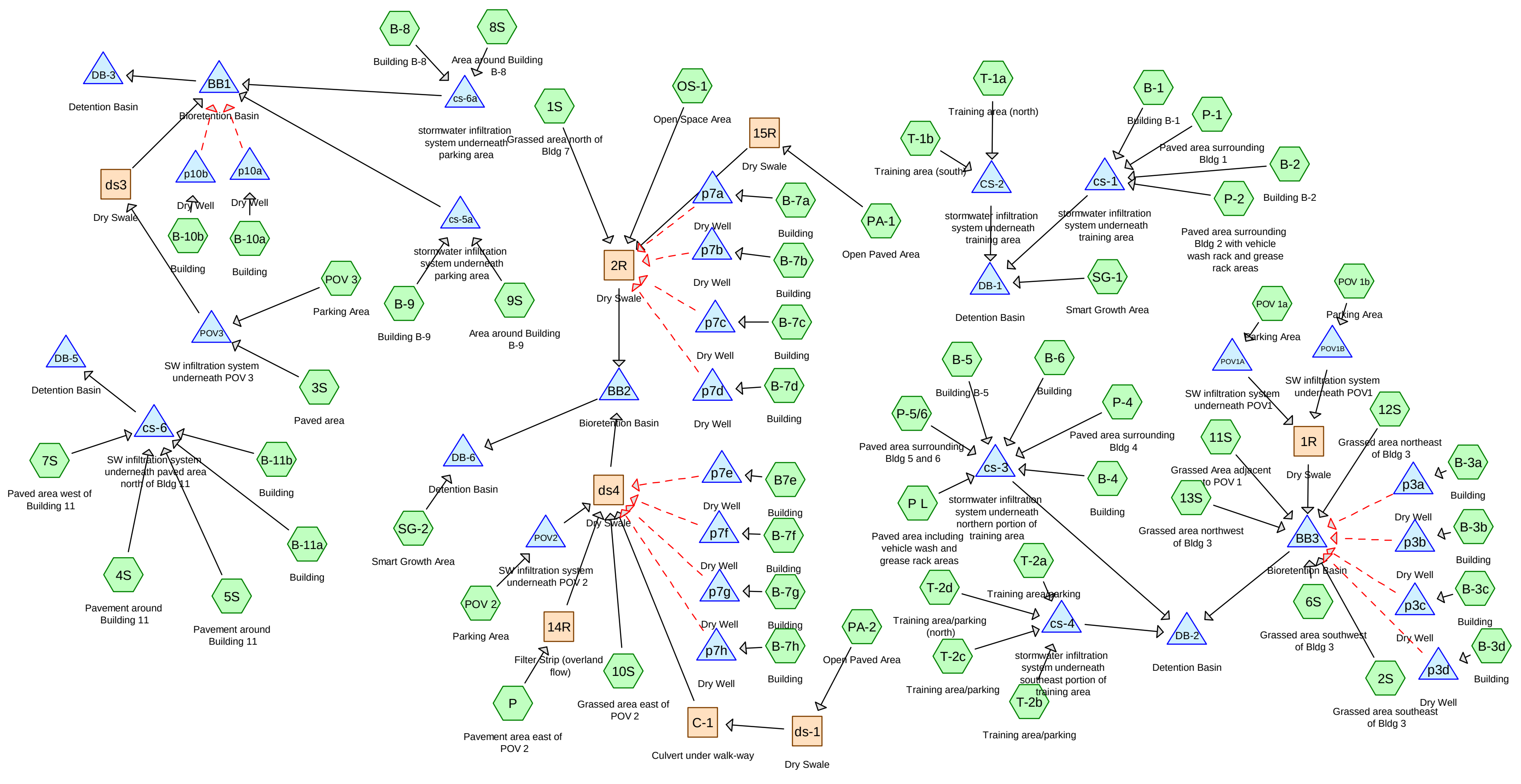
Device	Routing	Invert	Outlet Devices
#1	Primary	343.20'	**18.0" x 420.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 342.70' S= 0.0012 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Discarded	0.00'	**5.000 in/hr Exfiltration over Surface area**

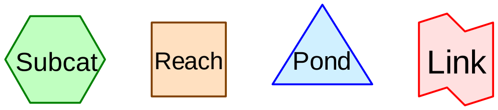
Discarded OutFlow Max=0.14 cfs @ 7.23 hrs HW=341.20' (Free Discharge)
↰**2=Exfiltration** (Exfiltration Controls 0.14 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=340.70' (Free Discharge)
↰**1=Culvert** (Controls 0.00 cfs)

Pond 1P: SW infiltration system underneath POV 1 parking area







Drainage Diagram for Sub Basin BB final

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Pond BB2: Bioretention Basin

Inflow Area = 3.067 ac, Inflow Depth = 0.53" for 95 % event
Inflow = 0.70 cfs @ 7.91 hrs, Volume= 0.135 af
Outflow = 0.19 cfs @ 8.97 hrs, Volume= 0.135 af, Atten= 73%, Lag= 63.5 min
Discarded = 0.19 cfs @ 8.97 hrs, Volume= 0.135 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 456.98' @ 8.97 hrs Surf.Area= 2,728 sf Storage= 1,184 cf

Plug-Flow detention time= 43.1 min calculated for 0.135 af (100% of inflow)
Center-of-Mass det. time= 43.1 min (691.4 - 648.3)

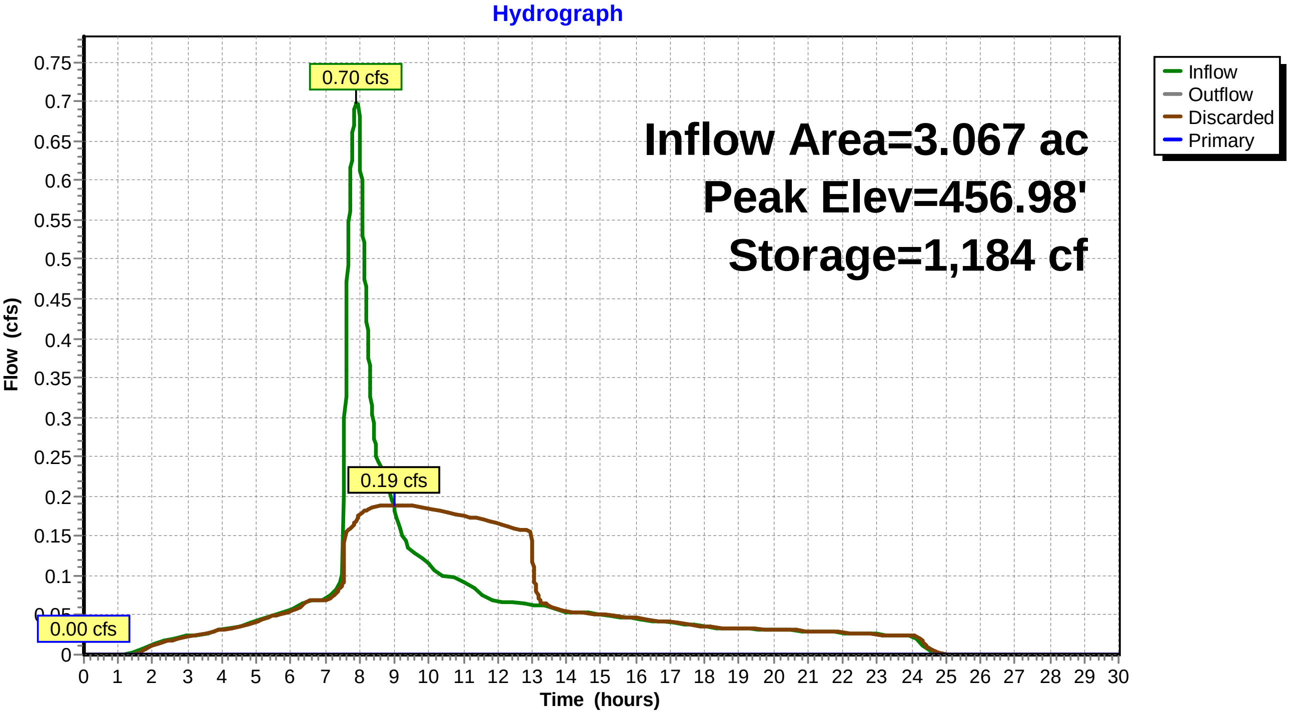
Volume	Invert	Avail.Storage	Storage Description
#1	456.50'	9,181 cf	**20.00'W x 110.00'L x 2.50'H Prismatoid Z=4.1**

Device	Routing	Invert	Outlet Devices
#1	Primary	455.50'	**12.0" x 220.0' long Culvert Barrel** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 454.00' S= 0.0068 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean
#2	Device 1	457.00'	**24.0" Horiz. Top of Riser** Limited to weir flow C= 0.600
#3	Primary	458.00'	**6.0' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#4	Discarded	0.00'	**3.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.19 cfs @ 8.97 hrs HW=456.98' (Free Discharge)
↑—**4=Exfiltration** (Exfiltration Controls 0.19 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=456.50' (Free Discharge)
↑—**1=Culvert Barrel** (Passes 0.00 cfs of 2.11 cfs potential flow)
  ↑—**2=Top of Riser** (Controls 0.00 cfs)
└—**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond BB2: Bioretention Basin



Pond cs-3: stormwater infiltration system underneath southeast portion of training area

```
Inflow Area =       4.359 ac,  Inflow Depth =   1.97"    for  95 % event
Inflow      =       2.18 cfs @    7.98 hrs,  Volume=          0.717 af
Outflow     =       0.48 cfs @    6.13 hrs,  Volume=          0.692 af,  Atten= 78%,  Lag= 0.0 min
Discarded  =        0.48 cfs @    6.13 hrs,  Volume=          0.692 af
Primary     =       0.00 cfs @    0.00 hrs,  Volume=          0.000 af

Routing by Stor-Ind method, Time Span= 0.00-26.00 hrs, dt= 0.01 hrs
Peak Elev= 458.17' @ 11.02 hrs   Surf.Area= 3,723 sf   Storage= 6,897 cf

Plug-Flow detention time= 154.3 min calculated for 0.692 af (97% of inflow)
Center-of-Mass det. time= 129.2 min ( 812.2 - 683.1 )

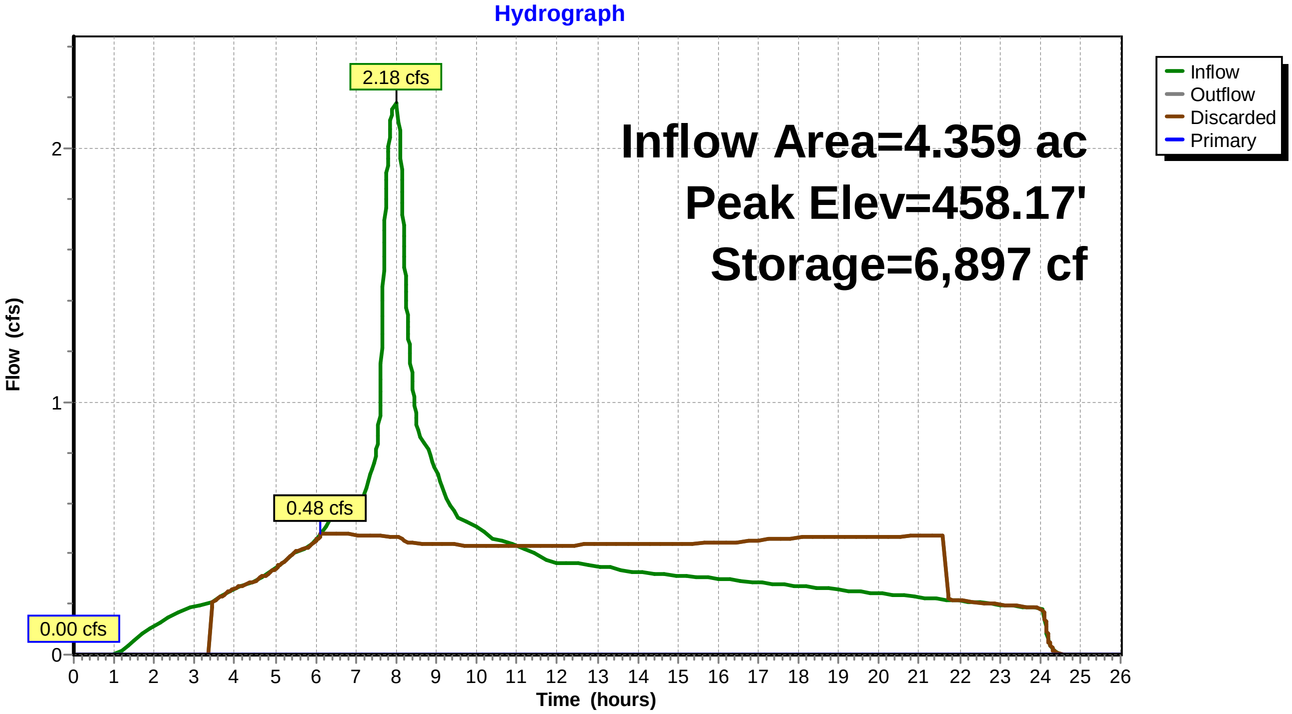
Volume        Invert     Avail.Storage   Storage Description
    #1       457.20'          7,684 cf   47.8"W x 30.0"H x 6.25'L Cultec R-330  x 165
    #2       456.70'          7,504 cf   54.63'W x 97.00'L x 3.54'H Excavation w/stone backfill -Impervious
                                         18,759 cf Overall  x 40.0% Voids
                             15,187 cf   Total Available Storage

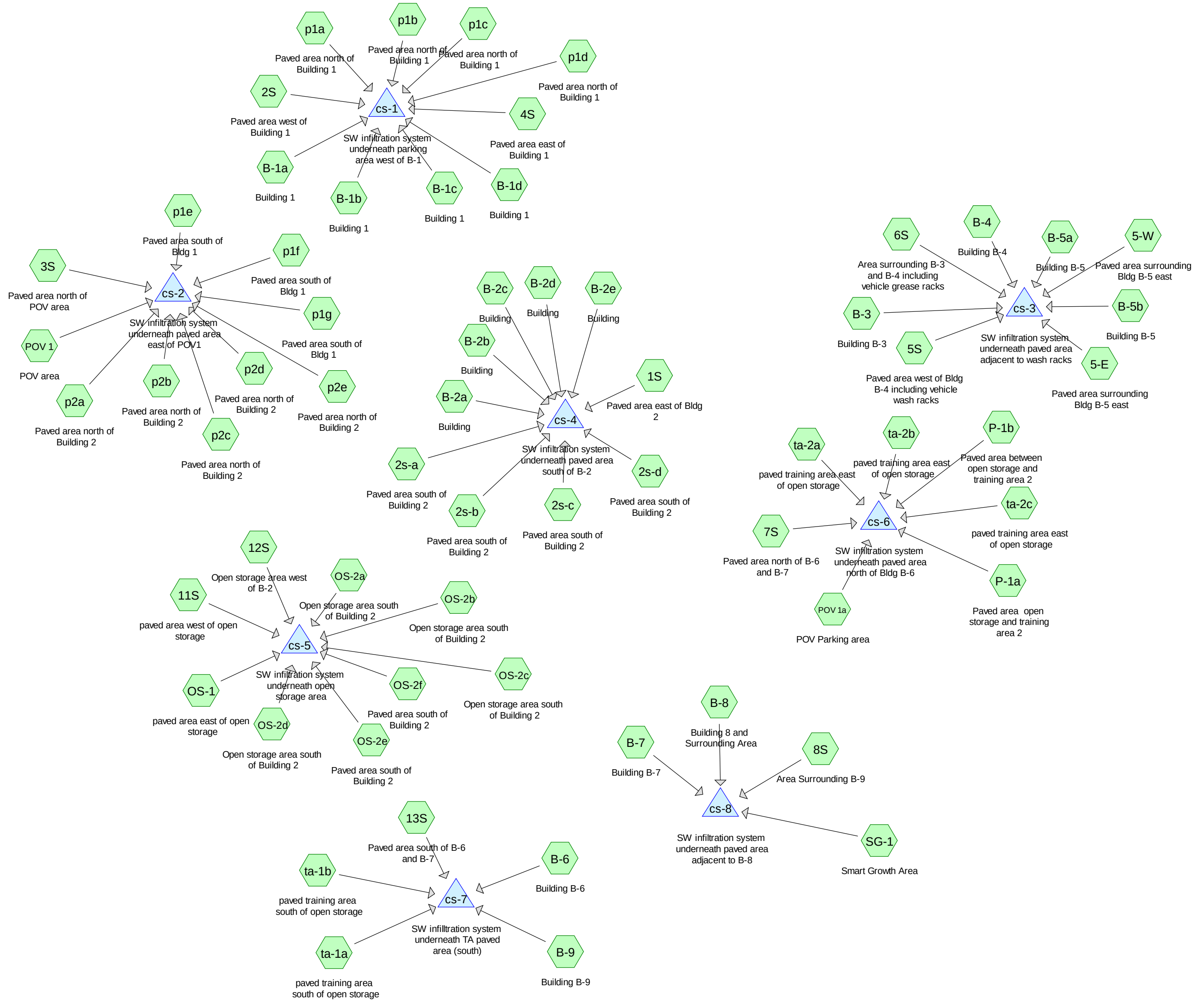
Device   Routing            Invert   Outlet Devices
   #1    Primary           459.70'   18.0"  x 150.0' long Culvert   CMP, projecting, no headwall,  Ke= 0.900
                                     Outlet Invert= 458.70'   S= 0.0067 '/'   Cc= 0.900
                                     n= 0.010  PVC, smooth interior
   #2    Discarded           0.00'   5.000 in/hr Exfiltration over Surface area

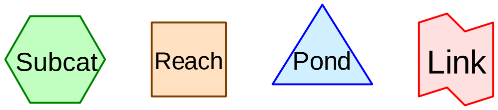
Discarded OutFlow  Max=0.48 cfs @ 6.13 hrs  HW=457.20'   (Free Discharge)
└─2=Exfiltration  (Exfiltration Controls 0.48 cfs)

Primary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=456.70'   (Free Discharge)
└─1=Culvert  ( Controls 0.00 cfs)
```

Pond cs-3: stormwater infiltration system underneath southeast portion of training area







Drainage Diagram for Sub Basin U final

Prepared by {enter your company name here} 4/26/2010

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Pond cs-6: SW infiltration system underneath paved area north of Bldg B-6

```
Inflow Area =      6.848 ac,  Inflow Depth =   1.97"    for  95 % event
Inflow      =      3.32 cfs @    7.92 hrs,  Volume=          1.126 af
Outflow     =      0.78 cfs @    6.14 hrs,  Volume=          1.090 af,  Atten= 77%,  Lag= 0.0 min
Discarded   =      0.78 cfs @    6.14 hrs,  Volume=          1.090 af
Primary     =      0.00 cfs @    0.00 hrs,  Volume=          0.000 af

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.02 hrs
Peak Elev= 445.10' @ 10.43 hrs   Surf.Area= 6,123 sf   Storage= 10,218 cf

Plug-Flow detention time= 134.7 min calculated for 1.089 af (97% of inflow)
Center-of-Mass det. time= 110.7 min ( 789.5 - 678.8 )

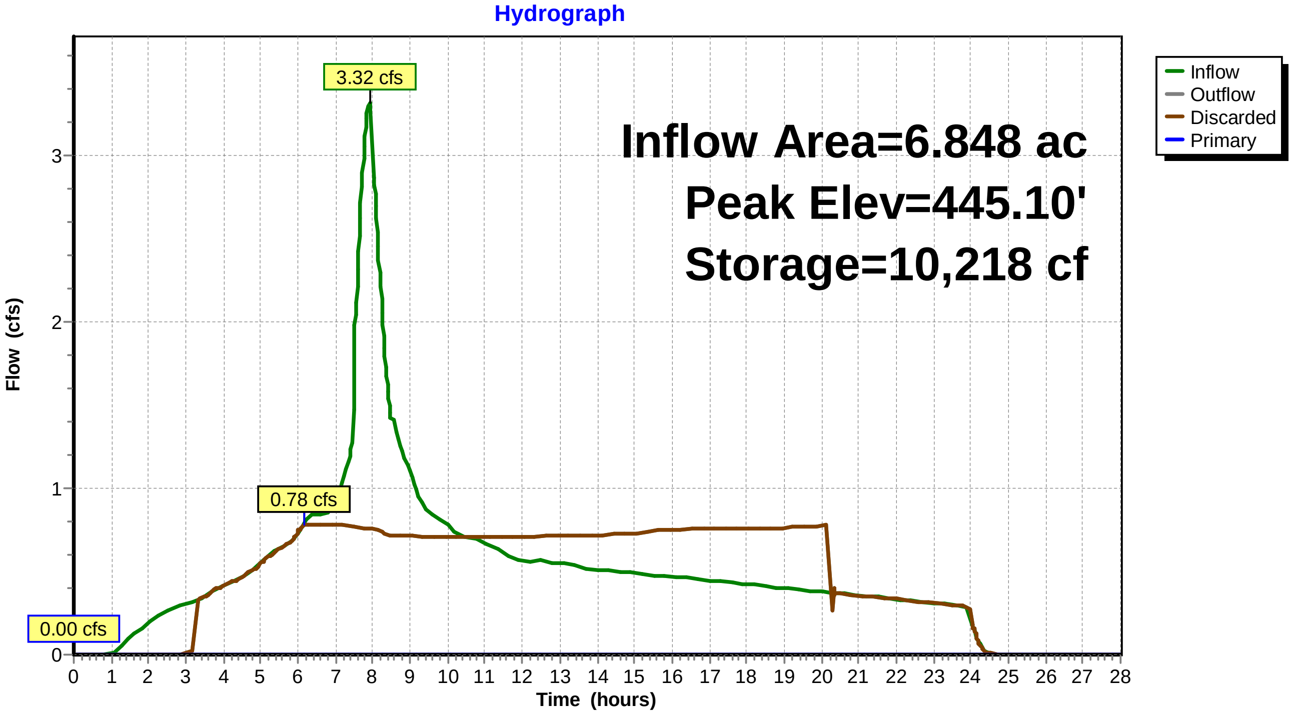
Volume      Invert    Avail.Storage   Storage Description
    #1     444.20'        12,574 cf   47.8"W x 30.0"H x 6.25'L Cultec R-330  x 270
    #2     443.70'        11,252 cf   49.80'W x 159.56'L x 3.54'H Excavation w/stone backfill -Impervious
                                      28,129 cf Overall  x 40.0% Voids
                          23,825 cf   Total Available Storage

Device   Routing        Invert   Outlet Devices
    #1   Primary       446.70'   18.0"  x 60.0' long Culvert   CMP, projecting, no headwall,  Ke= 0.900
                                 Outlet Invert= 445.70'   S= 0.0167 '/'   Cc= 0.900
                                 n= 0.010  PVC, smooth interior
    #2   Discarded       0.00'   5.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.78 cfs @ 6.14 hrs  HW=444.20'   (Free Discharge)
  └─2=Exfiltration  (Exfiltration Controls 0.78 cfs)

Primary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=443.70'   (Free Discharge)
  └─1=Culvert  ( Controls 0.00 cfs)
```

Pond cs-6: SW infiltration system underneath paved area north of Bldg B-6



AECOM

GUAM JOINT MILITARY MASTER PLAN

SUSTAINABILITY PROGRAM SUMMARY REPORT

June 18, 2010

JOINT GUAM PROGRAM OFFICE

DEPARTMENT OF THE NAVY UNITED STATES MARINE CORPS

NAVFAC

Information included in this document is meant for master planning purposes only. All modeling results provided are intended for guidance on possible strategies towards meeting or exceeding the Federal Mandates and are not intended to be building specific guides.

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Guam Joint Military Master Plan Sustainability Program

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Ecosystem Services
Low Carbon Development

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Glossary

APA	American Planning Association
ASHRAE	The American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAU	Business as Usual
BEQ/BOQ	Bachelor Enlisted Quarters/Bachelor Officer Quarters
CBECS	Commercial Building Energy Consumption Survey
CHP	Combined Heat and Power
CSA	Community Supported Agriculture
DEIS	Draft Environmental Impact Statement
DoD	Department of Defense
DoN	Department of Navy
ECMs	Energy Conservation Measures
EIS/OEIS	Environmental Impact Statement/Oversea Environmental Impact Statement
EISA 2007	The Energy Independence and Security Act of 2007
EO	Executive Order
EPA	Environmental Protection Agency
EPACT 2005	The Energy Policy Act of 2005
FAA	Federal Aviation Administration
GHG	Greenhouse Gas Emissions
GJMMP	Guam Joint Military Master Plan
GovGuam	Government of Guam
HQ	Headquarters
HVAC	Heating, Ventilating, and Air Conditioning
IAP	Installation Appearance Plan
IECC 2009	International Energy Conservation Code 2009
JGPO	Joint Guam Program Office
LEED	Leadership in Energy and Environmental Design
LEED NC	Leadership in Engineering and Environmental Design New Construction
LEED ND	Leadership in Engineering and Environmental Design Neighborhood Development
LID	Low Impact Development
MARFORPAC	Marine Corps Forces Pacific
MCBH	Marine Corps Base Hawaii
HQMC	U.S. Marine Corps Headquarters
MEP	Mechanical, Electrical, and Plumbing
MOU	Memorandum of Understanding
NAVFACMAR	Naval Facilities Engineering Command Marinas
NAVFACPAC	Naval Facilities Engineering Command Pacific

NAVWPNSTA	Naval Weapons Station
NCTS	U.S. Naval Computer and Telecommunications Station
NEV	Neighborhood Electric Vehicle
NPV	Net Present Value
O&M	Operations & Maintenance
BIPV	Building Integrated Photovoltaics
PV	Photovoltaics
QOL	Quality of Life
ROM	Rough Order of Magnitude
SPE	Special Purpose Entity
SSIM	Sustainable Systems Integration Model
SSIMe	Sustainable Systems Integration Model Energy
SSIMw	Sustainable Systems Integration Model Water
STHW	Solar Thermal Hot Water
TDM	Transportation Demand Management
UFC	Unified Facilities Criteria
ULI	Urban Land Institute
VMT	Vehicle Miles Traveled
WCMS	Water Conservation Measures

Executive Summary

Guam Joint Military Master Plan (GJMMP) Sustainability Program

Based on two **Smart Growth workshops**, the GJMMP Sustainable Systems Integration Model^{TM} (SSIM^{TM}) Pilot Study provided the basis for reviewing sustainable performance targets/benchmarks and potential costs. It also served as the start of the GJMMP Sustainability Program.

The Sustainability Program builds on the master planning effort underway and includes **five primary tasks**:

1) Identify Unified Facilities Criteria (UFC) that adversely impact sustainable efforts and propose alternative criteria

2) SSIM^{TM} Whole Systems Modelling

3) Integration of Leadership in Energy and Environmental Design (LEED) New Construction (NC)

4) Integration of sustainability into the master plan
5) Initial direction with regard to implementation and Monitoring

The **foundations** of the Sustainability Program are the federal mandates and targets related to energy, water, transportation, green building/LEED and greenhouse gas (GHG) emissions.

Based on the foundations, the goal of the GJMMP Sustainability Program is to seek to define a program that delivers the highest level of environmental improvement to meet the federal mandates at the lowest cost.

Overall Sustainability Program

The Sustainability Program meets the federal mandates and targets of: **LEED Silver certification, 30 percent energy reduction, 26 percent potable water reduction, 30 percent reduction of petroleum in fleet non-combat vehicles, 7.5 percent of total energy from renewable sources and a 34 percent reduction in GHG emissions**. The federal mandates and targets are met with an additional capital investment of approximately 6 percent over the reference standard.

Based on feedback from the stakeholders and focus groups, the sustainability team developed six programs (three programs for the entire site and three programs not including the family housing area) for achieving Least Capital Costs (First Costs); Quickest Payback; and Highest Lifecycle Cost Savings. Program “E” was selected by MARFORPAC and HQMC as detailed in Table A on the following page.

Sustainable Systems

Primary system: water, energy (building, district, renewable and public realm), green building/LEED, transportation, and ecosystem services were optimized to achieve the maximum environmental benefit for the least cost. Following is a summary of the selected Program E (Quickest Payback):

- The **whole systems water balance program** utilizes low flow fixtures, rainwater capture, and Low Impact Development (LID) integration to achieve a minimum of 26 percent potable water reduction for an additional initial capital cost of approximately $55M.

- The **building energy system** reduces energy demand over 40 percent by optimizing energy conservation measures including insulation, fenestration (windows), lighting systems, high efficiency HVAC systems and building integrated photovoltaics (PV). **Public realm lighting systems** incorporating light-emitting diode (LED) technology have also been identified for use.
- The **green building/LEED** program uses a LEED scenario generator to estimate the most cost effective way to achieve LEED Silver certification for 14 representative building types. In summary, LEED Silver certification for non-residential buildings is anticipated to be achieved at an average of 4.5 percent over conventional building construction cost (reference standard).
- The **transportation program** meets the agency wide target of 30 percent reduction of petroleum in fleet vehicles and reduces vehicle miles travelled by approximately 8.3 percent.
- The **ecosystem services** program calculates **carbon sequestration** for the base for a reduction of 1.5 percent of total GHG reduction and incorporates a local food component.

Conservation measures, technologies and integrated systems have been identified for incorporation into the Guam master planning process with regard to land use, site design and vertical/horizontal construction. See the Technical Appendix of this document for more detailed information.

Implementation

To ensure the proposed 14+ million square feet of new construction meets LEED Silver certification and the federal mandates, a thoughtful, well crafted implementation program will need to be developed and refined. Although an implementation program is not part of the Sustainability Program's current scope effort, a workshop on implementation discussed the following as part of the implementation program: **Sustainability Program Action Tracker Spreadsheet, Standard Sustainability performance requirements and language for DD1391 forms, Standard Sustainable Specifications, Common Components for Sustainability, LEED Database, Sustainable/LEED Implementation Team, Advanced Metering, Monitoring and Reporting, and Construction Waste recycling**.

Next Steps

MARFORPAC and HQMC carefully reviewed the overall programs (Programs A-F). After briefs May 6, 2010 in Honolulu and May 26, 2010 in Washington, DC, the Marines selected Program E (Quickest Payback without the SPE) for the GJMMP Sustainability Program. Section 2, Overall Sustainability Program, of this document describes Program E in detail. As follow up to the program selection, NAVFACPAC's next steps will execute implementation of the sustainability program to ensure federal mandates are met.

		Total Cost	Additional Costs	Life Cycle Costs	
Program:	**Entire Site (Including Family Housing)**	**Total Investment (Achieving All Mandates + Targets)[1]**	**Additional Investment (Over Baseline)[2]**	**Total O&M Savings (NPV) Over 42 Years[3]**	**Discounted Payback (Yrs)[4]**
A	Least Capital Cost	$9,237M	$107M (+1.2%)	$263M	28.8 Yrs
B	Quickest Payback	$9,267M	$137M (+1.5%)	$400M	25.2 Yrs
C	Highest Life Cycle Cost Savings	$9,351M	$221M (+2.4%)	$434M	25.8 Yrs

Program:	Entire Site (Excluding Family Housing)[5]	Non SPE Investment by (Achieving All Mandates)[1]	Additional Investment (Over Baseline)[2]	Total O&M Savings (NPV) Over 42 Years[3]	Discounted Payback (Yrs)[4]
D	Least Capital Cost	$7,639M	$107M (+1.4%)	$373M	23.6 Yrs
E	Quickest Payback	$7,651M	$119M (+1.6%)	$469M	21.5 Yrs
F	Highest Life Cycle Cost Savings	$7,749M	$217M (+2.9%)	$497M	23.0 Yrs

TABLE A: Overall Sustainability Program Cost/Benefit Results

[1] This is the Total Cost including all mandates = Standard Cost + Additional Mandate Costs (including GHG target)

[2] Baseline is defined as meeting federal facility mandates, but not overall installation mandates such as GHG and Renewable Energy Targets

[3] Federal Mandate EISA (Energy Independence Security Act) requires 42 year life cycle analysis (Costs are relative to Base Investment as Standard Costs)

[4] Discount rate 2.7% as defined by OMB criteria, Energy Costs Escalation rate at 3.4%, Maintenance Costs escalation at 2.0%

[5] All costs and benefits from SPE (Family Housing) are excluded

1. Introduction

Pilot Study: Guam Joint Military Master Plan (GJMMP) Smart Growth Planning Charrettes

On January 26-28, 2009 and June 18-19, 2009 in Guam, two Smart Growth Planning Charrettes/ Workshops were held with the Joint Guam Program Office (JGPO), NAVFACPAC, Naval Facilities Engineering Command Marianas (NAVFACMAR), MARFORPAC, Government of Guam (GovGuam), the Environmental Protection Agency (EPA), consultants, and key stakeholders to address sustainability for the proposed Guam base in North Finegayan. As a result of two workshops, the Guam Joint Military Master Plan (GJMMP) SSIM™ Pilot Study was developed and presented. This high level sustainability study provided the basis for reviewing performance targets/ benchmarks and potential costs. It also served as the start of the GJMMP Sustainability Program.

Guam JMMP Sustainability Program

The pilot study served as the basis to develop a more comprehensive, in-depth Sustainability Program for the GJMMP. The Sustainability Program scope of work builds on the master planning effort underway and includes five main tasks:

1. Identify Unified Facilities Criteria (UFC) that adversely impact sustainable efforts and propose alternative criteria to mitigate the impacts
2. Sustainable Systems Integration Modelling (SSIM™)
3. Integration of LEED NC and LEED Neighborhood Development (ND) (if applicable) in the master plan
4. Integration of sustainability into the master plan including the Low Impact Development (LID) guidelines completed by others
5. Initial direction with regard to Implementation and Monitoring (Note: The Sustainability Program current scope of work does not include a full Implementation and Monitoring component.)

One of the objectives of the GJMMP Sustainability Program is to position the master plan to not only achieve LEED Silver under the federal mandates but consider going beyond LEED as a well informed, financially attuned leader in sustainable base development for the 21st century.

Smart Growth Workshop, Guam 2009

Foundation

The goal setting process and the formation of guiding principles reflect the understanding and determination of compliance with various federal mandates, Department of Defense (DoD), and Department of Navy's (DoN) targets and commitments to building a highly energy efficient and environmentally sustainable base. The following federal mandates and regulations, DoD, and DoN targets are the foundation of this Sustainability Program:

- The Energy Independence and Security Act of 2007 (EISA 2007)
- The Energy Policy Act of 2005 (EPACT 2005)
- Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance"
- Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management"
- The Federal Leadership in High Performance and Sustainable Building Memorandum of Understanding (MOU) 2006
- Greenhouse Gas Targets Announcement for DoD, January 29, 2010
- Energy Awareness Message from Secretary of the Navy Ray Mabus, October 30, 2009
- NAVFAC Engineering and Construction Bulletins 2008-1 and 2009-2 (LEED Silver Requirement)

Guam Existing Landscape

Guam Existing Landscape

Federal Register

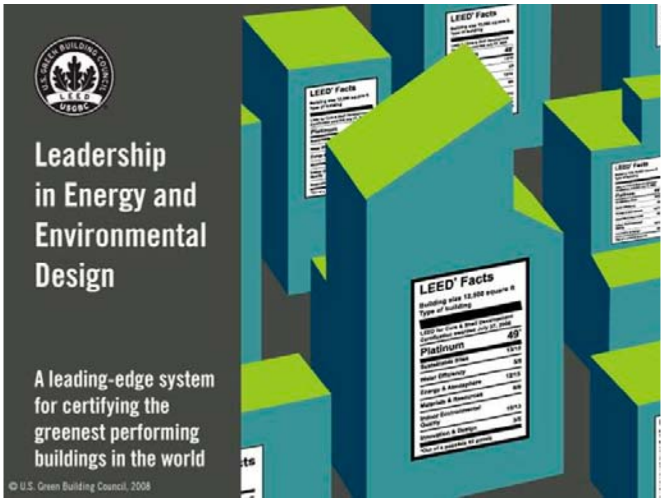
Thursday,
October 8, 2009

Part VII

The President

Executive Order 13514—Federal Leadership in Environmental, Energy, and Economic Performance

EO 13514, Oct. 2009



LEED Rating System

Goals, Objectives & Methodology

Goals & Objectives

The purpose of the GJMMP Sustainability Program is to develop and define a program that delivers the highest level of environmental improvement to meet all applicable federal mandates at the lowest possible cost.

The following goals were established for the GJMMP Sustainability Program based on the Federal Leadership in High Performance and Sustainable Building Memorandum of Understanding (MOU):

- Reduce the total ownership cost of facilities
- Improve energy efficiency and water conservation
- Provide safe, healthy, and productive built environments
- Promote sustainable environmental stewardship

Guiding Principles

The following Guiding Principles were adopted for the GJMMP Sustainability Program as seen in the MOU:

I. Employ Integrated Design Principles

II. Optimize Energy Performance

III. Protect and Conserve Water

IV. Enhance Indoor Environmental Quality

V. Reduce Environmental Impact of Materials

Methodology

Sustainable solutions for the GJMMP are merged from both the “vertical and horizontal construction” through a combination of green building and planning. The components include vertical design and construction elements such as building form, solar orientation, construction technology, and building energy efficiency. Equally important are the horizontal planning and site works elements such as sustainable mobility, ecosystem services, and whole systems water balance planning. These core systems are built from the ground up in terms of components and assumptions. This integrated systems methodology also incorporates a cost/benefit approach resulting in a set of sustainability measures that lead to the highest reductions in energy use and GHG emissions at the lowest incremental cost. A modelling approach incorporating this methodology was developed by AECOM, known as SSIM^{TM} or Sustainable Systems Integration Model^{TM}.

This three-stage process includes: 1) Master Plan Sustainability Integration; 2) Core Systems Strategy Development; and 3) Master Sustainability Program Synthesis. The process utilizes the latest modelling and cost/benefit analysis techniques, and is designed to construct a sound, defendable and affordable whole systems sustainability strategy to inform the GJMMP Sustainability Program.

Sustainability Program Workshop, Honolulu, 2010

Process

Stage One – Master Plan Sustainability Integration

Identify sustainability components within the GJMMP which include the following items:

- Passive solar orientation
- Green infrastructure system of open space, trails, recreation (see trails plan in Technical Appendix)
- Low Impact Development—allocation of land for on-site bio-swales, rain gardens, stormwater retention, etc.
- Water balance planning for dual use facilities such as stormwater retention and recreation
- Shared parking analysis where feasible
- On-site transportation systems such as a shuttle program, shared bike program, and car share program
- Compact, mixed use centers to reduce vehicle trips and VMT (Vehicle Miles Travelled)
- Walkable neighborhoods with access to parks, open space, services, and schools
- Areas identified for producing renewable energy systems
- Ecological systems such as carbon sequestration, habitat friendly guidelines and local food production

Stage Two – Core Systems Strategy Development

Sub-models are developed for each core theme or system including:

- Transportation
- Energy (including Building, Renewable, and Public Realm Energy)
- Water (including domestic, rooftop and condensate harvesting, recycled, and stormwater)
- Green Building/LEED
- Ecological systems

For each of the core system models, sustainability measures/strategies were developed that achieve four levels of increasing resource efficiency/performance while tracking capital and operational and maintenance costs required at each level.

The “Baseline” performance level was modeled to meet the existing federal mandates as applicable to the core system. In the case were no specific mandate was applicable (such as for Ecosystem Services), “Baseline” was modeled as the current typical business practice within the Navy. Packages A, B and C were modeled at increasing levels of performance efficiency for each core system.

Costs are estimated for each package of measures on both a first-cost and life-cycle cost basis. The team utilizes Guam resources from NAVFACMAR and a local Guam cost estimator/contractor to establish costs. These figures are compared to the percentage improvement of each package and a cost/benefit ratio is ascertained. This cost benefit ratio informs the team as to which packages achieve the highest reduction in resource use or GHG emissions at the lowest incremental cost.

Gaming of the components within each of the systems is completed for each package. The gaming occurs in a workshop setting, optimizing the systems to see the real-time cost/benefit results as well as the integration of the various systems.

As a parallel process, numerous focus group meetings, workshops, calls, and webinars have been conducted to guide the Sustainability Program team on package selection and program building (See Technical Appendix: Webinar Briefs 1-7). Focus groups are comprised of individuals from NAVFACPAC, NAVFACMAR, MARFORPAC, HQMC, and JGPO. Other stakeholders such as GovGuam and the EPA have been briefed on the sustainability process by NAVFACPAC.

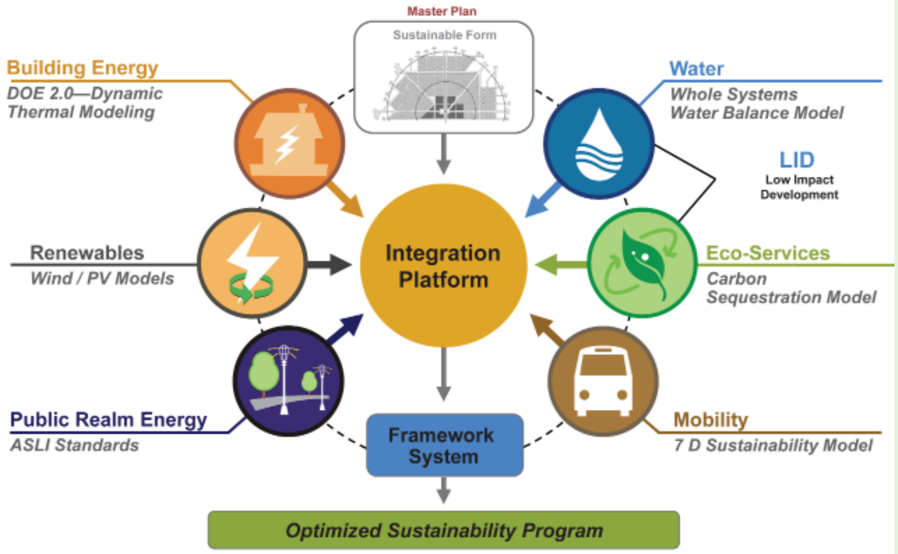


FIGURE 1-1: Core Systems Framework Diagram

Sustainability Strategy Terms

- **Option** refers to a set of sustainability measures/ particular performance target proposed for a *facility type*.
- **Package** consists of options that are chosen and gamed to represent particular *sub-model* performance for *the whole base*.
- **Program** is a set of synthesized and integrated specific packages from each of the separate sub-models for *whole system* sustainability of *the base*

Stage Three – Master Sustainability Program Synthesis

The individual core themes (i.e. water, energy, transportation, etc.) are combined into a set of comprehensive, all-systems master programs in this stage. Further gaming of core theme package combinations then becomes a master program. On March 23-25, 2010, a three-day long Sustainability Program synthesis workshop was held in Honolulu with participants from key stakeholder groups and core theme focus groups. The following three master programs with three different synthesis goals were defined in the workshop as follows:

Entire Base:

1. Program A – Least Capital Cost (First Cost)
2. Program B – Quickest Payback
3. Program C – Highest Lifecycle Cost Saving

The three programs have been rendered to remove the Special Purpose Entity (SPE) in order to track cost and performance with and without the Family Housing area.

Entire Base Minus the Special Purpose Entity:

4. Program D – Least Capital Cost (First Cost)
5. Program E – Quickest Payback
6. Program F – Highest Lifecycle Cost Saving

The six master Sustainability Programs are described in more detail in the following section entitled “Overall Sustainability Program”.

Next Steps

MARFORPAC and HQMC carefully reviewed the overall programs (Programs A-F). After briefs May 6, 2010 in Honolulu and May 26, 2010 in Washington, DC, the Marines selected Program E (Quickest Payback without the SPE) for the GJMMP Sustainability Program. Section 2, Overall Sustainability Program, of this document describes Program E in detail. As follow up to the program selection, NAVFACPAC’s next steps will execute implementation of the sustainability program to ensure federal mandates are met.

Smart Growth Workshop, Guam 2009

2. Overall Sustainability Program

Introduction

The GJMMP documents the Department of Defense planning efforts for the relocation of Marine Corps personnel and dependents from Okinawa to Guam. In November 2009, the Draft Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) was prepared to assess the potential environmental effects associated with proposed military activities. The preferred alternative would require a total of 2,580 ac for the Main Cantonment and family housing areas. The Main Cantonment would include portions of Naval Computer and Telecommunications Station (NCTS) Finegayan (1,610 ac), portions of South Finegayan (290 ac), and the Former FAA parcel (680 ac). The site is also bounded on the north by Andersen AFB NWF, and by Route 3; on the west by a cliff line and the Philippine Sea. To the east the site is bounded by limited residential development and to the south by the Harmon Village residential area.

The Main Cantonment will be the main base of operations for the Marine Corps. Facility requirements for the Main Cantonment Area include a full range of facility types, not unlike a small city: various types of housing, workplaces, recreation areas, education facilities, and health and safety-related functions. The workplace facilities are typical of a military base and include headquarters, maintenance facilities, warehouses, training areas (field and classroom), equipment/vehicle storage, and hazardous materials management and storage areas.

Over 14 million square feet of facilities including approximately 3,500 units of family housing are proposed for the site. These facilities (approximately 1,944 separate structures) are placed in a campus setting that includes nearly 53% of the overall 3,420-acre site as open space. This development program hosts approximately 23,500 residents in addition to 13,500 workers, and forms the basis for the proposed Sustainability Program.

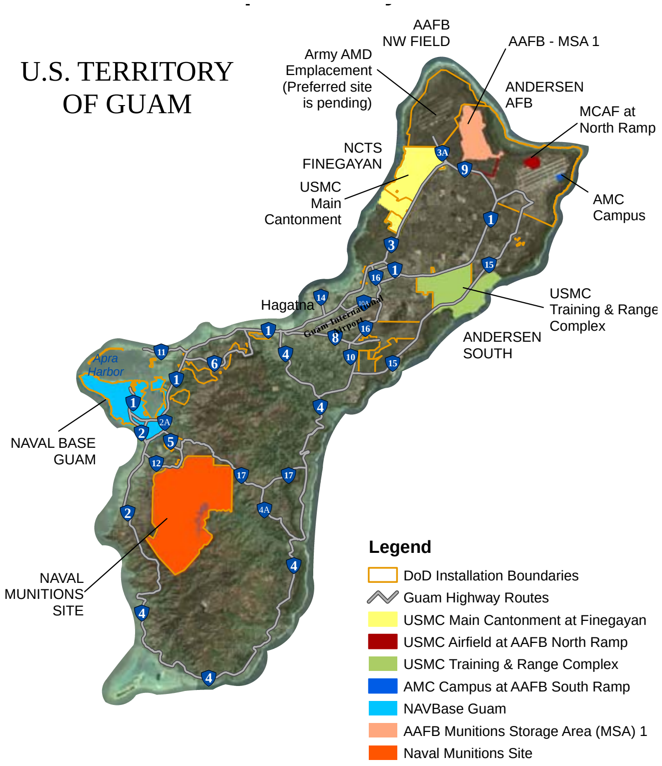


FIGURE 2-1: Installation Location Map

Program Development Goal Setting

Key federal mandates, regulations, and DoD and DoN official targets are used as the definition for sustainability criteria in Guam. Table 2-1 below outlines the specific standards set out for each of the key sustainability subjects, including non-residential building energy, residential building energy, LEED certification achievement, water system, sustainable transportation system, fossil fuel consumption, renewable energy, and overall greenhouse gas emissions.

The GHG emission target is an important DoD target used to guide the development of an integrated Sustainability Program for Guam. In accordance with Executive Order 13514, in January 2010, the DoD established an agency wide GHG 34% reduction of scope 1 and 2 emissions. DoD defined sources of GHG emissions:

- **Scope 1:** GHG emissions from sources that are owned or controlled by a federal agency
- **Scope 2:** GHG emissions resulting from the generation of electricity, heat, or steam purchased by a federal agency
- **Scope 3:** GHG emissions from sources not owned or directly controlled by a federal agency but related to agency activities, such as vendor supply chains, delivery systems, and employee travel and commuting

EO 13514 further requires that each federal agency establish a target for Scope 1 and 2 by January 2010 and an additional Scope 3 targeted by June 2010. It is very likely that the overall target for DoD may increase after June 2010. In the absence of any official specific installation level guidance on GHG targets, the Sustainability team, as discussed with MARFORPAC and NAVFACPAC, recommends that the new base adopt the overall agency target, which is a 34% reduction, in order to be positioned to comply with current DoD targets and with future, potentially more stringent GHG targets.

Guam Joint Federal Mandates/Targets

- **'Reference Standard'** refers to the key performance criteria to measure against as defined by relevant regulation.
- **'Baseline: Federal Mandate'** refers to the performance level to be achieved according to specific mandate, which is the minimum requirement to meet facility related mandates.
- **'Agency/Installation Targets'** are defined by regulations (such as Greenhouse Gas reductions) set at the Agency level. The Guam JMMP needs to assume a target that contributes to the overall agency target.

TABLE 2-1: Federal Standards and Mandates

Subject:	Reference Standard	Baseline: Federal Mandate
Facility Related Mandates		
Non-Residential Energy	ASHRAE 90.1	30% Reduction
Residential Energy	IECC[1]	30% Reduction
LEED ®	LEED NC v. 3.0	Silver
Agency / Installation Wide Mandates		
Water	EPAct / EISA 2007[2]	26% Reduction[3]
Transportation	EO 13514	30% Reduction of Petroleum in Fleet Vehicles[4]
Fossil Fuels	EISA 2007[2]	100% Fossil Fuel Reduction by 2030
Renewable Energy	EPAct / EISA 2007[2]	7.5% of Total Energy (by 2013)
Agency / Installation Wide Targets		
Greenhouse Gas Emissions (Overall Site)	EO 13514/DoD	34% Reduction[5]

[1] IECC: International Energy Conservation Code

[2] EPAct 1992 (active standard in 2007)

[3] (Executive Order 13514) performance based on year 2020. 26% potable water use intensity reduction from 2007

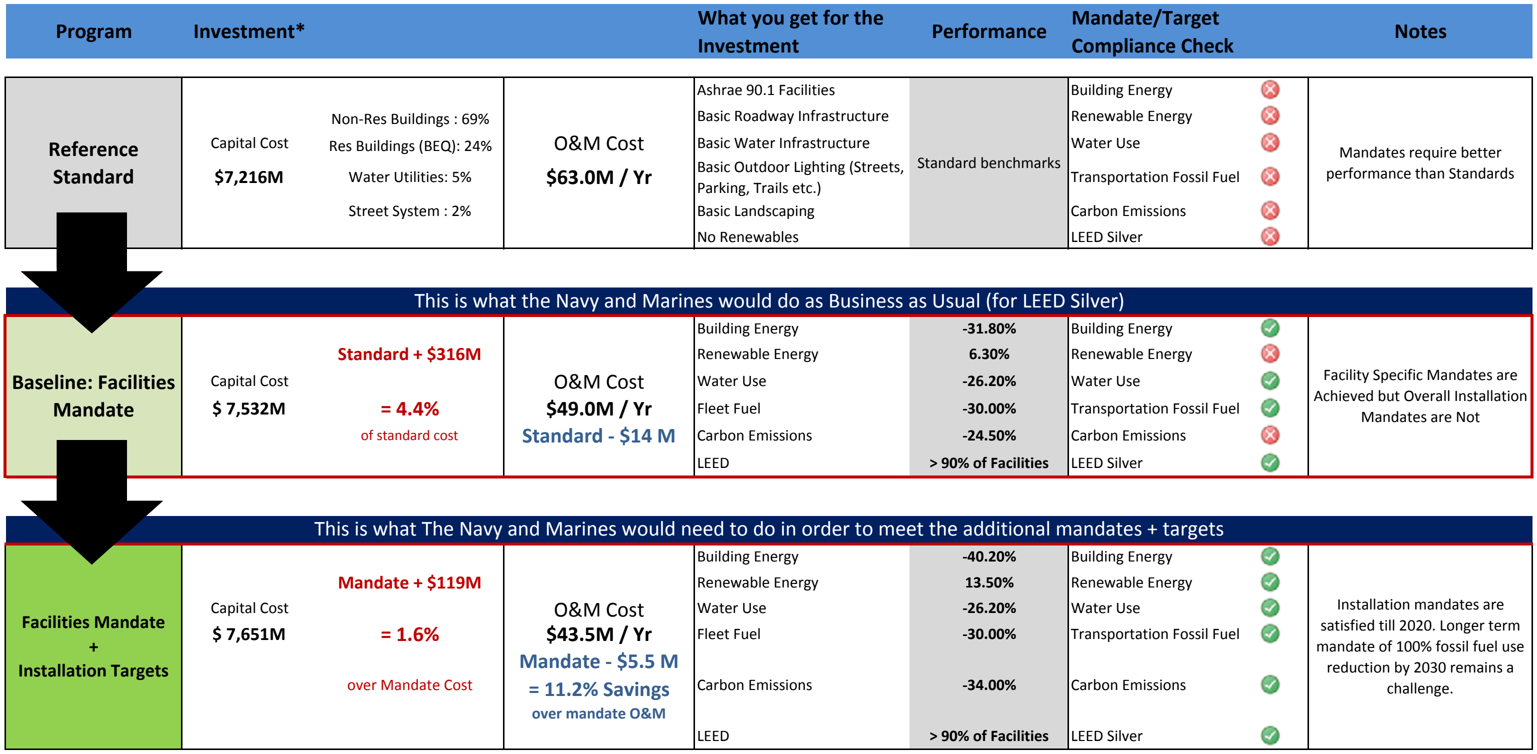
[4] EO 13514: by 2020

[5] EO 13514 and DoD 1/29/10 by 2020

Rationale for Costs and Mandate Compliance

Cost/Benefit workshops occurred with NAVFACPAC and MARFORPAC over a number of workshops and webinars to better understand the incremental capital costs and associated Operation & Maintenance (O&M) savings in various programs for Guam to achieve different levels of performance. As shown in Figure 2-2 below, key findings in this analysis include:

- **Reference Standard Program:** The program at the reference standard meets basic standards for construction in Guam such as ASHRAE 90.1 at an estimated cost of $7.2B.
- **Baseline Facility Level Mandate Program:** The program in which facilities meet federal mandates level is expected to cost approximately 4.4% more in initial capital investment in comparison with the reference standard level. The program meets building energy goals, water use goals, transportation fossil fuel goals and LEED Silver certification requirements. However, it will only meet 6.3% of the required 7.5% renewable energy goal. It will not achieve the GHG emission target of 34%.
- **Facilities Mandate and Installation Targets Program:** The program that addresses both facility level mandates and installation targets is estimated to cost an additional 1.6% over the Facilities Mandate Program, totaling approximately $7.7B. This $119M additional funding is required to meet both the renewable energy goal and the carbon emission target.



Program	Investment*			What you get for the Investment	Performance	Mandate/Target Compliance Check		Notes
Reference Standard	Capital Cost $7,216M	Non-Res Buildings : 69% Res Buildings (BEQ): 24% Water Utilities: 5% Street System : 2%	O&M Cost $63.0M / Yr	Ashrae 90.1 Facilities	Standard benchmarks	Building Energy	✗	Mandates require better performance than Standards
				Basic Roadway Infrastructure		Renewable Energy	✗	
				Basic Water Infrastructure		Water Use	✗	
				Basic Outdoor Lighting (Streets, Parking, Trails etc.)		Transportation Fossil Fuel	✗	
				Basic Landscaping		Carbon Emissions	✗	
				No Renewables		LEED Silver	✗	
This is what the Navy and Marines would do as Business as Usual (for LEED Silver)								
Baseline: Facilities Mandate	Capital Cost $ 7,532M	Standard + $316M = 4.4% of standard cost	O&M Cost $49.0M / Yr Standard - $14 M	Building Energy	-31.80%	Building Energy	✓	Facility Specific Mandates are Achieved but Overall Installation Mandates are Not
				Renewable Energy	6.30%	Renewable Energy	✗	
				Water Use	-26.20%	Water Use	✓	
				Fleet Fuel	-30.00%	Transportation Fossil Fuel	✓	
				Carbon Emissions	-24.50%	Carbon Emissions	✗	
				LEED	> 90% of Facilities	LEED Silver	✓	
This is what The Navy and Marines would need to do in order to meet the additional mandates + targets								
Facilities Mandate + Installation Targets	Capital Cost $ 7,651M	Mandate + $119M = 1.6% over Mandate Cost	O&M Cost $43.5M / Yr Mandate - $5.5 M = 11.2% Savings over mandate O&M	Building Energy	-40.20%	Building Energy	✓	Installation mandates are satisfied till 2020. Longer term mandate of 100% fossil fuel use reduction by 2030 remains a challenge.
				Renewable Energy	13.50%	Renewable Energy	✓	
				Water Use	-26.20%	Water Use	✓	
				Fleet Fuel	-30.00%	Transportation Fossil Fuel	✓	
				Carbon Emissions	-34.00%	Carbon Emissions	✓	
				LEED	> 90% of Facilities	LEED Silver	✓	

* Investment does not include Housing SPE capital costs

FIGURE 2-2: Rationale for Costs and Mandate Compliance (Based on Program E)

Results Summary

The sustainability modelling process summarizes the environmental impact of the development as built to the reference standard as resulting in:

- GHG emissions of nearly 163,710 MTCO$_2$eq/Yr (roughly equivalent to the carbon offset by 32,000 acres of pine forests)
- An electric power demand of 194.4 GWhr/Yr
- A potable water demand of 659.9M gallons/Yr (1.81 MGD)
- Stormwater outflow of 109M gallons/Yr
- Sewer outflow of nearly 527M gallons/Yr
- Vehicle Miles Travelled (VMT) of 73.2M miles/Yr
- Overall fuel consumption of approximately 1.9M gallons of gasoline/Yr

By Applying the Sustainability Program that meets the federal mandates and achieves installation targets, the selected program achieves the following improvements:

- A 34% reduction in GHG emissions or 55,661 MTCO$_2$eq/Yr (equivalent of 10,000 cars driven for a year)
- A reduction in power consumption by at least 30% or nearly 58.3 GWhr/Yr (equivalent of powering 1,400 Guamanian homes for a year)
- A reduction in water use by 26% or 171.5M gallons/Yr (equivalent of 286 Olympic swimming pools/Yr)
- A reduction of nearly 8.3% of VMT or 6M miles of driving per year

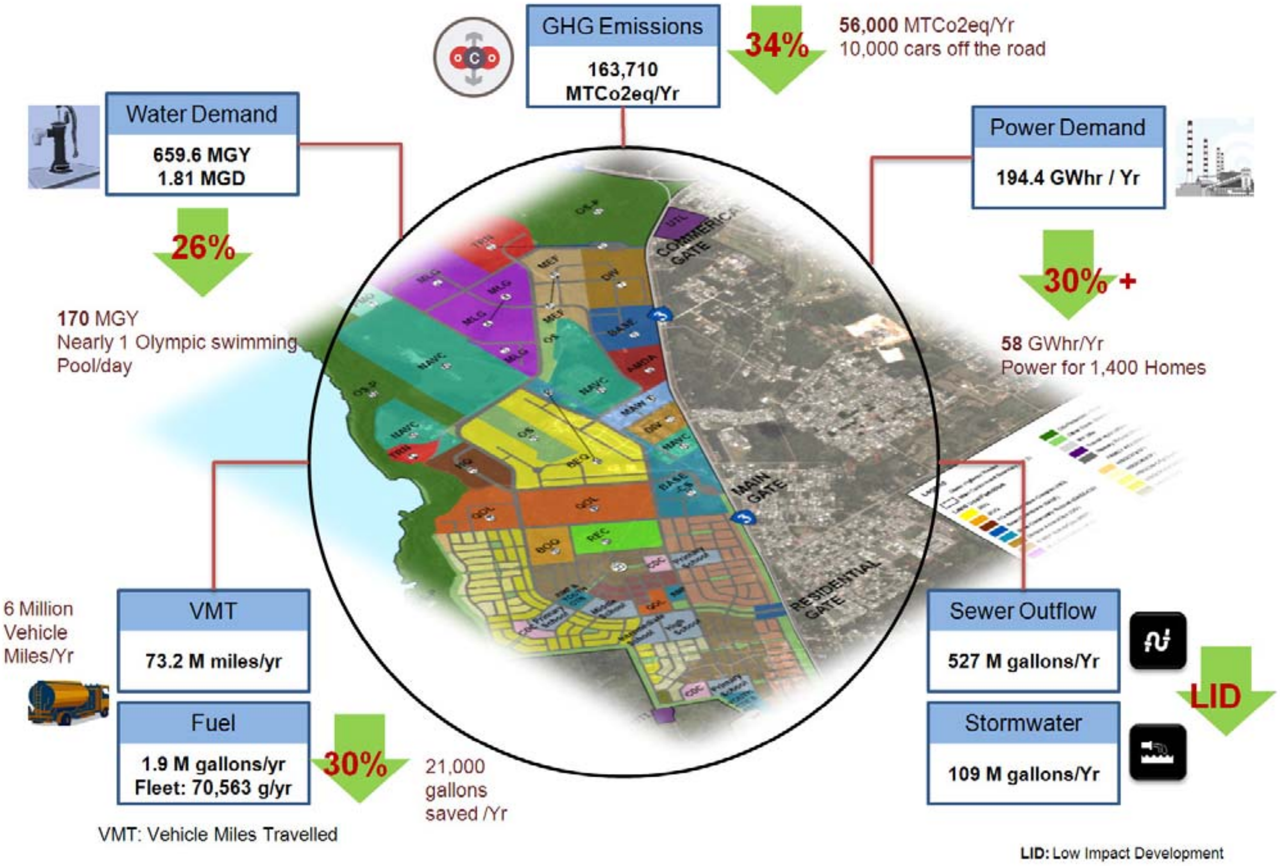


FIGURE 2-3: Performance Benchmark for Meeting Federal Mandates and Installation Target

Program Development Optimization

In the optimization process, two sets of programs are developed to achieve various economic thresholds while meeting the federal mandates at both facility and installation levels. Figure 2-4 shows the gaming process.

The level of control in what will be built and by which standards for family housing (or the Special Purpose Entities (SPE)) is uncertain at this time. Therefore, Program D, E, and F are created excluding the SPE and the associated capital and operating/maintenance cost components. In each set, a specific program is developed to achieve either the lowest initial capital cost, the quickest payback, or the highest life cycle cost savings.

All three programs listed below meet federal mandates at the facility and installation level targets. The key cost/benefit comparisons among the programs are summarized in Table 2-2. (See Technical Appendix for detailed calculation.)

Key findings from this comparison include:

- Program D is optimized with least amount of capital cost - $7,639M to achieve mandates and installation wide target.
- When comparing Program E to D, with an additional capital investment of $12M, Program E yields the quickest payback achieving approximately $96M more in life-cycle cost savings in Net Present Value (NPV) over 42 years.

Program:	Total Cost Benefit Analysis for Entire Site (Including Family Housing)
A	Least Capital Cost (First Costs)
B	Quickest Payback (Years)
C	Highest Life Cycle Cost Savings

Sustainability Program Set 1 (A, B, C)

Program:	Total Cost Benefit Analysis (Excluding Family Housing (SPE))
D	Least Capital Cost (First Costs)
E	Quickest Payback (Years)
F	Highest Life Cycle Cost Savings

Sustainability Program Set 2 (D, E, F)

		Total Cost	Additional Costs	Life Cycle Costs	
Program:	**Entire Site (Including Family Housing)**	**Total Investment (Achieving All Mandates + Targets)[1]**	**Additional Investment (Over Baseline)[2]**	**Total O&M Savings (NPV) Over 42 Years[3]**	**Discounted Payback (Yrs)[4]**
A	Least Capital Cost	$9,237M	$107M (+1.2%)	$263M	28.8 Yrs
B	Quickest Payback	$9,267M	$137M (+1.5%)	$400M	25.2 Yrs
C	Highest Life Cycle Cost Savings	$9,351M	$221M (+2.4%)	$434M	25.8 Yrs
Program:	**Entire Site (Excluding Family Housing)[5]**	**Non SPE Investment by (Achieving All Mandates)[1]**	**Additional Investment (Over Baseline)[2]**	**Total O&M Savings (NPV) Over 42 Years[3]**	**Discounted Payback (Yrs)[4]**
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F	Highest Life Cycle Cost Savings	$7,749M	$217M (+2.9%)	$497M	23.0 Yrs

[1] This is the Total Cost including all mandates = Standard Cost + Additional Mandate Costs (including GHG target)

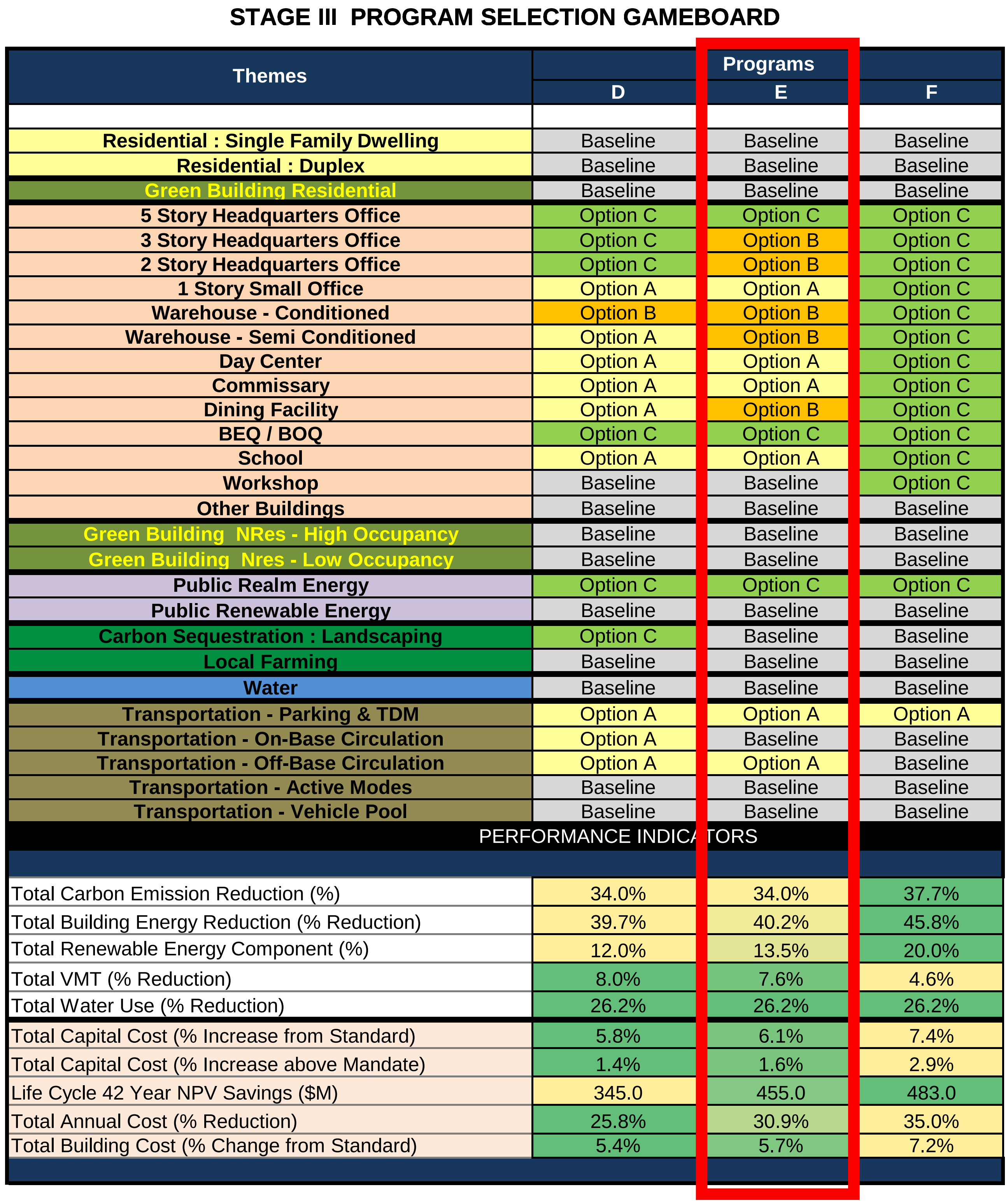
[2] Baseline is defined as meeting federal facility mandates, but not overall installation mandates such as GHG and Renewable Energy Targets

[3] Federal Mandate EISA (Energy Independence Security Act) requires 42 year life cycle analysis (Costs are relative to Base Investment as Standard Costs)

[4] Discount rate 2.7% as defined by OMB criteria, Energy Costs Escalated at 3.4%, Maintenance Costs escalation at 2.0%

[5] All costs and benefits from SPE (Family Housing) are excluded

TABLE 2-2: Program Comparison



STAGE III PROGRAM SELECTION GAMEBOARD

Themes		Programs	
	D	E	F
Residential : Single Family Dwelling	Baseline	Baseline	Baseline
Residential : Duplex	Baseline	Baseline	Baseline
Green Building Residential	Baseline	Baseline	Baseline
5 Story Headquarters Office	Option C	Option C	Option C
3 Story Headquarters Office	Option C	Option B	Option C
2 Story Headquarters Office	Option C	Option B	Option C
1 Story Small Office	Option A	Option A	Option C
Warehouse - Conditioned	Option B	Option B	Option C
Warehouse - Semi Conditioned	Option A	Option B	Option C
Day Center	Option A	Option A	Option C
Commissary	Option A	Option A	Option C
Dining Facility	Option A	Option B	Option C
BEQ / BOQ	Option C	Option C	Option C
School	Option A	Option A	Option C
Workshop	Baseline	Baseline	Option C
Other Buildings	Baseline	Baseline	Baseline
Green Building NRes - High Occupancy	Baseline	Baseline	Baseline
Green Building Nres - Low Occupancy	Baseline	Baseline	Baseline
Public Realm Energy	Option C	Option C	Option C
Public Renewable Energy	Baseline	Baseline	Baseline
Carbon Sequestration : Landscaping	Option C	Baseline	Baseline
Local Farming	Baseline	Baseline	Baseline
Water	Baseline	Baseline	Baseline
Transportation - Parking & TDM	Option A	Option A	Option A
Transportation - On-Base Circulation	Option A	Baseline	Baseline
Transportation - Off-Base Circulation	Option A	Option A	Baseline
Transportation - Active Modes	Baseline	Baseline	Baseline
Transportation - Vehicle Pool	Baseline	Baseline	Baseline
	PERFORMANCE INDICATORS		
Total Carbon Emission Reduction (%)	34.0%	34.0%	37.7%
Total Building Energy Reduction (% Reduction)	39.7%	40.2%	45.8%
Total Renewable Energy Component (%)	12.0%	13.5%	20.0%
Total VMT (% Reduction)	8.0%	7.6%	4.6%
Total Water Use (% Reduction)	26.2%	26.2%	26.2%
Total Capital Cost (% Increase from Standard)	5.8%	6.1%	7.4%
Total Capital Cost (% Increase above Mandate)	1.4%	1.6%	2.9%
Life Cycle 42 Year NPV Savings ($M)	345.0	455.0	483.0
Total Annual Cost (% Reduction)	25.8%	30.9%	35.0%
Total Building Cost (% Change from Standard)	5.4%	5.7%	7.2%

FIGURE 2-4: Screen Capture of Program Optimization Gaming Board

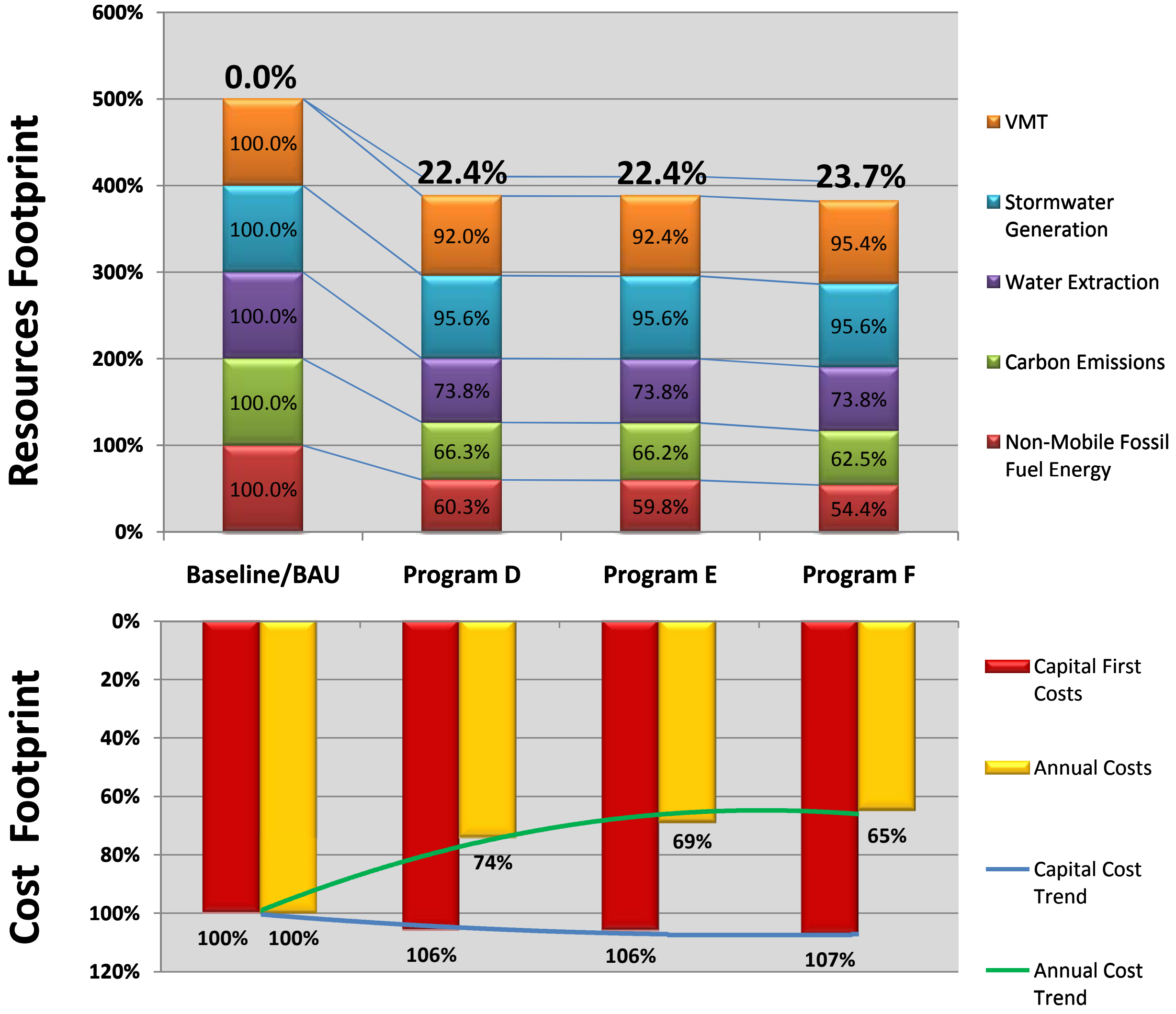


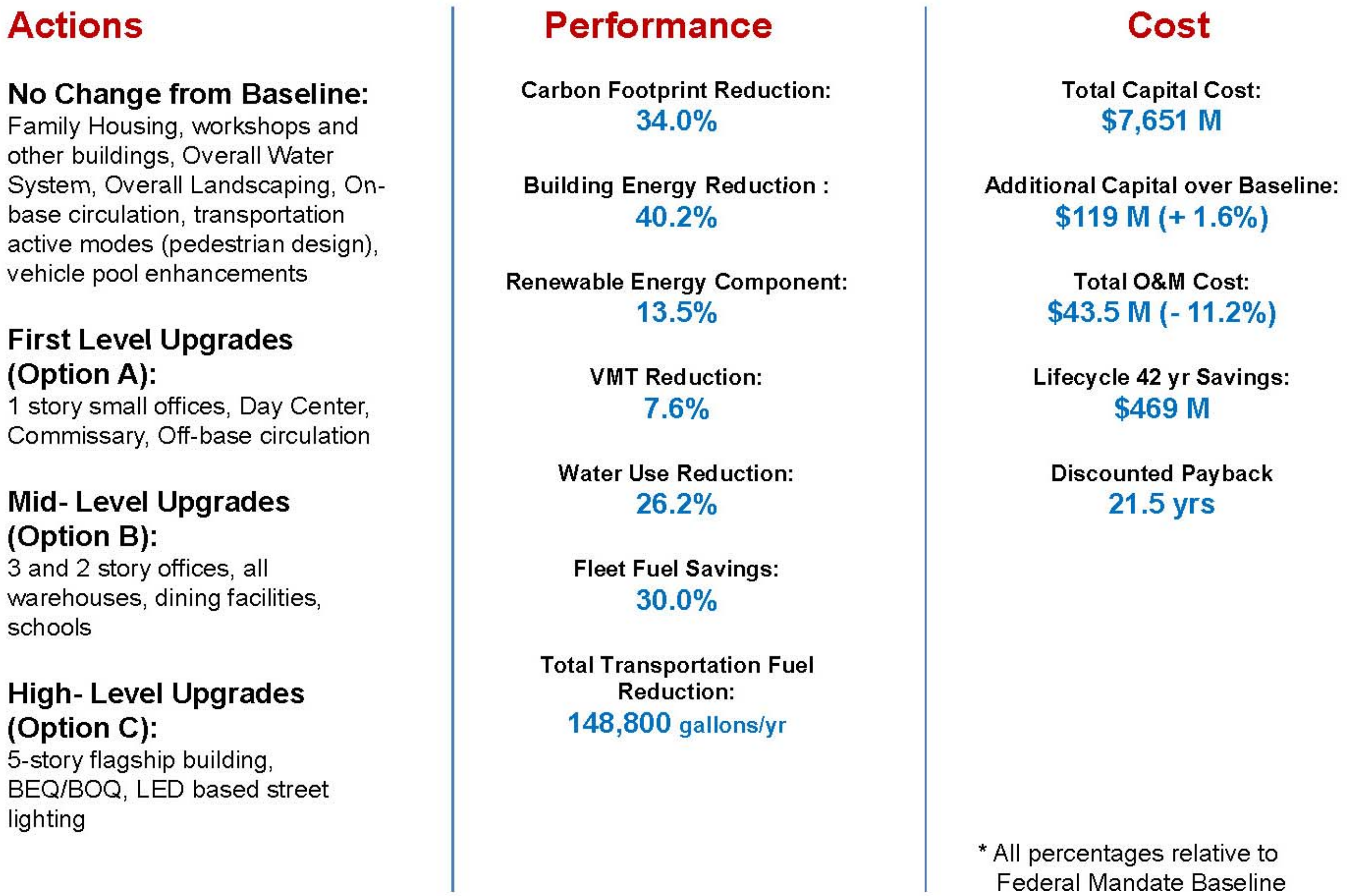
FIGURE 2-4: Screen Capture of Program Optimization Gaming Board

- When comparing Program F to D, with an additional capital investment of $110M, Program F saves an additional $124M (NPV) in life-cycle costs, reaching the highest life-cycle cost savings of $497M over 42 years.

Program Development Final Recommendation

MARFORPAC has selected Program E as the preferred program and following are the main characteristics and performance of Program E. HQMC has concurred the selection of Program E.

Main characteristics and performance of Program E is summarized as follows:



Actions

No Change from Baseline:
Family Housing, workshops and other buildings, Overall Water System, Overall Landscaping, On-base circulation, transportation active modes (pedestrian design), vehicle pool enhancements

First Level Upgrades (Option A):
1 story small offices, Day Center, Commissary, Off-base circulation

Mid- Level Upgrades (Option B):
3 and 2 story offices, all warehouses, dining facilities, schools

High- Level Upgrades (Option C):
5-story flagship building, BEQ/BOQ, LED based street lighting

Performance

Carbon Footprint Reduction:
34.0%

Building Energy Reduction :
40.2%

Renewable Energy Component:
13.5%

VMT Reduction:
7.6%

Water Use Reduction:
26.2%

Fleet Fuel Savings:
30.0%

Total Transportation Fuel Reduction:
148,800 gallons/yr

Cost

Total Capital Cost:
$7,651 M

Additional Capital over Baseline:
$119 M (+ 1.6%)

Total O&M Cost:
$43.5 M (- 11.2%)

Lifecycle 42 yr Savings:
$469 M

Discounted Payback
21.5 yrs

* All percentages relative to Federal Mandate Baseline

TABLE 2-3: Program E Summary

3. Sustainable Systems

3.1 Water

Introduction

The goal of the whole systems water model for the GJMMP is to optimize the water demand estimate and conservation strategies to produce the highest performance at the lowest cost. By modelling various water conservation strategies, overall potable and non-potable water usage and associated project costs can be determined in order to meet the federal mandates.

Process

The SSIM™ water sub-model enables the user to establish a Standard Option for an existing or proposed facility by calibrating fixture flow rates, user patterns, and landscape water demand to match actual water project demand based on meter data. The model can be calibrated to national averages, industry standards, or specialized criteria, such as LEED or federal mandates to establish a Baseline condition as a basis for greater water conservation. With this calibrated water demand and with a detailed project program, the total water demand can be correlated to water consumption per facility type, household, or to a single user. The detail in the model provides great flexibility to modify water use from specific water fixtures, user groups, or facility types to estimate water consumption savings and associated costs for each conservation strategy evaluated.

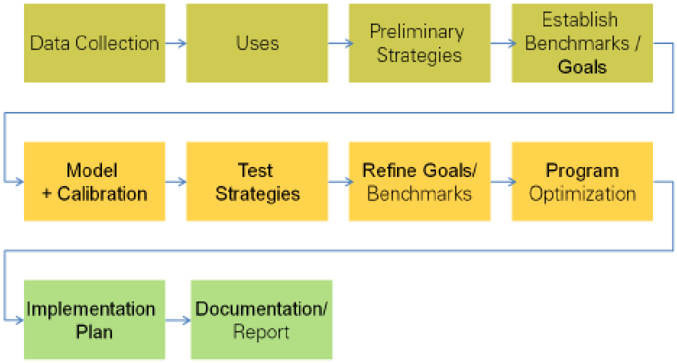


FIGURE 3-1: Water System Process Diagram

The water demand estimate for the GJMMP was calibrated using a series of data sources and ground truthing efforts to accurately represent the proposed water use within the site and establish a Baseline water demand as a basis of comparison for more aggressive water conservation strategies. These sources included numerous NAVFAC utility reports, UFC Design Guidelines, the Draft Environmental Impact Statement, Guam Water Works Authority “Water Master Plan”, the program provided and other documents. The ground truthing consisted of discussions with Guam Water Works and various mechanical, electrical, plumbing (MEP), and civil professional consultants on Guam.

As with energy, various water conservation measures are used in establishing and facilitating the comparisons between the Baseline and additional performance based conservation packages within the SSIM™ model. The primary sustainability and conservation guidelines (goals) used in the water modelling were issued by the Federal Government as Executive Orders. Other guidelines include the Unified Facilities Criteria (UFC) for guidance of design of DoD Facilities, NAVFAC “Common Components Study,” and NAVFAC Engineering Construction Bulletins.

The water planning results provided by the SSIM™ water model are intended to provide guidance on possible strategies toward water conservation and are not intended to be a building specific design guide.

Individual buildings may use the selected strategies as part of the design and construction process. However, some buildings may not achieve the projected water savings, while other buildings may achieve more. As each building is planned, designed and constructed, the selected design team and general contractor will be responsible for ensuring implementation of the specific performance level as part of the overall installation sustainability goals and as recommended in the Sustainability Program.

The water demand for the GJMMP was estimated and calibrated for the specific needs of Joint Base Guam. Water consumption was estimated separately for each of the 4 major facility types. These consist of Single Family Residences, Bachelor Enlisted Quarters/ Bachelor Officer Quarters (BEQ/BOQs), High Density Commercial, and Low Density Commercial. Since each of these facility types requires different water needs, the demand for each was calibrated and estimated for that specific facility use.

The various water conservation and reuse strategies were then applied to each of the facility types to determine the most efficient and cost effective way to achieve the required water savings. The strategies applied consist of low flow fixtures and interior reuse of harvested rainwater and air conditioning condensate. Irrigation use is not anticipated or included in water consumption savings calculations based on Guam's annual rainfall and direction provided by NAVFACMAR. Additional reuse strategies such as the reuse of harvested graywater and treated sewage effluent were not included in the analysis for the GJMMP.

Recommended Strategies

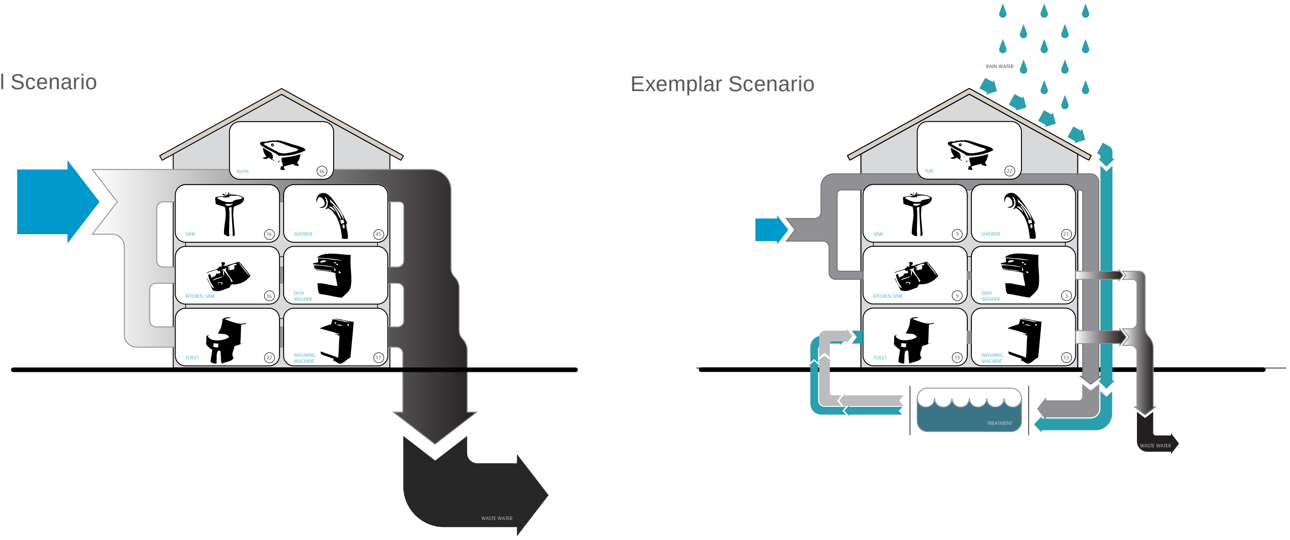
As shown in Figure 3-3 water model gameboard and described in more detail in the Technical Appendix, the water demand estimate and conservation strategies have been optimized to produce the highest performance at the lowest cost. This performance and cost based analysis has been optimized for three separate packages, A, B & C which are also defined and described in detail in the Technical Appendix. Following is a summary of these packages.

Standard Package:

This package was calibrated to the minimum requirements for potable water use through water fixture flow rates for FY 2007 which is defined in EPAct 1992, the current standard for fixture flow rates in 2007. This package is used as the starting point for water consumption reduction measurements as required by federal mandates.

Baseline Package:

This package is defined as the minimum requirement that meets water consumption reduction related mandates for federal facilities. This package is the first conservation package capable of being selected and implemented since it just meets the facility related



Typical Scenario

Exemplar Scenario

FIGURE 3-2: Residential Domestic Water Specification Conceputal Diagram reduction requirements, including the 26% potable water consumption intensity reduction from the (Effective Baseline) or Standard Package as described in E.O. 13514. Additional conservation and larger life cycle savings are seen in the more aggressive conservation packages A, B & C, described below.

Package A:

This performance based package is designed to exceed the baseline package only slightly while optimizing the performance and minimizing the capital cost (First Cost) required.

Package B:

This performance based package is designed to further exceed the baseline package for sustainability and focus on the quickest payback term for the infrastructure required to meet these aggressive water consumption reducing strategies.

Package C:

This performance based package is designed to maximize the use of sustainability strategies that provide the highest life cycle cost savings over 42 years.

Packages A, B and C all meet the federal water reduction mandates for federal facilities; however, offer differing results as it relates to additional first costs and life cycle cost savings. Each of these packages will benefit the project and stakeholders in different ways and should be evaluated from each of the respective stakeholder perspectives for final determination of selected package.

A detailed evaluation of the water related capital and operation and maintenance costs for each of these packages is provided in the Technical Appendix. The selected program for water under overall Program E is the baseline package. Figure 3-3 is a screen capture of the SSIM model Gameboard representing baseline, meeting the federal mandates with lowest first costs.

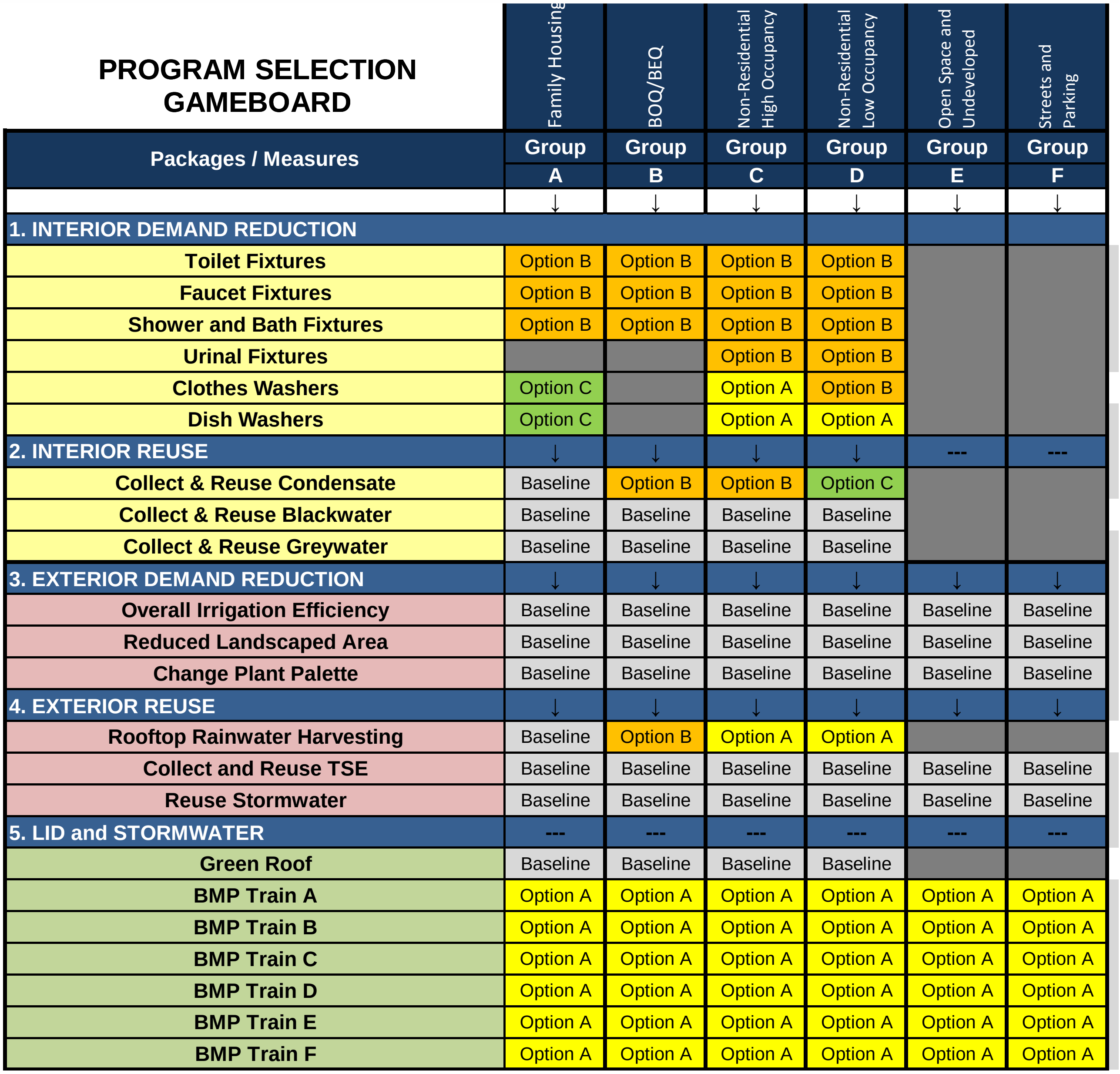
(See Tables 3-1 and 3-2 for package performance)

	Additional Capital Cost	Annual O&M Cost Saving	% Water Reduction
Standard	0	0	0%
Baseline	$55.3M	$0.2M	26.0%
Package A	$55.3M	$0.2M	26.2%
Package B	$52.5M	$0.3M	35.2%
Package C	$51.3M	$0.4M	39.1%

TABLE 3-1: Water Reduction, Capital and O&M Cost (Comparison from Standard), Percentage Water Reduction
Note: Information Shown Above is Measured from Reference Standard

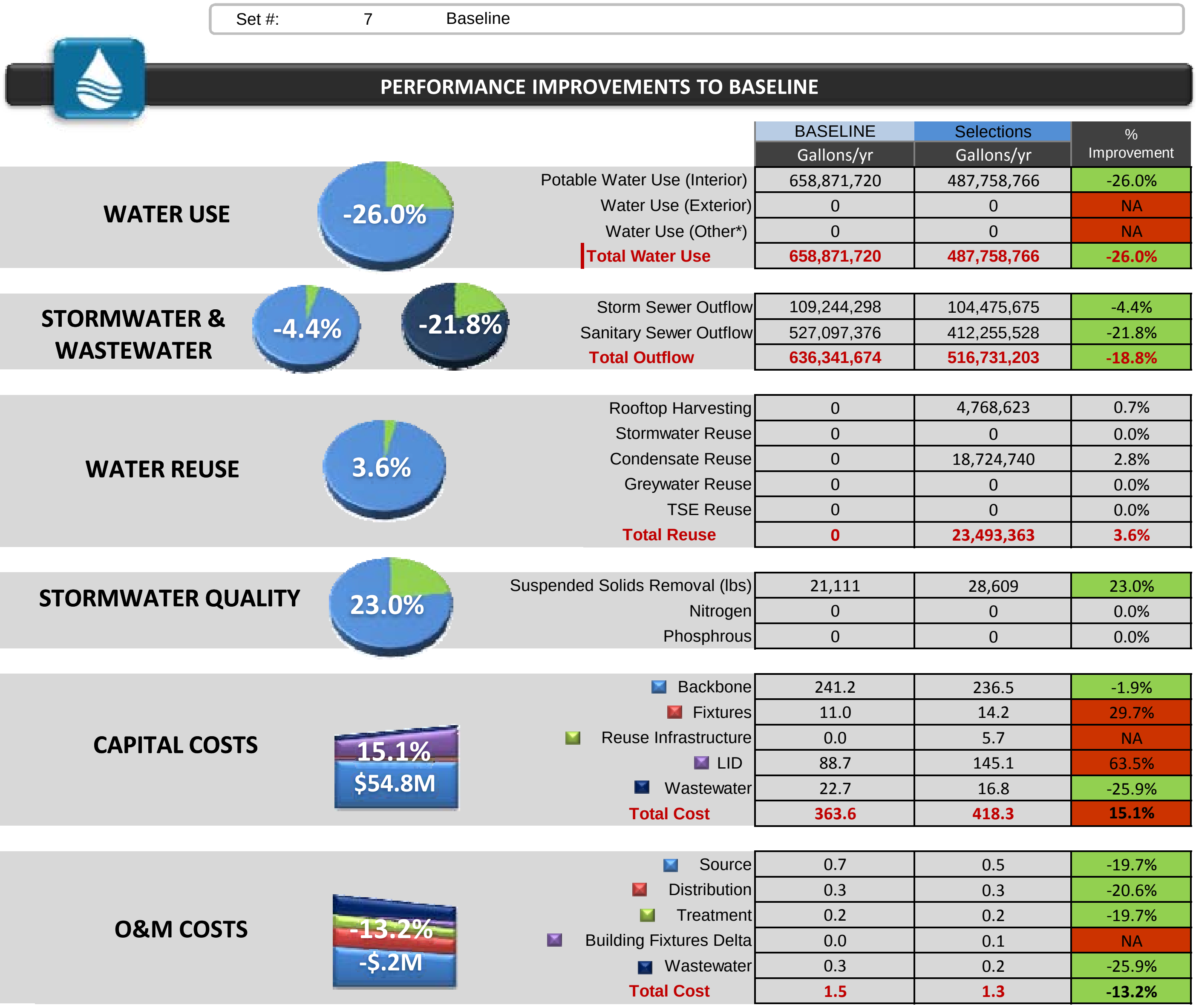
	Capital Cost change from Baseline	O&M Cost from Baseline
Standard	-15.3%	12.8%
Baseline	0%	0%
Package A	0%	-0.2%
Package B	-0.8%	-7.5%
Package C	-1.1%	-10.9%

TABLE 3-2: Water Reduction, Capital and O&M Cost (Comparison from Baseline)



PROGRAM SELECTION GAMEBOARD	Family Housing	BOQ/BEQ	Non-Residential High Occupancy	Non-Residential Low Occupancy	Open Space and Undeveloped	Streets and Parking
Packages / Measures	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**
	↓	↓	↓	↓	↓	↓
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option B	Option B	Option B	Option B		
Faucet Fixtures	Option B	Option B	Option B	Option B		
Shower and Bath Fixtures	Option B	Option B	Option B	Option B		
Urinal Fixtures			Option B	Option B		
Clothes Washers	Option C		Option A	Option B		
Dish Washers	Option C		Option A	Option A		
2. INTERIOR REUSE	↓	↓	↓	↓	---	---
Collect & Reuse Condensate	Baseline	Option B	Option B	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	↓	↓	↓	↓	↓	↓
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	↓	↓	↓	↓	↓	↓
Rooftop Rainwater Harvesting	Baseline	Option B	Option A	Option A		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	---	---	---	---	---	---
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train B	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train C	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train D	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train E	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train F	Option A	Option A	Option A	Option A	Option A	Option A

FIGURE 3-3: Water Model Gameboard



Set #: 7 Baseline

PERFORMANCE IMPROVEMENTS TO BASELINE

			BASELINE	Selections	% Improvement
			Gallons/yr	Gallons/yr	
WATER USE	-26.0%	Potable Water Use (Interior)	658,871,720	487,758,766	-26.0%
		Water Use (Exterior)	0	0	NA
		Water Use (Other*)	0	0	NA
		Total Water Use	**658,871,720**	**487,758,766**	**-26.0%**
STORMWATER & WASTEWATER	-4.4% -21.8%	Storm Sewer Outflow	109,244,298	104,475,675	-4.4%
		Sanitary Sewer Outflow	527,097,376	412,255,528	-21.8%
		Total Outflow	**636,341,674**	**516,731,203**	**-18.8%**
WATER REUSE	3.6%	Rooftop Harvesting	0	4,768,623	0.7%
		Stormwater Reuse	0	0	0.0%
		Condensate Reuse	0	18,724,740	2.8%
		Greywater Reuse	0	0	0.0%
		TSE Reuse	0	0	0.0%
		Total Reuse	**0**	**23,493,363**	**3.6%**
STORMWATER QUALITY	23.0%	Suspended Solids Removal (lbs)	21,111	28,609	23.0%
		Nitrogen	0	0	0.0%
		Phosphrous	0	0	0.0%
CAPITAL COSTS	15.1% $54.8M	🟦 Backbone	241.2	236.5	-1.9%
		🟥 Fixtures	11.0	14.2	29.7%
		🟩 Reuse Infrastructure	0.0	5.7	NA
		🟪 LID	88.7	145.1	63.5%
		🟦 Wastewater	22.7	16.8	-25.9%
		Total Cost	**363.6**	**418.3**	**15.1%**
O&M COSTS	-13.2% -$.2M	🟦 Source	0.7	0.5	-19.7%
		🟥 Distribution	0.3	0.3	-20.6%
		🟩 Treatment	0.2	0.2	-19.7%
		🟪 Building Fixtures Delta	0.0	0.1	NA
		🟦 Wastewater	0.3	0.2	-25.9%
		Total Cost	**1.5**	**1.3**	**-13.2%**

FIGURE 3-3: Water Model Gameboard

Ongoing Sustainability Efforts

In addition to water conservation efforts required to initially meet federal mandates, as represented above, the continuation of these efforts will be required to maintain these efficiencies over time. This can be accomplished through various projects implemented as portions of the Finegayan Cantonment infrastructure are constructed and begin operation or in future years as needs arise and opportunities present themselves. Some examples of these projects are described in the Technical Appendix.

All new construction on the GJMMP will be equipped with meters accommodating an “advanced metering system” according to Navy and Marine specifications.

A user-friendly, non-proprietary metering system utilizing wireless technology is recommended. A proposed Direct Digital Control (DDC) system connected to the Building Management System (BMS) will accommodate effective operations and maintenance on the base in order to meet the federal mandates.

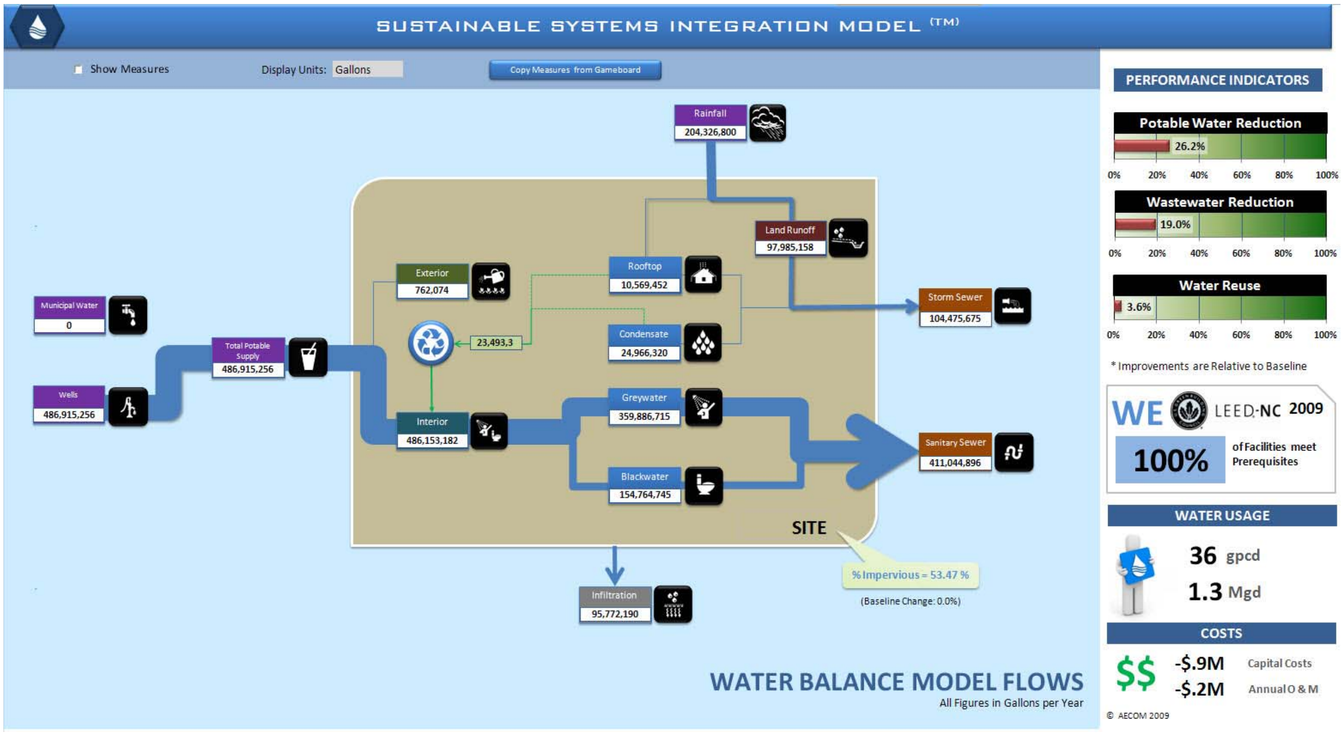


FIGURE 3-4: Water Dashboard

Low Impact Development (LID)

Low Impact Development has been incorporated into the water modelling process. Costs for the LID program have also been included in water modelling costs. For more information related to LID, please see the Technical Appendix and the LID study completed by AECOM.

Conclusion

By building a “bottom up” whole systems water balance model, water conservation measures have been incorporated such as use of low flow fixtures, interior reuse of harvested rainwater and air conditioning condensate, LID, and no irrigation. Combined in an integrated manner on the site, the water program achieves a 26% reduction from the standard to meet the federal mandate at the least amount of cost while achieving LEED points.

Water - precious resource

3.2 Energy

BUILDING ENERGY

Introduction

Energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the GJMMP Sustainability Program in order to meet the federal mandates at the least cost. A total of two typical residential building types and 12 typical non-residential building types were analyzed as part of the study:

- Single family dwellings
- Duplex dwellings
- 5-story HQ office
- 3-story HQ office
- 1-story small office
- Climate controlled storage warehouse
- Semi-conditioned warehouse
- Day Center
- Commissary
- Dining Facility
- Bachelor Enlisted Quarters
- School
- Workshop

For each building type, assessment was made of the different combinations of passive and active energy conservation measures (ECMs) that could be applied to the buildings, in order to determine which packages of measures could help to achieve increasing levels of energy performance. The Sustainability Program and SSIMe (or SSIM™ Energy) building energy studies provide guidance to possible routes compliance and the cost associated with doing so. In defining ECMs for each package, it is recognized that this is a master planning level study. The measures proposed may not be applicable to all buildings on the site, and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study. As such, the results of this study do not represent a prescriptive checklist of energy conservation measures that can be applied to each building type. However, key ECMs and cost trends have been extracted from the analysis for detailed analysis by the design teams during the design phase of each building. Details of these for each building type are provided in the Technical Appendix.

Process

Facilities to be constructed as part of the GJMMP build up are required to comply with a number of federal mandates as well as the Commandant of the Marine Corps' own sustainability goals. These are addressed in different forms by Energy Policy Act (EPAct) 2005, Executive Order (EO) 13423, and Energy Independence and Security Act (EISA) 2007. Details of all energy mandates and goals as they relate to building energy and the energy modelling process are provided in the Technical Appendix. A summary of the key federal mandates as they relate to building energy is provided in Table 3-3.

Act #	Topic	Target
EPAct 2005 Act 109	Federal building performance standards	Achieve 30% better performance (new buildings) relative to an ASHRAE 90.1 2004 baseline, where life cycle cost efficient
EISA 2007 Act 433	Energy efficiency performance standards	Reduce fossil fuel use (new/renovated buildings) by 55% in 2010 and 100% by 2030, relative to 2003 CEBCS baseline.

TABLE 3-3: Key Legislation Relating to Building Energy

Additionally, it is noted that all new federal construction must be LEED Silver certified, therefore the effects of increasing levels of energy performance on the number of LEED points attained has also been assessed. In addition, Marine Corps policy also requires all new USMC construction to incorporate roof-top solar thermal and/or photovoltaic technologies into the project where fiscally and operationally appropriate.

It is recognised that typhoon proofing requirements for structures at Guam effectively precludes the use of roof mounted solar thermal hot water (STHW) or crystalline PV technologies. When utilized, these technologies must be ground mounted and protected by solid half walls and manual roll down covers to meet Guam's 170mph wind loading requirements. As such, only the use of amorphous building integrated PV (BIPV), solar thermal hot water (STHW) has been considered when assessing the packages of ECMs required to meet the federal mandates. Any STHW systems must be ground mounted and designed to meet the appropriate typhoon proofing criteria, as noted above. Where the use of STHW is not appropriate, condenser heat reclaim technologies should be considered as an alternative hot water heat solution.

Summary of Performance Requirements

Five different options of ECMs were produced for each building type, thus allowing alternative strategies to be optimized in order to produce an overall site wide sustainability strategy to be developed which best meets the project requirements. As part of the overall sustainability package for the site, performance based targets were developed based on the ECM packages that were produced for each building type during the analysis phase of the report.

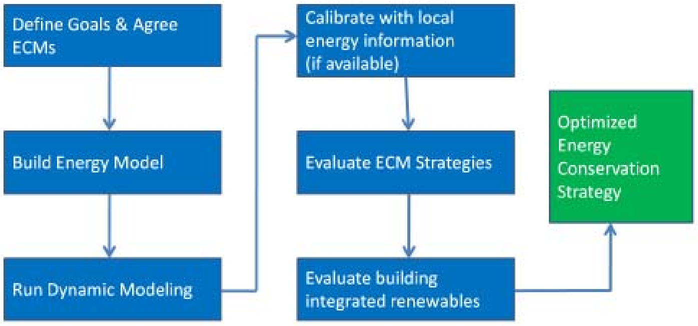


FIGURE 3-5: Energy Model Analysis Flows

Sample High Efficient Appliance/Building System

The recommended options for each building type are defined by the need to meet the overall sustainability goals (with particular respect to achieving a 34% greenhouse gas emissions reduction and 7.5% site wide renewable energy target). Table 3-4 summarizes the performance targets that each building must meet in order to achieve the overall program sustainability goals. The corresponding ECM package developed as part of the analysis to demonstrate compliance with each performance target is also included.

In defining ECMs for each of the option, it is recognized that this is a master planning level study, therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined. As such, the results of this study do not represent a prescriptive checklist of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design team will have responsibility for the selection of systems and ECMs to ensure compliance with the federal mandates and sustainability goals for the base.

To ensure compliance with the overall installation-wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum levels of energy performance that should be achieved (for example ~43.0% energy use improvement over reference standard for 1 story small offices). The packages proposed above (and outlined in the Technical Appendix) can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner.

Building Types	% Reduction	% Renewables	ECM Package to meet the target
Single Family	30.5%	18.0%	Baseline
Duplex	34.0%	22.0%	Baseline
5 Story HQ Office	41.0%	12.5%	Option C
3 Story HQ Office	36.5%	15.0%	Option B
2 Story HQ Office	38.5%	13.5%	Option B
1 Story Small Office	43.0%	20.5%	Option A
Climate Control Warehouse	48.0%	23.5%	Option B
Semi-conditioned Warehouse	90.0%	85.5%	Option B
Day Center	42.5%	13.0%	Option A
Commissary	34.5%	14.0%	Option A
Dining Facility	40.5%	14.5%	Option B
BEQ - 6 Story 300 Occupant	46.5%	15.5%	Option C
School	31.3%	0.9%	Option A
Workshop	31.1%	1.5%	Baseline

TABLE 3-4: Performance Targets for Each Building to Achieve the Overall Program Sustainability Goals

Ground mounted PV with site wall for wind protection

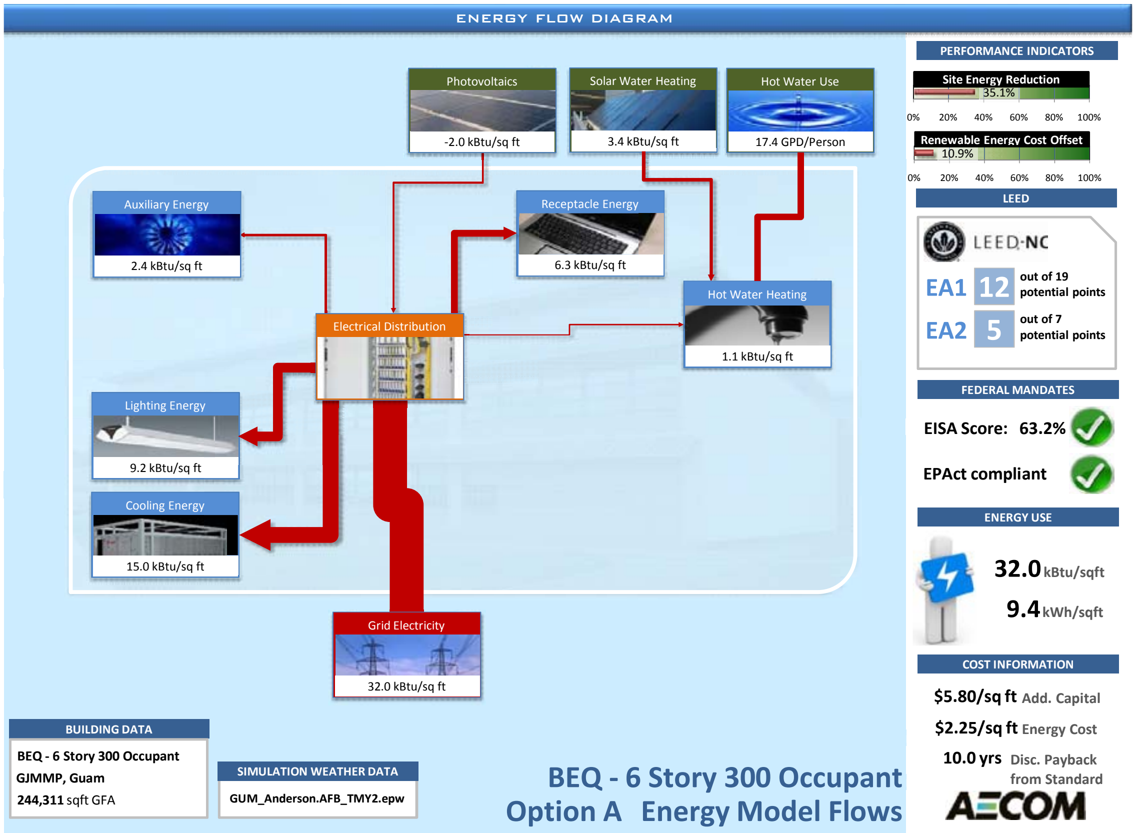


FIGURE 3-6: Building Energy Dashboard

However, these should not be used as prescriptive requirements for achieving compliance in each building type.

During the design and construction process it is recommended that a review team oversees the energy performance documentation submitted for each building to ensure compliance with the performance goals outlined above. This should be a multi phase approach that involves the validation of initial concepts and then continues to further document the energy performance of the final design.

Overall Building Energy Performance

The 14 building types, which are analyzed through dynamic thermal energy modelling, represent the majority of the facilities and buildings proposed in the main cantonment and family housing area. The proposed building/facility program for the main cantonment is grouped into building types shown in Table 3-6.

Performance based targets have been developed for the individual building types, and then applied to the overall program through gaming exercises to monitor the main cantonment’s overall building energy performance. Several “Buildings of High Energy Influence” are identified as their large gross floor areas and quantities, and their energy performances will have significant impacts on the overall building energy as well as cost benefit performance. In order to achieve the 34% GHG reduction goal, as a major contributor to the GHG emission, it is important to strategically set a high target for the overall building energy. The “High Influence” will need to outperform the federal mandates.

Conclusion

Federal targets related to energy (including a 30% reduction of energy use and 7.5% of energy used to be supplied from renewable sources) are certainly achievable in a cost effective manner for the GJMMP. Each of the 14 modeled building types has been optimized to meet and or exceed the mandates to assist with achieving energy security as defined by the EO.

	Building Types	*Approx. GFA*	*Approx. Percentage*
Main Cantonment	5 Story Headquarters Office	N/A	N/A
	1 Story Small Office	90,476	1.3%
	1 Story Headquarters Office	4,840	0.1%
	2 Story Headquarters Office	239,037	3.4%
	3 Story Headquarters Office	616,718	8.9%
	Armory	40,175	0.6%
	BEQ	**2,718,108**	**39.2%**
	Climate Controlled Warehouse	262,792	3.8%
	Conditioned Auto/Maintenance Workshop	603,037	8.7%
	Dining Facility	120,365	1.7%
	Exempt	2,554	0.0%
	Indoor Fitness/Swimming Pool/Bathhouse/RR	125,133	1.8%
	Medical	107,220	1.5%
	Other	476,406	6.9%
	Retail/Commissary	201,315	2.9%
	Simulator Facility	163,824	2.4%
	Semi-conditioned Warehouse	**1,157,023**	**16.7%**
	Subtotal		100%
Family Housing Area	SFD	29,047	0.4%
	Duplex	**5,662,464**	**83.6%**
	School	**785,010**	**11.6%**
	Community Building/Day Care	274,573	4.1%
	Community Building	21,000	0.3%
	Subtotal		100%

TABLE 3-5: GJMMP Overall Building Program Summary

PUBLIC REALM ENERGY

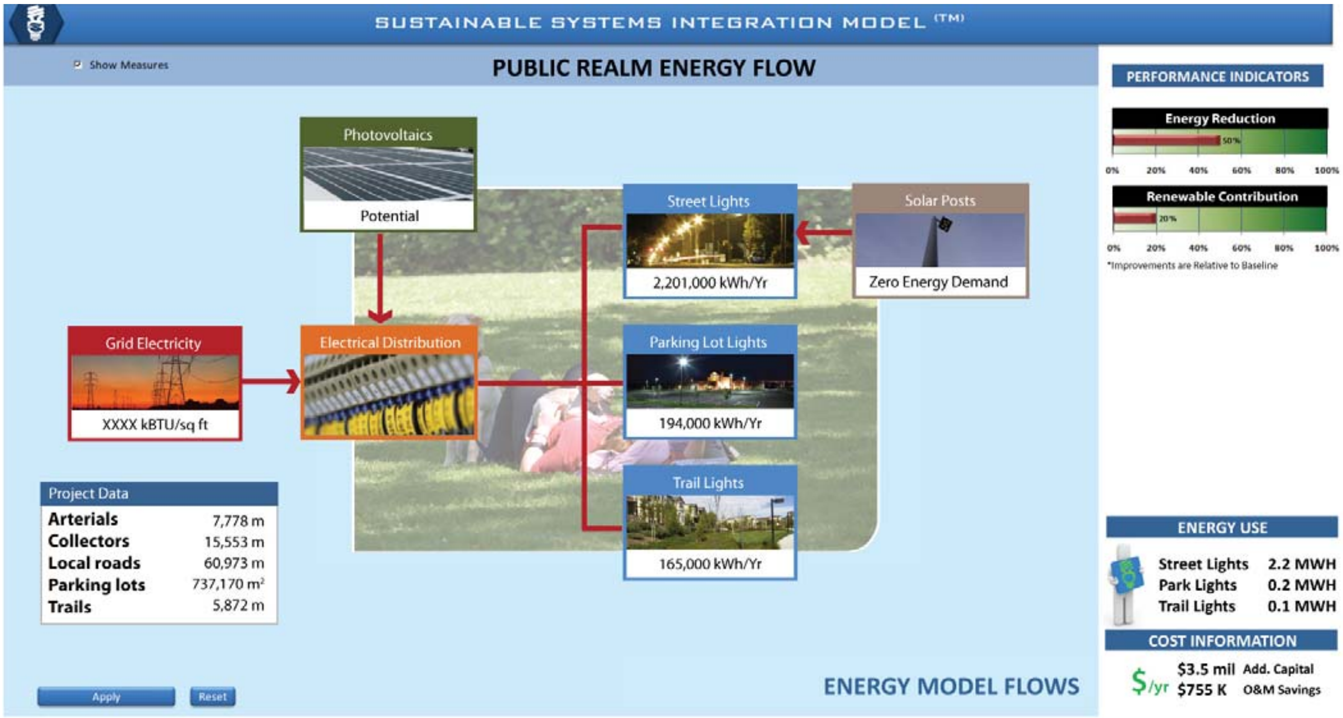
Introduction

The GJMMP has over 52 miles of streets, 3.6 miles of trails within the area defined by “public realm”. Therefore, the public realm provides opportunities for significant improvements in energy conservation and associated cost savings. The primary approach to saving public realm energy is to integrate efficient lamp technologies, optimum pole placement, and efficient fixture photometrics (light distribution), while using the least amount of energy and cost to meet Unified Facilities Criteria, federal mandates, and Navy Sustainability goals. The public realm areas were identified and modeled to ensure safety, dark skies, and to explore the potential for energy and cost savings through reasonable measures at the conceptual master planning level and provide a direction for more detailed lighting design and implementation.

Process

The Public Realm Energy model starts with the analysis of public realm lighting measures that follow the standard practice outlined in the UFC and NAVFACMAR Common Components Study. The overall energy demand per year and associated costs are measured to establish the Baseline case. Three scenarios of increasing efficiency are developed as Package A, B and C. The three scenarios along with the Baseline case are then put side by side to be evaluated on how each scenario can provide opportunities and benefits listed below as compared to the baseline:

- Energy Saving
- Capital Cost Saving
- Maintenance Cost Saving
- Improved Sense of Security
- Reduced Glare and Improved Visibility
- Protection of Dark Sky



Street Lights: 2,201,000 kWh/Yr

Solar Posts: Zero Energy Demand

Grid Electricity: XXXX kBTU/sq ft

Parking Lot Lights: 194,000 kWh/Yr

Trail Lights: 165,000 kWh/Yr

Project Data	
Arterials	7,778 m
Collectors	15,553 m
Local roads	60,973 m
Parking lots	737,170 m²
Trails	5,872 m

ENERGY USE	
Street Lights	2.2 MWH
Park Lights	0.2 MWH
Trail Lights	0.1 MWH

COST INFORMATION		
$/yr	$3.5 mil	Add. Capital
	$755 K	O&M Savings

FIGURE 3-7: Public Realm Energy Dashboard

Recommended Strategy

Based on the input from the Sustainability Program Workshop in Honolulu, Package C is recommended as the preferred package. Table 3-6 shows the comparison between the Baseline Package and Package C.

Summary Performance and Results

The combination of street, parking lot, and pedestrian trail lighting measures identify significant opportunities for energy savings. The selected Package C provides an overall 59% energy reduction compared to Baseline. The capital cost (first cost) of approximately $20M is driven by the type and number of lighting fixtures and number of light poles required. The annual operating costs are directly dependent on the type of fixture chosen as the energy consumption and replacement costs differ by fixture type. Although Package C includes mostly LED fixtures and solar poles which result in an increase of capital cost, the energy savings and longer lifespan of the LED fixture help to reduce the annual maintenance and operating cost (saving $542,000 per year). The simple payback of this recommended package to baseline is about six years.

Conclusion

Due to the substantial lifecycle savings, the recommendation of the sustainability team is to implement Package C.

Public Realm Types	Baseline	Recommended
STREET LIGHTING		
Arterial	High Pressure Sodium 250W	High Power LED 200W with solar pole
Non-Residential Collector	High Pressure Sodium 150W	High Power LED 140W with solar pole
Residential Collector	High Pressure Sodium 150W	LED 100W
Local Access Street	Low Pressure Sodium	LED
Neighborhood Street	Low Pressure Sodium	LED
PARKING LOT LIGHTING	High Pressure Sodium 150W	LED 100W
PEDESTRIAN TRAIL LIGHTING		
Natural Greenway	Bollard Compact Fluorescent Lighting, 180 degree cut off	Bollard LED Lighting, 180 degree cut off
Natural Pathway	Bollard Compact Fluorescent Lighting, 180 degree cut off	Bollard LED Lighting, 180 degree cut off
Developed Corridor	Bollard High Pressure Sodium Lighting, 360 degree cut off	Bollard LED Lighting, 360 degree cut off

TABLE 3-6: Public Realm Energy Recommended Package

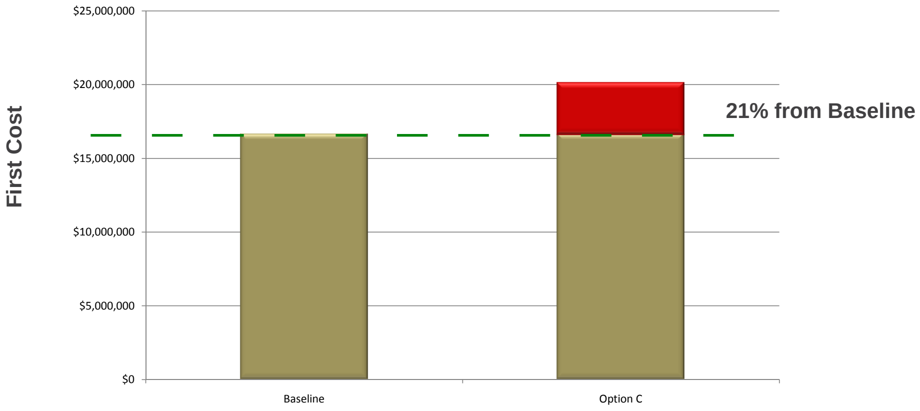


FIGURE 3-8: First Cost and Annual Cost Comparison

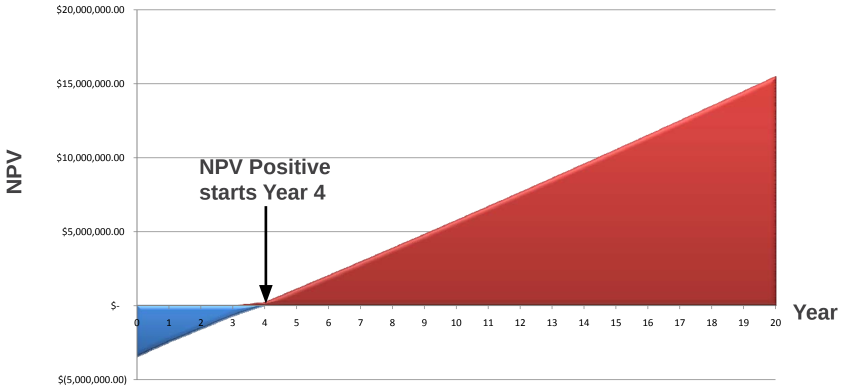
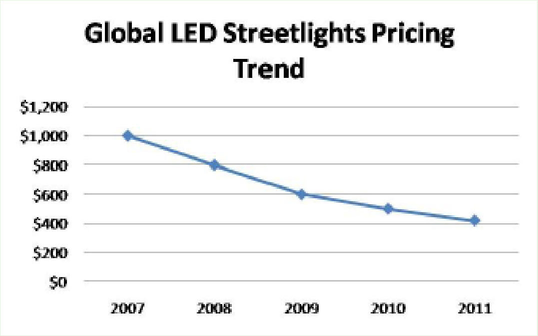


FIGURE 3-9: Package C Lifecycle Cost Payback Analysis

Quantified Public Realm:

- Street Lighting – over 84,000 meters (52 miles) long streets
- Parking Lot Lighting – over 735,000 square meters (176 acres) in area
- Pedestrian/Trail Lighting – over 5,800 meters (3.6 miles) long trails

Sample LED Fixture



DISTRICT/RENEWABLE ENERGY

District Energy Analysis

There has been significant discussion over the course of the sustainability program energy master planning pertaining to the provision of a district wide energy system at the proposed GJMMP and in particular, a district wide cooling system. District wide energy systems can be an effective way of reducing energy use across a number of buildings, campuses or even towns and cities, by generating energy (typically hot and cold water for space heating, hot water heating and space cooling) efficiently at a central point and distributing via insulated pipe work to buildings across a site.

For the main cantonment, there are a number of issues that make the decision more complex than at many other locations. In particular, it is noted that there is no requirement for space heating in Guam. District hot water energy systems are generally not designed to supply only domestic hot water, due to the large infrastructure costs associated with district systems and the potential for using other more efficient "at source" methods of domestic hot water heating, such as solar water heating systems. On that basis, only a district cooling system has been considered for use.

Considerations

The primary objective of a district energy system is to allow energy (in the case of Guam, "cooling") to be generated more efficiently at a central source. When heating systems are required, this is generally done through the use of waste heat, combined heat and power (CHP) or biomass technologies, where significant energy, cost or carbon savings can be achieved. For a cooling only system, such alternatives are less readily available. Because of that, it is most likely that based on current technical and financially feasible technologies, a district cooling system in Guam would use water cooled chillers, which minimizes the energy savings that could be achieved compared to individual building systems. Other technologies, including ocean water cooling have been discussed throughout the master planning process. However it is not believed that an ocean cooling system could be cost effectively implemented at this stage. In addition, a thorough review of the environmental impacts of such a system would have to be undertaken before any detailed recommendations could be made. In addition, site wide cooling systems typically experience higher losses than heating systems due to the higher temperature differential between the ground temperature and chilled water distribution temperature. For that reason, the energy savings that could be achieved from district cooling systems are likely to be minimal. The high costs associated with installing preinsulated pipe work for chilled water distribution make such a system financially unfeasible on a site wide basis.

It is also noted that there are complexities associated with the phased procurement process of the facilities to be constructed as part of the build-up. As the base will not be constructed to 100% build-out right away, any district cooling system would be required to be designed and constructed in phases alongside the build out. A number of different design and construction companies will be also involved in the development of the buildings adding further complexity.

The method by which the new buildings are funded (through "1391s") adds a further layer of complexity to the construction of a district wide cooling system. This process requires facilities to be costed individually, with funds allocated to each building for the provision of individual HVAC systems. The protocols involved in the process do not readily lend themselves to the development of centralized cooling plants. As such, it is not recommended that a base-wide district cooling system is pursued at this time.

Despite this, in some instances smaller distributed cooling systems could be used to serve small groups of buildings from a single central cooling source. The most likely area for this type of system is determined as being the BEQ area, where the buildings have a large cooling requirement (primarily due to their size) and are more closely located which minimizes the requirement for large runs of chilled water distribution piping. Although the energy savings associated with doing this are likely to be minimal (in particular, the size of the BEQs makes them likely candidates for the use of central water cooled chiller plant anyway), operations and maintenance savings are likely to be attained. It is noted that the BEQs will be procured to design and building contracting teams as groups of two or three which would make the procurement of this type of system more feasible. In this circumstance, it is recommended that the use of smaller distributed cooling systems are investigated by the design teams.

Renewable Energy Analysis Results

Analysis has been carried out at a conceptual level to determine the feasibility of the use of district wide renewable energy strategies at the base. Specifically, this analysis assessed the feasibility of the use of photovoltaic solar power generation and solar wind generation at the main cantonment.

Photovoltaic Solar Power Generation

Analysis of Andersen Air Force Base “TMY2” weather data indicates that Guam benefits from an enviable year round solar resource. Average year round solar radiation on Guam is estimated to be around 171kWh/sq ft (compared to around 169kWh/sq ft in Los Angeles, which is widely regarded as having one of the best solar resources in the US).   Due to Guam’s location on the globe (13.6°N, 144.8° W), the peak solar resource for solar energy technologies such as PV is found at comparatively little tilt from the horizontal (around 9°).

Although Guam benefits from an excellent solar resource that would support the wide scale use of photovoltaic technologies, it is also recognized that Guam regularly has typhoon winds. Around 30 to 40 tropical storms form each year to the southeast of Guam, which then track westward towards and past Guam. Of these, about four to six reach typhoon level wind strengths (over 100 mph) and about one to two will track over Guam or near enough to do damage. Every 12 to 15 years Guam has experienced a super-typhoon (over 150 mph winds) although the storms have been increasing in intensity and frequency over the past 15 years which led to an increase of the design wind load from 155 mph to 170 mph currently. Additionally, during typhoon season, flying debris is likely to be an issue and concern has been raised that this would present a danger to the use of conventional solar panels.

In line with the Department of the Navy policy (CMC ltr Ser 11300/LFF-1), the energy team has adopted an aggressive approach with regards to the use of amorphous building integrated photovoltaics (BIPV) on the rooftops of each building. This technology is less susceptible to damage during typhoons as the PV layer is flexible (and so does not have a glass surface) and is also integrated into the roof membrane itself, rendering it highly unlikely to detach from the building during high winds (assuming the adhesives to the roof are adequate). Although an excellent application for building integrated or building mounted applications, amorphous PV is less suitable for use in district wide applications, due to its much lower power density (~231 sq ft/kW, compared to around 83 sq ft/kW for polycrystalline PV panels). As a result, a much larger area is required to achieve the same output as with crystalline PV panels. However, it is noted, that BIPV is more effective in cloudy weather than hard PV panels.

Due to the typhoon issues, the widespread use of crystalline PV has effectively been ruled out at the new cantonment. The limited availability of large amounts of land for locating PV means that amorphous PV is unlikely to be a suitable strategy for developing a district wide renewables plan. The aggressive use of BIPV technologies on the buildings across the site does however reduce the need to adopt an aggressive “district” renewable energy strategy. As such, it is not proposed that a district wide PV strategy be adopted as part of the sustainable master plan for the Finegayan build up, unless the risk associated with the potential typhoon damage to ground mounted crystalline panels is considered by the DoD to be low enough to allow their use. Should this be the case, further analysis could be then undertaken to identify the potential site-wide energy offset that a large PV array could provide.

Wind Energy Generation

Assessment has also been made regarding the use of wind energy generation technologies as part of a district-wide renewable energy strategy at the site. Analysis of the Andersen Air Force Base weather tape indicates that the island has a modest wind resource with an average of wind speed of around 9.3 mph at 10m (~33 feet) above ground level. Although the use of very large scale wind energy generation has not been considered as part of the sustainable master plan, assessment has been made of the use of small wind energy generation technologies, and specifically turbines in the sub 15kW range.

Although not eminently suitable for the use of wind generation technologies, the wind resource on the site is likely to be sufficient to support the use of small scale wind generation, with a capacity factor of around 14% predicted for turbines in the 15kW size range (with a hub height in the region 30 feet high). Accordingly, without any rebates, payback for a turbine would be expected to be achieved in approximately 32 years (based on mainland costs escalated to Guam costs).

The “typhoon proofing” requirements are likely to preclude the installation of wind turbines, due to the difficulty in finding turbines rated to 170mph design conditions. This is particularly pertinent for use in built up areas such as the new base, due to the risk of the turbines themselves damaging other property should they fail under typhoon conditions. As the Department of Defense is self insuring, determination will need to be made on the risk of the use of wind turbines rated at less than this condition. If this risk is deemed too great, it is not recommended that a wind turbine strategy is aggressively pursued at the base.

Conclusions

The feasibility of the provision of a district cooling system, as well as the use of district scale PV and wind power generation systems has been assessed as part of the Sustainability Program study. A detailed discussion of each is provided above. Based on that discussion, the following key conclusions are drawn:

- It is not thought that the provision of a base-wide district cooling system would provide significant energy benefit at the site. There are also significant complexities associated with the technical and financial procurement of such a system. As such, it is not recommended that a base-wide district cooling system is pursued at this time.
- Although it is not recommended that a base-wide district system be pursued, it is noted that in some instances smaller distributed cooling systems could be used to serve small groups of buildings from a single central cooling source. Although the energy savings associated with doing this are not likely to be significant, operations and maintenance savings are likely to be attained.
- Despite the fact that Guam benefits from an enviable year round solar resource, due to the typhoon issues, the widespread use of crystalline PV has effectively been ruled out at the new base. As such, it is not proposed that a district wide PV strategy be adopted as part of the sustainable master plan for the Finegayan build up, unless the risk associated with the potential typhoon damage to ground mounted crystalline panels is considered by the DoD to be low enough to allow their use.
- Guam has a wind resource that is moderately favorable for the use of wind power generation technologies and is likely to be sufficient to support the use of small scale wind generation. However the typhoon proofing requirements are likely to preclude the installation of wind turbines, due to the difficulty in finding turbines rated to 170mph design conditions. As the DoD is self insuring, determination will need to be made on the risk of the use of wind turbines rated at less than this condition.

CASE STUDY: Marine Corps Base Hawaii, Kaneohe Bay, Hawaii

The base has a total area of 5.8 square miles (15.1 km²)

- 4.4 square miles (11.4 km²) of the land occupies the entire Mokapu Peninsula
- 1.4 square miles (3.7 km²) of it (24.74%) is water

MCBH is home to the 3rd Marine Regiment and Marine Aircraft Group 24 and 3rd Radio Battalion.

Design Components:

- Total population of 11,827, is home to Marines, sailors, their family members, and civilian employees
- Population density is 2,696.2 people/square mile
- 2,388 housing units at an average density of 544.4 units/square mile
- Two areas of the base are classified conservation land which includes the Ulupau Crater area and the Nuupia Pond area

Sustainable Components:

- Photovoltaics on barracks, solar water heater, and LEDs light bulbs
- Since 2004, MCBH has renewable energy plans which aim to exceed power needs in less than 10 years
- Build state’s largest photovoltaic solar farm for a multi-megawatts solar array
- Build a biofuel electricity-producing plant, which could run on locally-grown palm oil or sugar cane
- Partnered with Ocean Power Technologies, Inc. to test the generation of electric power from ocean waves using a “PowerBuoy” wave energy converter, one of the first wave power projects in the U.S.

The Future:

- Working towards renewable and alternative energy project to turn up the green intensity to the next level
- Partnerships with private industry to build and operate the facilites

3.3 Green Building/LEED (NC&ND)

Introduction

The US Green Building Council (USGBC)'s LEED program has a number of components to utilize for Guam including:

1. **LEED Building Design and Construction (BD+C)** Version 3.0 (2009) is designed for new non-residential construction. LEED Silver is currently a federal mandate.
2. **LEED Home** is a program designed for new residential construction.
3. **LEED ND** is a program that is not required but voluntary and designed for neighborhoods or communities.

As part of the Sustainability Program for the GJMMP, a preliminary LEED Building Design and Construction (BD+C) Version 3.0 (2009) analysis has been conducted to assess the LEED certification potential of the non-residential buildings that are to be constructed as part of the build-up. A total of 12 typical non-residential building types were analyzed as part of the study, as follows:

- 5 story Headquarters (HQ) office
- 3 story HQ office
- 1 story small office
- Climate control warehouse
- Semi-conditioned warehouse
- Day Center (or Community Center)
- Commissary
- Dining Facility
- Bachelor Enlisted Quarters (BEQ)/Bachelor Officer Quarters (BOQ)
- School
- Workshop

Smart Growth Workshop, Guam 2009

The LEED certification studies provide guidance as to possible routes to compliance and the Rough Order of Magnitude (ROM) cost associated with doing so. In defining credit strategies for each package, it is recognized that this is a master planning level study, therefore the credit strategies proposed may not be applicable for each specific building due to specific project constraints. As such the results of this study do not represent a prescriptive checklist of LEED credits that can be applied to each building type, and each credit will have to be analyzed by each design team during the design phase of each building. Details of the LEED credit packages for each building type are provided in the Technical Appendix.

The focus of the Sustainability Program for the GJMMP is on LEED Building Design and Construction (BD+C) Version 3.0 (2009) described in the following section. All of the checklists for the non-residential types are included in the Technical Appendix. Also found in the Technical Appendix are recommendations for LEED Home.

The Guam Smart Growth Charettes in Guam in 2009 identified the opportunity to consider LEED ND for the family housing area and BEQ area of the main cantonment. Both areas after review and analysis do not meet the pre-requisites of LEED ND and are therefore not able to qualify for the voluntary program. However, there are still a number of good planning and design principles that can be considered for the master plan. These strategies include:

- Enhanced trail system
- Base-wide shuttle system
- Enhanced Green/Open Space
- Connectivity
- Onsite Tree Preservation

LEED NC

LEED for New Construction and Major Renovations is designed to guide and distinguish high-performance commercial and institutional projects..

LEED ND

LEED for Neighborhood Development integrates the principles of smart growth, urbanism and green building into the first national program for neighborhood design.

LEED Home

LEED for Homes promotes the design and construction of high-performance green homes.

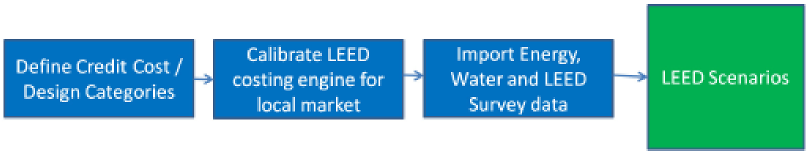


FIGURE 3-10: LEED Process Diagram

Smart Growth Workshop, Guam 2009

Sustainability Goals and Mandates

Facilities to be constructed as part of the GJMMP build up are required to comply with a number of federal mandates as noted previously. From a LEED perspective, the mandates require that all new buildings must receive a minimum of LEED Silver certification. Therefore, LEED Silver has been used as the minimum LEED requirement for the project.

In addition to federal mandates, an online client survey was undertaken, with responses collected from a number of key stakeholders. These results were utilized to assess the effectiveness of each LEED scenario at achieving the client's underlying sustainability goals.

Process Overview

The LEED Scenario Generator tool, developed by AECOM, has therefore been developed to assess the viability of each credit using two high level evaluation metrics:

- Construction Cost (Low/High)
- Restrictiveness on Design (Low/High)

Each LEED credit has been assessed against these criteria which resulted in each credit being placed into one of four following credit categories (See Table 3-7):

Credit Category	Cost Impact	Design Impact
1	Low	Low
2	Low	High
3	High	Low
4	High	High

TABLE 3-7: LEED Cost/Design Impact Matrix

As one of the key elements of this study was to validate the cost impact of seeking LEED certification, a simple ROM cost has been attached to each credit. These costs are broken down into three component parts each covering a different element of the project as follows: percentage increase on construction cost; percentage increase on design fee; and cost of LEED documentation. Where a more detailed analysis has been undertaken, such as that undertaken by the building energy and water teams, these more detailed costs are utilized in the total cost build up.

Four separate scenarios were generated to allow assessment of the LEED opportunities. As noted in the Table 3-8 below, all scenarios assume the use of those credits that have a low impact on both the design and the construction cost.

Scenario	Low / Low Credits	Low / High Credits	High / Low Credits	High / High Credits
Option A	✓			
Option B	✓	✓		
Option C	✓		✓	
Option D	✓	✓	✓	

TABLE 3-8: LEED Opportunities (Cost/Design)

Option A assesses the LEED potential of only utilizing credits designated as low cost/low design impact. Options B and C have been generated that assess the potential benefit associated with also seeking those credits that have either a higher design impact or a higher construction cost impact. Option D however, looks at incorporating all credits included within Options B and C.

Those credits that have been defined as having high design impact and high construction cost impact have not been included within any of the scenarios on the basis that these credits should be evaluated at a project by project basis given the potential impact on cost or design flexibility.

Additionally, none of the new regional credits have been defined for Guam; and as such, LEED Silver has been sought without reliance on these credits.

Results

Four different LEED certification scenarios were generated for each building type. Based upon this evaluation, the following percentage cost premium has been identified for each of the notional building types. It is however noted that these percentage increases are dependent upon the base construction costs, as provided by NAVFAC, and are therefore provided for guidance only. In addition, these figures relate to the cost of achieving LEED Silver at the targeted level of energy performance required to meet the overall sustainability program goals, as outlined in Section 3.2. It is noted that for the majority of building types, these targets are higher than both the minimum energy performance requirements to meet LEED certification and the federal mandate energy targets, therefore the cost of achieving LEED certification is increased due to the additional cost of achieving the energy goals.

While it is evident that some of the building types indicate a significantly lower percentage cost premium for LEED Certification, this is primarily due to those building types having a much higher baseline cost per square foot. Therefore, should the baseline costs for those building types be revised during the project, the LEED cost premium (when stated as a percentage of the baseline construction cost) would increase accordingly.

These cost premiums are in general higher than those seen to achieve LEED Silver on the US mainland. There are a number of reasons for this:

- The project is also looking to achieve the energy reduction requirements of EISA:2007 and EPAct 2005.
- The remote location of the facility eliminates the potential use of a number of the sustainable site credits.

Building Type:	ECM Package to meet the target	Construction Cost Increase(%) to meet project target (Energy Infrastructure)*	LEED Certification Level Target	Construction Cost Increase(%) to achieve LEED (excluding energy infrastructure) *	Approx. % Total Construction Cost Increase*
Single Family	Baseline	3.5%	-	-	3.5%
Duplex	Baseline	3.0%	-	-	3.0%
5 Story HQ Office	Option C	4.0%	Gold	2.0%	6.0%
3 Story HQ Office	Option B	4.5%	Silver	1.5%	6.0%
2 Story HQ Office	Option B	5.0%	Silver	2.0%	7.0%
1 Story Small Office	Option A	4.5%	Silver	2.5%	7.0%
Organic Storage Warehouse	Option B	6.0%	Silver	2.0%	8.0%
General Storage Warehouse	Option B	12.0%	Silver	2.5%	14.5%
Day Care Center/Community Center	Option A	1.5%	Silver	2.0%	3.5%
Commissary	Option A	3.5%	Silver	1.5%	5.0%
Dining Facility	Option B	5.0%	Silver	2.0%	7.0%
BEQ - 6 Story 300 Occupant	Option C	3.0%	Silver	1.5%	4.5%
School	Option A	2.0%	Silver	1.5%	3.5%
Workshop	Baseline	1.5%	Silver	2.0%	3.5%

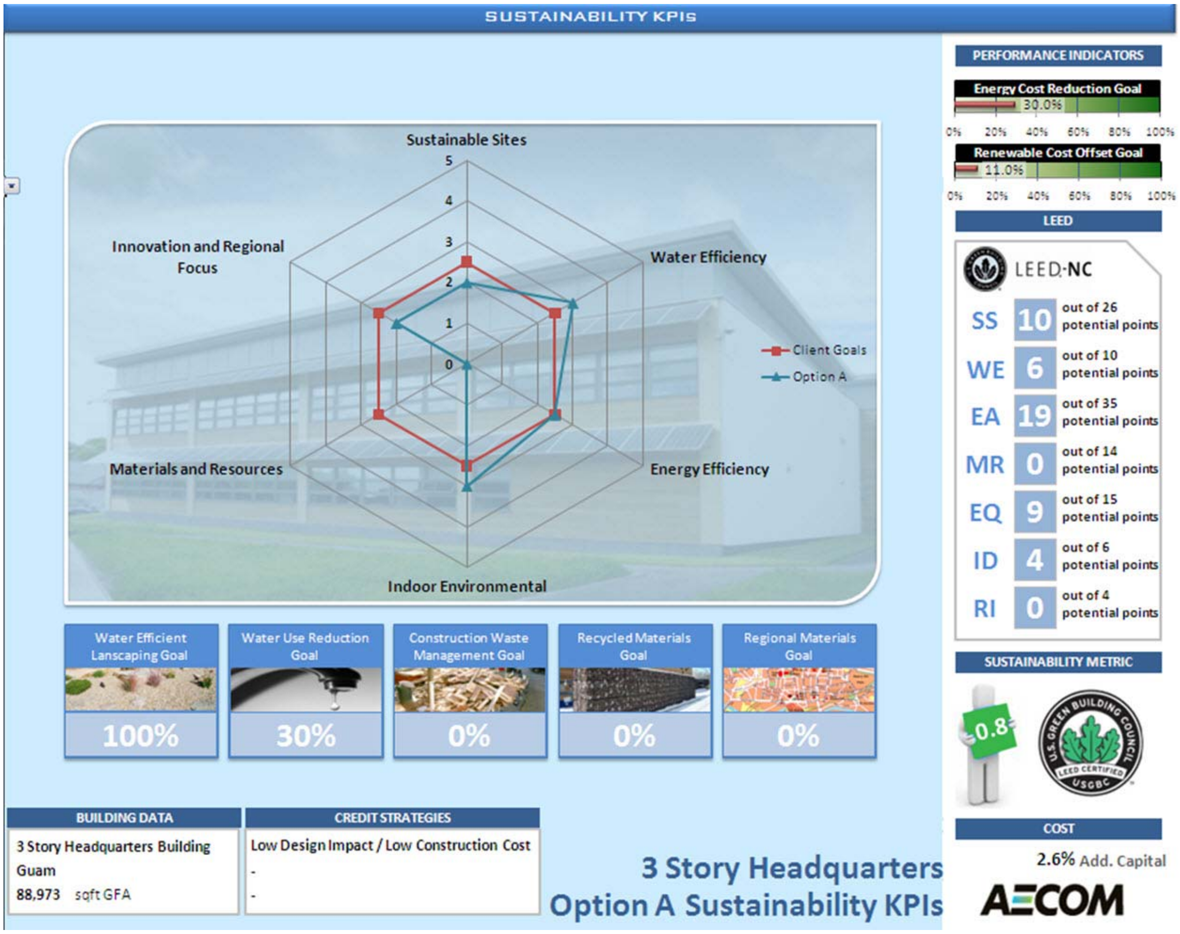
*% Construction Cost Increase is measured against standard construction

TABLE 3-9: LEED Cost For Building Types

- Guam does not currently have any regional focus credit strategies defined, which means that they cannot be relied upon, thus eliminating five potential points from consideration.

Recommendations

All scenarios proposed as part of the LEED analysis are designed to meet the overarching federal requirements (of a 30% improvement over ASHRAE and 55% improvement in fossil fuel use relative to a 2003 CBECS baseline) and to do so while achieving the LEED Silver Certification. This study has however indicated that for a minor additional premium, LEED Gold can be achieved.



BUILDING DATA

3 Story Headquarters Building
Guam
88,973 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

FIGURE 3-11: Sample SSIM^{TM} LEED Dashboard

Table 3-9 identifies the initial recommendations as to the percentage cost allowances that should be made prior to the development of a DD 1391 to cover the total cost of achieving LEED Certification, excluding the cost of any LEED Review fees. **It is noted that the average construction cost increase needed to achieve LEED Silver of approximately 4.5% is in line with those projects currently in development in Guam.**

In defining the ROM costs for the LEED study packages, it is recognized that this is a master planning level study, therefore the credits proposed may not be applicable to all buildings on the site, may require further investigation and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study. As such the results of this study do not represent a prescriptive checklist for achieving LEED certification that can be applied to each building type. As each building is designed and constructed, the individual designer will have responsibility for the selection of systems, energy conservation measures and LEED credit strategies to ensure compliance with the federal mandates and sustainability goals for the base.

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum levels of LEED certification performance that should be achieved, with the potential for providing additional credit for achieving LEED Gold during the bid evaluation process. The credit strategies proposed above (and detailed in the Technical Appendix) can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, these should not be used as prescriptive requirements for achieving compliance in each building type.

During the design and construction process it is recommended that a review team oversees the LEED certification documentation submitted for each building to ensure compliance with the performance goals outlined above. This should be a multi-phase approach that involves the validation of initial concepts and then continues to full documentation of the final design.

CASE STUDY: The Villages at Belvoir—Military Family Housing, Fort Belvoir, Fairfax County, Virginia

Under the U.S. Army's Residential Communities Initiative, a private developer and the Department of the Army (DA) formed a 50-year public-private partnership to develop 2,070 homes located in 12 villages throughout the 8,656 acres of Fort Belvoir

Fort Belvoir is home to one of the Army's major command headquarters; 19 different agencies; eight elements of the U.S. Army Reserve and the Army National Guard; 26 DoD agencies; a Marine Corps detachment, a U.S. Air Force activity; and an agency from the Department of the Treasury.

Design Components:

- The Congress for the New Urbanism 2006 Charter Awards honor the Villages at Belvoir for the exceptional designs that complement, enhance, and repair their built and natural environments
- Homes are closer to the street and garages are loaded from rear alleyways to hide automobiles
- Pedestrian-friendly streetscape is accentuated with wide sidewalks, front porches, stoops, street trees, and generous open space
- First-ever mixed-use development with "Main Street Retail" and "live/work" unit on an Army post

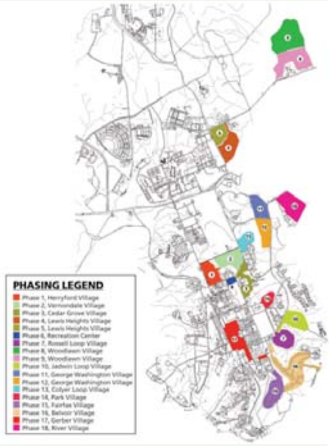
Sustainable Components:

- More than 1,000 new homes equipped with more efficient heating and cooling systems, as well as ENERGY STAR® certified appliances
- New Urbanism Master Planning for new villages focuses on compact, infill development to preserve land but also foster a sense of community
- Planting 3,000 new trees and another 1,000 being preserved
- Compact Fluorescent Light bulbs in all new homes
- Modernized Stormwater Management
- Construction Waste Recycling and Neighborhood Recycling, 80,000 tons of concrete have been recycled on-site for use as structural fill within the site work phase of development
- Fairfax Village Neighborhood Center achieved LEED® Platinum certification

The Future:

- Green education program provides significant educational value for both Fort Belvoir residents and the general public
- Partnership with the Audubon Society of Northern Virginia to increase environmental awareness of the local bird population
- A Utility Residents Responsibility Program to provide residents with report of their consumption and costs compared to the allowance for their home

Fort Belvoir Family Housing
Phase 15
August 24, 2008



Guam Existing Landscape

3.4 Transportation

Introduction

Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance (EO 13514) requires a 30% reduction of petroleum in fleet vehicles (non-combat vehicles) and a reduction of greenhouse gas emissions. Following EO 13514, guidance was provided by the DoD to target a 34% reduction of greenhouse gas (GHG) emissions. Because vehicle associated travel or vehicle miles traveled (VMT) is a significant contributor of GHG emissions, the GJMMP Sustainability Program addresses reduction of VMT and incorporates a sustainable mobility program.

Based on the goals and strategies identified in EO 13514, the following transportation goals were developed for the GJMMP Sustainability Program:

- Meet or exceed the mandates described in EO 13514
- Reduce vehicle miles of travel
- Develop a transportation system that complements the land use plan
- Develop intuitive, user-friendly programs that fit well with the travel patterns, needs, and the environment on Guam

Similar targets are reinforced by other federal policies including Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management, signed by President George W. Bush on January 24, 2007 and the Energy Independence and Security Act of 2007 (EISA 2007). Both of these policies required federal agencies to reduce their vehicle fleet petroleum consumption by 2% annually through 2015 as compared to a 2005 baseline (a 20% reduction). It also requires increases in non-petroleum based fuel by 10% annually and use of plug-in hybrid vehicles when life-cycle costs are competitive with standard vehicles.

Neighborhood Electric Vehicle on Guam

ALNAV 068/09 also addresses the need for reducing petroleum based fuel consumption and increasing alternative energy sources. This policy states, by 2015, the Navy will reduce its petroleum use by 50 percent through the phased adoption of hybrid, electric, and flex fuel vehicles.

Process

The approach shown in Figure 3-12 was used to develop the transportation strategies and estimate their efficacy and cost. Three packages of transportation measures, Package A, B, and C, were defined; and then refined through the process outlined below based on feedback and insight from the GJMMP Sustainability Team. A detailed list of the strategies in each of the three packages and their effectiveness and cost, along with a description of the modelling approach and assumptions is located in the Technical Appendix.

Transportation strategies were grouped in to five broad categories as described in the packages:

- Parking and Demand Management
- On-Base Circulation
- Off-Base Circulation
- Active Modes
- Vehicle Fleet

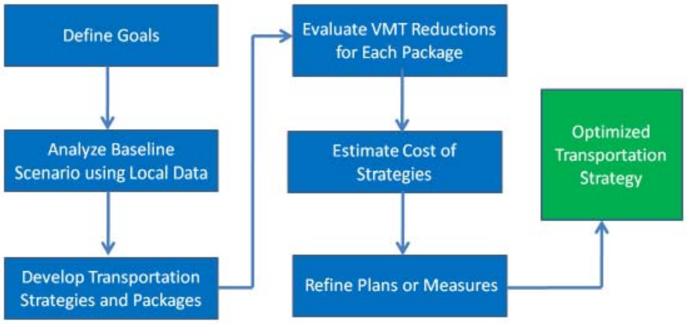


FIGURE 3-12 Transportation Process Diagram

Recommended Strategies

The Preferred Package strategies for each category are defined in Table 3-10. Each strategy's relative effectiveness, capital, and operating costs as compared to baseline conditions are also summarized. Detailed supporting information on the development of these measures, their efficacy and cost can be found in the Technical Appendix.

Summary of Performance Results

This Preferred Package exceeds the mandates as part of EO 13514 to achieve a 30% reduction in petroleum consumption of the vehicle fleet by 2020. The Preferred Package also exceeds the mandates of EO 13423 and EISA 2007. Assuming the same vehicle miles are travelled regardless of the fleet composition, the change in fuel consumption from gasoline to hybrid vehicles will produce the mandated reduction. Direction from the Transportation sustainable focus group is that electric only vehicles are currently not planned to be included in the vehicle fleet other than on-base NEVs (Neighborhood Electric Vehicles). Overall, the strategies defined as part of the Preferred Package result in approximately an 8.3% reduction in VMT over baseline conditions. This is a commendable reduction in VMT. These strategies will continue to shift travel behavior and social norms over time as alternative transportation modes are provided and made accessible and convenient.

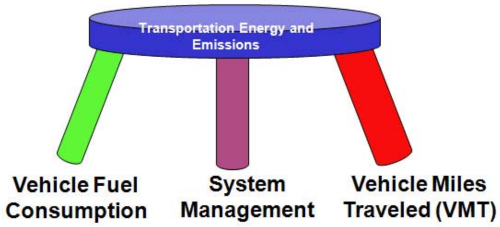


FIGURE 3-13 Transportation GHG Diagram

Conclusion

The GJMMP sustainability transportation program provides feasible and implementable solutions to reduce number of vehicle trips generated by the base, vehicle miles travelled, number of vehicle trips and gallons of gasoline associated with fleet vehicles. Overall the package results meet the federal mandates, saving 1.9 million gallons of gasoline a year and reducing VMT by approximately 8.3%.

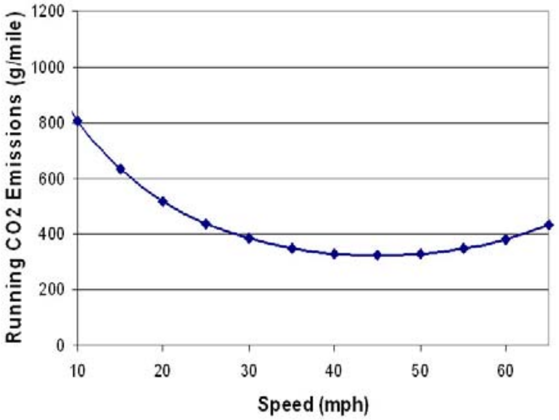


FIGURE 3-14: Transportation GHG Emission Rates

Element	Strategy	Performance (Reduction Of Vmt)	Approx. Capital Costs	Approx. Operating Costs
PARKING AND DEMAND MANAGEMENT	• Land bank area for 1730 spaces or 8% of total and provide car share and NEV parking • Limit Transient Auto Ownership (not including UDPs) • TDM (Transportation Demand Management) Program Incentives and Full-Time (40 hrs/wk) Coordinator	4.6%	($3,890,000)	$160,000
ON-BASE CIRCULATION	• No On base Shuttle (in this program however, an on base shuttle has been discussed with MARFORPAC and HQMC, detailized below:) • *On-base Shuttle:15-minute headways during peak periods, 30-minute other hours* • *Operates 12 hours/day on weekdays and 12 hours/day on weekends*	Potential Benefit & Cost *0.4%*	*$3,000,000*	*$2,310,000*
OFF-BASE CIRCULATION	• Operates during peak hours (6 round trips/day) • 30-minute headways during 6am – 6pm; hourly otherwise • Shuttle and Guam Transit have convenient transfer schedules	3.1%	$200,000	$0
ACTIVE MODES	• Bike share program with 100 bikes, multiple racks/stations • Pedestrian improvements at 30 intersections (e.g., curb extensions, wider paths)	0.3%	$210,000	$0
VEHICLE POOL	• 60% Hybrid • Neighborhood Electric Vehicle program with minimum of two stations. NEVs would be purchased as part of vehicle fleet • Car share program with 100 cars, minimum of two stations	0.0%	$0	$0
TOTAL		8.3%	($480,000)*	$2,680,000*

*** Including costs of potential on-base circulation measures**

TABLE 3-10: Recommended Transportation Package

3.5 Ecosystem Services

Overview

Ecosystem Services in the GJMMP directly impact three areas of the base:

1. Quality of life
2. Habitat enhancement
3. The ability to reduce GHG emissions (a goal and target of Executive Order 13514)

Ecosystem Services in the GJMMP Sustainability Program focuses on three aspects of ecosystem services: habitat friendly design strategies, carbon sequestration and local food production.

HABITAT FRIENDLY DESIGN STRATEGIES

Because of the impact to existing habitats by proposed development, as identified in the Draft Environmental Impact Statement (DEIS), an opportunity exists to apply habitat friendly design strategies.

Process

As an integrated part of planning process, the GJMMP team has conducted site assessments including an inventory of on-site and adjacent offsite conditions; as well as evaluated topography, soils, hydrology, vegetation, and water features to assist in identifying habitat related issues and concerns. Concerns are identified in the DEIS and the LID Study. The Sustainability Program recommends habitat enhancement strategies are in concert with the LID study.

Ecosystem Services:

Ecosystem services are the benefits people obtain from ecosystems. This includes benefits from natural assets (soil, air, water, flora and fauna), and the economic and social values inherent in these services and the opportunities that can arise from considering these services more fully in master planning contexts.

Guam Existing Landscape

Recommended Strategies

Following are a number of recommended strategies related to habitat friendly design for incorporation into the GJMMP:

- Enhance greenbelts for watershed protection, wildfire control, and restoration of habitat
- Integrate community fruit gardens with reforesting areas or “plots” to improve habitat
- Provide links with ecological corridors between open space areas. In addition, provide recreation opportunities, pedestrian and bicycle corridors and improved connectivity of the open space network. Green links help to reduce urban heat island effects,

improves microclimate and provides opportunities for carbon sequestration.

- Integrate stormwater drainage networks to create a natural system for the conveyance, storage and infiltration of stormwater, reducing the need for hard infrastructure
- Provide a comprehensive sustainable trails system connecting together the base (See Technical Appendix for details)
- Utilize entitled native plants in landscaping designs (See Dr. Anne Brooke's "Landscaping with Native Plants: Navy Base Guam")
- Coordinate with Biosecurity Plan and existing high quality habitat with perimeter fencing to exclude invasive animals and for establishment of foraging plots
- Where feasible, transplant existing vegetation that may be disturbed due to construction activities
- Provide habitat friendly guidelines to homeowners to create backyard habitat for birds
- Coordinate with University of Guam Agriculture extension to provide education opportunities to homeowners on habitat friendly planting guidelines and biosecurity
- Install informational signage at focal points throughout the greenbelts and other existing accessible forest areas to provide information as to the type of ecosystem, types of flora and fauna, especially endangered species.

Conclusion

Because of the impact on existing habitat, the Sustainability Program recommends the master plan incorporates habitat friendly design strategies as noted above to minimize impacts on existing resources.

CARBON SEQUESTRATION

Carbon sequestration is an increasingly important consideration in GHG inventories. A project wide landscape strategy with maximized carbon sequestration effect has become one of the most cost-effective ways in helping offsetting greenhouse gas emissions. As stated in Executive Order 13514: "… pursuing opportunities with vendors and contractors to address and incorporate incentives to reduce greenhouse gas emissions..." Therefore, it is important for NAVFAC to coordinate the landscape design and planning to ensure optimum carbon sequestration potential when developing the Installation Appearance Plan (IAP) and other related documents.

Process

The carbon sequestration analysis for the GJMMP involves four steps: 1) develop landscape prototype; 2) select complete land cover type; 3) select vegetation species; and 4) compute carbon reductions.

Step 1

There are five primary landscape prototypes identified in the GJMMP:

- Park Landscape
- Streetscape (median, parkways, landscape setbacks etc.)
- Residential Landscape
- Open Space Landscape
- Preserved Areas

Step 2

For each landscape prototype, proper assumptions on tree/shrub planting density and coverage are made by experienced landscape architects.

Step 3

Selection of species are based on the recommended species list in Dr. Anne Brooke's "Landscaping with Native Plants: Navy Base Guam".

Step 4

The carbon sequestration rates for each tree/shrub are identified for the model calculation. Baseline, Option A, B, and C scenarios are developed with increasing carbon sequestration effect.

Carbon Sequestration:

Carbon Sequestration is the process by which atmospheric carbon dioxide is absorbed by trees (and vegetation) through photosynthesis and stored as carbon in biomass and soils.

Guam Existing Landscape

Recommended Strategies

- Include planting (existing and proposed) occurring on base to assist with reducing the total carbon footprint of the GJMMP through carbon sequestration calculations.
- Understand the impact of super typhoons on the survival of trees by incorporating a viable clustered tree concept. Such urban forest cover in the developed environment provides additional environmental benefits by reducing ozone and other air quality problems, reducing the “urban heat island effect”, reducing building energy use through shading, and providing habitat for wildlife.The following planting types identified in Table 3-11 are noted with relative strategy:

Carbon Sequestration Planting Types	
Park Landscape	• Regular Planting with 50% native species • 13 trees per acre
Streetscape	• Regular Planting with 50% native species • 70 trees per mile
Residential Landscape	• Regular Planting Palette • 7 trees per acre
Open Space	• Regular Planting with 50% native species • 16 trees per acre
Preserved Area	• Undisturbed

TABLE 3-11: Baseline Carbon Sequestration Package

Guam Existing Trees

FIGURE 3-15: Section Examples of Carbon Sequestration Concept

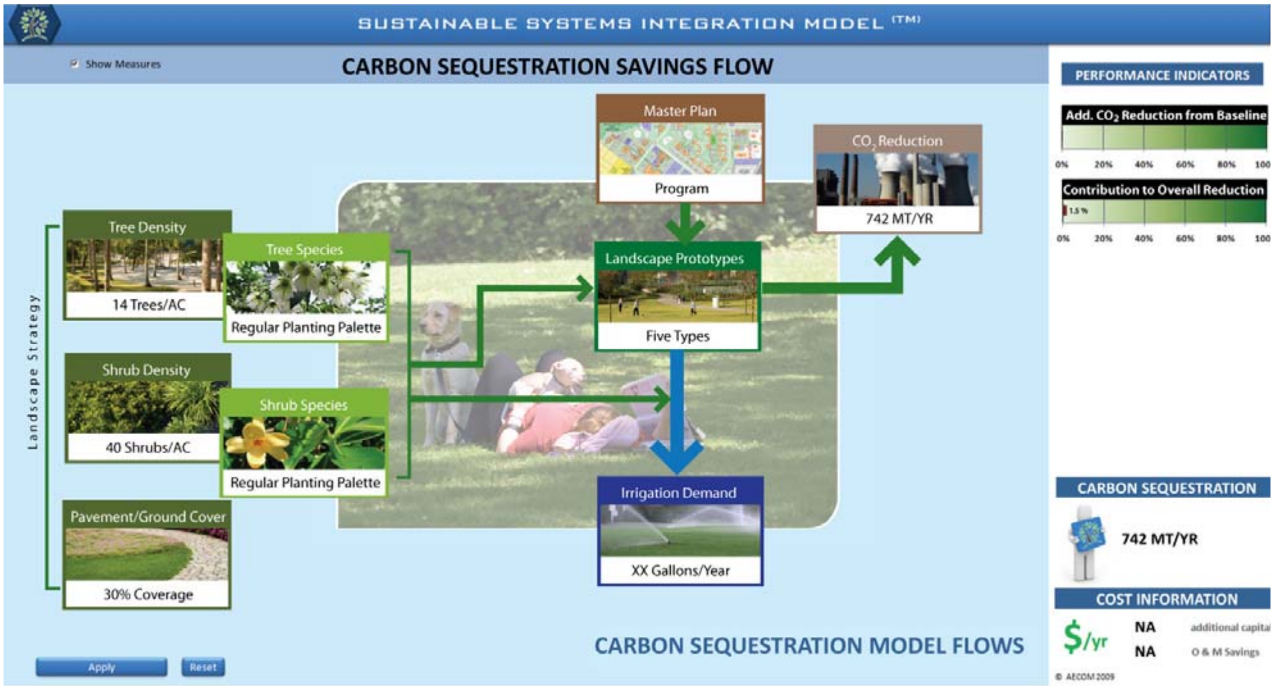


FIGURE 3-16: Carbon Sequestration Dasboard

PARK LANDSCAPE: Utilize native/adapted trees planted in clusters (for typhoon protection); provide shade and amenity to the surrounding communities.

STREETSCAPE: Trees planted along streets, in the median, and parkway areas shall include species that have higher carbon sequestration values while meeting the base appearance objectives.

RESIDENTIAL LANDSCAPE: The front yards and back yards of the family housing area present opportunities to reduce building energy use through shading as well as capture the carbon sequestration benefit.

OPEN SPACE: The open space areas on base should focus on improving disturbed site conditions, selecting more native species with high carbon sequestration rates, minimizing the amount of maintenance related emissions; and designing the reforestation plan to maximize long-term survival of trees.

PRESERVED AREA: Most of the 800 acres of preserved limestone forest will remain intact, proper long-term forestry management practice as the primary measure will help to increase carbon sequestration potential.

Conclusion

Plant the proposed base according to the IAP and the recommended carbon sequestration strategies identified below to assist with the reduction of greenhouse gas emissions from the base. Table 3-12 shows a cost/benefit summary.

Summary of Cost/Benefit	
Carbon Sequestration (Metric Tons of CO^2 Equivalent Per Year)	742
First Cost (in $1,000)	3,191
Sequestration Benefit per $1,000 investment (MT CO^2 Per Year)	0.23

TABLE 3-12: Baseline Carbon Sequestration Benefit/Cost

COMMUNITY AGRICULTURE/ LOCAL FOOD PRODUCTION

Introduction

The Sustainability Program for the GJMMP has identified a practical and expandable local food production program for the proposed base to:

- Foster a “good neighbor” policy with local farmers
- Provide opportunities for the community inside the fence to interact and with the University of Guam and the local community outside the fence
- Grow local fruits on site in neighborhood fruit gardens (on a small scale) for use, education, carbon sequestration (reduction of overall GHG emissions) and to enhance habitat areas
- Earn additional LEED NC points through innovation credits

Process

Local food production for Guam can be grouped into two categories: 1) Small Scale Neighborhood Fruit Gardens, and 2) Community Supported Agriculture (CSA). Both are local food systems representing farmers who market and sell directly to consumers or food buyers that contribute to food miles within 150 miles from the project site. A local food production emission reduction model was designed to quantify the reduction fuel usage and emissions by recommending a local food production policy for the GJMMP. Three packages (A, B and C) were designed with increasing scale of application. (See Technical Appendix Report for option details).

Local Food Production

Promotes community-based food production, improves nutrition through increased access to fresh produce, supports preservation of small farms producing a wide variety of crops.

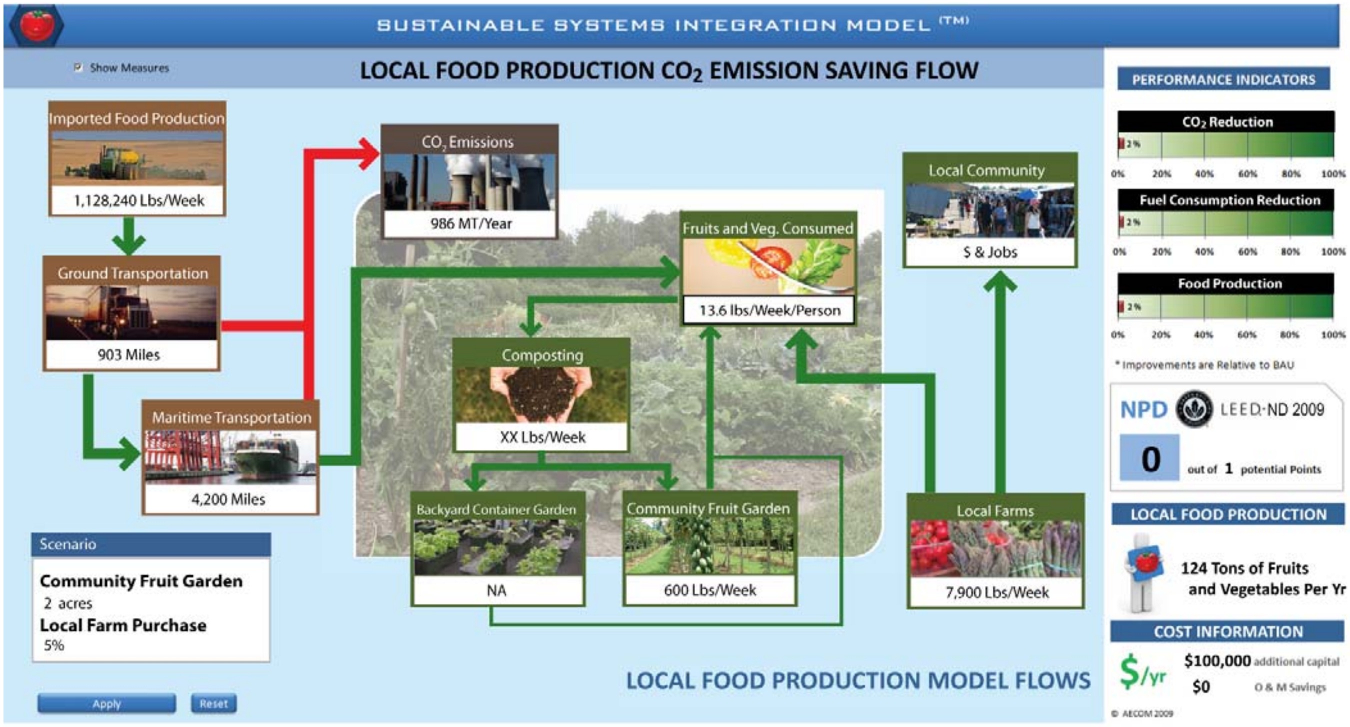
Recommended Strategies and Conclusion

Table 3-13 indicates the recommended local food production strategy (Package A) for its minimal costs and ease of implementation at a small scale that could be expanded in the future. It is also noted by the stakeholder group and sustainability team that the program can serve as a pilot program for potential future expansion.

Local Food Production:	Recommendation:
Community Fruit Garden	2 acres Fruit Garden in Family Housing Area; Operated by families (in conjunction with the QOL areas) with training from University of Guam Agriculture Extension Program
Local Farm Purchase	Approximately 5% of weekly consumption; Purchase through commissary, dining facilities, schools, etc.
Total Reduction on Fruit & Vegetable Importation	272,160 lbs per year
Total CO² Equivalent Reduction Per Year	17 MT per year
CO² Reduction from Food Importation “no-local-food baseline”	2%
First Cost*	$100,000

TABLE 3-13: Local Food Production Package & Benefit

*First cost for setting up community garden



Scenario

Community Fruit Garden
2 acres
Local Farm Purchase
5%

* Improvements are Relative to BAU

0 out of 1 potential Points

124 Tons of Fruits and Vegetables Per Yr

$100,000 additional capital
$0 O & M Savings

FIGURE 3-17: Local Food Production Gameboard

CASE STUDY: Naval Weapon Station, Seal Beach, Orange County, California

- The Station comprises 5,000 acres of land located on the Pacific coast
- 920 acres within the southwest portion of the station have been designated as the Seal Beach National Wildlife Refuge
- One of the last natural wetlands preserves surrounded by highly developed urban areas

Naval Weapons Station (NAVWPNSTA) Seal Beach is the headquarters for Navy Munitions Command CONUS West Division and its detachments, which provides ready-for-use ordnance to approximately one-half of the fleet combatants of the U.S. Pacific Fleet.

Design Components:

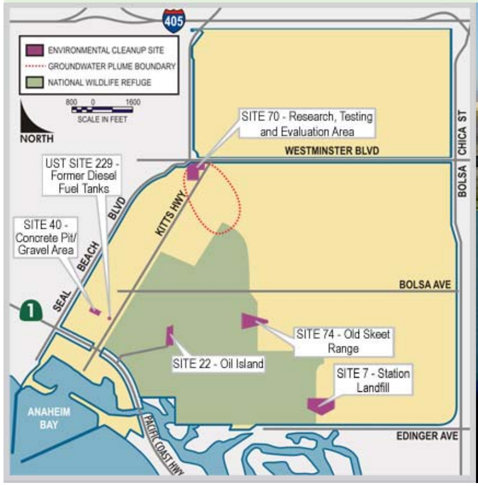
- Secretary of Defense Environmental Awards for Natural Resources Conservation - Small Installation, Fiscal Year 2007
- Wildlife Refuge buffers the Station from the surrounding metropolitan area
- The Station insulates the Refuge from the encroachment of new projects
- Natural Resource Program oversees two agricultural out-leases that encompass over 2,500 acres
- The program supports the Station mission through the avoidance of fire and security hazards, as well as, manage the area for agriculture farming

Sustainable Components:

- Environmental Management System will manage the Station’s Natural Resources in support of military mission
- Manage, protect, and enhance the populations of endangered, threatened, and at-risk species and their habitat
- Partner with outside organizations to leverage their expertise and support for natural resource management
- Involve the Station and surrounding community in programs that enhance and protect natural resources and increase awareness and appreciation of these resources
- Natural Resource program generates nearly $1,000,000 annually for the Department of the Treasury that supports a sustainable agricultural program

The Future:

- Ongoing stewardship program for preserving sensitive ecosystems and enhancing beneficial wetlands habitat for migratory, endangered, and threatened bird species



4. Integration of Sustainability into the Master Plan

Overview

Integration of sustainability into the GJMMP has occurred for the North Finegayan site through each of the sustainable systems and the overall program. Sustainability is clearly evident and readily visible, but can also be subtle and less evident or visible. As an example, the integration of sustainability is readily visible in the form of solar panels and cisterns for rainwater catchment. However, it is less than visible in the form of building orientation, “green” buildings, bio-swales, and construction waste management. As part of the GJMMP process, the Sustainability Program has focused on effective and implementable systems that can be strategic and tactical in order to meet all applicable federal mandates at the lowest possible cost.

Recommended Sustainability Strategies

Sustainability components proposed for the master plan include the following organized by land use or site design.

Land Use:

- Utilize compact, mixed use development centers where feasible such as in the family housing Quality of Life area. This will encourage walking, gathering and reduction of vehicle trips and vehicle miles traveled
- Develop a green infrastructure system of open space, trails, and recreation. See the trails master plan found in the Technical Appendix
- Provide for community fruit gardens adjacent to preserve areas to create an opportunity for habitat enhancement, local food production, and education
- Allocate land for LID such as bio-swales, rain gardens, stormwater retention, check dams, drywells, etc.
- Incorporate water balance planning in the form of duel uses of facilities such as stormwater retention and recreation areas
- Create opportunities for shared use parking to minimize parking requirements, thereby minimizing impervious surfaces
- Create walkable neighborhoods in the family housing area with access to parks, open space, and schools
- Seek locations for onsite renewables such as solar farms in setback areas where feasible

Site Design:

- Site buildings for optimum passive solar orientation when feasible
- Plan for on-site transportation systems such as a shuttle system, shared bike program, and car share program
- Utilize highly reflective (albedo) materials when possible to minimize “urban heat islands”
- Plant streets, open space, parks and front yards/ backyards with native or adapted native vegetation to

enhance habitat, restore disturbed sites, and create shade and opportunities for carbon sequestration

- Many of these strategies have already been and are currently being integrated into the current master planning process. To ensure success of these strategies from planning through construction, a strong implementation program will be required. See the Implementation Strategy section of this document for more information.

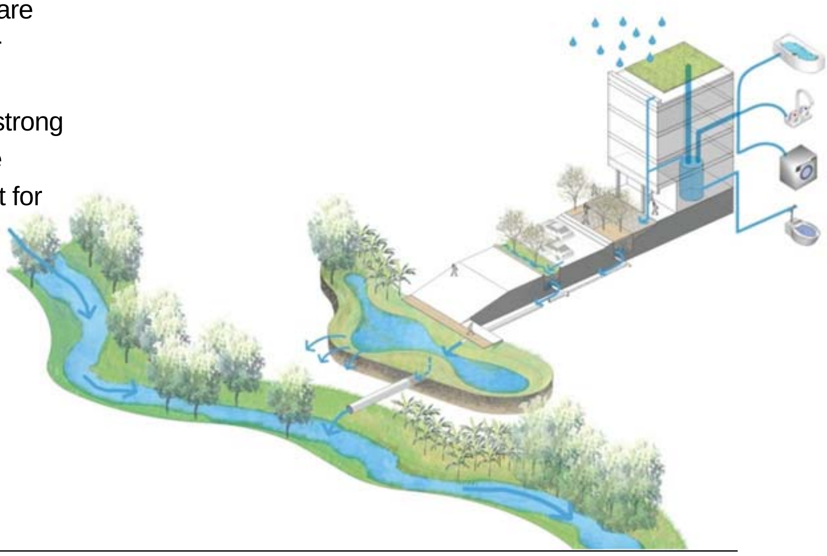


FIGURE 4-1: Example of LID is Coordinated With the Sustainability Program and the Site Pan

CASE STUDY: Treasure Island, San Francisco Bay Area, CA

- 393 ac. master planned development
- Client: Treasure Island Community Development
- Design Team: Arup, BKF, SOM

Main Design Components:

- Dense, compact, walkable design with easy access to transit
- Maximized access to a variety of open space and parks
- Self sufficient community
- Street and building orientation to maximize the sun effect and minimize wind impact

Main Sustainable Components:

- Resources are used efficiently and replenished over time
- Effective use of the sun, wind, climate, and tree canopy
- Walkable, bikeable streets
- Thriving mixed-income, cross-generational community in a self sufficient, urban setting
- Sufficient on-site education, recreation and cultural opportunities

5. Sustainability Program Implementation Strategy

Implementation of the GJMMP Sustainability Program will require an ongoing process throughout planning, design, construction and monitoring/reporting. To ensure the proposed 14+ million square feet of new construction meets LEED Silver and the various federal mandates, a thoughtful, well crafted implementation program will need to be developed and refined.

Although an implementation program is not part of the Sustainability Program's current scope effort, the following items have been identified as key elements of the Implementation phase that would define, communicate and monitor the various specific goals and requirements of the GJMMP Sustainability Program.

- **Minimum Performance Standards:** A key element of the implementation process is the communication of the increased performance standards to the various design and construction teams that will be involved in the various packages of work developed as part of the overall phased build out. While these performance requirements have been demonstrated to be viable within a reasonable economic payback, the associated study package of measures is not a prescriptive method of compliance and the method in which they are achieved will remain the responsibility of the individual project team. Providing a performance rather than prescriptive based approach has a number of benefits to NAVFAC, namely that it provides the design team the flexibility to develop strategies that are best suited for each particular project site in as cost effective a manner as possible and also that it allows for the future inclusion of future, new technologies as part of these strategies without changes being required to the minimum performance standards themselves. Many Authorities Having Jurisdiction (AHJ) have either moved or are in the process of moving to performance based standards for exactly that reason.

  This type of performance based metric is applicable to a number of elements of the GJMMP program, including building water and energy usage as noted below. During the implementation phase, the full spectrum of these elements will be identified and appropriate performance based requirements defined.

- **Minimum Energy Performance Standards by Building Type** (See Table 3-4, Page 27)
- **Minimum Water Performance Standards: overall installation meets 26% potable water use reduction**
- **Program-wide Sustainability Initiatives:** In addition to the performance based requirements noted above, there are other elements of the program that fall into the realm of Initiatives. A number of such initiatives were discussed with the sustainability working group in Honolulu on March 24, 2010, including the following information found in the Table 4-1 to 4-5 found on following pages.
- **Standard Sustainability Performance Requirements and Language for 1391s**: In order to ensure that the various sustainability requirements are adequately accounted for within the phased procurement process it is essential that in the necessary requirements are included within the 1391s performance requirements. During the

implementation phase of the GJMMP Sustainability Program, it is proposed that standard language be developed that clearly defines the overall program targets and performance requirements for each element (i.e. water, energy, transportation) and building type (i.e. BEQ, office, duplex, etc.). This language would then be included in all future 1391s developed during the phased procurement of the GJMMP Base.

- **Standard Sustainable Specifications**: A key element in the success of such a wide arching, multi-phased sustainability program is consistency and standardization. This is even more important in this case given the remote geographic location. It is therefore proposed that during the implementation phase, a detailed review would be undertaken of the current NAVFAC specifications and additional language developed as required to ensure that the sustainability goals and requirements of the program are adequately captured, all federal mandates are met and any program wide initiatives or standards are stipulated to ensure consistency among systems and building types. This specification augmentation effort will need to be developed in concert with the common components study.
- **Common Components for Sustainability**: It is recommended that the current “Common Components Study” is reviewed and expanded as necessary to ensure that high performance standards are mandated. This assists in meeting federal targets and reducing operational and maintenance costs, while fulfilling the federal procurement requirements.
- **LEED Database:** It is recommended that GJMMP develop a LEED website, such as SharePoint, to serve as a database or clearing house of credit information. This tool will ensure that information relating to the early phases of the site improvement projects is not lost and is easily accessible by each subsequent LEED project. Such information will include any Base- wide stormwater strategies as well as any base-wide initiatives, with each team taking this information and adapting as necessary before posting to LEED-Online. LEED scorecards and credit interpretation from each project should also be posted to ensure compliance and share resources.
- **GJMMP LEED Prerequisite credits**: One way of ensuring that the goals of the Sustainability Program are successfully communicated to the design and construction teams is through the translation of these goals into additional prerequisite credits that must be achieved by all buildings as they achieve the LEED Silver Mandate requirement. The full list of LEED pre-requisites will be developed during the Implementation phase, but are likely to include the following:
    - SSc4.2 – Alternative Transportation – Bicycle Storage and Changing Rooms
    - SSc4.3 – Alternative Transportation – Low Emitting and Fuel Efficient Vehicles
    - SSc6 – Stormwater Design
    - WEc1 – Water Efficient Landscaping
    - WEc3 – Water Use Reduction
    - EAc1 – Optimized Energy Performance
    - EAc2 – Onsite Renewable Energy
    - EAc3 – Enhanced Commissioning
    - EAc5 – Measurement and Verification
    - MRc4 – Recycled Content
- **Sustainable/LEED Implementation Team:** It is recommended that a team of individuals well versed in sustainable construction at a large, “Greenfield” development scale to ensure federal compliance at least amount of cost is developed to manage implementation of the Sustainability program. This team of experts will need extensive experience in applying LEED on complex, integrated, multi-phased development projects.
- **Sustainability Manager Checklist and Data Forms:** Develop a detailed checklist and corresponding data forms for the Sustainability Manager to ensure design reviews, from the initial 139 to final design submittals, is not just focused on

CASE STUDY: Ladera Ranch (Terramor), Orange County, CA

- 4,000 ac. master planned community
- 8,100 residential units
- Client: Rancho Mission Viejo
- Design Team: EDAW, William Hezmalhalch Architects

Main Design Components:

- Non-gated community
- Neighborhoods linked by social, recreational, and innovative technological connections
- Architecture forward design
- Mixed density neighborhoods with different characteristics

Main Sustainable Components:

- Biofiltration & water treatment system
- Enhanced energy conservation
- Pedestrian friendly streetscapes with reduced street width
- Diverse educational system
- Two-thirds of area preserved for open space
- Enhanced water conservation
- New construction recycling
- Residential green building program
- PV on more than one-third of homes

budget allocation for LEED but demonstrates the necessary items for compliance with the Sustainability Program and all federal mandates. This checklist would identify each of the key metrics, defined in the sustainability submittal requirements discussed below, that must be demonstrated by each design team to demonstrate compliance.

- **Sustainability Submittal Requirements:** Develop a list of submittal requirements for each stage of the design process, from the initial 1391 to final design submittals, to demonstrate compliance with the Sustainability Program's requirements. These would include each of the key metrics, including energy and water performance that must be demonstrated by each design team to demonstrate compliance. As part of this effort, standard templates should be developed to ensure consistency in submittals between projects.
- **Advanced Metering:** A coordinated metering program will need to be set up with "pulse meters" as part of a site-wide "advanced metering solution" according to Navy and Marine specifications and in line with the federal mandate requirements. The information generated by these meters will then be utilized to provide the necessary monitoring and reporting required to demonstrate compliance with the energy and water efficiency requirements of the federal mandates and Executive Orders.
- **Monitoring and Reporting:** Developing and implementing a comprehensive sustainability monitoring and reporting program will provide a number of benefits to the GJMMP program. In addition to simplifying the increasing mandate performance requirements, it will also assist in identifying inefficient elements of the program and inform a proactive operations and maintenance strategy.
- **Sustainability Dashboard:** A Sustainability Dashboard is recommended as a "web-based visual report card" to see how effectively sustainable strategies are being implemented in compliance with the federal mandates. This dashboard could be multilevel, providing varying levels of information to different types of users – i.e. DPW; Base Commander and NAVFAC Central Command.
- **Sustainability Education:** An education program for those involved in implementation (such as an advanced LEED implementation course for large scale Greenfield development) and ongoing contractor education goes a long way in ensuring compliance with the federal mandates. The education program can be set up as a web-based on-line resource to minimize cost and maximize participation.
- **Construction Waste Recycling:** In order to minimize impact on Guam's landfill, save on cost and achieve LEED points, a comprehensive construction waste recycling program is required. (See also the latest document on Construction Waste Recycling issued by NAVFACPAC.) This coordinated effort will need to be fully established to ensure contractor compliance and to minimize cost of operations.
- **Green Waste Recycling:** Green waste recycling from grass clippings, leaves and debris should be incorporated into the master plan and bio-security plan to ensure the program reduces waste, enhances soil amendments and serves the new base effectively.

Additional Resources for Large Scale Sustainable Development

The GJMMP Sustainability Program recommends a full implementation program be developed by NAVFAC to ensure the federal mandates are met or exceeded. Implementation of the GJMMP Sustainability Program is a daunting task when considering the timing, complexity and scale of the new base—over 14 million square feet of new construction. However, there are good examples of complex, sustainable Greenfield developments to draw from. A few of these case studies are summarized in the Technical Appendix of this document such as Terramor at Ladera Ranch in southern Orange County, California. In addition, numerous projects are illustrated in the Urban Land Institute (ULI) book entitled: Developing Sustainable Planned Communities.

TRANSPORTATION

#	Priority	Action	Comments
1	High	Fleet purchase program of 30% electric and 30% hybrid or 60% hybrid electric vehicles (HEVs)	GSA non-combat vehicles, relates to EO 13514 mandate
2	Medium	Internal on-base shuttle	15 minute headways 12 hrs per day, Friday and Sat extended hours, location of stops, needs to be identified by transportation group
3	Medium	Develop TDM (Transportation Demand Management) program & hire coordinator	Could oversee all aspects of transportation program, one full time coordinator
4	Medium	NEV (Neighborhood Electric Vehicle) programs	150 NEVs assigned for government use, allow for charging at residences
5	Medium	Bike share program	100 bikes with 25 pods
6	Medium	Car share program (i.e. "Zip Car")	100 cars with 2+ locations, a private company such as Zip Car is recommended so private company assumes liability
7	Medium	Pedestrian cross-section improvements	Identify locations and enhancements: FAST TRACK ON SCHEDULE
8	Low	Limit auto ownership of transients only (not UDP)	Approximately 800 spaces
9	Low	Land banking of parking (8%) in identified areas	Shared parking areas such as the commissary and exchange to have 8% land banking for shared parking
10	Low	Coordination with Guam Transit	Important to connect to on-site to off-site routes, identify shelter locations

TABLE 4-1: Sustainability Program Action Tracker - Transportation

WATER

#	Priority	Action	Comments
1	High	Low flow fixtures (See water fixture flow rate table)	Required to meet EPACT, EISA and EO, LEED Silver.
2	High	Roof top collection of water with cisterns (buried or incorporated into the structure if above ground)	Required to reduce potable water consumption and meet federal mandates. A detailed evaluation of the location, size and grouping of these systems will be required to maximize the efficiency without occurring unnecessary capital cost. All cisterns to be coordinated and integrated with bio-security plan
3	High	Condensate capture (except for family housing)	Combined with rainwater collection system at little extra capital cost. Since the generation of condensate occurs year round from dehumidification, it will be an important part of the solution during the dry season.
4	High	Eliminate all irrigation use	The elimination of irrigation will enable the project to obtain LEED credit WE-1, and will affect the water consumption calculations for EO 13514 as it relates to industrial, agricultural, and irrigation water use.
5	Medium	Integration of Low Impact Development from LID study into SSIM™ for costing and LEED point evaluation	Important component for maintaining water quality of groundwater source and for meeting federal mandates, however, this effort does not reduce water consumption.
6	Medium	Curb and Gutter to be implemented by exception only (intersections may have curb and gutter for safety reasons)	Supports LID efforts

TABLE 4-2: Sustainability Program Action Tracker - Water

ENERGY			
Energy Items Overall:			
#	**Priority**	**Action**	**Comments**
1	High	LED for Streetlights, parking lot lights and path lights	Assists with meeting EPAC, EISA and EO, LEED Silver
2	High	All buildings (over 5000 SF) PV ready or have BIPV	Assists with meeting EPAC, EISA and EO, LEED Silver
Energy Items for Non-Residential Buildings:			
3	High	High efficiency HVAC equipment	i.e. high efficiency packaged DX, air cooled chillers, & water cooled chillers
4	High	Solar thermal hot water heating	Where technically and functionally feasible, ground mounted
5	High	Use of variable volume fan controls	Where appropriate
6	High	High Efficiency T5 lighting in all buildings	
7	High	Use of lighting controls	Where appropriate, day lighting dimming and motion controls
Energy Items for Residential Buildings:			
8	High	High efficiency cooling equipment	
9	High	Condenser heat reclaim in lieu of solar thermal hot water heating	Where technically and functionally feasible, ground mounted
10	High	Use of compact fluorescent lighting	
11	High	Energy star appliances	

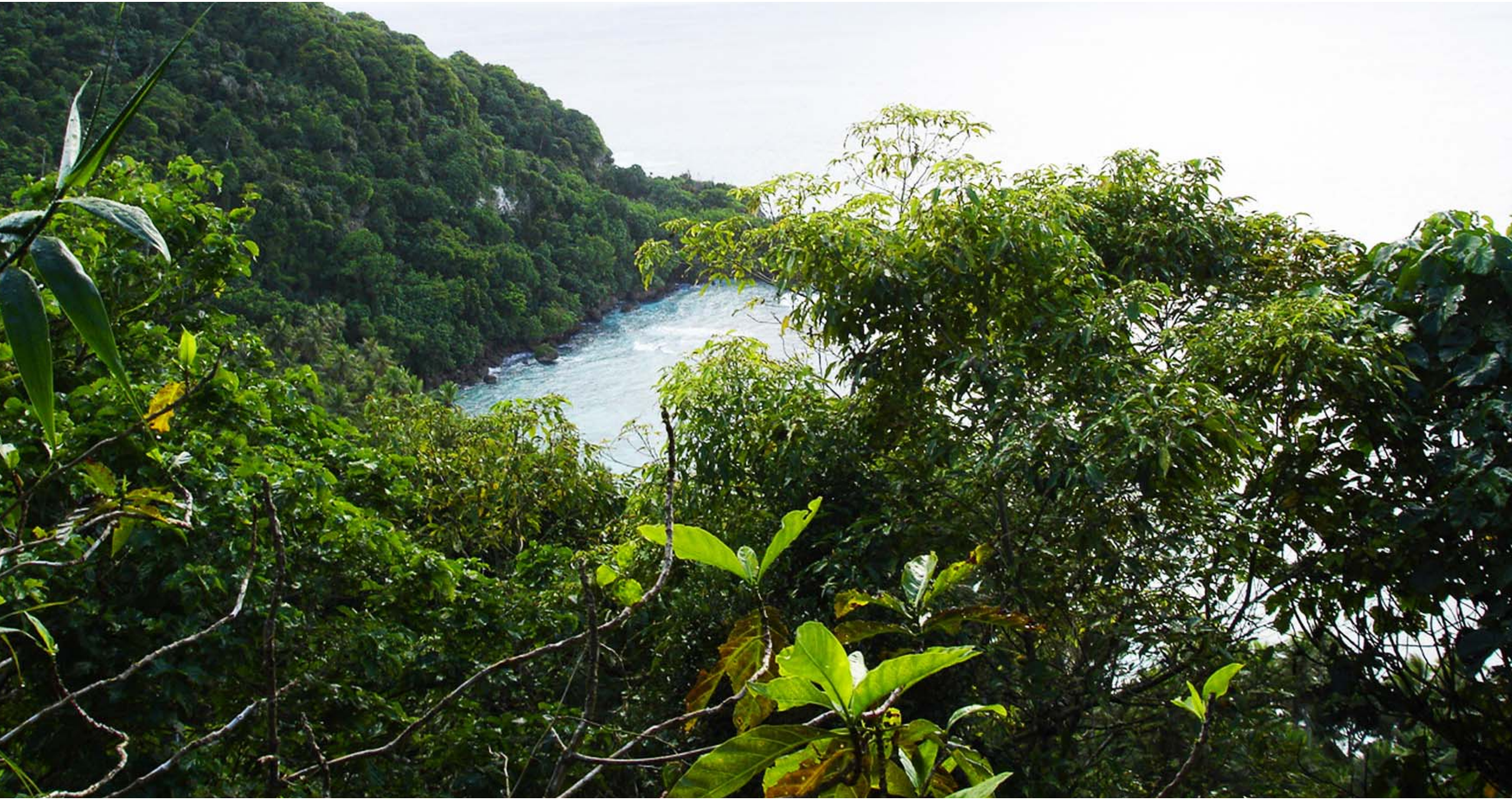
TABLE 4-3: Sustainability Program Action Tracker - Energy

LEED/GREEN BUILDING (for Non-Residential)			
#	**Priority**	**Action**	**Comments**
1	High	Construction Waste Recycling: 50% achievable, 75% recommended	1 LEED Point obtained for 50%, 2 points for 75%. Coordinate all recycling and green waste collection with bio-security plan.
2	High	LEED Database (SharePoint site) needed for data	Collective data base for all Guam JMMP credits and backup
3	High	Site credits need to be well documented	Documentation will be used by multiple contractors for multiple sites. IMPT: if site documentation is not completed correctly and according to USGBC, all future projects are subject to not meeting LEED mandate.
4	High	Overall LEED Coordinator	Coordinates individual projects with overall sustainability goals
5	Medium	Recycled content: 10%	1 LEED Point

TABLE 4-4: Sustainability Program Action Tracker - LEED/Green Building

ECOLOGY / ECOSYSTEM SERVICES			
#	**Priority**	**Action**	**Comments**
1	Medium	Coordinate planting palette with IAP	Get credit for planting through carbon sequestration

TABLE 4-5: Sustainability Program Action Tracker - Ecology/Ecosystem Services



AECOM

GUAM JOINT MILITARY MASTER PLAN

SUSTAINABILITY PROGRAM TECHNICAL APPENDIX

June 18, 2010

JOINT GUAM PROGRAM OFFICE

DEPARTMENT OF THE NAVY · UNITED STATES MARINE CORPS

NAVFAC

Information included in this document is meant for master planning purposes only. All modeling results provided are intended for guidance on possible strategies towards meeting or exceeding the Federal Mandates and are not intended to be building specific guides.

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1. Sustainability Program

The GJMMP documents the Department of Defense planning efforts for the relocation of Marine Corps personnel and dependents from Okinawa to Guam. In November 2009, the Draft Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) was prepared to assess the potential environmental effects associated with the proposed military activities. The preferred alternative would require a total of 2,580 ac for the Main Cantonment and family housing areas. The Main Cantonment would include portions of Naval Computer and Telecommunications Station (NCTS) Finegayan (1,610 ac), portions of South Finegayan (290 ac), and the Former FAA parcel (680 ac). The site is also bounded on the north by Andersen AFB NWF, and by Route 3; on the west by a cliff line and the Philippine Sea. To the east the site is bounded by limited residential development and to the south by the Harmon Village residential area. (See Figure 1-1)

The Main Cantonment would be the main base of operations for the Marine Corps. Facility requirements for the Main Cantonment Area include a full range of facility types, not unlike a small city: various types of housing, workplaces, recreation areas, education facilities, and health and safety-related functions. The workplace facilities are typical of a military base and include headquarters, maintenance facilities, warehouses, training areas (field and classroom), equipment/vehicle storage, and hazardous materials management and storage areas

Development Program

Over 14 million square feet of facilities including approximately 3,500 units of family housing are proposed for the site. These facilities (approximately 1,944 separate structures) are placed in a campus setting that includes nearly 53% of the overall 3,420 acre site as open space. This development program hosts around 23,500 residents in addition to 13,500 workers, and forms the basis for the proposed Sustainability Program. (See Figure 1-2)

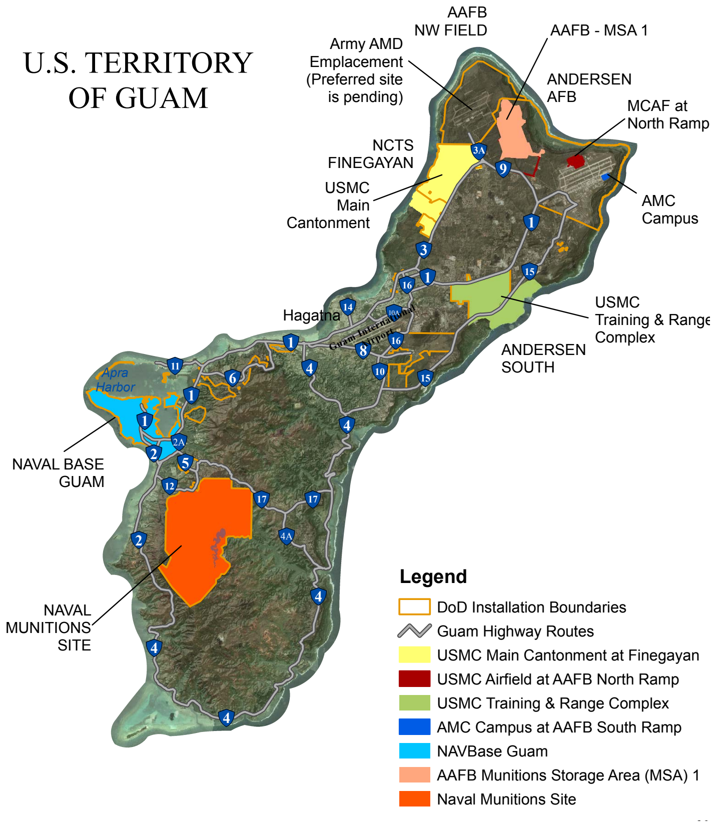


FIGURE 1-1 Project Location

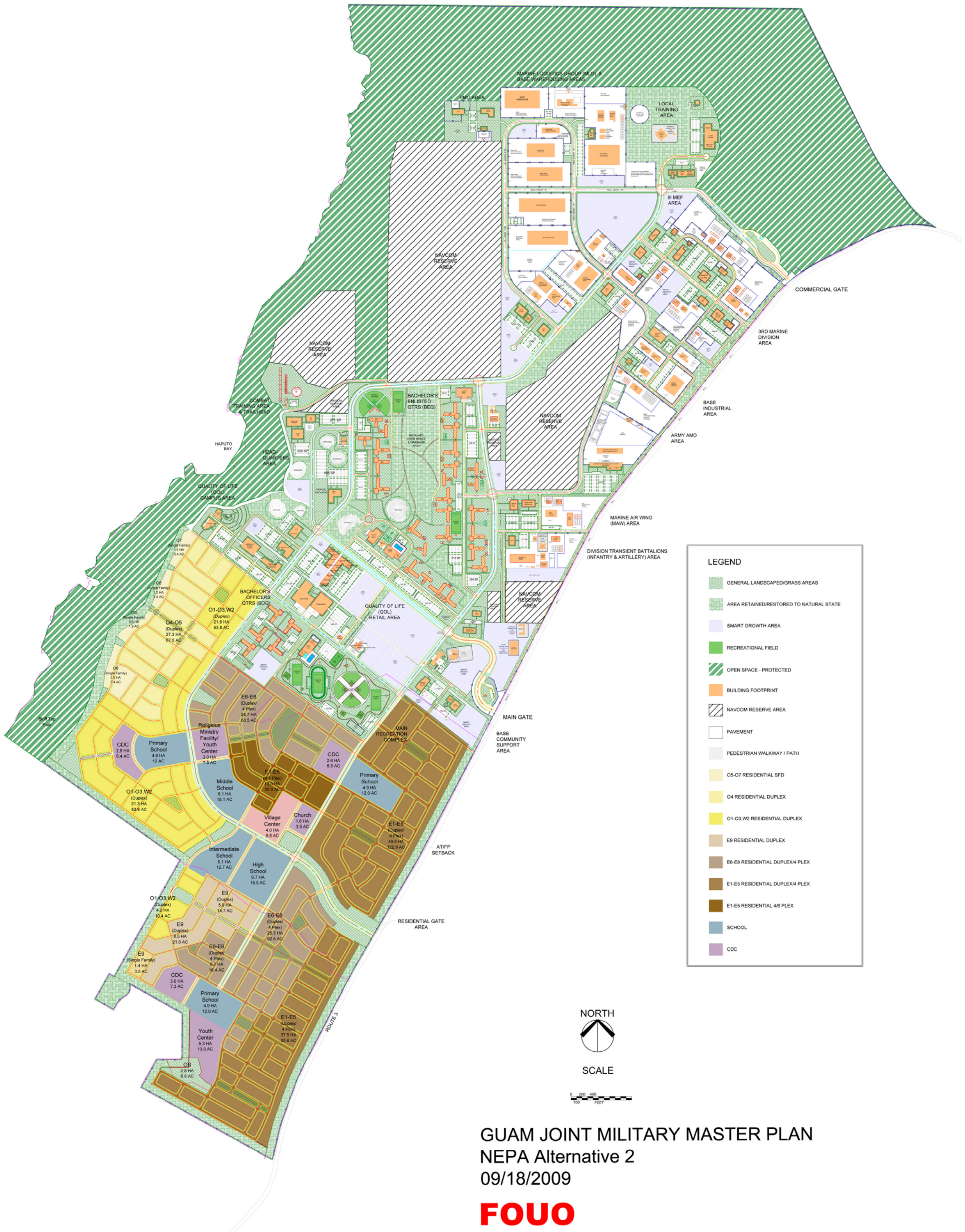


FIGURE 1-2 Preferred Development Alternative (DEIS)

2. Water

Introduction & Goals

The goal of the Guam Finegayan Water Sub-model is to help stakeholders understand the effects of various water conservation strategies for overall potable water use and related project costs. In addition, water conservation mandates, guidelines, and requirements have been established by the Federal Government and the Navy to help ensure a reduction in water consumption for new construction. The Water sub-model is intended to facilitate the comparison of impacts for a combination of program and water conservation measures on project water use. The model is used to demonstrate compliance with mandates and guidelines and provides an outline of these strategies. Currently, the Water sub-model resides in an interlinked spreadsheet which is one piece of the much larger, all inclusive SSIM^{TM} model.

The Water sub-model approach, input, assumptions, and output are summarized in the sections below. The water conservation goals are summarized as well as the assumptions, measures, and packages which make up the strategies. Package and Performance Sections summarize the performance of the various conservation approaches, their cost and benefit, and a series of recommendations based on this study.

Modeling Approach

The SSIM^{TM} Water sub-model resides in a series of linked spreadsheets which take into account water use factors including interior, exterior, cooling demand, evapotranspiration, condensate, water harvesting, and precipitation associated with the proposed development. The effectiveness of the sub-model lies in the capability to balance and optimize variables, demands, related costs, overall program, land use, alternative water conservation strategies to quantify the results in graphical and numerical tables and figures.

For example, potable water demand can be reduced using water efficient fixtures in housing, BEQs, offices, and warehouses. Reducing demand in this manner should be the first priority and is relatively low in cost. To further reduce potable demand, using recycled or harvested water for fixtures and appliances that do not require treated potable water provides an opportunity, though at a higher per gallon cost. Developing the guideline for the implementation strategy to meet mandates and guidelines, and minimize cost is complex and iterative. Using a model that is programmed to consider the trade-offs, costs, individual demands, and the effect on supply is essential.

Figure 2-1 below illustrates the general inputs, calculations, and outputs for the SSIM^{TM} Water sub-model; however, it does not necessarily represent the detailed model as revised for the Main Cantonment. It is only intended to provide a quick graphical view of the data evaluated in the model.

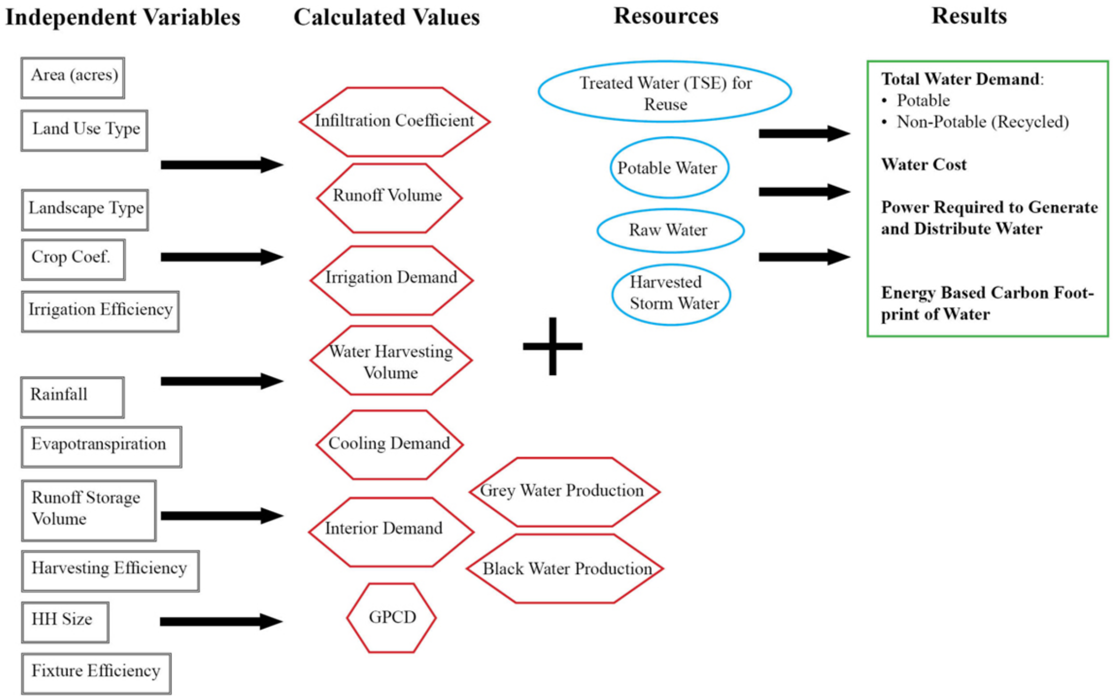


FIGURE2-1: SSIM^{TM} Water sub-model flow chart

LID Integration

Sustainability goals act as the basis for the Comprehensive Drainage and Low Impact Development (LID) Implementation Study being completed as a separate and concurrent effort entitled, “Comprehensive Drainage and Low Impact Development Implementation Study, Finegayan Main Cantonment Area, Guam.” This study provided the basis for LID strategies for the SSIM^{TM} water model. In 2006, the “Federal Leadership in High Performance and Sustainable Building Memorandum of Understanding” was enacted, which committed signatory federal agencies to design, construct, and operate their facilities in an energy-efficient and sustainable manner. In the context of the Finegayan Main Cantonment project, the goals for sustainably managing water resources of the LID implementation strategy are to convey, treat, and store large stormwater flows, to protect public health and safety and existing infrastructure, and to treat and infiltrate stormwater to recharge and protect the underlying groundwater aquifer. The goals for LID implementation listed below were established in response to the characteristics of the project site and receiving environment.

The SSIM^{TM} model takes sustainability further by evaluating all of the proposed sustainable system approaches and checking for Leadership in Energy and Environmental Design (LEED) points for the 2009 rating system. As the efficiency level of each system is modified to create the desired results with the best life cycle savings and cost return, tracking the project’s LEED score occurs automatically within the water sub-model.

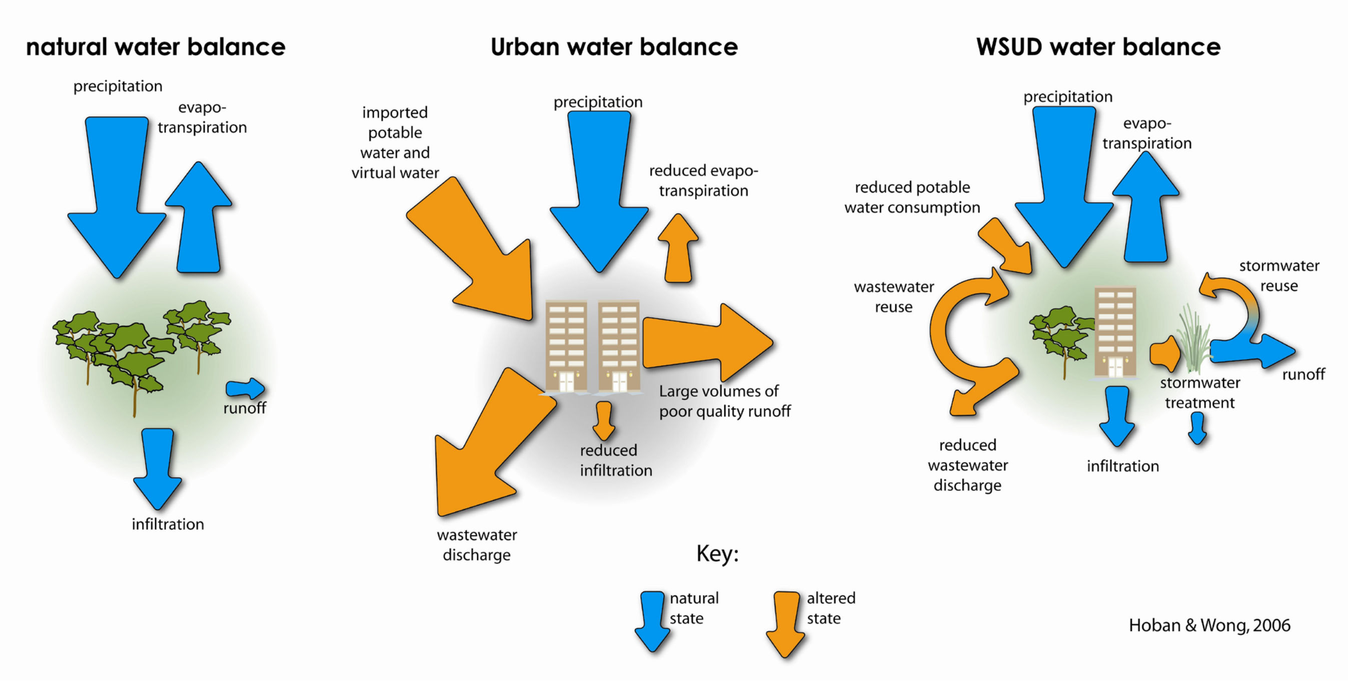


FIGURE 2-2: Low impact development (also known as water sensitive urban design) water balance in an urban environment

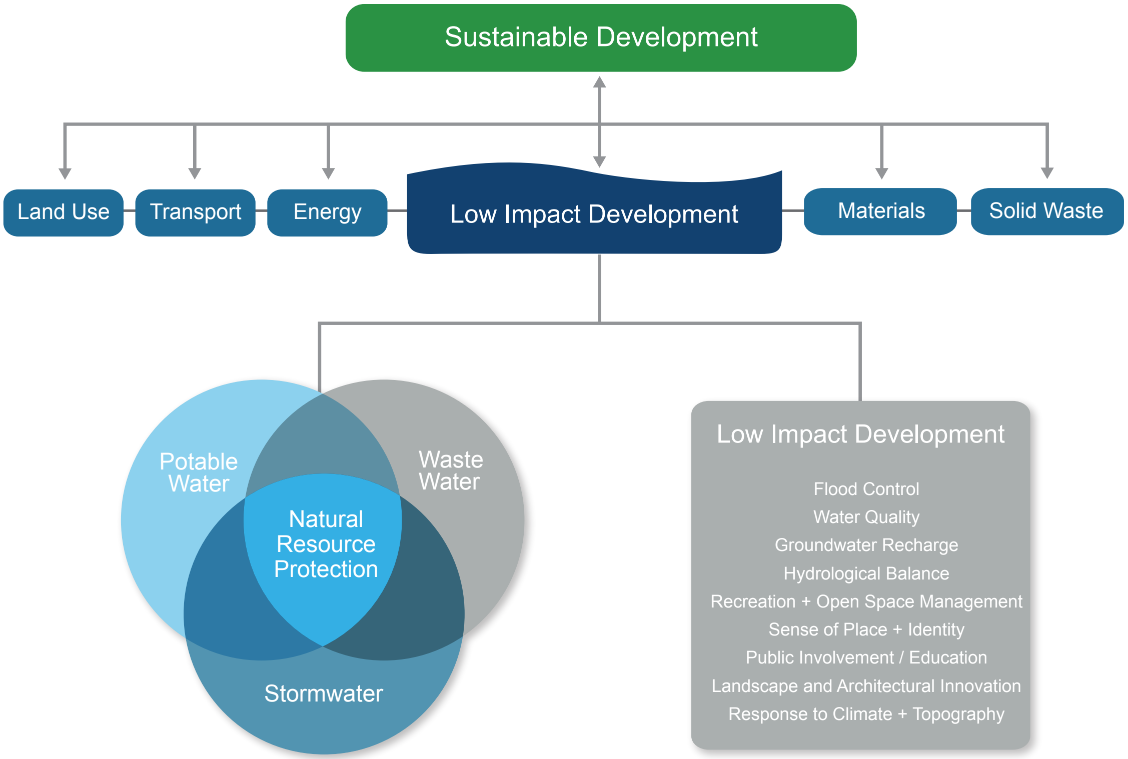


FIGURE 2-3: Low Impact Development is an Essential Component to Sustainable Development of the Landscape.

As part of a similar ongoing effort for master planning and sustainability on the Finegayan installation, the LID strategies from this report, including rooftop rainwater harvesting, are incorporated into our SSIM^{TM} model to maximize the use of all available water sources and improve the overall balance and sustainability of the facility (Figure 2-3).

The Water sub-model focuses on the LEED credits SSc 6.1 and SSc 6.2 and calculates stormwater runoff separately for rooftop and surface conditions using appropriate run-off coefficients for landscape areas, roads, sidewalks, rooftops, porous paving, and other site conditions. The calculations are used to compare strategies such as porous pavement in place of standard pavement, the volume of stormwater available for water harvesting, and the pre-development vs. post-development stormwater runoff volume. Specific building calculations for stormwater flow rate and volume attenuation, and water quality treatment trains are required during the design phase of a project. However, the water sub-model can provide guidance for strategies to meet LEED requirements SSc6.1 and SSc6.2. The LID study provided example treatment trains and flow and volume calculations that estimate costs for the various development areas and basins. This information was used in the water sub-model to extrapolate the cost for LID construction, and the potential impact of reduced pervious area and rooftop harvesting.

The goals for LID implementation include:

- Protect quality of surface water and groundwater
- Protect existing natural features and ecological processes
- Maintain pre-development hydrologic behavior of catchments
- Minimize demand for potable water used as irrigation

- Minimize maintenance requirements using simple passive systems
- Integrate water into the landscape to enhance visual, social, cultural, and ecological values

This LID Implementation Study was established in accordance with principles outlined in "Federal Leadership in High Performance and Sustainable Building MOU" to allow full flexibility in the integration of stormwater elements into the urban and landscape design.

These guiding principles are achieved by:

- Maintaining, to the maximum extent technically feasible, the predevelopment hydrology regarding the temperature, rate, volume, and duration of flow
- Integrating water management measures into the development form and landscape to ensure efficient use of landscape spaces while maximizing the visual amenity
- Protecting groundwater quality by pre-treating stormwater flows, as appropriate;utilizing vegetation for water quality enhancement
- Maximizing water harvesting for non-potable uses

With all elements working together, the stormwater management system in the Finegayan Main Cantonment area treats pollutants, recharges the groundwater, maintains the water table, and provides flood control, while preventing destructive effects downstream. The primary strategy affecting the reduction of potable water is rooftop harvesting of rainwater. The effect of rooftop harvesting on stormwater quality and downstream treatment train sizing is minimal, and not given any value in the LID study. The LID study does, however, demonstrate the sizing and cost of an Integrated Management Practice (IMP) that will meet LEED credit SSc6.2. It is also clear from the LID study and the water model that LEED credit SSc6.1, limiting volume and peak flow rate to pre-development conditions for the 2-year, 24 hour storm, is very difficult to meet for the installation as a whole; though some specific projects within the facility may be designed to achieve this credit.

Topography (From LID Study)

Finegayan lies north of the island's central fault on the internally drained limestone plateau. The plateau ranges from about 500 ft above mean sea level on the northeast to approximately 300 ft above mean sea level in the southwest before the coastal cliffs plunge into the Philippine Sea. The landscape is gently rolling with numerous shallow closed depressions and sinkholes. The limestone is so permeable that normal stream drainage has not been able to develop. Instead a gentle, karst topography is present wherein drainage is internal, either by direct infiltration into the ground or through sinkholes. Karst topography is defined as a limestone landscape, characterized by caves, fissures, and underground streams.

Climate (From LID Study)

The climate on Guam is warm and humid throughout the year. Average temperatures range from 85 to 89 degrees Fahrenheit (°F) in the afternoon and 70°F to 75 °F in the evening. The relative humidity is 65–75% in the afternoon and 85–100% in the evening.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
mm	122.7	127.8	94.6	108.7	164.4	132.8	262.5	354.6	323.4	343.7	208.8	151.6	2396.8
inches	4.8	5.0	3.7	4.3	6.5	5.2	10.3	14.0	12.7	13.5	8.2	6.0	94.4

Note: mm = millimeters.
Source: Andersen AFB Guam data derived from NCDC Cooperative Stations. Data recorded between 1952 and 1995

TABLE 2-1: Monthly and Yearly Rainfall Averages in Guam (from LID study)

IMP (Integrated Management Practices)	Recharge	Water Quality Treatment	Flood Control (< 2 yr, 24 hr storm)	Flood Control (> 2-yr, 24 hr storm)
Detention Basin	✓		✓	✓
Bioretention Basin	✓	✓	✓	
Filter Strip	✓	✓		
Dry Swale	✓	✓	✓	
Sedimentation Basin	✓	✓	✓	
Oil and Grit Separator		✓		
Green Roof		✓	✓	
Dry Well	✓		✓	
Permeable Paving	✓		✓	
Downspout Disconnection	✓		✓	
Curb Inlet Protector		✓		

TABLE 2-2: BM / IMP Selection Matrix Stormwater Management Capacity (from LID study)

The constant northeasterly trade winds result in a well-defined dry season that runs from January through May, which is broken by an occasional shower. July to November is the wet season during which trade winds are frequently interrupted by tropical storms with heavy rain. The months of June and December separate the two seasons and are transitional in nature.

The average annual rainfall on Guam is 80–90 inches, but is locally variable. Near Apra on the western coast, the mean is 85 inches, while it averages 115 inches in the southern mountains. On the northern limestone plateau, including NCTS Finegayan, rainfall averages between 85 and 105 inches annually. About 68 to 73 percent of the annual precipitation occurs during the wet season and 15 to 20 percent during the dry season. The remainder occurs during the transitional months.

Treatment Train Pollutant Removal Efficiencies

Individual IMPs (Integrated Management Practices) were assessed for pollutant removal efficiency for each of the seven pollutants of concern. IMPs were then grouped together and sequenced to create six general treatment train types to address six general categories of stormwater treatment anticipated at the Finegayan Main Cantonment Area.

The six treatment trains defined are:

- Treatment Train A: Rooftop Runoff
- Treatment Train B: Impervious Paved Areas with Insignificant Oil/Suspended Metals
- Treatment Train C: Impervious Paved Areas w/ Significant Oil/Suspended Metals (with little available room for surface IMPs)
- Treatment Train D: Impervious Paved Roadways with Insignificant Oil/Suspended Metals
- Treatment Train E: Site-Optional Pervious - Non-Vehicle
- Treatment Train F: Landscaping, Grass, Recreation Areas

Model Assumptions

The Finegayan Water sub-model focuses on interior water demand and conservation measures in order to reduce overall potable water demand. Exterior water demand is minimal. The use of grey water and treated sewage effluent are not considered viable strategies because there is little outdoor demand for the recycled water and the underlying aquifer is close to the surface with little opportunity for natural treatment of nutrient laden water. Protection and enhancement of the aquifer is a high priority. Guam does offer a significant opportunity for water harvesting due to the rainfall patterns and volume of rainfall. Rooftop rainfall collection can provide a relatively clean source of water for non-potable demands, such as toilet flushing and clothes washing. Harvesting water close to the source of the demand can help reduce the pumping, treatment, and system losses associated with a greater demand and the larger water supply and distribution system.

Interior Water Demand Assumptions:

Interior water demand is based on fixture types, counts, and use patterns. The fixtures vary depending on the building type and intended use, i.e., residential, schools, offices, BEQ, etc. Water use patterns have been adjusted to better fit typical use on Guam, based on discussions with Guam Water Works Authority. Figure 2-4 and 2-5 show fixture flow rates, typical use patterns, and provides an estimate of daily water demand.

Exterior Water Demand Assumptions

Given the very high annual precipitation received on Guam, the need for irrigation is very low if not completely non-existent. For this reason, no irrigation demand is calculated as part of the water demand. However, if the use of irrigation is needed and pursued in the future, for areas such as the sports fields, parade grounds, or headquarters building landscaping, there may be some opportunities for irrigation water conservation and reuse strategies that can be implemented in order to maintain compliance with the federal mandates.

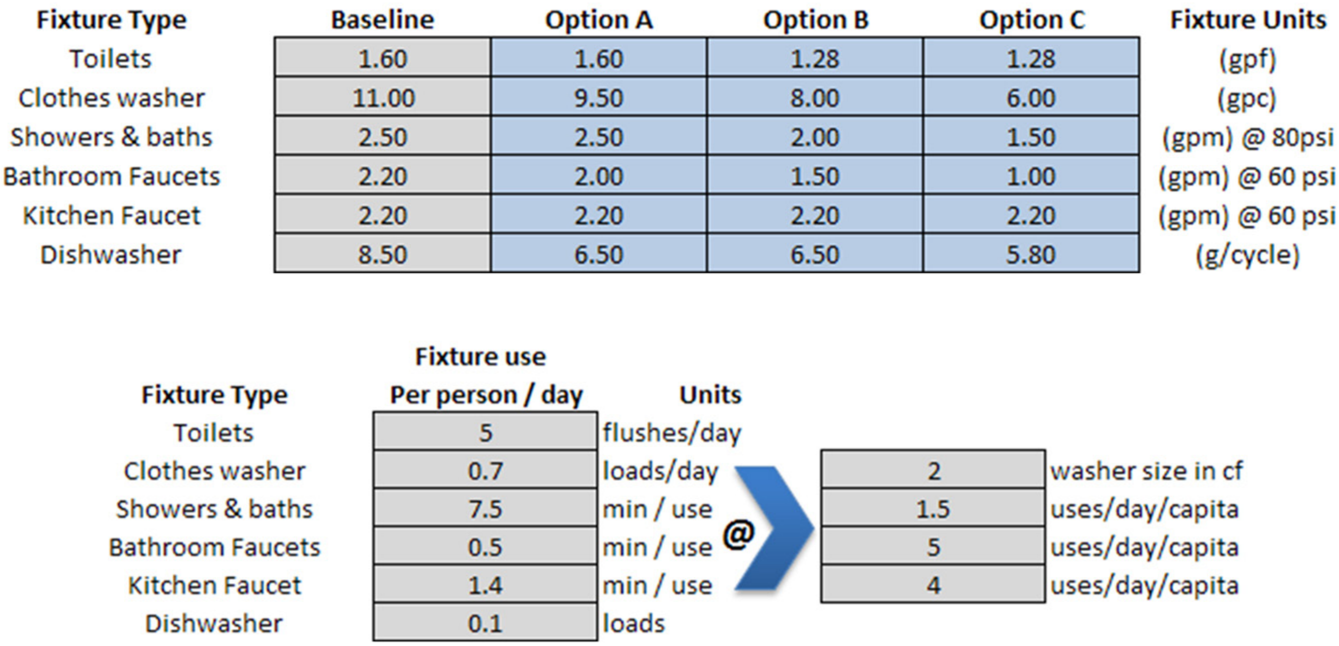
Some of these strategies may include:

- Selection of low water plant material and turf grass
- Use of climate based control systems
- Use of central control systems for management efficiency
- Irrigation leak detection and automatic shutoff equipment
- Reuse of stormwater from holding ponds

Water Reuse

The use of cisterns will be necessary to hold harvested rooftop rainwater and air conditioning condensate for use on demand. The sizing of the cisterns is based on the toilet flushing demand for a two-week supply assuming no rainfall, rather than on the amount of rainfall available. Much of the rainfall captured will overflow from the system and not be reused. This overflow will enter the stormwater management system much in the same way it would without the cistern and reuse system and will be treated per the LID study.

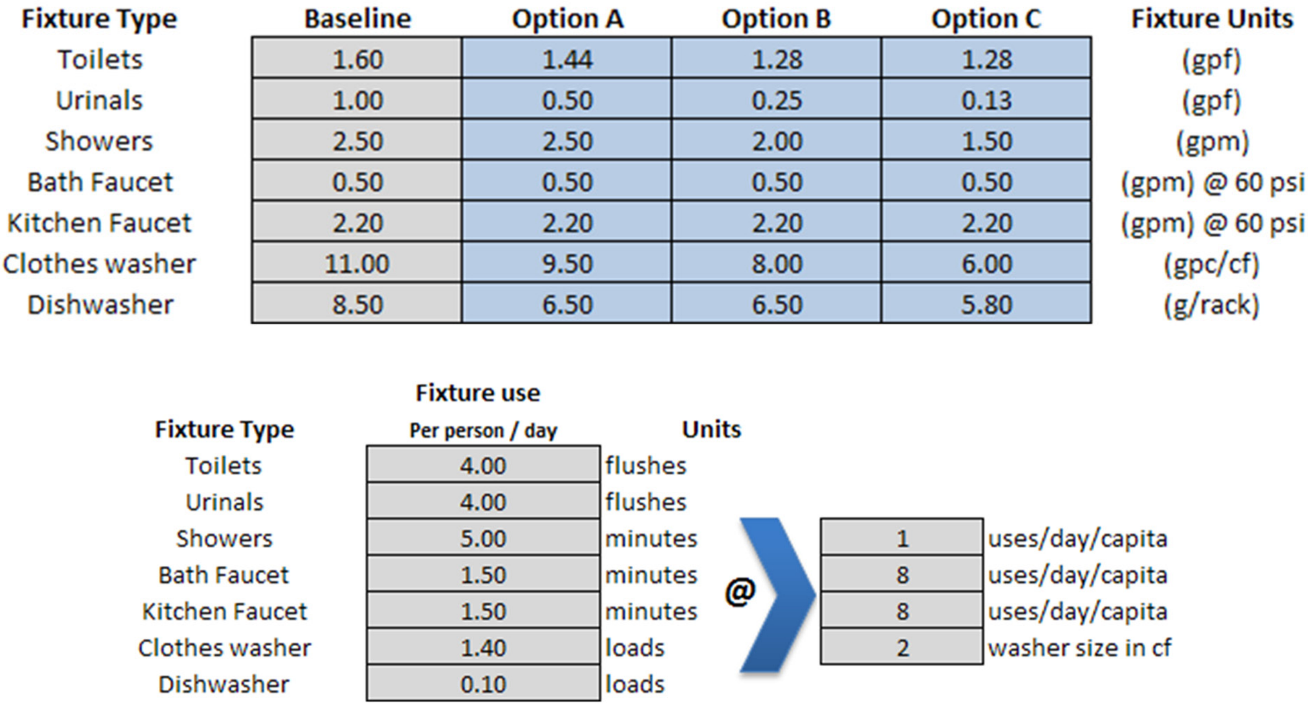
The best application of the cisterns is for facilities with the highest toilet flushing demand, which usually occurs in the housing areas and offices. If implemented in the residential housing areas, the systems would be small individual systems capturing the rooftop runoff from each home and reused for toilet flushing and possibly clothes washing with only simple filtration. The BEQ/BOQ facilities also have a sizable toilet flushing demand, and due to multistory buildings, have less rooftop area per capita. For this reason, and because the buildings are grouped, combined multi-tank cistern systems may be best suited for use at these buildings.



Fixture Type	Baseline	Option A	Option B	Option C	Fixture Units
Toilets	1.60	1.60	1.28	1.28	(gpf)
Clothes washer	11.00	9.50	8.00	6.00	(gpc)
Showers & baths	2.50	2.50	2.00	1.50	(gpm) @ 80psi
Bathroom Faucets	2.20	2.00	1.50	1.00	(gpm) @ 60 psi
Kitchen Faucet	2.20	2.20	2.20	2.20	(gpm) @ 60 psi
Dishwasher	8.50	6.50	6.50	5.80	(g/cycle)

Fixture Type	Fixture use Per person / day	Units			
Toilets	5	flushes/day			
Clothes washer	0.7	loads/day	@	2	washer size in cf
Showers & baths	7.5	min / use		1.5	uses/day/capita
Bathroom Faucets	0.5	min / use		5	uses/day/capita
Kitchen Faucet	1.4	min / use		4	uses/day/capita
Dishwasher	0.1	loads			

FIGURE 2-4: Residential Fixture Flow Rates – From SSIM^{TM} Model



Fixture Type	Baseline	Option A	Option B	Option C	Fixture Units
Toilets	1.60	1.44	1.28	1.28	(gpf)
Urinals	1.00	0.50	0.25	0.13	(gpf)
Showers	2.50	2.50	2.00	1.50	(gpm)
Bath Faucet	0.50	0.50	0.50	0.50	(gpm) @ 60 psi
Kitchen Faucet	2.20	2.20	2.20	2.20	(gpm) @ 60 psi
Clothes washer	11.00	9.50	8.00	6.00	(gpc/cf)
Dishwasher	8.50	6.50	6.50	5.80	(g/rack)

Fixture Type	Fixture use Per person / day	Units			
Toilets	4.00	flushes			
Urinals	4.00	flushes			
Showers	5.00	minutes		1	uses/day/capita
Bath Faucet	1.50	minutes	@	8	uses/day/capita
Kitchen Faucet	1.50	minutes		8	uses/day/capita
Clothes washer	1.40	loads		2	washer size in cf
Dishwasher	0.10	loads			

FIGURE 2-5: Non-Residential Fixture Flow Rates – From SSIM™ model

UFC Analysis

Unified Facilities Criteria UFC 3-230-19N (June 8, 2005)

This document provides design guidelines for sizing water supply and distribution systems and calculates the average potable domestic water per capita per day based on residential type, transient workers, and industrial facilities. This guideline also takes into account growth factors, peaking factors, fire-flow factors, unaccounted for water factors, and sustainability factors to ensure the proposed design provides adequate supply.

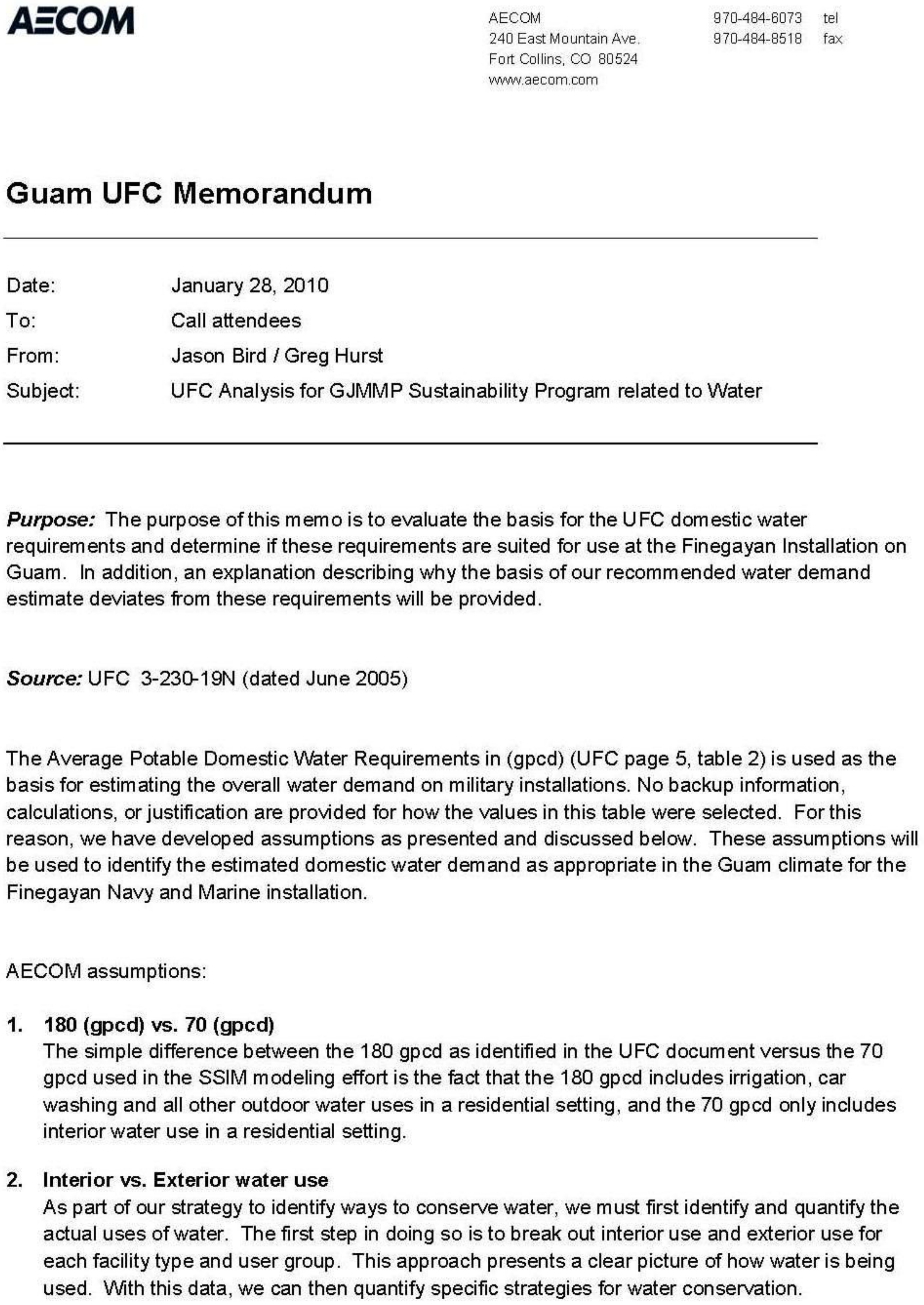
The UFC design criteria estimates potable water demand for tropic climates as follows (gpcd: gallon per capita per day):

Family Housing	180 gpcd
Unaccompanied Personnel Housing	155 gpcd
Workers (per shift)	45 gpcd

This top down method of estimating potable water demand is designed to ensure adequate supply is provided, and is not a detailed estimate of actual water use. This estimate is also designed for facilities nationwide and includes irrigation and other external water use. The objective is to understand the actual water consumption on the Finegayan Cantonment in order to identify opportunities for conservation.

For this reason, the SSIM™ water model is built from the ground up, meaning that the proposed program data including population, facility type, and facility square footage is used to determine not only the water use per person per day, but the number of water fixtures used within each facility group. It is this ground up approach that gives the SSIM™ water model its strength, while maintaining the flexibility to provide detailed results of the anticipated water savings based on each water conservation strategy down to changing a specific fixture type within a specific facility type. The model results also track the cost impact with each conservation strategy, the life cycle savings, and whether the combined savings from all gamed strategies achieves each Federal Mandate including LEED.

The following memos are included to demonstrate some of the assumptions made as they are related to water demand estimating and the use of the UFC guidelines. Although the definitions and use of the term Baseline have been revised, the intent for the use of this data is the same.



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Guam UFC Memorandum

Date:	January 28, 2010
To:	Call attendees
From:	Jason Bird / Greg Hurst
Subject:	UFC Analysis for GJMMP Sustainability Program related to Water

Purpose: The purpose of this memo is to evaluate the basis for the UFC domestic water requirements and determine if these requirements are suited for use at the Finegayan Installation on Guam. In addition, an explanation describing why the basis of our recommended water demand estimate deviates from these requirements will be provided.

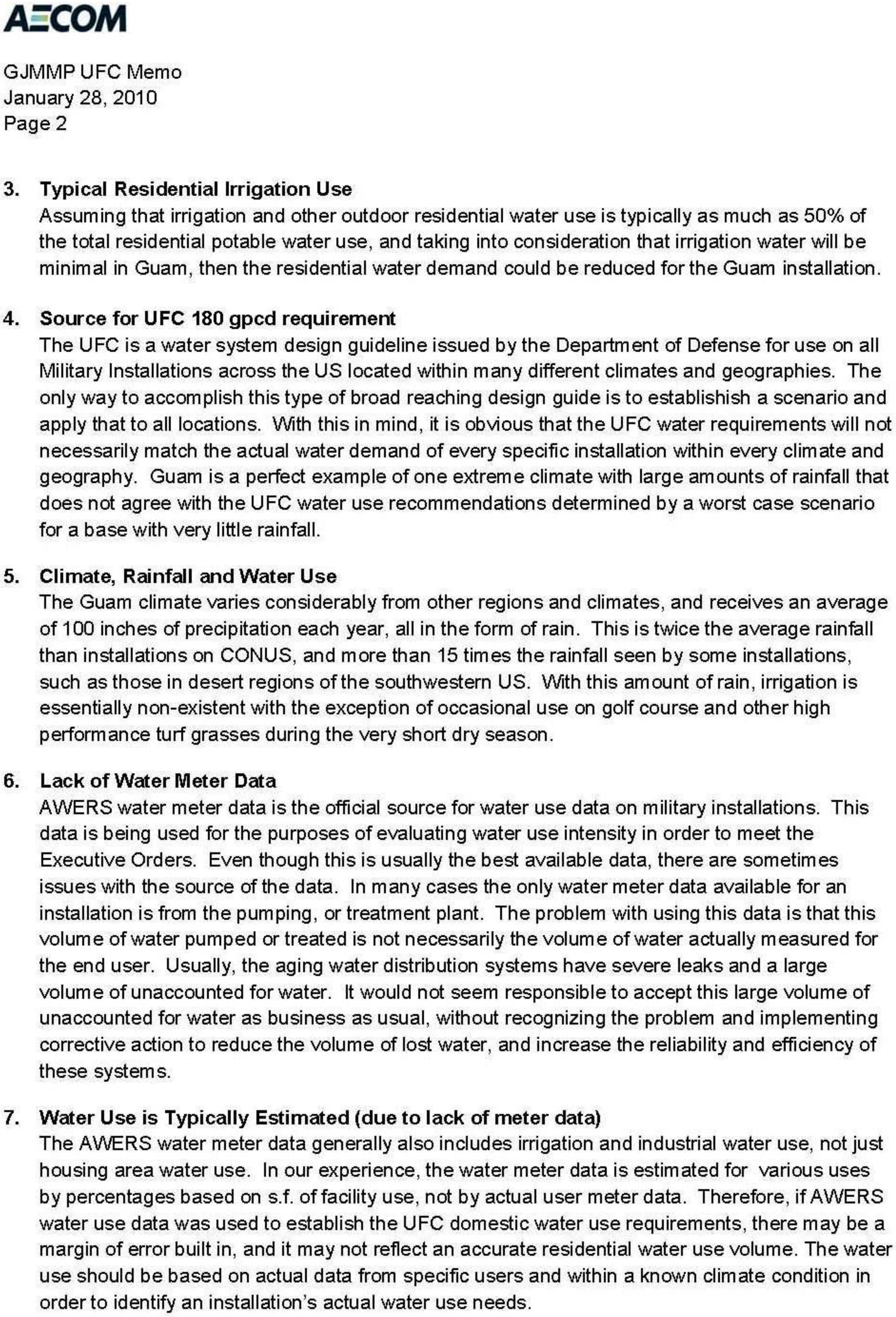
Source: UFC 3-230-19N (dated June 2005)

The Average Potable Domestic Water Requirements in (gpcd) (UFC page 5, table 2) is used as the basis for estimating the overall water demand on military installations. No backup information, calculations, or justification are provided for how the values in this table were selected. For this reason, we have developed assumptions as presented and discussed below. These assumptions will be used to identify the estimated domestic water demand as appropriate in the Guam climate for the Finegayan Navy and Marine installation.

AECOM assumptions:

1. **180 (gpcd) vs. 70 (gpcd)**
   The simple difference between the 180 gpcd as identified in the UFC document versus the 70 gpcd used in the SSIM modeling effort is the fact that the 180 gpcd includes irrigation, car washing and all other outdoor water uses in a residential setting, and the 70 gpcd only includes interior water use in a residential setting.

2. **Interior vs. Exterior water use**
   As part of our strategy to identify ways to conserve water, we must first identify and quantify the actual uses of water. The first step in doing so is to break out interior use and exterior use for each facility type and user group. This approach presents a clear picture of how water is being used. With this data, we can then quantify specific strategies for water conservation.



AECOM

GJMMP UFC Memo
January 28, 2010
Page 2

3. **Typical Residential Irrigation Use**
   Assuming that irrigation and other outdoor residential water use is typically as much as 50% of the total residential potable water use, and taking into consideration that irrigation water will be minimal in Guam, then the residential water demand could be reduced for the Guam installation.

4. **Source for UFC 180 gpcd requirement**
   The UFC is a water system design guideline issued by the Department of Defense for use on all Military Installations across the US located within many different climates and geographies. The only way to accomplish this type of broad reaching design guide is to establishish a scenario and apply that to all locations. With this in mind, it is obvious that the UFC water requirements will not necessarily match the actual water demand of every specific installation within every climate and geography. Guam is a perfect example of one extreme climate with large amounts of rainfall that does not agree with the UFC water use recommendations determined by a worst case scenario for a base with very little rainfall.

5. **Climate, Rainfall and Water Use**
   The Guam climate varies considerably from other regions and climates, and receives an average of 100 inches of precipitation each year, all in the form of rain. This is twice the average rainfall than installations on CONUS, and more than 15 times the rainfall seen by some installations, such as those in desert regions of the southwestern US. With this amount of rain, irrigation is essentially non-existent with the exception of occasional use on golf course and other high performance turf grasses during the very short dry season.

6. **Lack of Water Meter Data**
   AWERS water meter data is the official source for water use data on military installations. This data is being used for the purposes of evaluating water use intensity in order to meet the Executive Orders. Even though this is usually the best available data, there are sometimes issues with the source of the data. In many cases the only water meter data available for an installation is from the pumping, or treatment plant. The problem with using this data is that this volume of water pumped or treated is not necessarily the volume of water actually measured for the end user. Usually, the aging water distribution systems have severe leaks and a large volume of unaccounted for water. It would not seem responsible to accept this large volume of unaccounted for water as business as usual, without recognizing the problem and implementing corrective action to reduce the volume of lost water, and increase the reliability and efficiency of these systems.

7. **Water Use is Typically Estimated (due to lack of meter data)**
   The AWERS water meter data generally also includes irrigation and industrial water use, not just housing area water use. In our experience, the water meter data is estimated for various uses by percentages based on s.f. of facility use, not by actual user meter data. Therefore, if AWERS water use data was used to establish the UFC domestic water use requirements, there may be a margin of error built in, and it may not reflect an accurate residential water use volume. The water use should be based on actual data from specific users and within a known climate condition in order to identify an installation's actual water use needs.

Summary:

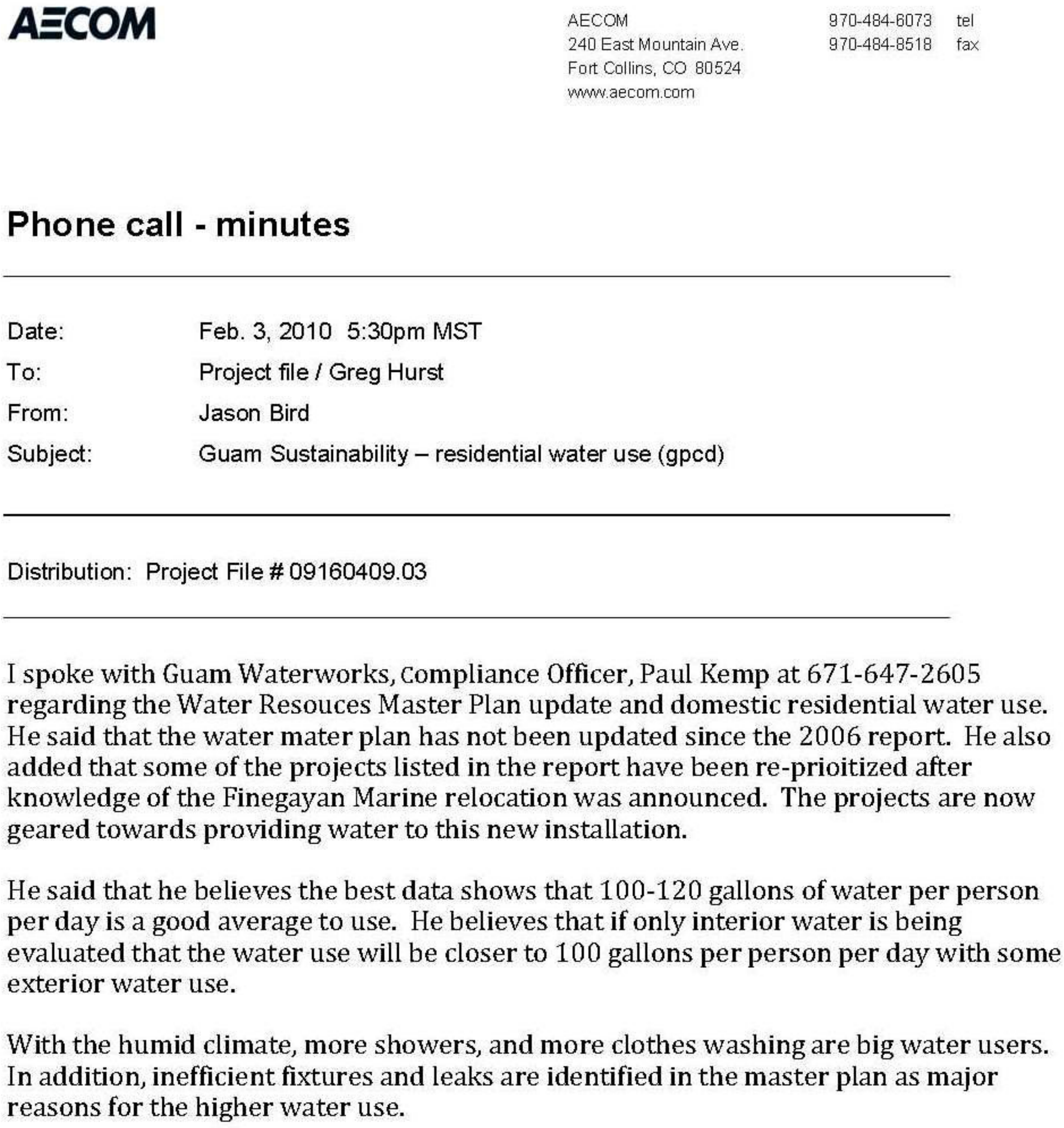
The only way to understand the proposed water demand for facilities in Guam is to understand the actual domestic water use for each type of facility and user group. Our primary goal with the SSIM water balance model is, to develop and understanding of actual water use based on local practices and recommend strategies to improve on the water use intensity or Baseline. If the anticipated water use, as estimated in our analysis, is determined to be the Baseline in SSIM for water consumption intensity, and the UFC criteria is considered Business as Usual for Finegayan, an immediate water savings will be presented with little effort or sustainable strategies. Then our sustainable strategies can present additional ways to reduce that water use intensity even further to not only meet the Executive Orders, DOD and Navy Mandates, but to surpass those requirements and reduce the strain on a limited and sensitive water supply by developing a truly sustainable development.

Residential Water Use Estimate (for Guam)

UFC requirement	180 (gpcd)
50% irrigation & outdoor water	- 90 (gpcd)
5% unaccounted for water	- 9 (gpcd)
5% error in estimating water use	- 9 (gpcd)
5% increase in national standards	- 9 (gpcd)
Approximate interior residential water use for Guam.	63 (gpcd)

These percentages are only estimates, however, they provide a good argument for how the 180 gpcd may have been created and how it relates to the industry standard that we use of 60 gpcd for interior water use. For this project, an interior water use of 70 gpcd is being used based on a request to increase particular types of interior water use such as shower time and additional clothes washing as a result of the humid climate. The 70 gpcd we are suggesting in our water demand calculations for interior water use adequately covers the calculated 63 gpcd shown above.

Once all of the water use demands are identified and quantified as accurately as possible, additional factors can be added such as growth factors, peak flow factors, and safety factors, etc. in order to provide a “UFC based” safe design estimate for overall water supply (pumping) and the water system sizing. The SSIM process builds the estimate of total water demand from the “bottom up” in order to develop a reasonable and acceptgable end user demand. The additional factors that may require an increase in delivery infrastructure can then be clearly identified and applied appropriately.



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Phone call - minutes

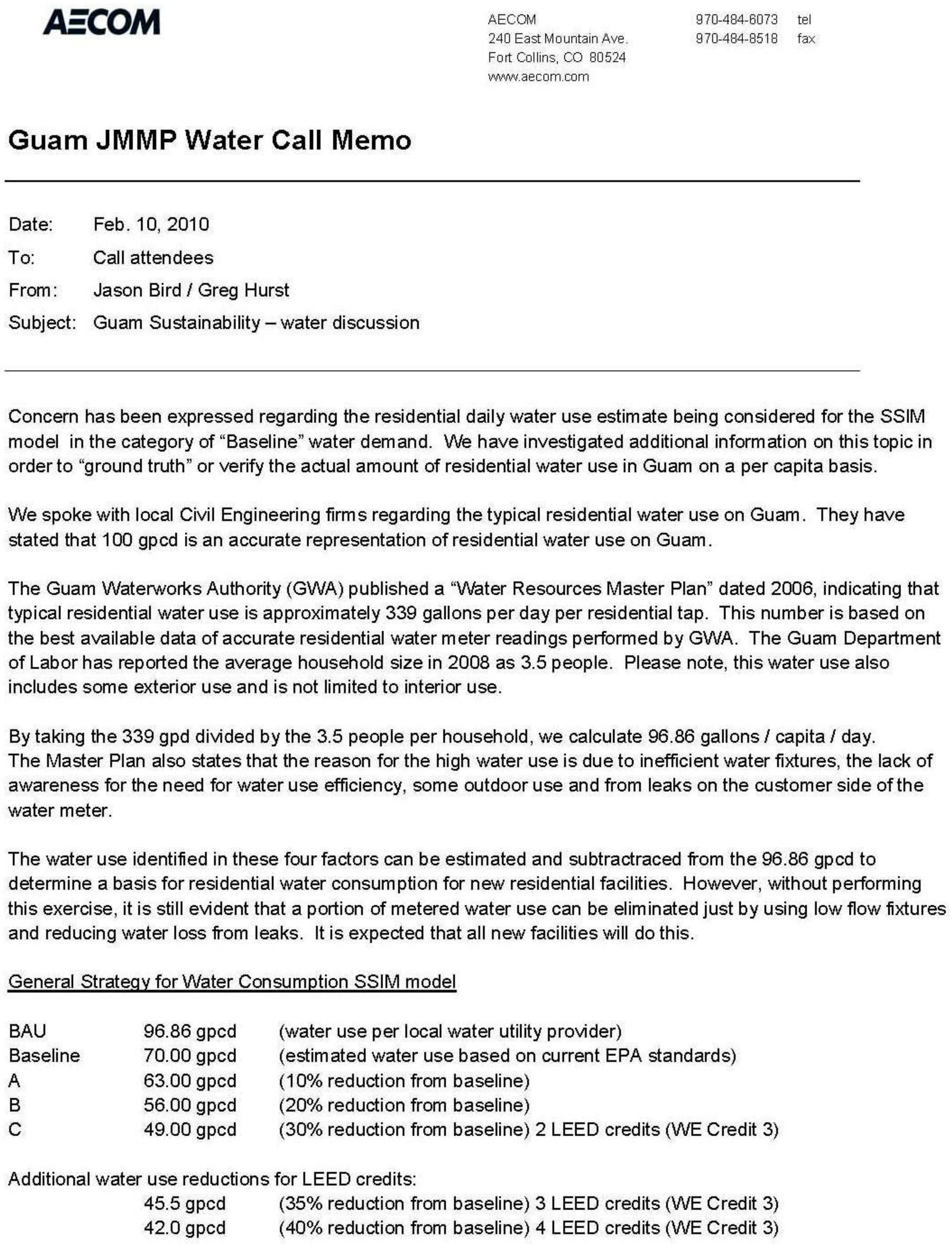
Date: Feb. 3, 2010 5:30pm MST
To: Project file / Greg Hurst
From: Jason Bird
Subject: Guam Sustainability – residential water use (gpcd)

Distribution: Project File # 09160409.03

I spoke with Guam Waterworks, Compliance Officer, Paul Kemp at 671-647-2605 regarding the Water Resouces Master Plan update and domestic residential water use. He said that the water mater plan has not been updated since the 2006 report. He also added that some of the projects listed in the report have been re-prioitized after knowledge of the Finegayan Marine relocation was announced. The projects are now geared towards providing water to this new installation.

He said that he believes the best data shows that 100-120 gallons of water per person per day is a good average to use. He believes that if only interior water is being evaluated that the water use will be closer to 100 gallons per person per day with some exterior water use.

With the humid climate, more showers, and more clothes washing are big water users. In addition, inefficient fixtures and leaks are identified in the master plan as major reasons for the higher water use.



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Guam JMMP Water Call Memo

Date: Feb. 10, 2010
To: Call attendees
From: Jason Bird / Greg Hurst
Subject: Guam Sustainability – water discussion

Concern has been expressed regarding the residential daily water use estimate being considered for the SSIM model in the category of "Baseline" water demand. We have investigated additional information on this topic in order to "ground truth" or verify the actual amount of residential water use in Guam on a per capita basis.

We spoke with local Civil Engineering firms regarding the typical residential water use on Guam. They have stated that 100 gpcd is an accurate representation of residential water use on Guam.

The Guam Waterworks Authority (GWA) published a "Water Resources Master Plan" dated 2006, indicating that typical residential water use is approximately 339 gallons per day per residential tap. This number is based on the best available data of accurate residential water meter readings performed by GWA. The Guam Department of Labor has reported the average household size in 2008 as 3.5 people. Please note, this water use also includes some exterior use and is not limited to interior use.

By taking the 339 gpd divided by the 3.5 people per household, we calculate 96.86 gallons / capita / day.
The Master Plan also states that the reason for the high water use is due to inefficient water fixtures, the lack of awareness for the need for water use efficiency, some outdoor use and from leaks on the customer side of the water meter.

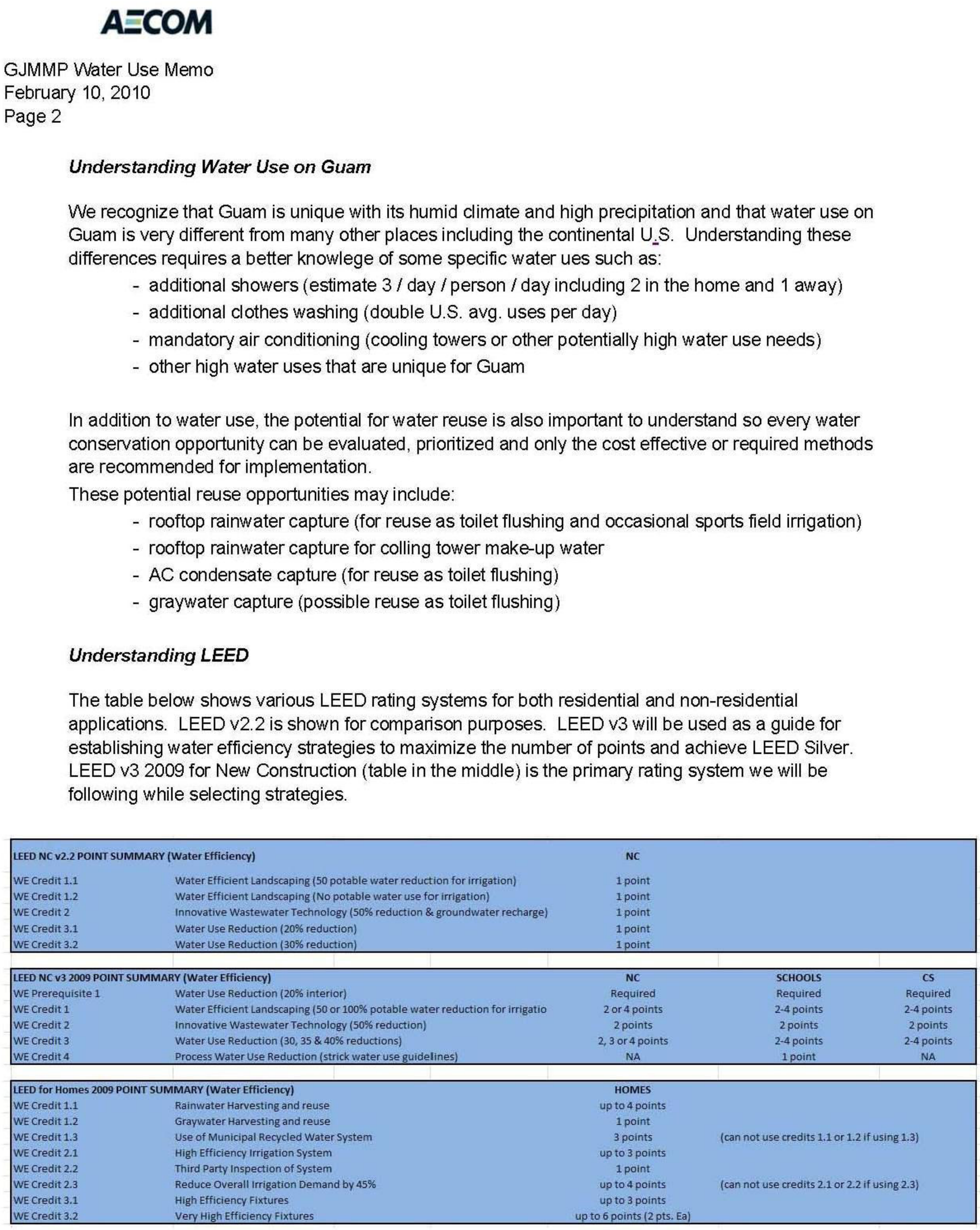
The water use identified in these four factors can be estimated and subtractraced from the 96.86 gpcd to determine a basis for residential water consumption for new residential facilities. However, without performing this exercise, it is still evident that a portion of metered water use can be eliminated just by using low flow fixtures and reducing water loss from leaks. It is expected that all new facilities will do this.

General Strategy for Water Consumption SSIM model

BAU	96.86 gpcd	(water use per local water utility provider)
Baseline	70.00 gpcd	(estimated water use based on current EPA standards)
A	63.00 gpcd	(10% reduction from baseline)
B	56.00 gpcd	(20% reduction from baseline)
C	49.00 gpcd	(30% reduction from baseline) 2 LEED credits (WE Credit 3)

Additional water use reductions for LEED credits:

	45.5 gpcd	(35% reduction from baseline) 3 LEED credits (WE Credit 3)
	42.0 gpcd	(40% reduction from baseline) 4 LEED credits (WE Credit 3)



GJMMP Water Use Memo
February 10, 2010
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Understanding Water Use on Guam

We recognize that Guam is unique with its humid climate and high precipitation and that water use on Guam is very different from many other places including the continental U.S. Understanding these differences requires a better knowlege of some specific water ues such as:

- additional showers (estimate 3 / day / person / day including 2 in the home and 1 away)
- additional clothes washing (double U.S. avg. uses per day)
- mandatory air conditioning (cooling towers or other potentially high water use needs)
- other high water uses that are unique for Guam

In addition to water use, the potential for water reuse is also important to understand so every water conservation opportunity can be evaluated, prioritized and only the cost effective or required methods are recommended for implementation.

These potential reuse opportunities may include:

- rooftop rainwater capture (for reuse as toilet flushing and occasional sports field irrigation)
- rooftop rainwater capture for colling tower make-up water
- AC condensate capture (for reuse as toilet flushing)
- graywater capture (possible reuse as toilet flushing)

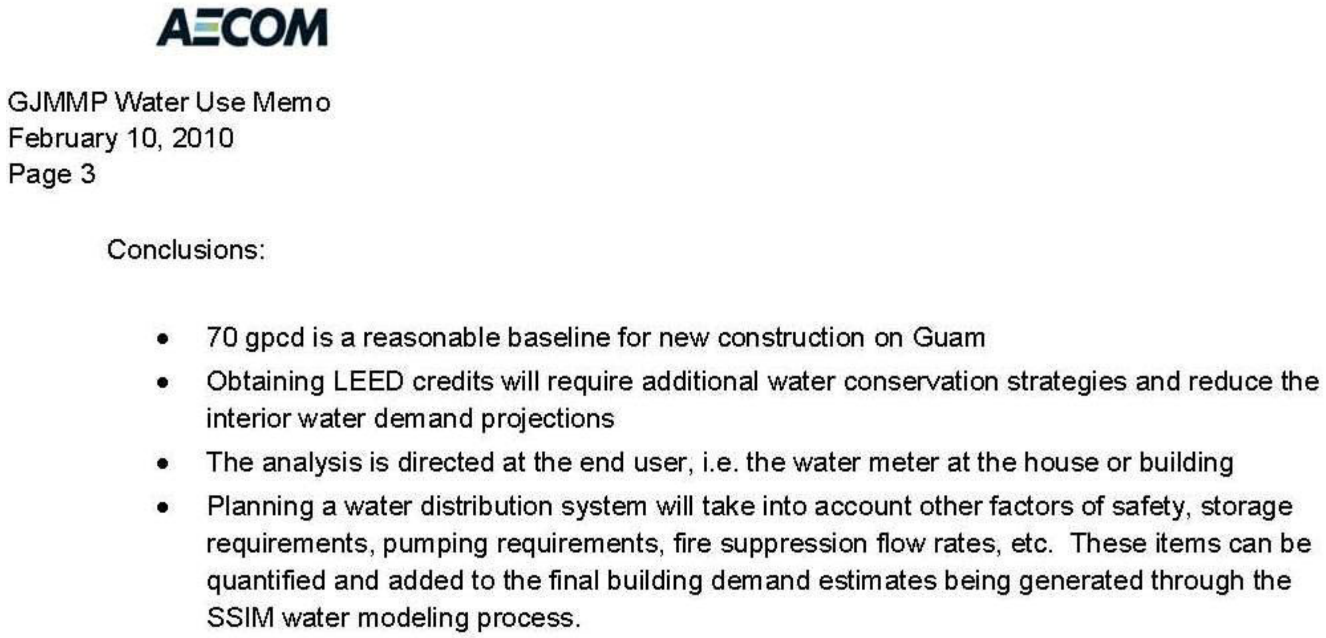
Understanding LEED

The table below shows various LEED rating systems for both residential and non-residential applications. LEED v2.2 is shown for comparison purposes. LEED v3 will be used as a guide for establishing water efficiency strategies to maximize the number of points and achieve LEED Silver. LEED v3 2009 for New Construction (table in the middle) is the primary rating system we will be following while selecting strategies.

LEED NC v2.2 POINT SUMMARY (Water Efficiency)		**NC**
WE Credit 1.1	Water Efficient Landscaping (50 potable water reduction for irrigation)	1 point
WE Credit 1.2	Water Efficient Landscaping (No potable water use for irrigation)	1 point
WE Credit 2	Innovative Wastewater Technology (50% reduction & groundwater recharge)	1 point
WE Credit 3.1	Water Use Reduction (20% reduction)	1 point
WE Credit 3.2	Water Use Reduction (30% reduction)	1 point

LEED NC v3 2009 POINT SUMMARY (Water Efficiency)		**NC**	**SCHOOLS**	**CS**
WE Prerequisite 1	Water Use Reduction (20% interior)	Required	Required	Required
WE Credit 1	Water Efficient Landscaping (50 or 100% potable water reduction for irrigatio	2 or 4 points	2-4 points	2-4 points
WE Credit 2	Innovative Wastewater Technology (50% reduction)	2 points	2 points	2 points
WE Credit 3	Water Use Reduction (30, 35 & 40% reductions)	2, 3 or 4 points	2-4 points	2-4 points
WE Credit 4	Process Water Use Reduction (strick water use guidelines)	NA	1 point	NA

LEED for Homes 2009 POINT SUMMARY (Water Efficiency)		**HOMES**	
WE Credit 1.1	Rainwater Harvesting and reuse	up to 4 points	
WE Credit 1.2	Graywater Harvesting and reuse	1 point	
WE Credit 1.3	Use of Municipal Recycled Water System	3 points	(can not use credits 1.1 or 1.2 if using 1.3)
WE Credit 2.1	High Efficiency Irrigation System	up to 3 points	
WE Credit 2.2	Third Party Inspection of System	1 point	
WE Credit 2.3	Reduce Overall Irrigation Demand by 45%	up to 4 points	(can not use credits 2.1 or 2.2 if using 2.3)
WE Credit 3.1	High Efficiency Fixtures	up to 3 points	
WE Credit 3.2	Very High Efficiency Fixtures	up to 6 points (2 pts. Ea)	



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GJMMP Water Use Memo
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Conclusions:

- 70 gpcd is a reasonable baseline for new construction on Guam
- Obtaining LEED credits will require additional water conservation strategies and reduce the interior water demand projections
- The analysis is directed at the end user, i.e. the water meter at the house or building
- Planning a water distribution system will take into account other factors of safety, storage requirements, pumping requirements, fire suppression flow rates, etc. These items can be quantified and added to the final building demand estimates being generated through the SSIM water modeling process.

List of NAVFAC Utility Reports:

- Potable Water Supplemental Analysis Letter Report (Oct. 2009)
- Wastewater Supplementary Analysis Letter Report (Oct. 2009)
- Draft Environmental Impact Statement for Guam and CNMI Military Relocation (Nov. 2009)

The above mentioned guiding documents were utilized during the SSIM^{TM} model calibration of the water demand estimate for the Marine Relocation to the Finegayan Cantonment.

Federal Mandates & Sustainability Guidelines

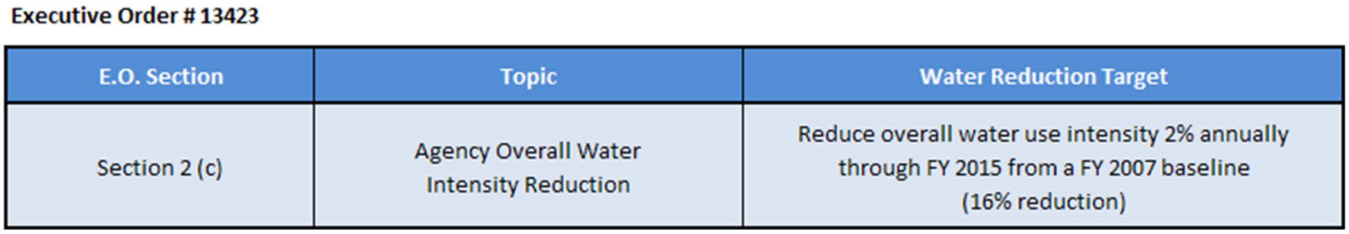
Following is a listing of the federal mandates and sustainability guidelines used to create, evaluate and optimize the water demand estimates and conservation strategies within the SSIM^{TM} model. Each is explained in further detail.

- Executive Order (EO) 13423 (Jan. 24, 2007)
- Executive Order (EO) 13514 (Oct. 5, 2009)
- The Energy Policy Act (EPAct) of (1992)
- Low Impact Development Report (LID) (2010)
- Energy Independence and Security Act (EISA) (January 4, 2007)
- Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU) (January 24, 2006)
- USGBC Leadership in Energy and Environmental Design (LEED) v3 (2009)
- NAVFAC Common Components Study (Sept. 30, 2009)
- NAVFAC Engineering & Construction Bulletin (ECB 2008-01)
- NAVFAC Engineering & Construction Bulletin (ECB 2009-02)
- DoD, Military Handbook of Water Conservation (MIL-HDBK-1165) (April 7, 1997)

Executive Order (EO) 13423 (Jan. 24, 2007)

The EO 13423 for Strengthening Federal Environmental, Energy, and Transportation Management establishes performance based targets for implementation of the Critical Sustainability Performance Plan. Beginning in 2008, federal agencies must reduce water consumption intensity through life-cycle cost-effective measures, related to the baseline of the agency's water consumption. Section 2(c) of the order identifies an overall target for water conservation.

(c) beginning in FY 2008, reduce water consumption intensity, relative to the baseline of the agency's water consumption in FY 2007, through life-cycle cost-effective measures by 2 percent annually through the end of FY 2015 or 16 percent by the end of FY 2015.



Executive Order # 13423

E.O. Section	Topic	Water Reduction Target
Section 2 (c)	Agency Overall Water Intensity Reduction	Reduce overall water use intensity 2% annually through FY 2015 from a FY 2007 baseline (16% reduction)

TABLE 2-3: Executive Order 13423

Executive Order (EO) 13514 (Oct. 5, 2009)

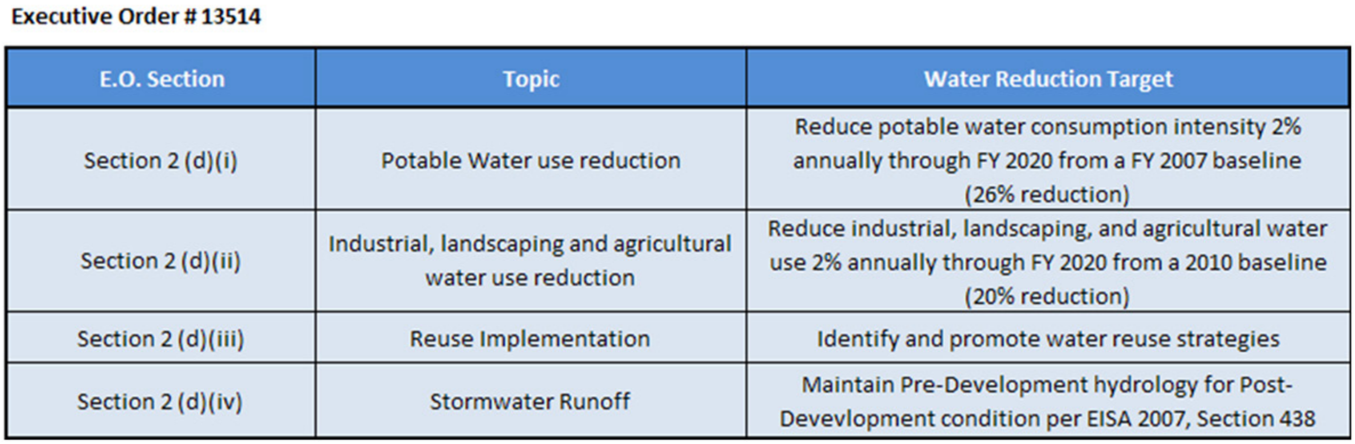
The EO 13514 for Federal Leadership in Environmental, Energy, and Economic Performance establishes performance based targets for implementation of the Critical Sustainability Performance Plan. Section 2(d) identifies three targets for water consumption reduction and one strategy for conservation of predevelopment stormwater quantity.

(d) improve water use efficiency and management by:

> (ii) reducing agency industrial, landscaping, and agricultural water consumption by 2 percent annually or 20 percent by the end of fiscal year 2020 relative to a baseline of the agency's industrial, landscaping, and agricultural water consumption in FY 2010;
>
> (iii) consistent with State law, identifying, promoting, and implementing water reuse strategies that reduce potable water consumption; and
>
> (iv) implementing and achieving the objectives identified in the stormwater management guidance referenced in section 14 of this order.

Sec. 14. Stormwater Guidance for Federal Facilities. Within 60 days of the date of this order, the Environmental Protection Agency, in coordination with other federal agencies as appropriate, shall issue guidance on the implementation of Section 438 of the Energy Independence and Security Act (EISA) 2007 (42 U.S.C. 17094).

The Executive Orders specify a reduction in water use from the actual consumption as it was recorded in the baseline year of 2007. Since the Finegayan Cantonment did not exist in 2007, a water consumption baseline was established utilizing the "National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances" as published by the EPA. This specification includes fixture flow rates as listed in the EPAct 1992.



Executive Order # 13514

E.O. Section	Topic	Water Reduction Target
Section 2 (d)(i)	Potable Water use reduction	Reduce potable water consumption intensity 2% annually through FY 2020 from a FY 2007 baseline (26% reduction)
Section 2 (d)(ii)	Industrial, landscaping and agricultural water use reduction	Reduce industrial, landscaping, and agricultural water use 2% annually through FY 2020 from a 2010 baseline (20% reduction)
Section 2 (d)(iii)	Reuse Implementation	Identify and promote water reuse strategies
Section 2 (d)(iv)	Stormwater Runoff	Maintain Pre-Development hydrology for Post-Devevlopment condition per EISA 2007, Section 438

TABLE 2-4: Executive Order 13514

The Energy Policy Act (EPAct) of 1992

This act sets goals, created mandates, and amended utility laws to increase clean energy use and improve overall energy efficiency in the United States. The Act consists of twenty-seven titles detailing various measures designed to lessen the nation's dependence on imported energy, provide incentives for clean and renewable energy, and promote energy conservation in buildings.

Water fixture flow rates are established and recommended within Section 123, "Energy Conservation Requirements for Certain Lamps and Plumbing Products." Below is a partial summary of these fixtures and associated flow rates.

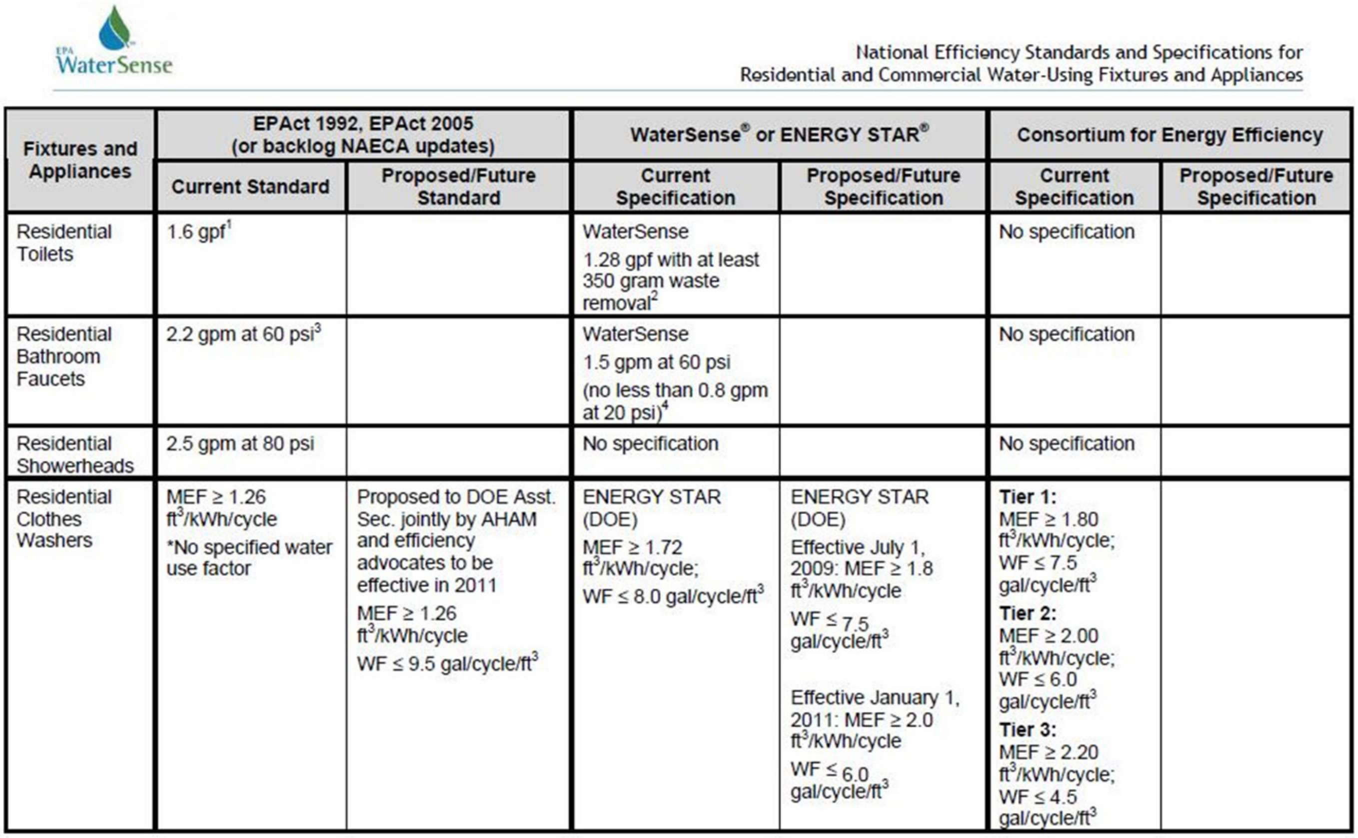
Energy Independence and Security Act (EISA) Section 438 (January 4, 2007)

EISA Section 438 requirements apply to projects that construct facilities with a footprint greater than 5,000 gross square feet, or expand the footprint of existing facilities by more than 5,000 gross square feet. The overall design objective for each project is to maintain predevelopment hydrology and prevent any net increase in storm water runoff. Project site design options shall be evaluated to achieve the design objective to the maximum extent technically feasible. If the design objective cannot be met within the project footprint, LID measures may be applied at nearby locations on DoD property, downstream from the project, within available resources.

Low Impact Development (LID) strategies and Best Management Practice (BMP) devices, if implemented properly, can achieve a reduction in post-development storm water runoff to match the pre-development condition and reduce the transportation of total suspended solids and other pollutants.

Low Impact Development Report (LID) (2010)

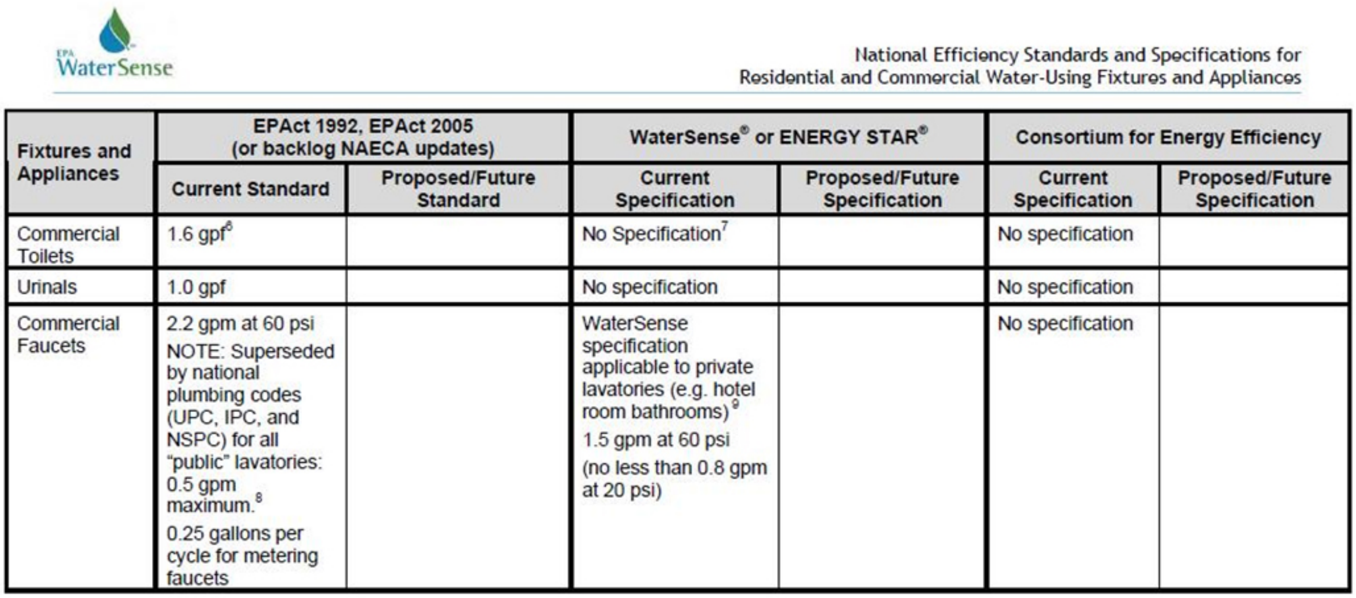
In addition to the SSIM™ Modeling and Sustainability Report, a Low Impact Development Report is being


EPA WaterSense

National Efficiency Standards and Specifications for
Residential and Commercial Water-Using Fixtures and Appliances

Fixtures and Appliances	EPAct 1992, EPAct 2005 (or backlog NAECA updates)		WaterSense® or ENERGY STAR®		Consortium for Energy Efficiency	
	Current Standard	Proposed/Future Standard	Current Specification	Proposed/Future Specification	Current Specification	Proposed/Future Specification
Residential Toilets	1.6 gpf[1]		WaterSense 1.28 gpf with at least 350 gram waste removal[2]		No specification	
Residential Bathroom Faucets	2.2 gpm at 60 psi[3]		WaterSense 1.5 gpm at 60 psi (no less than 0.8 gpm at 20 psi)[4]		No specification	
Residential Showerheads	2.5 gpm at 80 psi		No specification		No specification	
Residential Clothes Washers	MEF ≥ 1.26 ft³/kWh/cycle *No specified water use factor	Proposed to DOE Asst. Sec. jointly by AHAM and efficiency advocates to be effective in 2011 MEF ≥ 1.26 ft³/kWh/cycle WF ≤ 9.5 gal/cycle/ft³	ENERGY STAR (DOE) MEF ≥ 1.72 ft³/kWh/cycle; WF ≤ 8.0 gal/cycle/ft³	ENERGY STAR (DOE) Effective July 1, 2009: MEF ≥ 1.8 ft³/kWh/cycle WF ≤ 7.5 gal/cycle/ft³ Effective January 1, 2011: MEF ≥ 2.0 ft³/kWh/cycle WF ≤ 6.0 gal/cycle/ft³	**Tier 1:** MEF ≥ 1.80 ft³/kWh/cycle; WF ≤ 7.5 gal/cycle/ft³ **Tier 2:** MEF ≥ 2.00 ft³/kWh/cycle; WF ≤ 6.0 gal/cycle/ft³ **Tier 3:** MEF ≥ 2.20 ft³/kWh/cycle; WF ≤ 4.5 gal/cycle/ft³	

TABLE 2-5: The Energy Policy Act of 1992 Residential



National Efficiency Standards and Specifications for
Residential and Commercial Water-Using Fixtures and Appliances

Fixtures and Appliances	EPAct 1992, EPAct 2005 (or backlog NAECA updates)		WaterSense® or ENERGY STAR®		Consortium for Energy Efficiency	
	Current Standard	Proposed/Future Standard	Current Specification	Proposed/Future Specification	Current Specification	Proposed/Future Specification
Commercial Toilets	1.6 gpf[6]		No Specification[7]		No specification	
Urinals	1.0 gpf		No specification		No specification	
Commercial Faucets	2.2 gpm at 60 psi NOTE: Superseded by national plumbing codes (UPC, IPC, and NSPC) for all "public" lavatories: 0.5 gpm maximum.[8] 0.25 gallons per cycle for metering faucets		WaterSense specification applicable to private lavatories (e.g. hotel room bathrooms)[9] 1.5 gpm at 60 psi (no less than 0.8 gpm at 20 psi)		No specification	

TABLE 2-6: The Energy Policy Act of 1992 Commercial

created concurrently. This report is evaluating various BMP/IMP treatment trains implemented across the Finegayan Cantonment. Although the final report and recommendations will not be available in time for inclusion into the SSIM™ model and sustainability report, the draft LID report currently contains guidance on pollutant loading, anticipated treatment train effectiveness for removing TSS, ability to reduce the post-development stormwater runoff and the ability to meet the federal mandates. These preliminary results including associated costs for the BMP devices were taken from the LID report and are included in the current SSIM™ water model results and recommendations.

Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU) (Jan 24, 2006)

In January 2006, the EPA signed an MOU with 16 other federal agencies to promote high performance and sustainable buildings. On December 1, 2008, the Interagency Sustainability Working Group released a High Performance and Sustainable Buildings Guidance document that updated the MOU Guiding Principles and established Guiding Principles for Sustainable Existing Buildings.

The Guiding Principles, which incorporate requirements from EISA, require agencies to employ design and construction strategies that reduce stormwater runoff, polluted site water runoff, and the use of potable water for irrigation. They promote the use of decentralized stormwater management design strategies to maintain or restore site hydrology to pre-development conditions and promote water-efficient landscaping and irrigation strategies.

To address the high performance and sustainable building requirements, NAVFAC has adopted the use of the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design Green Building Rating System. NAVFAC gave direction to plan and program to achieve at least a USGBC LEED Silver rating which satisfies both the MOU and the EPAct 1992 & 2005 requirements. This direction was provided by the NAVFAC Engineering & Construction Bulletin (ECB) 2008-01.

NAVFAC Common Components Study (Sept. 30, 2009)

The purpose of this report is to "Establish consistency and excellence in the design and construction of Marine Base Facilities, and to function as a working guide that provides direction to planners, designers, architects, engineers, contractors by listing appearance standards and proven construction components that work in Guam's challenging environment...which is subject to salty environment, high humidity, high wind velocity and strong seismic forces." This document lists specific fixtures including EPA Water Sense fixtures, and references the EPAct 1992 and the NAVFAC ECB 2008-01 for water fixture performance standards.

NAVFAC Engineering & Construction Bulletin (ECB 2008-01)

The purpose of the ECB 2008-01 is to provide guidance for complying with the design and construction requirements of the Energy Policy Act (EPAct) of 2005, reference (a) and the Executive Order 13423, reference (b); and to provide guidance on achieving LEED Silver level performance and USGBC certification. This bulletin provides policy on water and energy reduction, USGBC LEED Silver performance, Budget cost items, and Life Cycle cost analysis. The water specific items are discussed below.

Section 3 states, “For indoor water, after meeting the baseline Energy Policy Act (EPAct) of 1992 fixture performance requirements calculated for buildings, employ strategies that use a minimum of 20% less potable water. For outdoor water, employ water efficient landscape and irrigation strategies, including water reuse and recycling, to reduce outdoor potable water consumption by a minimum of 50% over that consumed by conventional means (plant species and plant densities).

NAVFAC Engineering & Construction Bulletin (ECB 2009-02)

Provides guidance/policy for registering projects with the USGBC for LEED certification during transition from LEED v2.2 to LEED v3. This bulletin discusses requirements for USGBC LEED registration for projects from FY09 to FY11. It also states requirements for new Design-Bid-Build and Design-Build projects to be designed, constructed and certified using LEED-NC v3.

USGBC Leadership in Energy and Environmental Design (LEED) v3 (2009)

New Construction (NC) v3.0 (2009) has replaced v2.2 and is required for all LEED projects registered after June 27, 2009. Site Sustainability and Water Efficiency related LEED credits for Finegayan Cantonment are listed below. Brief descriptions of the LEED credits below are informational only and do not fully represent the intent of the LEED reference guide. The USGBC reference guide remains the source that should be used for all LEED credit definitions.

Sustainable Sites Prerequisite
(Construction Activity Pollution Prevention)

Intent: To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.

Requirements: Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2003 EPA Construction General Permit or local standards and codes, whichever is more stringent. The plan must describe the measures implemented to accomplish the following objectives:

- To prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse
- To prevent sedimentation of storm sewers or receiving streams
- To prevent pollution of the air with dust and particulate matter

The EPA’s construction general permit outlines the provisions necessary to comply with Phase I and Phase II of the National Pollutant Discharge Elimination System (NPDES) program. While the permit only applies to construction sites greater than 1 acre, the requirements are applied to all projects for the purposes of this prerequisite. Information on the EPA construction general permit is available at http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

Sustainable Sites Credit 6.1 (Stormwater Design – Quantity Control) 1 Point

Intent: To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.

Requirements:

Case 1: Sites with Existing Imperviousness 50% or Less

Option 1: Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the predevelopment peak discharge rate and quantity for the 1- and 2-year 24-hour design storms.

OR

Option 2: Implement a stormwater management plan that protects receiving stream channels from excessive erosion. The stormwater management plan must include stream channel protection and quantity control strategies.

Case 2: Sites with Existing Imperviousness Greater than 50%

Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the 2-year 24-hour design storm.

Sustainable Sites Credit 6.2 (Stormwater Design – Quality Control) 1 Point

Intent: To limit disruption and pollution of natural water flows by managing stormwater runoff.

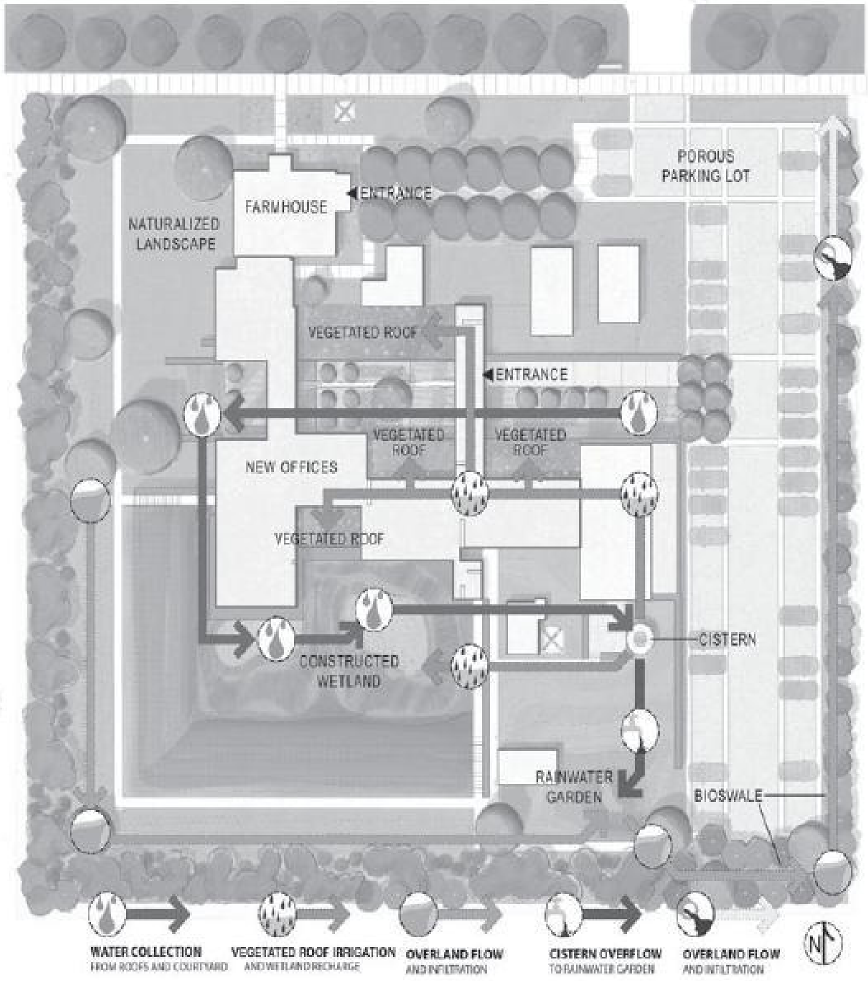


FIGURE 2-6: Sample site plan implementing BMPs (Image from USGBC LEED reference guide for NC v3)

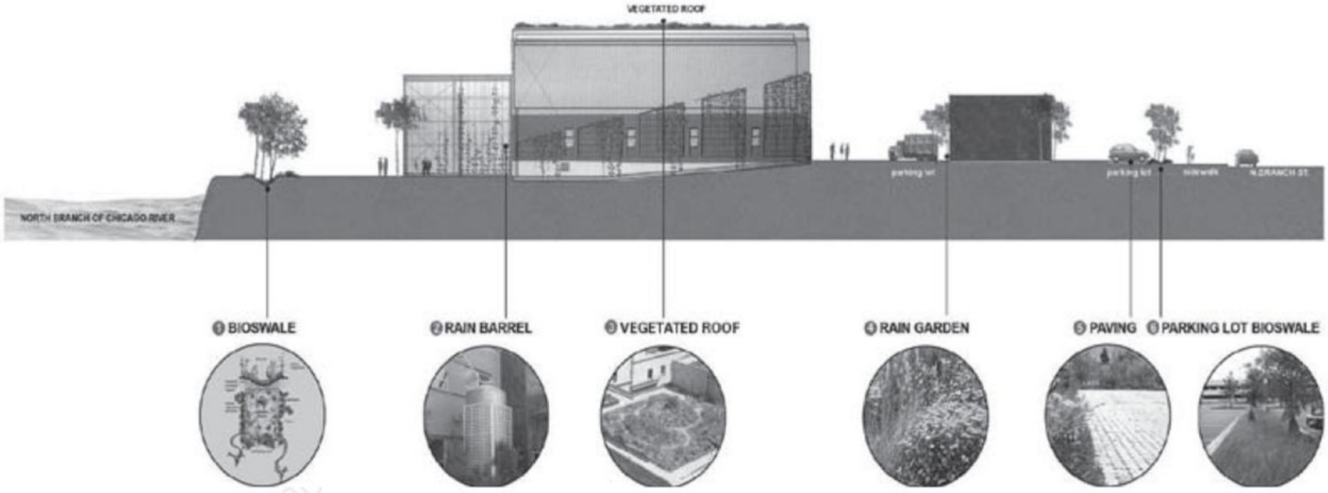
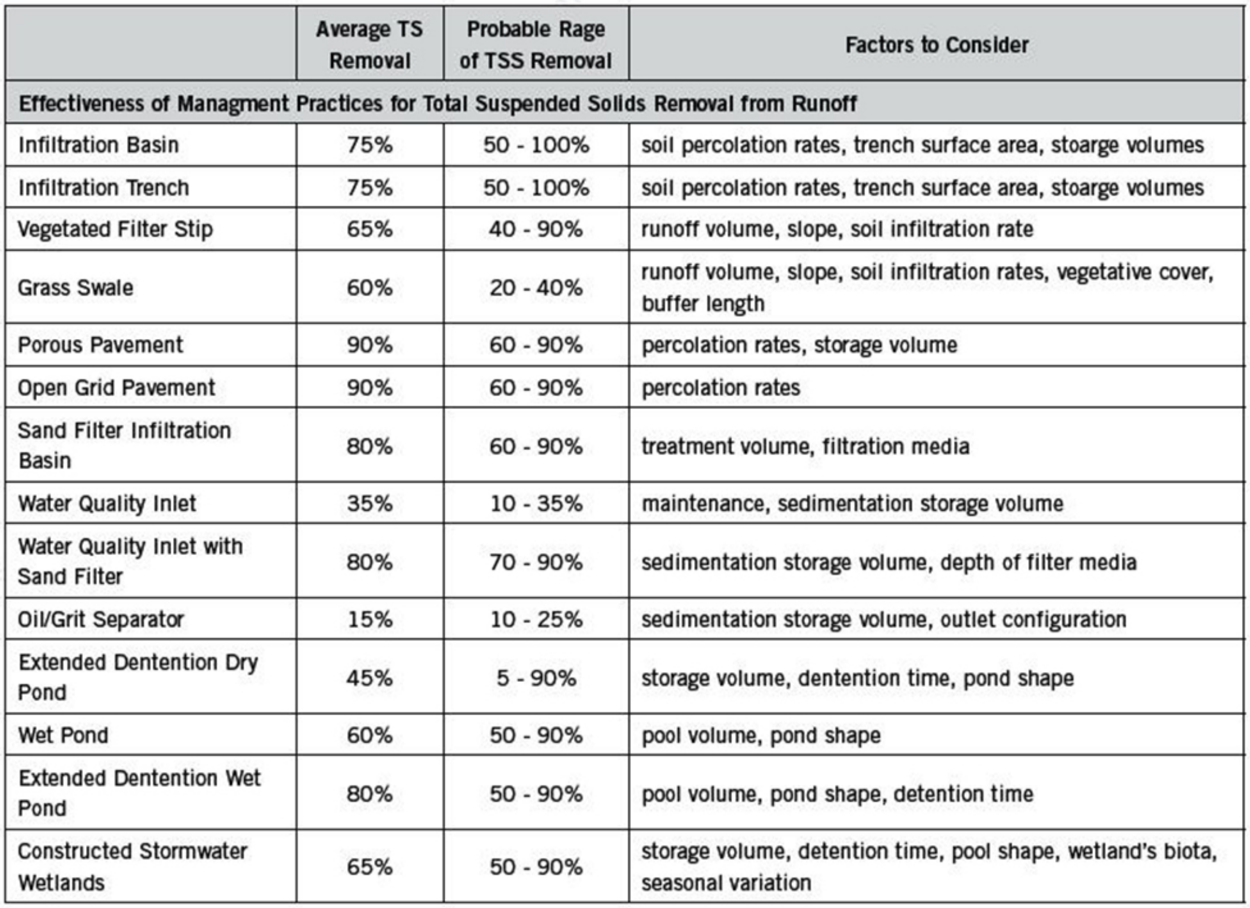


FIGURE 2-7: Sample BMP Device Locations (Image from USGBC LEED reference guide for NC v3)



	Average TS Removal	Probable Rage of TSS Removal	Factors to Consider
Effectiveness of Managment Practices for Total Suspended Solids Removal from Runoff			
Infiltration Basin	75%	50 - 100%	soil percolation rates, trench surface area, stoarge volumes
Infiltration Trench	75%	50 - 100%	soil percolation rates, trench surface area, stoarge volumes
Vegetated Filter Stip	65%	40 - 90%	runoff volume, slope, soil infiltration rate
Grass Swale	60%	20 - 40%	runoff volume, slope, soil infiltration rates, vegetative cover, buffer length
Porous Pavement	90%	60 - 90%	percolation rates, storage volume
Open Grid Pavement	90%	60 - 90%	percolation rates
Sand Filter Infiltration Basin	80%	60 - 90%	treatment volume, filtration media
Water Quality Inlet	35%	10 - 35%	maintenance, sedimentation storage volume
Water Quality Inlet with Sand Filter	80%	70 - 90%	sedimentation storage volume, depth of filter media
Oil/Grit Separator	15%	10 - 25%	sedimentation storage volume, outlet configuration
Extended Dentention Dry Pond	45%	5 - 90%	storage volume, dentention time, pond shape
Wet Pond	60%	50 - 90%	pool volume, pond shape
Extended Dentention Wet Pond	80%	50 - 90%	pool volume, pond shape, detention time
Constructed Stormwater Wetlands	65%	50 - 90%	storage volume, detention time, pool shape, wetland's biota, seasonal variation

TABLE 2-7: Table listing BMPs and performance (Image from USGBC LEED reference guide for NC v3)

Requirements: Implement a stormwater management plan that reduces impervious cover, promotes infiltration and captures and treats the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs). BMPs used to treat runoff must be capable of removing 80% of the average annual post-development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if:

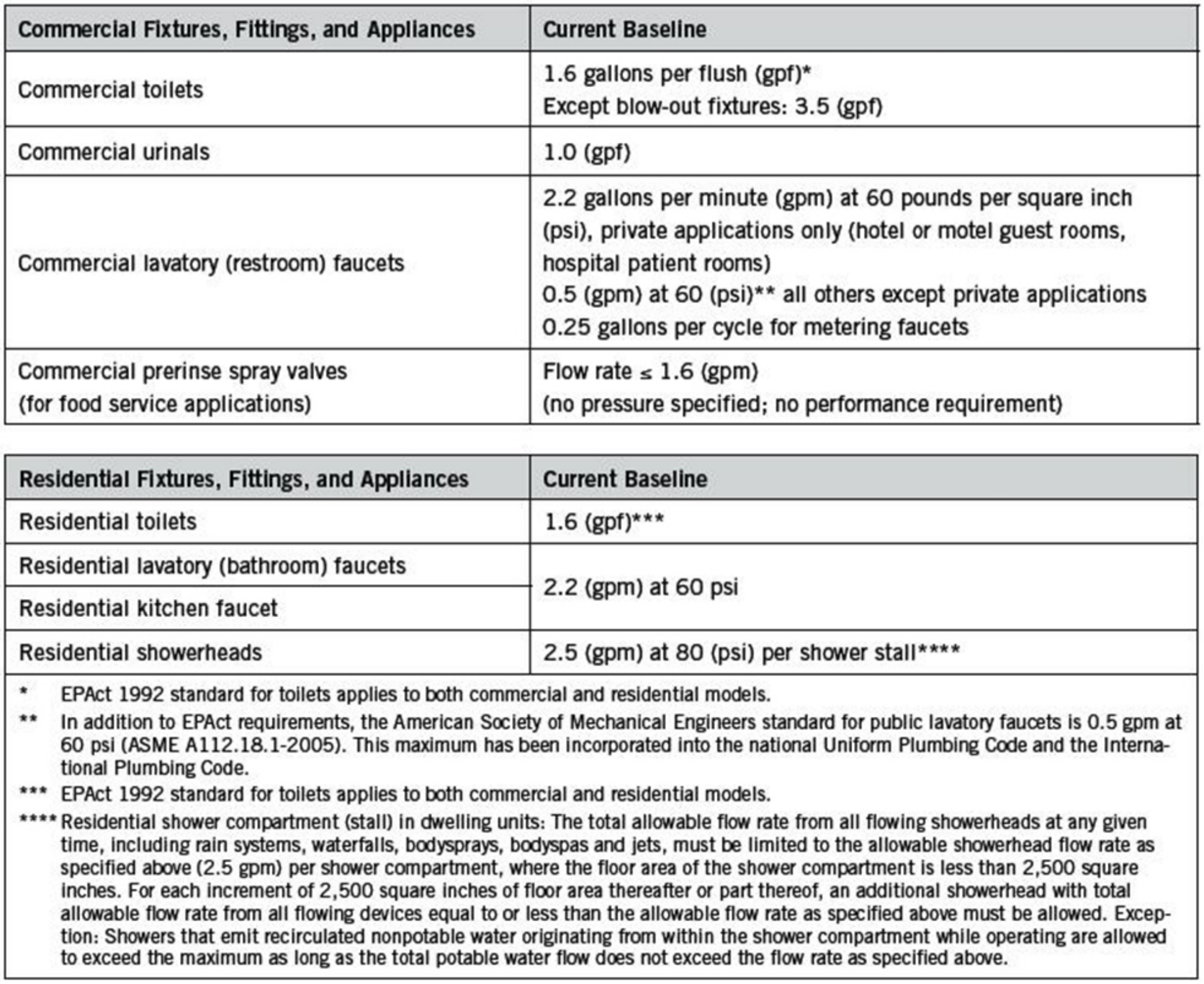
They are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards,

OR

There exists infield performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (ie. Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

Water Efficiency Prerequisite

Intent: To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.



Commercial Fixtures, Fittings, and Appliances	Current Baseline
Commercial toilets	1.6 gallons per flush (gpf)* Except blow-out fixtures: 3.5 (gpf)
Commercial urinals	1.0 (gpf)
Commercial lavatory (restroom) faucets	2.2 gallons per minute (gpm) at 60 pounds per square inch (psi), private applications only (hotel or motel guest rooms, hospital patient rooms) 0.5 (gpm) at 60 (psi)** all others except private applications 0.25 gallons per cycle for metering faucets
Commercial prerinse spray valves (for food service applications)	Flow rate ≤ 1.6 (gpm) (no pressure specified; no performance requirement)

Residential Fixtures, Fittings, and Appliances	Current Baseline
Residential toilets	1.6 (gpf)***
Residential lavatory (bathroom) faucets	2.2 (gpm) at 60 psi
Residential kitchen faucet	
Residential showerheads	2.5 (gpm) at 80 (psi) per shower stall****

* EPAct 1992 standard for toilets applies to both commercial and residential models.

** In addition to EPAct requirements, the American Society of Mechanical Engineers standard for public lavatory faucets is 0.5 gpm at 60 psi (ASME A112.18.1-2005). This maximum has been incorporated into the national Uniform Plumbing Code and the International Plumbing Code.

*** EPAct 1992 standard for toilets applies to both commercial and residential models.

**** Residential shower compartment (stall) in dwelling units: The total allowable flow rate from all flowing showerheads at any given time, including rain systems, waterfalls, bodysprays, bodyspas and jets, must be limited to the allowable showerhead flow rate as specified above (2.5 gpm) per shower compartment, where the floor area of the shower compartment is less than 2,500 square inches. For each increment of 2,500 square inches of floor area thereafter or part thereof, an additional showerhead with total allowable flow rate from all flowing devices equal to or less than the allowable flow rate as specified above must be allowed. Exception: Showers that emit recirculated nonpotable water originating from within the shower compartment while operating are allowed to exceed the maximum as long as the total potable water flow does not exceed the flow rate as specified above.

TABLE 2-8: Table identifying Fixture Flow Rates for calculations from Baseline (Image from USGBC LEED reference guide for NC v3)

Requirement: Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation). Calculations based on estimated occupant usage and must include only the following fixtures and fixture fittings (as applicable to the project scope): water closets, urinals, lavatory faucets, showers, kitchen sink faucets and pre-rinse spray valves. See tables below for conventional and low flow fixture flow rates.

Water Efficiency Credit 1 (Water Efficient Landscaping)

Intent: *T*o limit or eliminate the use of potable water or other natural surface or sub-surface water resources available on or near the project site for landscape irrigation.

Requirements:

Option 1: Reduce by 50% (2 points)
Reduce potable water consumption for irrigation by 50% from a calculated midsummer baseline case. Reductions must be attributed to any combination of the following items:

- Plant species, density and microclimate factor
- Irrigation efficiency
- Use of captured rainwater
- Use of recycled wastewater
- Use of water treated and conveyed by a public agency specifically for non-potable uses

Option 2: No Potable Water Use or Irrigation (4 points)

Requirements: Meet the requirements for Option 1, and

Path 1: Use only captured rainwater, recycled wastewater, recycled graywater or water treated and conveyed by a public agency specifically for non-potable uses for irrigation.

OR

Path 2: Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within 1 year of installation.

Water Efficiency Credit 2 (Innovation in Wastewater Technologies) 2 points

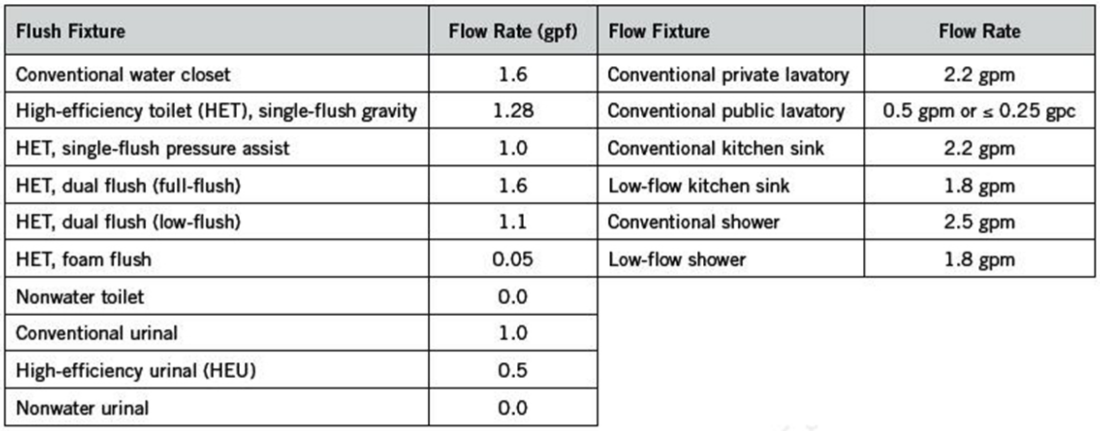
Intent: To reduce wastewater generation and potable water demand while increasing the local aquifer recharge.

Requirements:

Option 1: Reduce potable water use for building sewage conveyance by 50% through the use of water-conserving fixtures (ie. water closets, urinals) or non-potable water (ie. captured rainwater, recycled graywater, on-site or municipally treated wastewater).

OR

Option 2: Treat 50% of wastewater on-site to tertiary standards. Treated water must be infiltrated or used on-site.



Flush Fixture	Flow Rate (gpf)	Flow Fixture	Flow Rate
Conventional water closet	1.6	Conventional private lavatory	2.2 gpm
High-efficiency toilet (HET), single-flush gravity	1.28	Conventional public lavatory	0.5 gpm or ≤ 0.25 gpc
HET, single-flush pressure assist	1.0	Conventional kitchen sink	2.2 gpm
HET, dual flush (full-flush)	1.6	Low-flow kitchen sink	1.8 gpm
HET, dual flush (low-flush)	1.1	Conventional shower	2.5 gpm
HET, foam flush	0.05	Low-flow shower	1.8 gpm
Nonwater toilet	0.0		
Conventional urinal	1.0		
High-efficiency urinal (HEU)	0.5		
Nonwater urinal	0.0		

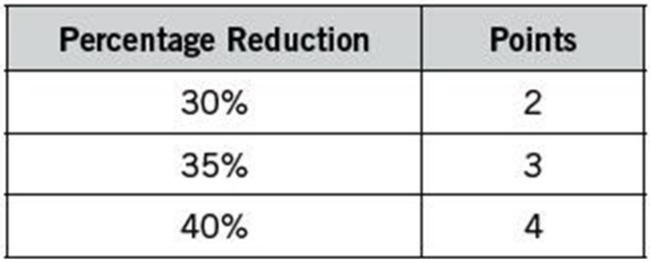
TABLE 2-9: Fixture Flow Rates for Efficient Fixtures (Image from USGBC LEED reference guide for NC v3)

Water Efficiency Credit 3 (Water Use Reduction) 2-4 points

Intent: To further increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements: Employ strategies that in aggregate use less water than the water use baseline calculated for the building (not including irrigation).

The minimum water savings percentage for each point threshold is as follows:



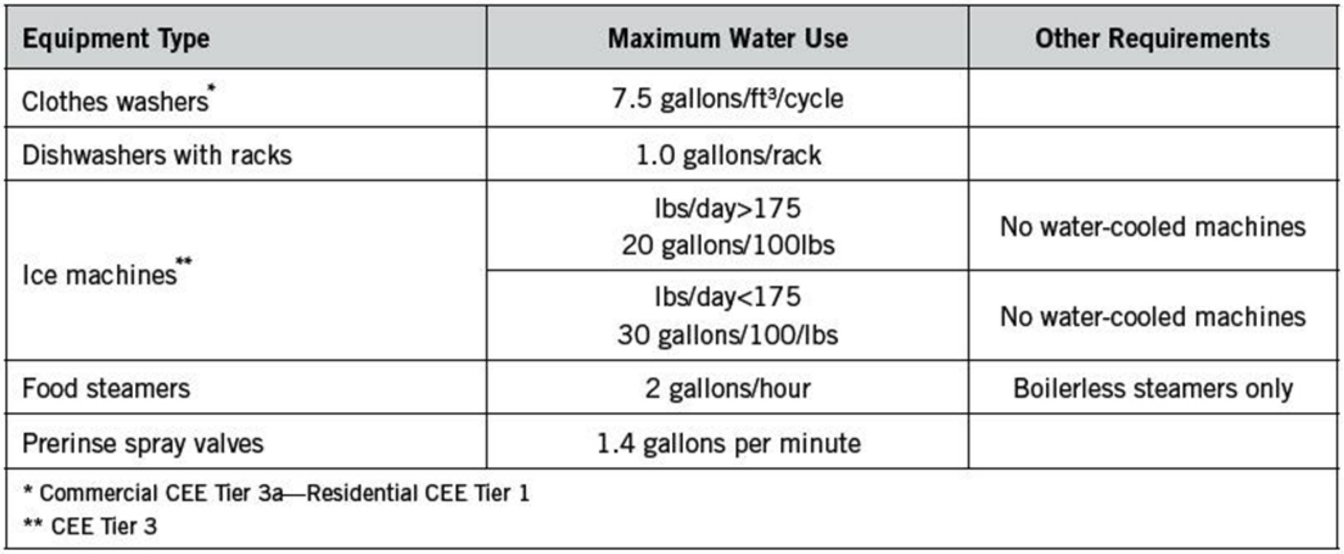
Percentage Reduction	Points
30%	2
35%	3
40%	4

Water Efficiency Credit 4 (Process Water Use Reduction) Schools only

Intent: To maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements:

- No refrigeration equipment using once-through cooling with potable water
- No garbage disposals
- At least 4 process items where water use is at or below the levels shown in the table below. Inclusion of any equipment not listed in the table below must be supported by documentation showing a 20% reduction in water use from a benchmark or industry standard.



Equipment Type	Maximum Water Use	Other Requirements
Clothes washers*	7.5 gallons/ft³/cycle	
Dishwashers with racks	1.0 gallons/rack	
Ice machines**	lbs/day>175 20 gallons/100lbs	No water-cooled machines
	lbs/day<175 30 gallons/100/lbs	No water-cooled machines
Food steamers	2 gallons/hour	Boilerless steamers only
Prerinse spray valves	1.4 gallons per minute	
* Commercial CEE Tier 3a—Residential CEE Tier 1 ** CEE Tier 3		

TABLE 2-10: Table of Process Water Use for Schools

Packages & Performance

SSIM^{TM} WATER MODEL EVOLUTION

The definitions of the SSIM^{TM} model key performance indicators have evolved for use on the Finegayan Cantonment. This is important to understand since these assumptions for water consumption demand estimating affect the model results and recommendations. Originally, the model utilized industry standards for water consumption as the Baseline performance indicator which was subsequently determined to be inconsistent with the UFC water demand. After some discussion, the methodology was revised to increase water demand estimation to be more cohesive with EIS results, which were reduced from the UFC water demand. An evaluation and comparison between our water demand estimating method, the UFC and the EIS as been completed. This memo attempts to understand the basis for the high UFC water demand and to understand how our SSIM^{TM} model water demand relates to it.

In addition to modifications to our model water demand estimating, the frequency of water fixture use was calibrated and increased to match the known use on Guam. The increased fixture uses includes showers and clothes washers.

Through extensive discussion regarding the basis of our Baseline definition, we have adjusted the model to represent the following:

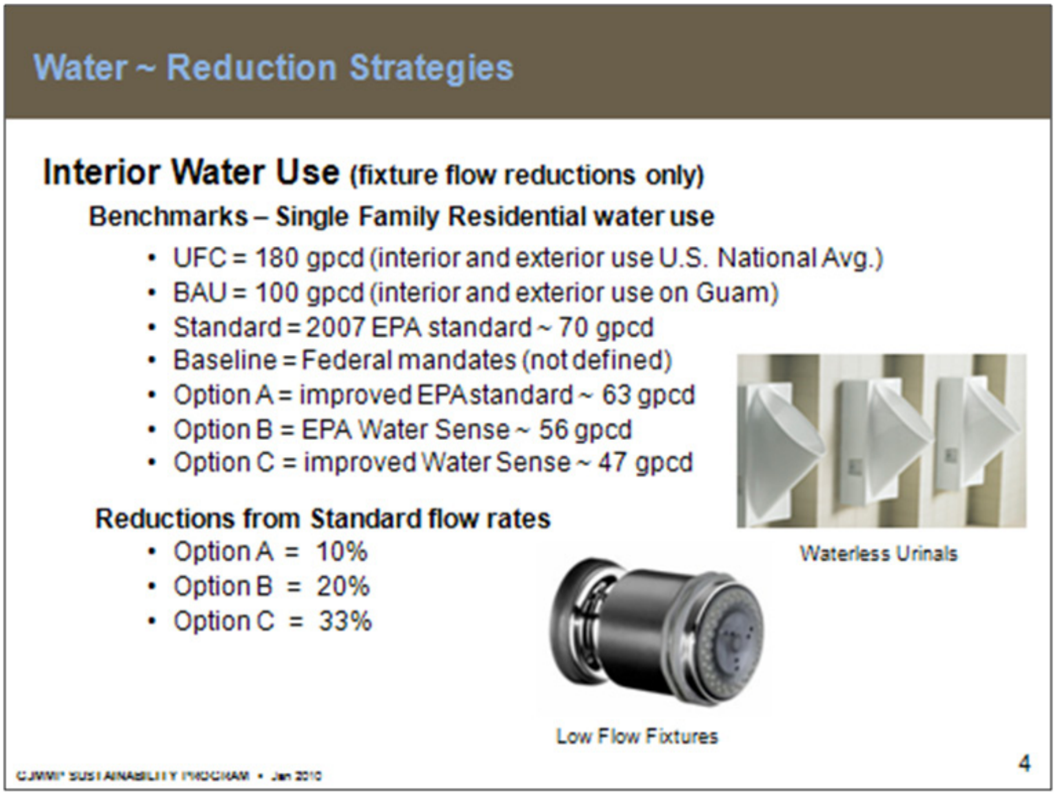
The following slide, taken from the January 2010 webinar water presentation to NAVFAC, has been revised to reflect the new definition of Baseline, and the addition of Standard, the base point used for all water consumption reduction calculations. Please note that this slide represents the gallon/capita/day interior water use in the single family residential area only. The percent reductions shown are isolated to this interior water use only and do not include commercial facility water use or other more aggressive strategies such as water harvesting or reuse.

i. Business As Usual (BAU)

Actual water use on Guam as field verified (ground truthed). According to local sources and Guam Water Works Authority, the residential water use on Guam is currently around 96.9 gallons per person per day. This data was used to define BAU for the SSIM^{TM} model calibration of the Baseline and the performance packages A, B & C. The BAU is not evaluated or used as a point of measurement for the revised performance evaluations as presented further.

ii. Standard

The water demand for this package was calibrated to the minimum requirements for potable water use through water fixture flow rates for FY 2007, which was defined in EPAct 1992, the current standard for fixture flow rates in 2007. These fixture flow rates were applied to the detailed population and facility data taken from the master plan. This detailed program data is applied to all packages for comparison. This package is used as the starting point for water consumption reduction calculations as required by the federal mandates.



Water ~ Reduction Strategies

Interior Water Use **(fixture flow reductions only)**

Benchmarks – Single Family Residential water use

- UFC = 180 gpcd (interior and exterior use U.S. National Avg.)
- BAU = 100 gpcd (interior and exterior use on Guam)
- Standard = 2007 EPA standard ~ 70 gpcd
- Baseline = Federal mandates (not defined)
- Option A = improved EPA standard ~ 63 gpcd
- Option B = EPA Water Sense ~ 56 gpcd
- Option C = improved Water Sense ~ 47 gpcd

Reductions from Standard flow rates

- Option A = 10%
- Option B = 20%
- Option C = 33%

Waterless Urinals

Low Flow Fixtures

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FIGURE 2-8: Interior Water Use – Fixture Flow Rate Reduction Strategies

iii. Baseline

This package is defined as the minimum requirement that meets water consumption reduction related mandates for federal facilities. This package is the first conservation package capable of being selected and implemented since it just meets the facility related reduction requirements, including the 26% potable water consumption intensity reduction from the (Effective Baseline) or Standard Package as described in E.O. 13514. Additional conservation and larger life cycle savings are seen in the more aggressive conservation packages A, B and C, described below.

Program Packages A, B & C:

These are performance levels that go beyond required facility mandates but are necessary to meet or exceed overall installation level mandates. These levels provide a reduction in water use and water consumption intensity beyond the required federally mandated reductions and provide various additional capital costs, operation and maintenance savings, and overall life cycle savings.

iv. Package A

This performance based package is designed to exceed the Baseline Package only slightly while Optimizing the performance and minimizing the capital cost (First Cost) required.

v. Package B

This performance based package is designed to further exceed the Baseline Package for sustainability and focus on the quickest payback term for the infrastructure required to meet these aggressive water consumption reducing strategies.

vi. Package C

This performance based package is designed to maximize the use of sustainability strategies that provide the highest life cycle cost savings over 42 years.

Packages A, B & C all meet the federal water reduction mandates for federal facilities; however, they offer differing results related to additional first costs and life cycle cost savings. Each of these packages will benefit the project and stakeholders in different ways and should be evaluated from each of the respective stakeholder perspectives for final determination of the selected package.

The following slide (Figure 2-16), taken from the January 2010 webinar water presentation, indicates the potential reduction in potable water resulting from implementation of reuse strategies. Since these strategies are closely related, the combined effort will not result a net combination of percent savings but rather an averaged savings. The percent savings represented are also assuming reductions in potable water use as measured from a business as usual case. The intent of this slide is to represent the importance of reuse as an important strategy in the overall sustainability effort.

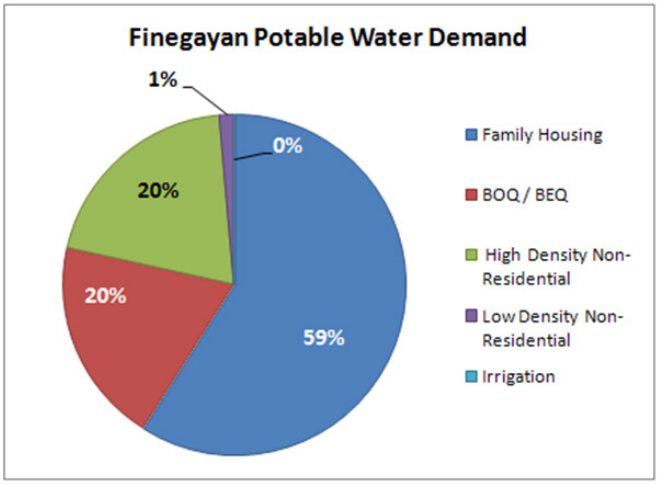


FIGURE 2-9: Potable Water Demand Allocation on the Finegayan Cantonment

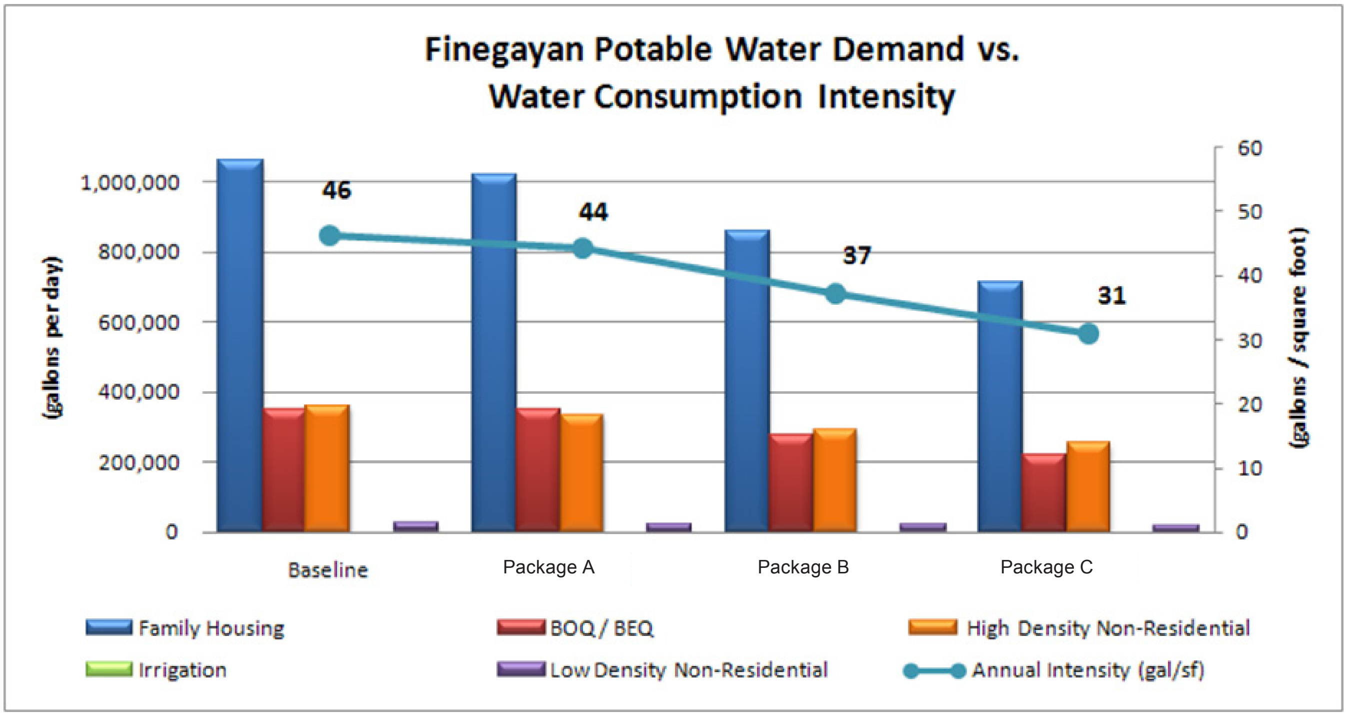


FIGURE 2-10: Potable Water Demand Allocation vs. Annual Use Intensity on the Finegayan Cantonment

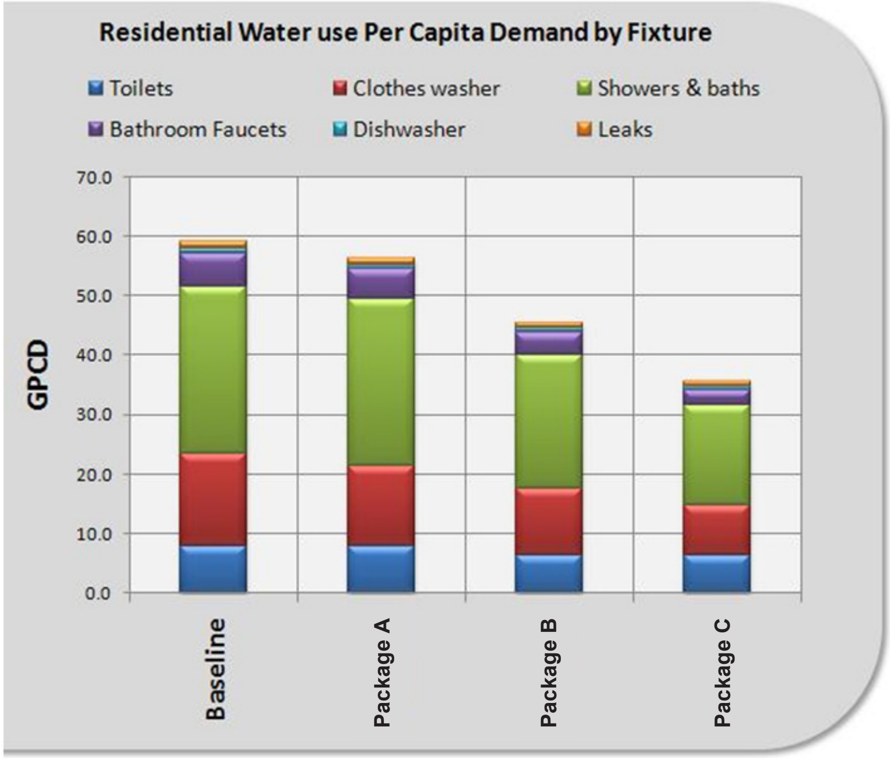


FIGURE 2-11: BEQ / BOQ Residential Water Use

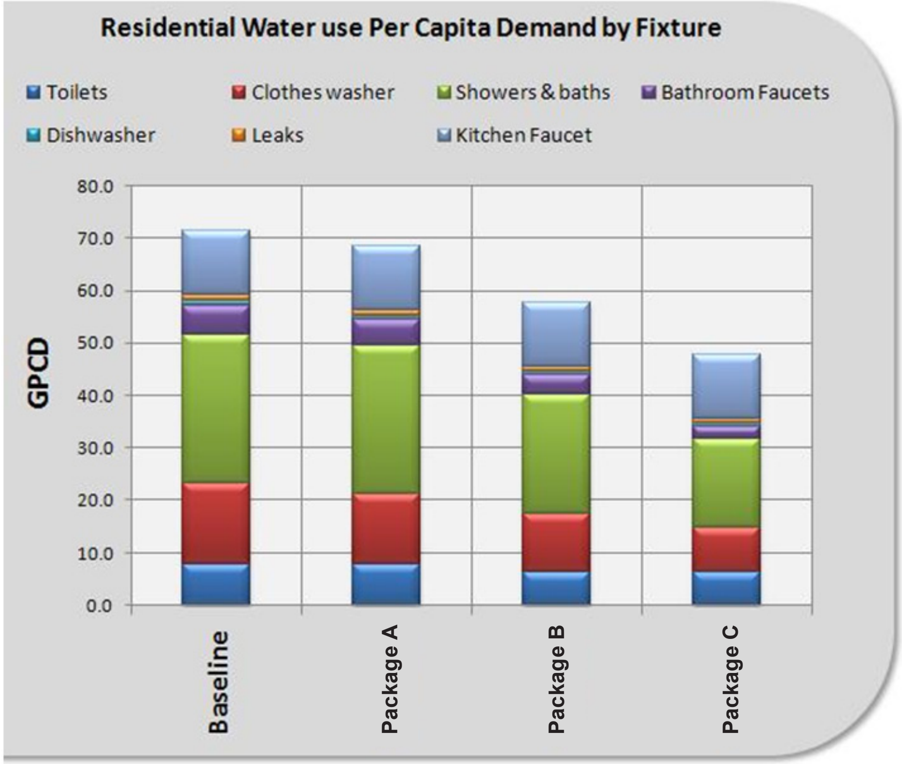


FIGURE 2-12: Single Family Residential Water Use

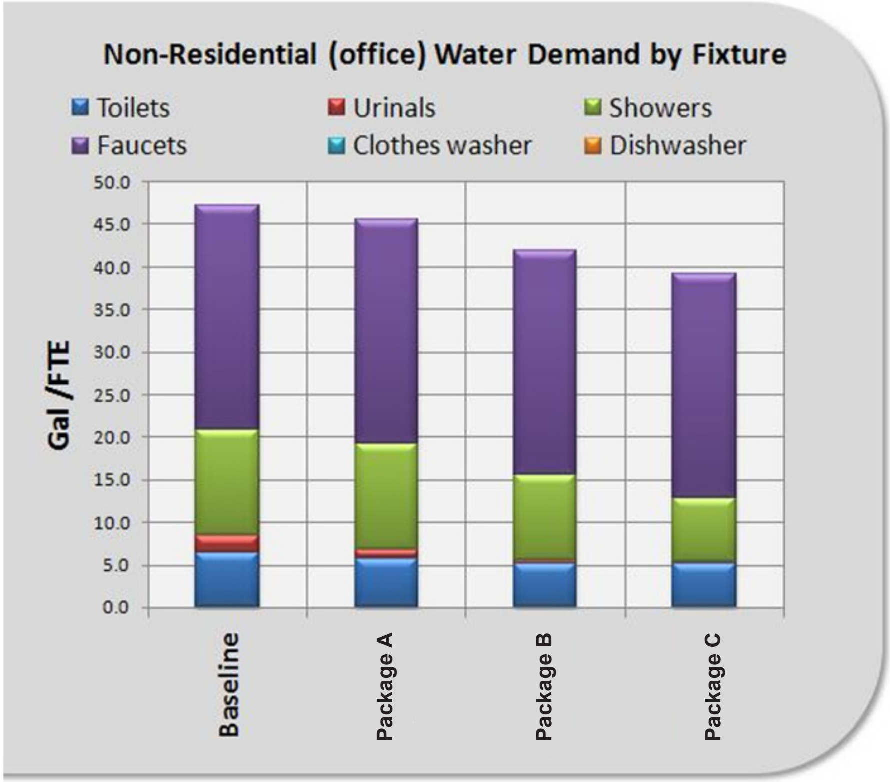


FIGURE 2-13: Non Residential (Office) Water Use

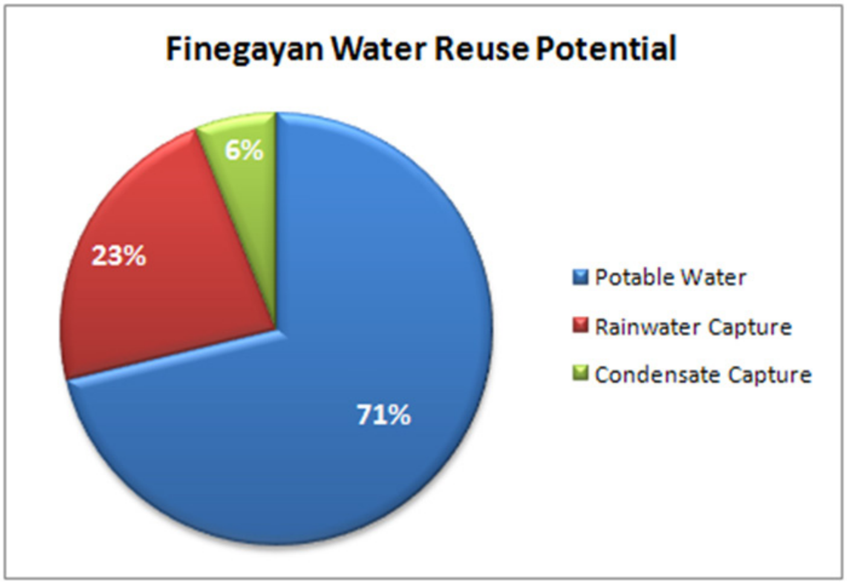


FIGURE 2-14: Finegayan Allocation of Water Reuse Potential

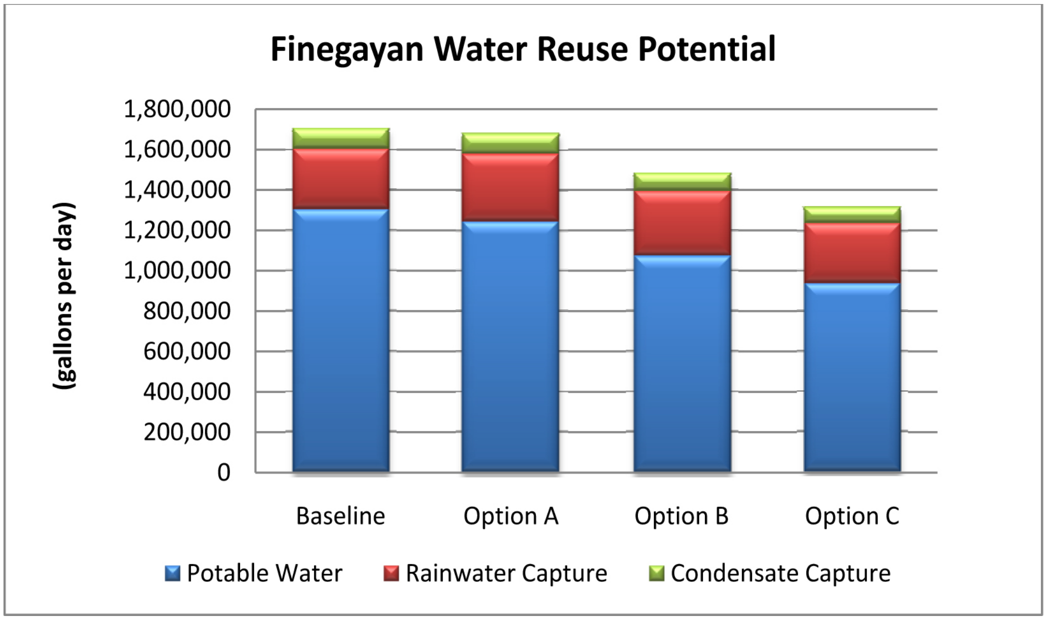
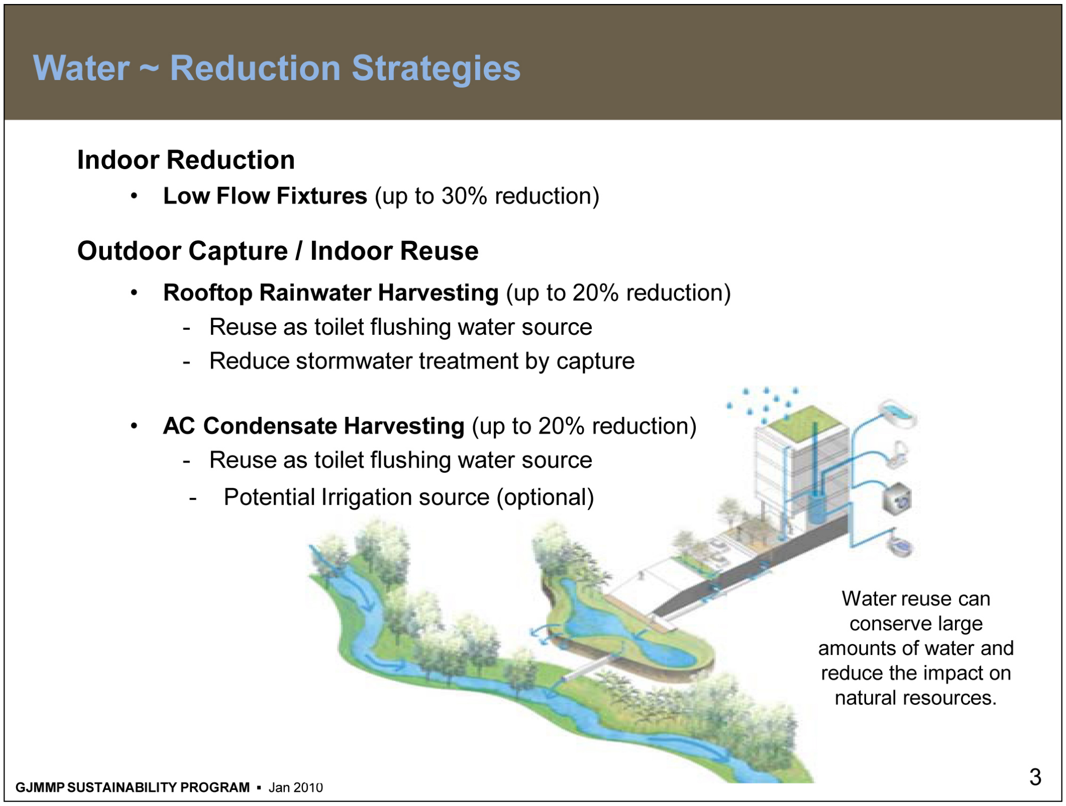


FIGURE 2-15: Finegayan Water Reuse Potential per Conservation Package



Water ~ Reduction Strategies

Indoor Reduction

- **Low Flow Fixtures** (up to 30% reduction)

Outdoor Capture / Indoor Reuse

- **Rooftop Rainwater Harvesting** (up to 20% reduction)
  - Reuse as toilet flushing water source
  - Reduce stormwater treatment by capture
- **AC Condensate Harvesting** (up to 20% reduction)
  - Reuse as toilet flushing water source
  - Potential Irrigation source (optional)

Water reuse can conserve large amounts of water and reduce the impact on natural resources.

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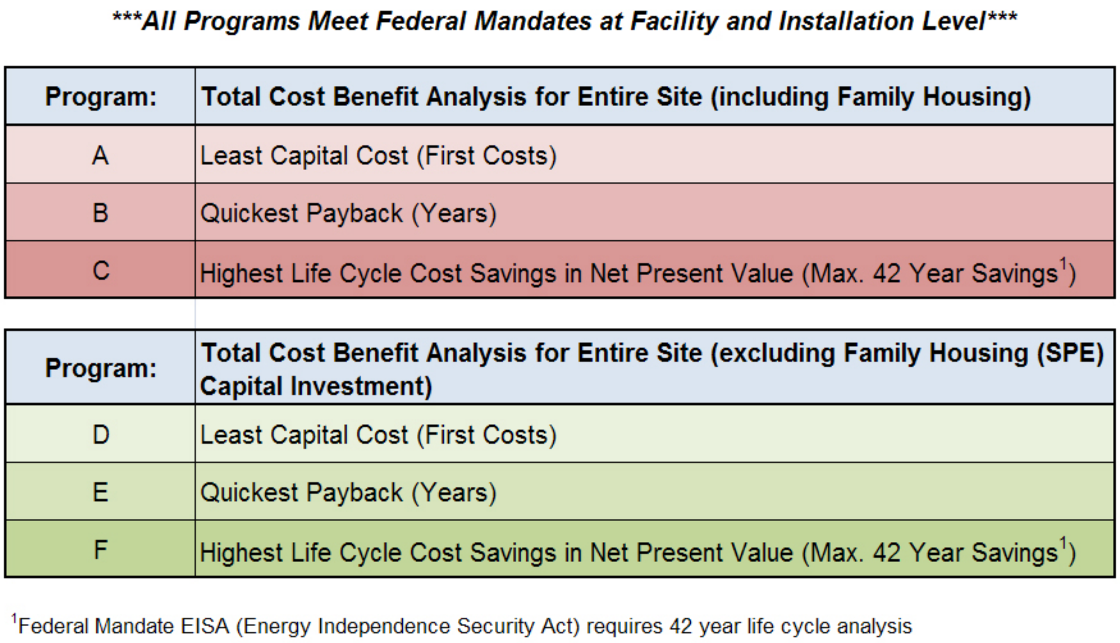
FIGURE 2-16: Water Reduction Strategies

Cost/Benefit Analysis

Generally, the ability to reduce the backbone infrastructure and associated capital costs through potable water demand reductions provides ample cost savings that more than covers the additional capital cost of the higher efficiency fixtures and systems. The Finegayan Cantonment is unique in that no cost savings will be realized from a reduction in the backbone infrastructure. This is due to the use of the UFC design guide to size the infrastructure and because no reduction in well water, treatment, storage or distribution will be realized. Instead all additional water supplied, treated and pumped, but not used on site, will be sent offsite to Guam Water Works Authority to supplement their system and ensure that the island wide water needs are met.

Although meeting this offsite demand is very important to support the construction and other support needs of the installation, the lack of flexibility to reduce this water system will require additional cost. The reimbursement cost for the water sold to offsite users is not known. If this water is sold at cost, then this cost should include a portion of the additional capital cost for the larger and additional infrastructure in addition to the actual cost of pumping, treatment, storage and any other O&M costs. If these costs are offset by the sale of this water, the installation will be less likely to lose money through the production, distribution and sale of this water.



All Programs Meet Federal Mandates at Facility and Installation Level

Program:	Total Cost Benefit Analysis for Entire Site (including Family Housing)
A	Least Capital Cost (First Costs)
B	Quickest Payback (Years)
C	Highest Life Cycle Cost Savings in Net Present Value (Max. 42 Year Savings[1])

Program:	Total Cost Benefit Analysis for Entire Site (excluding Family Housing (SPE) Capital Investment)
D	Least Capital Cost (First Costs)
E	Quickest Payback (Years)
F	Highest Life Cycle Cost Savings in Net Present Value (Max. 42 Year Savings[1])

[1] Federal Mandate EISA (Energy Independence Security Act) requires 42 year life cycle analysis

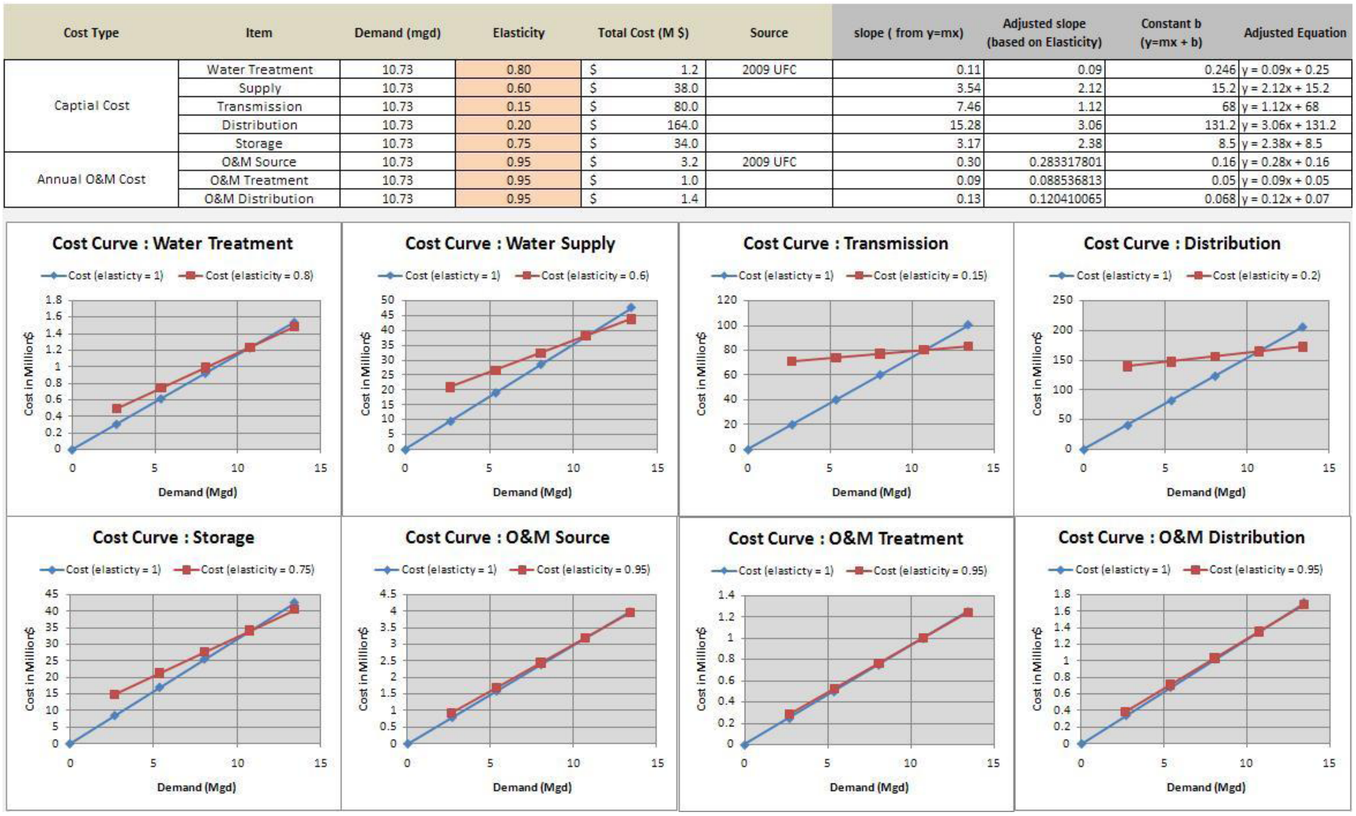
FIGURE 2-17: Cost Benefit Results Description for Sustainable Programs

Water Infrastructure Cost Elasticity

The use of cost elasticity factors for each of the components of the water infrastructure provides a more realistic cost adjustment as the overall water demand is adjusted using the conservation strategies in the model. Simply put, the infrastructure cost and water demand relationship is not linear. If the water demand is reduced by 10%, a 10% reduction in cost will not be realized. Instead a lesser percentage reduction will be observed based on the elasticity of that infrastructure component. See Figure 2-18.

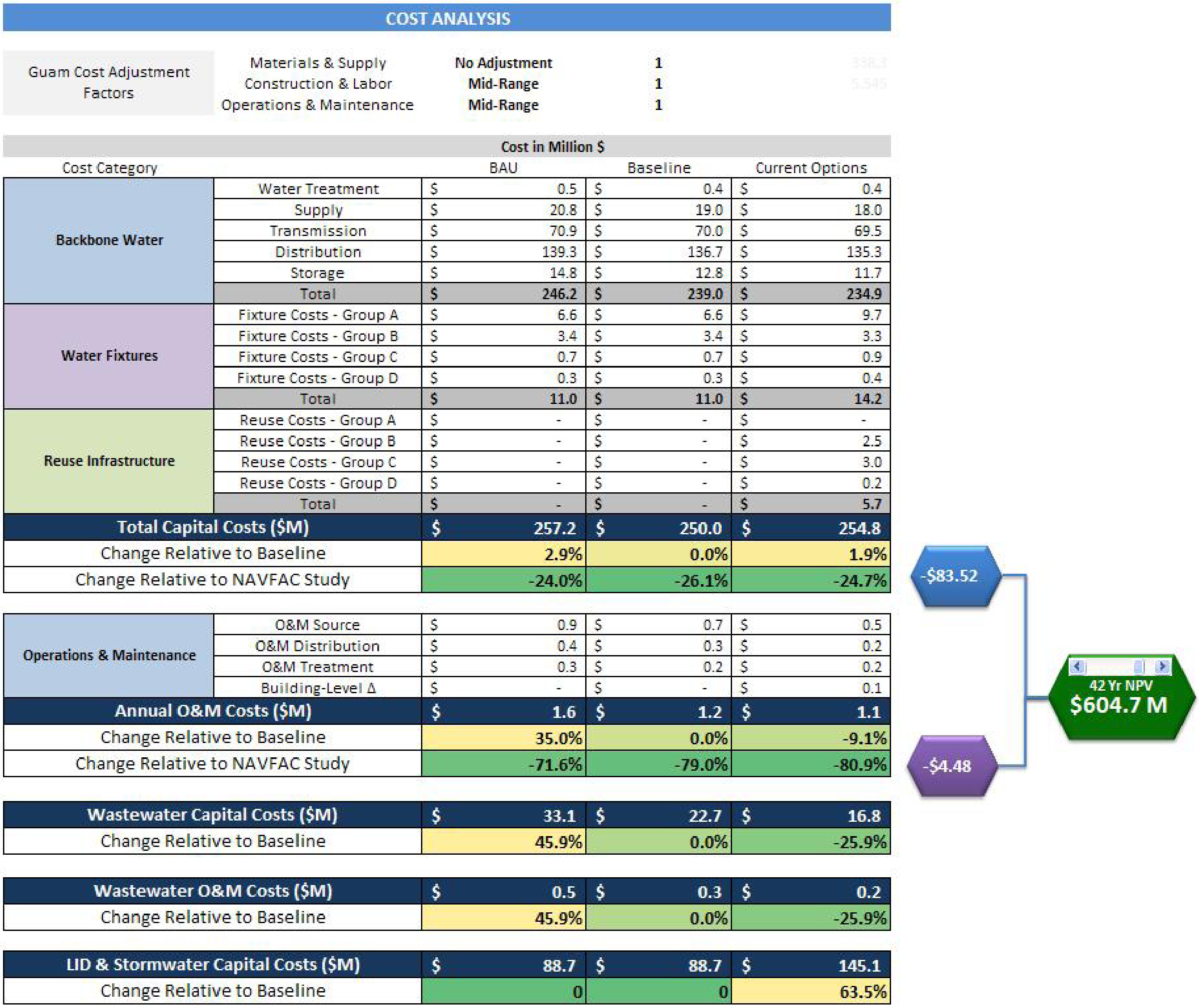
The final water and sewer cost analysis evaluated both the capital and operations and maintenance costs for every strategy associated with each of the conservation package. The capital water costs were broken down into sub-categories and the appropriate elasticity factors were applied to each automatically calculating the cost adjustments as the overall water demand was reduced. With the reduction in water demand, a reduction in costs associated with the wastewater treatment was also included.

The combined capital and operations and maintenance costs and savings were evaluated and estimate a savings when implementing the Water Conservation Program A. See the full SSIM^{TM} model cost analysis results includes a more detailed life cycle analysis.



Cost Type	Item	Demand (mgd)	Elasticity	Total Cost (M $)	Source	slope (from y=mx)	Adjusted slope (based on Elasticity)	Constant b (y=mx + b)	Adjusted Equation
Captial Cost	Water Treatment	10.73	0.80	$ 1.2	2009 UFC	0.11	0.09	0.246	y = 0.09x + 0.25
	Supply	10.73	0.60	$ 38.0		3.54	2.12	15.2	y = 2.12x + 15.2
	Transmission	10.73	0.15	$ 80.0		7.46	1.12	68	y = 1.12x + 68
	Distribution	10.73	0.20	$ 164.0		15.28	3.06	131.2	y = 3.06x + 131.2
	Storage	10.73	0.75	$ 34.0		3.17	2.38	8.5	y = 2.38x + 8.5
Annual O&M Cost	O&M Source	10.73	0.95	$ 3.2	2009 UFC	0.30	0.283317801	0.16	y = 0.28x + 0.16
	O&M Treatment	10.73	0.95	$ 1.0		0.09	0.088536813	0.05	y = 0.09x + 0.05
	O&M Distribution	10.73	0.95	$ 1.4		0.13	0.120410065	0.068	y = 0.12x + 0.07

FIGURE 2-18: Cost Elasticity Analysis for Water Infrastructure



COST ANALYSIS

Guam Cost Adjustment Factors				
	Materials & Supply	**No Adjustment**	**1**	338.3
	Construction & Labor	**Mid-Range**	**1**	5.545
	Operations & Maintenance	**Mid-Range**	**1**	

Cost Category		Cost in Million $ BAU	Baseline	Current Options
Backbone Water	Water Treatment	$ 0.5	$ 0.4	$ 0.4
	Supply	$ 20.8	$ 19.0	$ 18.0
	Transmission	$ 70.9	$ 70.0	$ 69.5
	Distribution	$ 139.3	$ 136.7	$ 135.3
	Storage	$ 14.8	$ 12.8	$ 11.7
	Total	**$ 246.2**	**$ 239.0**	**$ 234.9**
Water Fixtures	Fixture Costs - Group A	$ 6.6	$ 6.6	$ 9.7
	Fixture Costs - Group B	$ 3.4	$ 3.4	$ 3.3
	Fixture Costs - Group C	$ 0.7	$ 0.7	$ 0.9
	Fixture Costs - Group D	$ 0.3	$ 0.3	$ 0.4
	Total	**$ 11.0**	**$ 11.0**	**$ 14.2**
Reuse Infrastructure	Reuse Costs - Group A	$ -	$ -	$ -
	Reuse Costs - Group B	$ -	$ -	$ 2.5
	Reuse Costs - Group C	$ -	$ -	$ 3.0
	Reuse Costs - Group D	$ -	$ -	$ 0.2
	Total	**$ -**	**$ -**	**$ 5.7**
Total Capital Costs ($M)		**$ 257.2**	**$ 250.0**	**$ 254.8**
Change Relative to Baseline		**2.9%**	**0.0%**	**1.9%**
Change Relative to NAVFAC Study		**-24.0%**	**-26.1%**	**-24.7%**

Operations & Maintenance	O&M Source	$ 0.9	$ 0.7	$ 0.5
	O&M Distribution	$ 0.4	$ 0.3	$ 0.2
	O&M Treatment	$ 0.3	$ 0.2	$ 0.2
	Building-Level Δ	$ -	$ -	$ 0.1
Annual O&M Costs ($M)		**$ 1.6**	**$ 1.2**	**$ 1.1**
Change Relative to Baseline		**35.0%**	**0.0%**	**-9.1%**
Change Relative to NAVFAC Study		**-71.6%**	**-79.0%**	**-80.9%**

Wastewater Capital Costs ($M)	**$ 33.1**	**$ 22.7**	**$ 16.8**
Change Relative to Baseline	**45.9%**	**0.0%**	**-25.9%**

Wastewater O&M Costs ($M)	**$ 0.5**	**$ 0.3**	**$ 0.2**
Change Relative to Baseline	**45.9%**	**0.0%**	**-25.9%**

LID & Stormwater Capital Costs ($M)	**$ 88.7**	**$ 88.7**	**$ 145.1**
Change Relative to Baseline	**0**	**0**	**63.5%**

Figure 2-19: Screen Capture of Water Cost Analysis (Program A)

Findings & Recommendations

Recommendation Summary

As shown in the Gameboard images below, the water demand estimate and conservation strategies have been optimized to produce the highest performance at the lowest cost. This performance and cost based analysis has been optimized for four separate programs, Baseline, A, B & C. Here is a summary of these programs and their results.

With the large number of variables, detail and flexibility in the SSIM^{TM} water model, there are many ways to build packages that represent the highest efficiency or lowest cost options while still meeting the mandates. Each facility type and building will have specific needs and water consumption patterns that will require differing conservation strategies to meet the mandates. Packages A, B & C, identified below, are examples of packages that were built for this purposes.

Packages A, B & C all meet the federal water reduction mandates for federal facilities, however, offer differing results as it relates to additional first costs and life cycle cost savings. Each of these packages will benefit the project and stakeholders in different ways and should be evaluated from each of the respective stakeholder perspectives for final determination of selected package. Figure 2-20 is a screen capture of the SSIM^{TM} model Gameboards representing Package A, or the optimized package with lowest first costs.

Packages / Measures	Group A Family Housing	Group B BOQ/BEQ	Group C Non-Residential High Occupancy	Group D Non-Residential Low Occupancy	Group E Open Space and Undeveloped	Group F Streets and Parking
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option B	Option B	Option B	Option B		
Faucet Fixtures	Option B	Option B	Option B	Option B		
Shower and Bath Fixtures	Option B	Option B	Option B	Option B		
Urinal Fixtures			Option B	Option B		
Clothes Washers	Option C		Option B	Option B		
Dish Washers	Option C		Option B	Option B		
2. INTERIOR REUSE					---	---
Collect & Reuse Condensate	Baseline	Option B	Option B	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Baseline	Option B	Option A	Option A		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	---	---	---	---	---	---
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Option A	Option A	Option A	Option A	Baseline	Baseline
BMP Train B	Option A	Option A	Option A	Option A	Baseline	Baseline
BMP Train C	Option A	Option A	Option A	Option A	Baseline	Baseline
BMP Train D	Option A	Option A	Option A	Option A	Baseline	Baseline
BMP Train E	Option A	Option A	Option A	Option A	Baseline	Baseline
BMP Train F	Option A	Option A	Option A	Option A	Baseline	Baseline

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
WATER USE	Potable Water Use (Interior)	658,871,720	485,933,036	-26.2%
	Water Use (Exterior)	0	0	NA
	Water Use (Other*)	0	0	NA
	Total Water Use	**658,871,720**	**485,933,036**	**-26.2%**
STORMWATER & WASTEWATER	Storm Sewer Outflow	109,244,298	104,475,675	-4.4%
	Sanitary Sewer Outflow	527,097,376	410,794,944	-22.1%
	Total Outflow	**636,341,674**	**515,270,619**	**-19.0%**
WATER REUSE	Rooftop Harvesting	0	4,768,623	0.7%
	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	18,724,740	2.8%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	**0**	**23,493,363**	**3.6%**
STORMWATER QUALITY	Suspended Solids Removal	21,111	28,609	23.0%
	Nitrogen	0	0	0.0%
	Phosphrous	0	0	0.0%
CAPITAL COSTS	Backbone	239.0	234.8	-1.7%
	Fixtures	11.0	14.3	30.3%
	Reuse Infrastructure	0.0	5.7	NA
	LID	88.7	145.1	63.5%
	Wastewater	22.7	16.8	-26.1%
	Total Cost	**361.4**	**416.7**	**15.3%**

Figure 2-20: Overview Screen capture of SSIM^{TM} water model Gameboard

Standard Package

This package was calibrated to the minimum requirements for potable water use through water fixture flow rates for FY 2007 which is defined in EPAct 1992, the current standard for fixture flow rates in 2007. This package is used as the starting point for water consumption reduction measurements as required by federal mandates. The Standard setting in the model gameboard is called Baseline, which is different from the redefined Baseline which is now a 26% reduction from Standard.

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
	↓	↓	↓	↓	↓	↓
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Baseline	Baseline	Baseline	Baseline		
Faucet Fixtures	Baseline	Baseline	Baseline	Baseline		
Shower and Bath Fixtures	Baseline	Baseline	Baseline	Baseline		
Urinal Fixtures	Baseline	Baseline	Baseline	Baseline		
Clothes Washers	Baseline	Baseline	Baseline	Baseline		
Dish Washers	Baseline	Baseline	Baseline	Baseline		
2. INTERIOR REUSE	---	---	---	---	---	---
Collect & Reuse Condensate	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	---	---	---	---	---	---
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	---	---	---	---	---	---
Rooftop Rainwater Harvesting	Baseline	Baseline	Baseline	Baseline		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	---	---	---	---	---	---
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
BMP Train B	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
BMP Train C	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
BMP Train D	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
BMP Train E	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
BMP Train F	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline

FEDERAL MANDATE TRACKING

MANDATES

- ☒ ECB/EPAct Compliance
- ☒ EISA Compliance
- ☒ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequite	0%
0 - 2	0%
3 - 4	0%
5 - 6	0%
7 - 8	0%
9 - 10	0%

Figure 2-21: Gameboard Screen Capture for Water Standard Program (0% Reduction in Water Demand)

Baseline Package

This package is defined as the minimum requirement that meets water consumption reduction related mandates for federal facilities. This package is the first conservation package capable of being selected and implemented since it just meets the facility related reduction requirements, including the 26% potable water consumption intensity reduction from the (Effective Baseline) or Standard Package as described in E.O. 13514.

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
	↓	↓	↓	↓	↓	↓
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option B	Option B	Option B	Option B		
Faucet Fixtures	Option B	Option B	Option B	Option B		
Shower and Bath Fixtures	Option B	Option B	Option B	Option B		
Urinal Fixtures			Option B	Option B		
Clothes Washers	Option C		Option A	Option B		
Dish Washers	Option C		Option A	Option A		
2. INTERIOR REUSE	↓	↓	↓	↓	---	---
Collect & Reuse Condensate	Baseline	Option B	Option B	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	↓	↓	↓	↓	↓	↓
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	↓	↓	↓	↓	↓	↓
Rooftop Rainwater Harvesting	Baseline	Option B	Option A	Option A		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	---	---	---	---	---	---
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train B	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train C	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train D	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train E	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train F	Option A	Option A	Option A	Option A	Option A	Option A

FEDERAL MANDATE TRACKING

MANDATES

- ✓ ECB/EPAct Compliance
- ✓ EISA Compliance
- ✓ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequite	92%
0 - 2	0%
3 - 4	68%
5 - 6	3%
7 - 8	21%
9 - 10	0%

Figure 2-22: Gameboard Screen Capture for Water Baseline Program (26.0% Reduction in Water Demand)

Package A

This performance based package is designed to exceed the Baseline Package only slightly while Optimizing the performance and minimizing the capital cost (First Cost) required. This package contains the use of low flow fixtures and begins introducing rooftop rainwater and condensate harvesting for the BEQ / BOQ and commercial facilities. This package also standardizes the low flow fixtures for ease of implementation.

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
	↓	↓	↓	↓	↓	↓
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option B	Option B	Option B	Option B		
Faucet Fixtures	Option B	Option B	Option B	Option B		
Shower and Bath Fixtures	Option B	Option B	Option B	Option B		
Urinal Fixtures			Option B	Option B		
Clothes Washers	Option C		Option B	Option B		
Dish Washers	Option C		Option B	Option B		
2. INTERIOR REUSE	↓	↓	↓	↓	—	—
Collect & Reuse Condensate	Baseline	Option B	Option B	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	↓	↓	↓	↓	↓	↓
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	↓	↓	↓	↓	↓	↓
Rooftop Rainwater Harvesting	Baseline	Option B	Option A	Option A		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	—	—	—	—	—	—
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train B	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train C	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train D	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train E	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train F	Option A	Option A	Option A	Option A	Option A	Option A

FEDERAL MANDATE TRACKING

MANDATES

- ✓ ECB/EPAct Compliance
- ✓ EISA Compliance
- ✓ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequite	92%
0 - 2	0%
3 - 4	67%
5 - 6	4%
7 - 8	21%
9 - 10	0%

Figure 2-23: Gameboard Screen Capture for Water Program A (26.2% Reduction in Water Demand)

Package B

This performance based package is designed to further exceed the Baseline Package for sustainability and focus on the quickest payback term for the infrastructure required to meet these aggressive water consumption reducing strategies. Package B further reduces the water demand by introducing the use of ultra low flow fixtures in all residential applications and increasing the reuse strategies on the BEQ / BOQ and commercial facilities.

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
	↓	↓	↓	↓	↓	↓
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option C	Option C	Option B	Option B		
Faucet Fixtures	Option C	Option C	Option B	Option B		
Shower and Bath Fixtures	Option C	Option C	Option B	Option B		
Urinal Fixtures			Option B	Option B		
Clothes Washers	Option C		Option B	Option B		
Dish Washers	Option C		Option B	Option B		
2. INTERIOR REUSE	↓	↓	↓	↓	—	—
Collect & Reuse Condensate	Baseline	Option B	Option B	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	↓	↓	↓	↓	↓	↓
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	↓	↓	↓	↓	↓	↓
Rooftop Rainwater Harvesting	Baseline	Option B	Option A	Option A		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	—	—	—	—	—	—
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train B	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train C	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train D	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train E	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train F	Option A	Option A	Option A	Option A	Option A	Option A

FEDERAL MANDATE TRACKING

MANDATES

✓ ECB/EPAct Compliance

✓ EISA Compliance

✓ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequite	92%
0 - 2	0%
3 - 4	0%
5 - 6	69%
7 - 8	23%
9 - 10	0%

Figure 2-24: Gameboard Screen Capture for Water Program B (35.2% Reduction in Water Demand)

Package C

This performance based package is designed to maximize the use of sustainability strategies that provide the highest life cycle cost savings over 42 years. Package C maximizes the use of ultra low flow fixtures for the commercial facilities and implements reuse strategies on all facilities.

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
	↓	↓	↓	↓	↓	↓
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option C	Option C	Option C	Option C		
Faucet Fixtures	Option C	Option C	Option C	Option C		
Shower and Bath Fixtures	Option C	Option C	Option C	Option C		
Urinal Fixtures			Option C	Option C		
Clothes Washers	Option C		Option C	Option C		
Dish Washers	Option C		Option C	Option C		
2. INTERIOR REUSE	↓	↓	↓	↓	---	---
Collect & Reuse Condensate	Baseline	Option C	Option C	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	↓	↓	↓	↓	↓	↓
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	↓	↓	↓	↓	↓	↓
Rooftop Rainwater Harvesting	Baseline	Option C	Option C	Option C		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	---	---	---	---	---	---
Green Roof	Baseline	Baseline	Baseline	Baseline		
BMP Train A	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train B	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train C	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train D	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train E	Option A	Option A	Option A	Option A	Option A	Option A
BMP Train F	Option A	Option A	Option A	Option A	Option A	Option A

FEDERAL MANDATE TRACKING

MANDATES

✓ ECB/EPAct Compliance

✓ EISA Compliance

✓ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequite	92%
0 - 2	0%
3 - 4	0%
5 - 6	67%
7 - 8	25%
9 - 10	0%

Figure 2-25: Gameboard Screen Capture for Water Program C (39.1% Reduction in Water Demand)

	Capital Cost change from Baseline	O&M Cost from Baseline	% Water Reduction from Baseline
Standard	-15.3% ($-55.3M)	12.8% ($-0.2M)	-26%
Baseline	0% ($0M)	0% ($0M)	0%
Option A	0% ($0M)	-0.2% ($-0.01M)	0.20%
Option B	-0.8% ($-2.8M)	-7.5% ($-0.1M)	9.20%
Option C	-1.1% ($-4.0M)	-10.9% ($-0.2M)	13.10%

TABLE 2-11: Water reduction, capital and O&M cost (comparison from Baseline)

Continuing Performance of Sustainability

In addition to the water conservation efforts required to initially meet the federal mandates, the continuation of these efforts will be required to maintain these efficiencies over time. This can be accomplished through various projects implemented as portions of the Finegayan Cantonment infrastructure are constructed and begin operation. Some examples of these projects are described below.

Use of high efficient water and wastewater treatment systems

The use of high efficiency water and wastewater treatment systems can save on the substantial costs associated with treatment. The use of treatment system work exchangers and other water and energy saving devices can contribute to an overall higher system efficiency, energy efficiency and ultimate result in extensive savings. There are many other benefits to the use of these efficient systems besides cost savings such as extended equipment service life and a reduced environmental impact from less wastewater discharge.

Installation of water meters for all taps and users including all privatized use

Install water meters to help clarify water use by individual users and also assist in reducing loss from leaks by early detection. Metering will encourage conservation by the users by comparing water use intensity against similar uses at other facilities within the installation. The use of meters with electronic reading capability should be evaluated because of their ability to reduce maintenance and management cost.

Hydraulic modeling of entire water system to maintain system efficiency

Create a hydraulic model of the overall water system as management tool to enable managers to understand the weaknesses of the system and identify areas in need of improvement such as areas of poor system circulation and poor water quality.

Use of Remote monitoring system

Use electronic water meters and other remote sensing devices to assist with the overall water system management to enable faster detection of system leaks and better control of system inefficiencies. This system allows the manager to watch the function of the entire system at once saving valuable time and resources while maintaining a very high level of service.

Harvesting and reuse of vehicle wash-rack water

Improve water use efficiency at vehicle wash racks. With the exception of the wash areas that require a higher level of water quality, the other wash area ponds can be supplemented with alternate sources of water including stormwater capture and effluent water treated to a tertiary level. If this water is mixed with other recycled water from the wash racks within the holding ponds, the level of nutrients will remain low and the amount of domestic water needed to recharge this system can be reduced. This water can be used for a first wash application with a higher water quality used for the final rinse cycle.

Green Procurement Policy to standardize high efficiency equipment

Create equipment standards policy that ensures the quality and efficiency of infrastructure components, fixtures, etc. The development of these minimum standards will also enable sustainability training efforts to focus on particular types of systems and devices allowing for a more efficient use of resources.

Maintenance mentoring program for DPW staff

Provide an overlap period (3 to 6 months as an example) to help mentor the new members in order to pass along institutional knowledge the existing staffers have accumulated from the years of service at the facility. An ongoing problem is the difficulty in replacing the institutional knowledge of the O&M staff as they retire, relocate or contracts change. Current policy appears to allow hiring of replacement personnel only after the staffer has left.

Sustainable education/awareness program

Create overall knowledge and awareness of sustainable practices as a key element in a major shift in the way water is used by all personnel and their families. The idea of simple day-to-day smart use of water, when brought to the forefront, will become an important part of the solution to conserve the limited water supply.

Water reduction incentives and friendly competition

Various facilities on the installation can compete to reduce their water use intensity. A reward system can be created to motivate this effort and keep the concepts of water conservation at the forefront.

Implement water use restrictions

Establish irrigation water use and development guidelines that define best use practices to conserve water in everyday use and/or assess additional fees to penalize overconsumption.

3. Building Energy

Introduction & Goals

SSIM^{TM} Energy (SSIMe) was developed by AECOM to provide master planning level building energy analysis for commercial and residential buildings. SSIMe is unique in the marketplace in that it allows building Energy Conservation Measures (ECMs) to be 'gamed' and cost assessed in real time at the master planning stage of a development, allowing key building energy strategies to be determined prior to the design development stage of the buildings to be constructed on site.

SSIMe provides guidance on the attainment of LEED EA1 and EA2 credits for each package of ECMs, as well as compliance with the federal energy mandates. When combined with the other tools within the SSIM family, the most cost effective sustainability strategies for the whole development can be rapidly determined.

For the Guam Sustainability Masterplan study, SSIMe was used to assess the energy performance of a number residential and non-residential building types, determined to be representative of those that will be constructed as part of the new Marine base at Finegayan. For each building type, an assessment was made of the different combinations of passive and active ECMs in order to determine which combination of measures to achieve increasing levels of energy performance.

Table 3.1 targets and definitions for each package were established prior to commencement of the study.

Subject:	Standard	Baseline: Federal Mandate	Option A	Option B	Option C
Residential Energy	IECC[1]	30% reduction	30%+ reduction	30%+ reduction	30%+ reduction
Non-residential Energy	ASHRAE 90.1	30% reduction	30%+ reduction	30%+ reduction	30%+ reduction

TABLE 3-1: SSIMe Package Targets

1. IECC: international energy conservation code

In defining ECMs for each package, it is recognized that this is a master planning level study, therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study. It is also noted that the typical building types assessed as part of the study were assumed to be “passive design neutral” (i.e. including only generic design features) and that additional energy savings can be achieved through good quality, and holistic performance based detailed design of the facilities. As such, the results of this study do not represent a prescriptive checklist of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design team will have responsibility for the selection of systems and ECMs to ensure compliance with the federal mandates and sustainability goals for the base.

The Sustainability Masterplan and SSIMe building energy study does however, provide guidance as to possible routes to compliance and the cost associated with doing so. Key ECMs and cost trends can also be extracted from the analysis for detailed analysis by the design teams during the design phase of each building.

Sustainability Goals & Federal Mandates

Requirements for energy supply at Federal agencies are addressed in different forms by Energy Policy Act (EPAct) 2005, Executive Order (EO) 13423, and Energy Independence and Security Act (EISA) 2007.

The requirements of each of these mandates are outlined in Tables 3-2,3-3,3-4, and 3-5:

Act #	Topic	Target
102	Energy reduction goals for existing federal buildings	Provide 20% energy reduction by 2015 (superseded by EISA 2007)
103	Electricity metering	Sub-meter all buildings by 2012
109	Federal building performance standards	Achieve 30% better performance (new buildings) relative to an ASHRAE 90.1 2004 baseline, where life-cycle cost efficient
203	Renewable energy purchases	Purchase renewable energy: 3% (of all electricity consumed) in FY07, 5% in FY10, and up to 7.5% in FY13, where economically feasible and technically practicable

TABLE 3-2: Energy Policy Act (EPACT), 2005

Act #	Topic	Target
Sec 2 (a)	Energy reduction goals for existing federal buildings	Reduce energy use by 3% per year (FY08-FY15) and 30% total reduction by 2015, relative to a 2003 baseline.
Sec 2 (b)	Renewable energy	Secure 50% of renewable energy from new sources (built after January 1, 1999).

TABLE 3-3: Executive Order #13423 (ENERGY)

Act #	Topic	Target
431	Energy reduction goals for existing federal buildings	Reduce energy use by 3% per year (FY08-FY15) and 30% total by 2015, relative to a 2003 baseline.
432	Energy and water efficiency management	Employ an energy manager, do evaluations every 4 years for 25% of facilities and implement measures that are life-cycle cost effective within 2 years.
433	Energy efficiency performance standards	Reduce fossil fuel use (new/renovated buildings) by 55% in 2010 and 100% by 2030, relative to 2003 CEBCS baseline.
434	Federal building efficiencies management	Use most energy efficiency design / equipment for major replacements, where life-cycle cost efficient. Meter all natural gas and steam building supplies by October 2016.
523	Solar hot water (new/renovated buildings)	Meet 30% hot water demand via solar systems by 2015, where life-cycle cost efficient.

TABLE 3-4: Energy Independence and Security Act (EISA) 2007

Act #	Topic	Target
Subtitle E, Energy Security, sec. 2852	Renewable energy	Produce/procure 25% of electrical energy from renewables by 2025, where life-cycle cost efficient.

TABLE 3-5: National Defence Authorization Act (NDAA) 2007

Of these, those pertaining to new construction projects (specifically EPAct 2005 Act 109 which requires new buildings to achieve 30% better energy performance relative to an ASHRAE baseline, EISA 2007 Act 433 (to reduce fossil fuel use in new and renovated buildings by 55% in 2010 and 100% by 2030 relative to 2003 CEBCS baseline) and EISA 2007 Act 525, which requires 30% of hot water demand to be met by solar systems) have been applied to the SSIMe analysis.

Additionally, it is noted that all new federal construction must be LEED Silver certified, therefore the effects of increasing levels of energy performance on the number of LEED points attained has also been assessed.

In addition to the federal mandates outlined above, Commandant of the Marine Corps directive *CMC ltr Ser 11300/Lff-1* requires the following:

- 3.a. “All USMC new building construction (starting with the POM 2012 MILCON program) and major renovation projects involving complete roof replacement (starting with FY2010 FSRM projects where design requirements will not substantially impact project execution) **will incorporate roof-top solar thermal and/or photovoltaic technologies into the project.**”
- 3.e. “As an alternative to the required roof-top solar thermal and photovoltaics systems mandated by paragraph 3.a, the project scope should also examine the technical and economic feasibility of utilizing available land area to supply solar thermal and photovoltaic ground mounted systems in combination with or as an alternative to roof mounted systems”.

As a result of this directive, the use of Building Integrated PV (BIPV) and Solar Thermal Hot Water (STHW) technologies has been considered when assessing the packages of ECMs required to meet the federal mandates.

UFC Analysis

Analysis has been undertaken to evaluate the basis for the Unified Facilities Criteria (UFC) energy requirements and to determine if these requirements are suited for use at the new Finegayan main cantonment. A short narrative describing the applicability of the UFC to the SSIMe energy masterplanning study has been provided for each UFC and, where applicable an explanation of why recommendations deviate from these requirements has also been given.

A. UFC 3-400-01: Energy Conservation

UFC 3-400-01 establishes minimum standards of policy for energy conservation in new construction and renovation of existing facilities. Federal facilities are required to comply with various Executive Orders and Congressional actions regarding energy use, conservation, and efficiency standards.

The UFC implements the following laws and standards:

- ASHRAE Standard 90.1–2007 Energy Standard for Buildings Except Low-Rise Residential Buildings, American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta Georgia
- USC Title 10, Part 433, Energy Efficient Standards for the Design and Construction of New Federal and Commercial and Multi-Family High Rise Residential Buildings
- USC Title 10, Part 435, Energy Efficient Standards for New Federal Low Rise Residential Buildings
- Title 10 Code of Federal Regulations, Part 436 – Federal Energy Management and Planning Programs, Subpart A – Methodology and Procedures for Life-cycle Cost Analysis
- ICC International Energy Conservation Code 2006

The UFC also notes that specifically, "…new buildings shall be designed to comply with ASHRAE Standard 90.1. In addition, to complying with the standard, new buildings shall also achieve an energy consumption level that is at least 30 percent below the level achieved under ASHRAE Standard 90.1. If a minimum of 30 percent energy consumption savings cannot be achieved in a life-cycle cost effective manner, the maximum savings level that is cost effective shall be achieved."

New and single family housing is required to be designed in line with the ICC International Energy Conservation Code. In addition, to complying with the code, buildings are also required to achieve an energy consumption level that is at least 30 percent below the level achieved under International Code Council International Energy Conservation Code. Energy consumption levels for both the baseline building and proposed building shall be determined by using the Simulated Performance Alternative found in the ICC International Energy Conservation Code.

It is also noted that all energy consuming products shall be either Energy Star-qualified or Federal Energy Management Program (FEMP) recommended. These products are in the upper 25 percent of energy efficiency in their class. These purchasing requirements are codified by Federal Acquisition Regulations (FAR) Part 23.

Application in the AECOM SSIMe Study

The AECOM study was performed in line with the requirements of the laws and standards outlined above, with the following exceptions:

Baseline building systems performances for the residential and non-residential buildings are based on the minimum standards outlined in the ICC International Energy Conservation Code and ASHRAE 90.1-2007 Appendix G respectively, in line with the requirements of the UFC.

At this stage of analysis, and in line with the requirements of a ‘master planning’ level study, the energy improvement associated with each building type (including the residential buildings) is estimated using AECOM’s proprietary SSIMe software. This uses first principles building systems calculations to calculate building energy use from Integrated Environmental Solutions’ “Virtual Environment” software (IES-VE) energy models, based on the methodology outlined in ASHRAE 90.1-2007 Appendix G. Although the IES Apache tool is approved by the Department of Energy (DoE) for use in energy simulations, as a proprietary “master planning” tool, SSIMe is not. Although the SSIMe software can be used to demonstrate an improvement in building energy performance over the minimum standards and to demonstrate the life-cycle costs associated with each energy conservation measure applied to the design, absolute improvements cannot be guaranteed.

UFC requires the percentage improvement in energy performance to be calculated with process and receptacle loads excluded. This raises a disconnect between the requirements of the UFC and those of EPAct 2005, which requires new buildings to be designed to be at least 30% below the levels established in the version of the ASHRAE Standard or the International Energy Conservation Code, but does not make an allowance for the exclusion of process loads. As such, performance improvements are estimated in line with the requirements of EPAct 2005 (with process loads included in the calculation) on the basis that this is the most onerous criteria.

B. UFC 3-400-02: Design: Engineering Weather Data

UFC 3-400-02 provides an overview of and instructions for access to climatological data available for use by engineers designing government structures.

Application in the AECOM SSIMe Study

AECOM’s SSIMe study utilizes the Guam Anderson Air Force Base TMY2 weather tape in the baseline IES <VE> modeling, which is used to calibrate the energy performance of each building type in the SSIMe tool. Estimates of system size requirements are calculated based on the ASHRAE design weather database criteria for Guam, based on 0.4% design conditions.

C. UFC 3-410-01FA: Heating, Ventilation and Air Conditioning

UFC 3-410-01FA outlines the requirements for Heating, Ventilation, and Air Conditioning (HVAC) systems for all new DoD facilities. This includes the principles of design that any new federal facility should follow.

The majority of requirements of UFC 3-410-01FA are only relevant during the design phase of each individual building (such as specifying filters or refrigerants). Specific requirements are outlined pertaining to system selection within specific building types. Special criteria are listed for humid areas (which would include Guam), including the following:

- System Selection. HVAC systems will typically consist of a central air handling unit with chilled water coils or unitary direct expansion-type unit(s) capable of controlling the dew point of the supply air for all load conditions. The designer must base system selection on the capability of the air-conditioning system to control the humidity in the conditioned space continuously under full load and part load conditions.
- Air Handling Units. Specify draw-through type air-handling units in order to use the fan energy for

reheat. Design the air distribution system to prevent infiltration at the highest anticipated sustained prevailing wind.

- Variable Air Volume (VAV) Units. Use air throttling type VAV terminal units with an integral heating coil and a pressure independent air valve that modulates in response to space temperature.
- Ventilation. Condition outdoor air at all times through a continually operating air-conditioning system. Consider using a separate system for outdoor air where necessary to maintain a sensible heat ratio of the mixed air entering the primary air conditioning unit within the required limits of commercially available equipment and/or to reduce corrosive, salt-laden air from entering the primary air distribution system. Ensure that the building is maintained under a slightly positive pressure to minimize infiltration to the greatest extent possible.

Application in the AECOM SSIMe Study

In the majority of cases, the requirements contained within UFC 3-410-01FA pertain to the selection and specification of specific systems during building design, and so are beyond the scope of this master planning level of study. At this stage however, a review of the criteria contained within the UFC indicates that the AECOM SSIMe team is not recommending any deviation from its requirements.

It is noted that the UFC precludes the use of electric resistance heating systems and specifies certain conditions where deviation from the UFC is allowed. The exclusions do not specifically include the lack of a suitable alternative supply (e.g. a natural gas supply on the site) however it is noted the use of electric heating is allowed under those circumstances under the requirements of ASHRAE 90.1-2007. As such, the use of electric resistance heating for domestic/service hot water heating systems will be considered as part of the SSIMe study.

D. UFC 3-410-02N: Heating, Ventilation, Air Conditioning and Dehumidification Systems

UFC 3-410-02N provides general criteria for the design of passive solar buildings, as well as HVAC, and dehumidification systems for all new DoD facilities.

The majority of requirements of UFC 3-410-02N are only relevant during the design phase of each individual building. Specific requirements are outlined pertaining to system design and selection within specific building types which are also included in UFC 3-410-01FA.

Application in the AECOM SSIMe Study

In the majority of cases, the requirements contained within UFC 3-410-01FA pertain to the selection and specification of specific systems during building design, and so are beyond the scope of this “master planning” level of study. At this stage however, a review of the criteria contained within the UFC indicates that the AECOM SSIMe team is not recommending any deviation from its requirements.

E. UFC 3-430-01FA: Heating and Cooling Distribution Systems

UFC 3-430-01FA provides criteria and guidance for the design and construction of heating and cooling distribution systems and supplements information in the “Notes to the Designer” of the guide specifications. These distribution systems include Heat Distribution Systems in Concrete Trenches, Pre-engineered Underground Heat Distribution Systems, Prefabricated Underground Heating/Cooling Distribution Systems, and Aboveground Heat Distribution Systems. The mediums used in these distribution systems, as defined by the Department of Defense, include:

- High temperature hot water (HTHW) (251 deg. F to 450 deg. F)
- Low temperature hot water (LTHW) (150 deg. F to 250 deg. F)
- Low pressure steam systems (up to 15 psig)
- High pressure steam systems (over 15 psig)
- Condensate returns systems (up to 200 deg. F)
- Chilled water systems

Application in the AECOM SSIMe Study

As part of AECOM's SSIMe study, only the use of distributed condensate return or chilled water systems is currently being considered. Should the results of the SSIMe study recommend the use of distributed chilled or condensate water systems, it is expected that they would be designed in line with the requirements of UFC 3-430-01FA.

F. UFC 3-430-01FA: Tropical Engineering

UFC 3-430-01FA provides a general overview of information that directly relates to construction within tropical regions. The UFC focuses on construction components which are directly affected by the aggressive climatological and environmental elements found in these regions. Tropical areas are also defined and the adverse environmental and climatological elements unique to them are highlighted. The UFC discusses various construction materials and systems commonly in use, makes recommendations regarding their selection and use, and highlights problems that have resulted in failures with suggestions and recommendations regarding their elimination or mitigation.

Information is presented pertaining to the design of a number of building systems and components, including: Site Work, Concrete, Masonry, Metals, Wood and Plastics, Thermal and Moisture Protection, Doors and Windows, Finishes, Specialties, Equipment, Furnishings, Special Constructions, Mechanical Systems, and Electrical Systems.

Application in the AECOM SSIMe Study

In the majority of cases, the requirements contained within UFC 3-410-01FA pertain to the selection and specification of specific systems during building design, and therefore are beyond the scope of this master planning level of study. At this stage however, a review of the criteria contained within the UFC indicates that the AECOM SSIMe team is not recommending any deviation from its requirements.

The UFC requires that the Philippines, Guam, Diego Garcia, and other areas with one percent ambient dew point temperatures equal to or greater than 75°F to maintain internal room conditions of 75°F/55 percent realtive humidity (RH). Although the SSIMe study uses these criteria (with the exception of the Unconditioned Warehouse, Climate Controlled Warehouse, and Commissary), it is noted that energy savings could be achieved by allowing the internal RH to ride above 55%, whilst still maintaining comfortable conditions.

The SSIMe Process

A two-phase approach was used to analyze the various combinations of energy efficient measure that could be used to reduce the overall grid-based energy usage of each building types. This process is outlined below.

Phase 1: IES Thermal Modeling

The first phase involved the development of a dynamic energy model of each building type utilizing the IES Virtual Environment software, upon which Dynamic Thermal Modeling (DTM) analysis was undertaken.

IES Virtual Environment is an integrated suite of applications based around one 3D geometrical model. The modules used for SSIM analysis include “SunCast” for solar shading analysis, “Apache-Sim” for thermal simulation calculations, “Macro-Flo” for bulk airflow modeling and “Apache Loads” for thermal design load calculations. Guam Anderson Air Force Base TMY2 weather data (GUM_Anderson.AFB_TMY2.epw) was used for the analysis; being the closest available TMY weather data to the Finegayan site.

- SunCast generates shadows and internal solar insolation from any sun position defined by date, time, orientation, and site latitude and longitude. This shading information is stored in a database and used to take account of shading from surroundings in subsequent thermal simulation calculations.
- Apache-Sim is a dynamic thermal simulation program based on first-principles mathematical modeling of the heat transfer processes occurring within and around a building. The program provides an environment for the detailed evaluation of building and system designs, allowing them to be optimized with regard to comfort criteria and energy use.
- MacroFlo is a program for analyzing bulk air movement in buildings, driven by buoyancy and wind induced pressures.
- Apache-Loads is a thermal simulation program based on first-principles mathematical modeling of the heat transfer processes occurring within and around a building. The program provides an environment for the assessment of peak heating and cooling loads based on ASHRAE approved weather data.

A number of thermal models were created for each building type to provide baseline energy loads for the four different passive measures assessed using the DTM process; namely orientation, glazing thermal performance, solar shading, and infiltration.

Phase 2: SSIMe Tool Analysis

Following the DTM analysis, the results from the energy models were inputted into the SSIMe tool, an Excel based “post processor” analysis and selection tool developed by AECOM for use in sustainable master planning design. For each of the building types analyzed, a number of prescriptive passive and active energy reduction measures were compared in order to determine packages of measures which could meet predetermined criteria for energy performance, carbon emissions and cost effectiveness. The measures assessed for the Guam program includes (but are not limited to) the following:

- Building envelope alternatives (including high efficiency insulation)

- Building fenestration alternatives (including high efficiency glazing and solar shading)
- HVAC alternatives (including both packaged and central plant systems)
- Lighting strategy alternatives (including the use of lighting control strategies such as daylight controls and motion sensors)
- Exterior lighting strategy alternatives
- Hot water heating alternatives (including solar hot water heating systems)
- Renewable energy systems (including different photovoltaic strategies)
- Use of Energy Star appliances in residential houses

It is noted that the purpose of this analysis was not to provide a prescriptive criteria or set of measures to be implemented across all projects, but to demonstrate one possible solution that would achieve the recommended minimum performance criteria in a cost effective manner.

SSIMe Building Energy Results

SSIMe analysis was undertaken on each of the typical building types assessed as part of the GJMMP Sustainability Program.

Five different packages of ECMs (and hence five different levels of energy performance) were produced for each building type, thus allowing alternative strategies to be played off against one another, in order to produce an overall site wide sustainability strategy to be developed which best meets the project requirements.

In line with the requirements of the federal energy mandates, the following nomenclature has been used for each of the packages of options:

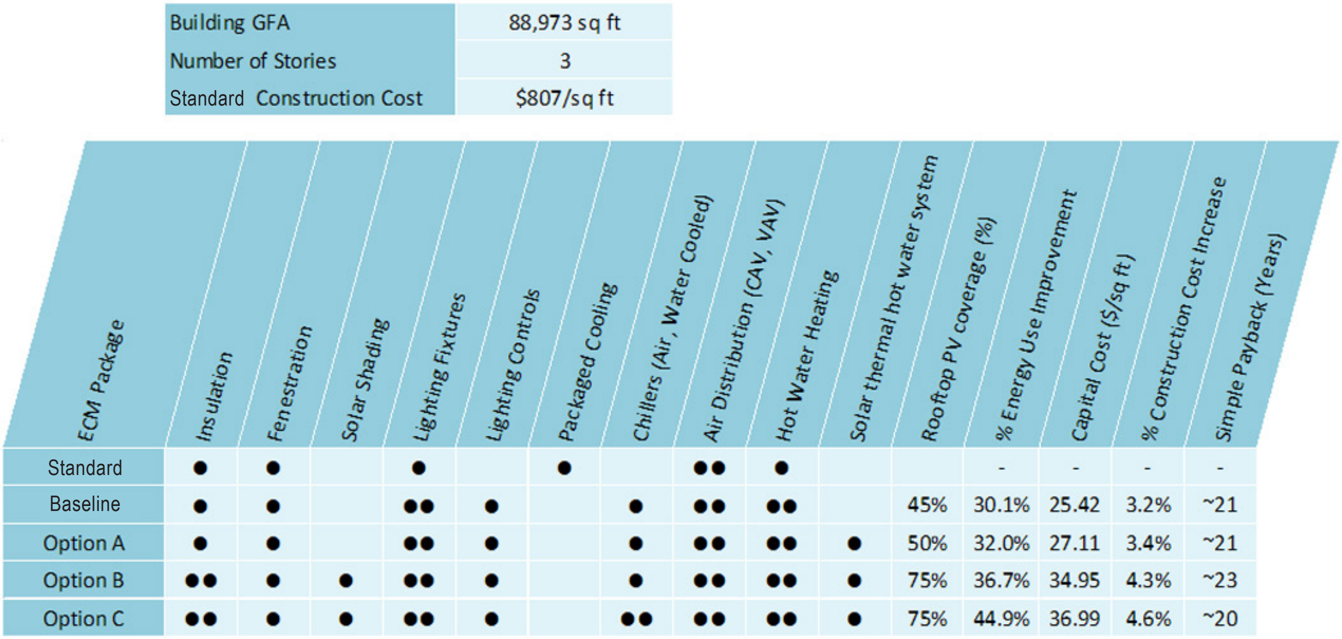
- ”The “Standard” package was calibrated to the minimum requirements of ASHRAE 90.1-2007 for the non-residential buildings and IECC-2009 for the residential buildings. It defines a fixed baseline from which other packages can be measured against. It is recognized that the mandates require all buildings at the base to be constructed to exceed the standard by 30%, however it is necessary to build up this package of ECMs from which the other packages can be referenced against. The energy performance, projected LEED credits, cost delta, and payback periods of each of the subsequent options (including the baseline option) are referenced against the standard package.
- “Baseline” was determined as being the level required to meet the minimum performance requirements of EPAct 2005 (i.e. to achieve a 30% energy performance improvement over the baseline case). As EPAct mandates a performance target, rather than prescriptive energy conservation requirements, the packages of ECMs shown to meet this target differs for each building type.

  In addition to meeting the EPAct target, consideration was given to the other federal mandates and policies, therefore the baseline packages were designed to incorporate some levels of building integrated PV (BIPV) or solar thermal hot water heating, where technically feasible.
- Options A, B and C represent alternative packages of ECMs to provide increasing levels of energy performance over the “Baseline” case. Throughout the analysis process, the primary goal was to achieve a balance between energy reduction and payback.

Detailed analysis summaries, documenting the ECMs applied to each building type, the additional cost associated with each measure, the total energy use and energy costs associated with each package and the savings achieved compared to baseline, are provided in the **Attachment A** of this document. A summary of the ECMs and energy performance of each building type is provided below for each building type. This summarizes the key ECMs that have been applied to the different packages for each building type, the energy savings (and by inference, energy cost and carbon emissions savings) associated with each package, as well as the additional capital cost and percentage construction cost increase for each.

Tables 3-6 through 3-19 include the following respective notes:

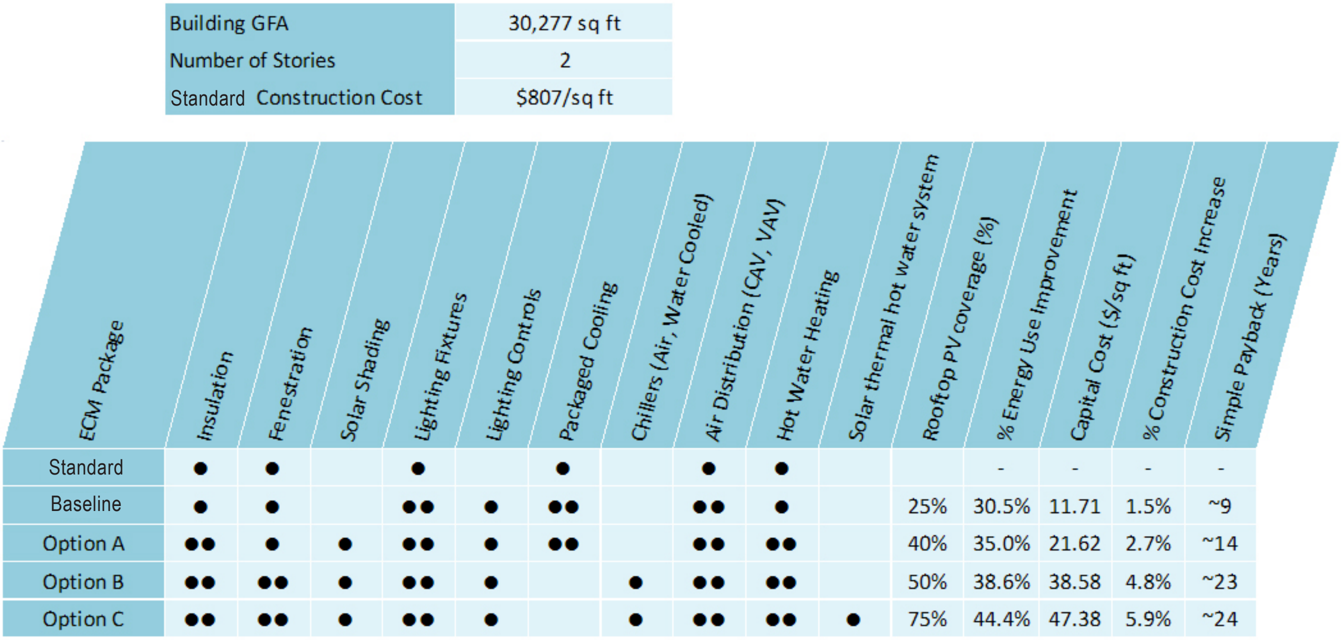
- ● Typically denotes a baseline or "code minimum" efficiency alternative, a constant volume air distribution system or an air cooled chiller central plant option.
- ●● Typically denotes a high efficiency alternative, a variable volume air distribution system or a water cooled central plant option.



Building GFA	88,973 sq ft
Number of Stories	3
Standard Construction Cost	$807/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●●	●			-	-	-	-
Baseline	●	●		●●	●		●	●●	●●		45%	30.1%	25.42	3.2%	~21
Option A	●	●		●●	●		●	●●	●●	●	50%	32.0%	27.11	3.4%	~21
Option B	●●	●	●	●●	●		●	●●	●●	●	75%	36.7%	34.95	4.3%	~23
Option C	●●	●	●	●●	●		●●	●●	●●	●	75%	44.9%	36.99	4.6%	~20

TABLE 3-6: 3-Story Headquarters Office



Building GFA	30,277 sq ft
Number of Stories	2
Standard Construction Cost	$807/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●	●			-	-	-	-
Baseline	●	●		●●	●	●●		●●	●		25%	30.5%	11.71	1.5%	~9
Option A	●●	●	●	●●	●	●●		●●	●●		40%	35.0%	21.62	2.7%	~14
Option B	●●	●●	●	●●	●		●	●●	●●		50%	38.6%	38.58	4.8%	~23
Option C	●●	●●	●	●●	●		●	●●	●●	●	75%	44.4%	47.38	5.9%	~24

TABLE 3-7: 2-Story Headquarters Office

Building GFA	15,139 sq ft
Number of Stories	1
Standard Construction Cost	$807/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●	●			-	-	-	-
Baseline	●	●		●●	●	●●		●	●		30%	31.0%	22.81	2.8%	~16
Option A	●●	●	●	●●	●	●●		●●	●		40%	42.8%	35.35	4.4%	~18
Option B	●●	●●	●	●●	●	●●		●●	●●		50%	46.6%	41.99	5.2%	~20
Option C	●●	●●	●	●●	●		●	●●	●●		75%	57.6%	73.25	9.1%	~28

TABLE 3-8: 1-Story Small Office

Building GFA	35,000 sq ft
Number of Stories	1
Standard Construction Cost	$755/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●			●		●		●●	●			-	-	-	-
Baseline	●●			●●	●	●●		●●	●		10%	32.1%	9.19	1.2%	~5
Option A	●●			●●	●	●●		●●	●		50%	44.7%	35.58	4.7%	~15
Option B	●●			●●	●		●	●●	●		50%	48.1%	46.64	6.2%	~18
Option C	●●			●●	●		●	●●	●		75%	56.0%	63.14	8.4%	~21

TABLE 3-9: Climate Controlled Organic Storage Warehouse

Building GFA	35,000 sq ft
Number of Stories	1
Standard Construction Cost	$336/sq ft

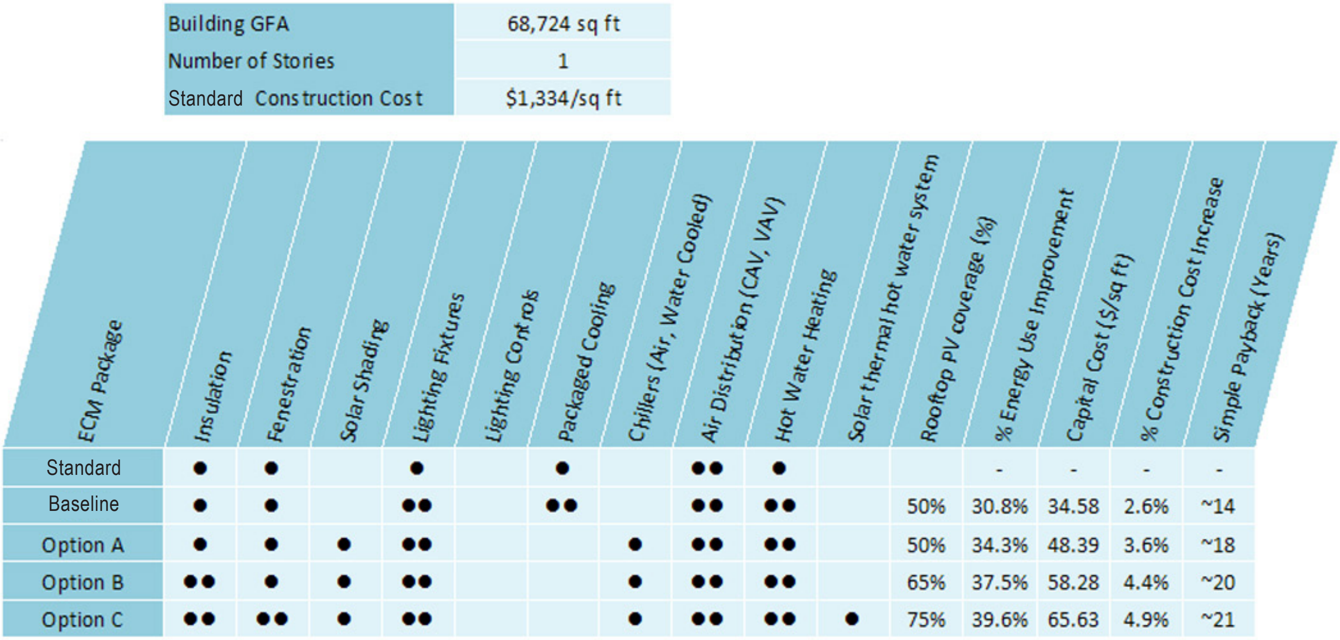
ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●			●		●		●●	●			-	-	-	-
Baseline	●●			●●	●	●●		●●	●		0%	31.5%	2.18	0.6%	~5
Option A	●●			●●	●	●●		●●	●		25%	60.5%	18.68	5.6%	~22
Option B	●●			●●	●		●	●●	●		50%	90.2%	40.40	12.0%	~31
Option C	●●			●●	●		●	●●	●		75%	119%	56.90	16.9%	~34

TABLE 3-10: Semi Conditioned General Warehouse

Building GFA	20,019 sq ft
Number of Stories	1
Standard Construction Cost	$1574/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●	●			-	-	-	-
Baseline	●	●		●●	●	●●		●	●●		20%	30.7%	16.28	1.0%	~11
Option A	●●	●	●	●●	●	●●		●●	●●		25%	42.6%	22.70	1.4%	~11
Option B	●●	●	●	●●	●		●	●●	●●	●	40%	51.0%	43.72	2.8%	~18
Option C	●●	●●	●	●●	●		●	●●	●●	●	50%	54.8%	51.47	3.3%	~20

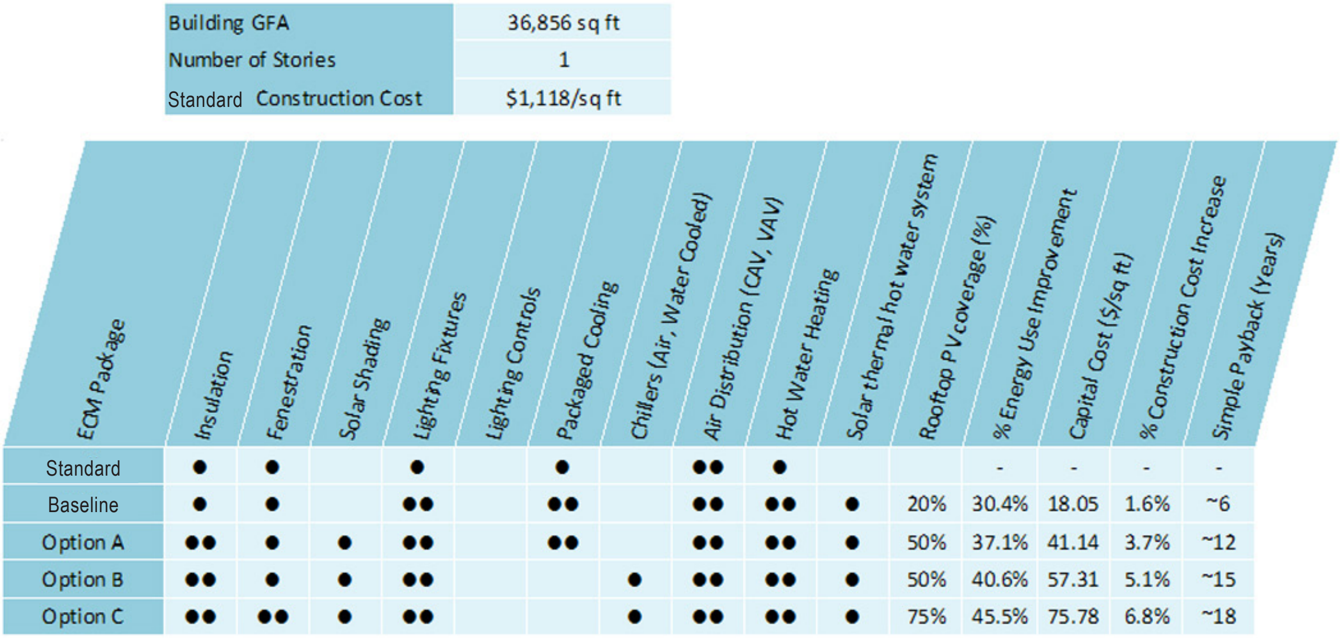
TABLE 3-11: Day Care Center



Building GFA	68,724 sq ft
Number of Stories	1
Standard Construction Cost	$1,334/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●●	●			-	-	-	-
Baseline	●	●		●●		●●		●●	●●		50%	30.8%	34.58	2.6%	~14
Option A	●	●	●	●●			●	●●	●●		50%	34.3%	48.39	3.6%	~18
Option B	●●	●	●	●●			●	●●	●●		65%	37.5%	58.28	4.4%	~20
Option C	●●	●●	●	●●			●	●●	●●	●	75%	39.6%	65.63	4.9%	~21

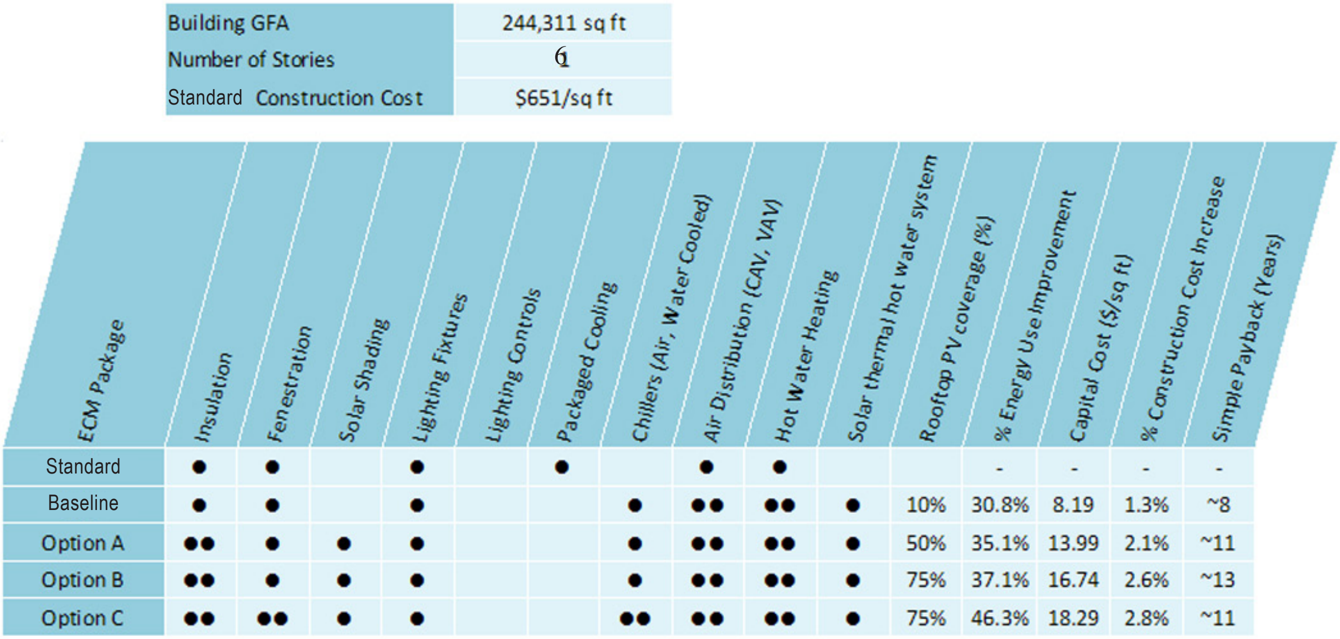
TABLE 3-12: Commissary



Building GFA	36,856 sq ft
Number of Stories	1
Standard Construction Cost	$1,118/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●●	●			-	-	-	-
Baseline	●	●		●●		●●		●●	●●	●	20%	30.4%	18.05	1.6%	~6
Option A	●●	●	●	●●		●●		●●	●●	●	50%	37.1%	41.14	3.7%	~12
Option B	●●	●	●	●●			●	●●	●●	●	50%	40.6%	57.31	5.1%	~15
Option C	●●	●●	●	●●			●	●●	●●	●	75%	45.5%	75.78	6.8%	~18

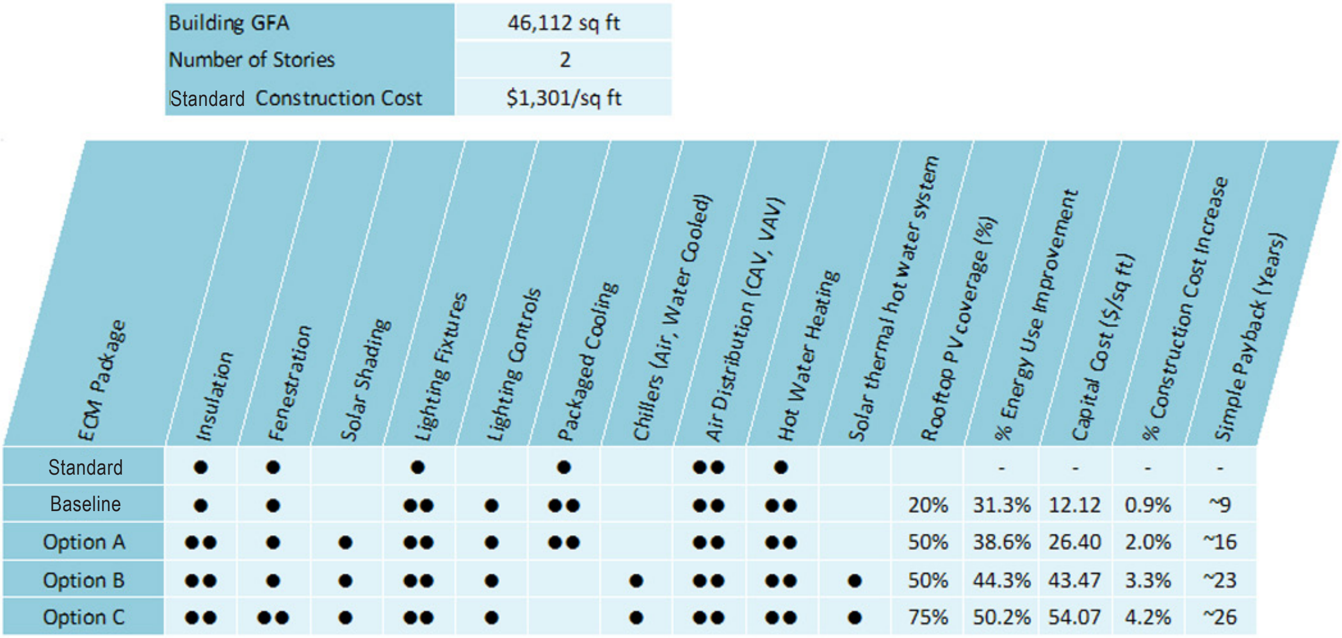
TABLE 3-13: Dining Facility



Building GFA	244,311 sq ft
Number of Stories	6
Standard Construction Cost	$651/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●	●			-	-	-	-
Baseline	●	●		●			●	●●	●●	●	10%	30.8%	8.19	1.3%	~8
Option A	●●	●	●	●			●	●●	●●	●	50%	35.1%	13.99	2.1%	~11
Option B	●●	●	●	●			●	●●	●●	●	75%	37.1%	16.74	2.6%	~13
Option C	●●	●●	●	●			●●	●●	●●	●	75%	46.3%	18.29	2.8%	~11

TABLE 3-14: BEQ – 6 Story 300 Occupant



Building GFA	46,112 sq ft
Number of Stories	2
Standard Construction Cost	$1,301/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●●	●			-	-	-	-
Baseline	●	●		●●	●	●●		●●	●●		20%	31.3%	12.12	0.9%	~9
Option A	●●	●	●	●●	●	●●		●●	●●		50%	38.6%	26.40	2.0%	~16
Option B	●●	●	●	●●	●		●	●●	●●	●	50%	44.3%	43.47	3.3%	~23
Option C	●●	●●	●	●●	●		●	●●	●●	●	75%	50.2%	54.07	4.2%	~26

TABLE 3-15: School

Building GFA	18,724 sq ft
Number of Stories	1
Standard Construction Cost	$1,200/sq ft

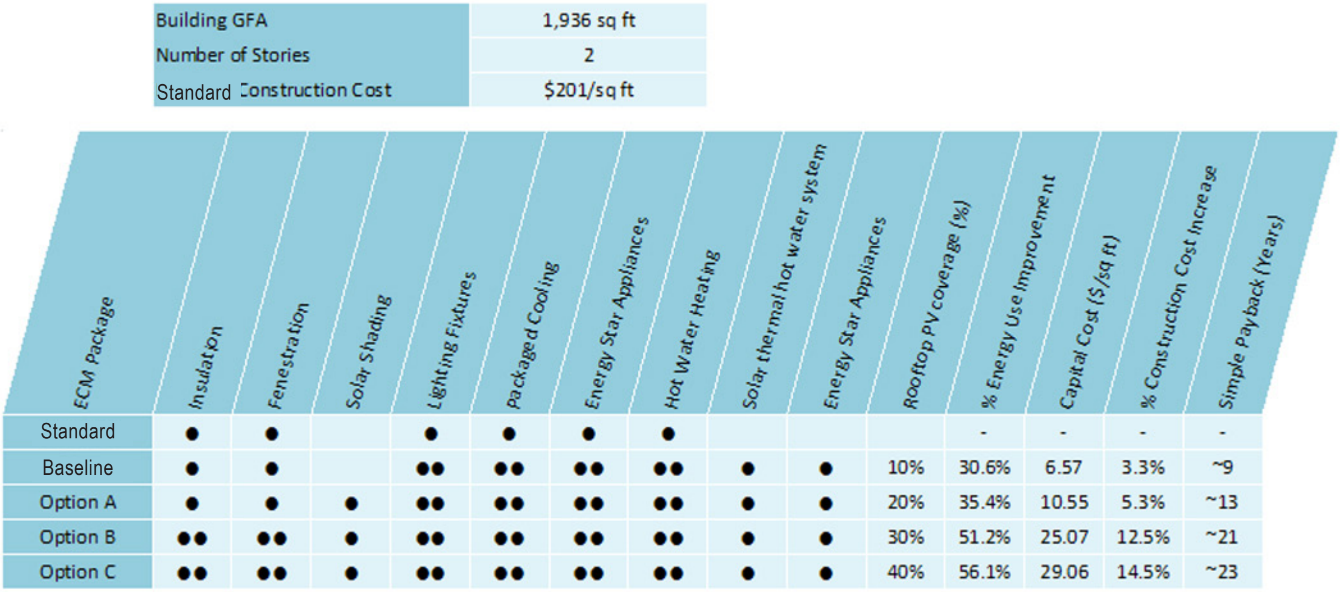
ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●	●			-	-	-	-
Baseline	●	●		●●	●	●●		●●	●●		30%	31.1%	18.55	1.5%	~10
Option A	●	●		●●	●	●●		●●	●●		50%	35.6%	29.39	2.4%	~14
Option B	●	●		●●	●	●●		●●	●●		75%	41.3%	42.94	3.6%	~17
Option C	●	●		●●	●		●	●●	●●		75%	43.7%	59.62	5.0%	~23

TABLE 3-16: Workshop

Building GFA	18,724 sq ft
Number of Stories	5
Standard Construction Cost	$1,200/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Lighting Controls	Packaged Cooling	Chillers (Air, Water Cooled)	Air Distribution (CAV, VAV)	Hot Water Heating	Solar thermal hot water system	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●		●		●	●			-	-	-	-
Baseline	●	●	●	●●	●		●	●●	●●	●	60%	30.0%	24.83	3.1%	~20
Option A	●●	●	●	●●	●		●	●●	●●	●	75%	31.3%	27.05	3.4%	~21
Option B	●●	●	●	●●	●		●●	●●	●●	●	75%	39.6%	29.07	3.6%	~18
Option C	●●	●	●	●●	●		●●	●●	●●	●	75%	40.8%	31.05	3.8%	~19

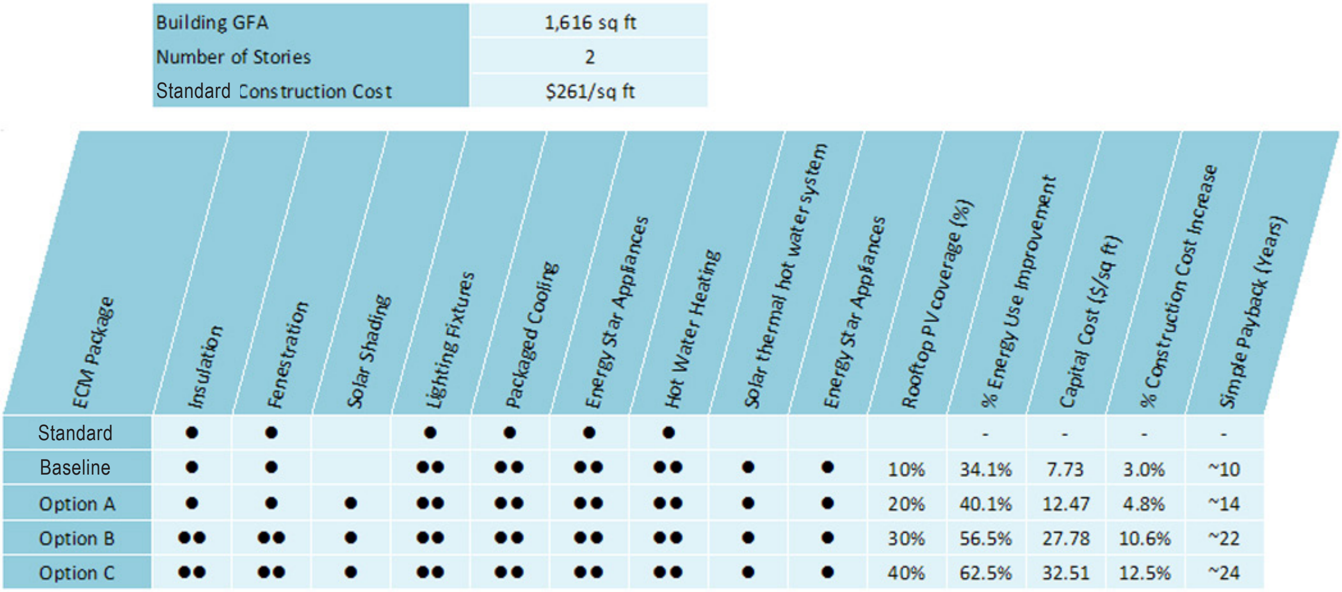
TABLE 3-17: 5-Story Headquarters Office



Building GFA	1,936 sq ft
Number of Stories	2
Standard Construction Cost	$201/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Packaged Cooling	Energy Star Appliances	Hot Water Heating	Solar thermal hot water system	EnerBy Star Appliances	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●	●	●	●				-	-	-	-
Baseline	●	●		●●	●●	●●	●●	●	●	10%	30.6%	6.57	3.3%	~9
Option A	●	●	●	●●	●●	●●	●●	●	●	20%	35.4%	10.55	5.3%	~13
Option B	●●	●●	●	●●	●●	●●	●●	●	●	30%	51.2%	25.07	12.5%	~21
Option C	●●	●●	●	●●	●●	●●	●●	●	●	40%	56.1%	29.06	14.5%	~23

TABLE 3-18: Single Family Dwelling



Building GFA	1,616 sq ft
Number of Stories	2
Standard Construction Cost	$261/sq ft

ECM Package	Insulation	Fenestration	Solar Shading	Lighting Fixtures	Packaged Cooling	Energy Star Appliances	Hot Water Heating	Solar thermal hot water system	EnerBy Star Appliances	Rooftop PV coverage (%)	% Energy Use Improvement	Capital Cost ($/sq ft)	% Construction Cost Increase	Simple Payback (Years)
Standard	●	●		●	●	●	●				-	-	-	-
Baseline	●	●		●●	●●	●●	●●	●	●	10%	34.1%	7.73	3.0%	~10
Option A	●	●	●	●●	●●	●●	●●	●	●	20%	40.1%	12.47	4.8%	~14
Option B	●●	●●	●	●●	●●	●●	●●	●	●	30%	56.5%	27.78	10.6%	~22
Option C	●●	●●	●	●●	●●	●●	●●	●	●	40%	62.5%	32.51	12.5%	~24

TABLE 3-19: Duplex Dwelling

Summary of Key Strategies

Based on the analysis of each building type the following key strategies are common to all buildings to achieve at least federal mandate compliance:

- Space cooling is the predominant energy use for almost all building types. In order to achieve and surpass the federal energy mandates, high efficiency alternatives should be used in lieu of “code minimum” cooling systems. Where appropriate, the most cost effective way of doing this is through the use of high efficiency packaged cooling equipment. However in some circumstances the use of “central plant” type systems (typically utilizing air cooled chillers) is necessitated. Where more aggressive energy reductions are desired or the detailed design of each building is more appropriate to such a system, the use of high efficiency air cooled or water cooled chillers should be considered.
- The considerable cooling requirement on Guam necessitates large volumes of supply air to be provided to conditioned spaces in order to maintain comfortable conditions. When Constant Air Volume (CAV) fan controls are employed, supply fans are required to run at peak flow volume and power whenever cooling is required. Fan energy is therefore likely to form a significant proportion of the total energy use of the building. The use of Variable Air Volume fan controls may generate significant energy savings by reducing the supplied air volume (while maintaining constant supply temperature) to conditioned spaces in order to respond to varying space conditioning loads. This allows fans to run at part load for the majority of the time, which significantly reduces their energy consumption over the course of a year. In addition it is also noted that dehumidification is greater with VAV systems than CAV systems, which modulate the discharge air temperature to attain part load cooling capacity.
- In order to minimize building cooling requirements, the use of increased levels of building insulation, the use of high efficiency glazing options, and solar shading should be considered to minimize solar gain and thermal conduction into the buildings. Although an aggressive approach to the use of high efficiency glazing and shading may not be required to meet the federal mandates their use should nevertheless be encourage as a method of reducing energy consumption. It is recognized that caution should be observed when specifying solar shading systems as these must be designed to withstand the requirements of the typhoon winds experienced on Guam.
- An aggressive approach to the use of lighting controls is recommended to reduce energy consumption in each of the facilities. After cooling, lighting energy is one of the largest energy uses in the majority of buildings (particularly for the non residential areas). The use of daylight controls and motion sensors should be encouraged as a cost effective way to ensure that lights are not used unnecessarily. By minimizing lighting use, cooling requirements are also reduced by reducing heat gains from the lighting into conditioned spaces. Where higher levels of energy performance are required or where the use of lighting controls is not appropriate (for example in retail spaces) the use of high efficiency T5 lighting should considered as a

means of reducing lighting energy use. In the residential homes, the use of compact fluorescent lighting should be mandated as the most cost effective means of reducing lighting energy consumption.

- In line with the requirements of Commandant of the Marine Corps directive *CMC ltr Ser 11300/Lff-1*, the use of STHW technologies has been analyzed as a method of reducing energy consumption in the proposed facilities. The use of solar heating systems for domestic hot water heating purposes is recommended as a technology for reducing energy consumption in buildings with sufficient hot water heating requirements (such as residential houses, BEQ/BOQs, community and child development centers or larger office buildings). Although solar water heating systems are unlikely to be designed to completely offset a building's total water heating demand, it is expected that the excellent solar resource in Guam would be sufficient to offset over 50% with a suitably sized array. It is noted that a number of the buildings (particularly the warehouses and industrial type buildings) are unlikely to have sufficient hot water heating demand to support the use of solar water heating systems. As such, the strategy should only be pursued where sufficient water heating demand exists.

- Commandant of the Marine Corps directive *CMC ltr Ser 11300/Lff-1* requires that all USMC new building construction incorporate roof-top solar thermal and/or photovoltaic technologies into the project. Significant discussion has taken place over the course of the project regarding the use of photovoltaic technologies in Guam, with specific reference as to meeting the typhoon wind loading requirements. As a result, a decision was made not to pursue the use of crystalline (monocrystalline and polycrystalline) PV technologies as it was determined that these were too susceptible to damage from typhoons. The use of BIPV is therefore recommended as a key strategy for meeting the requirements of the CMC directive and federal energy reduction mandates. The high price of electricity on Guam (with a blended rate of around 24c/kWh) means that any renewable strategies that are employed are likely to pay back in a much shorter length of time than on the mainland. In addition, it is noted that payback periods will only decrease as the cost of energy continues to rise and the price of PV falls further. It is likely that BIPV can be applied to the majority of building types to be constructed as part of the Marines build-up. A number of building types are noted as being key to the site wide BIPV strategy including the warehouses and industrial buildings, workshops and low rise offices. In these facilities, the large roof area (compared to gross floor area) means that significant energy reductions can be obtained from BIPV alone. In addition it is noted that in some of the building types (such as the general, semi conditioned storage buildings) net zero energy use for those buildings is expected to be achievable with an aggressive approach to BIPV.

Cost/Benefit Analysis

A life-cycle cost analysis of each building was undertaken to determine the least cost way to reach the federal mandates and to assess the total life-cycle costs of each package over the 42-year life-cycle analysis period defined by EO 13423. Discounted payback periods for the Baseline (i.e. ~30% energy reduction compared to the Standard package) and Options A, B and C packages compared to the Standard package. It is recognized that the Standard Package represents a package which does not meet the federal mandates and therefore cannot be constructed as part of the GJMMP build up. The reasons that the life-cycle cost analysis has been undertaken against this package and not the Baseline package are twofold:

- The standard package defines a fixed baseline (i.e. a building constructed to ASHRAE 90.1 or IECC standards) from which other packages can be measured against. The Baseline scenario is defined by a performance based target (30% improvement over Standard) and not by prescriptive requirements. The ECMs and associated costs required to reach the target are therefore flexible and will be determined by the design team for each building.
- The federal energy mandates and LEED EA1 energy points are defined against the Standard scenario. Therefore in order to provide an "apples to apples" comparison of energy performance against cost, life-cycle cost analysis must be performed against the Standard package.

All packages presented as part of the SSIMe analysis have been demonstrated to payback in less than 42 years; defined by EO 13423 as being the time frame in which ECMs are considered to return "reasonable payback". The high cost of electricity on Guam (coupled with the projected rising future cost of electricity) means that for most packages, discounted payback is achieved in significantly less than 42 years. As part of the life-cycle cost analysis, consideration has been given to the effects of equipment replacement and its effect on life-cycle cost and discounted payback. This is particularly important when considering strategies where equipment lifespan differs between alternative packages (for example packaged HVAC units versus central plant solutions).

Detailed analysis summaries documenting the ECMs applied to each building type, the additional cost associated with each measure, the total energy use and energy costs associated with each package, and the savings achieved compared to baseline, are provided in the **Attachment A** of this document. Detailed life-cycle cost analysis has also been undertaken, the results of which are provided in the analysis summaries for each building type. A summary of the key baseline ECM cost assumptions used in the analysis is provided in **Attachment B**. Table 3-20 below shows the baseline construction costs used for the analysis.

Building Type	Standard Construction Costs
Single Family	$201/sq ft
Duplex	$261/sq ft
5 Story HQ Office	$807/sq ft
3 Story HQ Office	$807/sq ft
2 Story HQ Office	$807/sq ft
1 Story Small Office	$807/sq ft
Organic Storage Warehouse	$755/sq ft
General Storage Warehouse	$336/sq ft
Day Care Center	$1574/sq ft
Commissary	$1334/sq ft
Dining Facility	$1118/sq ft
BEQ - 6 Story 300 Occupant	$651/sq ft
School	$1301/sq ft
Workshop	$1200/sq ft

TABLE 3-20: Baseline Construction Costs

Recommendations

As noted in the introductory section of this report, the purpose of this analysis is not to provide a prescriptive criteria or set of measures to be implemented across all projects, but to demonstrate possible solutions that would achieve compliance with the federal mandates and meet the required minimum performance criteria in the most cost effective manner, and alternative strategies that would achieve increasing levels of energy performance while achieving financial payback within the criteria defined by EO 13423.

The recommended packages for each building type are defined by the need to meet the overall sustainability goals (particular with respect to achieving a 34% carbon emissions reduction and 7.5% site-wide renewable energy target). With the exception of the Standard package (which is the datum package from which building energy mandate compliance is measured against) all packages are design to meet the federal mandates for individual buildings) and do so within a 42-year discounted payback period as defined by EO 13423. Based on the overall recommended sustainability program (encompassing factors other than just building energy, the following energy performance targets as shown in Table 3-21 are recommended for each building type.

Building Types	% Reduction	% Renewables	ECM Package to meet the target
Single Family	30.5%	18.0%	Baseline
Duplex	34.0%	22.0%	Baseline
5 Story HQ Office	41.0%	12.5%	Option C
3 Story HQ Office	36.5%	15.0%	Option B
2 Story HQ Office	38.5%	13.5%	Option B
1 Story Small Office	43.0%	20.5%	Option A
Climate Control Warehouse	48.0%	23.5%	Option B
Semi-conditioned Warehouse	90.0%	85.5%	Option B
Day Center	42.5%	13.0%	Option A
Commissary	34.5%	14.0%	Option A
Dining Facility	40.5%	14.5%	Option B
BEQ - 6 Story 300 Occupant	46.5%	15.5%	Option C
School	31.3%	0.9%	Option A
Workshop	31.1%	1.5%	Baseline

TABLE 3-21: Performance Targets for Each Building to Achieve the Overall Program Sustainability Goals

In proposing these targets, it is recognized that prescriptive requirements related to the design of the buildings on-site cannot (and should not) be placed on the design teams. Each design time will have responsibility for the selection of systems and ECMs to ensure compliance with the federal mandates and sustainability goals for the base.

To ensure compliance with the overall installation-wide sustainability goals, performance based language should be included within the design and construction contracts for each facility mandating the minimum levels of energy performance that should be achieved (for example ~43% energy use improvement over baseline for 1-story small offices). The packages outlined in Attachment A can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for meeting the targets for each building type.

During the design and construction process it is recommended that a review team oversees the energy performance documentation submitted for each building to ensure compliance with the performance goals outlined above. This should be a multi phase approach that involves the validation of initial concepts and then continues to full documentation of the energy performance of the final design.

4. Public Realm Energy

Introduction

The impact of the public realm (public streets, trails, and parking lots) in influencing the character of an installation is an important consideration. The public realm also provides opportunities for significant improvements in energy conservation and associated cost savings. The primary approach to saving public realm energy is to integrate efficient lamp technologies, optimum pole placement, and efficient fixture photometrics (light distribution), while using the least amount of energy and cost to meet Unified Facilities Criteria (UFC), Federal Mandates, and Navy Sustainability goals. The purpose of the model is to explore the potential for energy and cost savings through reasonable measures at the conceptual master planning level and provide a direction for more detailed lighting design and implementation.

The Model

The model starts with the analysis of public realm lighting measures that follow the standard practice outlined in UFC and NAVFAC Marianas' (Common Components Study). The overall energy demand per year and associated costs are measured to establish the "Baseline" case. Three scenarios of increasing efficiency are developed as Option A, B and C. Those three scenarios along with the "Baseline" case are then put side by side to be evaluated on how each scenario can provide opportunities and benefits listed below to the base:

- Energy Saving
- Capital Cost Saving
- Maintenance Cost Saving
- Improved Sense of Security
- Reduced Glare and Improved Visibility

Public Realm Energy Program

Based on the Guam Joint Military Master Plan in Draft EIS/OEIS submitted November 2009, the extent of public realm is quantified as following:

- Street Lighting – over 84,000 linear meters (52 miles) of street
- Parking Lot Lighting – over 735,000 square meters (176 acres) in area
- Pedestrian/Trail Lighting – over 5,800 linear meters (3.6 miles) of trails

Types of Light Fixture

The model uses a standard set of lighting fixtures for comparison and performance analysis. These may or may not reflect the actual specifications that would be installed. The fixtures data used are shown in the tables 4-1 through 4-3.

Street Lighting - Lamp	High Pressure Sodium (SON/T)	Low Pressure Sodium (SOX)	Metal Halide (HPI-T)	CosmoPolis	LED 1	LED 2
Cost Per Fixture	$850	$990	$950	$1,500	$1,400	$1,600
Power Consumption (Lamp) (W)	250	250	250	210	100	140
Power Consumption (Circuit) (W)	285	300	275	240	128	183
Mean Output (Lumens)	10,100	10,700	8,300	24,150	5,365	3,430
Avg. Lumens/Watt	40	43	33	115	96	66
Annual KWH	1,144	1,205	1,104	964	514	735
Number of Fixtures Multiplier	1.0	1.0	1.0	1	1.0	1.0
Initial Cost	**$850**	**$990**	**$1,000**	**$1,200**	**$1,500**	**$1,650**
Lifespan (hrs)	26,000	16,000	12,500	30000	120,000	120,000
Lamp Replacement Cost	$130	$130	$130	$130	$650	$650
Annual Maintenance Cost	$16	$28	$42	$17	$22	$22
Electrical Operating Cost	$195	$205	$188	$164	$87	$125
Total Annual Operating Cost	**$211**	**$233**	**$229**	**$181**	**$109**	**$147**
Rec. Spacing (m)	40	36	36	45	36	36
Parking Lot Light Density (per m2)	0.0006250	0.0007716	0.0007716	0.0004938	0.0007716	0.0007716
Replacement (every)	6	4	3	7	30	30

TABLE 4-1: Street Light Fixture

Light Fixture Types	**PK-High Pressure Sodium (SON/T)**	**PK-Metal Halide**	**PK-LED**
Cost Per Fixture	$850	$950	$1,000
Power Consumption (Lamp) (W)	250	250	80
Power Consumption (Circuit) (W)	285	275	85
Mean Output (Lumens)	10,100	8,300	4,160
Avg. Lumens/Watt	40	33	52
Annual KWH	1,144	1,104	341
Number of Fixtures Multiplier	1.0	1.0	1
Initial Cost	**$900**	**$990**	**$1,000**
Lifespan (hrs)	23,000	12,500	120,000
Lamp Replacement Cost	$130	$130	$650
Annual Maintenance Cost	$18	$42	$19
Electrical Operating Cost	$195	$188	$58
Total Annual Operating Cost	**$213**	**$229**	**$77**
Rec. Spacing (m)	45	45	36
Parking Lot Light Density (per m2)	0.0004938	0.0004938	0.0007716
Replacement (every)	6	3	30

TABLE 4-2: Parking Light Fixture

Light Fixture Types	Bollard Lighting - Compact Fluorescent	Bollard Lighting - Metal Halide	Bollard Lighting - High Pressure Sodium	Bollard Lighting - LED
Cost Per Fixture	$820	$900	$850	$1,000
Power Consumption (Lamp) (W)	70	60	70	35
Power Consumption (Circuit) (W)	75	65	75	40
Mean Output (Lumens)				
Avg. Lumens/Watt				
Annual KWH	301	261	301	161
Number of Fixtures Multiplier	1.0	1.0	1.0	1.0
Initial Cost	**$820**	**$900**	**$850**	**$1,000**
Lifespan (hrs)	12,000	15,000	25,000	120,000
Lamp Replacement Cost	$130	$130	$130	$650
Annual Maintenance Cost	$38	$30	$18	$19
Electrical Operating Cost	$51	$44	$51	$27
Total Annual Operating Cost	**$89**	**$75**	**$69**	**$46**
Replacement (every)	3	4	6	30

TABLE 4-3: Trail Lighting Fixtures

Light Poles

The model uses a standard set of lighting poles for comparison and performance analysis. These may or may not reflect the actual specifications that would be installed. The lighting pole data used are shown in the Table 4-4.

Street Lighting - Post	Post-6m	Post-9m	Post-12m	Solar & Wind Hybrid	Solar Post
Height (m)	6	9	12	10	25
Installation Cost	$1,762	$2,445	$2,891	$3,000	$5,000
Concrete Foundation	$341	$341	$341	$341	$341
First Cost	$2,103	$2,786	$3,232	$3,341	$5,341

TABLE 4-4: Lighting Pole Data

Cost

The first cost of different light fixture and poles are based on Guam Cost Data Book by NAFVAC PAC, with additional quotes from vender and manufacturer. The first cost includes the material and labor. The annual cost includes electricity cost as well as lamp replacement cost averages in its lifespan. Based on the research, the lamp replacement cost is averaged at $130 for most types of fixture except LED. The replacement cost for LED lamp is at $650.

Measures & Package

Street Lighting

LIGHTING STRATEGY—Baseline						
	Lamp Type	**Post Type**	**Spacing**	**Duration (hrs)**	**% On**	**#**
Arterial	High Pressure Sodium (SON/T)	Post-12m	40	11	100%	389
Collector-Residential	Low Pressure Sodium (SOX)	Post-9m	36	11	100%	415
Collector-Non-residential	High Pressure Sodium (SON/T)	Post-9m	40	11	100%	405
Local-Res	Low Pressure Sodium (SOX)	Post-6m	36	11	100%	211
Local-Nonres	Low Pressure Sodium (SOX)	Post-6m	36	11	100%	378
Family Housing Area Neighborhood Streets	Low Pressure Sodium (SOX)	Post-6m	36	11	100%	2,798

TABLE 4-5: Baseline

LIGHTING STRATEGY—Option A						
	Lamp Type	**Post Type**	**Spacing**	**Duration (hrs)**	**% On**	**#**
Arterial	High Pressure Sodium (SON/T)	Post-12m	40	11	100%	389
Collector-Residential	Low Pressure Sodium (SOX)	Post-9m	36	11	100%	415
Collector-Non-residential	High Pressure Sodium (SON/T)	Post-9m	40	11	100%	405
Local-Res	Metal Halide (HPI-T)	Post-6m	36	11	100%	211
Local-Nonres	Metal Halide (HPI-T)	Post-6m	36	11	100%	378
Family Housing Area Neighborhood Streets	Metal Halide (HPI-T)	Post-6m	36	11	100%	2,798

TABLE 4-6: Option A

LIGHTING STRATEGY—Option B						
	Lamp Type	**Post Type**	**Spacing**	**Duration (hrs)**	**% On**	**#**
Arterial	High Pressure Sodium (SON/T)	Post-12m	40	11	100%	389
Collector-Residential	Metal Halide (HPI-T)	Post-9m	36	11	100%	415
Collector-Non-residential	High Pressure Sodium (SON/T)	Post-9m	40	11	100%	405
Local-Res	Metal Halide (HPI-T)	Post-6m	36	11	100%	211
Local-Nonres	Metal Halide (HPI-T)	Post-6m	36	11	100%	378
Family Housing Area Neighborhood Streets	LED 1	Post-6m	36	11	100%	2,798

TABLE 4-7: Option B

LIGHTING STRATEGY—Option C	Lamp Type	Post Type	Spacing	Duration (hrs)	% On	#
Arterial	LED 2	Solar Post	45	11	100%	346
Collector-Residential	LED 1	Solar Post	36	11	100%	415
Collector-Non-residential	LED 2	Post-9m	36	11	100%	449
Local-Res	LED 2	Post-6m	36	11	100%	211
Local-Nonres	LED 2	Post-6m	36	11	100%	378
Family Housing Area Neighborhood Streets	LED 1	Post-6m	36	11	100%	2,798

TABLE 4-8: Option C

Parking Lighting

LIGHTING STRATEGY	Lamp Type	Post Type	Spacing	Duration (hrs)	% On	#
Baseline	PK-High Pressure Sodium (SON/T)	Post-6m	45	11	100%	364
Option A	PK-Metal Halide	Post-6m	45	11	100%	364
Option B	CosmoPolis	Post-6m	45	11	100%	364
Option C	PK-LED	Post-6m	36	11	100%	569

TABLE 4-9: Parking Lighting Strategy

Trail and Pedestrian Lighting

LIGHTING STRATEGY—Baseline	Lamp Type	Cut Off Types	Spacing	Duration (hrs)	% On	#
Natural Greenway	Bollard Lighting - Compact Fluorescent	180 degree Cut Off	12	11	100%	387
Natural Pathway	Bollard Lighting - Compact Fluorescent	180 degree Cut Off	12	11	100%	52
Urban Corridor	Bollard Lighting - High Pressure Sodium	360 degree Cut Off	6	11	100%	101

TABLE 4-10: Baseline

LIGHTING STRATEGY—Option A	Lamp Type	Cut Off Types	Spacing	Duration (hrs)	% On	#
Natural Greenway	Bollard Lighting - High Pressure Sodium	180 degree Cut Off	12	11	100%	387
Natural Pathway	Bollard Lighting - High Pressure Sodium	180 degree Cut Off	12	11	100%	52
Urban Corridor	Bollard Lighting - Metal Halide	360 degree Cut Off	6	11	100%	101

TABLE 4-11: Option A

LIGHTING STRATEGY—Option B						
	Lamp Type	**Cut Off Types**	**Spacing**	**Duration (hrs)**	**% On**	**#**
Natural Greenway	Bollard Lighting - Metal Halide	180 degree Cut Off	12	11	100%	387
Natural Pathway	Bollard Lighting - Metal Halide	180 degree Cut Off	12	11	100%	52
Urban Corridor	Bollard Lighting - LED	360 degree Cut Off	6	11	100%	101

TABLE 4-12: Option B

LIGHTING STRATEGY—Option C						
	Lamp Type	**Cut Off Types**	**Spacing**	**Duration (hrs)**	**% On**	**#**
Natural Greenway	Bollard Lighting - LED	180 degree Cut Off	12	11	100%	387
Natural Pathway	Bollard Lighting - LED	180 degree Cut Off	12	11	100%	52
Urban Corridor	Bollard Lighting - LED	360 degree Cut Off	6	11	100%	101

TABLE 4-13: Option C

Public Realm Energy Packages

ELEMENT	PROGRAM	COST	IMPROVEMENT
Street Lighting	Arterial: High Pressure Sodium Non-Res. Collector: High Pressure Sodium Res. Collector: Low Pressure Sodium Local Access St.: Low Pressure Sodium Neighborhood St.: Low Pressure Sodium All Standard Steel Poles	Initial Cost: $15,101,000; Annual O&M: $1,053,000;	Based on UFC Standard
Parking Lot Lighting	High Pressure Sodium	Initial Cost: $1,093,000; Annual O&M: $77,000	Based on UFC Standard
Pedestrian/Trail Lighting	Bollard Lighting - Compact Fluorescent & High Pressure Sodium	Initial Cost: $445,000 Annual O&M: $46,000	Based on UFC Standard
TOTAL		Initial Cost: $16,639,000 Annual O&M: $1,176,000	

TABLE 4-14: Baseline

ELEMENT	PROGRAM	COST	IMPROVEMENT
Street Lighting	Arterial: High Pressure Sodium Non-Res. Collector: High Pressure Sodium Res. Collector: Low Pressure Sodium Local Access St.: Metal Halide Neighborhood St.: Metal Halide All Standard Poles	Initial Cost: $15,135,000; Annual O&M: $1,041,000;	CO2e Saving: 244 MT Energy Saving: 6%
Parking Lot Lighting	Metal Halide	Initial Cost: $1,126,000; Annual O&M: $83,500	CO2e Saving: 10 MT Energy Saving: 4%
Pedestrian/Trail Lighting	Bollard Lighting - Metal Halide and Efficient High Pressure Sodium	Initial Cost: $464,000 Annual O&M: $38,000	CO2e Saving: 6 MT Energy Saving: 3%
TOTAL		Initial Cost: $16,725,000 Annual O&M: $1,162,000	CO2e Saving: 280 MT Energy Saving: 6%

TABLE 4-15: Package A

ELEMENT	PROGRAM	COST	IMPROVEMENT
Street Lighting	Arterial: High Pressure Sodium Non-Res. Collector: High Pressure Sodium Res. Collector: Low Pressure Sodium Local Access St.: Metal Halide Neighborhood St.: LED All Standard Poles	Initial Cost: $16,538,000; Annual O&M: $663,000;	CO2e Saving: 1460 MT Energy Saving: 37%
Parking Lot Lighting	Cosmopolis	Initial Cost: $1,202,000; Annual O&M: $66,000	CO2e Saving: 47 MT Energy Saving: 16%
Pedestrian/Trail Lighting	Bollard Lighting - Compact Fluorescent and Efficient High Pressure Sodium	Initial Cost: $496,000 Annual O&M: $37,000	CO2e Saving: 44 MT Energy Saving: 20%
TOTAL		Initial Cost: $18,236,000 Annual O&M: $769,000	CO2e Saving: 1551 MT Energy Saving: 35%

TABLE 4-16: Package B

ELEMENT	PROGRAM	COST	IMPROVEMENT
Street Lighting	Arterial: LED Non-Res. Collector: LED Res. Collector: LED Local Access St.: LED Neighborhood St.: LED Solar Pole & Standard Poles	Initial Cost: $17,609,000; Annual O&M: $560,000;	CO2e Saving: 2360 MT Energy Saving: 60%
Parking Lot Lighting	LED	Initial Cost: $1,765,000; Annual O&M: $37,000	CO2e Saving: 160 MT Energy Saving: 53%
Pedestrian/Trail Lighting	Bollard Lighting - LED	Initial Cost: $540,000 Annual O&M: $21,000	CO2e Saving: 104 MT Energy Saving: 47%
TOTAL		Initial Cost: $19,914,000 Annual O&M: $618,000	CO2e Saving: 2623 MT Energy Saving: 59%

TABLE 4-17: Package C

Performance & Cost Analysis

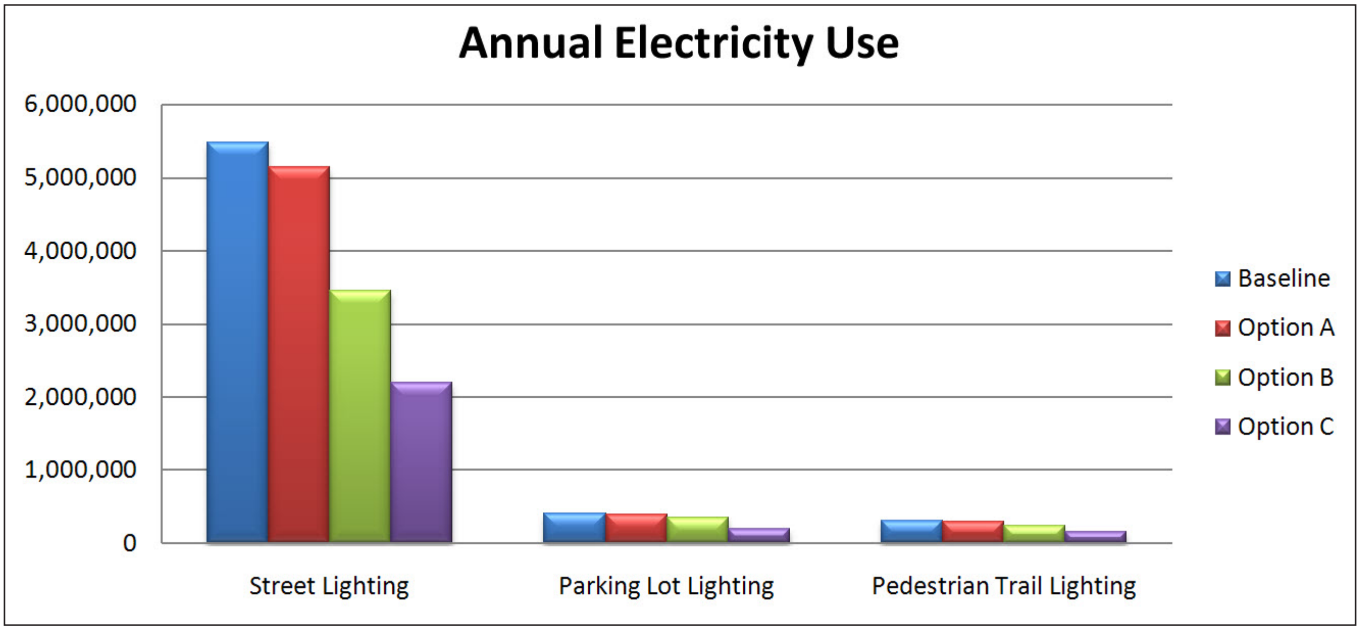


FIGURE 4-1: Annual Electricity Use

The combination of street, parking lot, and pedestrian trail lighting measures identifies significant opportunities for energy savings. Package A to C package provides an overall energy reduction ranges from 6 percent to 59 percent compared to “Baseline”.

The upfront capital cost (first cost) is driven by the type and number of lighting fixtures and types and number of light poles resulted from chosen package. The annual operating costs are directly dependent on the type of fixture chosen as the energy consumption and replacement costs differ by fixture type.

Although Option C package includes mostly LED fixtures and solar poles which result an increase of capital cost, the energy saving and longer lifespan of the LED fixture help to reduce the annual maintenance and operating cost. The simple payback of Option C to Baseline is about six years.

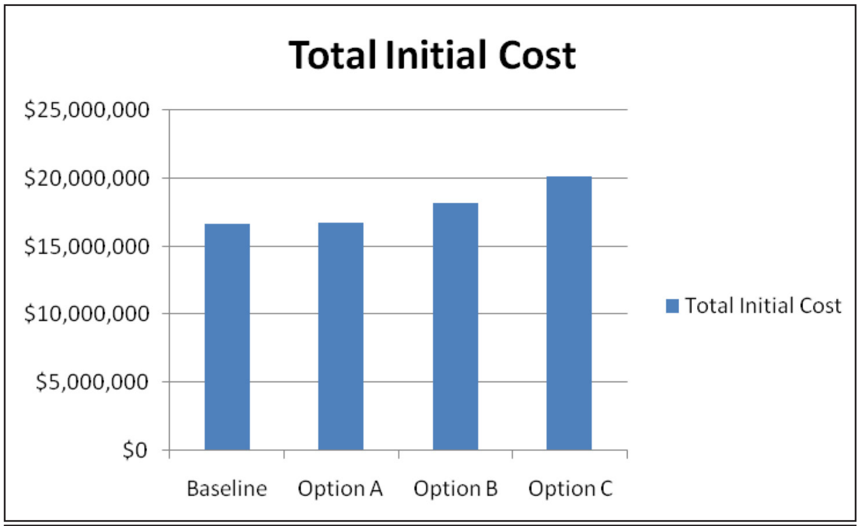


FIGURE 4-2: Total Inital Cost

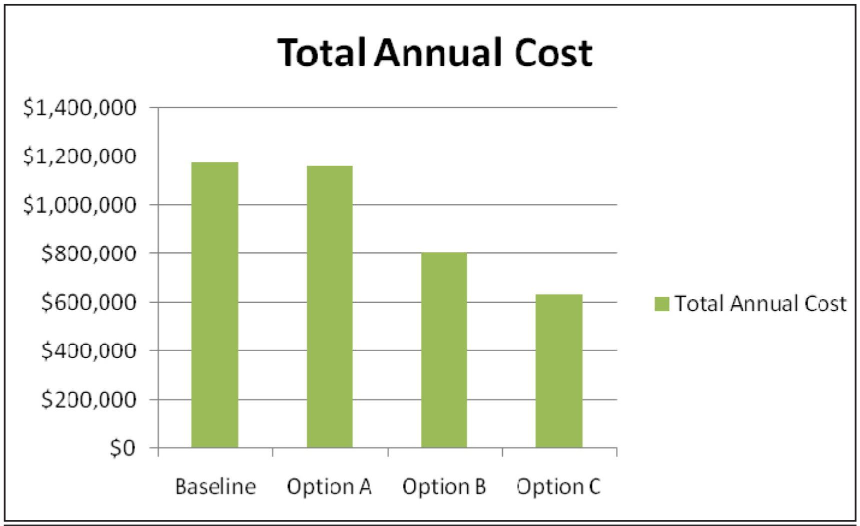


FIGURE 4-3: Total Annual Cost

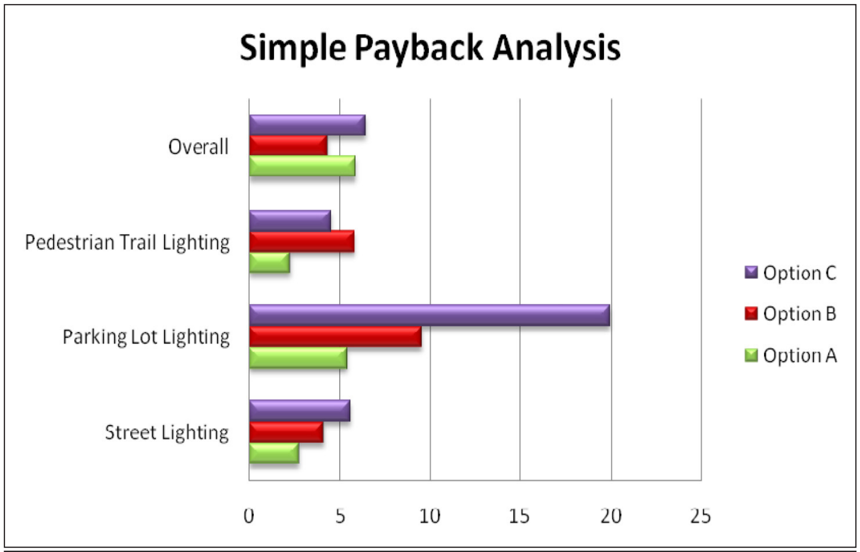


FIGURE 4-4: Simple Payback Analysis

5. District/Renewable Energy

SSIMe District Energy Analysis Results

There has been significant discussion over the course of the SSIM energy masterplanning exercise pertaining to the provision of a district wide energy system at the base and in particular, a district wide cooling system. District wide energy systems can be an effective way of reducing energy use across a number of buildings, campuses or even towns and cities, by generating energy (typically hot and cold water for space heating, hot water heating and space cooling) efficiently at a central point and distributing via insulated pipe work to buildings across a site.

For the main cantonment at the Finegayan base, there are a number of issues that make the decision more complex than at many other locations. In particular, it is noted that there is no requirement for space heating in Guam. District hot water energy systems are generally not designed to supply only domestic hot water, due to the large infrastructure costs associated with district systems and the potential for using other more efficient “at source” methods of domestic hot water heating, such as solar water heating systems. On that basis, only a district cooling system has been considered for use.

The primary objective of a district energy system is to allow energy (in the case of Guam, “cooling”) to be generated more efficiently at a central source. When heating systems are required, this is generally done through the use of waste heat, combined heat and power (CHP) or biomass technologies, where significant energy, cost or carbon savings can be achieved. For a cooling only system, such alternatives are less readily available. Because of that, it is most likely that a district cooling system would use water cooled chillers, which minimizes the energy savings that could be achieved compared to individual building systems (in some cases, water cooled chillers may be used on individual buildings anyway). In addition, it is also noted that site wide cooling systems typically experience higher losses than heating systems, due to the higher temperature differential between the ground temperature and chilled water distribution temperature. For that reason, the energy savings that could be achieved from a district cooling systems are likely to be minimal. The high costs associated with installing preinsulated pipe work for chilled water distribution make such a system financially unfeasible on a site wide basis.

It is also noted that there are complexities associated with the phased procurement process of the facilities to be constructed as part of the build-up. As the base will not be constructed to 100 percent build-out straight away, any district cooling system would be required to be designed and constructed in phases alongside the build out, with significant up front design and construction work required prior to the first building development taken place. A number of different design and construction companies will be also involved in the development of the buildings; with significant complexities added to this process should each building be required to be serviced by a district cooling system (from the point of view of both the design of the buildings on site and the design of the cooling system itself).

The method by which the new buildings are funded (through DD 1391s) adds a further layer of complexity to the construction of a district wide cooling system. This process requires facilities to be costed individually, with funds allocated to each building for the provision of individual HVAC systems. The protocols involved in the process therefore do not readily lend themselves to the development of centralized cooling plants. As such, it is not recommended that an base wide district cooling system is pursued at this time.

Despite this, it is noted that in some instances smaller distributed cooling systems could be used to serve small groups of buildings from a single central cooling source. The most likely area for this type of system is determined as being the BEQ area, where the buildings have a large cooling requirement (primarily due to their size) and are more closely located which minimizes the requirement for large runs of chilled water distribution piping. Although the energy savings associated with doing this are likely to be minimal (in particular the size of the BEQs makes them likely candidates for the use of central water cooled chiller plant anyway), operations and maintenance savings are likely to be attained. It is noted that the BEQs will be procured to design and building contracting teams as groups of two or three) which would make the procurement of this type of system more feasible. In this circumstance, it is recommended that the use of smaller distributed cooling systems is investigated by the design teams.

SSIMe District Renewable Energy Analysis Results

Analysis has been carried out at a conceptual level to determine the feasibility of the use of district wide renewable energy strategies at the campus. Specifically, this analysis assessed the feasibility of the use of photovoltaic solar power generation and solar wind generation at the main cantonment:

Photovoltaic Solar Power Generation

Analysis of Anderson Air Force Base TMY2 weather data indicates that Guam benefits from an enviable year round solar resource. Average year round solar radiation on Guam is estimated to be around 171kWh/sq ft (compared to around 169kWh/sq ft in Los Angeles, which is widely regarded as having one of the best solar resources in the US). Due to Guam's location on the globe (13.6°N, 144.8° W), the peak solar resource for solar energy technologies such as PV is found at comparatively little tilt from the horizontal (around 9°).

Although Guam benefits from an excellent solar resource that would support the wide scale use of photovoltaic technologies, it is also recognized that Guam regularly suffers from typhoon winds. Around 30 to 40 tropical storms form each year to the southeast of Guam, which then track westward towards and past Guam. Of these, about four to six reach typhoon level wind strengths (over 100 mph) and about one to two will track over Guam or near enough to do damage. In the past, every 12 to 15 years, Guam has experienced a a super-typhoon (over 150 mph winds) but the storms have been increasing in intensity and frequency over the past 15 years which has led to an increase of the design wind load from 155 mph to 170 mph currently. Additionally during typhoons, flying debris is likely to be an issue and concern has been raised that this would present a danger to the use of conventional solar panels.

In line with the Department of the Navy policy (CMC ltr Ser 11300/LFF-1), the SSIMe team has adopted an aggressive approach with regards to the use of amorphous building integrated photovoltaics (BIPV) on the rooftops of each building. This technology is less susceptible to damage during typhoons as the PV layer flexible (and so does not have a glass surface) and is also integrated into the roof membrane itself, rendering it highly unlikely to detach from the building during high winds. Although an excellent application for building integrated or building mounted applications, amorphous PV is less suitable for use in district wide applications, due to its much lower power density (~231 sq ft/kW, compared to around 83 sq ft/kW for polycrystalline PV panels). As a result, a much larger area is required to achieve the same output as with crystalline PV panels.

Due to the typhoon issues, the widespread use of crystalline PV has effectively been ruled out at the new cantonment. The limited availability of large amounts of land for locating PV means that amorphous PV is unlikely to be a suitable strategy for developing a district wide renewables plan. The aggressive use of BIPV technologies on the buildings across the site

Wind Energy Generation

Assessment has also been made regarding the use of wind energy generation technologies as part of a “district wide’ renewable energy strategy at the site. Analysis of the Anderson Air Force Base TMY2 weather tape indicates that the island has a modest wind resource, with an average of wind speed of around 9.3 mph at 10m (~33 feet) above ground level. Although the use of very large scale wind energy generation has not been considered as part of the sustainable master plan, assessment has been made of the use of small wind energy generation technologies and specifically turbines in the sub 15kW range.

Although not eminently suitable for the use of wind generation technologies, the wind resource on the site is likely to be sufficient to support the use of small scale wind generation, with a capacity factor of around 14 percent predicted for turbines in the 15kW size range (with a hub height in the region 30 feet high). Accordingly, without any rebates, payback for a turbine would be expected to be achieved in approximately 32 years (based on mainland costs escalated to Guam costs using the 2.64 Guam factor.

As has been noted regarding the use of solar panels however, the typhoon-proofing requirements are likely to preclude the installation of wind turbines, due to the difficulty in finding turbines rated to 170mph design conditions. This is particularly pertinent for use in built up areas such as the new base, due to the risk of the turbines themselves damaging other property should they fail under typhoon conditions. As the Department of Defense is self insuring, determination will need to be made on the risk of the use of wind turbines rated at less than this condition. If this risk is deemed too great, it is not recommended that a wind turbine strategy is aggressively pursued at the base.

6. Green Building / LEED NC & ND

Introduction & Goals

Introduction

As part of the AECOM SSIM^{TM} Sustainability Master Plan study undertaken on the proposed new US Marines base in Finegayan, Guam, a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings that are to be constructed as part of the build-up. A total of 12 typical non residential building types were analyzed as part of the study, as follows:

- 5-story HQ office
- 3-story HQ office
- 2-story office
- 1-story small office
- Organic storage warehouse
- General storage warehouse
- Day Center
- Commissary
- Dining Facility
- Bachelor Enlisted Quarters
- School
- Workshop

The Sustainability Master Plan and SSIM LEED certification studies provide guidance as to possible routes to compliance and the Rough Order of Magnitude (ROM) cost associated with doing so. In defining credit strategies for each package, it is recognized that this is a master planning level study therefore the credit strategies proposed may not be applicable for each specific building. As such the results of this study do not represent a prescriptive checklist of LEED credits that can be applied to each building type, and each credit will have to be analyzed by each design teams during the design phase of each building. Details of the LEED credit packages for each building type are provided in the **Attachment A** of this document.

Sustainability Goals and Mandates

Facilities to be constructed as part of the GJMMP build up are required to comply with a number of federal mandates as well as the Commandant of the Marine Corps' own sustainability goals. These are addressed in different forms by Energy Policy Act (EPAct) 2005, Executive Order (EO) 13423, and Energy Independence and Security Act (EISA) 2007.

From a LEED perspective, the mandates require that all new buildings must receive a minimum of LEED Silver certification. This has therefore been used as the minimum LEED requirement for the project.

In addition to federal mandates, an online client survey was undertaken (the survey results are included in **Attachment D** of the document), with responses collected from seven key stakeholders. These results were utilized to assess the effectiveness of each LEED scenario at achieving the client's underlying sustainability goals.

Modeling Approach

Process Overview

As this assessment of LEED certification potential is being done during the master planning phase, information has not yet been developed on each specific building's form and site factors that may significantly impact the LEED certification strategy.

The LEED Scenario Generator has therefore been developed to assess the viability of each credit using two high level evaluation metrics:

- Construction Cost
- Restrictiveness on Design

Each LEED DB+C credit has been assessed against these criteria which resulted in each credit being placed into one of four credit categories as shown in Table 6-1:

Credit Category	Cost Impact	Design Impact
1	Low	Low
2	Low	High
3	High	Low
4	High	High

TABLE 6-1: LEED Credit Category Matrix

As one of the key elements of this study was to validate the cost impact of seeking LEED certification, a simple ROM cost has been attached to each credit. These costs are broken down into three component parts each covering a different element of the project as follows: percentage increase on construction cost; percentage increase on design fee; and cost of LEED documentation. Where a more detailed analysis has been undertaken such as that undertaken by SSIMe, these more detailed costs are utilized in the total cost build-up.

Four separate scenarios have been generated to allow assessment of the LEED opportunities. As noted in Table 6-2, all scenarios assume the use of those credits that have a low impact on both the design and the construction cost.

Scenario	Low / Low Credits	Low / High Credits	High / Low Credits	High / High Credits
Good	✓			
Better 1	✓	✓		
Better 2	✓		✓	
Best	✓	✓	✓	

TABLE 6-2: LEED Credit Category Preference Scenario (Cost/ Design)

The "Good" scenario assesses the LEED potential of only utilizing credits designated as low cost / low design impact. Two "Better" scenarios have been generated that assess the potential benefit associated with also seeking those credits that have either a higher design impact or a higher construction cost impact. The "Best" scenario however, looks at incorporating all credits included within the "Better" packages.

It is noted, however, that those credits that have been defined as having high design impact and high construction cost impact have not been included within any of the scenarios on the basis that these credits should be evaluated at a project by project basis given the potential impact on cost or design flexibility.

Additionally it is noted that none of the new regional credits have been defined for Guam, and as such LEED Silver has been sought without reliance on these credits.

Findings & Recommendations

Results

Four different LEED certification scenarios have been generated for each building type. Based upon this evaluation, Table 6-4 shows percentage cost premium for each of the notional building types. It is however noted that these percentage increases are dependent upon the base construction costs, as provided by NAVFAC, and are therefore provided for guidance only.

While it is evident that some of the building types indicate a significantly lower percentage cost premium for LEED Certification, this is primarily due to those building types having a much higher baseline cost per square foot. Therefore, should the baseline costs for those building types be revised during the project, the LEED cost premium (when stated as a percentage of the baseline construction cost) would increase accordingly.

It is also noted that these cost premiums are in general higher than those seen to achieve LEED Silver on the US mainland. There are a number of reasons for this:

- The project is also looking to achieve the energy reduction requirements of EISA:2007 and EPAct 2005.

Building Type:	ECM Package to meet the target	Construction Cost Increase(%) to meet project target (Energy Infrastructure)*	LEED Certification Level Target	Construction Cost Increase(%) to achieve LEED (excluding energy infrastructure) *	Approx. % Total Construction Cost Increase*
Single Family	Baseline	3.5%	-	-	3.5%
Duplex	Baseline	3.0%	-	-	3.0%
5 Story HQ Office	Option C	4.0%	Gold	2.0%	6.0%
3 Story HQ Office	Option B	4.5%	Silver	1.5%	6.0%
2 Story HQ Office	Option B	5.0%	Silver	2.0%	7.0%
1 Story Small Office	Option A	4.5%	Silver	2.5%	7.0%
Organic Storage Warehouse	Option B	6.0%	Silver	2.0%	8.0%
General Storage Warehouse	Option B	12.0%	Silver	2.5%	14.5%
Day Care Center/Community Center	Option A	1.5%	Silver	2.0%	3.5%
Commissary	Option A	3.5%	Silver	1.5%	5.0%
Dining Facility	Option B	5.0%	Silver	2.0%	7.0%
BEQ - 6 Story 300 Occupant	Option C	3.0%	Silver	1.5%	4.5%
School	Option A	2.0%	Silver	1.5%	3.5%
Workshop	Baseline	1.5%	Silver	2.0%	3.5%

TABLE 6-3: LEED Cost For Building Types (*% Construction Cost Increase is measured against standard construction)

- The remote location of the facility eliminates the potential use of a number of the sustainable site credits.
- Guam does not currently have any regional focus credit strategies defined which means that they cannot be relied upon, thus eliminating five potential points from consideration.

Recommendations

All of scenarios proposed as part of the $\text{SSIM}_{\text{LEED}}$ study are designed to meet the overarching federal requirements (a 30% reduction over ASHRAE and 55% reduction in fossil fuel use relative to a 2003 CBECS baseline) and to do so while achieving the LEED Silver certification.

This study has however indicated that for a minor additional premium, achieving LEED Gold can be achieved.

Table 6-3 identifies the initial recommendations as to the percentage cost allowances that should be made prior to the development of a DoD 1391 to cover the total cost of achieving LEED certification, excluding the cost of any LEED review fees. It is noted that the average construction cost increase needed to achieve LEED Silver of approximately 4.5% is in line with those projects currently in development in Guam.

In defining the ROM costs for each of the $\text{SSIM}_{\text{LEED}}$ study packages, it is recognized that this is a master planning level study therefore the credits proposed may not be applicable to all buildings on the site, may require further investigation and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study. As such the results of this study do not represent a prescriptive checklist for achieving LEED certification that can be applied to each building type. As each building is designed and constructed, the individual design time will have responsibility for the selection of systems, ECMs and LEED credit strategies to ensure compliance with the federal mandates, and sustainability goals for the base.

To ensure compliance with the overall installation-wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum levels of LEED certification performance that should be achieved, with the potential for providing additional credit for achieving LEED Gold during the bid evaluation process. The credit strategies proposed in **Attachment A** can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

During the design and construction process it is recommended that a review team oversees the LEED certification documentation submitted for each building to ensure compliance with the performance goals outlined above. This should be a multi-phase approach that involves the validation of initial concepts and then continues to full documentation of the final design.

Scorecard Assumptions

The recommended scorecards for each of the 12 building types modeled for the project, are included in the **Attachment A** of this document.

LEED NC Strategy

Introduction

The purpose is to secure LEED NC Silver (minimum) for all qualifying structures.

General Strategies

The following are general strategies for achieving LEED efficiently.

1. A project digital data base needs to be established as a repository of project documentation for LEED credits. This may also include information for other military buildings being LEED certified on the island. The data base should also include a section for lessons learned.
2. A minimum of 50 points is required to achieve LEED Silver for LEED NCv3.
3. All pre-requisites need to be met to receive LEED certification.
4. The following is a list of criteria the USGBC indicated is the Minimum Program Requirements (MPR) for a project to become LEED certified:

- Must comply with environmental laws
- Must be a complete, permanent building or space
- Must use a reasonable site boundary
- Must use the same boundary for all LEED credits
- Must be larger than 1,000 sf gross floor area (Many parking structures do not meet this definition if they are essentially large roofed-over areas, because such areas are not counted within the total gross floor area)
- Must have one Full Time Equivalent (Occupant) calculated as an annual average in order to use LEED in its entirety (1,920 hours per year)
- Must allow USGBC access to the whole building energy and water usage data
- Must comply with a minimum building area to site area ratio. The gross floor area of the building must be no less than 2% of the gross land area within the LEED project boundary

5. For LEED NC Multiple Buildings approach, certain credits maybe applied campus wide. The credit is reviewed once, and then needs to be verified that the conditions are the same afterwards providing it is the same phase of construction and the same version of LEED. The multiple buildings application guide is currently undergoing a substantial revision and the list of credits that will be available as Campus credits has not yet been finalized.

6. LEED Time Limits include:

- “Sunset Date” refers to the date occurring six (6) years after the close of registration for a rating system version. After this point, a project needs to be registered under the newest version of LEED NC.
- GBCI reserves the right to cancel any registered project that, as determined solely by GBCI, remains inactive for a period of four (4) years or more.

Strategies by Section

Sustainable sites

- Potentially land bank area that is designated as parking but is not built to meet UFC requirements while reducing pavement area.
- Incentivize reduced car ownership by causing the marines to pay for their cars to be shipped or by offering money instead of shipping their cars (this will not meet any LEED points).
- Reduce daily trips by creating an internal and external shuttle bus system, Car share program and a bike share program (this will not achieve any LEED points)

Note: While car/bike share will not garner any regular LEED points, these programs may qualify for ID credits.

A few Storm Water Management benchmarks may include:

- Maintain predevelopment hydrology to maximum extent technically feasible (METF)
- Total volume of rainfall from 95th percentile storm to be managed on-site through bio-retention areas, permeable pavement, cisterns-recycling, and green roofs

Water Efficiency

- For indoor water, after meeting the baseline Energy Policy Act of 1992 fixture performance requirements calculated for the building, employ strategies that use a minimum of 20 percent less potable water (per NAVFAC's Capital Improvements Engineering & Construction Bulletin December 13, 2007).
- For outdoor water, employ water efficient landscape and irrigation strategies, including water reuse and recycling, to reduce outdoor potable water consumption by a minimum of 50 percent over that consumed by conventional means (plant species and plant densities). (per NAVFAC's Capital Improvements Engineering & Construction Bulletin December 13, 2007). Due to the weather conditions in Guam, most landscaping will not require any irrigation. Golf courses and isolated, high profile locations are exceptions.
- Some strategies for reducing water use are low flow fixtures resulting in about 20-30% reduction in interior water use, rooftop rainfall harvesting as water supply for toilet flushing (residential) and incidental irrigation with a reduction in additional 25% of potable water, and reduction of 25% in wastewater requiring treatment, and use condensate as supplemental water supply for cisterns for toilet flushing (commercial/industrial)
- Minimize sediment runoff into the ocean – treat up to 2-year, 24-hour storm by implementing Low Impact Design (LID)

Energy and Atmosphere

- Reference (a) requires that new Federal buildings shall be designed to achieve energy consumption levels that are at least 30 percent below the levels established in the current ASHRAE Standard. Reference (f), or the International Energy Conservation Code (per Energy Policy Act (EPAct) of 2005).
- Purchase or generate and use renewable electricity: 3% in FY2007-2009, 5% in FY 2010-2012, 7.5% in FY2013 and thereafter (per Energy Policy Act (EPAct) of 2005).
- Buildings to be designed to 30% below ASHRAE standard (per Energy Policy Act (EPAct) of 2005).
- For new buildings and major renovations, reduce fossil fuel energy consumption 55% by 2010, and eliminate (100% reduction) by 2030 (per Energy Independence and Security Act of 2007)
- 30% of hot water demand provided by solar where cost effective (per Energy Independence and Security Act of 2007).
- Requires purchase of Energy Star and FEMP recommended products (per Energy Policy Act (EPAct) of 2005)
- Reduce petroleum consumption 20% by 2015. Only buy "low greenhouse gas emitting vehicles". CAFÉ =

35 mpg by 2020. (per Energy Independence and Security Act of 2007)

- Due to the humid climate and the need for air conditioning and dehumidifying in Guam, it would be difficult to exceed 30% Improved Energy Performance for LEED NC EA credit 1
- Measures to make the building more efficient include utilizing increased levels of insulation to reduce heat transfer through the building envelope and high performance fenestration systems to reduce solar gain and minimize cooling demand; and assess the effectiveness of the use of solar shading with ASHRAE standard and high performance fenestration systems.
- Install efficient plant and controls including: Use of high efficiency packaged units or chillers and cooling towers; Use of high efficiency lighting (including LED lighting) to reduce lighting energy and reduce the cooling demand; Utilize natural day lighting with daylight control; include Energy Star appliances and use low flow water fixtures reduce water heating demand
- The most cost effective renewable systems that are suitable for the site are amorphous PV (roof integrated) and Polycrystalline PV panels (ground mounted) and solar thermal hot water systems that can reduce hot water demand by over 50%.

Materials and Resources

- The project will divert 50% of the construction and demolition materials and debris (from the executive summary of the Construction and Demolition Debris Reuse and Diversion Study for DoD Bases, Guam dated January 20, 2010)

Regional Credits

USGBC currently does not have regional priority credits for Guam at this time. NAVFAC/USMC should open discussions with USGBC and GBCI for the potential to create Regional priority credits for Guam. Each Regional priority credit is worth an additional point with a maximum of four points.

The recommendations for potential LEED regional Credits based on AECOM experience to date potentially include:

- SSc6.1: Storm Water Design – quantity (limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from storm water runoff, and eliminating contaminants)
- WEc1, Option 2: Water efficient landscaping – No potable water use for irrigation (to eliminate the use of potable water or other natural surface of subsurface water resources available on or near the project site for landscape irrigation)
- SSc5.1: Site development – Protect or restore habitat (conserve natural areas and restore damaged areas to provide habitat)
- EQc10: Mold Prevention (reduce the potential presence of mold in schools through preventative design and construction)
- MRc2: Construction Waste Management (divert construction and demolition debris from disposal in landfills and incineration facilities, and redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate site.)

Potential Conflicts with UFC's, Codes and Mandates

Table 6-4 and 6-5 are a list of potential conflicts between ATFP standards and LEED credits (Per LEED DoD Anti-terrorism Standards Tool Available on WBDG.org).

Conflicting Requirements

LEED Credit	
SS-2 (Development Density)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
SS-5.2 (Reduce Site Disturbance, Development Footprint)	Standard 5 – Parking beneath buildings or on rooftops (Only potential problem)
	Standard 19 – Utility distribution and installation
SS 6.1 (Storm water management, rate and quantity)	Standard 5 – Parking beneath buildings or on rooftops (Only potential problem)

TABLE 6-4 Conflicting Requirment (Source: Whole Building Design Guide, LEED®-DoD Antiterrorism Standards Tool)

Conflicting and Complementary Requirements

LEED Credit	
SS 4.1 (Alternative Transportation-public transit)	Standard 1 – Standoff Distances
SS 5.1 (Reduce site disturbance – protect or restore open space)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
SS 5.2 (Reduce Site Disturbance, Development Footprint)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
SS 6.1 (Storm water management- rate and quantity)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
SS 6.2 (Storm water management – Treatment)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
WE 1.1 (Water efficient landscaping – reduce by 50%)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
WE 1.2 (Water efficient landscaping – reduce by 50%)	Standard 1 – Standoff Distances
	Standard 2 - Unobstructed Space
EA P2 (Minimum energy performance)	Standard 10 – Windows and skylights
	Standard 11 - Building entrance layout
EA 1 (Optimize energy performance)	Standard 10 – Windows and skylights
	Standard 11 - Building entrance layout
MR 1.1 (Building reuse, Maintain 75% of existing walls, floors and roof)	Standard 6 – Progressive collapse avoidance
	Standard 7 – Structural Isolation
	Standard 9 - Exterior masonry walls
MR 1.2 (Building reuse, Maintain 100% of existing walls, floors and roof)	Standard 6 – Progressive collapse avoidance
	Standard 7 – Structural Isolation
	Standard 9 - Exterior masonry walls
MR 1.3 (Building reuse, Maintain 100% of shell/structure and 50% Non-shell)	Standard 6 – Progressive collapse avoidance
	Standard 7 – Structural Isolation
	Standard 9 - Exterior masonry walls
EQ 6.1 (Controllability of systems, Perimeter spaces)	Standard 10 –Windows and skylights
EQ 7.1 (Thermal comfort, Compliance with ASHRAE 55-1992)	Standard 10 –Windows and skylights
EQ 8.1 (Daylight and views, daylight for 75% spaces)	Standard 10 –Windows and skylights
	Standard 11 - Building entrance layout
EQ 8.2 (Daylight and views – views for 90% of spaces)	Standard 10 –Windows and skylights
	Standard 11 - Building entrance layout

TABLE 6-5 Complementary and Conflicting Requirment (Source: Whole Building Design Guide, LEED®-DoD Antiterrorism Standards Tool)

LEED ND Strategy

Introduction

The purpose of this document is to provide guidance for achieving LEED ND for all applicable neighborhoods being proposed for the proposed Guam military base.

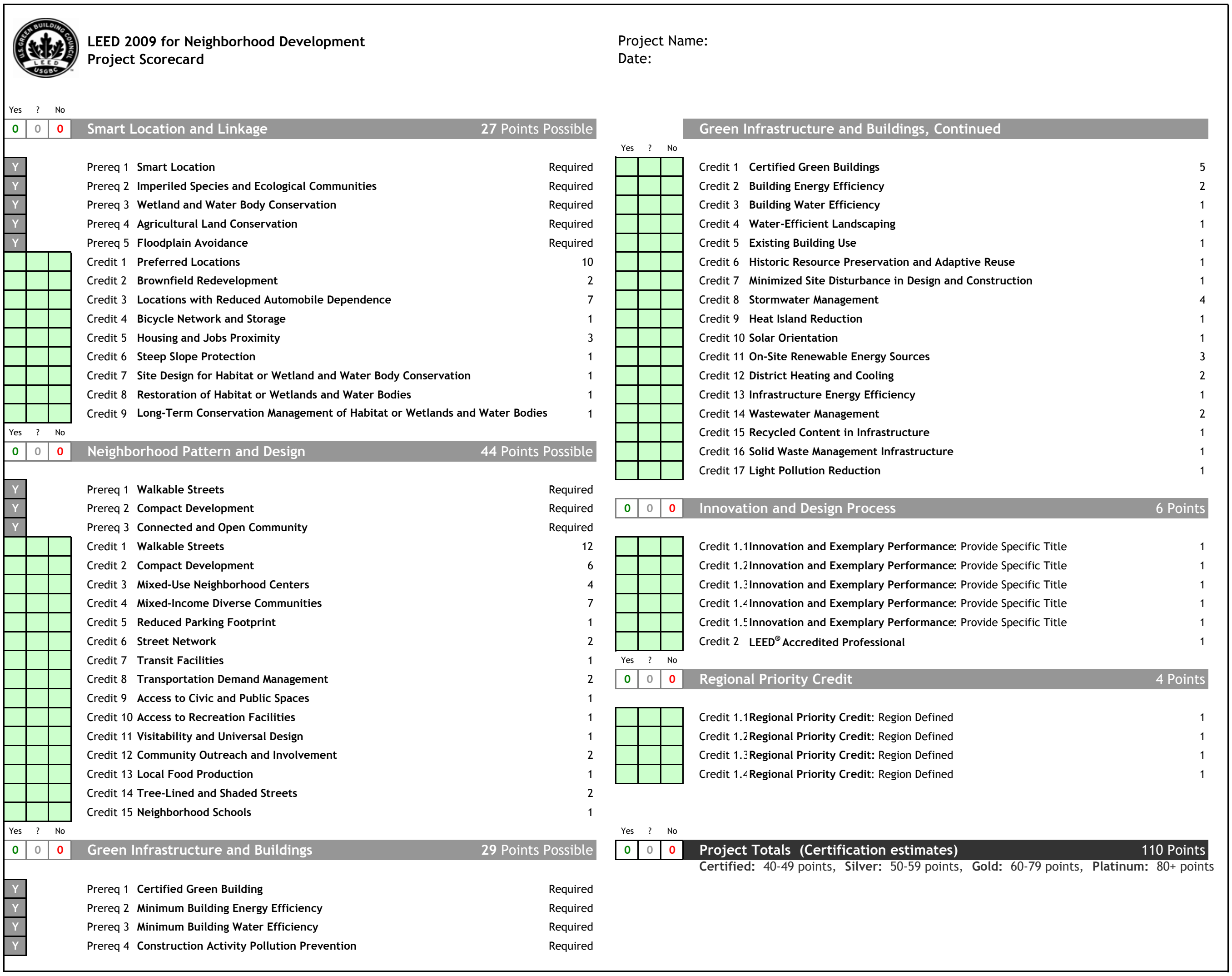
General Strategies

- LEED ND is not likely applicable for the Family Housing due to the minimum requirement of 7 du/ac.
- LEED ND may be possible for the BEQ area.

LEED ND Strategies that may be implemented are as follows:

- Enhanced trail system connecting
- Housing to “Quality of Life” services
- Base-wide shuttle system linking
- Enhanced Green/Open Space
- Connectivity
- Onsite tree preservation

LEED ND Scorecard



LEED 2009 for Neighborhood Development
Project Scorecard

Project Name:
Date:

Yes	?	No		Smart Location and Linkage	27 Points Possible
0	0	0			
Y			Prereq 1	**Smart Location**	Required
Y			Prereq 2	**Imperiled Species and Ecological Communities**	Required
Y			Prereq 3	**Wetland and Water Body Conservation**	Required
Y			Prereq 4	**Agricultural Land Conservation**	Required
Y			Prereq 5	**Floodplain Avoidance**	Required
			Credit 1	**Preferred Locations**	10
			Credit 2	**Brownfield Redevelopment**	2
			Credit 3	**Locations with Reduced Automobile Dependence**	7
			Credit 4	**Bicycle Network and Storage**	1
			Credit 5	**Housing and Jobs Proximity**	3
			Credit 6	**Steep Slope Protection**	1
			Credit 7	**Site Design for Habitat or Wetland and Water Body Conservation**	1
			Credit 8	**Restoration of Habitat or Wetlands and Water Bodies**	1
			Credit 9	**Long-Term Conservation Management of Habitat or Wetlands and Water Bodies**	1

Yes	?	No		Neighborhood Pattern and Design	44 Points Possible
0	0	0			
Y			Prereq 1	**Walkable Streets**	Required
Y			Prereq 2	**Compact Development**	Required
Y			Prereq 3	**Connected and Open Community**	Required
			Credit 1	**Walkable Streets**	12
			Credit 2	**Compact Development**	6
			Credit 3	**Mixed-Use Neighborhood Centers**	4
			Credit 4	**Mixed-Income Diverse Communities**	7
			Credit 5	**Reduced Parking Footprint**	1
			Credit 6	**Street Network**	2
			Credit 7	**Transit Facilities**	1
			Credit 8	**Transportation Demand Management**	2
			Credit 9	**Access to Civic and Public Spaces**	1
			Credit 10	**Access to Recreation Facilities**	1
			Credit 11	**Visitability and Universal Design**	1
			Credit 12	**Community Outreach and Involvement**	2
			Credit 13	**Local Food Production**	1
			Credit 14	**Tree-Lined and Shaded Streets**	2
			Credit 15	**Neighborhood Schools**	1

Yes	?	No		Green Infrastructure and Buildings	29 Points Possible
0	0	0			
Y			Prereq 1	**Certified Green Building**	Required
Y			Prereq 2	**Minimum Building Energy Efficiency**	Required
Y			Prereq 3	**Minimum Building Water Efficiency**	Required
Y			Prereq 4	**Construction Activity Pollution Prevention**	Required

Yes	?	No		Green Infrastructure and Buildings, Continued	
			Credit 1	**Certified Green Buildings**	5
			Credit 2	**Building Energy Efficiency**	2
			Credit 3	**Building Water Efficiency**	1
			Credit 4	**Water-Efficient Landscaping**	1
			Credit 5	**Existing Building Use**	1
			Credit 6	**Historic Resource Preservation and Adaptive Reuse**	1
			Credit 7	**Minimized Site Disturbance in Design and Construction**	1
			Credit 8	**Stormwater Management**	4
			Credit 9	**Heat Island Reduction**	1
			Credit 10	**Solar Orientation**	1
			Credit 11	**On-Site Renewable Energy Sources**	3
			Credit 12	**District Heating and Cooling**	2
			Credit 13	**Infrastructure Energy Efficiency**	1
			Credit 14	**Wastewater Management**	2
			Credit 15	**Recycled Content in Infrastructure**	1
			Credit 16	**Solid Waste Management Infrastructure**	1
			Credit 17	**Light Pollution Reduction**	1

Yes	?	No		Innovation and Design Process	6 Points
0	0	0			
			Credit 1.1	**Innovation and Exemplary Performance:** Provide Specific Title	1
			Credit 1.2	**Innovation and Exemplary Performance:** Provide Specific Title	1
			Credit 1.3	**Innovation and Exemplary Performance:** Provide Specific Title	1
			Credit 1.4	**Innovation and Exemplary Performance:** Provide Specific Title	1
			Credit 1.5	**Innovation and Exemplary Performance:** Provide Specific Title	1
			Credit 2	**LEED® Accredited Professional**	1

Yes	?	No		Regional Priority Credit	4 Points
0	0	0			
			Credit 1.1	**Regional Priority Credit:** Region Defined	1
			Credit 1.2	**Regional Priority Credit:** Region Defined	1
			Credit 1.3	**Regional Priority Credit:** Region Defined	1
			Credit 1.4	**Regional Priority Credit:** Region Defined	1

Yes	?	No	Project Totals (Certification estimates)	110 Points
0	0	0		

Certified: 40-49 points, **Silver:** 50-59 points, **Gold:** 60-79 points, **Platinum:** 80+ points

FIGURE 6-1: LEED ND Scorecard

LEED For Homes Strategy

Introduction

The purpose of this section is to provide guidance for achieving LEED for Homes for the family housing units being proposed for the proposed Guam military base.

General Strategies

- A minimum of 60 points is required for LEED Silver for homes.
- If Programming Benchmark floor area exceeds LEED Home Threshold Adjustment Neutral Rating it will result in needing to fulfill more credits to achieve and minimum LEED silver rating.
- A LEED for Homes provider is required to achieve LEED for Homes certification. The LEED for Homes Provider will oversee the Green Raters that will conduct on-site performance tests and visual inspections of various measures in the homes.
- Each house needs to be submitted individually but a group of houses can be combined into a “batch”. Within a batch, they perform a full field verification check on the “worst case scenario” house. The houses within the same batch need to be built within the same time frame (within 30 days). On average one in seven homes are tested.
- Examples of the types of Regional Design points that may be awarded include: exemplary performance of some of the existing LEED credits, something that benefits human health greatly or something that is very important to the region.
- If sustainability goals are set before the project begins and if there are no changes to the systems during construction, there should be no additional time need for the LEED process.
- LEED for Homes soft costs (paperwork) for a single home is $250 for USGBC fee and $300 for certification. With the volume discount for multiple homes, the costs could be $100 for USGBC fee and $50 for certification.
- Field verification cost for a batch of homes could be approximately $1,000 each for the sample verification protocol and paperwork.
- Hard costs could be between $2,000 and $8,000 per unit depending on LEED point pursued and the experience of the contractors with regards to sustainability.

GBCI Conference Notes

For the LEED multiple building approach, certain credits maybe applied campus-wide. The credit is reviewed once, and then it only needs to be verified that the conditions are the same afterwards providing it is the same phase of construction and the same version of LEED

- For current "Block Approach": the registration is free. The only benefit is to ensure the same reviewer will review the registered buildings within the same registered block. Currently, a building registered in LEED Online may be linked with only one block (overall campus block, in this case). As part of the build-out of multiple building functionality in LEED Online v3, it is hoped that individual buildings can be linked to multiple blocks (e.g. overall campus block, building type block, construction contract block etc.)
- For Shared Parking, a parking master plan is needed in which parking for specific uses is delineated. This assists with situations where a large parking lot is built up front and only some of the buildings are built in the first phase.
- Campus boundaries are fixed once they are approved. Another boundary may be added, but the process needs to start over for the additional area. The campus boundary may include buildings that are not eligible for LEED.
- There is an exception for military housing within a gate for LEED ND Neighborhood Pattern and Design Prerequisite 3
- GBCI is working to have a prerequisite review before the design phase submittal.
- Executive Orders are to be considered laws. When addressing a LEED credit, codes and laws need to be used if more stringent.
- There are currently no regional points available for Guam, even though they have US zip codes. Assume that they will not be available in the near future.
- A project must be complete within six years after the close of registration for a rating system version without having to re-register the project under a new version of the rating system. GBCI reserves the right to cancel any registered project that, as determined solely by GBCI, remains inactive for a period of four (4) years or more.
- Phase One could only be considered previously developed for Phase Two if it is constructed before the Phase 2 submission. Note that Phase One and Phase Two must be registered as separate projects in order for this instruction to apply. If it is desired to submit Phase One and Two as one project, the LEED-ND Project boundary must incorporate both phases and the project team would need to discern the appropriate stage for which the project is eligible to submit.
- The contractor or contract for block projects does not have to be the same through out the block but the projects all have to have the same project administrator. If one person that has access to the larger group of buildings, they should be able to block projects together.

LEED For Homes Green Provider

- Each house needs to be submitted individually but a group of houses can be combined into a batch. Within a batch, they perform a full field verification check on the "worst case scenario" house. The houses within the same batch need to be built within the same time frame (within 30 days). On average one in seven homes are tested.
- For the verification process, it does not matter if the unit is a single unit, duplex, etc. nor does the sf per unit, they could still be grouped together in a batch.
- Units that may go for a higher rating than LEED silver should be in a separate batch.
- All units are inspected for the same feature with one set of criteria.

- The points achieved in the Location and Linkages section of the LEED rating could be different for each homes based on its proximity to amenities and transit.
- Initially, a preliminary rating review, project goals, HERS rating process, and RESNET protocols need to be established. Verification and sampling protocols are set up in the beginning, as well.
- All homes have to meet Energy Star for Homes.
- There is no “Sunset Date” currently for LEED for Homes; but it is likely that there will be in the next version (2012)
- Examples of the types of Regional Design points that may be awarded: include exemplary performance of some of the existing LEED credits, something that benefits human health greatly or something that is very important to the region.
- If sustainability goals are set before the project begins and if there are no changes to the systems during construction, there should be no additional time need for the LEED process.
- Existing homes need to be finished for five years for new homes to be eligible for LEED for homes credit LL3.1 Edge development.
- There are two to three visits for each fully inspected home plus visual inspections of the others.
- The LEED for Homes documentation starts at the beginning of construction of the home, not installation of infrastructure.
- LEED for Homes soft costs (paperwork) for a single home is $250 for USGBC fee and $300 for certification. With the volume discount for multiple homes, the costs could be $100 for USGBC fee and $50 for certification.
- Field verification cost for a batch of homes could be approximately $1,000 each for the sample verification protocol and paperwork.
- Hard costs could be between $2,000 and $8,000 per unit depending on LEED point pursued and the experience of the contractors with sustainability.
- Points in the EQ (Indoor Environmental Quality) section are difficult to reach due to the local climate in Guam.
- MR (Materials and Resources) points are difficult to acquire due to the isolation of the project.

7. Transportation

Introduction & Goals

For many developed areas, vehicular travel represents a major component of the associated Greenhouse Gas Emissions. The facility on Guam is no exception. This travel occurs as people drive to key destinations both on- and off-base to travel to and from work, go shopping, drop-off/pick-up children at school, run other personal errands, or complete various other tasks. Within the United States and its territories, much of this travel occurs through private automobile use.

The reliance on private automobiles has many root causes including the separation of housing and employment, lack of viable alternative travel modes, and personal choice. To effectively reduce Greenhouse Gas Emissions, these underlying issues must be addressed. Reducing automobile usage requires changing land use patterns while also providing comfortable and convenient alternatives in the form of walking, biking, and transit usage. For the Guam facility, these strategies can also include policies related to auto ownership and use.

These strategies to reduce automobile usage, and the resulting GHGs produced, are reinforced by Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance (EO 13514), signed by President Barack Obama on October 5, 2009. The mandate required all Federal agencies to:

- Increase energy efficiency
- Measure, report, and reduce greenhouse gas emissions from direct and indirect activities
- Conserve and protect water resources through efficiency, reuse and storm water management
- Eliminate waste, recycle, and prevent pollution

- Leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services
- Design, construct, maintain, and operate high performance sustainable buildings in sustainable locations
- Strengthen the vitality and livability of the communities in which Federal facilities are located

Goals

EO 13514 outlined eight goals with supporting framework, and prompted each agency to develop GHG emissions inventories and reduction targets and to prepare a Strategic Sustainability Performance Plan within 240 days. The key requirement for transportation-related policies (described in section 2.a.iii.C) requires agencies to reduce the vehicle fleet's total petroleum consumption by a minimum of 2% annually through the end of fiscal year 2020 as compared to a baseline of 2005, for a total reduction of 30%. Other strategies identified include:

- Implementing strategies and accommodations for transit, travel, training, and conferencing that actively support lower-carbon commuting and travel by agency staff (section 2.b.ii)

- Participating in regional transportation planning, recognizing existing community transportation infrastructure (section 2.f.i)
- Considering sites that are pedestrian-friendly, near existing employment centers, and are accessible to public transit (section 10.b)

Guam's environment presents some unique challenges to developing effective transportation strategies for reducing Greenhouse Gas Emissions on the installation. For example, the regulatory environment itself is unique – involving coordination and communication between multiple military agencies involved in the Build-up, the Government of Guam, and the United States federal government and supporting agencies. Additionally, security for the base and its residents are a key concern. Finally, weather plays a key role in identifying strategies that can be implemented effectively. The hot, humid climate with frequent rainfall requires development of programs and strategies that provide alternative modes of transportation, but do not rely on base personnel and residents to walk or bike during extreme weather conditions, such as typhoons or intense heat and humidity.

Based on the goals and strategies identified in EO 13514, the following transportation goals were developed for the Guam Joint Military Master Plan (JMMP) Sustainability Program:

- Meet or exceed the mandates described in EO 13514
- Reduce vehicle miles of travel
- Develop a transportation system that complements the land use plan
- Develop intuitive, user-friendly programs that fit well with the travel patterns, needs, and environment on Guam

Modeling Approach

The SSIM modeling process addresses goals by developing a range of alternative strategy packages for the sustainable integration of transportation and land use and then evaluating and optimizing the effectiveness of those strategies. The modeling approach for the SSIM transportation process is described using the flow chart illustrated below.

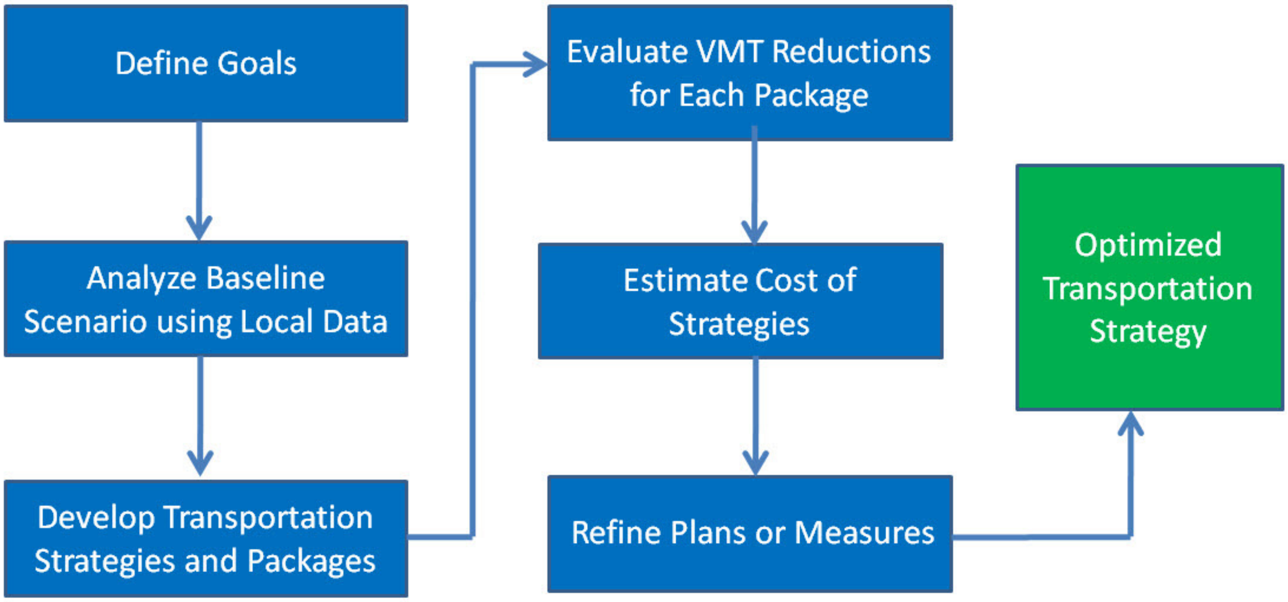


FIGURE 7-1: Transporation Analysis Flow

Model Assumptions

In conducting the analysis, several key assumptions were made related to vehicle trip generation and vehicle miles traveled (VMT). Vehicle trip generation estimates for the Guam JMMP were based on the number of trips generated per parking space. Trip generation rates included:

- Residential trip rate – BOQ, BEQ, Family Housing – 4 trips per day per space
- Retail and mess trip rate – Main Exchange, Exchange Retail Store, Clubs and Open Mess, Enlisted Dining Facility – 10 trips per day per space
- Quality of Life Facility trip rate – Gymnasiums, Swimming Pools, Field House, Library, Dental Clinic – 5 trips per day per space
- Office trip rate – Administrative Buildings – 4 trips per day per space
- School trip rate – 2.5 trips per day per space
- Other trip rates:
    - Temporary Quarters (TLF) – 1 trip per day per space
    - Fire Stations – 3 trips per day per space

Travel patterns on a military base are unique, as the base is mostly self-contained with many on-base destinations, such as housing, schools, commissary/shopping areas, and recreational uses located near each other. Therefore, many of the trips are internalized on base; the average trip lengths for on-base travel are subsequently shorter than those typically occurring in most non-military suburban communities. Trips with destinations off-base, however, have average lengths that are substantially longer than on-base trips, since other residential and shopping destinations and other military bases on Guam are spaced at much longer distances. Table 7-1 summarizes the percentage of on- and off-base trips and the average trip lengths for each.

Trip Type	Trip Distribution	Average Trip Length (miles)
On-Base Trips	88%[1]	1
Off-Base Trips	12%[1]	-
Military Personnel to/from Anderson “North Ramp”	(20%)	2
Military Personnel to/from other Guam areas	(5%)	15
Civilians Commuting to Base	(50%)	10
Civilian Residents to/from Base	(5%)	15
Family Members/Dependents to other Guam areas	(20%)	15

1. Revised Draft Main Cantonment Transportation Study to Support DoD Build-up on Guam, prepared by AECOM Technical Services, Inc., December 2009.

TABLE 7-1: Trip distribution and average trip lengths

Applying these factors leads to an initial estimate for the baseline scenario of approximately 200,530 VMT generated by the project on a daily basis.

To validate the assumptions listed above, an online survey was developed by the SSIM team and administered to military personnel and their families with the assistance of the Navy and Marines. Between February 24 and March 22, 2010, we received 109 responses to the survey. The results of the survey are summarized in following tables.

Question	Response 1	Response 2	Response 3
Are you military personnel or dependent?	Military Personnel = 57%	Dependents = 43%	N/A
Where are you stationed?	Anderson Air Force Base = 50%	US Naval Base or Hospital = 43%	Other = 7%
Which type of housing do you live in on base?	Bachelors Enlisted Quarters (BEQ) = 1%	Bachelors Officers Quarters (BOQ) = 5%	Family Housing = 94%
Where do you work?	Military Job On-Base = 70%	Military Job Off-Base = 11%	Civilian Job Off-Base = 19%
Question		Average	
How many licensed drivers live in your home?		2.02	
How many cars, trucks, or motorcycles are stored and used at your home?		1.85	
How many persons live in your home?		2.80	

TABLE 7-2: Transportation survey – demographic results

Question	Average
How many trips do you make from home on a typical weekday?	3.54 (all responses)
Family Housing Responses	3.56
BEQ Response	2.00
BOQ Responses	3.80
How many total trips do you make on a typical weekday?	3.99 (all responses)
Family Housing Responses	4.00
BEQ Response	2.00
BOQ Responses	4.20
How many times on a typical weekday do you drive off the base?	2.31
How many trips on a typical weekday do you make for:1	-
Work	1.60
Social/Recreation	1.54
Shopping	1.24
Other	1.33
1 Total number of trips by purpose sums to a slightly greater amount than the number of total trips reported, since these results are based on separate survey questions.	

TABLE 7-3: Transportation survey – trip generation results

Question	Yes	No	N/A
Besides your own children, do you ride with others or carpool at least one day per week?	15%	85%	-
If you are military personnel, do you use a motor pool vehicle for all other trips except for traveling to and from home on a typical weekday?	3%	49%	49%
Do you take a shuttle/bus, walk, or bike for any of your trips over the course of a typical weekday?	22%	78%	-

How often do you:	More than twice per day	About once per day	Several times a week	Rarely or never
Walk Somewhere	20%	25%	30%	25%
Ride a Bike	12%	4%	40%	44%
Take a Shuttle Bus	5%	0%	5%	89%

I would walk, bicycle, or take the shuttle/bus more often if:	
More walking paths	41%
More bicycle paths and/or lanes	50%
Safer places to bike or walk	46%
Less traffic and congestion	18%
Shorter waits between shuttle/bus service	22%
A shuttle/bus stop closer to my house	36%
Cleaner or newer shuttles/buses	9%
Shaded areas to wait for a shuttle/bus	25%
Other	31%

TABLE 7-4: Transportation Survey – Preferences Results

The Guam climate is a major inhibitor to walking and biking around the base. As part of the survey, respondents were also given the opportunity to describe other features and preferences that would encourage them to walk, bicycle, or take the shuttle/bus. Six of the respondents indicated that the climate (heat, humidity, rain, and wind) discouraged them from walking or biking.

UFC Analysis

The Unified Facilities Criteria (UFC) specifies the number of parking spaces required for each of the proposed basic facilities requirements (BFRs) for the GJMMP. The SSIM team prepared a summary of the requirements and resulting number of parking spaces needed for the proposed BFRs using three comparative criteria:

- UFC Baseline – UFC 2-000-05 “P-80”
- UFC Design criteria – Series 4: Multi-Disciplinary and Facility-Specific Design
- Leadership in Energy and Environmental Design 2009, Sustainable Sites 4.4 (Alternative Transportation)

The results are summarized in table 7-5 for the UFC Baseline, Design Phase, and LEED criteria. As shown, the total parking required from the UFC Baseline is 21,625 spaces and the UFC design criteria is 22,156 spaces. From the comparison, the following conclusions were determined:

- Where applicable, with the exception of UFC 4-731-10 (“Navy and Marine Corps Bachelor Housing, with Change 2”), a more stringent parking space requirement was not found in the design criteria UFCs.
- Where applicable, most design criteria UFCs studied deferred parking standards to the P-80. In these instances, the value in baseline was transferred to the design criteria field. When the applicable LEED criterion is also “to not exceed the existing zoning requirement,” the result is that all fields would have essentially same values.
- In most cases, the proposed BFRs will meet the criteria set forth in LEED SS 4.4.
- Where applicable, it is recommended that the proposed BFRs meet the criteria set forth in LEED SS 4.2 (“Alternative Transportation—Bicycle Storage and Changing Rooms”) and LEED SS 4.3 (“Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles”). Doing so will likely result in making changes to the present BFRs.

TABLE 5: UFC PARKING ANALYSIS

Facility Type	GJMMP notes	Baseline (UFC)[1]	# of SP	Design Phase (UFC)[2]	# of SP	LEED[3]	# preferred parking (95% less baseline)
residential						SS 4.4, Case 2, Option 1: size parking capacity to not exceed the existing local zoning requirements.	
Bachelor Housing - Officers (BOQ)		90% of capacity	302	provide parking for 70% of the residents	235		235
Bachelor Housing - Enlisted (BEQ)		60% of capacity	2,955	same as above	3,448	baseline < design phase	2,955
Bachelors Housing - Officers, Guest Parking		N/A		Provide parking for 2% of the resident capacity	7		0
Bachelors Housing - Enlisted, Guest Parking		N/A		same as above	99		0
Family Housing	2SP (1 in Garage, 1 driveway in current plan)	2 spaces per living unit	7,838	same as baseline[4]	7,838		7,838
Family Housing - Guest Parking		1/2 per unit	1,960	same as baseline[4]	1,960		1,960
non-residential						SS 4.4, Case 1, Option 1: size parking capacity to not exceed the existing local zoning requirements. Additionally, set aside 5% of parking spaces for carpools and vanpools	
Adminstrative Buildings		70% of assigned personnel	4,071	same as baseline[4]	4,071	set aside 5% of parking spaces for carpools and vanpools	204
Community Shopping Center (Main Exchange)		4% of military strength served	907	same as baseline[4]	907	set aside 5% of parking spaces for carpools and vanpools	45
Chapels (Religious Ministry Facilities)		15% of seating capacity	195	same as baseline[4]	195	set aside 5% of parking spaces for carpools and vanpools	10
Exchange Retail Store (when not included in the Community Shopping Center; three location exchanges)	2 Location Exchanges Planned	2% of military strength served	716	same as baseline[4]	716	set aside 5% of parking spaces for carpools and vanpools	36
Field House, combined with Football/Baseball Facilities	used for 3 Sports Complex Areas, BEQ, Family Housing N&S	1% of military strength served	358	same as baseline[4]	358	set aside 5% of parking spaces for carpools and vanpools	18
Fire Stations (3 stall/7stall)	52 personnel	per BFR provided, 57 Staff, 7 Visitor	64	same as baseline[4]	64	set aside 5% of parking spaces for carpools and vanpools	3
Correctional Center, Police Stations		30% of guard strength					
Temporary Quarters (TLF)	229 units per BFR	90% of units	206	same as baseline[4]	206	set aside 5% of parking spaces for carpools and vanpools	10
Gymnasiums (Fintess Centers)		1% of military strength served	239	same as baseline[4]	239	set aside 5% of parking spaces for carpools and vanpools	12
Pass/ID Office	parking requirement unknown						
Library - Central		1 space per 500 s f of floor area	48	same as baseline[4]	48	set aside 5% of parking spaces for carpools and vanpools	2
Maintenance Shops	# of FTE not yet ascertained	38% of assigned personnel during largest shift		same as baseline[4]		set aside 5% of parking spaces for carpools and vanpools	
Dental Clinic (either separate or a part of another medicial facility)		3 spaces per treatment room	144	same as baseline[4]	144	set aside 5% of parking spaces for carpools and vanpools	7
Hospital and Medical Clinics		59% of n = 38; 19% of m = 1649	336	same as baseline[4]	336	set aside 5% of parking spaces for carpools and vanpools	17
Security Offices (at gate)		special study required					
Swimming Pools		20% of design capacity	24	same as baseline[4]	24	set aside 5% of parking spaces for carpools and vanpools	1
Theaters, when not included in Community Shopping Center		25% of seating capacity	N/A				
Enlisted Dining Facility		30% capacity plus 38% of dining facility employees	143	same as baseline[4]	143	set aside 5% of parking spaces for carpools and vanpools	7
Clubs and Open Mess							
Officer		20% of officer strength served	276	same as baseline[4]	276	set aside 5% of parking spaces for carpools and vanpools	14
Enlisted		2% of enlisted strength served	211	same as baseline[4]	211	set aside 5% of parking spaces for carpools and vanpools	11
Warehouses	# of FTE not yet ascertained	1 space for each 500 sf of office area plus 1 space for each 4 persons assigned to the warehouse operations		same as baseline[4]		set aside 5% of parking spaces for carpools and vanpools	
schools						SS 4.4 Schools, Option 1: size parking capacity to not exceed the local zoning requirement. Provide preferred parking for	
All Other Schools- without Auditorum		2 spaces per classroom	409	same as baseline[4]	409	set aside 5% of parking spaces for carpools and vanpools	20
HS/MS - with Auditorum		2 spaces per classroom plus 15% of auditorium seats	223	same as baseline[4]	223	set aside 5% of parking spaces for carpools and vanpools	11
Total Parking Required			***21,625***		***22,156***		

TABLE 7-5: UFC Parking Analysis

Packages & Performance

Using input from the Guam JMPP charrette in Honolulu in October 2009 and previous work for other applications of the SSIM Model, potential measures that could be applied for this project were identified. These measures fall into five broad categories:

Parking and Demand Management

Shared Parking:

One way to reduce autombile use is to “right-size” parking so that no more parking is provided than is necessary. Shared parking allows uses with different demand peaks to use the same parking. For example, an office generates parking demand throughout the day but residences generate most of their parking demand in the early morning and evening hours. If both uses are parked to their theoretical maximums, then there will be numerous times when one parking facility is occupied while the other is not. It is anticipated that shared parking would be implemented only in mixed-use areas of the project; for example, near the BEQ and BOQ units, Quality of Life, and Recreation complexes. If a centrally located shared parking facility were to be provided, providing shuttle service to the parking facility would help to encourage its use.

Reduced Auto Ownership:

Another way to reduce auto use is through restricting or disincentivizing auto ownership for military personnel. Transients (personnel on assignment for six months or less) are typically restricted from owning a vehicle when stationed overseas. Expanding auto ownership restrictions for junior enlisted soldiers would reduce parking demand on base, and reduce the number of vehicle trips. These strategies could also be applied as incentives, where those military personnel who choose not to own a car on base would receive a financial bonus (or “cash out”). A robust set of alternative modes would need to be in place before vehicle ownership is restricted, as these soldiers would depend on non-auto transportation systems for on- and off-base travel.

TDM Coordinator and Program:

A Traffic Demand Management (TDM) coordinator would be responsible for implementing and overseeing some of the measures identified. It is anticipated that this coordinator would either be a part-time or full-time staff person. The TDM coordinator would be implementing various TDM programs, and would coordinate the transportation options for the base population, including military personnel, their dependents, and employees of the base. A coordinator would serve a key role in integrating the strategies defined as part of this assessment, and would be a resource to the entire base community on transportation concerns, issues, choices, and programs. These programs can be grouped into several broad categories including:

- Informational – An informational program is oriented towards providing information to facilitate alternative modes. Examples of these programs could include providing brochures about shuttles, providing regional bus schedules, and maintaining lists of potential carpoolers.

- Incentives – An incentive program might include providing on-base shuttle service and/or discounted regional transit passes to military personnel, residents and employees.
- Disincentives – Disincentives typically include financial and convenience disincentives, such as costs to ship a vehicle to the base, and restricting auto use from certain areas or streets and other related items.

On-Base Circulation

On-Base Fixed-Route Shuttle:

A key strategy to encouraging non-auto travel within the base would be to provide a convenient, frequent fixed-route shuttle. This shuttle would travel on a set route, traveling from one area of the project to another. Shuttle hours vary as defined in each package. As proposed in the Main Cantonment Transportation Study, the shuttle route would complete a circular route through the base, generally connecting the main gate, family housing area, schools, and the main commercial/employment area at the northern end of the base. Service would be provided on the perimeter of the quality of life (QOL) area, the BEQs, and BOQs. In residential areas, placement of shuttle stops every 1,000 feet will provide convenient stop locations within a 5-minute walk along the main route. Given the climate on Guam, it is expected that a 5-minute walk is the maximum a person would reasonably walk to a shuttle, given the climate on Guam. Providing shade trees or shelters, benches, and quick-reference schedule information (see example sign from Park City, Utah in the photo at right) at each stop would enhance the convenience and user-friendliness of the system.

Demand Responsive Van:

One way to supplement a fixed-route shuttle is to provide demand responsive service. Under this type of service, a smaller transit vehicle (usually a van) is dispatched to a person at their request. The transit vehicle picks up this person and then takes them to their destination. This service could be provided during fixed-route shuttle operating hours, or in the off-peak hours when the fixed-route shuttle is not in service. For personnel living on base, a demand responsive van would serve as a guaranteed ride home, in case of emergency.

Off-Base Circulation:

Coordination with Guam Transit:

To encourage military personnel, their family members and dependents, and civilians to travel to and from the base without using a personal vehicle, a reliable and convenient transit system would need to be provided. The Guam Mass Transit Authority (GMTA) currently provides service on the island; however, the current system would need to be enhanced to provide dependable, frequent service to attract regular ridership. Although security concerns limit provision of Guam Transit service on the base, the on-base shuttle and GMTA schedules may be coordinated to allow for convenient transfers between the system.

Active Modes

Bike Share Program:

Cycling is a low-cost transportation mode that can reduce vehicle emissions and promote active, healthy lifestyles. Bike share programs operate similar to a mini-car rental service, with enhanced practicality for short trips since bike parking can be placed in more convenient locations. Bicycle 'pods,' or racks with five to 25 bikes, would be located at convenient points around the base, and personnel could borrow a bike off the rack at either no cost or with a minimal charge, depending on the program. The bike can be ridden to another destination on base, and then returned to another pod at the users' convenience. Bicycle sharing programs have been implemented in several major cities around the world, including Denver, Colorado; Chicago, Illinois; Washington, D.C.; and Montreal, Canada, in North America; and on many University and large institutional campuses, including the University of California, Irvine, and Northern Arizona University.

Pedestrian Amenities:

A key issue related to street design is the manner in which a street accommodates not only automobiles but all travel modes and users of all ages and abilities. Streets that accommodate all travel modes and users often have lower speeds, narrower lane widths, reduced curb radii, and wider sidewalks. This measure would include pedestrian amenities at key intersections around the base, including crosswalk improvements such as additional signage, striping, pavement treatments, curb bulb-outs, and other improvements. Creating a safe and convenient street network designed with pedestrians in mind may help to encourage the base population to walk for short trips for which they may otherwise drive a vheicle.

Vehicle Pool

Electric/Hybrid Vehicle Fleet:

As part of the base installation, a vehicle fleet operated and maintained by the military is proposed. These vehicles are available for use by military personnel for work-related trips on- and off-base. Modifiying the fleet mix to electric and/or hybrid (either plug-in or self-recharging) vehicles may not reduce the vehicle-miles traveled with the fleet, but the petroleum consumed and emissions produced by the vehicles would be reduced. Since EO 13514 mandates a 30 percent reduction in petroleum consumption for the vehicle fleet by 2020; phasing electric and/or hybrid vehicles into the fleet will help meet this requirement. Several bases have already begun phasing electric and hybrid vehicles into their fleets, including March Air Reserve Base in Riverside, California.

Car Share Program:

A car share program allows users the convenience and flexibility of using a car from a shared pool when they need it, without requiring the expense of owning their own car. The programs work similar to car rental services (or bike share programs, as described above), where users can pick up a vehicle located at a car share station on the base for a nominal fee (per hour or per trip, depending on the program), use the vehicle as their personal car for that time, and return it to a station when finished. Car share programs have become extremely popular in urban areas and on university campuses within the continental United States in recent years, given the economic savings potential they offer their users, while still allowing access to a personal vehicle when needed.

Neighborhood Electric Vehicle Program:

A neighborhood electric vehicle (NEV) is intended to bridge the gap between walking and driving by providing additional mobility options for short-distance trips. An NEV might be used to travel from work to the commissary or a work meeting, for example. NEV's are typically electric powered and produce no GHG emission, which make them preferable to automobiles for these short-distance trips. NEV's may be considered for on-base travel where speeds are anticipated to be low; however, on 30 mph or higher-speed streets, NEV's require separate lanes or rights of way.

Table 7-6 describes the strategies defined as a part of each package for Baseline Conditions and Package A, B, and C. Package A and B are simliar, except Package A does not include an on-base shuttle system. In leiu of an on-base shuttle, Package A has enhanced bike and car share and NEV programs and more pedestrian amenities than Package B. Package C reprsents the most comprehensive program, with the elements of Package A and B, plus additional transportation measures to reduce vehicle miles of travel and resulting Greenhouse Gas Emissions.

ELEMENT	Baseline	Package A	Package B	Package C
PARKING AND DEMAND MANAGEMENT	UFC Parking	Land bank area for 800 spaces or 8% of total and provide car share and NEV parking	Land bank area for 800 spaces or 8% of total and provide car share and NEV parking	15% parking reduction, plus Option B and provide car share and NEV parking; Centrally located parking facility
	Limit Transient Auto Ownership	Limit auto ownership for Transients (not UDP)	Limit auto ownership for Transients (not UDP)	10% of Military Staff choose not to ship a vehicle to base for $2,000 "cash out", plus Option B
	No Transportation Demand Management (TDM) Program	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator	TDM Program Incentives / Disincentives and two Full-Time Coordinators (two at 40 hrs/wk)
ON-BASE CIRCULATION	No shuttle	No shuttle	Shuttle:15-minute headways during peak periods, 30-minutes other hours	Shuttle:15-minute headways during peak periods, 30-minutes other hours
			Shuttle: Operates 12 hours/day (6am to 6pm)	Shuttle: Operates 18 hours/day (6am to 12am)
				Demand-responsive van outside peak periods
OFF-BASE CIRCULATION	No off-base Circulation	Operates during peak hours (6 round trips/day)	Operates during peak hours (6 round trips/day)	All-day and late-night service, 6am – 12am (30 round trips/day)
		Hourly headways	Hourly headways	30-minute headways during 6am – 6pm; hourly otherwise
		Shuttle and Guam Transit have convenient transfers	Shuttle and Guam Transit have convenient transfers	Shuttle and Guam Transit have convenient transfer schedules
ACTIVE MODES	No Bike Sharing	One central bike share station with 100 bikes with manned oversight*	One central bike share station with 50 bikes with manned oversight*	One central bike share station with 50 bikes plus five satellite pods with 25 bikes/each*
	Limited Pedestrian Improvements	Pedestrian improvements at 20 intersections (e.g., curb extensions, wider paths)	Pedestrian improvements at 15 intersections (e.g., curb extensions, wider paths)	Pedestrian improvements at 30 intersections
VEHICLE POOL	20% Electric/ 20% Hybrid	20% Electric/ 20% Hybrid	20% Electric/ 20% Hybrid	60% Hybrid
	No car share	One central car share location with 100 cars*	One central car share location with 100 cars*	One central (100 cars) and five satellite (25 cars/each) car share locations*
	No Neighborhood Electric Vehicle (NEV) Program	One central NEV location with 300 NEVs	One central NEV location with 150 NEVs	One central (150 NEVs) and five satellite (25 NEVs/each) NEV locations

TABLE 7-6: Package Definition

VMT reductions for the various transportation measures are shown in Table 7-7 below. These reductions reflect a comparison to Baseline conditions.

Element	Package A	Package B	Package C
Parking & Demand Management	8.9%	11.0%	18.8%
On-Base Circulation	0.0%	0.3%	0.7%
Off-Base Circulation	0.8%	0.8%	3.0%
Active Modes	0.2%	0.2%	0.4%
Vehicle Pool	0.0%	0.0%	0.0%
Totals	9.9%	12.3%	22.9%

TABLE 7-7: Performance Results - Estimated VMT Reduction by Transportation Measure

Cost/Benefit Analysis

Tables below provide the estimated unit cost for the strategies defined under each package.

ELEMENT	STRATEGY	IMPLEMENTATION	OPERATIONS
PARKING AND DEMAND MANAGEMENT	Land bank area for 800 spaces or 4% of total parking, plus credit for reduced auto ownership of E1-E3	$2,500 savings per space	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	Limit auto ownership for E1-E3 (4,137 Marines)	$2,000 savings per Marine for car shipment	N/A
	Transportation Demand Management Program Incentives and Full-Time (40 hrs/wk) Coordinator	N/A	$310,000 annually for full-time coordinator and programming; plus $5,000 monthly incentives/prizes
ON-BASE CIRCULATION	No on-base shuttle	N/A	N/A
OFF-BASE CIRCULATION	Operates during peak hours (6 round trips/day)	$10,000 annual payments to Guam Transit for 20 years	40 hours annually of staff time for coordination at $150/hour
	Hourly headways		
	Shuttle and Guam Transit have convenient transfer schedules		
ACTIVE MODES	One central bike share station with 100 bikes1	$500 per bike, plus	$100 per bike, plus 4 hours/ week staff oversight at $150/ hr
	Pedestrian improvements at 20 intersections	$25,000 per intersection	N/A
VEHICLE POOL	20% Electric/20% Hybrid	N/A	N/A
	One central car share location with 250 cars1	$25,000 per vehicle plus $2,000 per vehicle facility/ infrastructure	$5,000 annual per vehicle (fuel, maintenance, operations)
	One central Neighborhood Electric Vehicles (NEV) location with 300 NEVs	$6,000 per NEV, plus $1,500 per NEV facility/infrastructure costs	$1,500 per NEV (maintenance, power supply, etc.)

TABLE 7-8: Unit cost estimates - Package A

ELEMENT	STRATEGY	IMPLEMENTATION	OPERATIONS
PARKING AND DEMAND MANAGEMENT	Land bank area for 800 spaces or 4% of total parking, plus credit for reduced auto ownership of E1-E3	$2,500 savings per space	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	Limit auto ownership for E1-E3 (4,137 Marines)	$2,000 savings per Marine for car shipment	N/A
	Transportation Demand Management Program Incentives and Full-Time (40 hrs/wk) Coordinator	N/A	$310,000 annually for full-time coordinator and programming; plus $5,000 monthly incentives/ prizes
ON-BASE CIRCULATION	Shuttle: 30-minute headways; Operates 12 hours/day (6am-6pm)	$250,000 per low-floor diesel neo-plan bus; 60 minute route @ 30 minute headways = 2 buses. Buses replaced every 10 years.	Two buses, each with 4,400 service hours annually at $50 per hour = $1,160,000
OFF-BASE CIRCULATION	Operates during peak hours (6 round trips/day)	$10,000 annual payments to Guam Transit for 20 years	40 hours annually of staff time for coordination at $150/hour
	Hourly headways		
	Shuttle and Guam Transit have convenient transfer schedules		
ACTIVE MODES	One central bike share station with 50 bikes1	$500 per bike, plus $1,500 per rack/station	$100 per bike, plus 4 hours/ week staff oversight at $150/hr
	Pedestrian improvements at 15 intersections	$25,000 per intersection	N/A
VEHICLE POOL	20% Electric/ 20% Hybrid	N/A	N/A
	One central car share location with 100 cars1	$25,000 per vehicle plus $2,000 per vehicle facility/infrastructure	$5,000 annual per vehicle (fuel, maintenance, operations)
	One central Neighborhood Electric Vehicles (NEV) location with 150 NEVs	$6,000 per NEV, plus $1,500 per NEV facility/infrastructure costs	$1,500 per NEV (maintenance, power supply, etc.)

TABLE 7-9: Unit Cost Estimates - Package B

ELEMENT	STRATEGY	IMPLEMENTATION	OPERATIONS
PARKING AND DEMAND MANAGEMENT	15% parking reduction. Centrally located parking facility, plus Option A	$2,500 savings per space	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	10% of personnel choose not to ship a vehicle to base for a $2,000 “cash out,” plus Option A	$2,000 savings per Marine for car shipment	N/A
	TDM Program Incentives/Disincentives and two full time coordinators (2 at 40 hours/week)	N/A	$620,000 annually for full-time coordinator and programming; plus $7,500 monthly incentives/prizes
ON-BASE CIRCULATION	Shuttle: 15-minute headways during peaks, 30-minutes other hours; Operates 18 hours/day (6am to 12am)	$250,000 per bus; 60 minute route @ 15 minute headways = 4 buses. Buses replaced every 10 years.	Four buses, each with 6,600 service hours annually at $50 per hour = $3,470,000
	Demand-responsive van outside peak periods (9am to 11am; 1pm to 3pm; 5pm to 12pm)	$25,000 per van (2 vans)	4,100 service hours annually at $50 per hour = $2,050,000
OFF-BASE CIRCULATION	All-day and late-night service, 6am–12am (30 round trips/day)	$12,500 annual payments to Guam Transit for 20 years	160 hours annually of staff time for coordination at $150/hour
	30-minute headways during 6am – 6pm; hourly otherwise		
	Shuttle and Guam Transit have convenient transfer schedules		
ACTIVE MODES	One central bike share station with 50 bikes plus five satellite pods with 25 bikes/each[1]	$500 per bike, plus $1,500 per rack/station	$100 per bike, plus 8 hours/week staff oversight at $150/hour
	Pedestrian improvements at 30 intersections	$25,000 per intersection	N/A
VEHICLE POOL	30% Electric/ 30% Hybrid	N/A	N/A
	One central (100 cars) and five satellite (25 cars/ each) car share locations[1]	$25,000 per vehicle plus $2,000 per vehicle facility/ infrastructure	$5,000 annual per vehicle (fuel, maintenance, operations)
	One central (150 NEVs) and five satellite (25 NEVs/each) NEV locations	$6,000 per NEV, plus $1,500 per NEV facility/ infrastructure costs	$1,500 per NEV (maintenance, power supply, etc.)

1 Assumed military would operate the car share and bike share programs to represent the most conservative cost model, but public-private partnerships may be considered for cost savings. Assumed no additional maintenance areas would be required for car share vehicles.

TABLE 7-10: Unit Cost Estimates - Package C

The total capital costs of each package relative to baseline conditions are summarized in Table 7-11. Cost savings (lower costs than baseline) are represented in parentheses.

Element	Option A	Option B	Option C
Parking & Demand Management	($9,060,000)	($9,630,000)	($12,770,000)
On-Base Circulation	$0	$1,500,000	$3,080,000
Off-Base Circulation	$200,000	$200,000	$500,000
Active Modes	$1,530,000	$1,050,000	$2,190,000
Vehicle Pool	$13,510,000	$5,440,000	$11,530,000
Totals	$6,180,000	$1,440,000	($8,680,000)

TABLE 7-11: Transportation measures – Capital costs

Operating costs for each package relative to the baseline conditions are summarized in Table 7-12. Cost savings (lower costs than baseline) are represented in parentheses.

Element	Option A	Option B	Option C
Parking & Demand Management	$110,000	($10,000)	($720,000)
On-Base Circulation	$0	$1,160,000	$4,000,000
Off-Base Circulation	$20,000	$20,000	$70,000
Active Modes	$100,000	$100,000	$210,000
Vehicle Pool	$3,160,000	$1,330,000	$2,850,000
Totals	$3,390,000	$2,600,000	$6,410,000

TABLE 7-12: Transportation Measures – Annual Operating Costs

Findings & Recommendations

The modeling results presented in the Packages and Performance and Cost/Benefit sections above were presented to the GJMMP Team for their consideration. The Team provided feedback and insight into the possible efficacy of each of the strategies; from this feedback a Preferred Package was developed. The Preferred Package and results are summarized in table below

ELEMENT	STRATEGY	VMT REDUCTION	CAPITAL COSTS	ANNUAL OPERATING COSTS
PARKING AND DEMAND MANAGEMENT	Land bank area for 1730 spaces or 8% of total and provide car share and NEV parking	3.6%	($3,890,000)	($820,000)
	Limit Transient Auto Ownership (not including UDPs)	-	-	-
	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator	1.0%	$0	$980,000
ON-BASE CIRCULATION	On-base Shuttle:15-minute headways during peak periods, 30-minutes other hours. Operates 12 hours/day on weekdays and 18 hours/day on weekends	0.4%	$3,000,000	$2,640,000
OFF-BASE CIRCULATION	Operates during peak hours (6 round trips/day)	0.8%	$200,000	$0
	30-minute headways during 6am – 6pm; hourly otherwise	1.9%		
	Shuttle and Guam Transit have convenient transfer schedules	0.4%		
ACTIVE MODES	Bike share program with 100 bikes, multiple racks/stations	0.1%	$210,000	$0
	Pedestrian improvements at 30 intersections (e.g., curb extensions, wider paths)	0.2%	$1,980,000	$0
VEHICLE POOL	60% Hybrid	-	-	-
	Neighborhood Electric Vehicle program with minimum of two stations. NEVs would be purchased as part of vehicle fleet	-	-	-
	Car share program with 100 cars, minimum of two stations	-	-	-
TOTAL		**8.3%**	**$5,550,000**	**$3,790,000**

TABLE 7-13: Preferred Package Summary

This Preferred Package exceeds the mandates as part of EO 13514 to achieve a 30% reduction in petroleum consumption of the vehicle fleet by 2020. Assuming the same vehicle-miles are traveled regardless of the fleet composition, the change in fuel consumption from gasoline to hybrid vehicles will produce the mandated reduction. Direction from military members of the Sustainability team is that electric only vehicles are not planned to be included in the vehicle fleet (other than on-base NEVs). Overall, the strategies defined as part of the Preferred Package result in an 8.3% reduction in VMT over baseline conditions. It is anticipated that these strategies will continue to shift travel behavior and social norms over time – as alternative transportation modes are provided and made accessible and convenient.

Potential Policy Modifications

Through the development of this plan, several policies have been identified that hinder further progress on greenhouse gas reductions from transportation. For example, the Department of Defense has a policy in place that prohibits the provision or subsidy of personal transportation for military personnel or their dependents living on installations. However, other benefits such as on-base housing costs are subsidized to some degree for both military personnel and their families/dependents. Adjustment of this policy should be made to transfer some of the costs saved through not shipping personal vehicles and not building or maintaining parking to funding that provides alternate transportation services and options for personnel and families. This cost savings would allow for convenient on-base travel via transit, bicycles, or other options, like Neighborhood Electric Vehicles (NEVs). Because many on-base destinations, such as housing, schools, commissary/shopping areas, and recreational uses are located so near each other, NEVs could be provided for on-base travel only to take advantage of the already high degree of internalization. Supplying NEVs within the family housing areas would greatly reduce cost of shipping vehicles to the base, reduce the land area required for streets and parking, and reduce the emissions associated with driving personal vehicles for short trips on-base. Coupled with an accessible and reliable transit system or car share program to give both military personnel and their families freedom to travel longer distances or off-base at their convenience, such a program would serve to greatly reduce the reliance on gas-powered cars.

As noted with the preferred program, Guam Transit buses carrying non-military personnel working on the base would have to transfer to the on-base shuttle system near the Main Gate. While this would provide a way for patrons to access their place of employment without a vehicle, every transfer between modes results in a substantive reduction in ridership. There are challenges of maintaining base security, especially on overseas installations, and the required transfer helps to minimize the security risk. To the extent feasible, allowing designated regional transit vehicles to travel onto and within the base reduces the number of transfers needed to arrive at a destination, and greatly improves the convenience of using the transit system. At NASA Ames Reserach Center, in Mountain View, California, the Valley Transportation Authority (VTA) regional transit buses are allowed on base after a security check – only approved personnel with appropriate identification and clearances are permitted to remain on the bus. Implementing a similar system, so that civilian employees working on base or military personnel living off-base but traveling to work, would decrease the time needed to travel to work via transit. Such a program would decrease traffic at the entry points, and reduce emissions associated with the longer, off-base trips.

8. Ecosystem Services

Introduction

Ecosystem Framework

Ecosystem services are the benefits people obtain from ecosystems, including benefits from natural assets (soil, air, water, flora, and fauna), the economic and social values inherent in these services, and the opportunities that can arise from considering these services more fully in master planning contexts. If natural assets are allowed to decline, the services and benefits that they provide also decline.

Ecosystem services are provided by both natural and modified ecosystems and include pollination, regulation of climate, insect pest control, provision of shade and shelter, maintenance of soil health and fertility, water filtration, and waste absorption and breakdown. For example, a diversity of species and a balanced ecosystem prevents individual species becoming pests or weeds. Vegetation regulates the composition of the atmosphere through uptake of carbon dioxide and the production of oxygen while at the same time influencing groundwater levels and the movement of water and wind across the landscape. Many of these services are not valued in the economy but are required for ecological sustainability.

These services can be integrated into master planning through provision of an Ecological Infrastructure which partially replaces materials, energy and engineering with natural systems. Habitats can be integrated into open space networks through incorporation of native plant species in plant palettes; sustainable urban drainage can be integrated into open space networks, by providing depressions in the landscape which are dry for the majority of the year and form part of the terrestrial landscape but which can serve as retention and infiltration areas during storm events; use of drought tolerant species enables greater vegetation cover for the same water demand, providing greater opportunity for carbon sequestration using vegetation.

This chapter focuses on three aspects of ecosystem services, habitat friendly development strategy, carbon sequestration, and local food production. While most projects typically evaluate ecology in terms of compliance with regulatory requirements, such an approach often results in overlooked opportunities to add value and enhance the environment through win (environment)/win (development) design strategies.

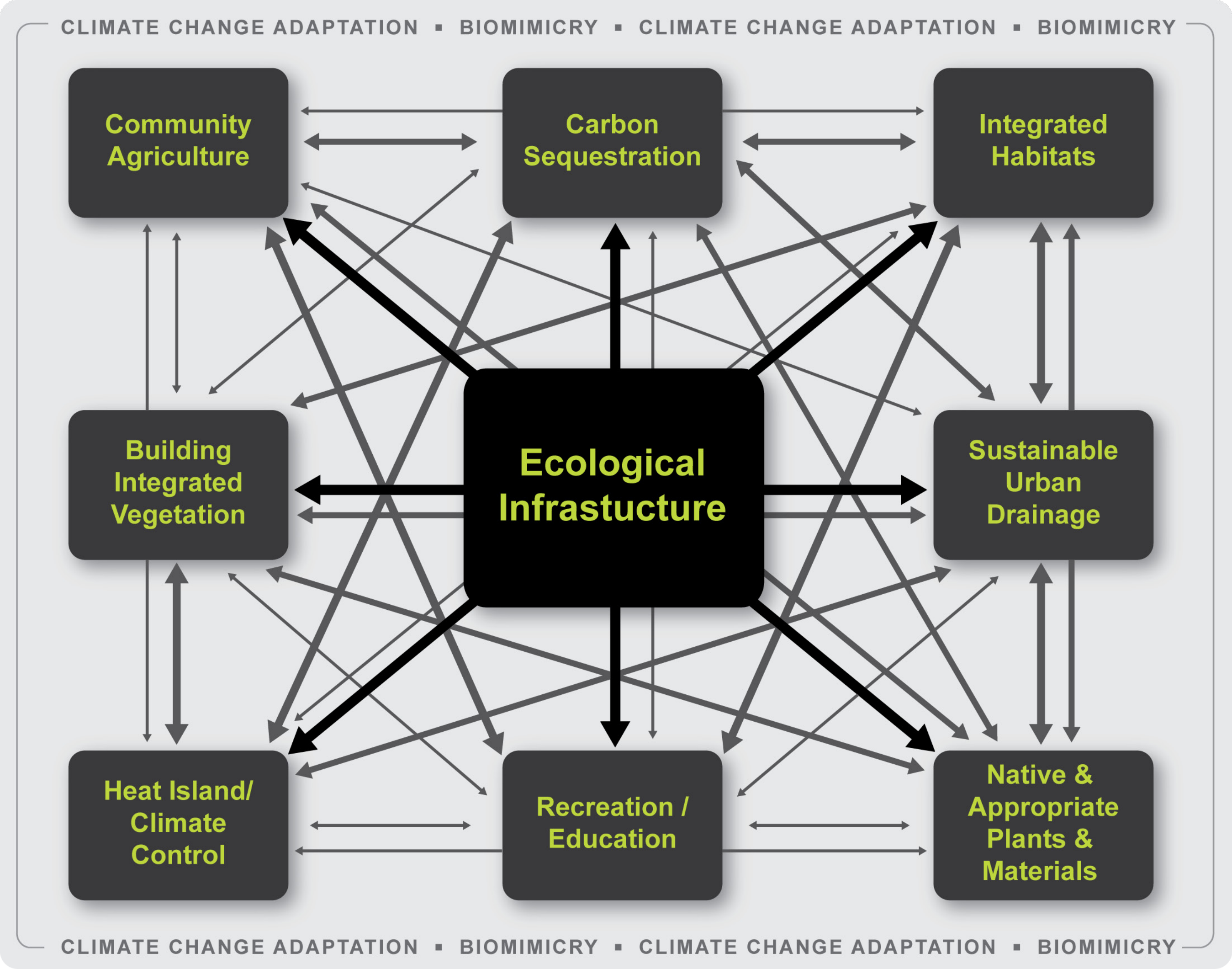


FIGURE 8-1: Ecological Infrastructure Model

Habitat Friendly Design Strategies

Introduction

Because of the impact to existing habitats by proposed development, as identified in the Draft Environmental Impact Statement (DEIS), an opportunity exists to apply habitat friendly design strategies.

Guam‘s vegetation types can be grouped into the following general plant communities: primary limestone forest (intact and never cleared), disturbed limestone forest (secondary, dominated by non-native species), halophytic/xerophytic scrub (adapted to grow in salt-laden air and dry conditions), scrub forest, tangantangan forest, strand, ravine forest, coconut groves, ironwood or Australian pine forest, savanna, wetlands, and developed.

Recommended Strategies

- Enhancing greenbelt for watershed protection, wildfire control, and restoration of habitat
- Integrating community fruit garden with reforesting plots to improve habitat
- Establishing ecological corridors provide links between open space areas, providing recreation opportunities, pedestrian and cycle corridors and improved connectivity of the open space network. Having green links helps to reduce heat island effects, improves microclimate and provides opportunities for carbon sequestration.
- Establishing ecological corridors that can also be combined with stormwater drainage networks, providing a natural system for the conveyance, storage and infiltration of stormwater, reducing the need for hard infrastructure.
- Establishing sustainable trails system weaving together the whole base
- Prioritizing the use of native plants in landscaping designs
- Coordinating with Biosecurity Plan and establishing high quality habitat with perimeter fencing to exclude invasive animals and for establishment of foraging plots

Greenbelt Enhancement

Over 800 acres of greenbelt surrounding the main cantonment creates sanctuary for essential habitat and recovery zones for ESA-listed Species on or in the vicinity of NCTS Finegayan. The further enhancement benefits provided through protection of natural features and creation of ecological corridors, provide additional opportunities for ecological enhancement through increasing the coverage and diversity of native species in landscaped areas. Native species of flora provide a key component of the food chain for a diversity of fauna, which can provide a range of benefits including food, pest control, and pollination.

Ecological Corridors

Ecological corridors through the site can provide multi-functional benefits to biodiversity and people, including the following:

- Connected wildlife corridors enabling carrying capacity for a diversity of species to be increased, including bats, invertebrates, and reptiles
- Linked open spaces providing recreation opportunities and pedestrian and cycle corridors
- Green links, helping to reduce heat island effects and improve microclimate
- Stormwater drainage networks, providing a natural system for the conveyance, storage and infiltration of stormwater, reducing the need for hard infrastructure

Carbon Sequestration

Introduction

Carbon sequestration is an increasingly important consideration in greenhouse gas inventories. A project wide landscape strategy with maximized carbon sequestration effect has become one of the most cost-effective ways in helping offsetting greenhouse gas emissions. As stated in Executive Order 13514: "… pursuing opportunities with vendors and contractors to address and incorporate incentives to reduce greenhouse gas emissions. ", it is important for Guam to incorporate a carbon sequestration strategy when developing the Installation Appearance Plan (IAP), and other documentation.

The greatest carbon sequestration benefits are achieved through maximizing preservation of forest and choices of forest management activities. Over 1000 acres of existing forests are going to be preserved, which provides a huge opportunity for carbon sequestration. Additionally, choosing proper species and increasing tree planting density within base development areas can provide considerable benefits including aesthetics, microclimate modification, water quality improvement, air pollutant removal, and urban habitat.

Carbon Sequestration

"Carbon Sequestration is the process by which atmospheric carbon dioxide is absorbed by trees and vegetation through photosynthesis and stored as carbon in biomass and soils."

-USDA Forest Service

Methodology and Process

The carbon sequestration analysis for the GJMMP involves four steps: 1) develop landscape prototype; 2) land cover type selection; 3) species selection; 4) carbon calculations. There are five primary landscape prototypes identified: Park Landscape, Streetscape (median, parkways, landscape setbacks etc.), Residential Landscape, Open Space Landscape, and Preserved Areas. For each landscape prototype, proper assumptions on tree/shrub planting density and coverage are made by experienced landscape architects. Then the selection of species are based on the recommended species list in Dr. Anna Brooke's "(Draft) Landscaping with Native Plants: Navy Base Guam". The carbon sequestration rates for each identified tree/shrub are identified for the model calculation. Baseline, Option A, B, and C scenarios are developed with increasing carbon sequestration effect.

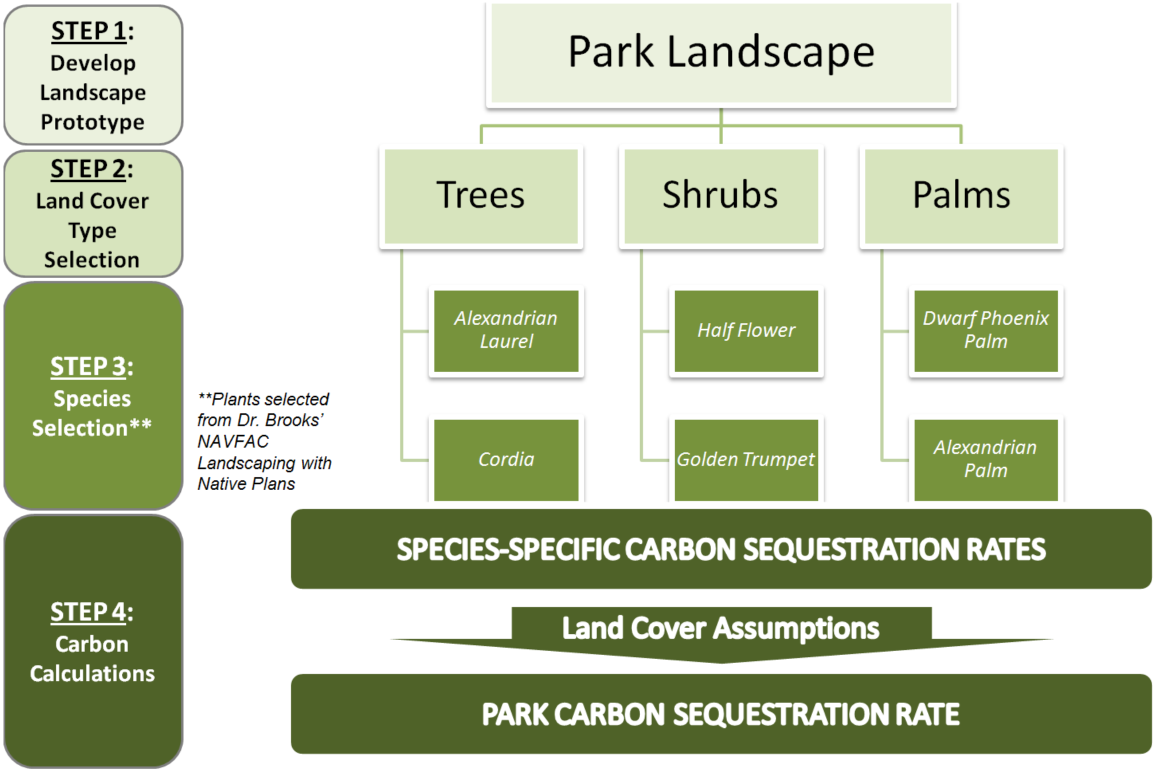


FIGURE 8-2: Caption Needed

Strategies & Options

1. Include the planting (existing and proposed) occurring on base to assist with reducing the total carbon footprint of the GJMMP through carbon sequestration calculation.

2. Understand the impact of super typhoons on the survival of trees by incorporating a viable clustered tree concept. Such urban forest cover in the urban environment provides additional environmental benefits by reducing ozone and other air quality problems, reducing the "urban heat island effect", reducing building energy use through shading, and providing habitat for urban wildlife.

3. The following planting types identified below are noted with their strategy:

- Park Landscape utilize nature trees planted in clusters (for typhoon protection); provide shade and amenity to the surrounding communities.
- Streetscape trees - planted along streets, in the median, and parkway areas shall include species that have higher carbon sequestration values while meeting the base appearance objectives.
- Residential landscape - the front yard and back yard of family housing present opportunity to reducing building energy use through shading as well as capture the carbon sequestration benefit.
- Open Space - the open space areas on base should focus on improving disturbed site conditions, selecting more native species with high carbon sequestration rates, minimizing the amount of maintenance related emissions; and designing the reforestation plan to maximize long-term survival of trees.
- Preserved Area - most of the 800 preserved limestone forest will remain intact, proper long-term forestry management practice as the primary measure will help to increase carbon sequestration potential.

	Baseline	Option A	Option B	Option C
Park Landscape	Regular Planting 13 trees per acre	Low Sequestration Planting Palette 18 trees per acre	Med Sequestration Planting Palette 24 trees per acre	High Sequestration Planting Palette 30 trees per acre
Streetscape	Regular Planting Palette; 70 trees per mile	Low Sequestration Planting Palette; 85 trees per mile	Med Sequestration Planting Palette 100 trees per mile	High Sequestration Planting Palette 120 trees per mile
Residential Landscape	Regular Planting Palette 7 trees per acre	Low Sequestration Planting Palette; 10 trees per acre	Med Sequestration Planting Palette; 15 trees per acre	High Sequestration Planting Palette; 20 trees per acre
Open Space	Regular Planting Palette; 16 trees per acre	Low Sequestration Planting Palette; 24 trees per acre	Med Sequestration Planting Palette; 30 trees per acre	High Sequestration Planting Palette; 40 trees per acre
Preserved Area	Undisturbed	Undisturbed	Undisturbed	Restoration with High Sequestration Planting Palette where applicable; Forestry Management

TABLE 8-1: Preserved Area

Cost and Benefit Analysis

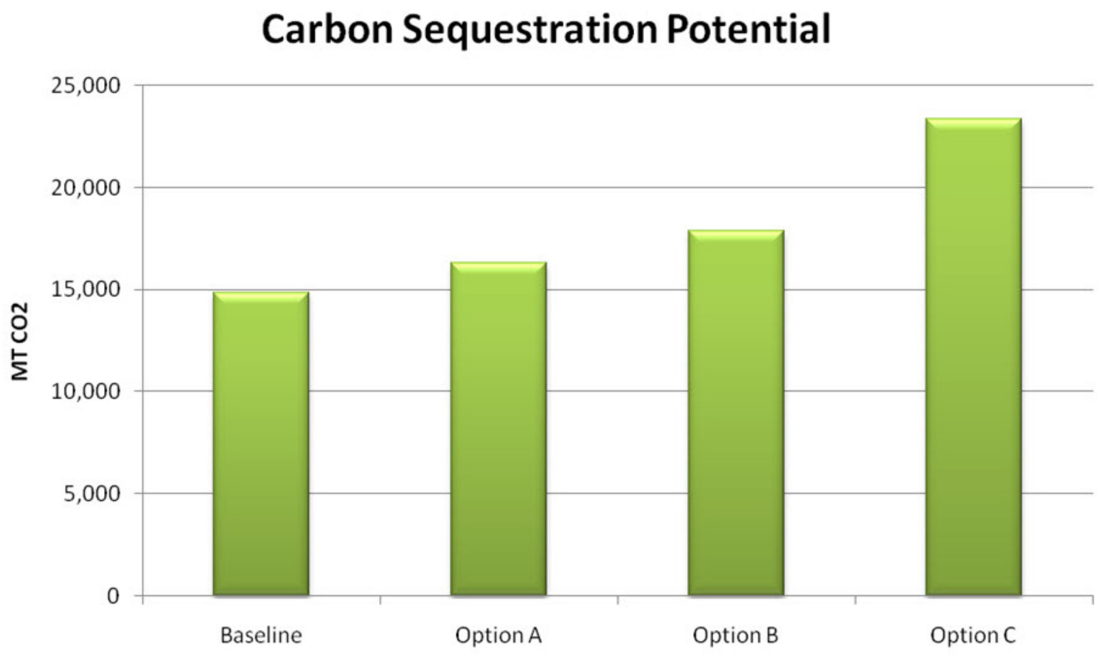
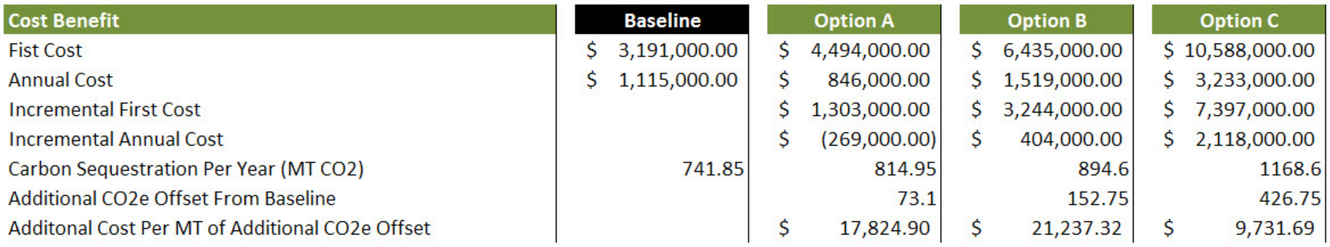


FIGURE 8-3: Carbon Sequestration Benefit



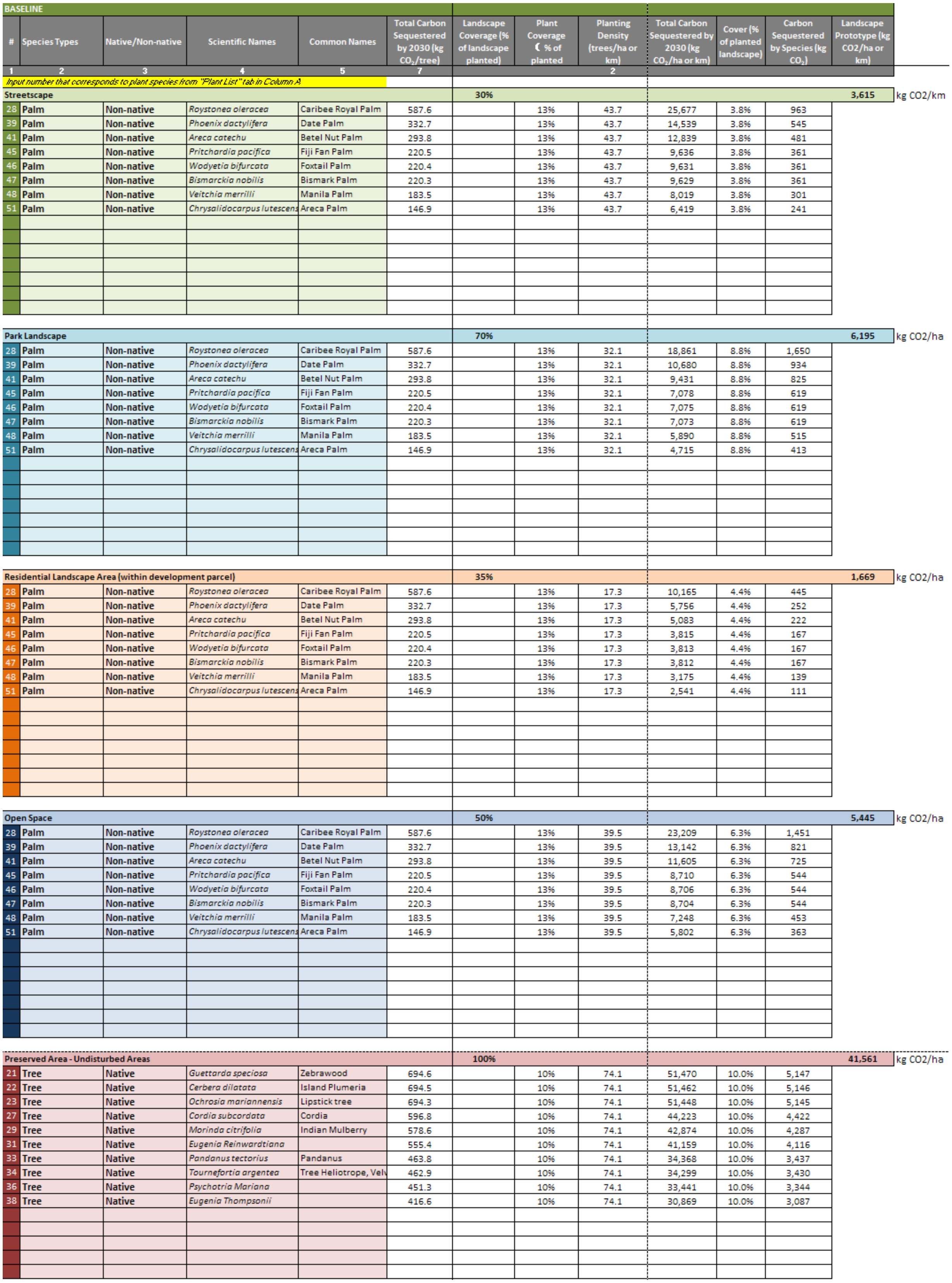
Cost Benefit	Baseline	Option A	Option B	Option C
Fist Cost	$ 3,191,000.00	$ 4,494,000.00	$ 6,435,000.00	$ 10,588,000.00
Annual Cost	$ 1,115,000.00	$ 846,000.00	$ 1,519,000.00	$ 3,233,000.00
Incremental First Cost		$ 1,303,000.00	$ 3,244,000.00	$ 7,397,000.00
Incremental Annual Cost		$ (269,000.00)	$ 404,000.00	$ 2,118,000.00
Carbon Sequestration Per Year (MT CO2)	741.85	814.95	894.6	1168.6
Additional CO2e Offset From Baseline		73.1	152.75	426.75
Additonal Cost Per MT of Additional CO2e Offset		$ 17,824.90	$ 21,237.32	$ 9,731.69

TABLE 8-2: Cost Benefit

Assumptions

Assumptions for trees planted and trees preserved within base areas were made based on per tree and per acre estimates for each landscape type. As trees age, sequestration will ultimately peak and trees will need to be removed and ideally buried or used in products to maintain stored carbon. In the near term newly planted trees will have a relatively high net sequestration of carbon. Additionally, it is assumed that existing forests on site can continue to sequester carbon for some time before trees begin to die and release carbon back into the atmosphere. Further analysis is needed to determine optimal long term management of carbon pools in forest areas.

FIGURE 8-4: Carbon Sequestration Scenario



BASELINE													
#	Species Types	Native/Non-native	Scientific Names	Common Names	Total Carbon Sequestered by 2030 (kg CO_2/tree)	Landscape Coverage (% of landscape planted)	Plant Coverage (% of planted	Planting Density (trees/ha or km)	Total Carbon Sequestered by 2030 (kg CO_2/ha or km)	Cover (% of planted landscape)	Carbon Sequestered by Species (kg CO_2)	Landscape Prototype (kg CO2/ha or km)	
1	2	3	4	5	7			2					
Input number that corresponds to plant species from "Plant List" tab in Column A													
Streetscape						30%						3,615	kg CO2/km
28	Palm	Non-native	*Roystonea oleracea*	Caribee Royal Palm	587.6		13%	43.7	25,677	3.8%	963		
39	Palm	Non-native	*Phoenix dactylifera*	Date Palm	332.7		13%	43.7	14,539	3.8%	545		
41	Palm	Non-native	*Areca catechu*	Betel Nut Palm	293.8		13%	43.7	12,839	3.8%	481		
45	Palm	Non-native	*Pritchardia pacifica*	Fiji Fan Palm	220.5		13%	43.7	9,636	3.8%	361		
46	Palm	Non-native	*Wodyetia bifurcata*	Foxtail Palm	220.4		13%	43.7	9,631	3.8%	361		
47	Palm	Non-native	*Bismarckia nobilis*	Bismark Palm	220.3		13%	43.7	9,629	3.8%	361		
48	Palm	Non-native	*Veitchia merrilli*	Manila Palm	183.5		13%	43.7	8,019	3.8%	301		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		13%	43.7	6,419	3.8%	241		
Park Landscape						70%						6,195	kg CO2/ha
28	Palm	Non-native	*Roystonea oleracea*	Caribee Royal Palm	587.6		13%	32.1	18,861	8.8%	1,650		
39	Palm	Non-native	*Phoenix dactylifera*	Date Palm	332.7		13%	32.1	10,680	8.8%	934		
41	Palm	Non-native	*Areca catechu*	Betel Nut Palm	293.8		13%	32.1	9,431	8.8%	825		
45	Palm	Non-native	*Pritchardia pacifica*	Fiji Fan Palm	220.5		13%	32.1	7,078	8.8%	619		
46	Palm	Non-native	*Wodyetia bifurcata*	Foxtail Palm	220.4		13%	32.1	7,075	8.8%	619		
47	Palm	Non-native	*Bismarckia nobilis*	Bismark Palm	220.3		13%	32.1	7,073	8.8%	619		
48	Palm	Non-native	*Veitchia merrilli*	Manila Palm	183.5		13%	32.1	5,890	8.8%	515		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		13%	32.1	4,715	8.8%	413		
Residential Landscape Area (within development parcel)						35%						1,669	kg CO2/ha
28	Palm	Non-native	*Roystonea oleracea*	Caribee Royal Palm	587.6		13%	17.3	10,165	4.4%	445		
39	Palm	Non-native	*Phoenix dactylifera*	Date Palm	332.7		13%	17.3	5,756	4.4%	252		
41	Palm	Non-native	*Areca catechu*	Betel Nut Palm	293.8		13%	17.3	5,083	4.4%	222		
45	Palm	Non-native	*Pritchardia pacifica*	Fiji Fan Palm	220.5		13%	17.3	3,815	4.4%	167		
46	Palm	Non-native	*Wodyetia bifurcata*	Foxtail Palm	220.4		13%	17.3	3,813	4.4%	167		
47	Palm	Non-native	*Bismarckia nobilis*	Bismark Palm	220.3		13%	17.3	3,812	4.4%	167		
48	Palm	Non-native	*Veitchia merrilli*	Manila Palm	183.5		13%	17.3	3,175	4.4%	139		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		13%	17.3	2,541	4.4%	111		
Open Space						50%						5,445	kg CO2/ha
28	Palm	Non-native	*Roystonea oleracea*	Caribee Royal Palm	587.6		13%	39.5	23,209	6.3%	1,451		
39	Palm	Non-native	*Phoenix dactylifera*	Date Palm	332.7		13%	39.5	13,142	6.3%	821		
41	Palm	Non-native	*Areca catechu*	Betel Nut Palm	293.8		13%	39.5	11,605	6.3%	725		
45	Palm	Non-native	*Pritchardia pacifica*	Fiji Fan Palm	220.5		13%	39.5	8,710	6.3%	544		
46	Palm	Non-native	*Wodyetia bifurcata*	Foxtail Palm	220.4		13%	39.5	8,706	6.3%	544		
47	Palm	Non-native	*Bismarckia nobilis*	Bismark Palm	220.3		13%	39.5	8,704	6.3%	544		
48	Palm	Non-native	*Veitchia merrilli*	Manila Palm	183.5		13%	39.5	7,248	6.3%	453		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		13%	39.5	5,802	6.3%	363		
Preserved Area - Undisturbed Areas						100%						41,561	kg CO2/ha
21	Tree	Native	*Guettarda speciosa*	Zebrawood	694.6		10%	74.1	51,470	10.0%	5,147		
22	Tree	Native	*Cerbera dilatata*	Island Plumeria	694.5		10%	74.1	51,462	10.0%	5,146		
23	Tree	Native	*Ochrosia mariannensis*	Lipstick tree	694.3		10%	74.1	51,448	10.0%	5,145		
27	Tree	Native	*Cordia subcordata*	Cordia	596.8		10%	74.1	44,223	10.0%	4,422		
29	Tree	Native	*Morinda citrifolia*	Indian Mulberry	578.6		10%	74.1	42,874	10.0%	4,287		
31	Tree	Native	*Eugenia Reinwardtiana*		555.4		10%	74.1	41,159	10.0%	4,116		
33	Tree	Native	*Pandanus tectorius*	Pandanus	463.8		10%	74.1	34,368	10.0%	3,437		
34	Tree	Native	*Tournefortia argentea*	Tree Heliotrope, Velv	462.9		10%	74.1	34,299	10.0%	3,430		
36	Tree	Native	*Psychotria Mariana*		451.3		10%	74.1	33,441	10.0%	3,344		
38	Tree	Native	*Eugenia Thompsonii*		416.6		10%	74.1	30,869	10.0%	3,087		

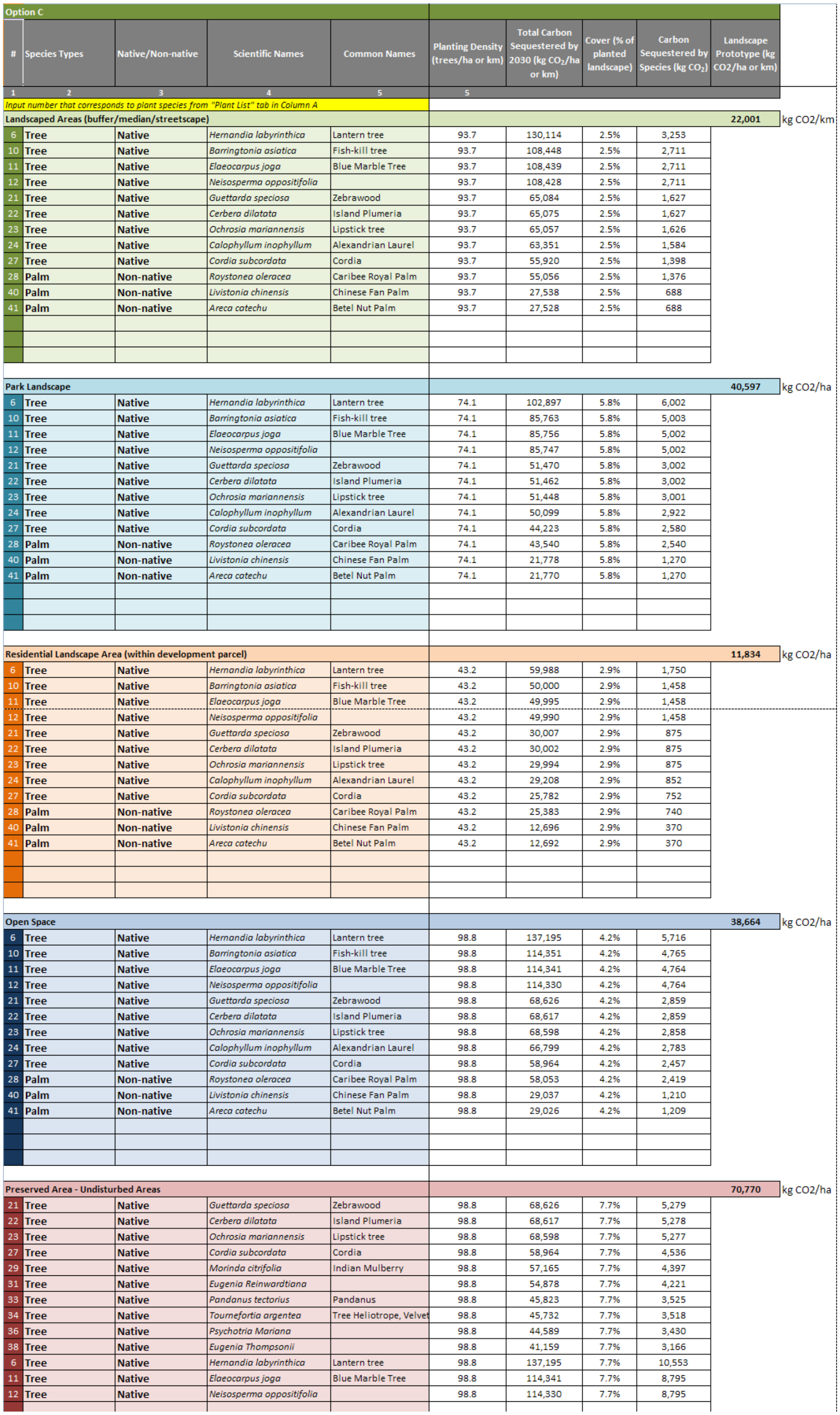
TABLE 8-3: Plant Species—Baseline

Option A															
#	Species Types	Native/Non-native	Scientific Names	Common Names	Total Carbon Sequestered by 2030 (kg CO_2/tree)	Landscape Coverage (% of landscape planted)	Plant Coverage (% of planted	Height (ft)	DBH (in)	Planting Density (trees/ha or km)	Total Carbon Sequestered by 2030 (kg CO_2/ha or km)	Cover (% of planted landscape)	Carbon Sequestered by Species (kg CO_2)	Landscape Prototype (kg CO2/ha or km)	
1	2	3	4	5	7			8	9	3					
Input number that corresponds to plant species from "Plant List" tab in Column A															
Landscaped Areas (buffer/median/streetscape)						30%								6,957	kg CO2/km
24	Tree	Native	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	54.7	36,983	2.5%	925		
27	Tree	Native	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	54.7	32,645	2.5%	816		
29	Tree	Native	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	54.7	31,649	2.5%	791		
30	Tree	Native	*Aglaia mariannensis*		555.5		8%	24.0	11.9	54.7	30,386	2.5%	760		
31	Tree	Native	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	54.7	30,383	2.5%	760		
33	Tree	Native	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	54.7	25,370	2.5%	634		
34	Tree	Native	*Tournefortia argentea*	Tree Heliotrope, Velv	462.9		8%	20.0	9.9	54.7	25,319	2.5%	633		
36	Tree	Native	*Psychotria Mariana*		451.3		8%	19.5	9.7	54.7	24,686	2.5%	617		
38	Tree	Native	*Eugenia Thompsonii*		416.6		8%	18.0	8.9	54.7	22,787	2.5%	570		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		8%	20.0	12.1	54.7	8,035	2.5%	201		
54	Palm	Non-native	*Cycas revoluta*	Sago Palm	110.2		8%	15.0	9.0	54.7	6,026	2.5%	151		
60	Palm	Non-native	*Phoenix roebelenii*	Dwarf Phoenix Palm	73.4		8%	10.0	6.0	54.7	4,018	2.5%	100		
Park Landscape						70%								13,206	kg CO2/ha
24	Tree	Native	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	44.5	30,086	5.8%	1,755		
27	Tree	Native	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	44.5	26,558	5.8%	1,549		
29	Tree	Native	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	44.5	25,747	5.8%	1,502		
30	Tree	Native	*Aglaia mariannensis*		555.5		8%	24.0	11.9	44.5	24,720	5.8%	1,442		
31	Tree	Native	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	44.5	24,717	5.8%	1,442		
33	Tree	Native	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	44.5	20,639	5.8%	1,204		
34	Tree	Native	*Tournefortia argentea*	Tree Heliotrope, Velv	462.9		8%	20.0	9.9	44.5	20,598	5.8%	1,202		
36	Tree	Native	*Psychotria Mariana*		451.3		8%	19.5	9.7	44.5	20,083	5.8%	1,172		
38	Tree	Native	*Eugenia Thompsonii*		416.6		8%	18.0	8.9	44.5	18,538	5.8%	1,081		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		8%	20.0	12.1	44.5	6,537	5.8%	381		
54	Palm	Non-native	*Cycas revoluta*	Sago Palm	110.2		8%	15.0	9.0	44.5	4,903	5.8%	286		
60	Palm	Non-native	*Phoenix roebelenii*	Dwarf Phoenix Palm	73.4		8%	10.0	6.0	44.5	3,268	5.8%	191		
Residential Landscape Area (within development parcel)						35%								3,843	kg CO2/ha
24	Tree	Native	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	25.9	17,511	2.9%	511		
27	Tree	Native	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	25.9	15,457	2.9%	451		
29	Tree	Native	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	25.9	14,986	2.9%	437		
30	Tree	Native	*Aglaia mariannensis*		555.5		8%	24.0	11.9	25.9	14,387	2.9%	420		
31	Tree	Native	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	25.9	14,386	2.9%	420		
33	Tree	Native	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	25.9	12,012	2.9%	350		
34	Tree	Native	*Tournefortia argentea*	Tree Heliotrope, Velv	462.9		8%	20.0	9.9	25.9	11,988	2.9%	350		
36	Tree	Native	*Psychotria Mariana*		451.3		8%	19.5	9.7	25.9	11,689	2.9%	341		
38	Tree	Native	*Eugenia Thompsonii*		416.6		8%	18.0	8.9	25.9	10,790	2.9%	315		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		8%	20.0	12.1	25.9	3,805	2.9%	111		
54	Palm	Non-native	*Cycas revoluta*	Sago Palm	110.2		8%	15.0	9.0	25.9	2,853	2.9%	83		
60	Palm	Non-native	*Phoenix roebelenii*	Dwarf Phoenix Palm	73.4		8%	10.0	6.0	25.9	1,902	2.9%	55		
Open Space						50%								12,570	kg CO2/ha
24	Tree	Native	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	59.3	40,093	4.2%	1,671		
27	Tree	Native	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	59.3	35,390	4.2%	1,475		
29	Tree	Native	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	59.3	34,310	4.2%	1,430		
30	Tree	Native	*Aglaia mariannensis*		555.5		8%	24.0	11.9	59.3	32,941	4.2%	1,373		
31	Tree	Native	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	59.3	32,938	4.2%	1,372		
33	Tree	Native	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	59.3	27,503	4.2%	1,146		
34	Tree	Native	*Tournefortia argentea*	Tree Heliotrope, Velv	462.9		8%	20.0	9.9	59.3	27,448	4.2%	1,144		
36	Tree	Native	*Psychotria Mariana*		451.3		8%	19.5	9.7	59.3	26,762	4.2%	1,115		
38	Tree	Native	*Eugenia Thompsonii*		416.6		8%	18.0	8.9	59.3	24,704	4.2%	1,029		
51	Palm	Non-native	*Chrysalidocarpus lutescens*	Areca Palm	146.9		8%	20.0	12.1	59.3	8,711	4.2%	363		
54	Palm	Non-native	*Cycas revoluta*	Sago Palm	110.2		8%	15.0	9.0	59.3	6,533	4.2%	272		
60	Palm	Non-native	*Phoenix roebelenii*	Dwarf Phoenix Palm	73.4		8%	10.0	6.0	59.3	4,355	4.2%	181		
Preserved Area - Undisturbed Areas						100%								41,561	kg CO2/ha
21	Tree	Native	*Guettarda speciosa*	Zebrawood	694.6		10%	30.0	14.9	74.1	51,470	10.0%	5,147		
22	Tree	Native	*Cerbera dilatata*	Island Plumeria	694.5		10%	30.0	14.9	74.1	51,462	10.0%	5,146		
23	Tree	Native	*Ochrosia mariannensis*	Lipstick tree	694.3		10%	30.0	14.9	74.1	51,448	10.0%	5,145		
27	Tree	Native	*Cordia subcordata*	Cordia	596.8		10%	27.1	13.8	74.1	44,223	10.0%	4,422		
29	Tree	Native	*Morinda citrifolia*	Indian Mulberry	578.6		10%	25.0	12.4	74.1	42,874	10.0%	4,287		
31	Tree	Native	*Eugenia Reinwardtiana*		555.4		10%	24.0	11.9	74.1	41,159	10.0%	4,116		
33	Tree	Native	*Pandanus tectorius*	Pandanus	463.8		10%	20.0	9.9	74.1	34,368	10.0%	3,437		
34	Tree	Native	*Tournefortia argentea*	Tree Heliotrope, Velv	462.9		10%	20.0	9.9	74.1	34,299	10.0%	3,430		
36	Tree	Native	*Psychotria Mariana*		451.3		10%	19.5	9.7	74.1	33,441	10.0%	3,344		
38	Tree	Native	*Eugenia Thompsonii*		416.6		10%	18.0	8.9	74.1	30,869	10.0%	3,087		

TABLE 8-4: Plant Species—Option A

Option B															
#	Species Types	Native/Non-native	Scientific Names	Common Names	Total Carbon Sequestered by 2030 (kg CO_2/tree)	Landscape Coverage (% of landscape planted)	Plant Coverage (% of planted area)	Height (ft)	DBH (in)	Planting Density (trees/ha or km)	Total Carbon Sequestered by 2030 (kg CO_2/ha or km)	Cover (% of planted landscape)	Carbon Sequestered by Species (kg CO_2)	Landscape Prototype (kg CO2/ha or km)	
1	2	3	4	5	7			8	9	4					
Input number that corresponds to plant species from "Plant List" tab in Column A															
Landscaped Areas (buffer/median/streetscape)						**30%**								**10,181**	kg CO2/km
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	694.6		8%	30.0	14.9	65.6	45,566	2.5%	1,139		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	694.5		8%	30.0	14.9	65.6	45,559	2.5%	1,139		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	694.3		8%	30.0	14.9	65.6	45,547	2.5%	1,139		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	65.6	44,352	2.5%	1,109		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	65.6	39,150	2.5%	979		
29	**Tree**	**Native**	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	65.6	37,956	2.5%	949		
30	**Tree**	**Native**	*Aglaia mariannensis*		555.5		8%	24.0	11.9	65.6	36,441	2.5%	911		
31	**Tree**	**Native**	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	65.6	36,437	2.5%	911		
33	**Tree**	**Native**	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	65.6	30,425	2.5%	761		
43	**Palm**	**Non-native**	*Archonphoenix alexandrae*	Alexander Palm	257.2		8%	20.7	22.0	65.6	16,872	2.5%	422		
45	**Palm**	**Non-native**	*Pritchardia pacifica*	Fiji Fan Palm	220.5		8%	30.0	18.1	65.6	14,465	2.5%	362		
46	**Palm**	**Non-native**	*Wodyetia bifurcata*	Foxtail Palm	220.4		8%	30.0	18.1	65.6	14,458	2.5%	361		
Park Landscape						**70%**								**21,474**	kg CO2/ha
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	694.6		8%	30.0	14.9	59.3	41,190	5.8%	2,403		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	694.5		8%	30.0	14.9	59.3	41,184	5.8%	2,402		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	694.3		8%	30.0	14.9	59.3	41,173	5.8%	2,402		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	59.3	40,093	5.8%	2,339		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	59.3	35,390	5.8%	2,064		
29	**Tree**	**Native**	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	59.3	34,310	5.8%	2,001		
30	**Tree**	**Native**	*Aglaia mariannensis*		555.5		8%	24.0	11.9	59.3	32,941	5.8%	1,922		
31	**Tree**	**Native**	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	59.3	32,938	5.8%	1,921		
33	**Tree**	**Native**	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	59.3	27,503	5.8%	1,604		
43	**Palm**	**Non-native**	*Archonphoenix alexandrae*	Alexander Palm	257.2		8%	20.7	22.0	59.3	15,252	5.8%	890		
45	**Palm**	**Non-native**	*Pritchardia pacifica*	Fiji Fan Palm	220.5		8%	30.0	18.1	59.3	13,076	5.8%	763		
46	**Palm**	**Non-native**	*Wodyetia bifurcata*	Foxtail Palm	220.4		8%	30.0	18.1	59.3	13,070	5.8%	762		
Residential Landscape Area (within development parcel)						**35%**								**6,265**	kg CO2/ha
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	694.6		8%	30.0	14.9	34.6	24,033	2.9%	701		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	694.5		8%	30.0	14.9	34.6	24,030	2.9%	701		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	694.3		8%	30.0	14.9	34.6	24,023	2.9%	701		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	34.6	23,393	2.9%	682		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	34.6	20,649	2.9%	602		
29	**Tree**	**Native**	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	34.6	20,019	2.9%	584		
30	**Tree**	**Native**	*Aglaia mariannensis*		555.5		8%	24.0	11.9	34.6	19,220	2.9%	561		
31	**Tree**	**Native**	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	34.6	19,218	2.9%	561		
33	**Tree**	**Native**	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	34.6	16,047	2.9%	468		
43	**Palm**	**Non-native**	*Archonphoenix alexandrae*	Alexander Palm	257.2		8%	20.7	22.0	34.6	8,899	2.9%	260		
45	**Palm**	**Non-native**	*Pritchardia pacifica*	Fiji Fan Palm	220.5		8%	30.0	18.1	34.6	7,629	2.9%	223		
46	**Palm**	**Non-native**	*Wodyetia bifurcata*	Foxtail Palm	220.4		8%	30.0	18.1	34.6	7,626	2.9%	222		
Open Space						**50%**								**20,460**	kg CO2/ha
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	694.6		8%	30.0	14.9	79.1	54,943	4.2%	2,289		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	694.5		8%	30.0	14.9	79.1	54,935	4.2%	2,289		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	694.3		8%	30.0	14.9	79.1	54,920	4.2%	2,288		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	676.1		8%	27.9	13.5	79.1	53,480	4.2%	2,228		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	596.8		8%	27.1	13.8	79.1	47,207	4.2%	1,967		
29	**Tree**	**Native**	*Morinda citrifolia*	Indian Mulberry	578.6		8%	25.0	12.4	79.1	45,767	4.2%	1,907		
30	**Tree**	**Native**	*Aglaia mariannensis*		555.5		8%	24.0	11.9	79.1	43,940	4.2%	1,831		
31	**Tree**	**Native**	*Eugenia Reinwardtiana*		555.4		8%	24.0	11.9	79.1	43,936	4.2%	1,831		
33	**Tree**	**Native**	*Pandanus tectorius*	Pandanus	463.8		8%	20.0	9.9	79.1	36,687	4.2%	1,529		
43	**Palm**	**Non-native**	*Archonphoenix alexandrae*	Alexander Palm	257.2		8%	20.7	22.0	79.1	20,345	4.2%	848		
45	**Palm**	**Non-native**	*Pritchardia pacifica*	Fiji Fan Palm	220.5		8%	30.0	18.1	79.1	17,442	4.2%	727		
46	**Palm**	**Non-native**	*Wodyetia bifurcata*	Foxtail Palm	220.4		8%	30.0	18.1	79.1	17,434	4.2%	726		
Preserved Area - Undisturbed Areas						**100%**								**41,561**	kg CO2/ha
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	694.6		10%	30.0	14.9	74.1	51,470	10.0%	5,147		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	694.5		10%	30.0	14.9	74.1	51,462	10.0%	5,146		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	694.3		10%	30.0	14.9	74.1	51,448	10.0%	5,145		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	596.8		10%	27.1	13.8	74.1	44,223	10.0%	4,422		
29	**Tree**	**Native**	*Morinda citrifolia*	Indian Mulberry	578.6		10%	25.0	12.4	74.1	42,874	10.0%	4,287		
31	**Tree**	**Native**	*Eugenia Reinwardtiana*		555.4		10%	24.0	11.9	74.1	41,159	10.0%	4,116		
33	**Tree**	**Native**	*Pandanus tectorius*	Pandanus	463.8		10%	20.0	9.9	74.1	34,368	10.0%	3,437		
34	**Tree**	**Native**	*Tournefortia argentea*	Tree Heliotrope, Velvet	462.9		10%	20.0	9.9	74.1	34,299	10.0%	3,430		
36	**Tree**	**Native**	*Psychotria Mariana*		451.3		10%	19.5	9.7	74.1	33,441	10.0%	3,344		
38	**Tree**	**Native**	*Eugenia Thompsonii*		416.6		10%	18.0	8.9	74.1	30,869	10.0%	3,087		

TABLE 8-5: Plant Species—Option B



Option C										
#	Species Types	Native/Non-native	Scientific Names	Common Names	Planting Density (trees/ha or km)	Total Carbon Sequestered by 2030 (kg CO_2/ha or km)	Cover (% of planted landscape)	Carbon Sequestered by Species (kg CO_2)	Landscape Prototype (kg CO2/ha or km)	
1	2	3	4	5	5					
Input number that corresponds to plant species from "Plant List" tab in Column A										
Landscaped Areas (buffer/median/streetscape)									**22,001**	kg CO2/km
6	**Tree**	**Native**	*Hernandia labyrinthica*	Lantern tree	93.7	130,114	2.5%	3,253		
10	**Tree**	**Native**	*Barringtonia asiatica*	Fish-kill tree	93.7	108,448	2.5%	2,711		
11	**Tree**	**Native**	*Elaeocarpus joga*	Blue Marble Tree	93.7	108,439	2.5%	2,711		
12	**Tree**	**Native**	*Neisosperma oppositifolia*		93.7	108,428	2.5%	2,711		
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	93.7	65,084	2.5%	1,627		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	93.7	65,075	2.5%	1,627		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	93.7	65,057	2.5%	1,626		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	93.7	63,351	2.5%	1,584		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	93.7	55,920	2.5%	1,398		
28	**Palm**	**Non-native**	*Roystonea oleracea*	Caribee Royal Palm	93.7	55,056	2.5%	1,376		
40	**Palm**	**Non-native**	*Livistonia chinensis*	Chinese Fan Palm	93.7	27,538	2.5%	688		
41	**Palm**	**Non-native**	*Areca catechu*	Betel Nut Palm	93.7	27,528	2.5%	688		
Park Landscape									**40,597**	kg CO2/ha
6	**Tree**	**Native**	*Hernandia labyrinthica*	Lantern tree	74.1	102,897	5.8%	6,002		
10	**Tree**	**Native**	*Barringtonia asiatica*	Fish-kill tree	74.1	85,763	5.8%	5,003		
11	**Tree**	**Native**	*Elaeocarpus joga*	Blue Marble Tree	74.1	85,756	5.8%	5,002		
12	**Tree**	**Native**	*Neisosperma oppositifolia*		74.1	85,747	5.8%	5,002		
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	74.1	51,470	5.8%	3,002		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	74.1	51,462	5.8%	3,002		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	74.1	51,448	5.8%	3,001		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	74.1	50,099	5.8%	2,922		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	74.1	44,223	5.8%	2,580		
28	**Palm**	**Non-native**	*Roystonea oleracea*	Caribee Royal Palm	74.1	43,540	5.8%	2,540		
40	**Palm**	**Non-native**	*Livistonia chinensis*	Chinese Fan Palm	74.1	21,778	5.8%	1,270		
41	**Palm**	**Non-native**	*Areca catechu*	Betel Nut Palm	74.1	21,770	5.8%	1,270		
Residential Landscape Area (within development parcel)									**11,834**	kg CO2/ha
6	**Tree**	**Native**	*Hernandia labyrinthica*	Lantern tree	43.2	59,988	2.9%	1,750		
10	**Tree**	**Native**	*Barringtonia asiatica*	Fish-kill tree	43.2	50,000	2.9%	1,458		
11	**Tree**	**Native**	*Elaeocarpus joga*	Blue Marble Tree	43.2	49,995	2.9%	1,458		
12	**Tree**	**Native**	*Neisosperma oppositifolia*		43.2	49,990	2.9%	1,458		
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	43.2	30,007	2.9%	875		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	43.2	30,002	2.9%	875		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	43.2	29,994	2.9%	875		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	43.2	29,208	2.9%	852		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	43.2	25,782	2.9%	752		
28	**Palm**	**Non-native**	*Roystonea oleracea*	Caribee Royal Palm	43.2	25,383	2.9%	740		
40	**Palm**	**Non-native**	*Livistonia chinensis*	Chinese Fan Palm	43.2	12,696	2.9%	370		
41	**Palm**	**Non-native**	*Areca catechu*	Betel Nut Palm	43.2	12,692	2.9%	370		
Open Space									**38,664**	kg CO2/ha
6	**Tree**	**Native**	*Hernandia labyrinthica*	Lantern tree	98.8	137,195	4.2%	5,716		
10	**Tree**	**Native**	*Barringtonia asiatica*	Fish-kill tree	98.8	114,351	4.2%	4,765		
11	**Tree**	**Native**	*Elaeocarpus joga*	Blue Marble Tree	98.8	114,341	4.2%	4,764		
12	**Tree**	**Native**	*Neisosperma oppositifolia*		98.8	114,330	4.2%	4,764		
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	98.8	68,626	4.2%	2,859		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	98.8	68,617	4.2%	2,859		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	98.8	68,598	4.2%	2,858		
24	**Tree**	**Native**	*Calophyllum inophyllum*	Alexandrian Laurel	98.8	66,799	4.2%	2,783		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	98.8	58,964	4.2%	2,457		
28	**Palm**	**Non-native**	*Roystonea oleracea*	Caribee Royal Palm	98.8	58,053	4.2%	2,419		
40	**Palm**	**Non-native**	*Livistonia chinensis*	Chinese Fan Palm	98.8	29,037	4.2%	1,210		
41	**Palm**	**Non-native**	*Areca catechu*	Betel Nut Palm	98.8	29,026	4.2%	1,209		
Preserved Area - Undisturbed Areas									**70,770**	kg CO2/ha
21	**Tree**	**Native**	*Guettarda speciosa*	Zebrawood	98.8	68,626	7.7%	5,279		
22	**Tree**	**Native**	*Cerbera dilatata*	Island Plumeria	98.8	68,617	7.7%	5,278		
23	**Tree**	**Native**	*Ochrosia mariannensis*	Lipstick tree	98.8	68,598	7.7%	5,277		
27	**Tree**	**Native**	*Cordia subcordata*	Cordia	98.8	58,964	7.7%	4,536		
29	**Tree**	**Native**	*Morinda citrifolia*	Indian Mulberry	98.8	57,165	7.7%	4,397		
31	**Tree**	**Native**	*Eugenia Reinwardtiana*		98.8	54,878	7.7%	4,221		
33	**Tree**	**Native**	*Pandanus tectorius*	Pandanus	98.8	45,823	7.7%	3,525		
34	**Tree**	**Native**	*Tournefortia argentea*	Tree Heliotrope, Velvet	98.8	45,732	7.7%	3,518		
36	**Tree**	**Native**	*Psychotria Mariana*		98.8	44,589	7.7%	3,430		
38	**Tree**	**Native**	*Eugenia Thompsonii*		98.8	41,159	7.7%	3,166		
6	**Tree**	**Native**	*Hernandia labyrinthica*	Lantern tree	98.8	137,195	7.7%	10,553		
11	**Tree**	**Native**	*Elaeocarpus joga*	Blue Marble Tree	98.8	114,341	7.7%	8,795		
12	**Tree**	**Native**	*Neisosperma oppositifolia*		98.8	114,330	7.7%	8,795		

TABLE 8-6: Plant Species—Option C

Local Food Production

Introduction

The sustainability program for the GJMMP has identified a practical and expandable local food production program for the proposed base to:

- Foster a “good neighbor” policy with local farmers
- Provide opportunities for the community inside the fence to interact and with the University of Guam and the local community outside the fence
- Grow local fruits on site in neighborhood fruit gardens (on a small scale) for use, education, carbon sequestration (reduction of overall GHG emissions) and to enhance habitat areas.
- Earn additional LEED (Leadership in Energy and Environmental Design) New Construction points through innovation credits.

The attention to the “Local Food Production/Local Farm” has been increasing. The Urban Land Institute and American Planning Association have published numerous research studies and case studies. More and more people realize that Local and regional food systems, where farmers produce, process, store, and transport their food to consumers within a relatively small area, may use less fossil fuel for transportation because the distance from farm to consumer is shorter, thus producing less CO_2 emissions.

The benefits of having local food production as an important component of a sustainable community on social, economic and environmental levels are well recognized:

- Social
  - Community interaction
  - Educational resource
- Economic
  - Support local economy
  - Create small business opportunities
- Environmental
  - Preserve open space and farmland
  - Reduce greenhouse gas emissions
  - Converting to bio-energy potential

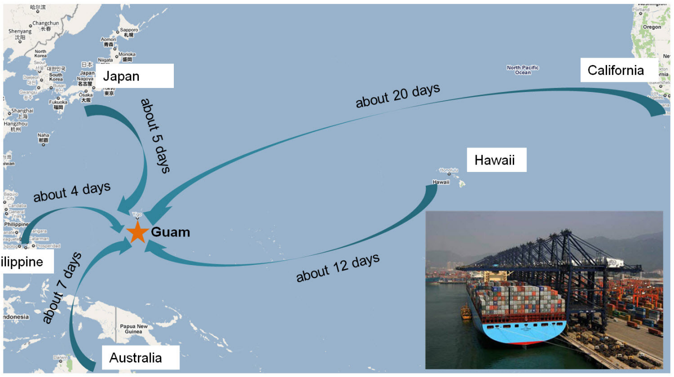
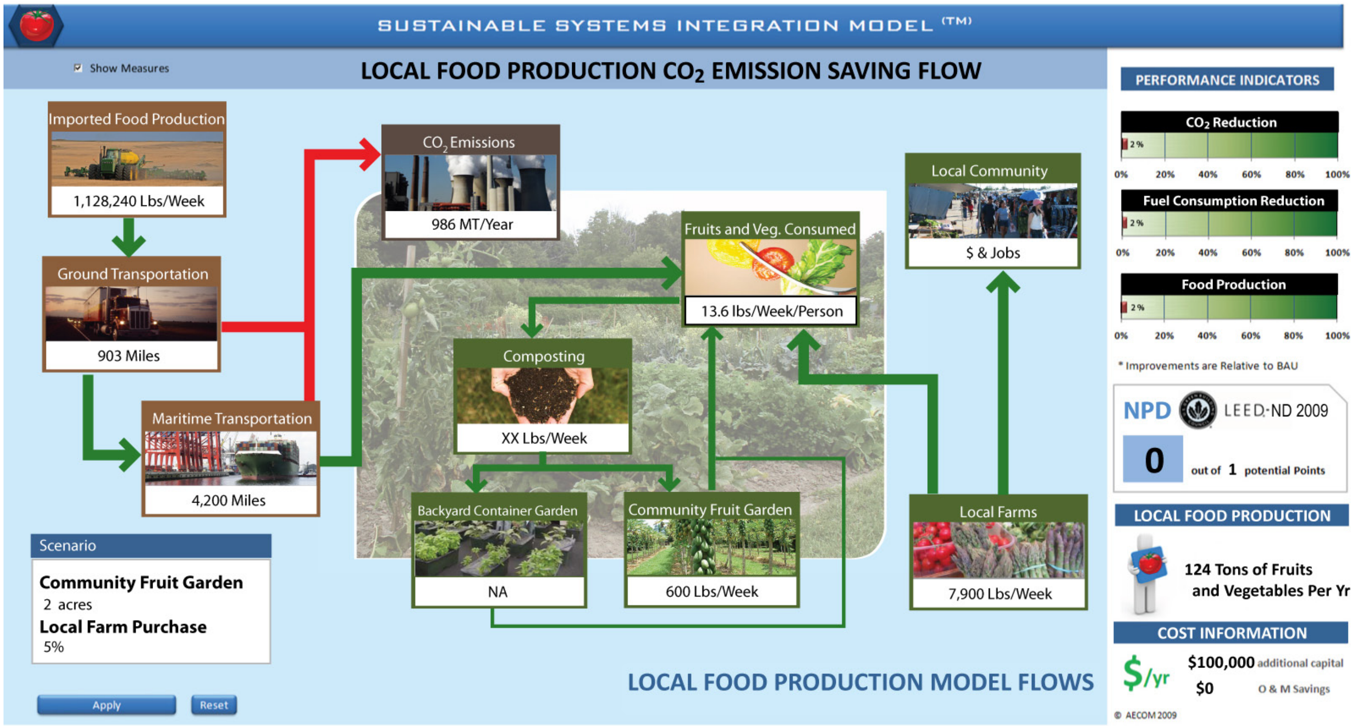


FIGURE 8-5: Guam Food Sources

The majority of the food consumed in Guam is imported. The origins of the food are places thousands of miles away such as California, Hawaii, Philippine, Australia, Japan etc. During the transportation of those foods, not only are greenhouse gas emitted through the consumption of the petroleum, but brings potential threats of invasive species that will endanger local ecology. The community fruit garden and local farming supporting strategy proposed in this Sustainability Program will effectively address those problems.

Process

Local food production for Guam can be grouped into two categories: 1) Small Scale Neighborhood Fruit Gardens, and 2) Community Supported Agriculture (CSA). Both are local food systems representing farmers who market and sell directly to consumers or food buyers contribute to food miles within 150 miles from the project site. A local food production emission reduction model was designed to quantify the reduction fuel usage and emissions by applying a local food production policy in Navy Base Guam. Three options (A, B and C) were designed with increasing scale of application.



Scenario

Community Fruit Garden
2 acres
Local Farm Purchase
5%

FIGURE 8-6: Screen Capture of Guam Local Food Production Dashboard

The formula:

Q = (F/V0) X E0 X DB - (F/V1) X E1 X DL

Where:

Q = greenhouse gas emission reduction

F = amount of local food consumed from the project area

V0 = large truck load volume

(heavy-duty semitrailer trucks utilized for transport food under conventional systems)

V1 = light truck load volume

(small and light trucks utilized to transport food to by local farms)

E0 = heavy truck carbon emission rate

E1 = light truck carbon emission rate

DB = average food miles under baseline condition

DL = average food miles of local food production program

Strategy and Options

Table 8-7 indicates the recommended local food production strategy (Option A) for its minimal costs and ease of implementation at a small scale that could be expanded in the future. It is also noted by the stakeholder group and sustainability team that the program can serve as a pilot program for potential future expansion.

Community Fruit Garden

A Community Fruit Garden can be designed along AT/FP setback areas where possible and in designated park/open space area within family housing area. It can serve as an ecological extension and corridors connecting preserved limestone forest to preserved open space and proposed open spaces and parks within the base. LEED ND credit achievement suggests 200 square feet per dwelling unit.

Several types of fruit trees have been identified that are suitable to grow:

- Papaya (Harvest Season: August – December; 2009 Farmers Co-op Association of Guam harvested 60,000 lbs. in 16-week-long season)
- Manzana (Apple Tree) (Exists on the island, in the wild Plants in cluster might withstand typhoons)
- Mango (Deep-rooted, able to withstand typhoons)
- Watermelon (2009 Farmers Co-op Association of Guam harvested over 70,000 lbs)

Local Food Production	Option A	Option B	Option C
Community Fruit Garden	2 acres Fruit Garden in Family Housing Area; Operated by military families, with training from University of Guam AG Extension	4 acres Fruit Garden in Family Housing Area; Operated by military families, with training from University of Guam AG Extension	6 acres Fruit Garden in Family Housing Area; Operated by military families, with training from University of Guam AG Extension
Local Farm Purchase	5% of weekly consumption; Purchase through commissary, dining facilities, schools etc.	10% of weekly consumption; Purchase through commissary, dining facilities, schools etc	15% of weekly consumption; Purchase through commissary, dining facilities, schools etc.

TABLE 8-7: Local Food Production

Local Farm Purchase

Fruits and vegetables are the most ideal to be purchased and consumed from local Guam market for their convenience, freshness, and healthiness. USDA's study shows that people should consume average 13.6 lbs of fruits and vegetables weekly. Given Guam JMMP's future population size, this provides an opportunity for promoting local purchase. Purchases can be made through commissary, dining facilities, and schools, etc. An convenient shuttle bus might be schedule for weekly farmers market nearby.

Cost and Benefit Analysis

	Option A	Option B	Option C
Community Garden	2 acres	4 acres	6 acres
Additional Local Food Purchase (Percentage of Total Fruit& Vegetable Consumption)	5%	10%	15%
Total Reduction on Fruit & Vegetable Importation	**272,160 lbs**	**544,320 lbs**	**816,480 lbs**
Total CO2 Equivalent Reduction Per Year	**17 MT**	**34 MT**	**51 MT**
Remaining CO2 Emission From Fruit & Vegetable Importation	**1041 MT**	**1024 MT**	**1007 MT**
CO2 Reduction Percentage	**2%**	**3%**	**5%**

TABLE 8-8: Greenhouse Gas Emission Reduction Benefit

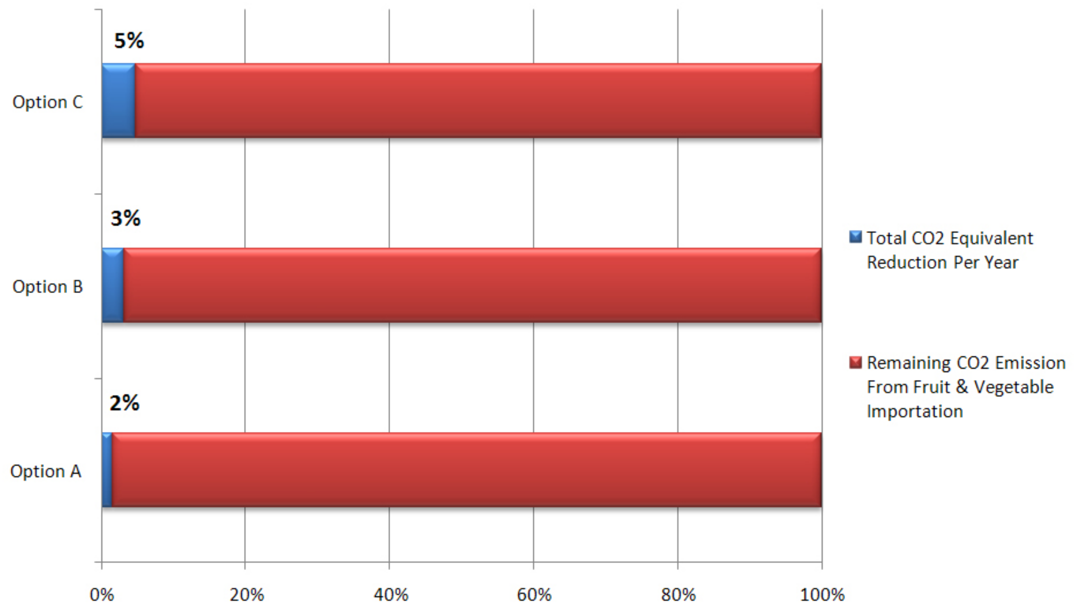
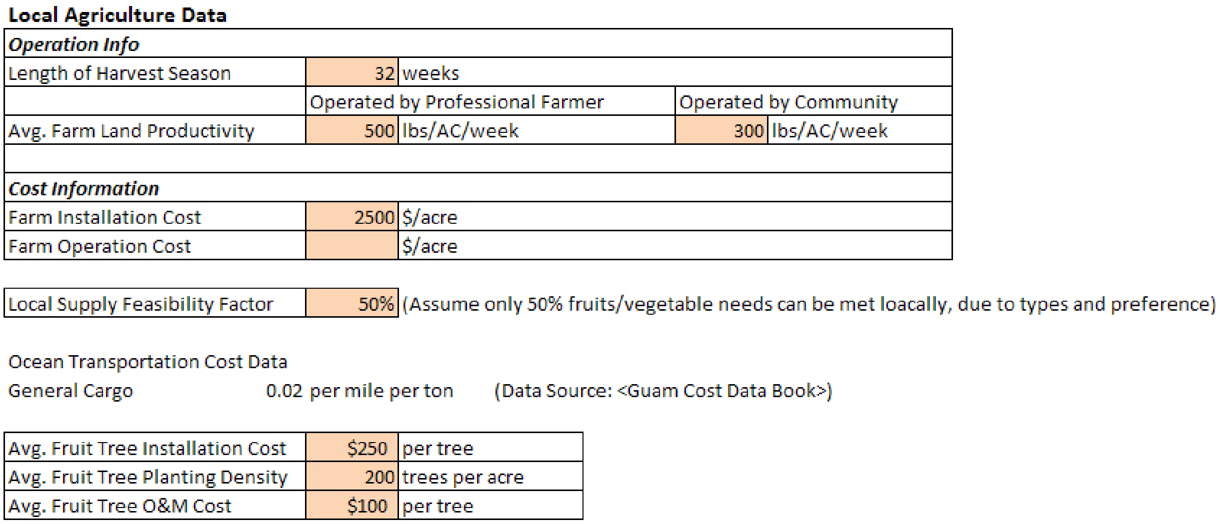


FIGURE 8-7: CO_2 Reduction Comparison

Assumption



Local Agriculture Data

Operation Info				
Length of Harvest Season	32	weeks		
	Operated by Professional Farmer		Operated by Community	
Avg. Farm Land Productivity	500	lbs/AC/week	300	lbs/AC/week
Cost Information				
Farm Installation Cost	2500	$/acre		
Farm Operation Cost		$/acre		

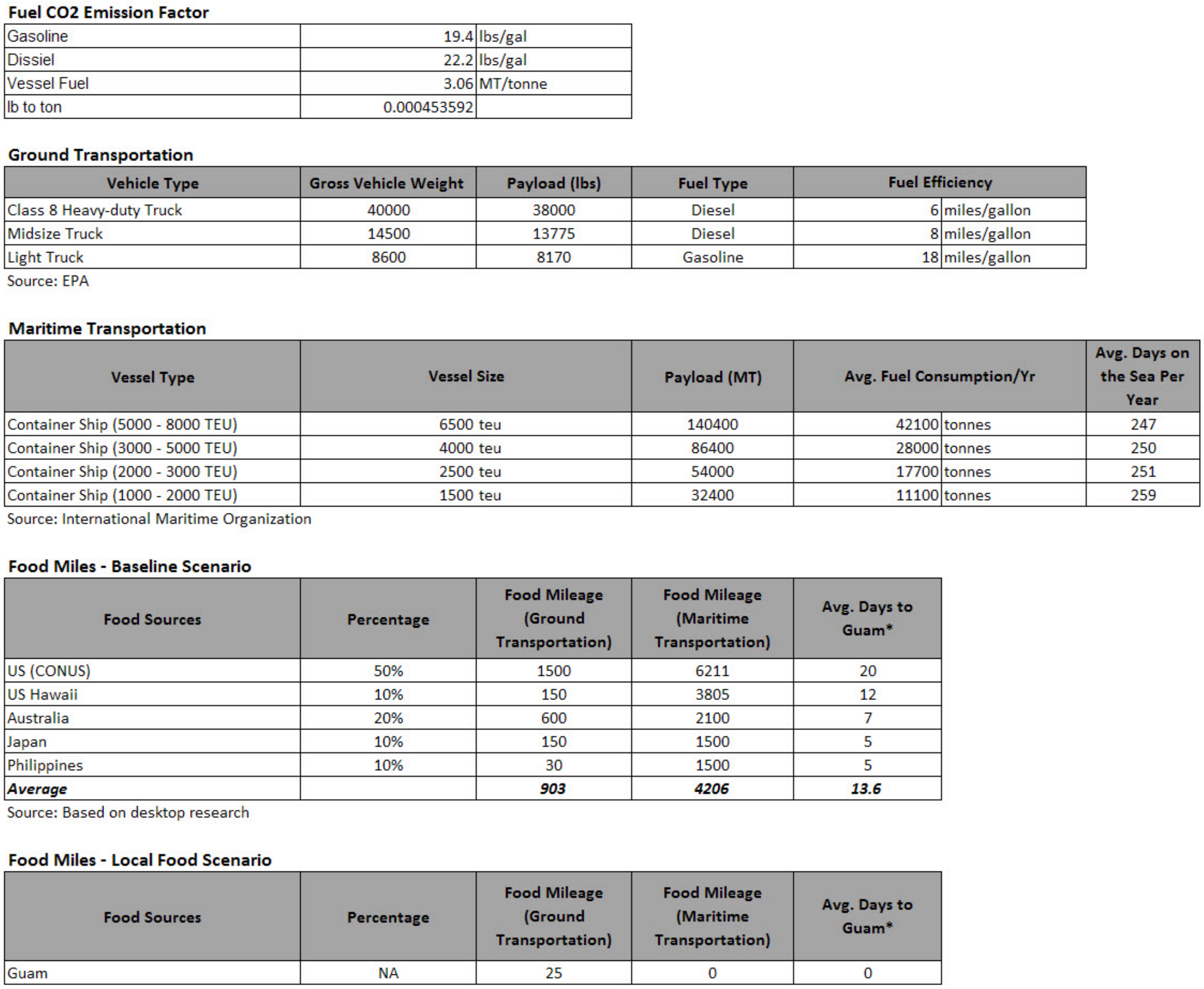
Local Supply Feasibility Factor	50%	(Assume only 50% fruits/vegetable needs can be met loacally, due to types and preference)

Ocean Transportation Cost Data

General Cargo	0.02 per mile per ton	(Data Source: <Guam Cost Data Book>)

Avg. Fruit Tree Installation Cost	$250	per tree
Avg. Fruit Tree Planting Density	200	trees per acre
Avg. Fruit Tree O&M Cost	$100	per tree

TABLE 8-9: Local Agriculture Data



Fuel CO2 Emission Factor

Gasoline	19.4	lbs/gal
Dissiel	22.2	lbs/gal
Vessel Fuel	3.06	MT/tonne
lb to ton	0.000453592	

Ground Transportation

Vehicle Type	Gross Vehicle Weight	Payload (lbs)	Fuel Type	Fuel Efficiency	
Class 8 Heavy-duty Truck	40000	38000	Diesel	6	miles/gallon
Midsize Truck	14500	13775	Diesel	8	miles/gallon
Light Truck	8600	8170	Gasoline	18	miles/gallon

Source: EPA

Maritime Transportation

Vessel Type	Vessel Size	Payload (MT)	Avg. Fuel Consumption/Yr		Avg. Days on the Sea Per Year
Container Ship (5000 - 8000 TEU)	6500 teu	140400	42100	tonnes	247
Container Ship (3000 - 5000 TEU)	4000 teu	86400	28000	tonnes	250
Container Ship (2000 - 3000 TEU)	2500 teu	54000	17700	tonnes	251
Container Ship (1000 - 2000 TEU)	1500 teu	32400	11100	tonnes	259

Source: International Maritime Organization

Food Miles - Baseline Scenario

Food Sources	Percentage	Food Mileage (Ground Transportation)	Food Mileage (Maritime Transportation)	Avg. Days to Guam*
US (CONUS)	50%	1500	6211	20
US Hawaii	10%	150	3805	12
Australia	20%	600	2100	7
Japan	10%	150	1500	5
Philippines	10%	30	1500	5
Average		***903***	***4206***	***13.6***

Source: Based on desktop research

Food Miles - Local Food Scenario

Food Sources	Percentage	Food Mileage (Ground Transportation)	Food Mileage (Maritime Transportation)	Avg. Days to Guam*
Guam	NA	25	0	0

TABLE 8-10: Fuel CO^2 Emission Factors

AECOM

Attachment A - Building Energy Modeling Summary and LEED NC Scorecard

List of buildings:

- Single Family Dwelling
- Duplex
- BEQ
- 1-Story Office
- 2-Story Headquarters Office
- 3-Story Headquarters Office
- 5-Story Headquarters Office
- Commissary
- Dining Facility
- General Storage Warehouse
- Organic Storage Warehouse
- Workshop
- Day Center
- School

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up.

Energy Requirements

The following document contains summary results for the single family dwelling, in line with the approved requirements of the overall sustainability program. For the single family dwelling, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Single Family	30.5%	18.0%	Baseline

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Baseline). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

Note

The results of this study do not represent a prescriptive list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design t**eam** will have responsibility for the selection of building systems and ECMs to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

AECOM

BUILDING SUMMARY

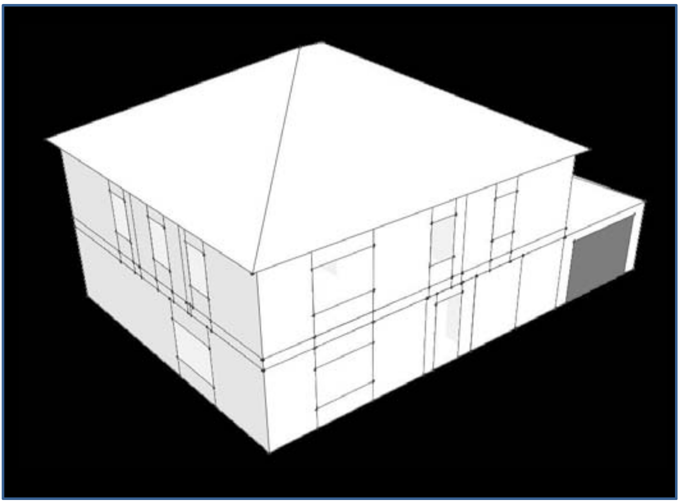
Building Name:	Single Family Dwelling
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Single Family Dwelling in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

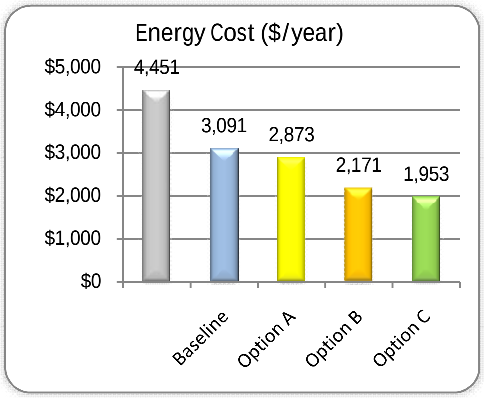
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

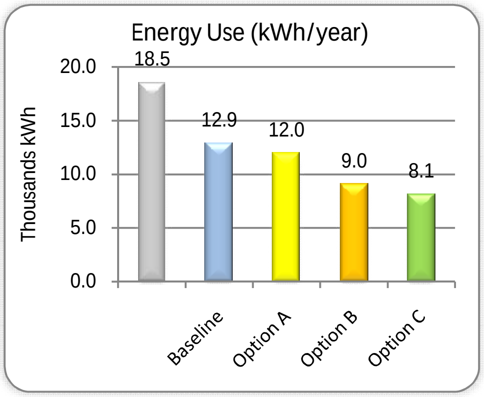


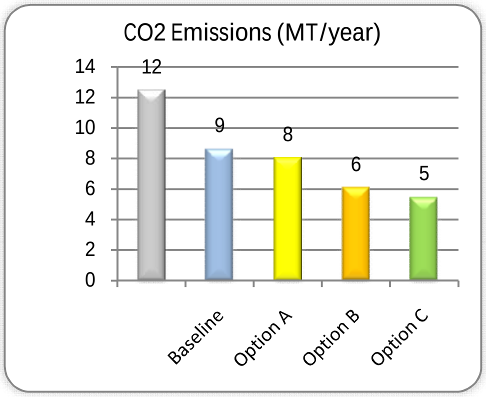
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 51.0 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 12.4 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $2.30/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



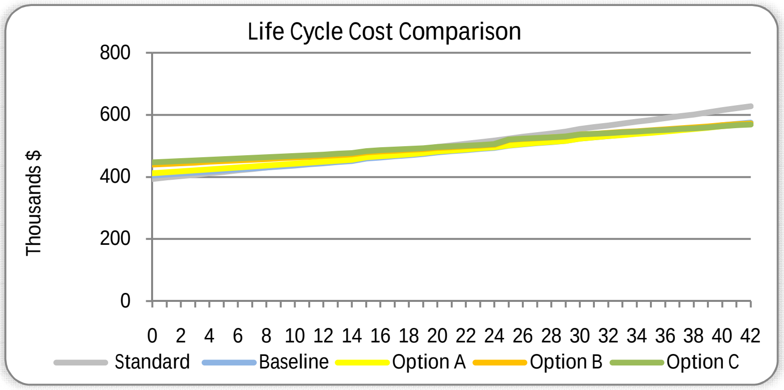




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 8.0 years for the Baseline scenario, 11.2 years for Option A, 19.0 years for Option B and 20.1 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064
Walls	IECC 2009. R3/4 Ins. U=0.1970	IECC 2009. R3/4 Ins. U=0.1970	IECC 2009. R3/4 Ins. U=0.1970	IECC 2009. R10 Ins. U=0.0812	IECC 2009. R10 Ins. U=0.0812
Roof	IECC 2009. R30 Ins. U=0.035	IECC 2009. R30 Ins. U=0.035	IECC 2009. R30 Ins. U=0.035	IECC 2009. R38 Ins. U=0.0269	IECC 2009. R38 Ins. U=0.0269
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	100% Incandescent Fixtures	100% CFL Fixtures	100% CFL Fixtures	100% CFL Fixtures	100% CFL Fixtures
Reduction from Baseline	0%	75%	75%	75%	75%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
SCoP / HSPF	1	1	1	1	1
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Standard Efficiency DX Cooling	High Efficiency DX Cooling	High Efficiency DX Cooling	High Efficiency DX Cooling	High Efficiency DX Cooling
SEER	13.0	15.0	15.0	15.0	15.0
Coolth Recovery Type	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply
Coolth Recovery Efficiency	0%	0%	0%	0%	0%
Delivery Method	Air System	Air System	Air System	Air System	Air System
Hot Water Reduction Measure	Standard Fixtures and Fittings	Standard Fixtures and Fittings	Standard Fixtures and Fittings	Standard Fixtures and Fittings	Standard Fixtures and Fittings
Reduction from Baseline	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Dishwasher	Standard Dishwasher	Energy Star Rated Dishwasher	Energy Star Rated Dishwasher	Energy Star Rated Dishwasher	Energy Star Rated Dishwasher
Refigerator	Standard Refigerator	Energy Star Rated Refigerator	Energy Star Rated Refigerator	Energy Star Rated Refigerator	Energy Star Rated Refigerator
Washer and Dryer	Standard Washing Machine	Energy Star Rated Washing and Dryer	Energy Star Rated Washing and Dryer	Energy Star Rated Washing and Dryer	Energy Star Rated Washing and Dryer
Cooking	Electric Range	Electric Range	Electric Range	Electric Range	Electric Range
Fireplace	No Fireplace	No Fireplace	No Fireplace	No Fireplace	No Fireplace
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	0.5	1.0	1.4	1.9
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	1177.1	294.3	294.3	294.3	294.3
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	8553.2	7201.5	7201.5	5602.8	5602.8
Aux Energy (kWh/year)	1428.6	1372.8	1372.8	951.3	951.3
DHW (kWh/year)	3101.0	1015.3	1015.3	1015.3	1015.3
Receptacle (kWh/year)	3744.3	3357.8	3357.8	3357.8	3357.8
Cooking (kWh/year)	542.2	542.2	542.2	542.2	542.2
Fireplace (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-906.1	-1812.1	-2718.2	-3624.2
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	18546.4	12877.9	11971.9	9045.6	8139.5
Reduction from Baseline (%)	0%	31%	35%	51%	56%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Electricity Use (kWh)	18546.4	12877.9	11971.9	9045.6	8139.5
Reduction from Baseline (%)	0%	31%	35%	51%	56%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	61945.0	43012.3	39986.1	30212.3	27186.1
Reduction from Baseline (%)	0%	31%	35%	51%	56%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Total (kWh)	61945.0	43012.3	39986.1	30212.3	27186.1
Reduction from Baseline (%)	0%	31%	35%	51%	56%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-217.5	-434.9	-652.4	-869.8
% of Building Energy Cost	0%	6%	12%	20%	27%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	-452.5	-452.5	-452.5	-452.5
% of Building Energy Cost	0%	12%	12%	14%	14%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	12.4	8.6	8.0	6.1	5.5
Reduction from Baseline (%)	0%	31%	35%	51%	56%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-0.6	-1.2	-1.8	-2.4
Proportion of Total (%)	0%	7%	13%	23%	31%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

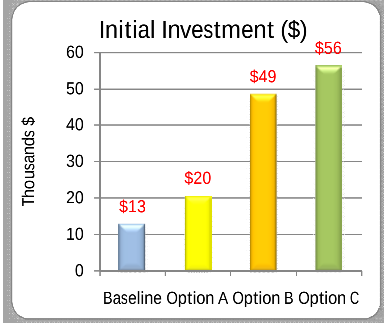
Total CO_2 Emissions (MT/yr)	12.4	8.6	8.0	6.1	5.5
Reduction from Baseline (%)	0%	31%	35%	51%	56%

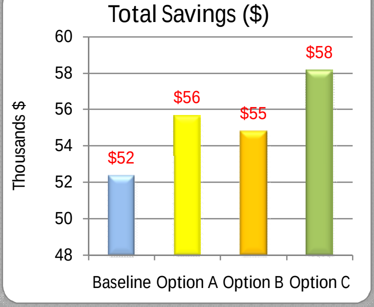
Energy Cost Summary

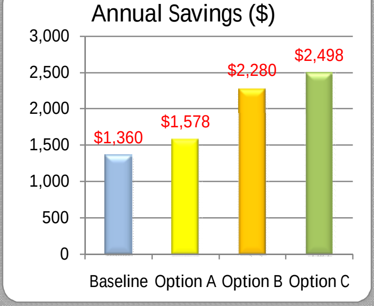
Electricity Cost ($/sq ft)	2.30	1.60	1.48	1.12	1.01
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	2.30	1.60	1.48	1.12	1.01
Reduction from Baseline (%)	0%	31%	35%	51%	56%
Simple Payback (Years)	-	9.3	13.0	21.3	22.5

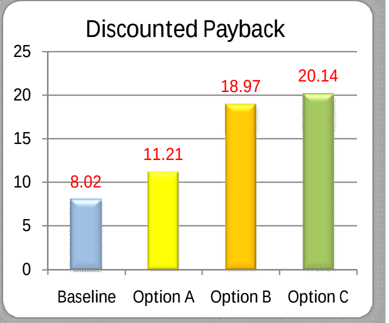
$/sq ft/kg of CO2 Emissions reduction	-	1725.82	2391.80	3932.19	4160.82

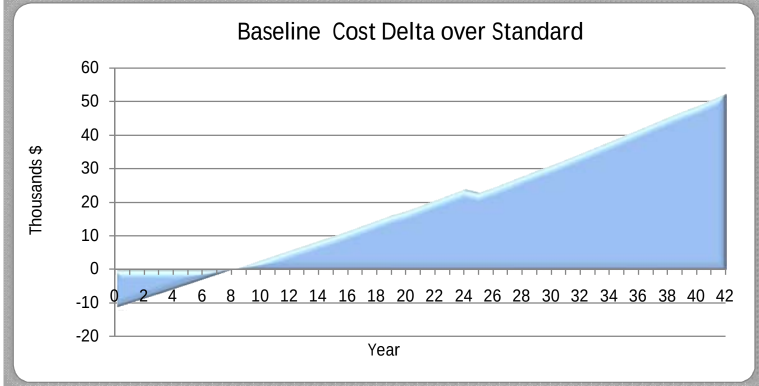
LIFE CYCLE COSTING

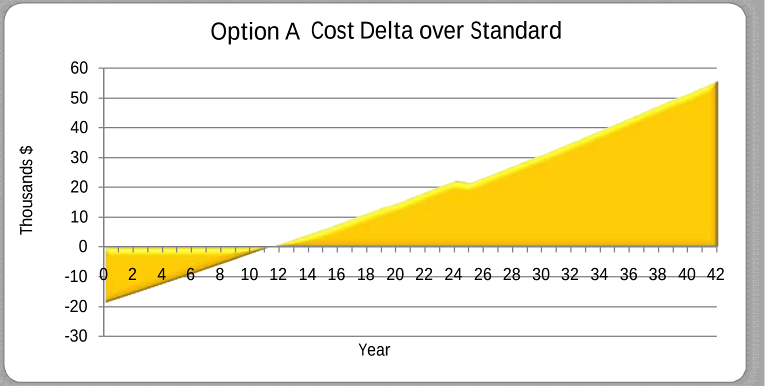

Initial Investment ($)

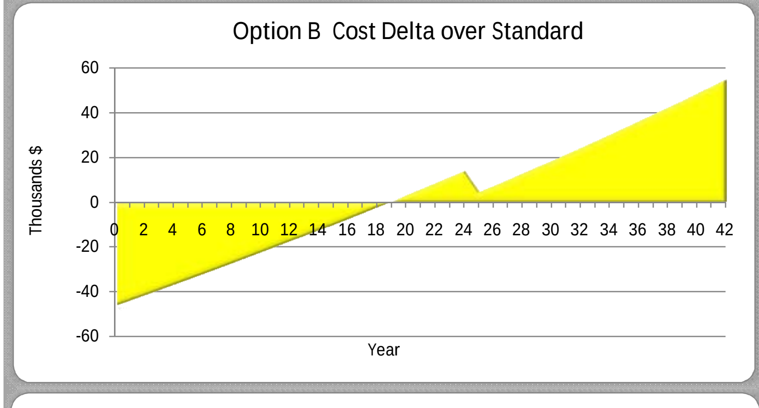

Total Savings ($)

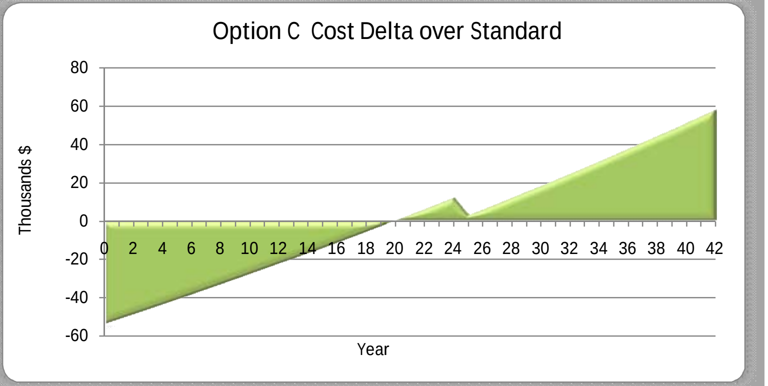

Annual Savings ($)

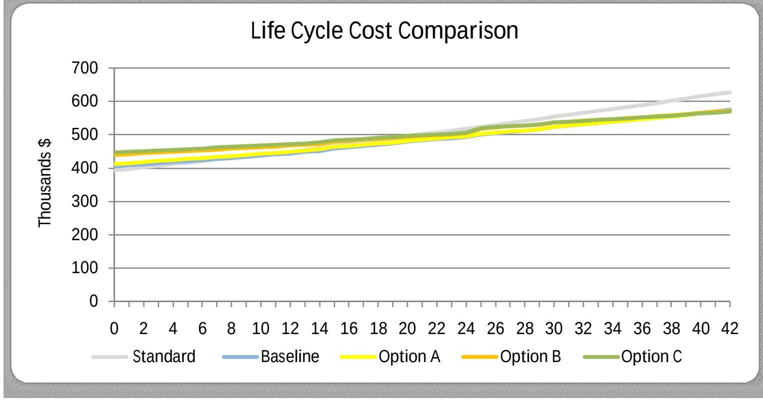

Discounted Payback

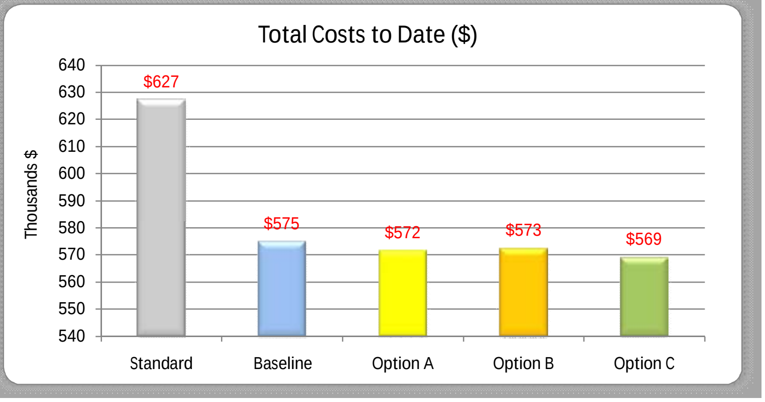

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

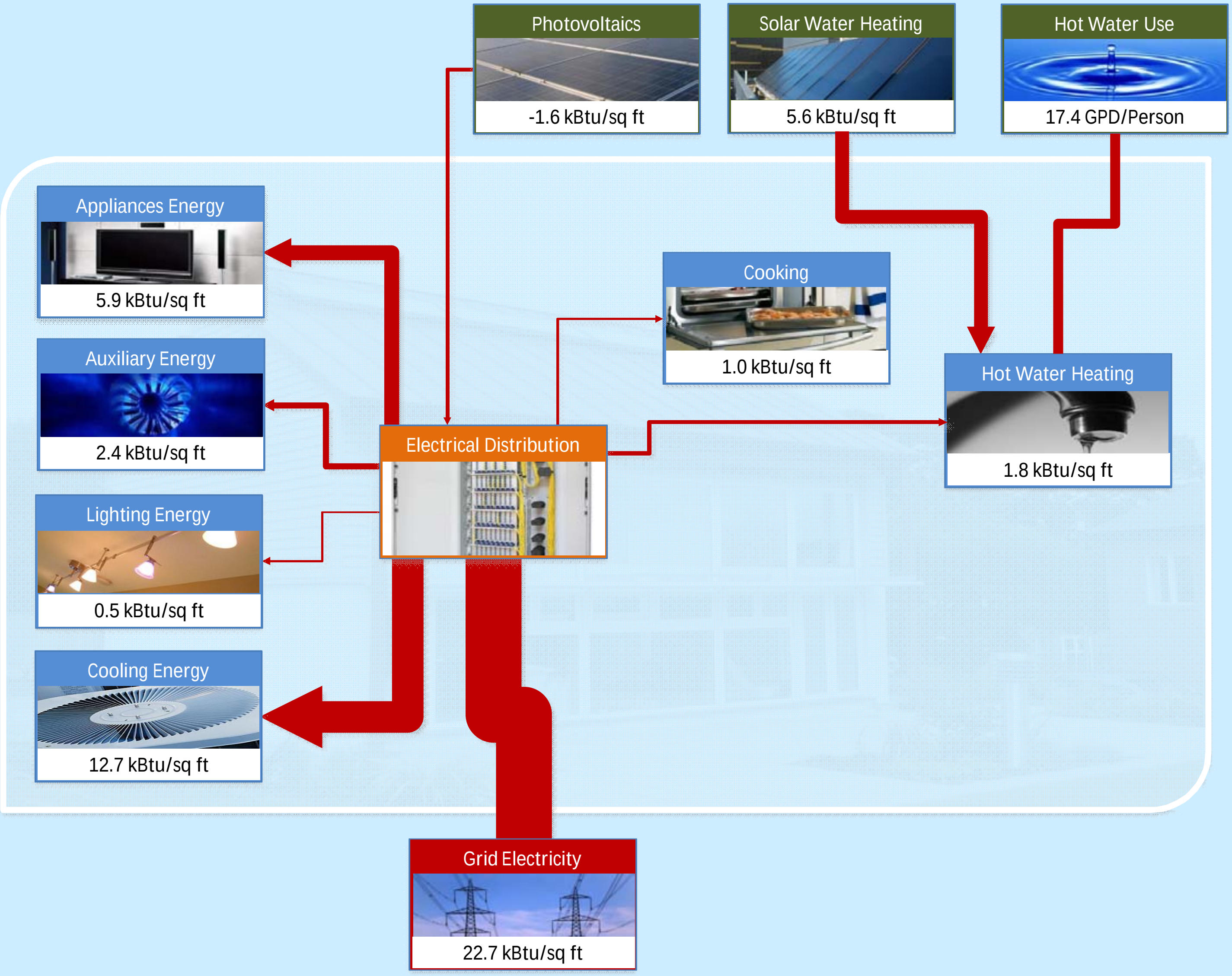

Option B Cost Delta over Standard


Option C Cost Delta over Standard

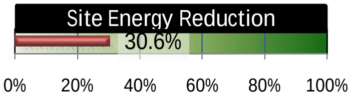

Life Cycle Cost Comparison

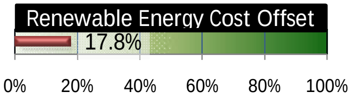

Total Costs to Date ($)

ENERGY FLOW DIAGRAM



PERFORMANCE INDICATORS





ENERGY USE

22.7 kBtu/sqft

6.7 kWh/sqft

COST INFORMATION

$1.60/sq ft Energy Cost/DU

8.0 yrs Disc. Payback from Standard

BUILDING DATA

Single Family Dwelling
GJMMP, Guam
1,936 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Single Family Dwelling
Baseline Energy Model Flows

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up.

Energy Requirements

The following document contains summary results for the duplex dwelling, in line with the approved requirements of the overall sustainability program. For the duplex dwelling, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Duplex	34.0%	22.0%	Baseline

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Baseline). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

Note

The results of this study do not represent a prescriptive list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design t**eam** will have responsibility for the selection of building systems and ECMs to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

AECOM

BUILDING SUMMARY

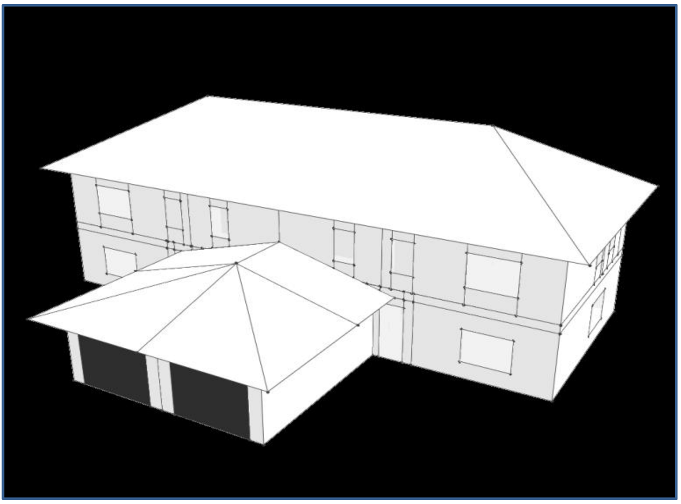
Building Name:	Duplex
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Duplex in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

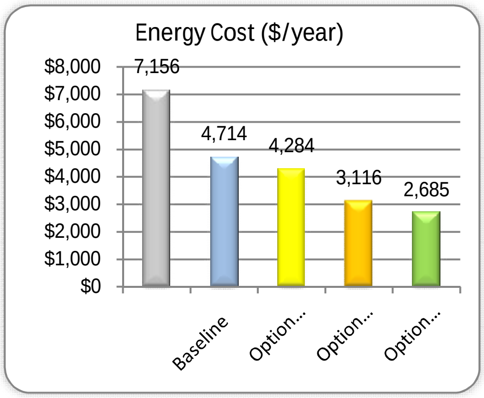
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

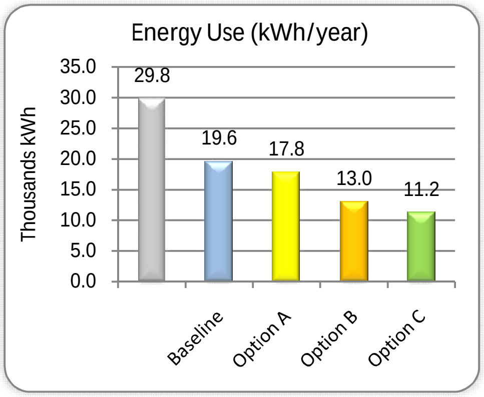


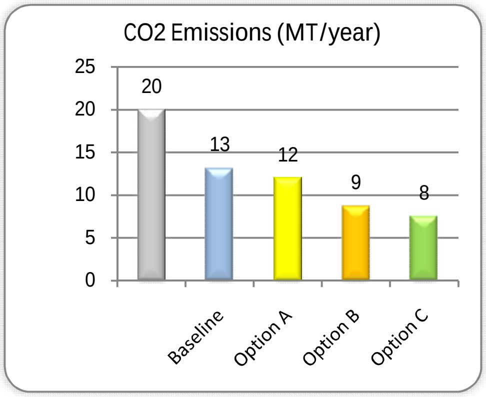
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 41.4 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 20.0 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $2.21/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



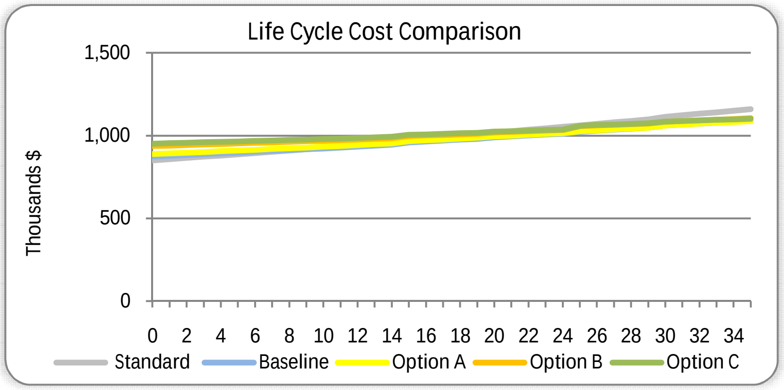




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the baseline standard scenerio.

Analysis indicates that discounted payback will be achieved in 8.5 years for the Baseline scenario, 12.2 years for Option A, 20.0 years for Option B and 21.1 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064	IECC 2009. R13 Ins. U=0.064
Walls	IECC 2009. R3/4 Ins. U=0.1970	IECC 2009. R3/4 Ins. U=0.1970	IECC 2009. R3/4 Ins. U=0.1970	IECC 2009. R10 Ins. U=0.0812	IECC 2009. R10 Ins. U=0.0812
Roof	IECC 2009. R30 Ins. U=0.035	IECC 2009. R30 Ins. U=0.035	IECC 2009. R30 Ins. U=0.035	IECC 2009. R38 Ins. U=0.0269	IECC 2009. R38 Ins. U=0.0269
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	100% Incandescent Fixtures	100% CFL Fixtures	100% CFL Fixtures	100% CFL Fixtures	100% CFL Fixtures
Reduction from Standard	0%	75%	75%	75%	75%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
SCoP / HSPF	1	1	1	1	1
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Standard Efficiency DX Cooling	High Efficiency DX Cooling	High Efficiency DX Cooling	High Efficiency DX Cooling	High Efficiency DX Cooling
SEER	13.0	15.0	15.0	15.0	15.0
Coolth Recovery Type	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply	No Dedicated Outside Air Supply
Coolth Recovery Efficiency	0%	0%	0%	0%	0%
Delivery Method	Air System	Air System	Air System	Air System	Air System
Hot Water Reduction Measure	Standard Fixtures and Fittings	Standard Fixtures and Fittings	Standard Fixtures and Fittings	Standard Fixtures and Fittings	Standard Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Dishwasher	Standard Dishwasher	Energy Star Rated Dishwasher	Energy Star Rated Dishwasher	Energy Star Rated Dishwasher	Energy Star Rated Dishwasher
Refigerator	Standard Refigerator	Energy Star Rated Refigerator	Energy Star Rated Refigerator	Energy Star Rated Refigerator	Energy Star Rated Refigerator
Washer and Dryer	Standard Washing Machine	Energy Star Rated Washing and Dryer	Energy Star Rated Washing and Dryer	Energy Star Rated Washing and Dryer	Energy Star Rated Washing and Dryer
Cooking	Electric Range	Electric Range	Electric Range	Electric Range	Electric Range
Fireplace	No Fireplace	No Fireplace	No Fireplace	No Fireplace	No Fireplace
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	1.0	1.9	2.9	3.8
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	1829.9	457.5	457.5	457.5	457.5
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	13044.0	10976.4	10976.4	8545.8	8545.8
Aux Energy (kWh/year)	2176.9	2090.3	2090.3	1449.5	1449.5
DHW (kWh/year)	6202.0	2030.6	2030.6	2030.6	2030.6
Receptacle (kWh/year)	5477.4	4799.7	4799.7	4799.7	4799.7
Cooking (kWh/year)	1084.4	1084.4	1084.4	1084.4	1084.4
Fireplace (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-1795.2	-3590.5	-5385.7	-7181.0
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	29814.7	19643.7	17848.4	12981.8	11186.6
Reduction from Standard (%)	0%	34%	40%	56%	62%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Electricity Use (kWh)	29814.7	19643.7	17848.4	12981.8	11186.6
Reduction from Standard (%)	0%	34%	40%	56%	62%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	99581.1	65609.9	59613.8	43359.3	37363.2
Reduction from Standard (%)	0%	34%	40%	56%	62%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	99581.1	65609.9	59613.8	43359.3	37363.2
Reduction from Standard (%)	0%	34%	40%	56%	62%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-430.9	-861.7	-1292.6	-1723.4
% of Building Energy Cost	0%	7%	14%	24%	32%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	-905.1	-905.1	-905.1	-905.1
% of Building Energy Cost	0%	15%	15%	17%	17%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	20.0	13.2	12.0	8.7	7.5
Reduction from Standard (%)	0%	34%	40%	56%	62%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-1.2	-2.4	-3.6	-4.8
Proportion of Total (%)	0%	8%	17%	29%	39%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

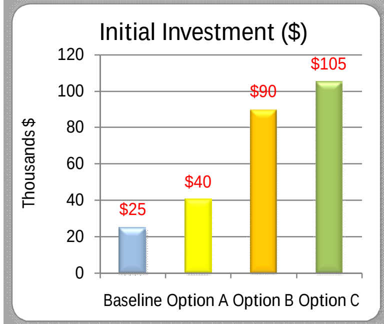
Total CO_2 Emissions (MT/yr)	20.0	13.2	12.0	8.7	7.5
Reduction from Standard (%)	0%	34%	40%	56%	62%

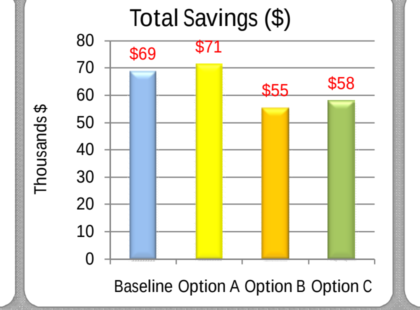
Energy Cost Summary

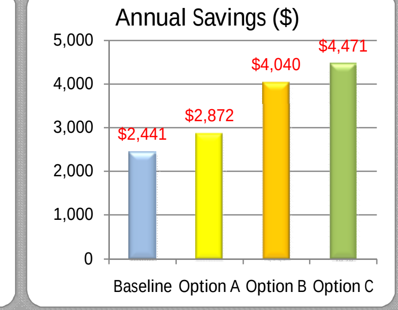
Electricity Cost ($/sq ft)	2.21	1.46	1.33	0.96	0.83
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	2.21	1.46	1.33	0.96	0.83
Reduction from Standard (%)	0%	34%	40%	56%	62%
Simple Payback (Years)	-	10.2	14.0	22.2	23.5

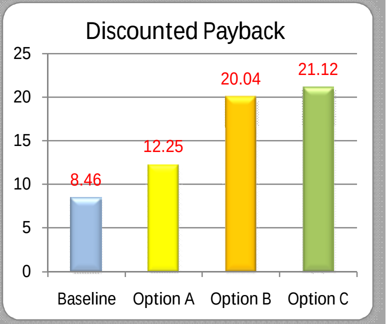
$/sq ft/kg of CO2 Emissions reduction	-	1132.82	1552.38	2458.80	2600.53

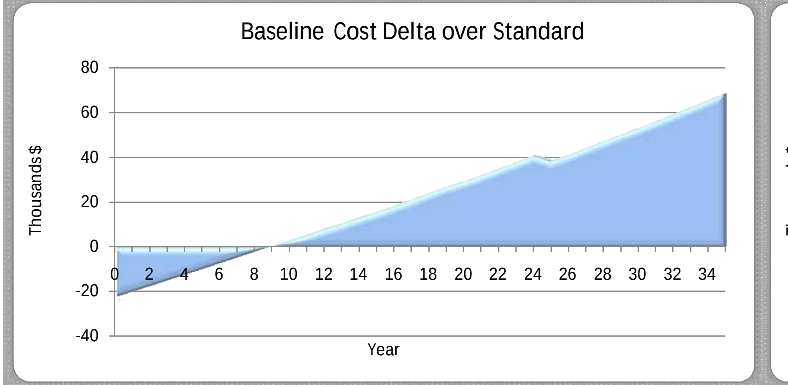
LIFE CYCLE COSTING

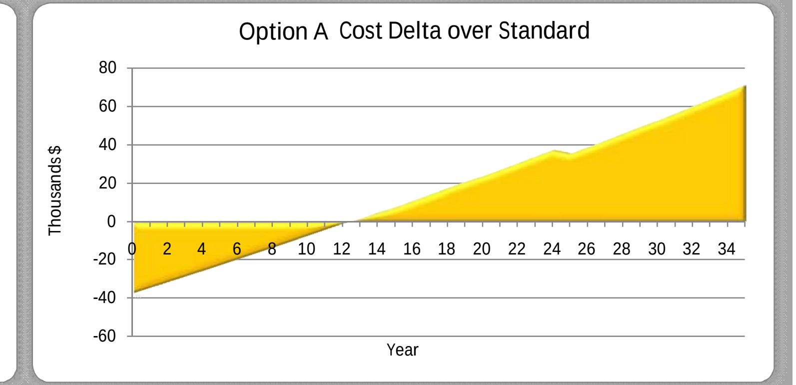

Initial Investment ($)

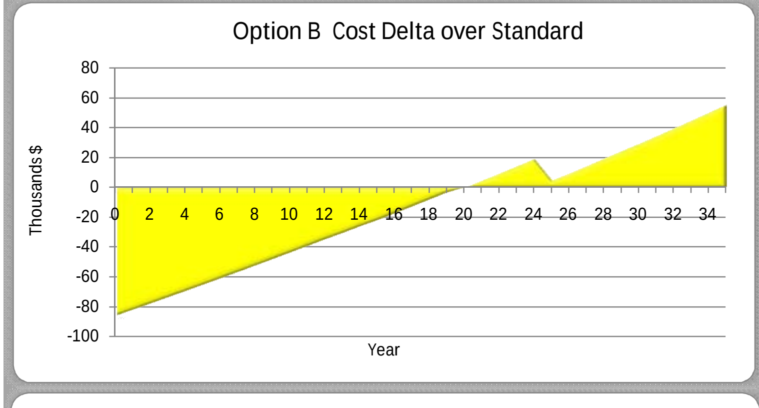

Total Savings ($)

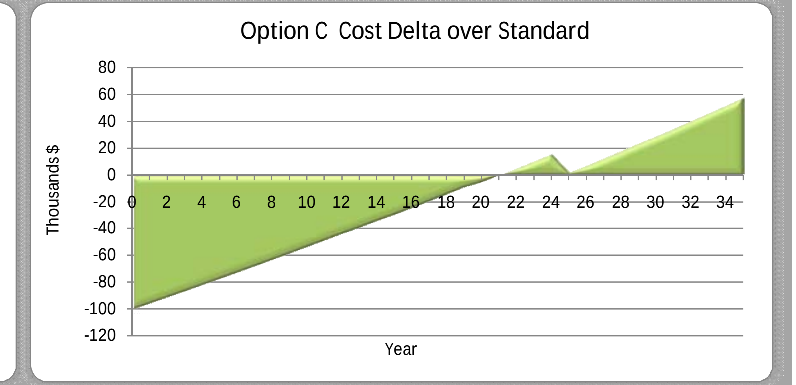

Annual Savings ($)

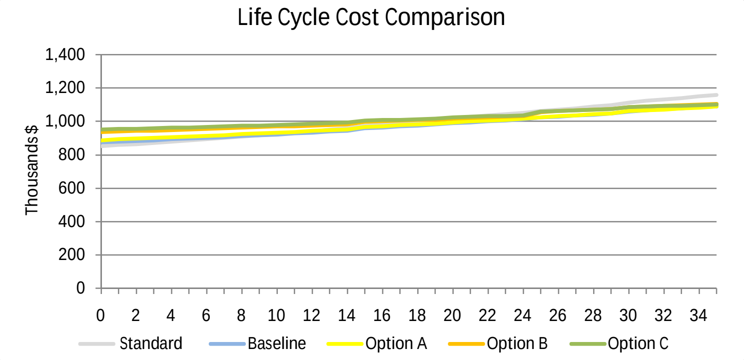

Discounted Payback

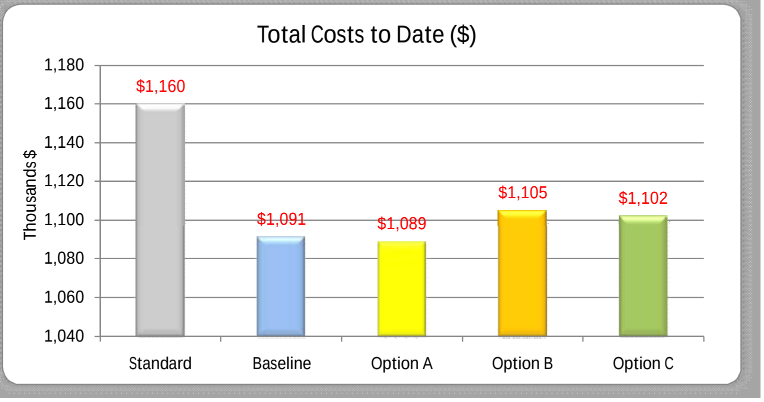

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

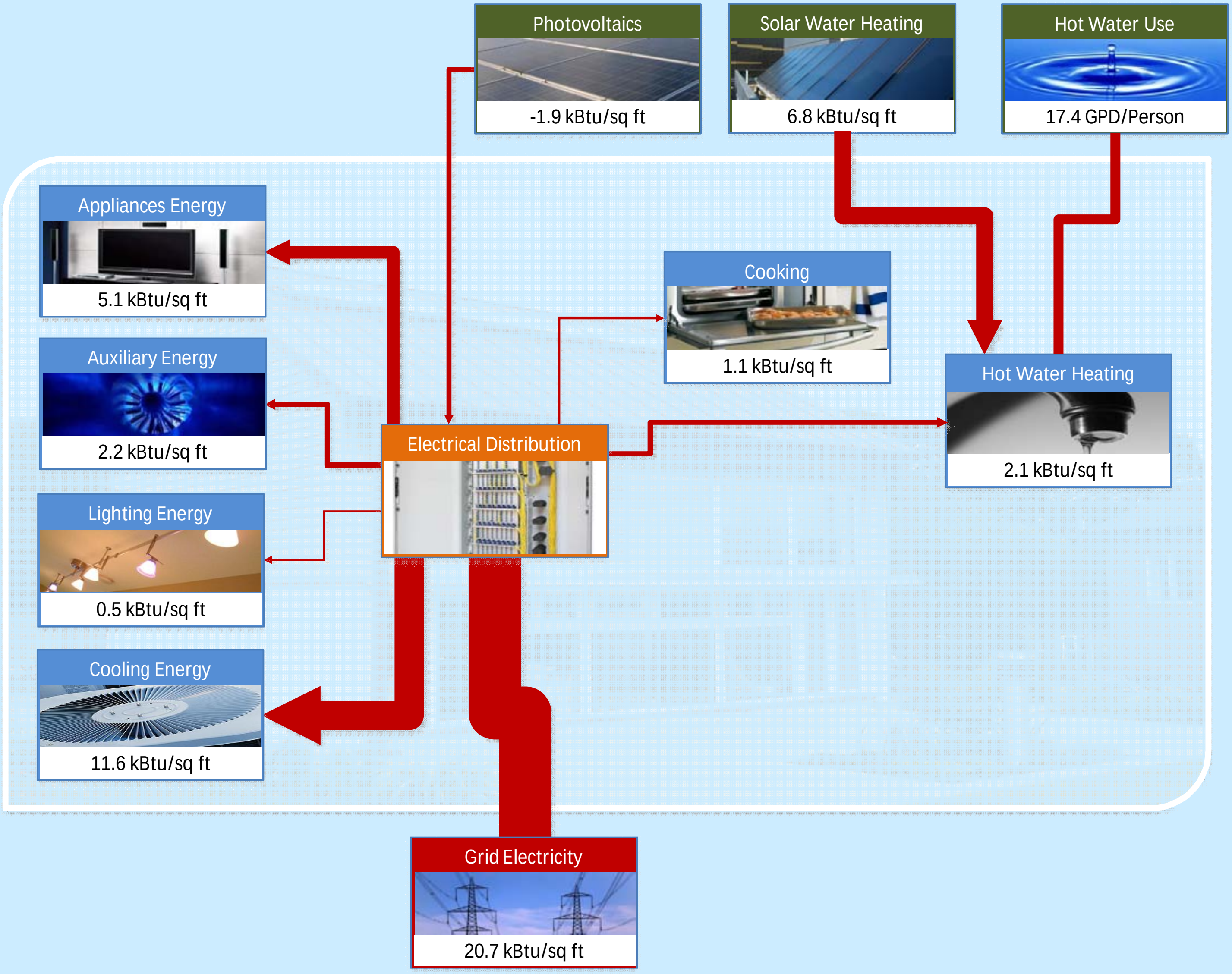

Option B Cost Delta over Standard


Option C Cost Delta over Standard

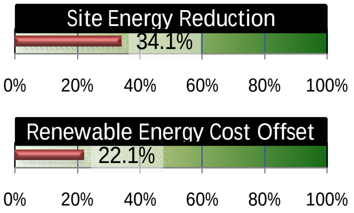

Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



PERFORMANCE INDICATORS



ENERGY USE

20.7 kBtu/sqft

6.1 kWh/sqft

COST INFORMATION

$1.46/sq ft Energy Cost/DU

8.5 yrs Disc. Payback

BUILDING DATA

Duplex
GJMMP, Guam
3,232 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Duplex
Baseline Energy Model Flows

AECOM

SSIME SUMMARY REPORT

Guam JMMP Sustainability Program Summary Report

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the BEQ, in line with the approved requirements of the overall sustainability program. For the BEQ, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
BEQ - 6 Story 300 Occupant	46.5%	15.5%	Option C

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option C). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
BEQ - 6 Story 300 Occupant	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

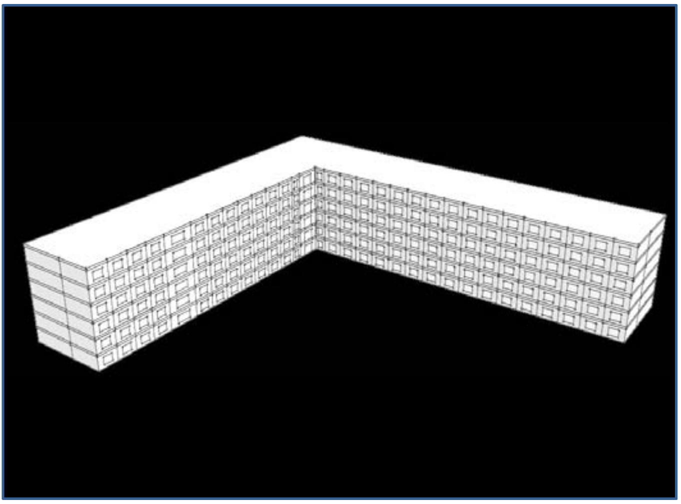
SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

Building Name:	BEQ - 6 Story 300 Occupant
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe



AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the BEQ - 6 Story 300 Occupant in GJMMP, Guam.

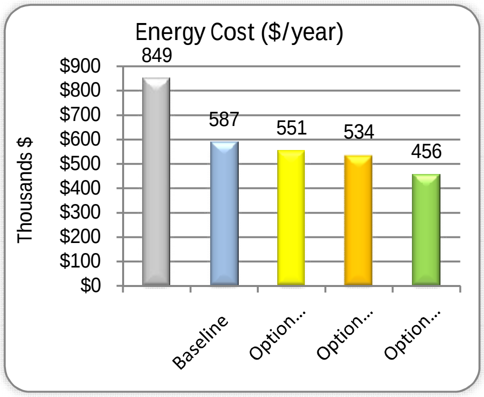
Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

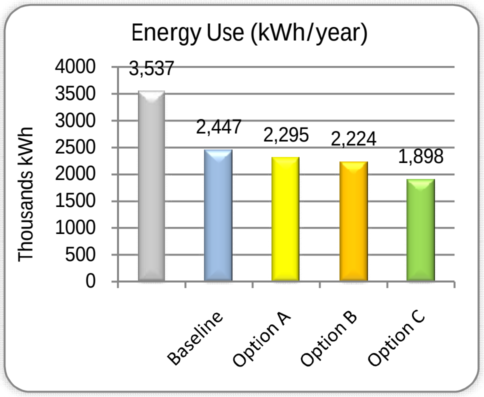
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

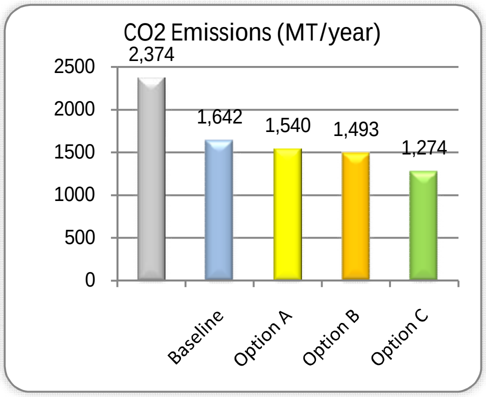
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 49.4 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 2373.7 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $3.47/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



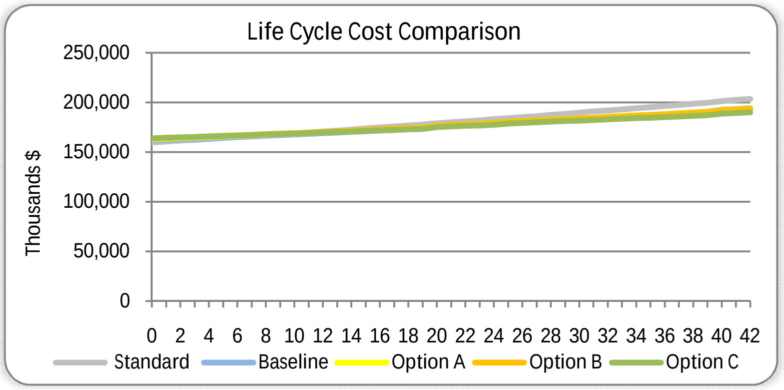




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 6.2 years for the Baseline scenario, 10.0 years for Option A, 11.2 years for Option B and 9.8 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	Compact T8 Fixtures. ASHRAE 90.1 LPD	Compact T8 Fixtures. ASHRAE 90.1 LPD	Compact T8 Fixtures. ASHRAE 90.1 LPD	Compact T8 Fixtures. ASHRAE 90.1 LPD	Compact T8 Fixtures. ASHRAE 90.1 LPD
Reduction from Standard	0%	0%	0%	0%	0%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	PTAC Units with DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers	High Eff. Water Cooled Centrifugal Chillers
SEER (If Packaged) COP (Central Plant)	11.1	4.5	4.5	4.5	6.4
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Constant Volume System	Local Fan Coil Units	Local Fan Coil Units	Local Fan Coil Units	Local Fan Coil Units
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	LEED-NC v3 Fixtures and Fittings	LEED-NC v3 Fixtures and Fittings	LEED-NC v3 Fixtures and Fittings	LEED-NC v3 Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction	0% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	HID Exterior Lighting	HID Exterior Lighting	HID Exterior Lighting	HID Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	5.00 W/sq ft	5.00 W/sq ft	5.00 W/sq ft	5.00 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	15.8	79.2	118.7	118.7
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	661763.3	661763.3	661763.3	661763.3	661763.3
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	1624711.2	1107062.2	1072950.0	1072950.0	746952.9
Auxiliary Energy (kWh/year)	563968.8	176389.5	170215.3	170215.3	170091.5
DHW (kWh/year)	232574.0	76149.2	76149.2	76149.2	76149.2
Exterior Lighting (kWh/year)	0	0	0	0	0
Equipment (kWh/year)	453553.7	453553.7	453553.7	453553.7	453553.7
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-28021.3	-140106.5	-210159.7	-210159.7
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	3536571.0	2446896.6	2294525.1	2224471.9	1898351.0
Reduction from Standard (%)	0%	31%	35%	37%	46%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	3536571.0	2446896.6	2294525.1	2224471.9	1898351.0
Reduction from Standard (%)	0%	31%	35%	37%	46%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	11812147.3	8172634.7	7663713.8	7429736.1	6340492.3
Reduction from Standard (%)	0%	31%	35%	37%	46%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	11812147.3	8172634.7	7663713.8	7429736.1	6340492.3
Reduction from Standard (%)	0%	31%	35%	37%	46%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-6725.1	-33625.5	-50438.3	-50438.3
% of Building Energy Cost	0%	1%	5%	8%	9%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	-33940.8	-33940.8	-33940.8	-33940.8
% of Building Energy Cost	0%	5%	5%	5%	6%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	2373.7	1642.3	1540.0	1493.0	1274.1
Reduction from Standard (%)	0%	31%	35%	37%	46%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-18.8	-94.0	-141.1	-141.1
Proportion of Total (%)	0%	1%	6%	9%	10%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

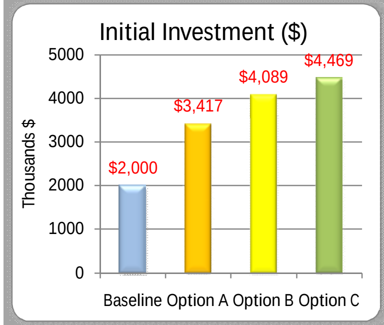
Total CO_2 Emissions (MT/yr)	2373.7	1642.3	1540.0	1493.0	1274.1
Reduction from Standard (%)	0%	31%	35%	37%	46%

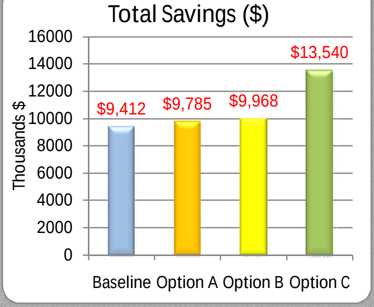
Energy Cost Summary

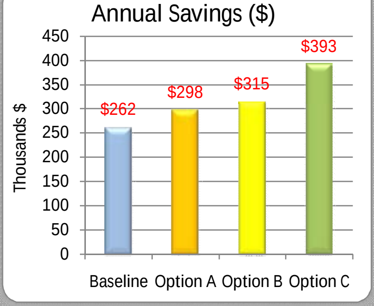
Electricity Cost ($/sq ft)	3.47	2.40	2.25	2.19	1.86
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	3.47	2.40	2.25	2.19	1.86
Reduction from Standard (%)	0%	31%	35%	37%	46%
Simple Payback (Years)	-	7.6	11.5	13.0	11.4

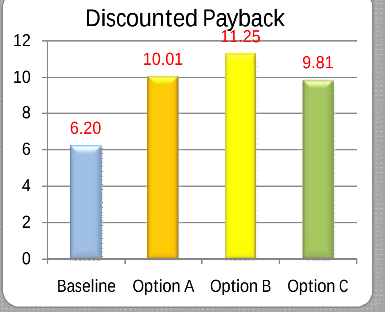
$/sq ft/kg of CO2 Emissions reduction	-	11.19	16.78	19.00	16.64

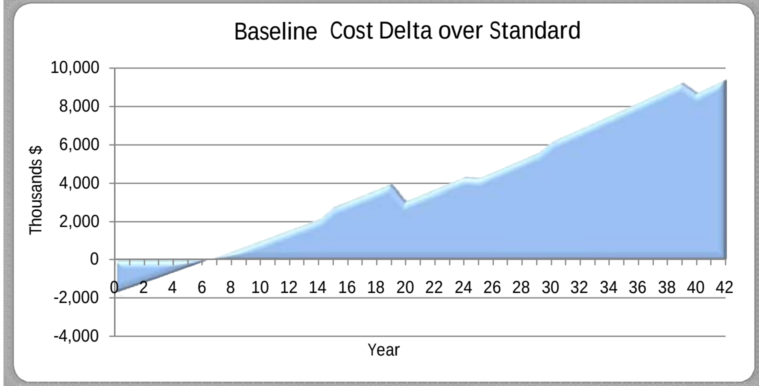
LIFE CYCLE COSTING

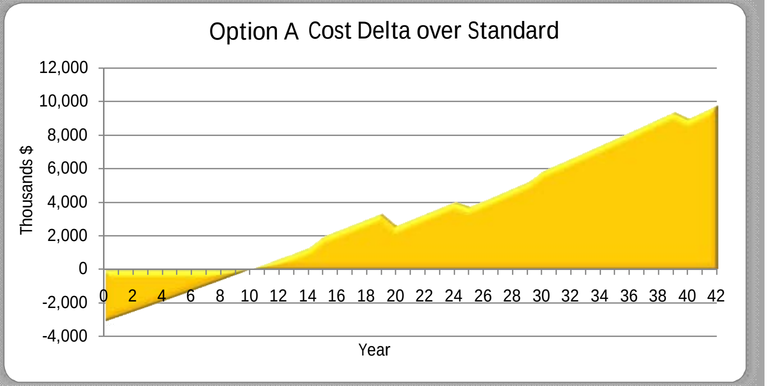

Initial Investment ($)

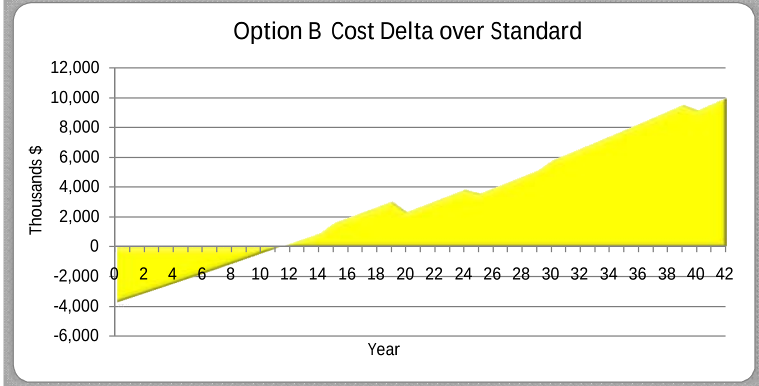

Total Savings ($)

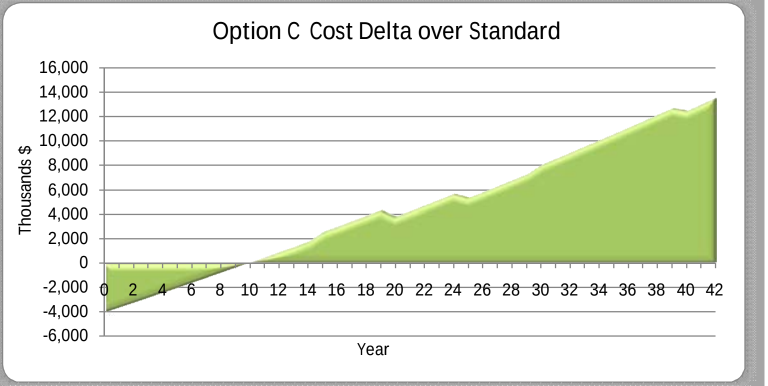

Annual Savings ($)

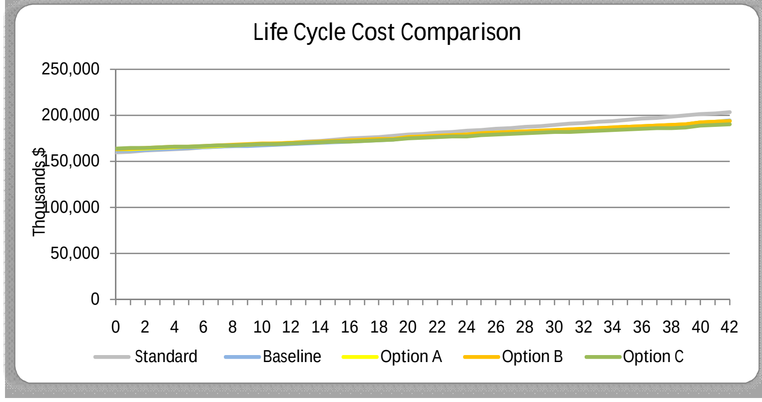

Discounted Payback

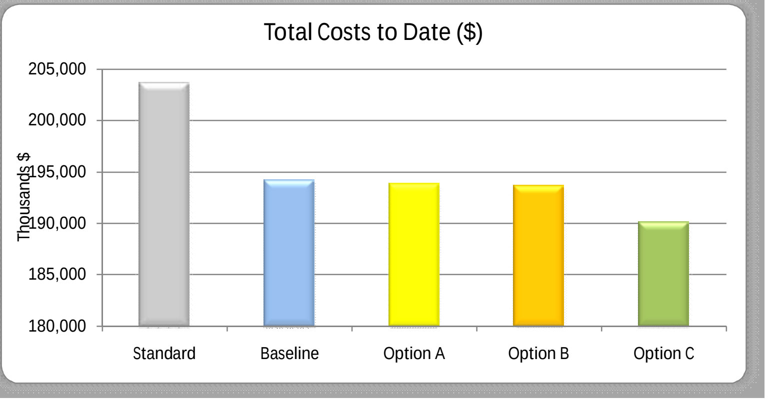

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

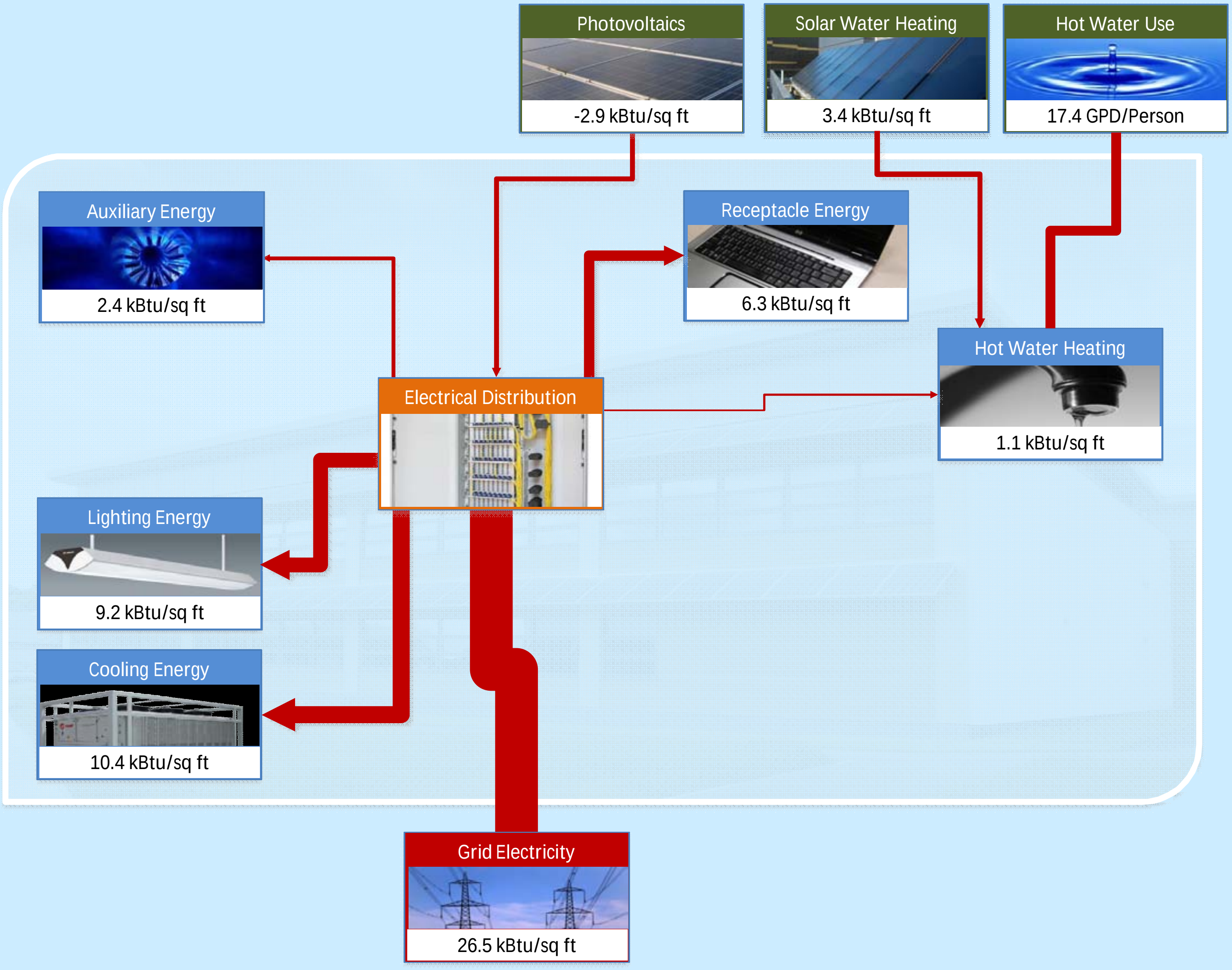

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Photovoltaics
-2.9 kBtu/sq ft

Solar Water Heating
3.4 kBtu/sq ft

Hot Water Use
17.4 GPD/Person

Auxiliary Energy
2.4 kBtu/sq ft

Receptacle Energy
6.3 kBtu/sq ft

Hot Water Heating
1.1 kBtu/sq ft

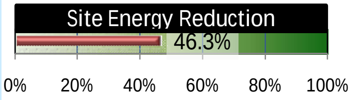
Electrical Distribution

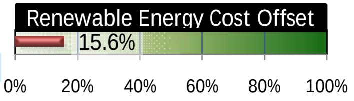
Lighting Energy
9.2 kBtu/sq ft

Cooling Energy
10.4 kBtu/sq ft

Grid Electricity
26.5 kBtu/sq ft

PERFORMANCE INDICATORS





LEED

LEED-NC

EA1	18	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: 69.5% ✓

EPAct compliant ✓

ENERGY USE

26.5 kBtu/sqft

7.8 kWh/sqft

COST INFORMATION

$1.86/sq ft Energy Cost

9.8 yrs Disc. Payback from Standard

BUILDING DATA

BEQ - 6 Story 300 Occupant
GJMMP, Guam
244,311 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

BEQ - 6 Story 300 Occupant Option C Energy Model Flows

AECOM

OPTION A SCORECARD

Name	BEQ
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Gold

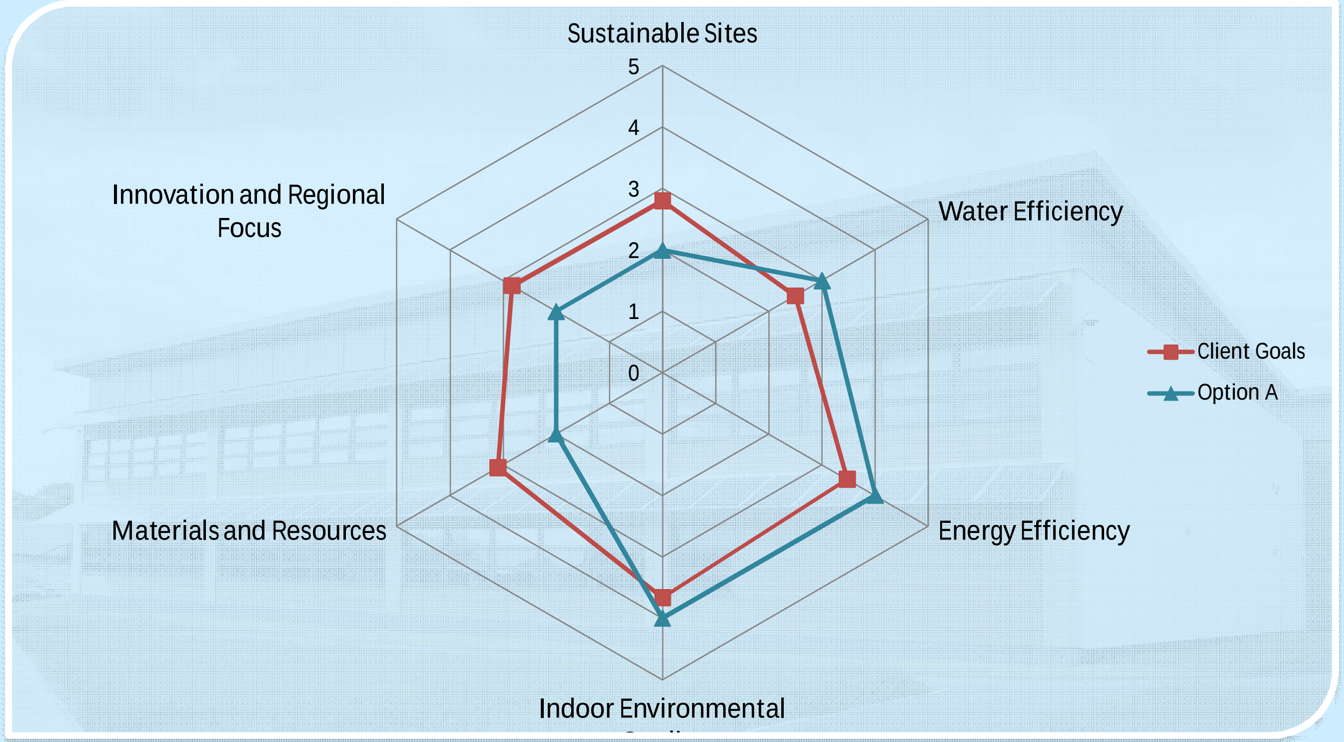
Y	?	N	
63	0	46	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Sustainable Sites
12	0	14		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3		Water Efficiency
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction
28	0	7		Energy and Atmosphere
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
18	0	1	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power
0	0	4		Regional Importance
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

Y	?	N	Credit	Materials and Resources
3	0	11		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
10	0	5		Indoor Environmental Quality
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
1	0	0	EQc8.2	Daylight & Views, Views for 90% of Spaces
4	0	2		Innovation in Design
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

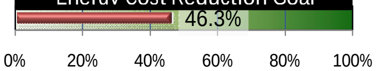
SUSTAINABILITY KPIs



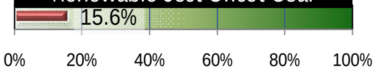
Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
				
100%	30%	75%	10%	0%

PERFORMANCE INDICATORS

Energy Cost Reduction Goal



Renewable Cost Offset Goal



LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	28	out of 35 potential points
MR	3	out of 14 potential points
EQ	10	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

LEED GOLD

BUILDING DATA

BEQ
Guam
244,311 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

BEQ
Option A Sustainability KPIs

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the 1 Story Small Office building, in line with the approved requirements of the overall sustainability program. For the 1 Story Small Office building, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
1 Story Small Office	43.0%	20.5%	Option A

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option A). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
1 Story Small Office	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design team will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

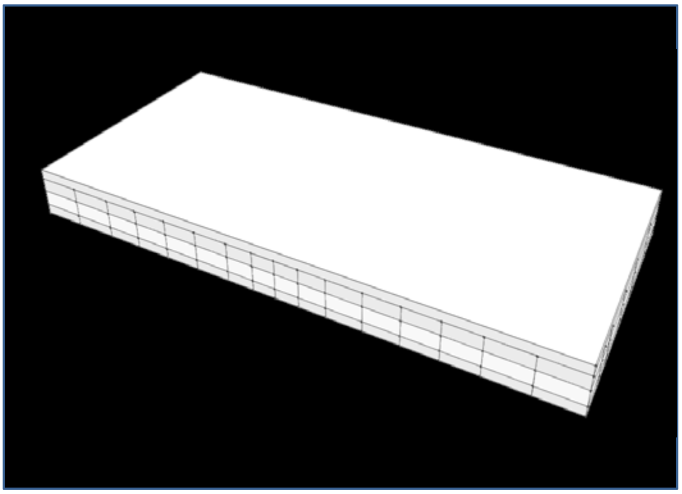
Building Name:	1 Story Small Office
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the 1 Story Small Office in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

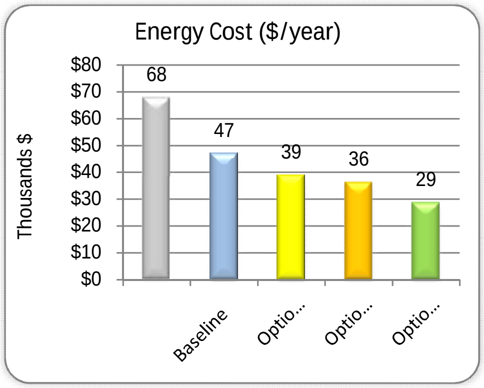
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

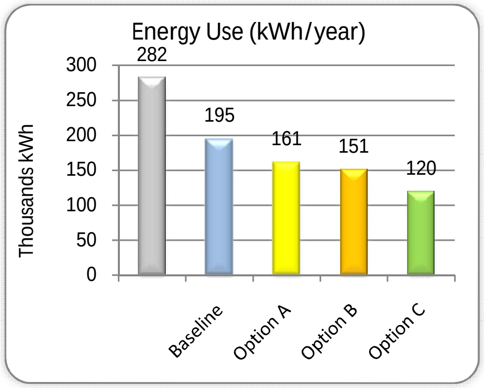


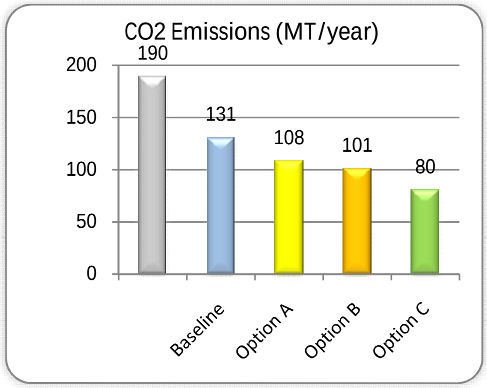
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 63.6 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 189.5 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $4.48/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



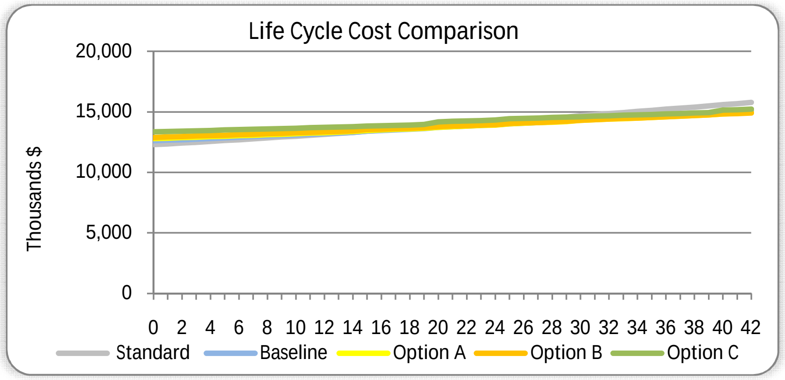




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 14.2 years for the Baseline scenario, 16.4 years for Option A, 18.0 years for Option B and 29.1 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	14.9	4.5
Coolth Recovery Type	No Coolth Recovery	No Coolth Recovery	No Coolth Recovery	No Coolth Recovery	No Coolth Recovery
Coolth Recovery Efficiency	0%	0%	0%	0%	0%
Delivery Method	Constant Volume System	Constant Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage
Heating Efficiency	87%	87%	87%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	17.7	23.5	29.4	44.1
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	61517.9	48599.1	48599.1	48599.1	48599.1
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	117692.8	81925.3	78382.6	78382.6	73085.1
Auxiliary Energy (kWh/year)	35257.4	35087.3	15596.3	15596.3	15765.3
DHW (kWh/year)	5925.9	4859.2	4859.2	4545.7	4545.7
Exterior Lighting (kWh/year)	9636	3372.6	3372.6	3372.6	3372.6
Equipment (kWh/year)	52361.6	52361.6	52361.6	52361.6	52361.6
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-31254.3	-41672.4	-52090.5	-78135.7
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	282391.5	194950.9	161499.1	150767.5	119593.8
Reduction from Standard (%)	0%	31%	43%	47%	58%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	282391.5	194950.9	161499.1	150767.5	119593.8
Reduction from Standard (%)	0%	31%	43%	47%	58%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	943187.7	651135.9	539406.9	503563.4	399443.2
Reduction from Standard (%)	0%	31%	43%	47%	58%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	943187.7	651135.9	539406.9	503563.4	399443.2
Reduction from Standard (%)	0%	31%	43%	47%	58%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-7501.0	-10001.4	-12501.7	-18752.6
% of Building Energy Cost	0%	14%	21%	26%	40%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%

Carbon Summary

Net Electricity CO$_2$ Emissions (MT/yr)	189.5	130.8	108.4	101.2	80.3
Reduction from Standard (%)	0%	31%	43%	47%	58%

Gas CO$_2$ Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO$_2$ Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO$_2$ Offset (MT/yr)	0.0	-21.0	-28.0	-35.0	-52.4
Proportion of Total (%)	0%	14%	21%	26%	40%

Wind Gen CO$_2$ Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

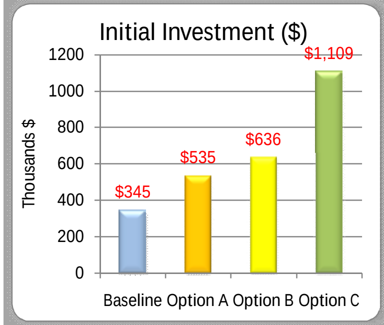
Total CO$_2$ Emissions (MT/yr)	189.5	130.8	108.4	101.2	80.3
Reduction from Standard (%)	0%	31%	43%	47%	58%

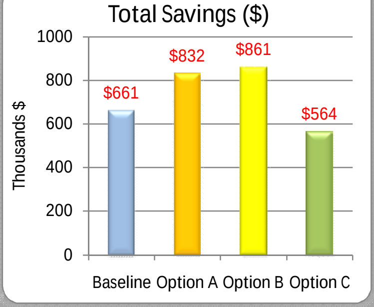
Energy Cost Summary

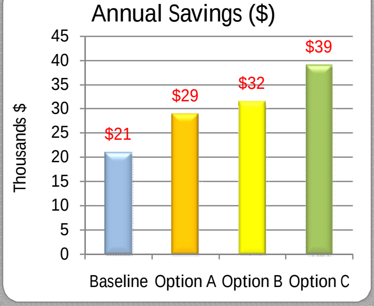
Electricity Cost ($/sq ft)	4.48	3.09	2.56	2.39	1.90
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	4.48	3.09	2.56	2.39	1.90
Reduction from Standard (%)	0%	31%	43%	47%	58%
Simple Payback (Years)	-	16.5	18.4	20.1	28.4

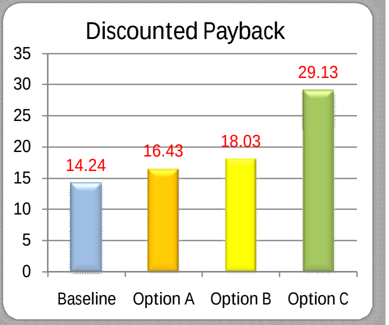
$/sq ft/kg of CO2 Emissions reduction	-	388.59	435.61	475.31	670.35

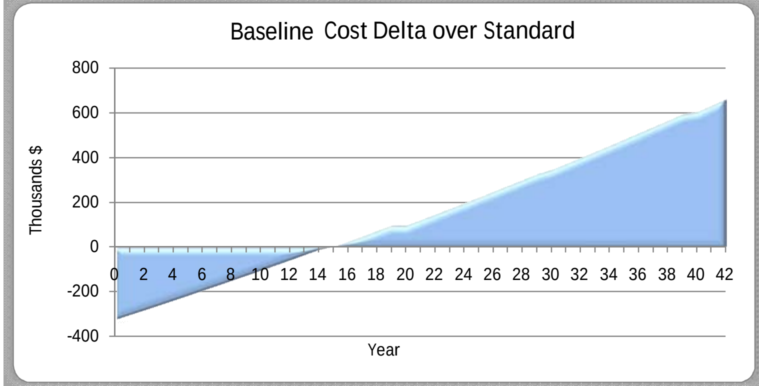
LIFE CYCLE COSTING

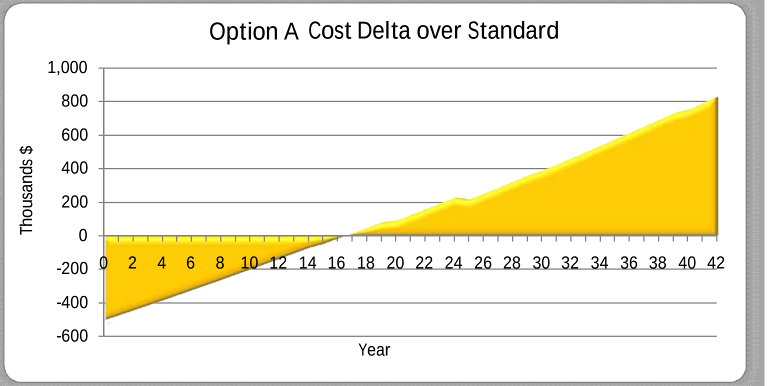

Initial Investment ($)

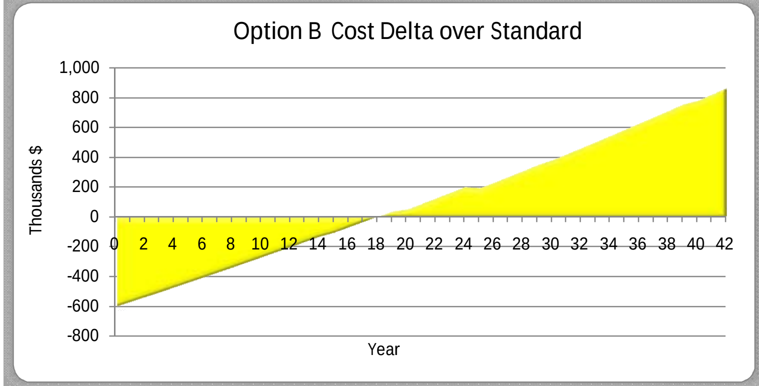

Total Savings ($)

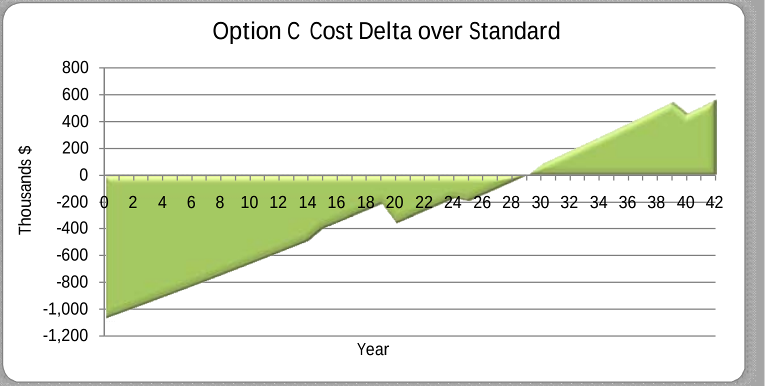

Annual Savings ($)

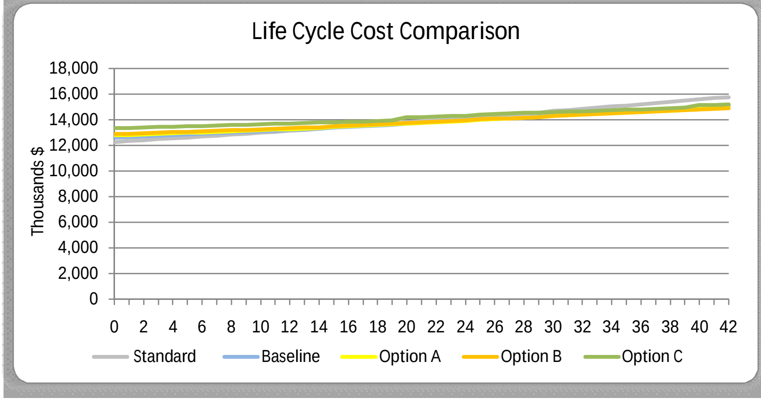

Discounted Payback

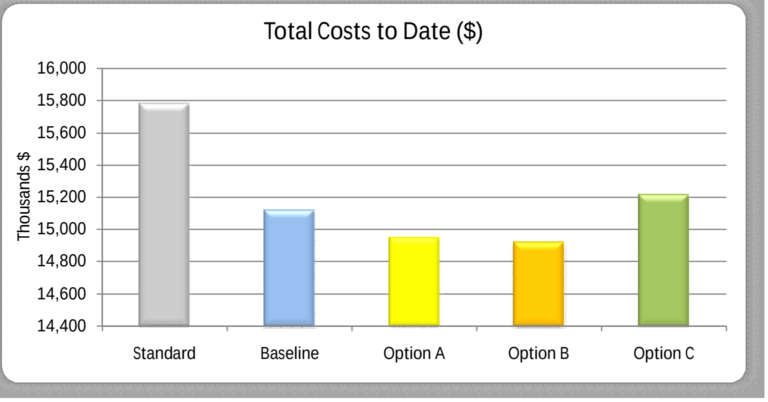

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

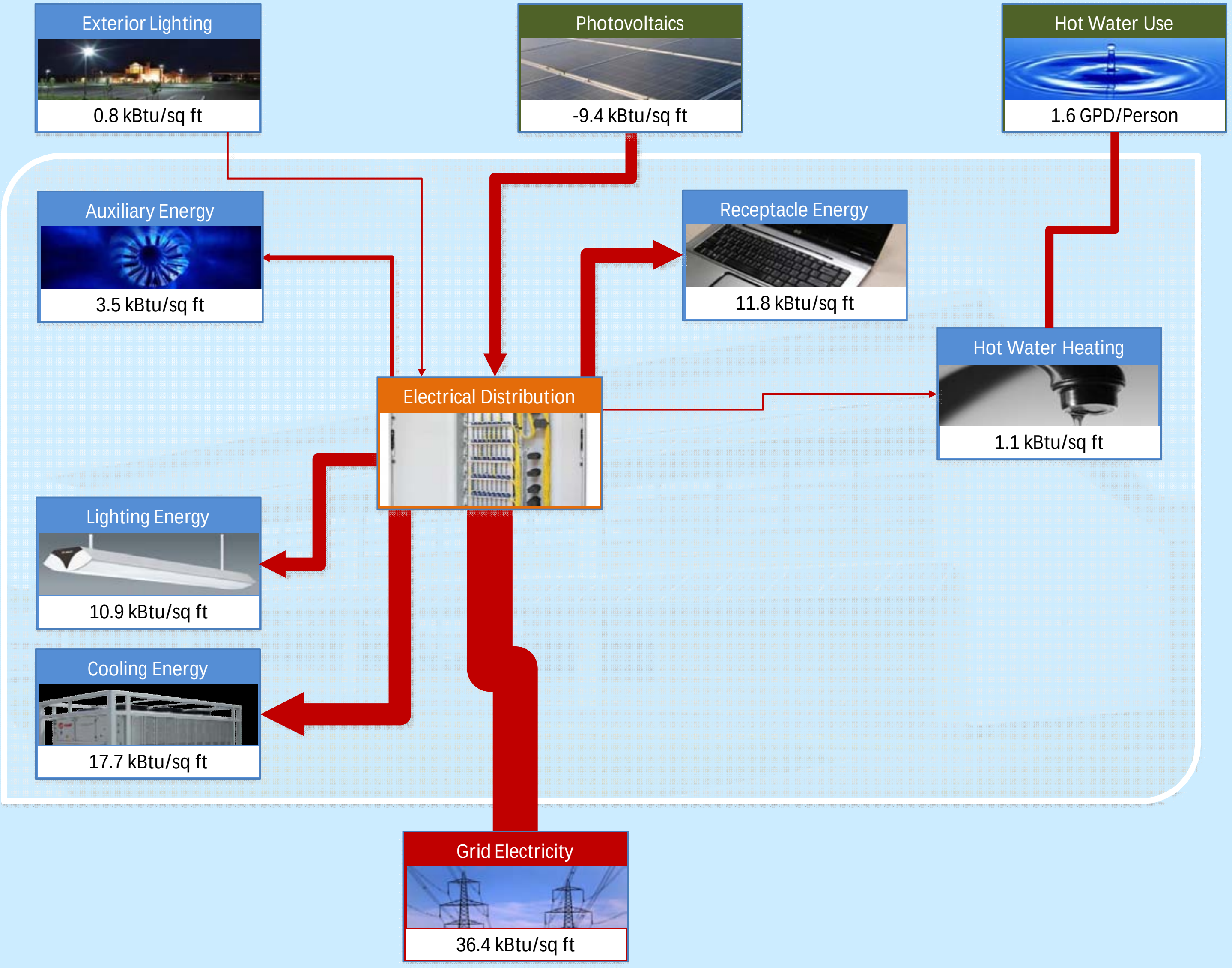

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.8 kBtu/sq ft

Photovoltaics
-9.4 kBtu/sq ft

Hot Water Use
1.6 GPD/Person

Auxiliary Energy
3.5 kBtu/sq ft

Receptacle Energy
11.8 kBtu/sq ft

Hot Water Heating
1.1 kBtu/sq ft

Electrical Distribution

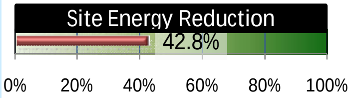
Lighting Energy
10.9 kBtu/sq ft

Cooling Energy
17.7 kBtu/sq ft

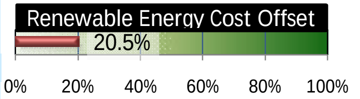
Grid Electricity
36.4 kBtu/sq ft

PERFORMANCE INDICATORS

Site Energy Reduction



Renewable Energy Cost Offset



LEED

LEED-NC

EA1	16	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: 64.3% ✓

EPAct compliant ✓

ENERGY USE

36.4 kBtu/sqft

10.7 kWh/sqft

COST INFORMATION

$2.56/sq ft Energy Cost

16.4 yrs Disc. Payback from Standard

BUILDING DATA

1 Story Small Office
GJMMP, Guam
15,139 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

1 Story Small Office
Option A Energy Model Flows

AECOM

OPTION A SCORECARD

Name	1 Story Small Office
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Gold

Y	?	N	
60	0	49	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Sustainable Sites
12	0	14		
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction

Y	?	N	Credit	Water Efficiency
6	0	3		
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction

Y	?	N	Credit	Energy and Atmosphere
26	0	9		
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
16	0	3	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power

Y	?	N	Credit	Regional Importance
0	0	4		
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

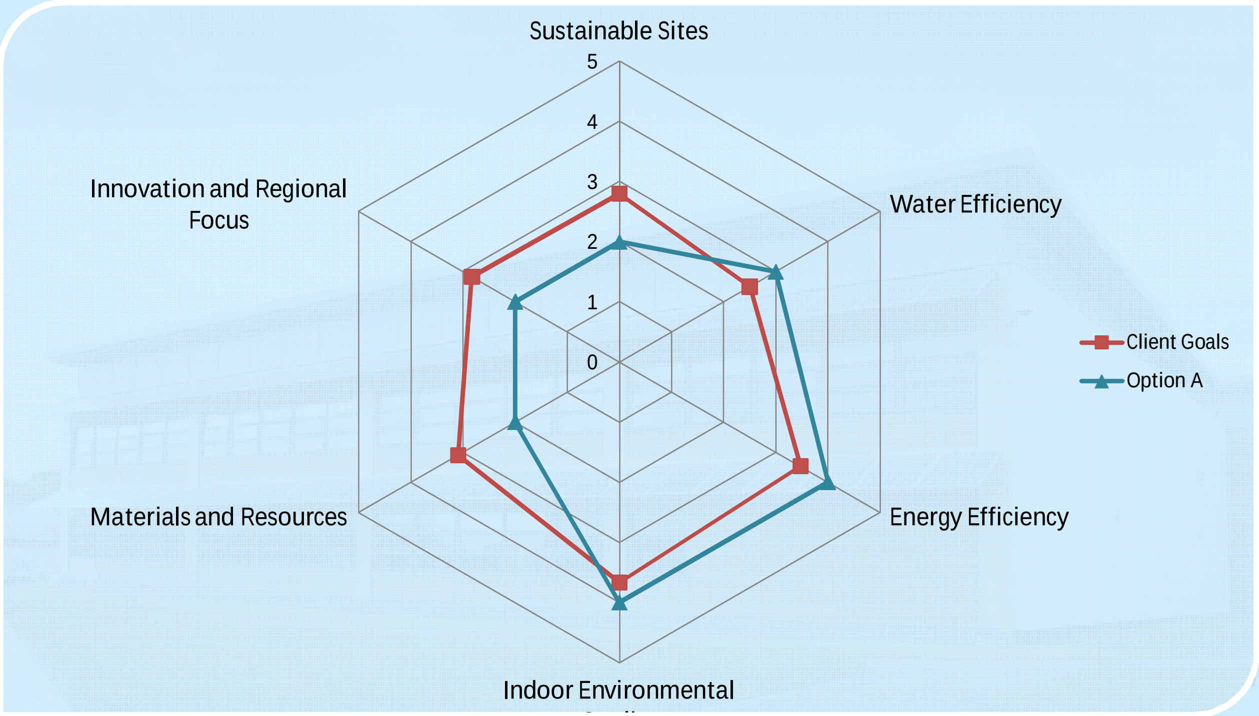
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

Y	?	N	Credit	Materials and Resources
3	0	11		
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood

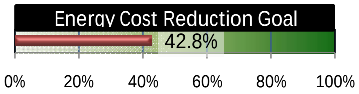
Y	?	N	Credit	Indoor Environmental Quality
9	0	6		
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces

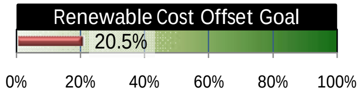
Y	?	N	Credit	Innovation in Design
4	0	2		
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



PERFORMANCE INDICATORS





LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	26	out of 35 potential points
MR	3	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

U.S. GREEN BUILDING COUNCIL LEED GOLD USGBC

Water Efficient Lanscaping Goal

100%

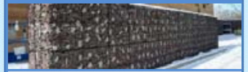
Water Use Reduction Goal

30%

Construction Waste Management Goal

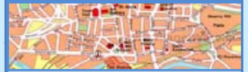
75%

Recycled Materials Goal



10%

Regional Materials Goal



0%

BUILDING DATA

1 Story Small Office
Guam
15,139 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

1 Story Small Office
Option A Sustainability KPIs

AECOM

SSIMe SUMMARY REPORT

Guam JMMP Sustainability Program Summary Report

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the 2 Story Headquarters building, in line with the approved requirements of the overall sustainability program. For the 2 Story Headquarters building, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
2 Story HQ Office	38.5%	13.5%	Option B

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option B). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
2 Story HQ Office	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe Analysis Summary Report

BUILDING SUMMARY

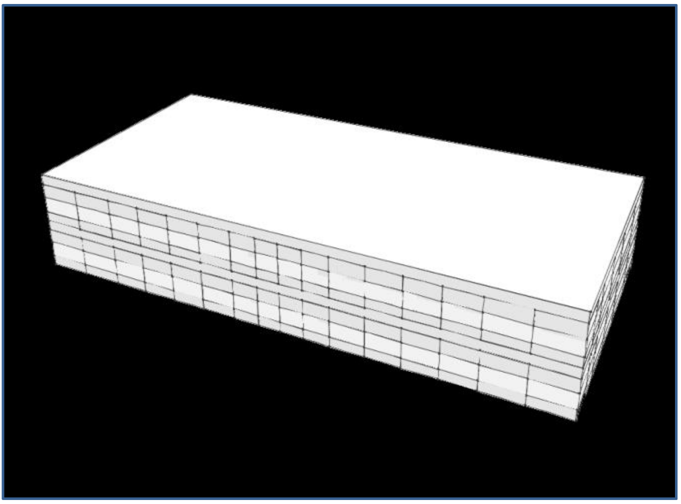
Building Name:	2 Story Headquarters Office
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the 2 Story Headquarters Office in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

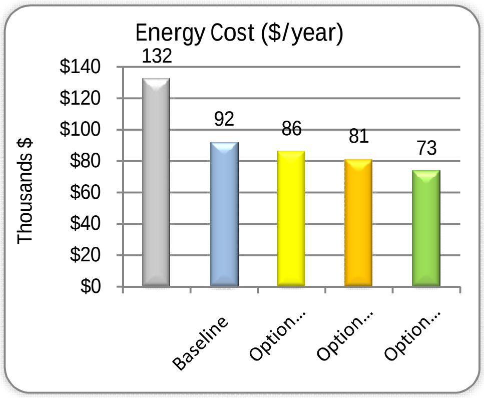
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

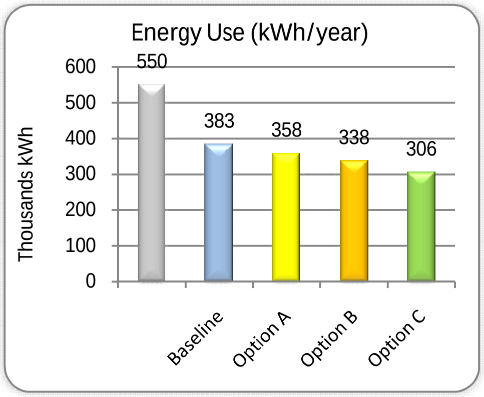


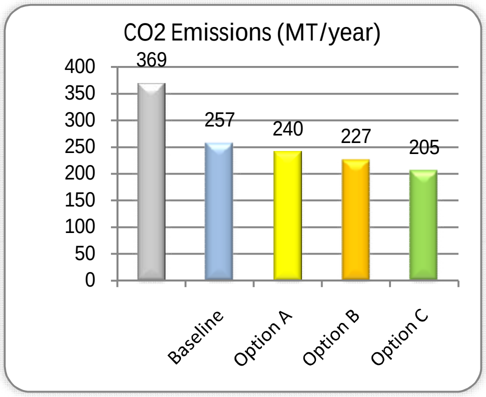
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 62.0 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 369.2 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $4.36/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



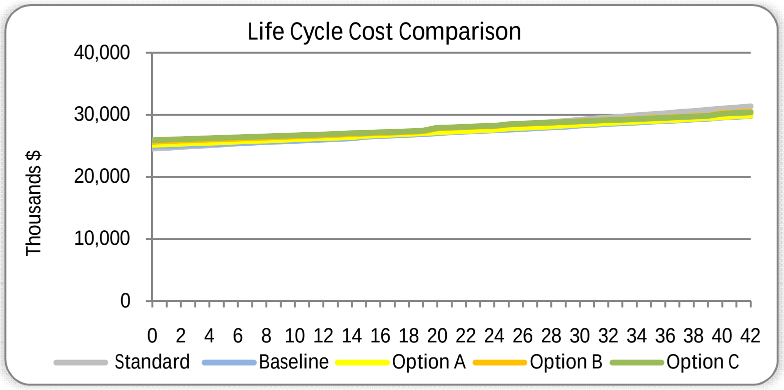




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 7.2 years for the Baseline scenario, 12.3 years for Option A, 18.4 years for Option B and 27.2 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	4.5	4.5
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Constant Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	87%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	14.7	23.5	29.4	44.1
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	123035.8	97198.3	97198.3	97198.3	97198.3
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	234760.8	160162.2	153146.0	142840.7	142840.7
Auxiliary Energy (kWh/year)	66120.7	33459.2	31696.6	32560.8	32560.8
DHW (kWh/year)	11788.0	9666.2	9042.5	9042.5	3164.9
Exterior Lighting (kWh/year)	9636	3372.6	3372.6	3372.6	3372.6
Equipment (kWh/year)	104723.2	104723.2	104723.2	104723.2	104723.2
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-26045.2	-41672.4	-52090.5	-78135.7
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	550064.4	382536.4	357506.7	337647.7	305724.8
Reduction from Standard (%)	0%	30%	35%	39%	44%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	550064.4	382536.4	357506.7	337647.7	305724.8
Reduction from Standard (%)	0%	30%	35%	39%	44%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	1837215.2	1277671.5	1194072.5	1127743.2	1021120.7
Reduction from Standard (%)	0%	30%	35%	39%	44%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	1837215.2	1277671.5	1194072.5	1127743.2	1021120.7
Reduction from Standard (%)	0%	30%	35%	39%	44%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-6250.9	-10001.4	-12501.7	-18752.6
% of Building Energy Cost	0%	6%	10%	13%	20%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	0.0	-1410.6
% of Building Energy Cost	0%	0%	0%	0%	2%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	369.2	256.8	240.0	226.6	205.2
Reduction from Standard (%)	0%	30%	35%	39%	44%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-17.5	-28.0	-35.0	-52.4
Proportion of Total (%)	0%	6%	10%	13%	20%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

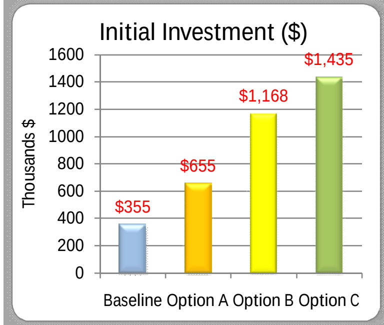
Total CO_2 Emissions (MT/yr)	369.2	256.8	240.0	226.6	205.2
Reduction from Standard (%)	0%	30%	35%	39%	44%

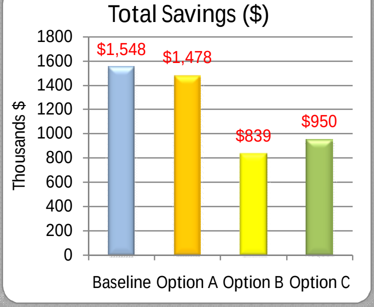
Energy Cost Summary

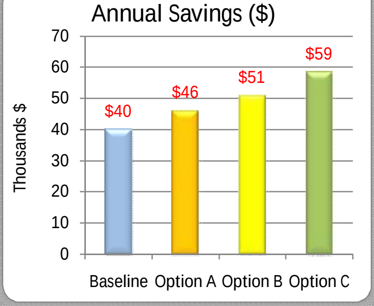
Electricity Cost ($/sq ft)	4.36	3.03	2.83	2.68	2.42
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	4.36	3.03	2.83	2.68	2.42
Reduction from Standard (%)	0%	30%	35%	39%	44%
Simple Payback (Years)	-	8.8	14.2	22.9	24.5

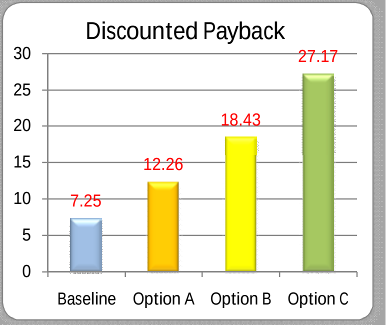
$/sq ft/kg of CO2 Emissions reduction	-	104.14	167.27	270.58	288.91

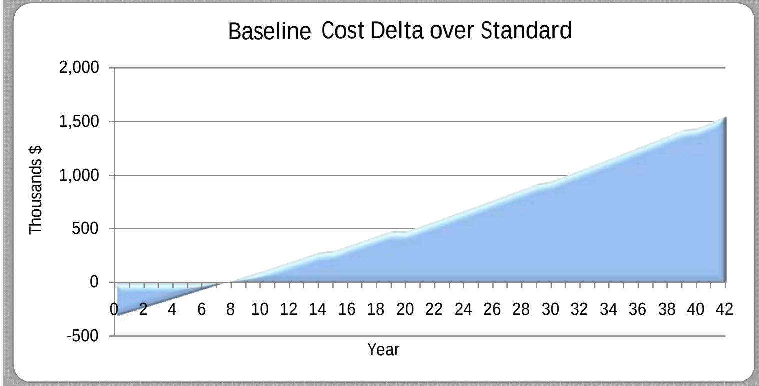
LIFE CYCLE COSTING

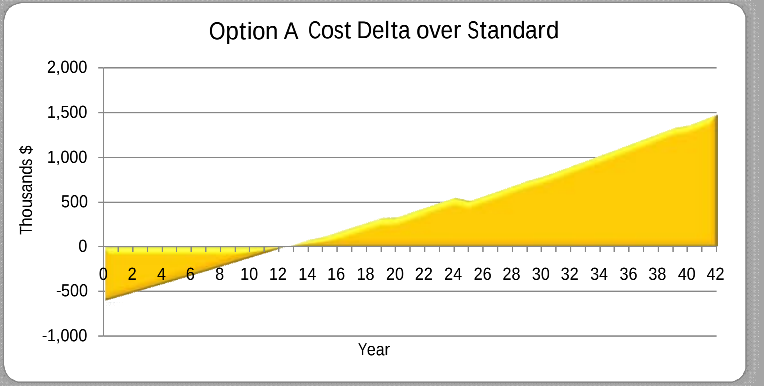

Initial Investment ($)

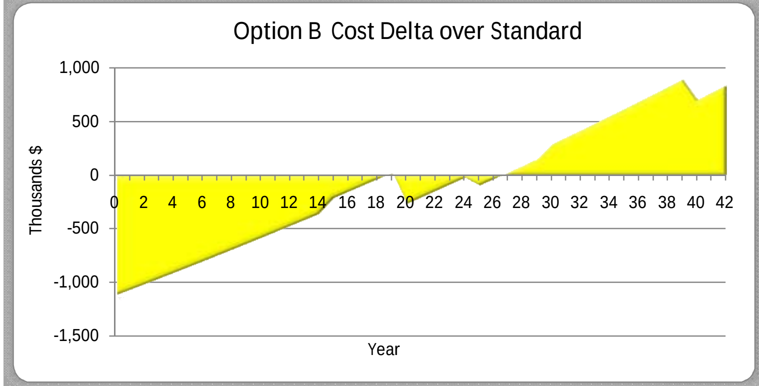

Total Savings ($)

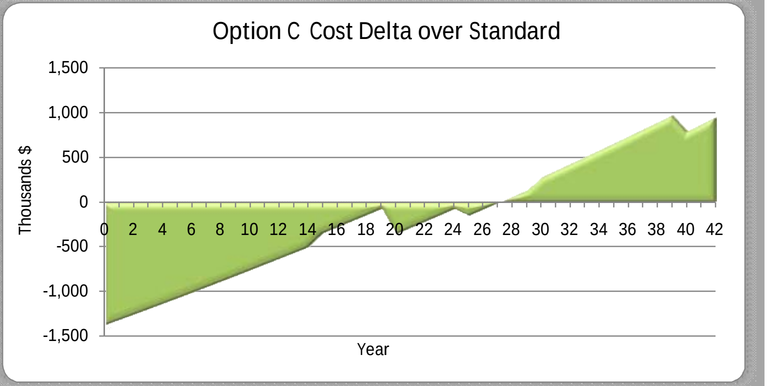

Annual Savings ($)

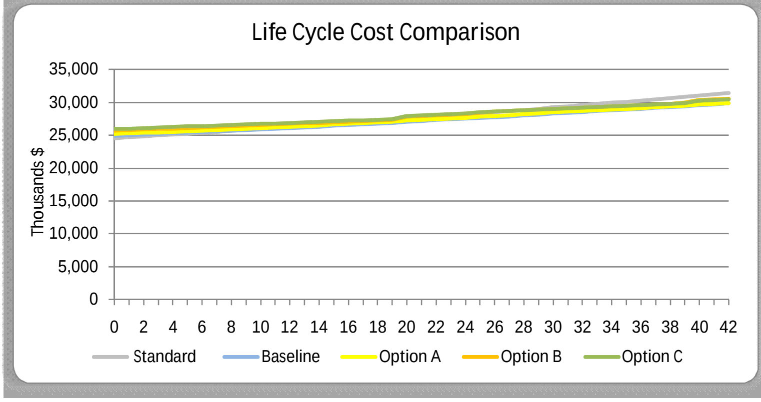

Discounted Payback

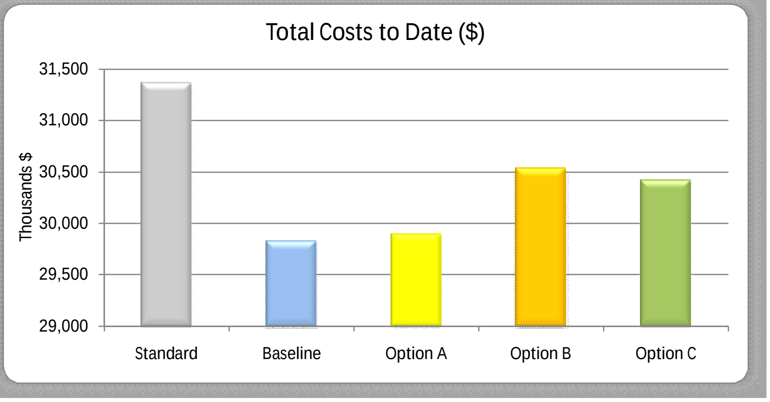

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

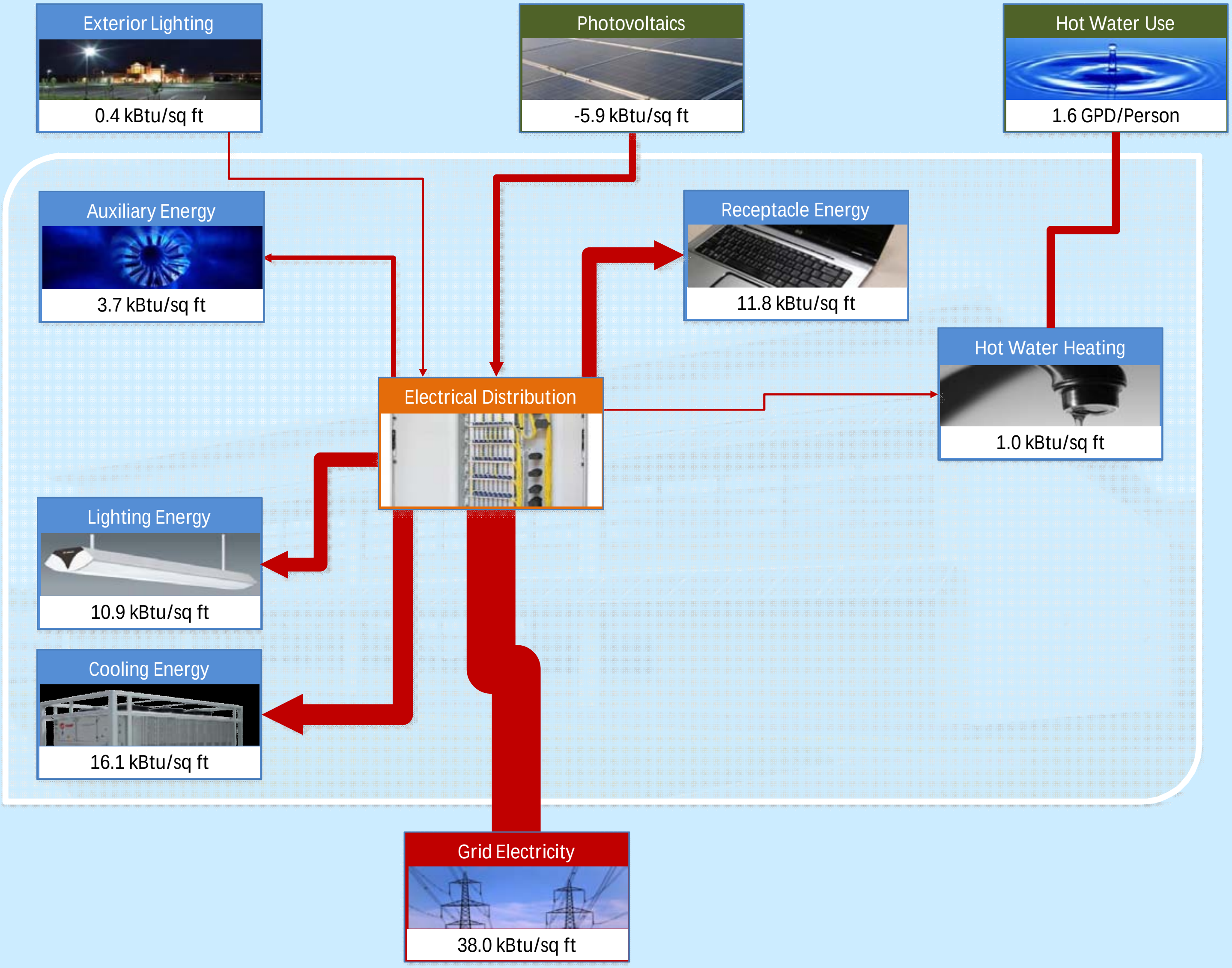

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.4 kBtu/sq ft

Photovoltaics
-5.9 kBtu/sq ft

Hot Water Use
1.6 GPD/Person

Auxiliary Energy
3.7 kBtu/sq ft

Receptacle Energy
11.8 kBtu/sq ft

Electrical Distribution

Hot Water Heating
1.0 kBtu/sq ft

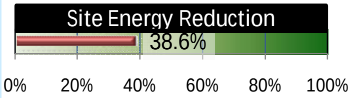
Lighting Energy
10.9 kBtu/sq ft

Cooling Energy
16.1 kBtu/sq ft

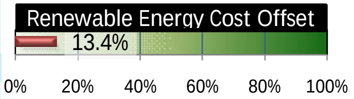
Grid Electricity
38.0 kBtu/sq ft

PERFORMANCE INDICATORS

Site Energy Reduction



Renewable Energy Cost Offset



LEED

LEED-NC

EA1 **14** out of 19 potential points

EA2 **7** out of 7 potential points

FEDERAL MANDATES

EISA Score: 62.7% ✓

EPAct compliant ✓

ENERGY USE

38.0 kBtu/sqft

11.2 kWh/sqft

COST INFORMATION

$2.68/sq ft Energy Cost

18.4 yrs Disc. Payback

BUILDING DATA

2 Story Headquarters Office
GJMMP, Guam
30,277 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

2 Story Headquarters Office
Option B Energy Model Flows

AECOM

OPTION A SCORECARD

Name	2 Story Headquarters Building
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver

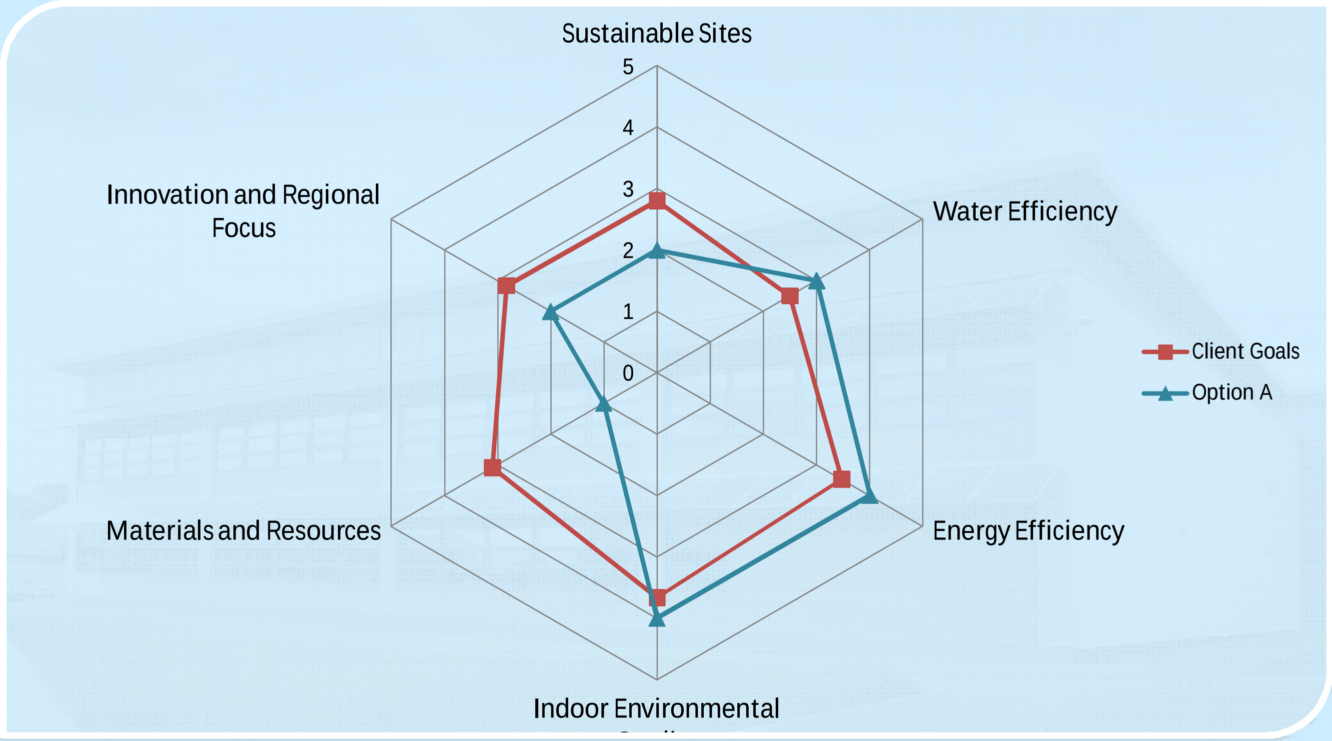
Y	?	N	
57	0	52	Project Totals (Pre-certification Estimate)

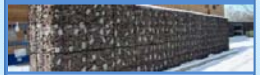
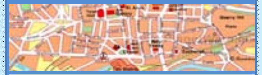
Y	?	N	Credit	
12	0	14		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3		Water Efficiency
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction
24	0	11		Energy and Atmosphere
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
14	0	5	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power
0	0	4		Regional Importance
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

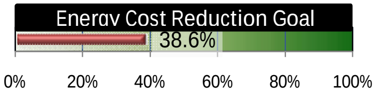
Y	?	N	Credit	
2	0	12		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
0	0	1	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
9	0	6		Indoor Environmental Quality
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces
4	0	2		Innovation in Design
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

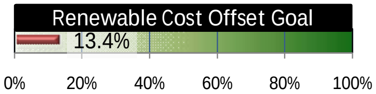
SUSTAINABILITY KPIs



Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
				
100%	30%	75%	0%	0%

PERFORMANCE INDICATORS





LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	24	out of 35 potential points
MR	2	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

U.S. GREEN BUILDING COUNCIL
LEED SILVER
USGBC

BUILDING DATA

2 Story Headquarters Building
Guam
30,277 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

2 Story Headquarters Option A Sustainability KPIs

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the 3 Story Headquarters building, in line with the approved requirements of the overall sustainability program. For the 3 Story Headquarters building, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
3 Story HQ Office	36.5%	15.0%	Option B

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option B). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
3 Story HQ Office	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

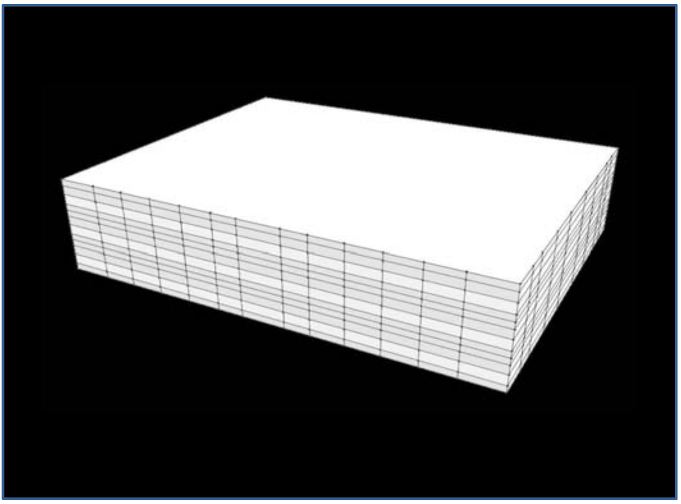
Building Name:	3 Story Headquarters Office
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the 3 Story Headquarters Office in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

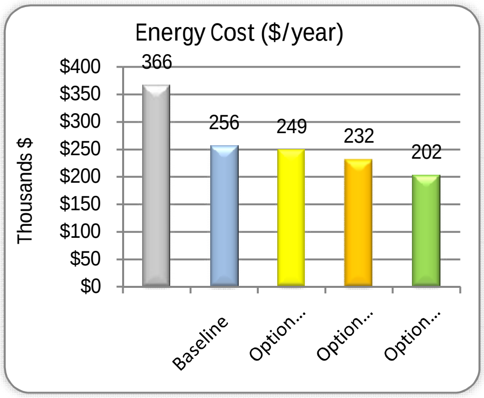
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

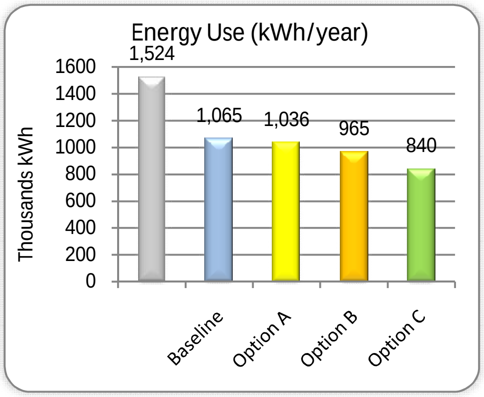


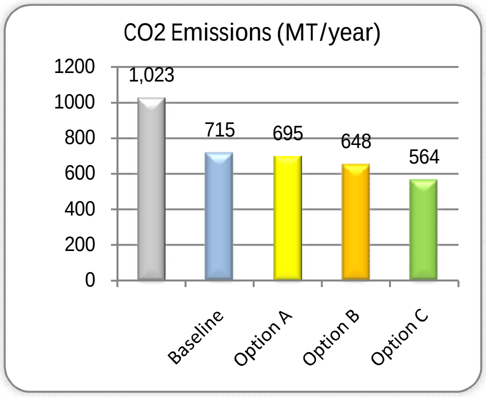
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 58.4 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 1022.7 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $4.11/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



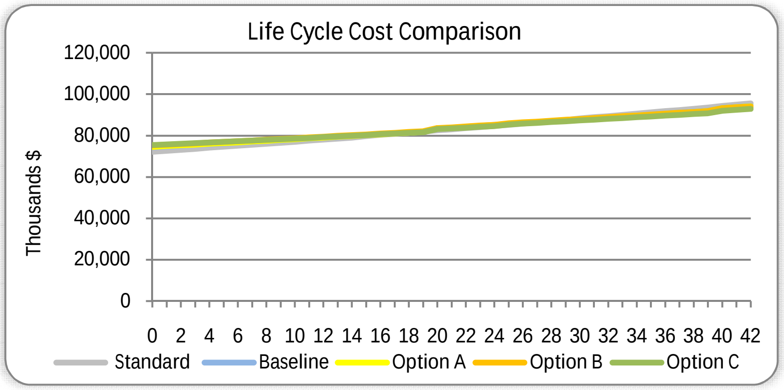




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 17.4 years for the Baseline scenario, 18.0 years for Option A, 29.4 years for Option B and 17.4 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

	Standard	Baseline	Option A	Option B	Option C
Options Summary					
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)	with Lighting Controls (Daylight and Motion)
Reduction from Standard	0%	25%	25%	25%	25%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers	High Eff. Water Cooled Centrifugal Chillers
SEER (If Packaged) COP (Central Plant)	11.1	4.5	4.5	4.5	6.4
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	87%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	52.5	58.3	87.5	87.5
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0
Energy Use Summary					
Lighting (kWh/year)	370649.3	277987.0	277987.0	277987.0	277987.0
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	686642.8	437852.4	437852.4	422659.2	297842.7
Auxiliary Energy (kWh/year)	109056.4	95738.8	95738.8	91470.6	91470.6
DHW (kWh/year)	33133.8	27169.7	8895.9	8895.9	8895.9
Exterior Lighting (kWh/year)	8212.5	2874.375	2874.375	2874.375	2874.375
Equipment (kWh/year)	315966.9	315966.9	315966.9	315966.9	315966.9
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-92873.8	-103193.1	-154789.6	-154789.6
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	1523661.6	1064715.4	1036122.2	965064.3	840247.7
Reduction from Standard (%)	0%	30%	32%	37%	45%
Energy Use by Fuel					
Grid Electricity Use (kWh)	1523661.6	1064715.4	1036122.2	965064.3	840247.7
Reduction from Standard (%)	0%	30%	32%	37%	45%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Source Energy Use					
Source Electricity Energy Use (kWh)	5089029.9	3556149.4	3460648.2	3223314.6	2806427.4
Reduction from Standard (%)	0%	30%	32%	37%	45%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	5089029.9	3556149.4	3460648.2	3223314.6	2806427.4
Reduction from Standard (%)	0%	30%	32%	37%	45%
Renewables Offset					
PV Energy Cost ($/year)	0.0	-22289.7	-24766.3	-37149.5	-37149.5
% of Building Energy Cost	0%	8%	9%	14%	15%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	-3965.0	-3965.0	-3965.0
% of Building Energy Cost	0%	0%	1%	1%	2%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	1022.7	714.6	695.4	647.7	564.0
Reduction from Standard (%)	0%	30%	32%	37%	45%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-62.3	-69.3	-103.9	-103.9
Proportion of Total (%)	0%	8%	9%	14%	16%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

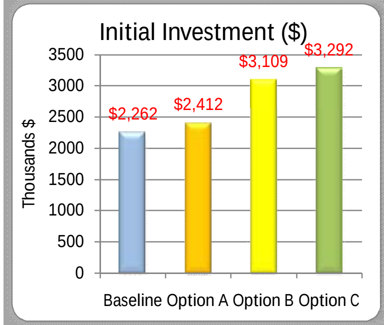
Total CO_2 Emissions (MT/yr)	1022.7	714.6	695.4	647.7	564.0
Reduction from Standard (%)	0%	30%	32%	37%	45%

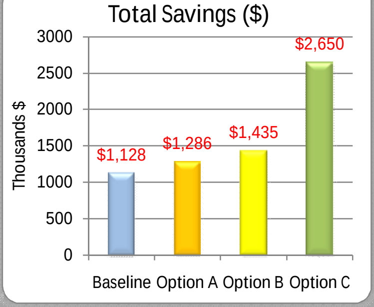
Energy Cost Summary

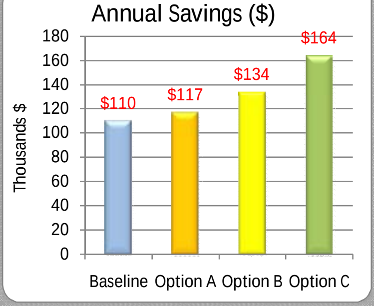
Electricity Cost ($/sq ft)	4.11	2.87	2.79	2.60	2.27
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	4.11	2.87	2.79	2.60	2.27
Reduction from Standard (%)	0%	30%	32%	37%	45%
Simple Payback (Years)	-	20.5	20.6	23.2	20.1

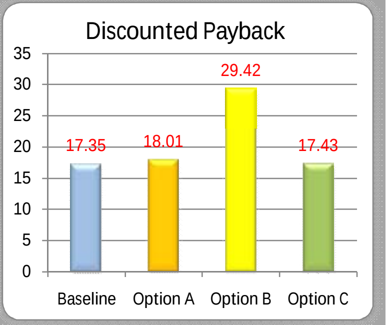
$/sq ft/kg of CO2 Emissions reduction	-	82.54	82.86	93.21	80.65

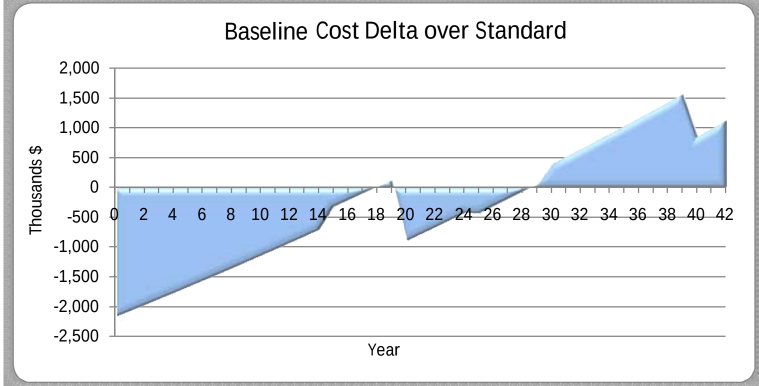
LIFE CYCLE COSTING

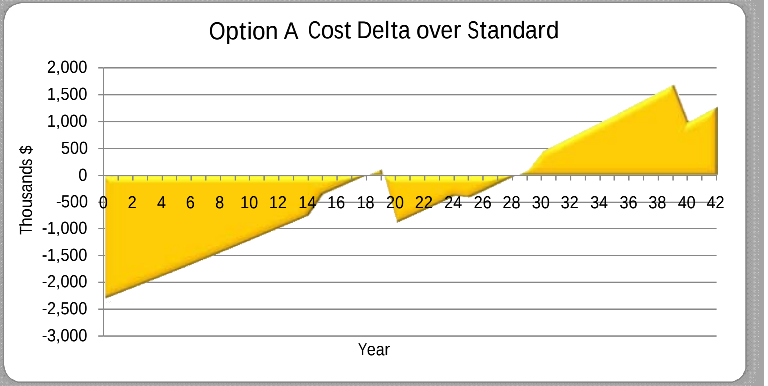

Initial Investment ($)

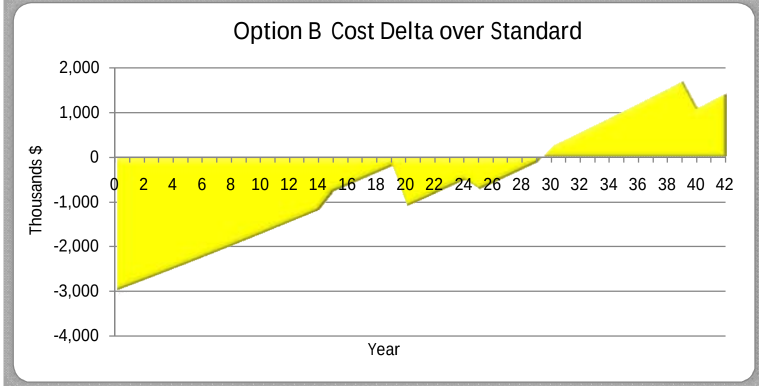

Total Savings ($)

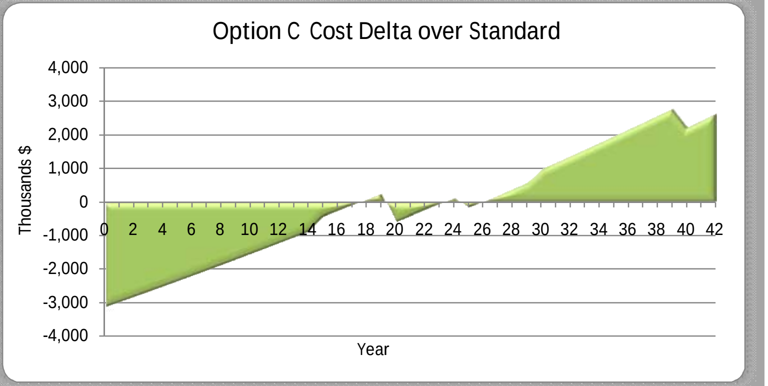

Annual Savings ($)

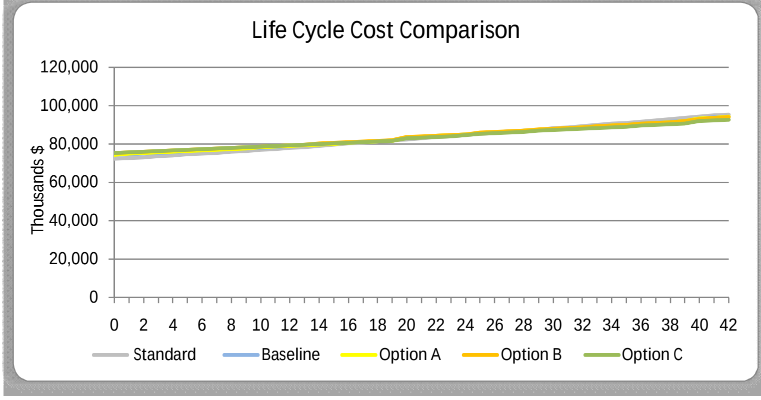

Discounted Payback

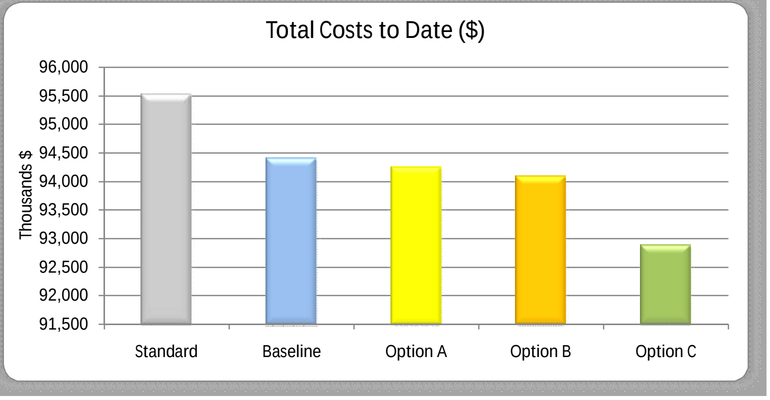

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

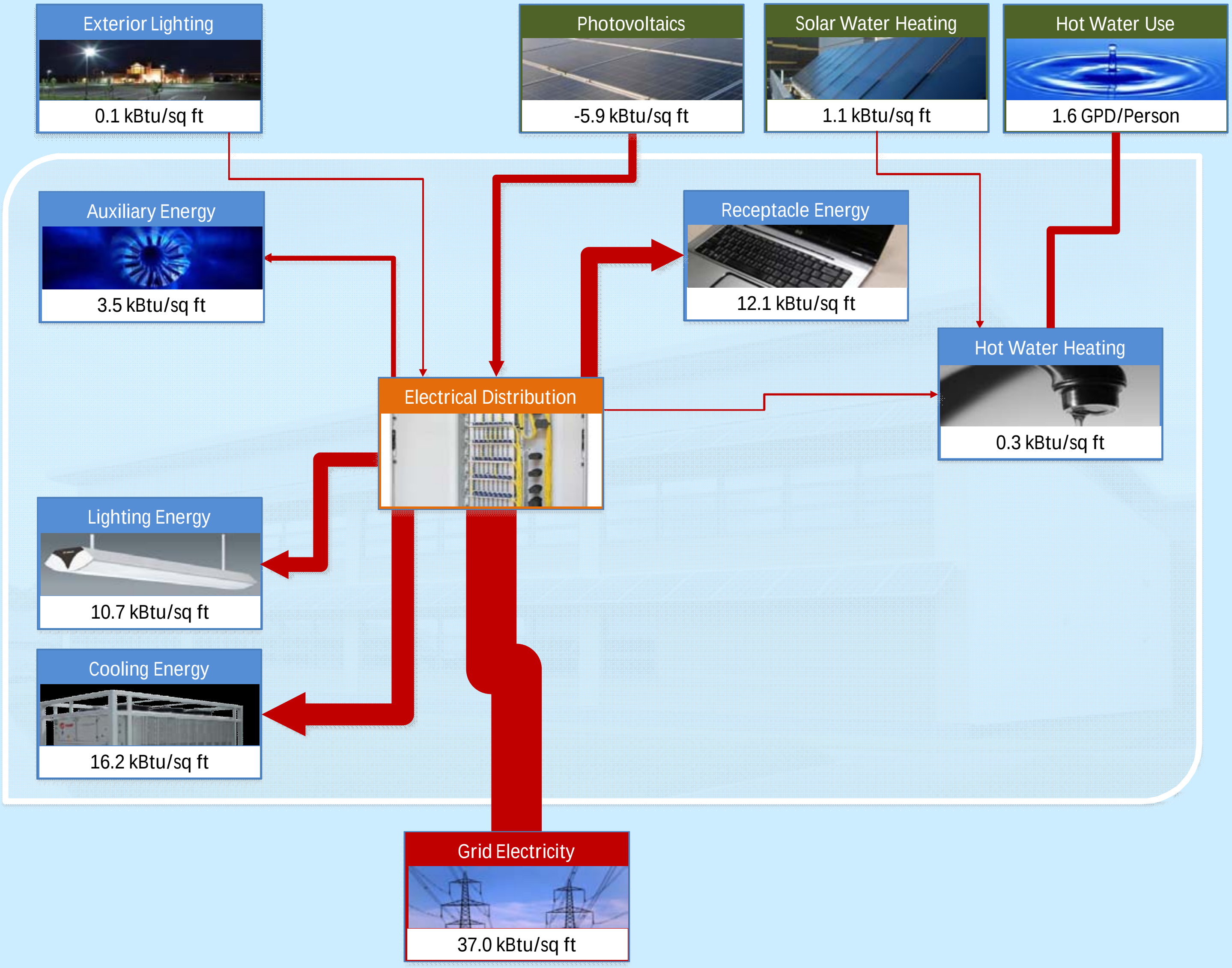

Option B Cost Delta over Standard


Option C Cost Delta over Standard

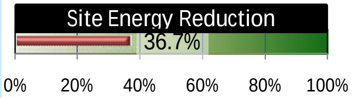

Life Cycle Cost Comparison

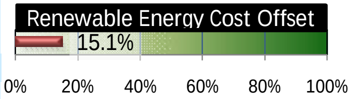

Total Costs to Date ($)

ENERGY FLOW DIAGRAM



PERFORMANCE INDICATORS





LEED

LEED-NC

EA1 **13** out of 19 potential points

EA2 **7** out of 7 potential points

FEDERAL MANDATES

EISA Score: 63.7% ✓

EPAct compliant ✓

ENERGY USE

37.0 kBtu/sqft

10.8 kWh/sqft

COST INFORMATION

$2.60/sq ft Energy Cost

5.7 yrs Disc. Payback from Standard

BUILDING DATA

3 Story Headquarters Office
GJMMP, Guam
88,973 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

3 Story Headquarters Office
Option B Energy Model Flows

AECOM

OPTION A SCORECARD

Name	3 Story Headquarters Building
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver

Y	?	N	
56	0	53	Project Totals (Pre-certification Estimate)

Y	?	N		Sustainable Sites
11	0	15		
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
0	0	1	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction

Y	?	N		Water Efficiency
6	0	3		
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction

Y	?	N		Energy and Atmosphere
23	0	12		
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
13	0	6	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power

Y	?	N		Regional Importance
0	0	4		
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

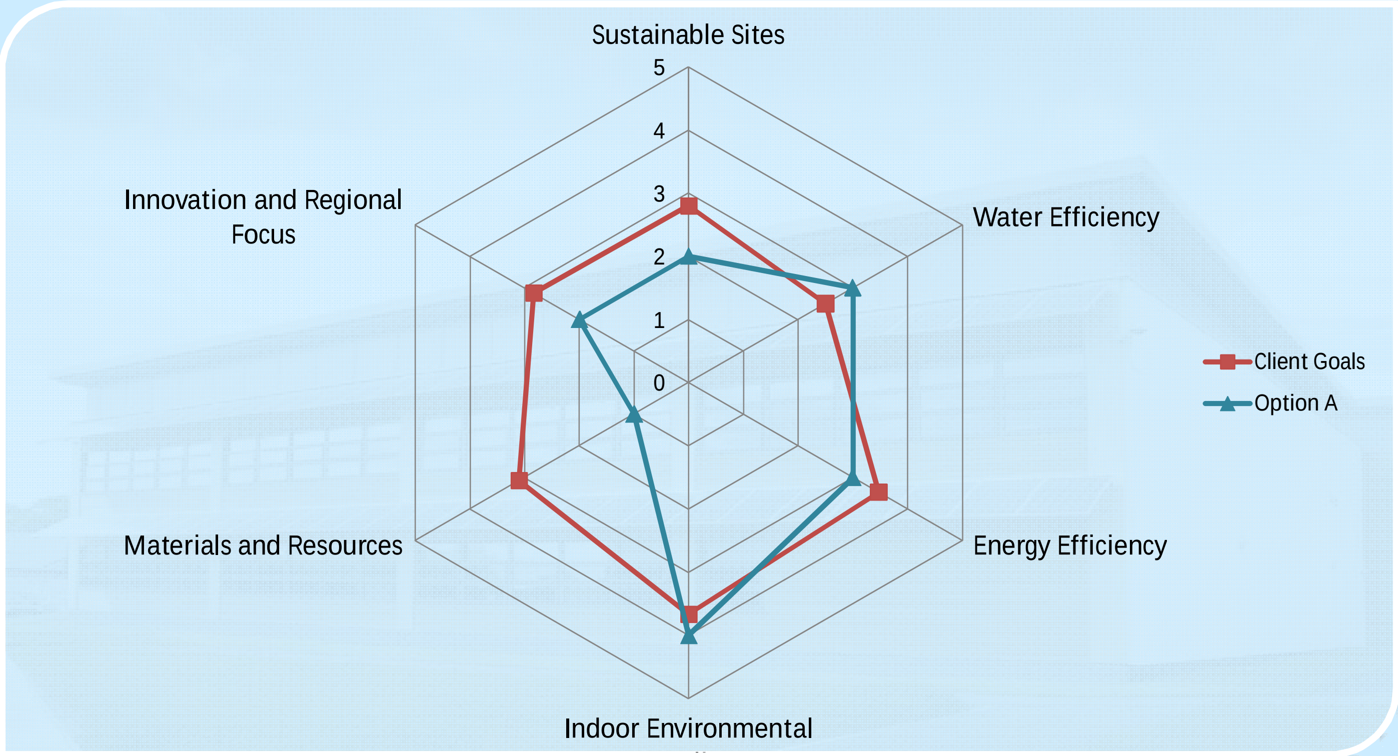
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

Y	?	N		Materials and Resources
2	0	12		
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
0	0	1	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood

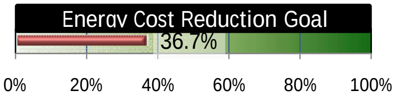
Y	?	N		Indoor Environmental Quality
9	0	6		
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
1	0	0	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
0	0	1	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces

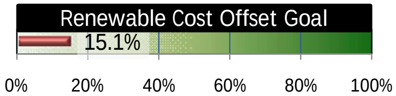
Y	?	N		Innovation in Design
5	0	1		
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
1	0	0	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 95% Construction Waste Management
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



PERFORMANCE INDICATORS





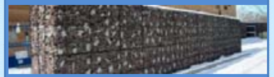
LEED

LEED-NC

SS	11	out of 26 potential points
WE	6	out of 10 potential points
EA	23	out of 35 potential points
MR	2	out of 14 potential points
EQ	9	out of 15 potential points
ID	5	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

LEED SILVER

Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
				
100%	30%	75%	0%	0%

BUILDING DATA

3 Story Headquarters Building
Guam
88,973 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

3 Story Headquarters
Option A Sustainability KPIs

AECOM

Guam JMMP Sustainability Program Summary Report

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the 5 Story Headquarters building, in line with the approved requirements of the overall sustainability program. For the 5 Story Headquarters building, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
5 Story HQ Office	41.0%	12.5%	Option C

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option C). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
5 Story HQ Office	Gold

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

AECOM

BUILDING SUMMARY

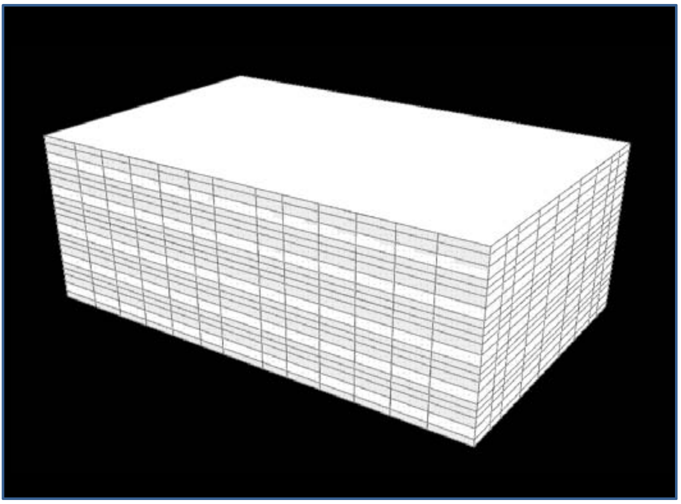
Building Name:	5 Story HQ Office
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the 5 Story HQ Office in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

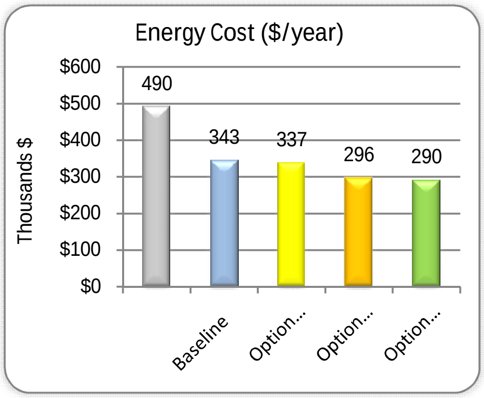
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

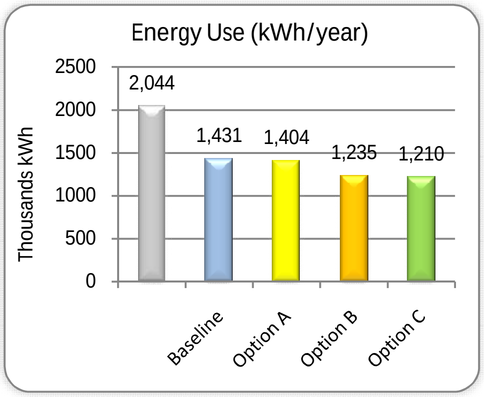


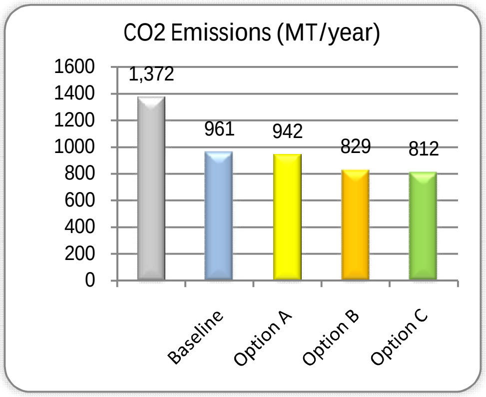
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 58.1 kBtu/sq ft of energy per year.   Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 1371.6 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $4.09/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



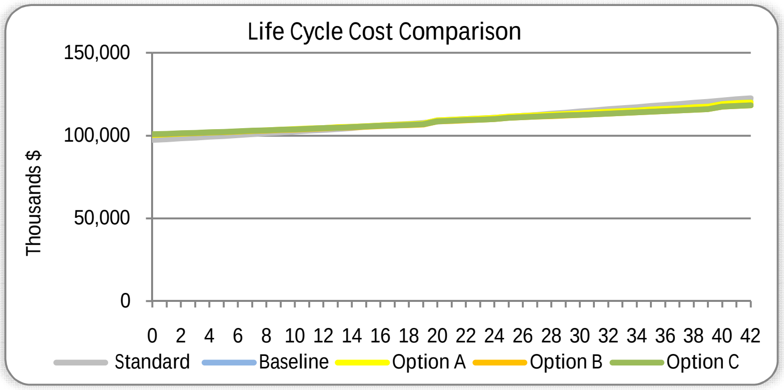




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 15.4 years for the Baseline scenario, 16.4 years for Option A, 15.2 years for Option B and 15.0 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	0.33 (Whole Assembly)	0.33 (Whole Assembly)	0.33 (Whole Assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	/ T5 Fixtures with Lighting Controls (Motion)	/ T5 Fixtures with Lighting Controls (Motion)	/ T5 Fixtures with Lighting Controls (Motion)	/ T5 Fixtures with Lighting Controls (Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers	High Eff. Water Cooled Centrifugal Chillers	High Eff. Water Cooled Centrifugal Chillers
SEER (If Packaged) COP (Central Plant)	11.1	4.5	4.5	6.4	6.4
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	56.0	70.0	70.0	84.0
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	494212.0	390427.5	390427.5	390427.5	390427.5
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	926187.6	575838.8	573598.0	404207.4	404207.4
Auxiliary Energy (kWh/year)	148414.7	127775.1	127552.5	127552.5	127552.5
DHW (kWh/year)	45877.6	12317.4	12317.4	12317.4	12317.4
Exterior Lighting (kWh/year)	7665	2682.75	2682.75	2682.75	2682.75
Equipment (kWh/year)	421272.4	421272.4	421272.4	421272.4	421272.4
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-99066.5	-123833.1	-123833.1	-148599.8
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	2043629.3	1431247.5	1404017.5	1234626.8	1209860.2
Reduction from Standard (%)	0%	30%	31%	40%	41%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	2043629.3	1431247.5	1404017.5	1234626.8	1209860.2
Reduction from Standard (%)	0%	30%	31%	40%	41%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	6825722.0	4780366.5	4689418.5	4123653.6	4040933.1
Reduction from Standard (%)	0%	30%	31%	40%	41%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	6825722.0	4780366.5	4689418.5	4123653.6	4040933.1
Reduction from Standard (%)	0%	30%	31%	40%	41%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-23776.0	-29720.0	-29720.0	-35663.9
% of Building Energy Cost	0%	6%	8%	9%	11%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	-5490.0	-5490.0	-5490.0	-5490.0
% of Building Energy Cost	0%	1%	1%	2%	2%

Carbon Summary

Net Electricity CO$_2$ Emissions (MT/yr)	1371.6	960.6	942.3	828.7	812.0
Reduction from Standard (%)	0%	30%	31%	40%	41%

Gas CO$_2$ Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO$_2$ Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO$_2$ Offset (MT/yr)	0.0	-66.5	-83.1	-83.1	-99.7
Proportion of Total (%)	0%	6%	8%	9%	11%

Wind Gen CO$_2$ Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

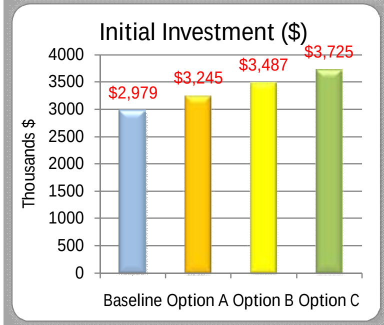
Total CO$_2$ Emissions (MT/yr)	1371.6	960.6	942.3	828.7	812.0
Reduction from Standard (%)	0%	30%	31%	40%	41%

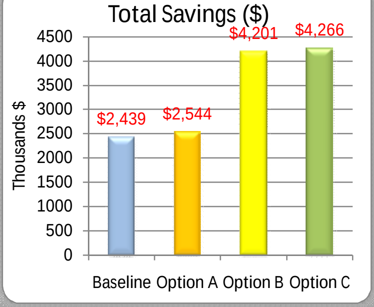
Energy Cost Summary

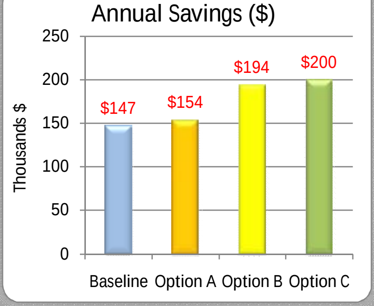
Electricity Cost ($/sq ft)	4.09	2.86	2.81	2.47	2.42
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	4.09	2.86	2.81	2.47	2.42
Reduction from Standard (%)	0%	30%	31%	40%	41%
Simple Payback (Years)	-	20.3	21.1	18.0	18.6

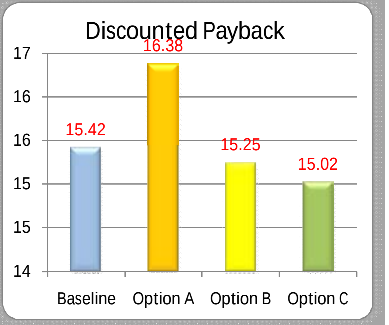
$/sq ft/kg of CO2 Emissions reduction	-	60.42	63.01	53.54	55.49

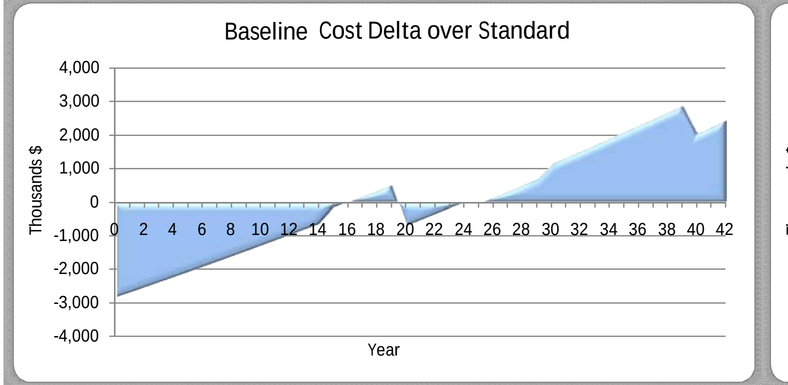
LIFE CYCLE COSTING

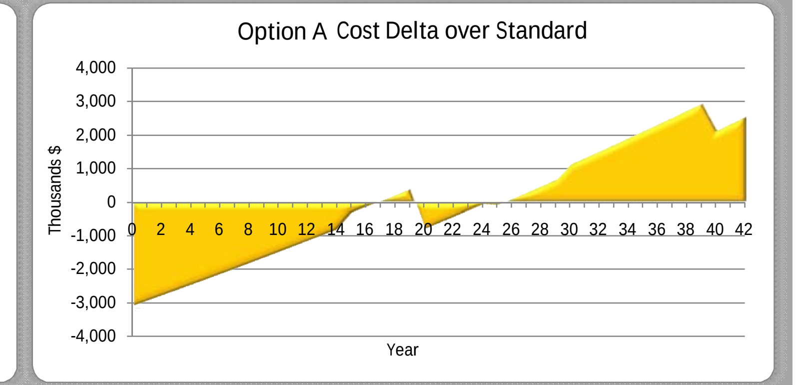

Initial Investment ($)

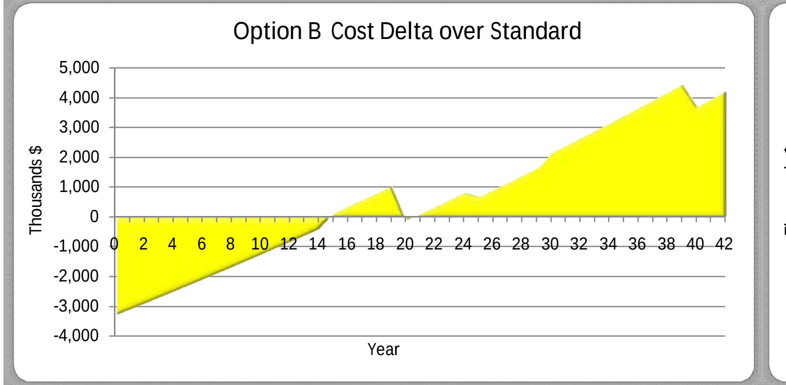

Total Savings ($)

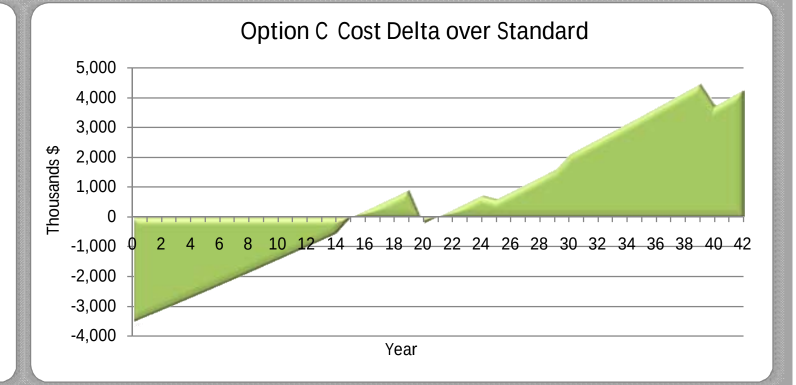

Annual Savings ($)

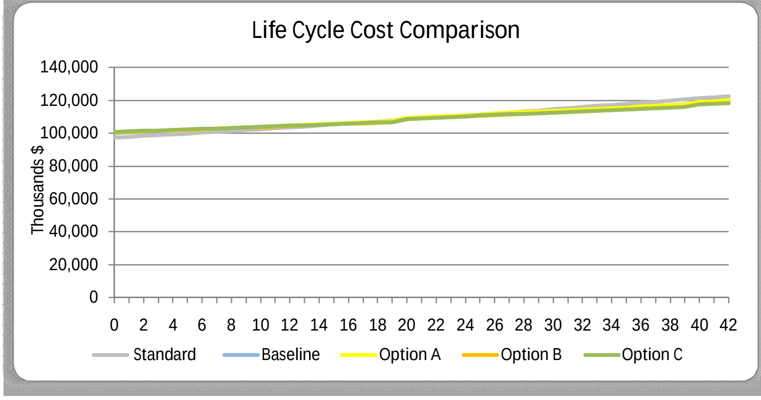

Discounted Payback

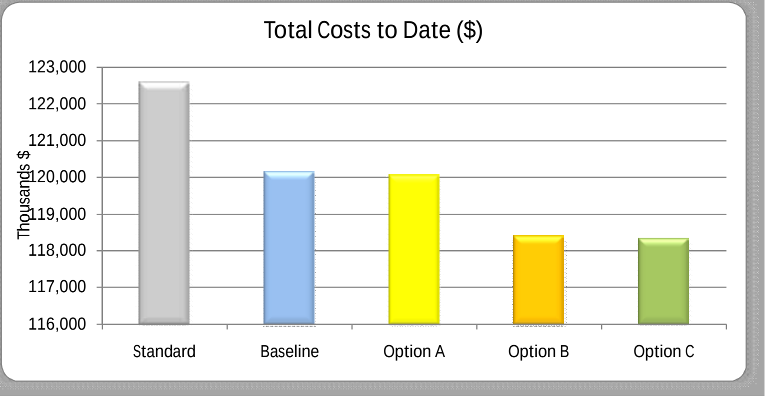

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

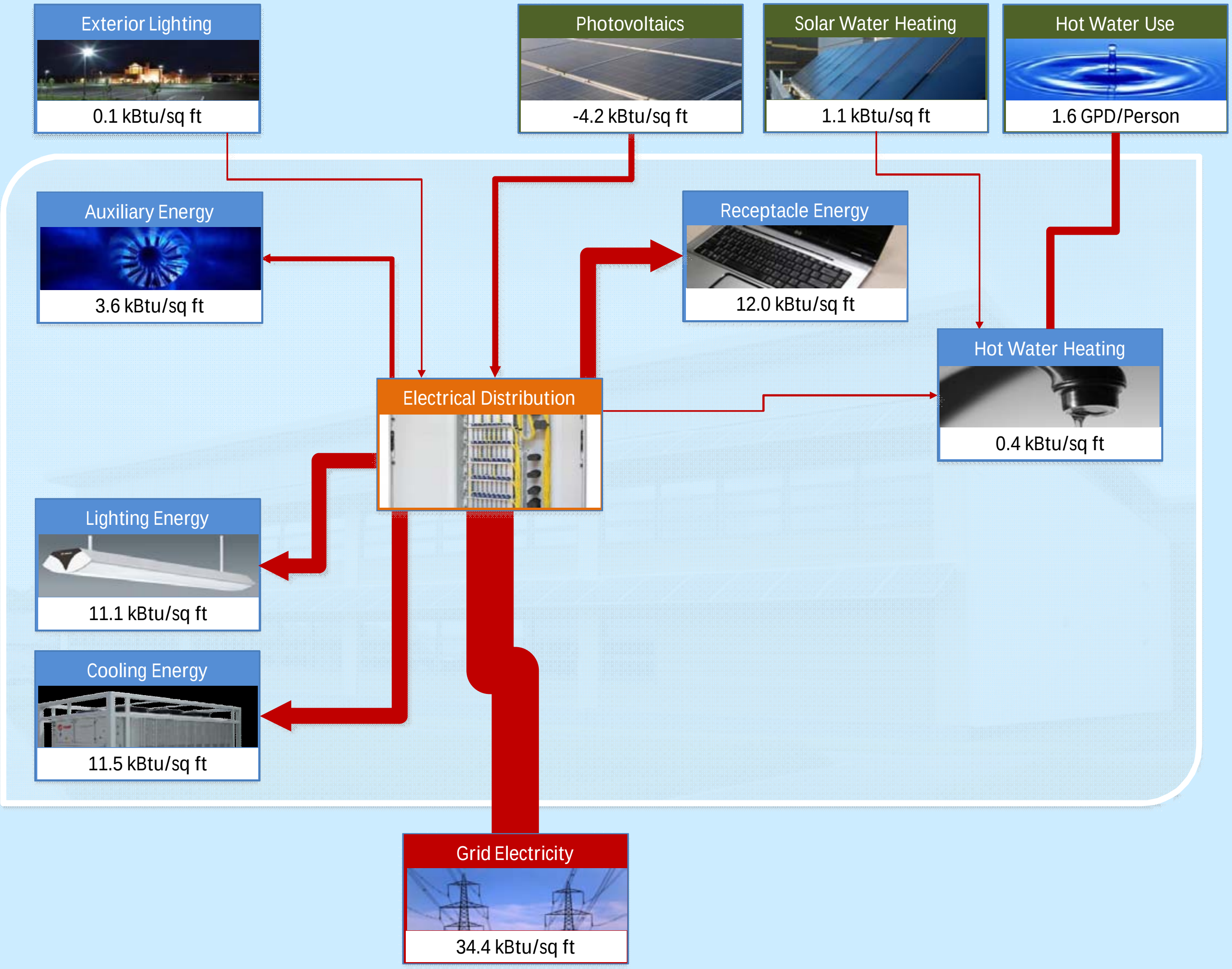

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.1 kBtu/sq ft

Photovoltaics
-4.2 kBtu/sq ft

Solar Water Heating
1.1 kBtu/sq ft

Hot Water Use
1.6 GPD/Person

Auxiliary Energy
3.6 kBtu/sq ft

Receptacle Energy
12.0 kBtu/sq ft

Hot Water Heating
0.4 kBtu/sq ft

Electrical Distribution

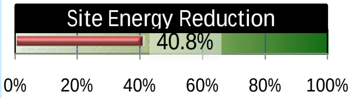
Lighting Energy
11.1 kBtu/sq ft

Cooling Energy
11.5 kBtu/sq ft

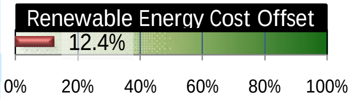
Grid Electricity
34.4 kBtu/sq ft

PERFORMANCE INDICATORS

Site Energy Reduction



Renewable Energy Cost Offset



LEED

LEED-NC

EA1	15	out of 19 potential points
EA2	6	out of 7 potential points

FEDERAL MANDATES

EISA Score: 66.3% ✓

EPAct compliant ✓

ENERGY USE

34.4 kBtu/sqft

10.1 kWh/sqft

COST INFORMATION

$2.42/sq ft Energy Cost

15.0 yrs Disc. Payback from Standard

BUILDING DATA

5 Story HQ Office
GJMMP, Guam
119,963 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

5 Story HQ Office
Option C Energy Model Flows

AECOM

OPTION C SCORECARD

Name	5 Story Headquarters Building
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Gold	Gold

Y	?	N	
68	0	42	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Sustainable Sites
12	0	14		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
0	0	1	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
1	0	0	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction

Y	?	N	Credit	Water Efficiency
7	0	3		Water Efficiency
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
1	0	0	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction

Y	?	N	Credit	Energy and Atmosphere
30	0	5		Energy and Atmosphere
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
17	0	2	EAc1	Optimize Energy Performance
6	0	1	EAc2	On-Site Renewable Energy
2	0	0	EAc3	Enhanced Commissioning
2	0	0	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power

Y	?	N	Credit	Regional Importance
0	0	4		Regional Importance
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

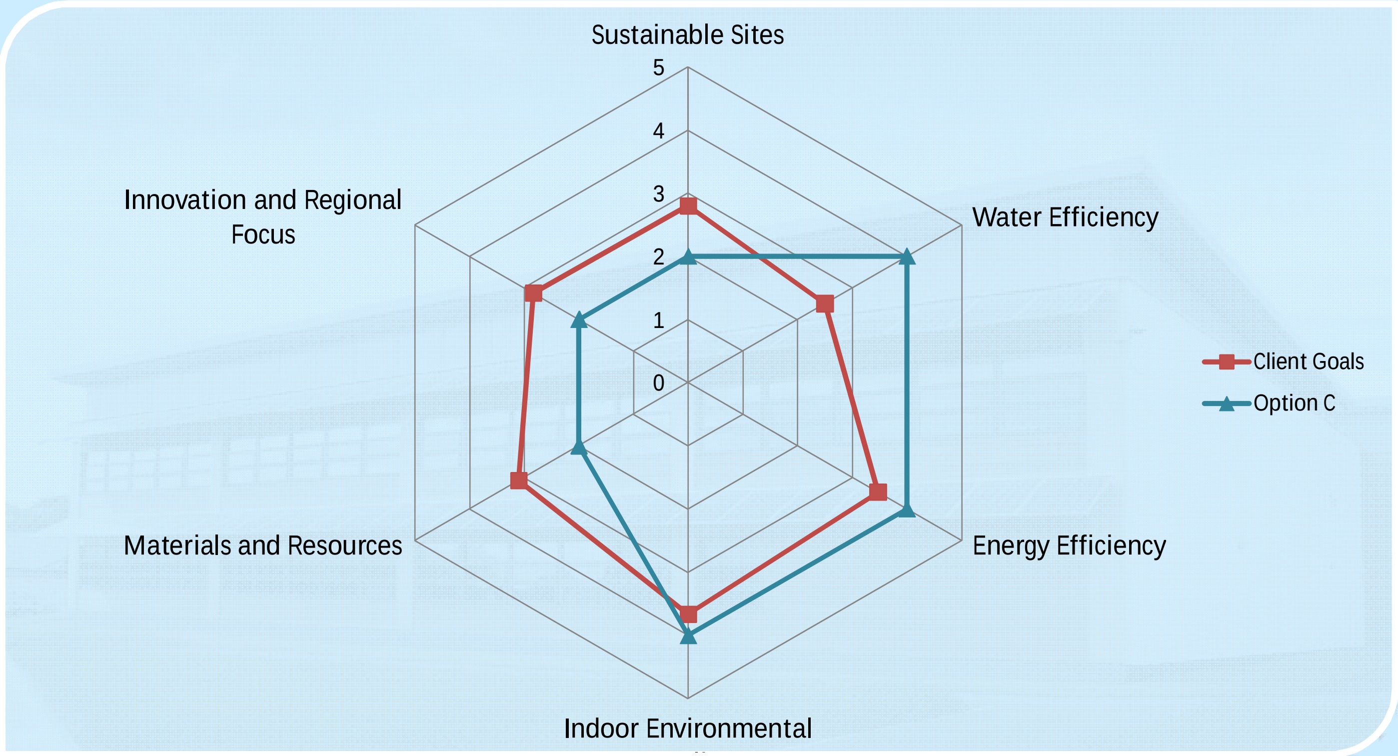
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost
Low Design Impact / High Construction Cost

Y	?	N	Credit	Materials and Resources
4	0	10		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
1	0	0	MRc7	Certified Wood

Y	?	N	Credit	Indoor Environmental Quality
10	0	5		Indoor Environmental Quality
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
1	0	0	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
1	0	0	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
0	0	1	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces

Y	?	N	Credit	Innovation in Design
5	0	1		Innovation in Design
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
1	0	0	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 95% Construction Waste Management
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

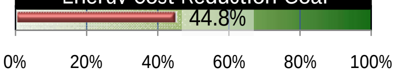
SUSTAINABILITY KPIs



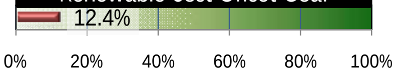
Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
				
100%	35%	75%	10%	0%

PERFORMANCE INDICATORS

Energy Cost Reduction Goal



Renewable Cost Offset Goal



LEED

LEED-NC

SS	12	out of 26 potential points
WE	7	out of 10 potential points
EA	30	out of 35 potential points
MR	4	out of 14 potential points
EQ	10	out of 15 potential points
ID	5	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

LEED GOLD

BUILDING DATA

5 Story Headquarters Building
Guam
119,963 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
Low Design Impact / High Construction Cost
-

5 Story Headquarters
Option C Sustainability KPIs

AECOM

Guam JMMP Sustainability Program Summary Report

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the Commissary, in line with the approved requirements of the overall sustainability program. For the Commissary, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Commissary	34.5%	14.0%	Option A

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option A). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
Commissary	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design t**eam** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

AECOM

BUILDING SUMMARY

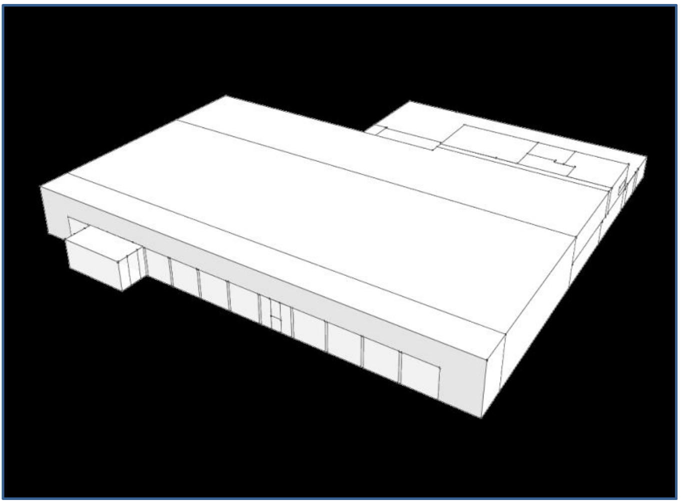
Building Name:	Commissary
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Commissary in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

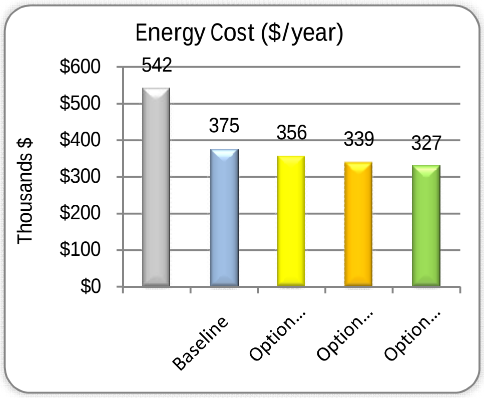
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

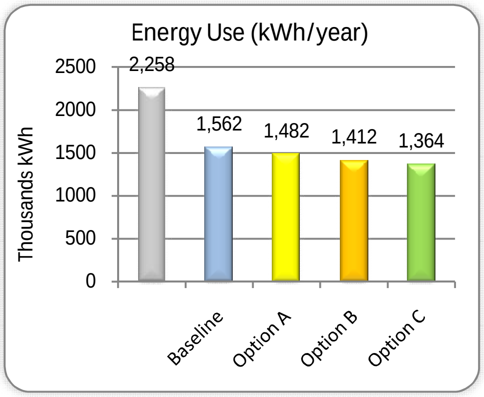


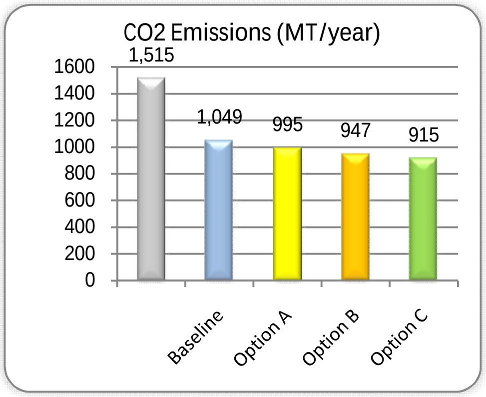
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 112.0 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 1515.5 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $7.89/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



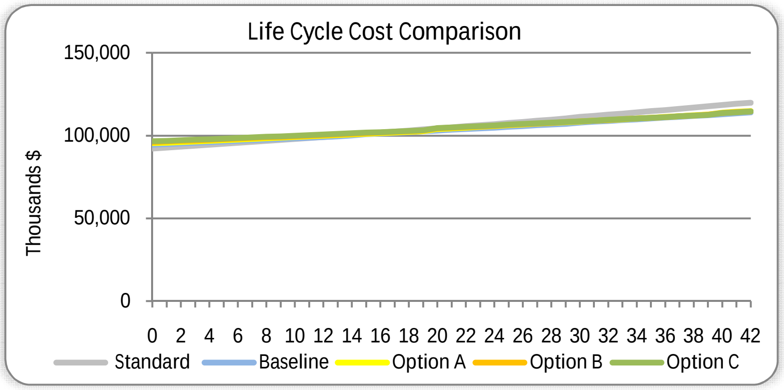




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 12.2 years for the Baseline scenario, 14.9 years for Option A, 16.0 years for Option B and 17.2 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	28W T5 Fixtures	28W T5 Fixtures	28W T5 Fixtures	28W T5 Fixtures
Reduction from Standard	0%	13%	13%	13%	13%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	4.5	4.5	4.5
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	133.6	133.6	173.7	200.4
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	624892.1	546780.6	546780.6	546780.6	546780.6
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	1205159.1	847592.5	767310.4	767310.4	767809.0
Auxiliary Energy (kWh/year)	132902.3	123427.6	123794.3	123794.3	125370.2
DHW (kWh/year)	4811.9	3691.2	3691.2	3691.2	1291.9
Exterior Lighting (kWh/year)	19655.25	6879.3375	6879.3375	6879.3375	6879.3375
Equipment (kWh/year)	270509.4	270509.4	270509.4	270509.4	270509.4
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-236466.4	-236466.4	-307406.3	-354699.6
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	2257929.9	1562414.2	1482498.8	1411558.9	1363940.8
Reduction from Standard (%)	0%	31%	34%	37%	40%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	2257929.9	1562414.2	1482498.8	1411558.9	1363940.8
Reduction from Standard (%)	0%	31%	34%	37%	40%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	7541486.0	5218463.5	4951546.0	4714606.7	4555562.3
Reduction from Standard (%)	0%	31%	34%	37%	40%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	7541486.0	5218463.5	4951546.0	4714606.7	4555562.3
Reduction from Standard (%)	0%	31%	34%	37%	40%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-56751.9	-56751.9	-73777.5	-85127.9
% of Building Energy Cost	0%	13%	14%	18%	21%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	0.0	-575.8
% of Building Energy Cost	0%	0%	0%	0%	0%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	1515.5	1048.7	995.0	947.4	915.4
Reduction from Standard (%)	0%	31%	34%	37%	40%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-158.7	-158.7	-206.3	-238.1
Proportion of Total (%)	0%	13%	14%	18%	21%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

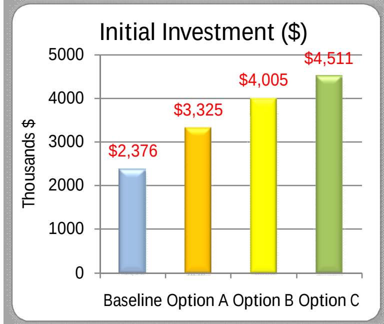
Total CO_2 Emissions (MT/yr)	1515.5	1048.7	995.0	947.4	915.4
Reduction from Standard (%)	0%	31%	34%	37%	40%

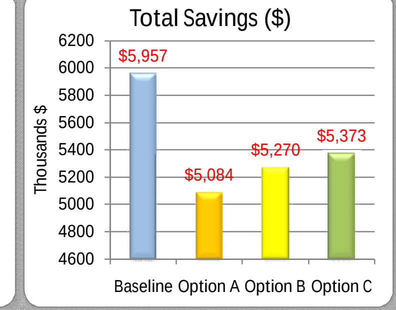
Energy Cost Summary

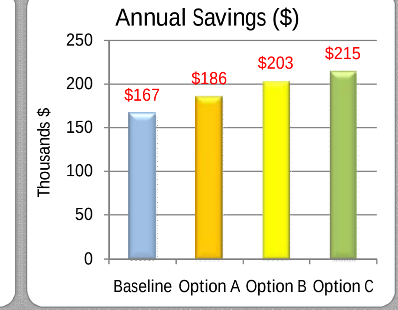
Electricity Cost ($/sq ft)	7.89	5.46	5.18	4.93	4.76
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	7.89	5.46	5.18	4.93	4.76
Reduction from Standard (%)	0%	31%	34%	37%	40%
Simple Payback (Years)	-	14.2	17.9	19.7	21.0

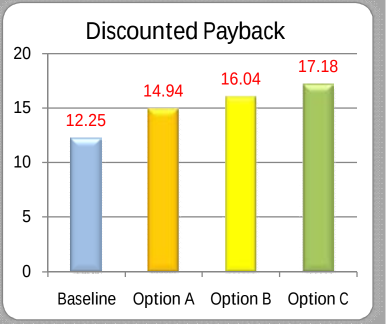
$/sq ft/kg of CO2 Emissions reduction	-	74.07	92.97	102.60	109.39

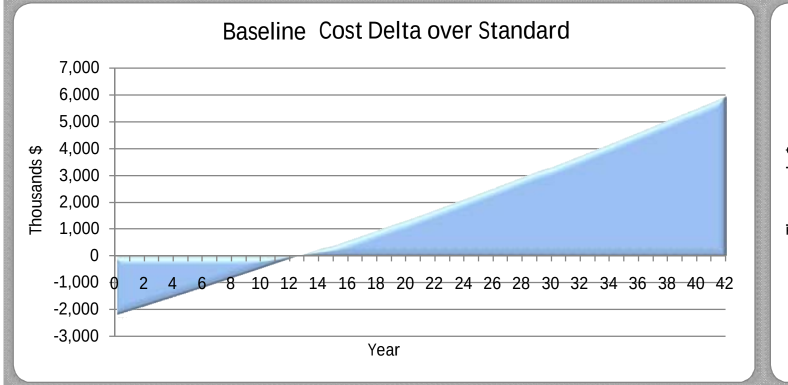
LIFE CYCLE COSTING

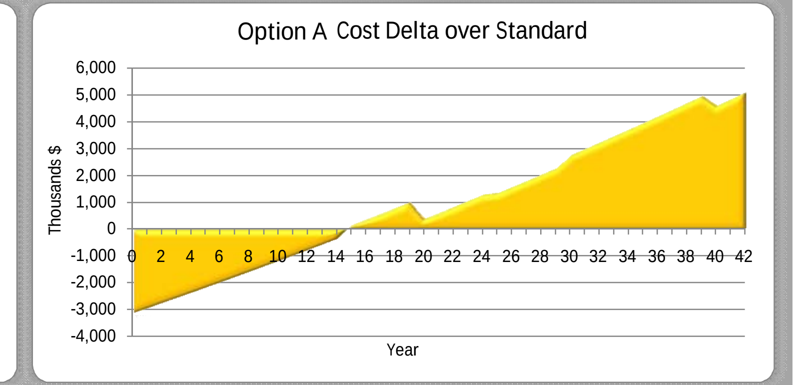

Initial Investment ($)

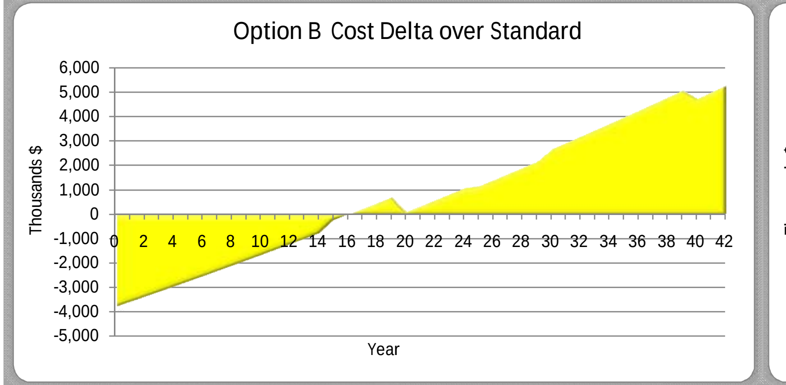

Total Savings ($)

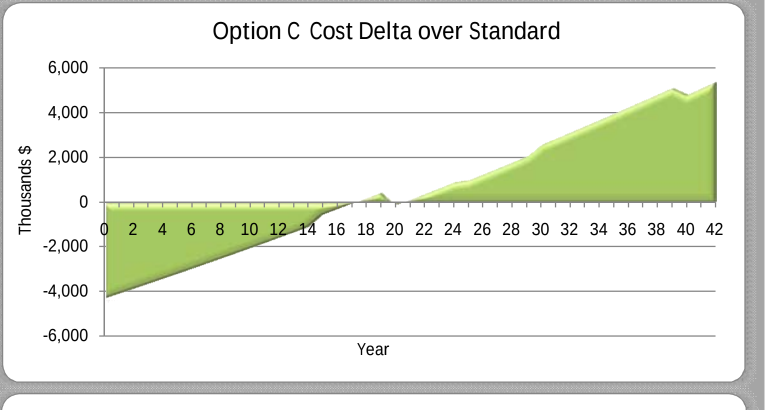

Annual Savings ($)

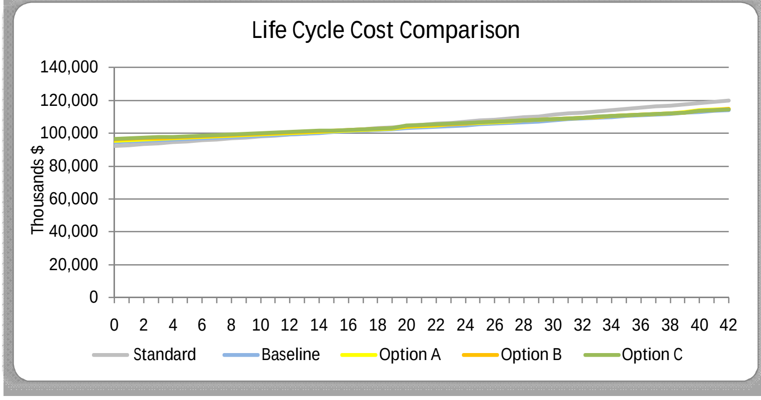

Discounted Payback

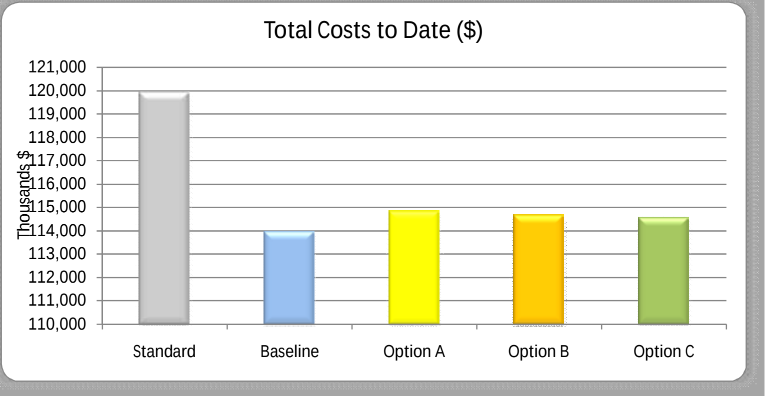

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

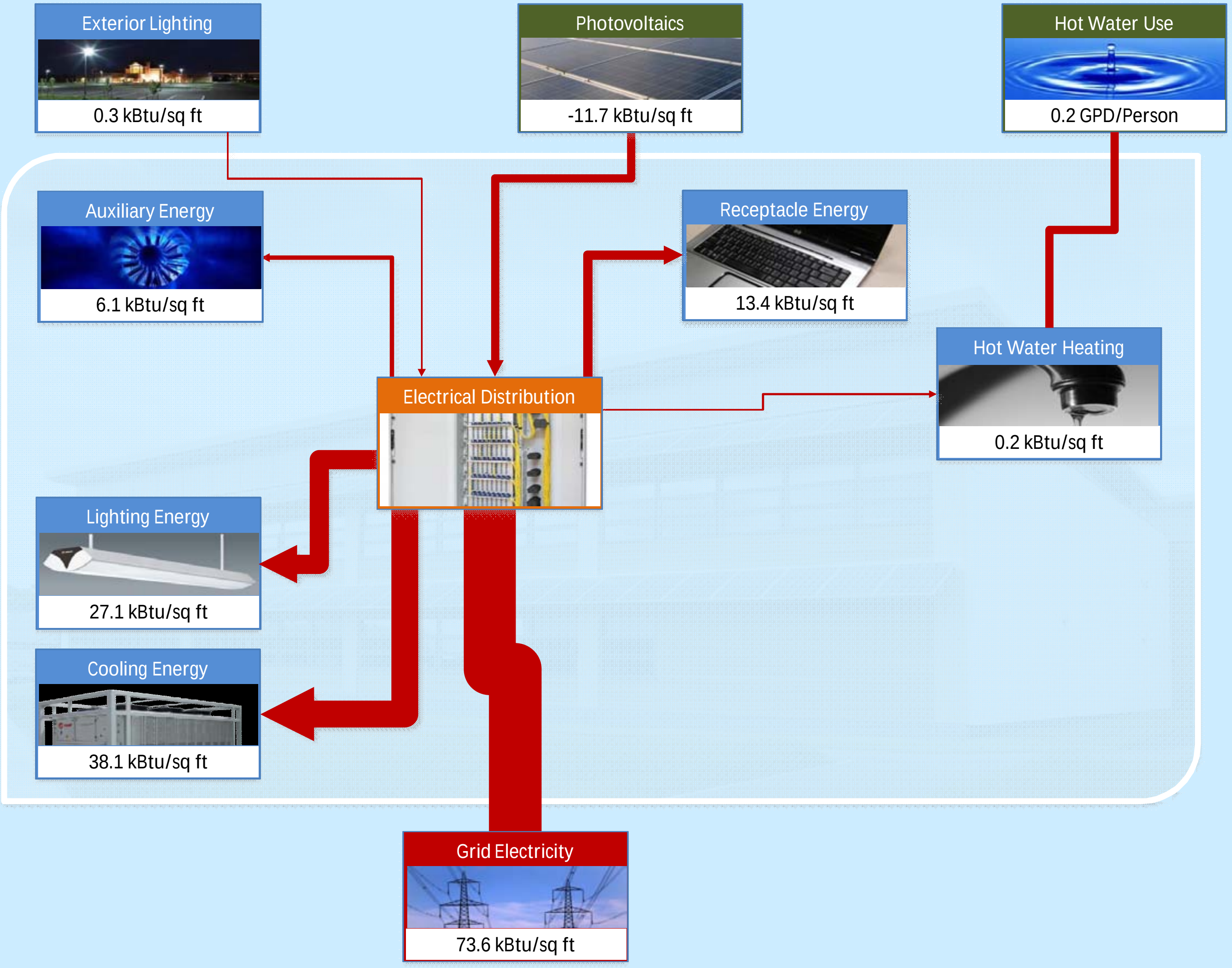

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.3 kBtu/sq ft

Photovoltaics
-11.7 kBtu/sq ft

Hot Water Use
0.2 GPD/Person

Auxiliary Energy
6.1 kBtu/sq ft

Receptacle Energy
13.4 kBtu/sq ft

Hot Water Heating
0.2 kBtu/sq ft

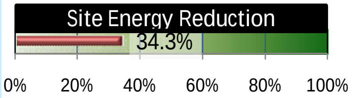
Electrical Distribution

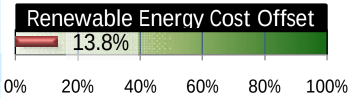
Lighting Energy
27.1 kBtu/sq ft

Cooling Energy
38.1 kBtu/sq ft

Grid Electricity
73.6 kBtu/sq ft

PERFORMANCE INDICATORS





LEED

LEED-NC

EA1	12	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: 62.2% ✓

EPAct compliant ✓

ENERGY USE

73.6 kBtu/sqft

21.6 kWh/sqft

COST INFORMATION

$5.18/sq ft Energy Cost

14.9 yrs Disc. Payback from Standard

BUILDING DATA

Commissary
GJMMP, Guam
68,724 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Commissary
Option A Energy Model Flows

AECOM

OPTION A SCORECARD

Name	Commissary
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver

Y	?	N	
56	0	53	Project Totals (Pre-certification Estimate)

12	0	14	Sustainable Sites	
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction

6	0	3	Water Efficiency	
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction

22	0	13	Energy and Atmosphere	
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
12	0	7	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power

0	0	4	Regional Importance	
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

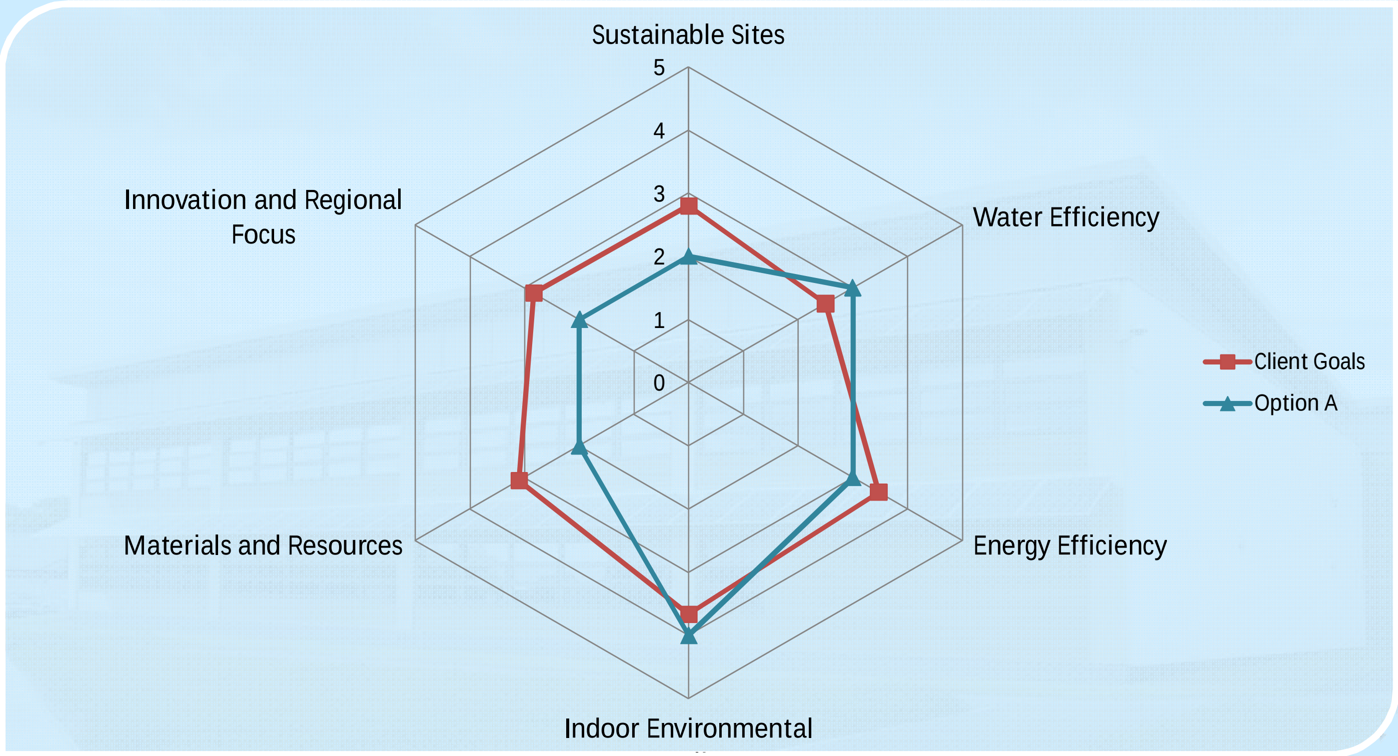
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

3	0	11	Materials and Resources	
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood

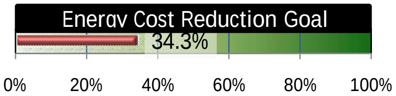
9	0	6	Indoor Environmental Quality	
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces

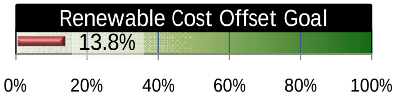
4	0	2	Innovation in Design	
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



PERFORMANCE INDICATORS





LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	22	out of 35 potential points
MR	3	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

Water Efficient Lanscaping Goal

100%

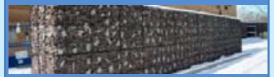
Water Use Reduction Goal

30%

Construction Waste Management Goal

75%

Recycled Materials Goal



10%

Regional Materials Goal

0%

SUSTAINABILITY METRIC

LEED SILVER USGBC

BUILDING DATA

Commissary
Guam
68,724 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

Commissary
Option A Sustainability KPIs

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the Dining Facility, in line with the approved requirements of the overall sustainability program. For the Dining Facility, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Dining Facility	40.5%	14.5%	Option B

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option B). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
Dining Facility	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

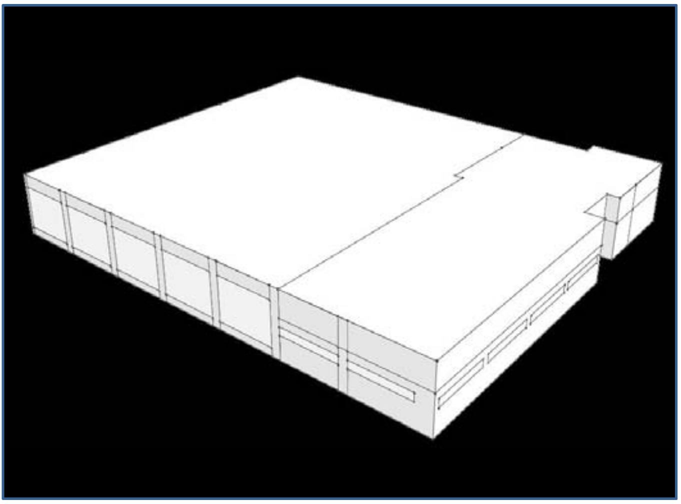
Building Name:	Dining Facility
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Dining Facility in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

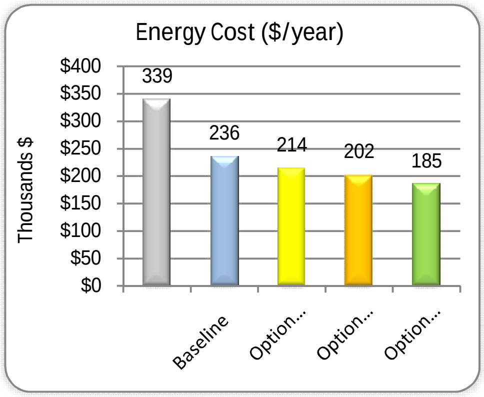
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

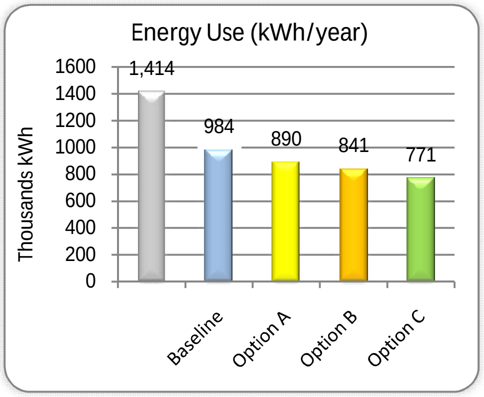


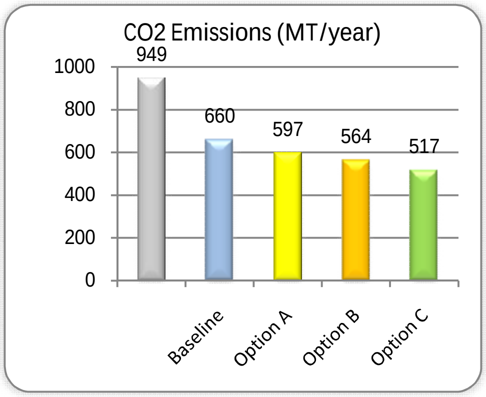
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 130.8 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 949.1 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $9.21/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



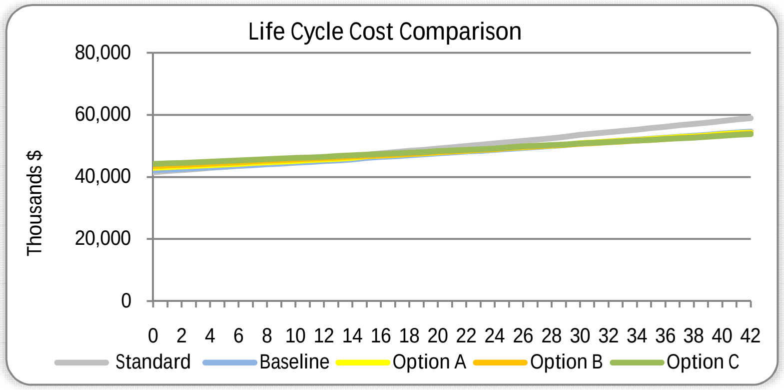




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 5.1 years for the Baseline scenario, 10.3 years for Option A, 13.4 years for Option B and 15.3 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

	Standard	Baseline	Option A	Option B	Option C
Options Summary					
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value SHGC	1.00 (Whole assembly) 0.25	1.00 (Whole assembly) 0.25	1.00 (Whole assembly) 0.25	1.00 (Whole assembly) 0.25	0.33 (Whole Assembly) 0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting Reduction from Standard	32W T8 Fixtures. ASHRAE 90.1 LPD 0%	ith Lighting Controls (Daylight and Motion) 21%	ith Lighting Controls (Daylight and Motion) 21%	ith Lighting Controls (Daylight and Motion) 21%	ith Lighting Controls (Daylight and Motion) 21%
Heating Heating Efficiency Heat Recovery Type Heat Recovery Efficiency	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%
Cooling SEER (If Packaged) COP (Central Plant) Coolth Recovery Type Coolth Recovery Efficiency	Packaged DX Cooling 11.1 No Coolth Recovery 0%	High Efficiency Packaged DX Cooling 14.9 Plate Coolth Exchangers 60%	High Efficiency Packaged DX Cooling 14.9 Plate Coolth Exchangers 60%	High Eff. Air Cooled Chillers 4.5 Plate Coolth Exchangers 60%	High Eff. Air Cooled Chillers 4.5 Plate Coolth Exchangers 60%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP Absorption Chillers	0.0 kW 0.0 kW	0.0 kW 0.0 kW	0.0 kW 0.0 kW	0.0 kW 0.0 kW	0.0 kW 0.0 kW
Hot Water Reduction Measure Reduction from Standard	LEED-NC v3 Fixtures and Fittings 0% DHW Use Reduction	Low Flow Fixtures and Fittings 18% DHW Use Reduction	Low Flow Fixtures and Fittings 18% DHW Use Reduction	Low Flow Fixtures and Fittings 18% DHW Use Reduction	Low Flow Fixtures and Fittings 18% DHW Use Reduction
Hot Water Heating Heating Efficiency	Minimum Eff. Electric Storage 87%	Solar Hot Water / High. Eff Electric Storage 93%	Solar Hot Water / High. Eff Electric Storage 93%	Solar Hot Water / High. Eff Electric Storage 93%	Solar Hot Water / High. Eff Electric Storage 93%
Exterior Lighting Exterior Lighting Density (W/sq ft)	HID Exterior Lighting 5.00 W/sq ft	LED Exterior Lighting 1.75 W/sq ft	LED Exterior Lighting 1.75 W/sq ft	LED Exterior Lighting 1.75 W/sq ft	LED Exterior Lighting 1.75 W/sq ft
Photovoltaics Installed Capacity (kW)	No PV Generation 0.0	Amorphous 28.7	Amorphous 71.6	Amorphous 71.6	Amorphous 107.5
Building Integrated Wind Installed Capacity (kW)	No Wind Generation 0.0	No Wind Generation 0.0	No Wind Generation 0.0	No Wind Generation 0.0	No Wind Generation 0.0
Energy Use Summary					
Lighting (kWh/year)	245330.2	193810.9	193810.9	193810.9	193810.9
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	854287.0	567374.4	552180.9	503035.1	497084.7
Auxiliary Energy (kWh/year)	89247.7	80780.2	77888.2	77888.2	77649.5
DHW (kWh/year)	31945.5	8576.9	8576.9	8576.9	8576.9
Exterior Lighting (kWh/year)	14089	4931.15	4931.15	4931.15	4931.15
Equipment (kWh/year)	179186.2	179186.2	179186.2	179186.2	179186.2
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-50725.8	-126814.6	-126814.6	-190221.9
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	1414085.7	983933.8	889759.6	840613.8	771017.4
Reduction from Standard (%)	0%	30%	37%	41%	45%
Energy Use by Fuel					
Grid Electricity Use (kWh)	1414085.7	983933.8	889759.6	840613.8	771017.4
Reduction from Standard (%)	0%	30%	37%	41%	45%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Source Energy Use					
Source Electricity Energy Use (kWh)	4723046.1	3286338.9	2971797.0	2807650.2	2575198.1
Reduction from Standard (%)	0%	30%	37%	41%	45%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	4723046.1	3286338.9	2971797.0	2807650.2	2575198.1
Reduction from Standard (%)	0%	30%	37%	41%	45%
Renewables Offset					
PV Energy Cost ($/year)	0.0	-12174.2	-30435.5	-30435.5	-45653.3
% of Building Energy Cost	0%	5%	12%	13%	19%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	-3822.8	-3822.8	-3822.8	-3822.8
% of Building Energy Cost	0%	2%	2%	2%	2%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	949.1	660.4	597.2	564.2	517.5
Reduction from Standard (%)	0%	30%	37%	41%	45%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-34.0	-85.1	-85.1	-127.7
Proportion of Total (%)	0%	5%	12%	13%	20%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

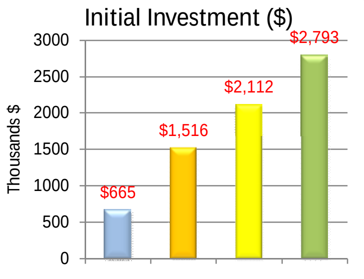
Total CO_2 Emissions (MT/yr)	949.1	660.4	597.2	564.2	517.5
Reduction from Standard (%)	0%	30%	37%	41%	45%

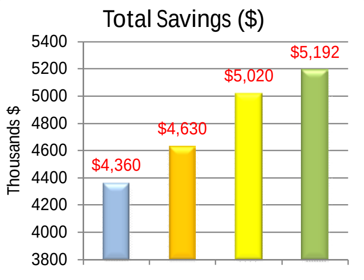
Energy Cost Summary

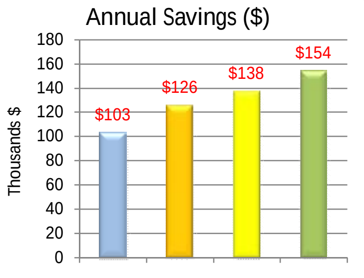
Electricity Cost ($/sq ft)	9.21	6.41	5.79	5.47	5.02
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	9.21	6.41	5.79	5.47	5.02
Reduction from Standard (%)	0%	30%	37%	41%	45%
Simple Payback (Years)	-	6.4	12.0	15.3	18.1

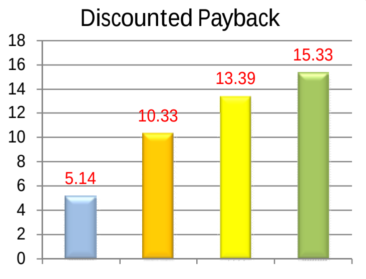
$/sq ft/kg of CO2 Emissions reduction	-	62.51	116.89	148.89	175.57

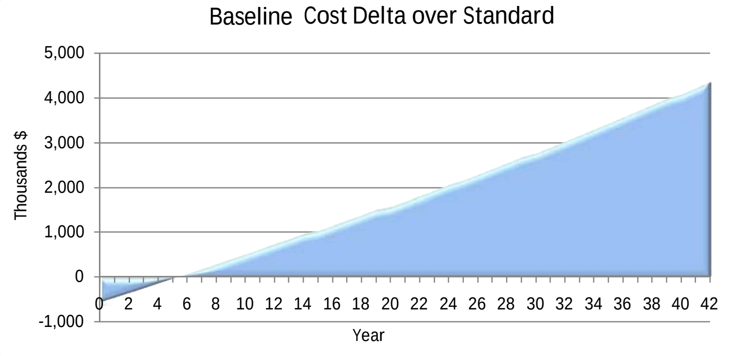
LIFE CYCLE COSTING

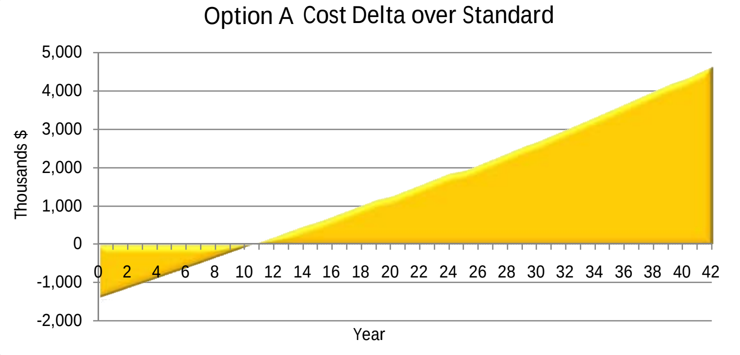

Initial Investment ($)

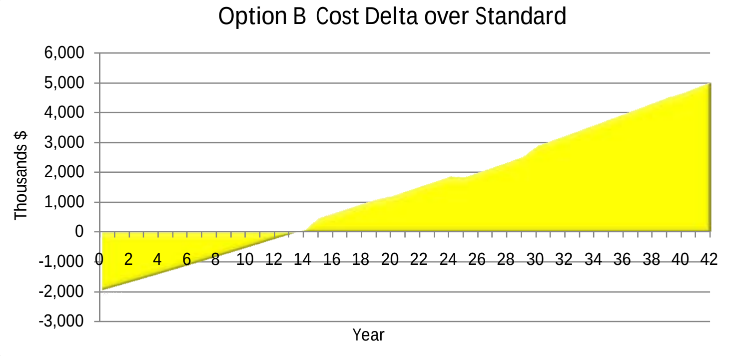

Total Savings ($)

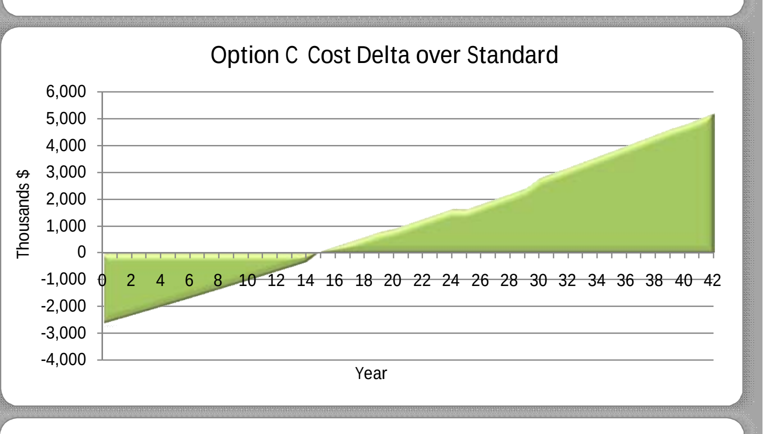

Annual Savings ($)

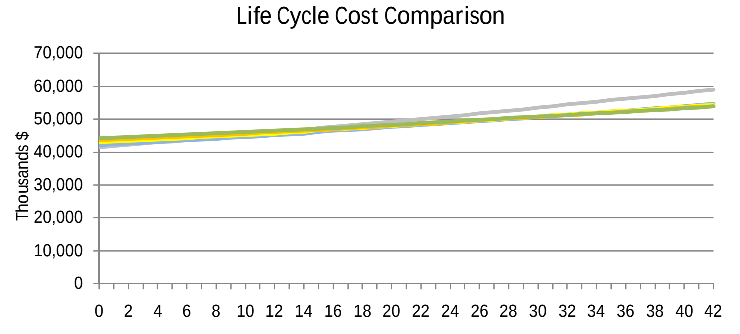

Discounted Payback

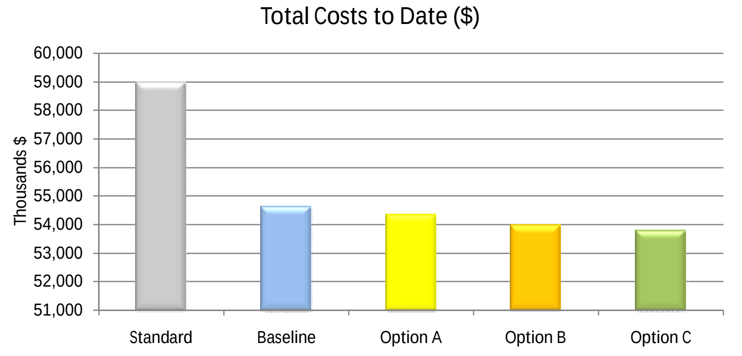

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

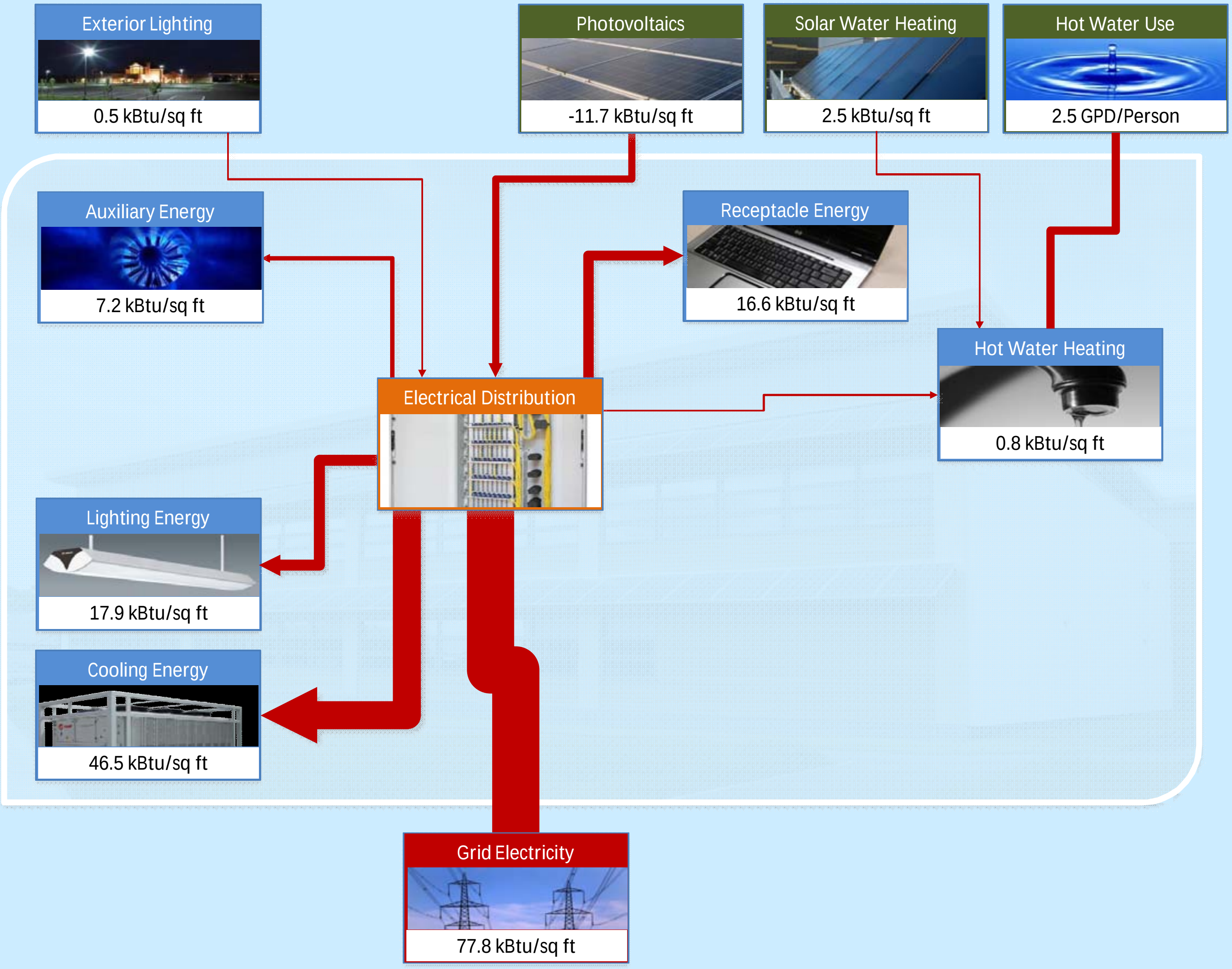

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.5 kBtu/sq ft

Photovoltaics
-11.7 kBtu/sq ft

Solar Water Heating
2.5 kBtu/sq ft

Hot Water Use
2.5 GPD/Person

Auxiliary Energy
7.2 kBtu/sq ft

Receptacle Energy
16.6 kBtu/sq ft

Hot Water Heating
0.8 kBtu/sq ft

Electrical Distribution

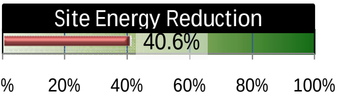
Lighting Energy
17.9 kBtu/sq ft

Cooling Energy
46.5 kBtu/sq ft

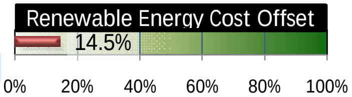
Grid Electricity
77.8 kBtu/sq ft

PERFORMANCE INDICATORS

Site Energy Reduction


40.6%

Renewable Energy Cost Offset


14.5%

LEED

LEED-NC

EA1	15	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: N/A

EPAct compliant ✓

ENERGY USE

77.8 kBtu/sqft

22.8 kWh/sqft

COST INFORMATION

$5.47/sq ft Energy Cost

13.4 yrs Disc. Payback from Standard

BUILDING DATA

Dining Facility
GJMMP, Guam
36,856 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Dining Facility
Option B Energy Model Flows

AECOM

OPTION A SCORECARD

Name	Dining Facility
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Gold

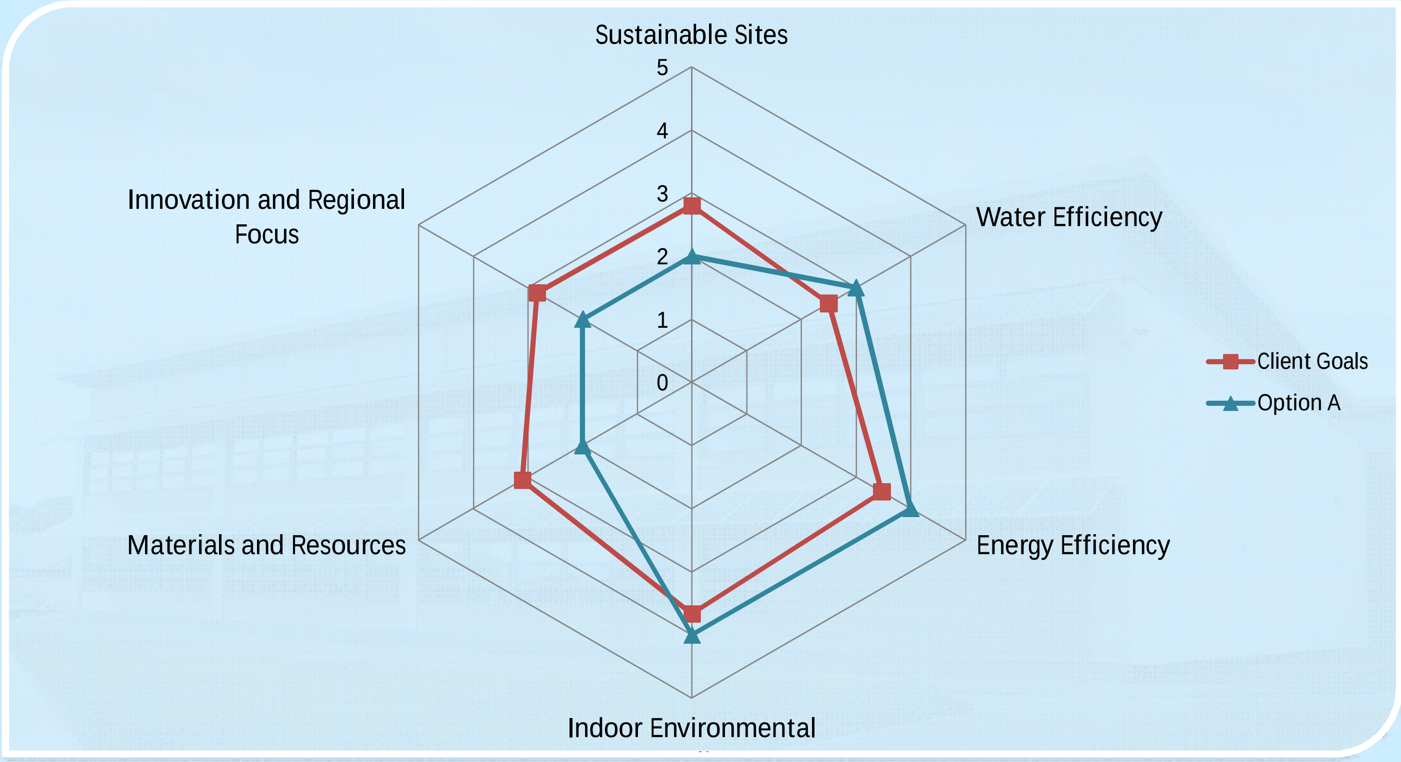
Y	?	N	
60	0	49	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	
12	0	14		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3		Water Efficiency
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction
25	0	10		Energy and Atmosphere
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
15	0	4	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power
0	0	4		Regional Importance
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

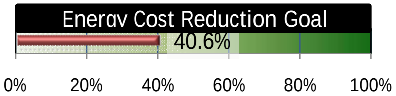
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

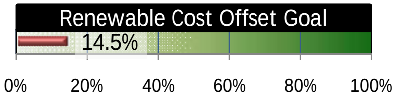
Y	?	N	Credit	
3	0	11		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
10	0	5		Indoor Environmental Quality
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
1	0	0	EQc8.2	Daylight & Views, Views for 90% of Spaces
4	0	2		Innovation in Design
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



PERFORMANCE INDICATORS





LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	25	out of 35 potential points
MR	3	out of 14 potential points
EQ	10	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

Water Efficient Lanscaping Goal

100%

Water Use Reduction Goal

30%

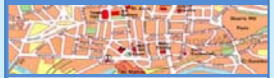
Construction Waste Management Goal

75%

Recycled Materials Goal

10%

Regional Materials Goal



0%

SUSTAINABILITY METRIC

U.S. GREEN BUILDING COUNCIL LEED GOLD USGBC

BUILDING DATA

Dining Facility
Guam
36,856 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

Dining Facility
Option A Sustainability KPIs

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the General Storage Warehouse, in line with the approved requirements of the overall sustainability program. For the General Storage Warehouse, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
General Storage Warehouse	90.0%	85.5%	Option B

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option C). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
General Storage Warehouse	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

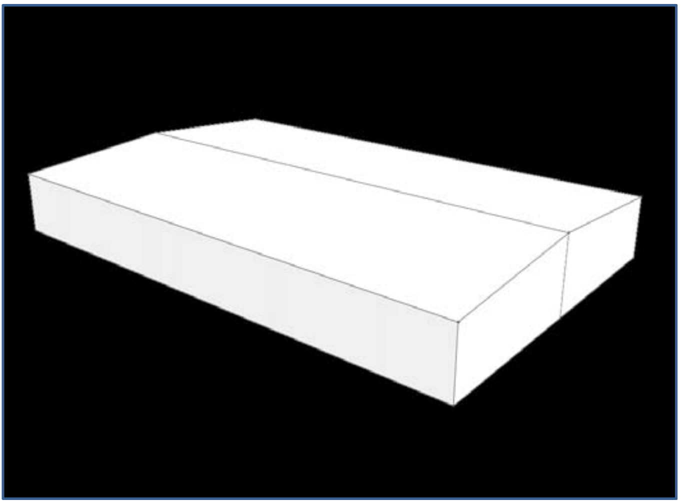
Building Name:	General Storage Warehouse
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the General Storage Warehouse in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

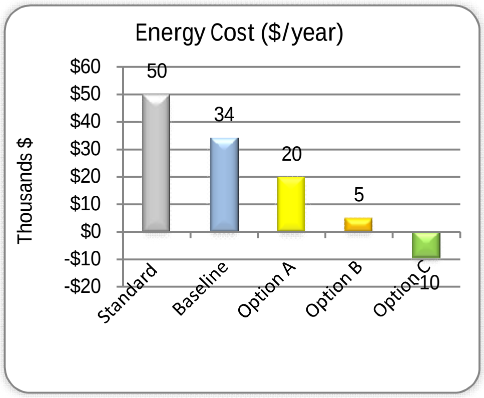
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

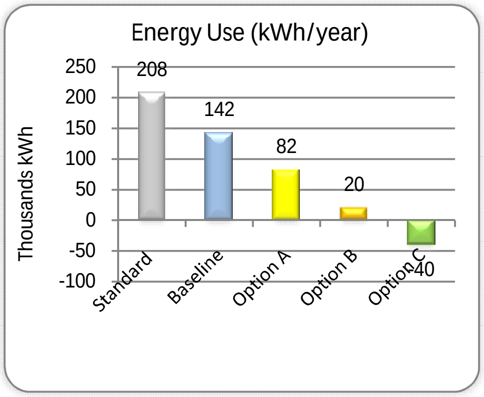


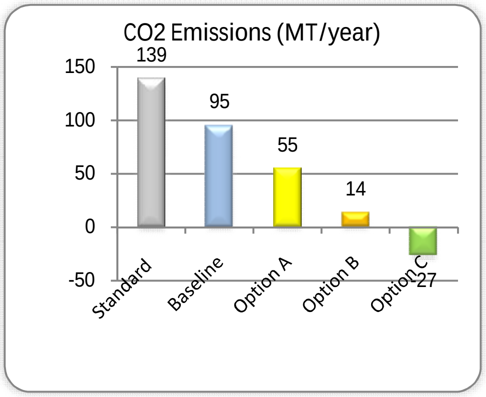
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 20.2 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 139.4 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $1.42/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



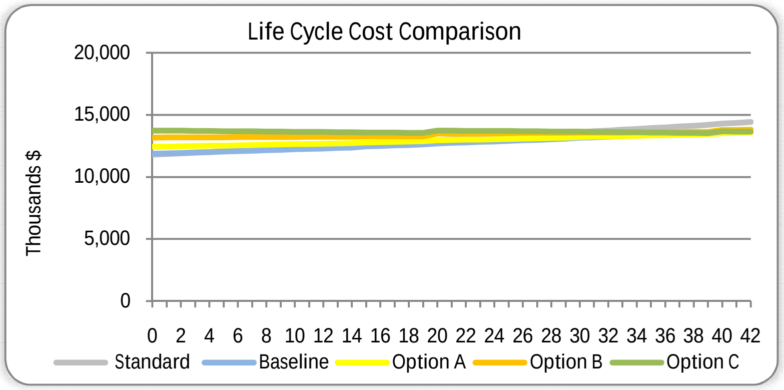




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 3.4 years for the Baseline scenario, 19.2 years for Option A, 30.4 years for Option B and 30.9 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	-	-	-	-	-
SHGC	-	-	-	-	-
Infiltration	0.00 ACH	0.00 ACH	0.00 ACH	0.00 ACH	0.00 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	T5 Fixtures with Lighting Controls (Motion)	T5 Fixtures with Lighting Controls (Motion)	T5 Fixtures with Lighting Controls (Motion)	T5 Fixtures with Lighting Controls (Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	4.5	4.5
Coolth Recovery Type	No Coolth Recovery	No Coolth Recovery	No Coolth Recovery	No Coolth Recovery	No Coolth Recovery
Coolth Recovery Efficiency	0%	0%	0%	0%	0%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage
Heating Efficiency	87%	87%	87%	87%	87%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	0.0	34.0	68.0	102.1
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

Lighting (kWh/year)	105300.9	83187.7	83187.7	83187.7	83187.7
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	80900.7	48583.3	48583.3	47203.5	47203.5
Auxiliary Energy (kWh/year)	6666.3	4811.2	4811.2	4811.2	4811.2
DHW (kWh/year)	891.1	730.7	730.7	730.7	730.7
Exterior Lighting (kWh/year)	13997.8	4899.2	4899.2	4899.2	4899.2
Equipment (kWh/year)	0.0	0.0	0.0	0.0	0.0
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	0.0	-60214.2	-120428.4	-180642.7
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	207756.8	142212.1	81997.9	20403.8	-39810.4
Reduction from Standard (%)	0%	32%	61%	90%	119%

Energy Use by Fuel

Grid Electricity Use (kWh)	207756.8	142212.1	81997.9	20403.8	-39810.4
Reduction from Standard (%)	0%	32%	61%	90%	119%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

Source Electricity Energy Use (kWh)	693907.6	474988.4	273872.9	68148.7	-132966.8
Reduction from Standard (%)	0%	32%	61%	90%	119%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	693907.6	474988.4	273872.9	68148.7	-132966.8
Reduction from Standard (%)	0%	32%	61%	90%	119%

Renewables Offset

PV Energy Cost ($/year)	0.0	0.0	-14451.4	-28902.8	-43354.2
% of Building Energy Cost	0%	0%	42%	86%	128%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	139.4	95.4	55.0	13.7	-26.7
Reduction from Standard (%)	0%	32%	61%	90%	119%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	0.0	-40.4	-80.8	-121.2
Proportion of Total (%)	0%	0%	42%	86%	128%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

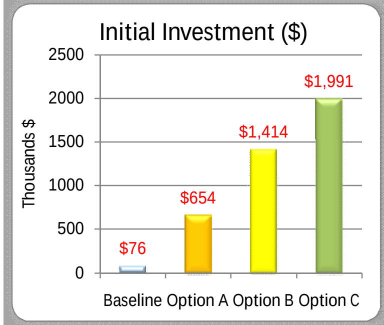
Total CO_2 Emissions (MT/yr)	139.4	95.4	55.0	13.7	-26.7
Reduction from Standard (%)	0%	32%	61%	90%	119%

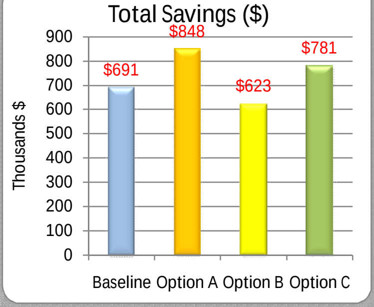
Energy Cost Summary

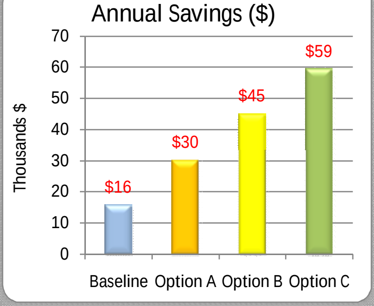
Electricity Cost ($/sq ft)	1.42	0.98	0.56	0.14	-0.27
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	1.42	0.98	0.56	0.14	-0.27
Reduction from Standard (%)	0%	32%	61%	90%	119%
Simple Payback (Years)	-	4.9	21.7	31.4	33.5

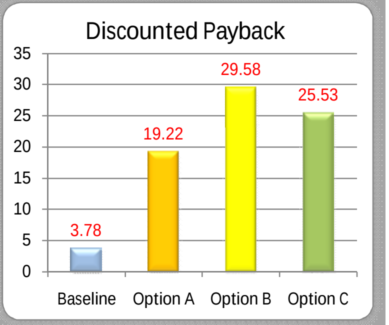
$/sq ft/kg of CO2 Emissions reduction	-	49.56	221.25	321.29	342.41

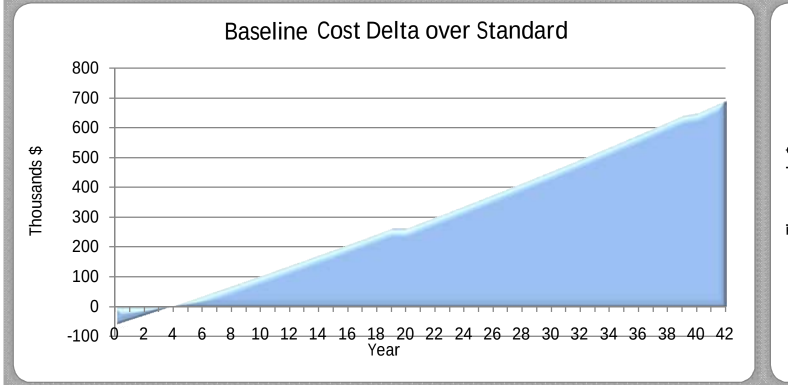
LIFE CYCLE COSTING

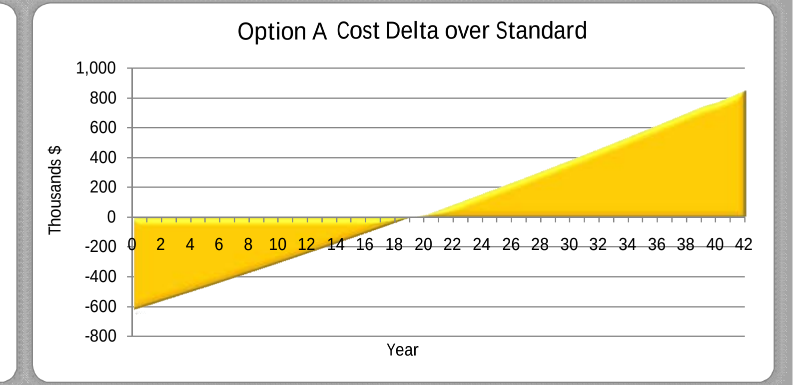

Initial Investment ($)

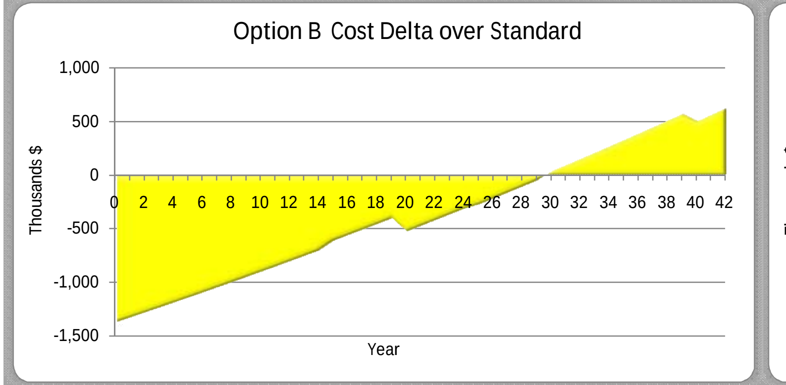

Total Savings ($)

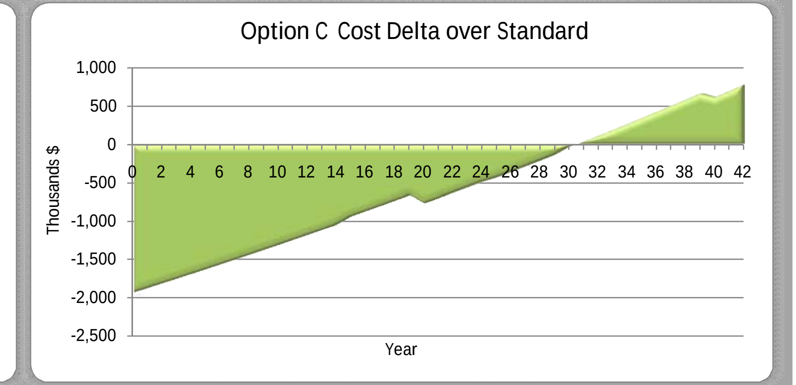

Annual Savings ($)

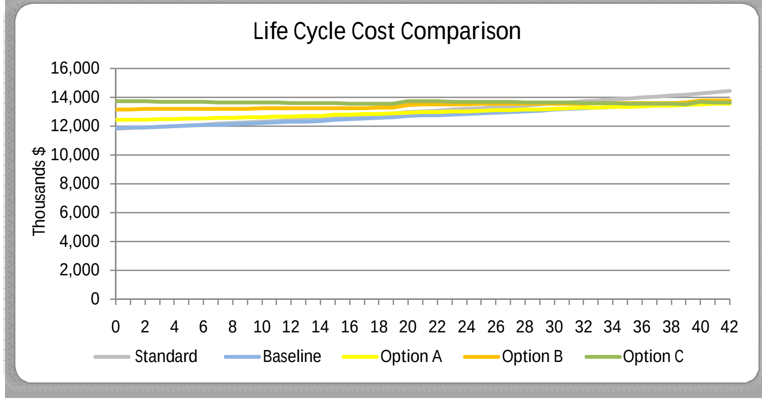

Discounted Payback

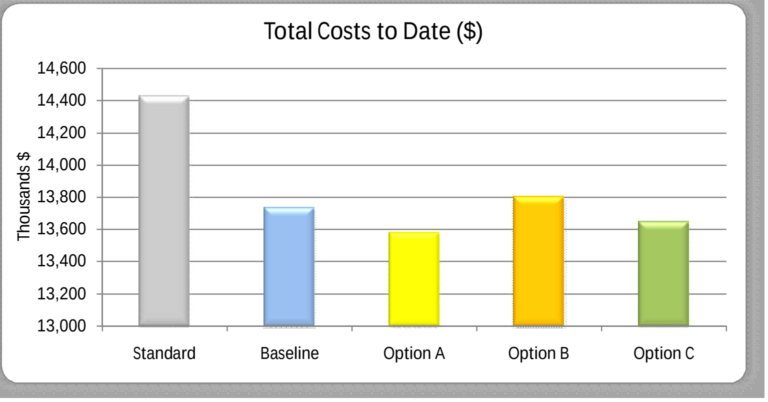

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

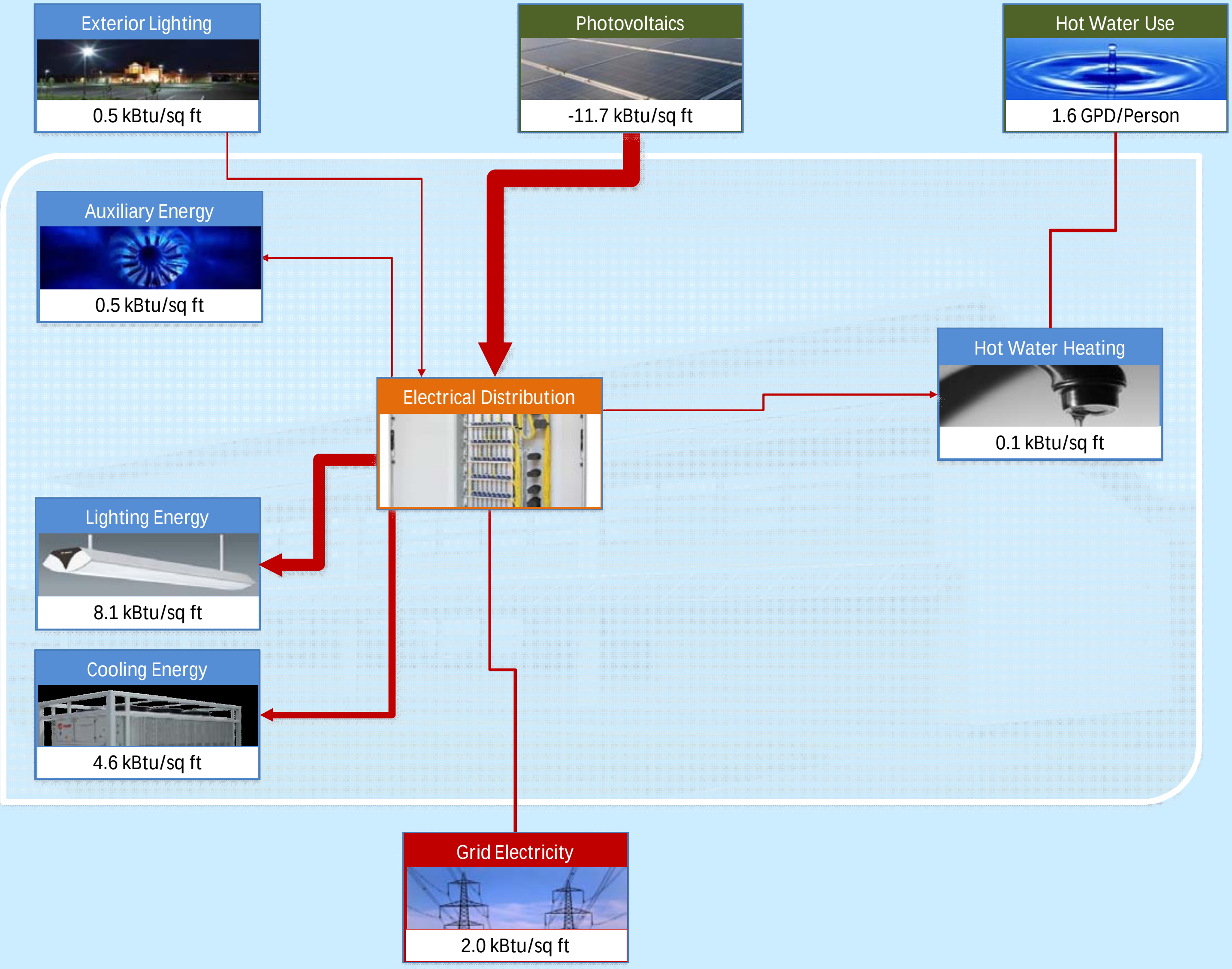

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.5 kBtu/sq ft

Photovoltaics
-11.7 kBtu/sq ft

Hot Water Use
1.6 GPD/Person

Auxiliary Energy
0.5 kBtu/sq ft

Electrical Distribution

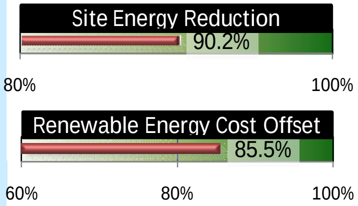
Hot Water Heating
0.1 kBtu/sq ft

Lighting Energy
8.1 kBtu/sq ft

Cooling Energy
4.6 kBtu/sq ft

Grid Electricity
2.0 kBtu/sq ft

PERFORMANCE INDICATORS



LEED

LEED-NC

EA1 **19** out of 19 potential points

EA2 **7** out of 7 potential points

FEDERAL MANDATES

EISA Score: N/A

EPAct compliant ✓

ENERGY USE

2.0 kBtu/sqft

0.6 kWh/sqft

COST INFORMATION

$0.14/sq ft Energy Cost

29.6 yrs Disc. Payback from Standard

BUILDING DATA

General Storage Warehouse
GJMMP, Guam
35,000 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

General Storage Warehouse
Option B Energy Model Flows

AECOM

OPTION A SCORECARD

Name	General Storage Warehouse
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Gold

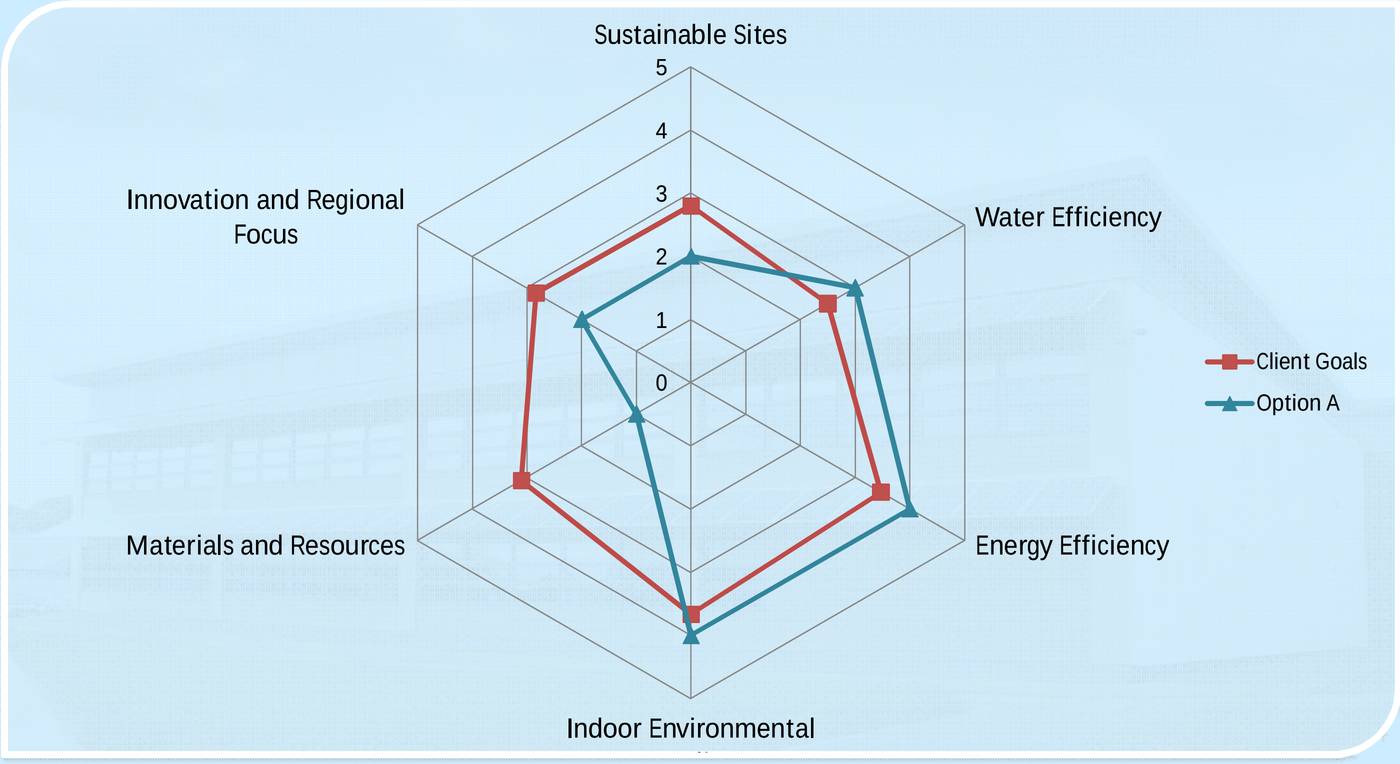
Y	?	N	
61	0	48	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Description
11	0	15	Sustainable Sites	
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
0	0	1	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3	Water Efficiency	
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction
29	0	6	Energy and Atmosphere	
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
19	0	0	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power
0	0	4	Regional Importance	
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

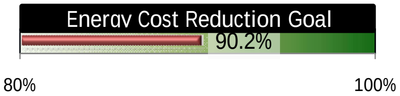
Y	?	N	Credit	Description
2	0	12	Materials and Resources	
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
0	0	1	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
9	0	6	Indoor Environmental Quality	
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces
4	0	2	Innovation in Design	
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs

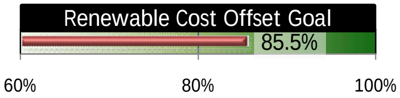


PERFORMANCE INDICATORS

Energy Cost Reduction Goal



Renewable Cost Offset Goal



LEED

LEED-NC

SS	11	out of 26 potential points
WE	6	out of 10 potential points
EA	29	out of 35 potential points
MR	2	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

U.S. GREEN BUILDING COUNCIL
LEED GOLD
USGBC

Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
				
100%	30%	75%	0%	0%

BUILDING DATA

General Storage Warehouse
Guam
35,000 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

General Storage Warehouse
Option A Sustainability KPIs

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the Organic Storage Warehouse, in line with the approved requirements of the overall sustainability program. For the Organic Storage Warehouse, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Organic Storage Warehouse	48.0%	23.5%	Option B

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option B). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
Organic Storage Warehouse	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

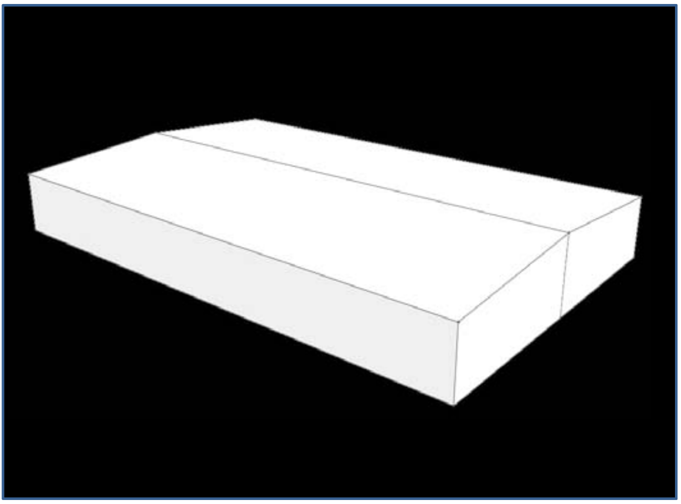
Building Name:	Organic Storage Warehouse
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Organic Storage Warehouse in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

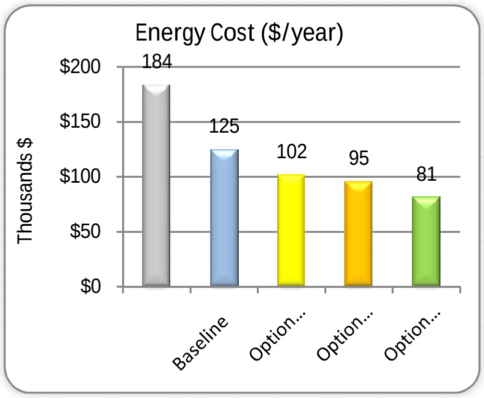
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

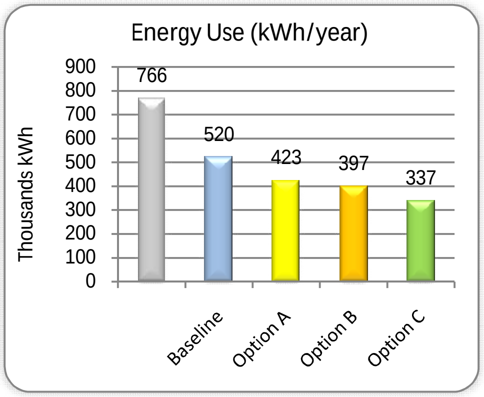


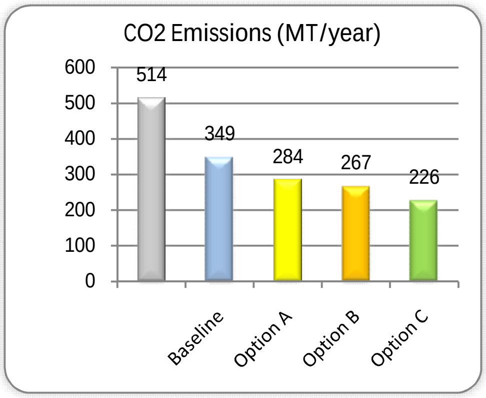
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 74.6 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 513.9 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $5.25/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



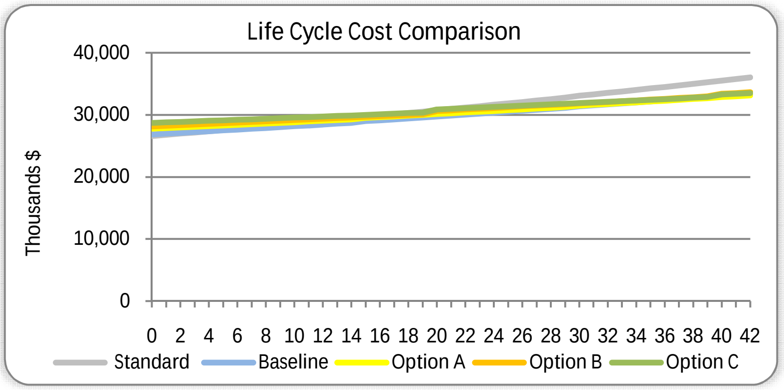




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 4.2 years for the Baseline scenario, 13.3 years for Option A, 15.2 years for Option B and 18.0 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	-	-	-	-	-
SHGC	-	-	-	-	-
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	T5 Fixtures with Lighting Controls (Motion)	T5 Fixtures with Lighting Controls (Motion)	T5 Fixtures with Lighting Controls (Motion)	T5 Fixtures with Lighting Controls (Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	4.5	4.5
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage	Minimum Eff. Electric Storage
Heating Efficiency	87%	87%	87%	87%	87%
Exterior Lighting	Induction Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	2.50 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	13.6	68.0	68.0	102.1
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	105300.9	83187.7	83187.7	83187.7	83187.7
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	579806.0	388473.1	388473.1	362497.6	362497.6
Auxiliary Energy (kWh/year)	72689.7	66455.8	66455.8	66455.8	66455.8
DHW (kWh/year)	891.1	730.7	730.7	730.7	730.7
Exterior Lighting (kWh/year)	6996.1375	4897.29625	4897.29625	4897.29625	4897.29625
Equipment (kWh/year)	0.0	0.0	0.0	0.0	0.0
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-24085.7	-120428.4	-120428.4	-180642.7
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	765683.7	519658.9	423316.2	397340.6	337126.4
Reduction from Standard (%)	0%	32%	45%	48%	56%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	765683.7	519658.9	423316.2	397340.6	337126.4
Reduction from Standard (%)	0%	32%	45%	48%	56%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	2557383.7	1735660.7	1413875.9	1327117.7	1126002.2
Reduction from Standard (%)	0%	32%	45%	48%	56%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	2557383.7	1735660.7	1413875.9	1327117.7	1126002.2
Reduction from Standard (%)	0%	32%	45%	48%	56%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-5780.6	-28902.8	-28902.8	-43354.2
% of Building Energy Cost	0%	4%	22%	23%	35%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	513.9	348.8	284.1	266.7	226.3
Reduction from Standard (%)	0%	32%	45%	48%	56%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-16.2	-80.8	-80.8	-121.2
Proportion of Total (%)	0%	4%	22%	23%	35%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

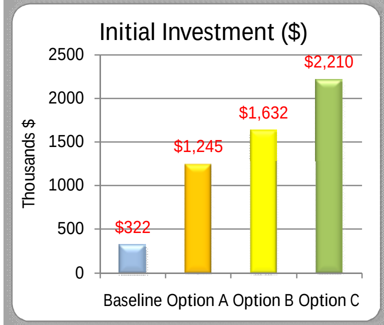
Total CO_2 Emissions (MT/yr)	513.9	348.8	284.1	266.7	226.3
Reduction from Standard (%)	0%	32%	45%	48%	56%

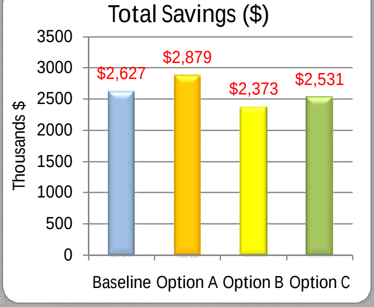
Energy Cost Summary

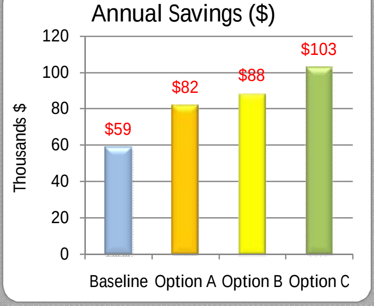
Electricity Cost ($/sq ft)	5.25	3.56	2.90	2.72	2.31
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	5.25	3.56	2.90	2.72	2.31
Reduction from Standard (%)	0%	32%	45%	48%	56%
Simple Payback (Years)	-	5.4	15.2	18.5	21.5

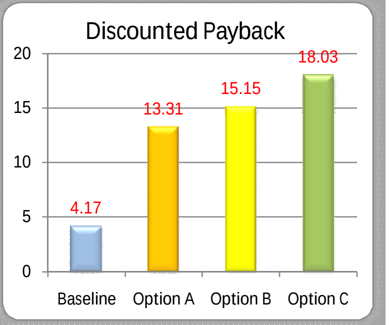
$/sq ft/kg of CO2 Emissions reduction	-	55.66	154.85	188.66	219.50

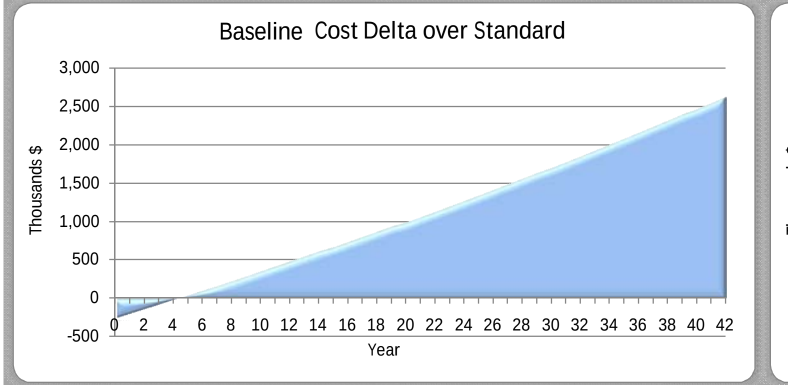
LIFE CYCLE COSTING

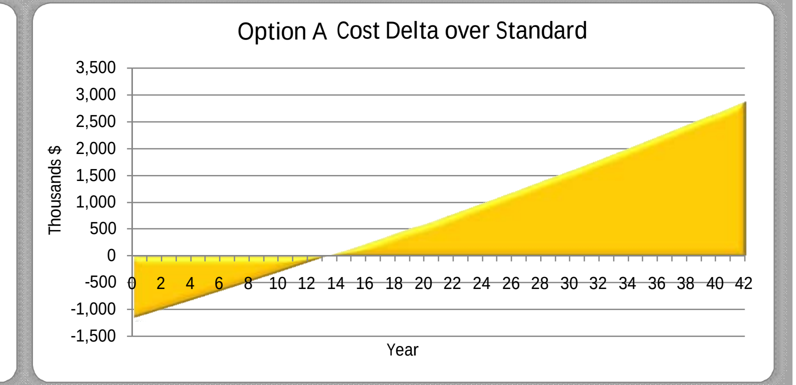

Initial Investment ($)

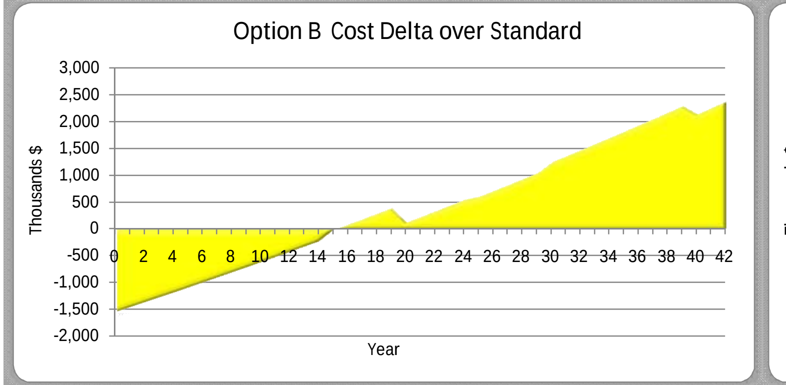

Total Savings ($)

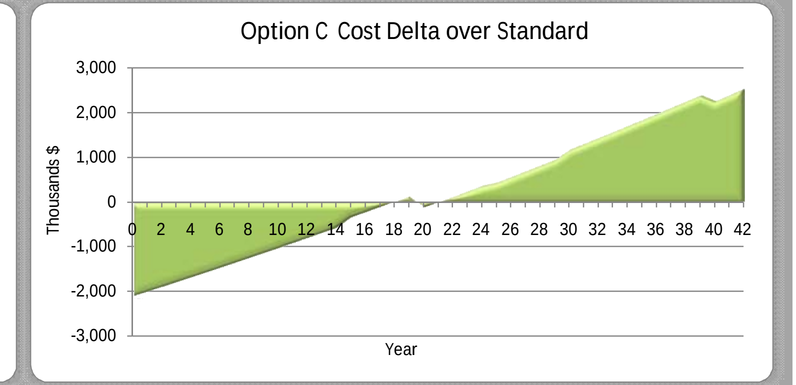

Annual Savings ($)

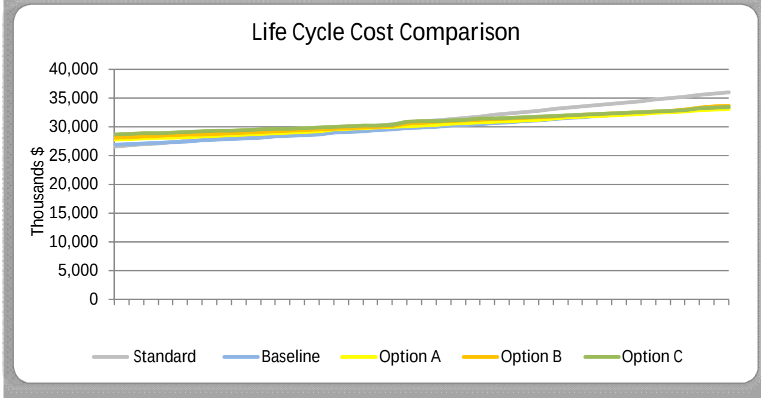

Discounted Payback

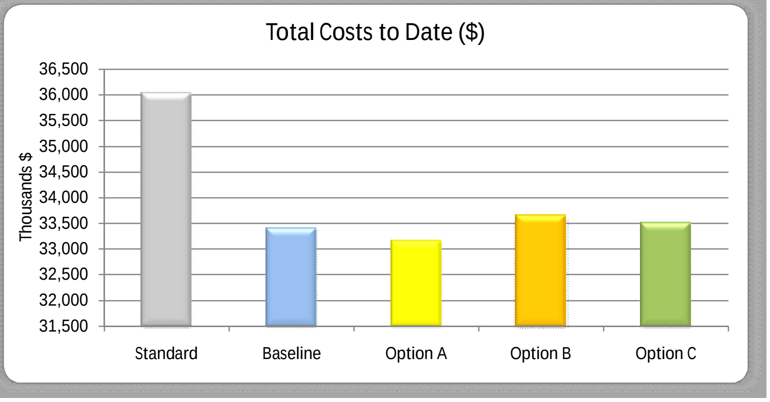

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

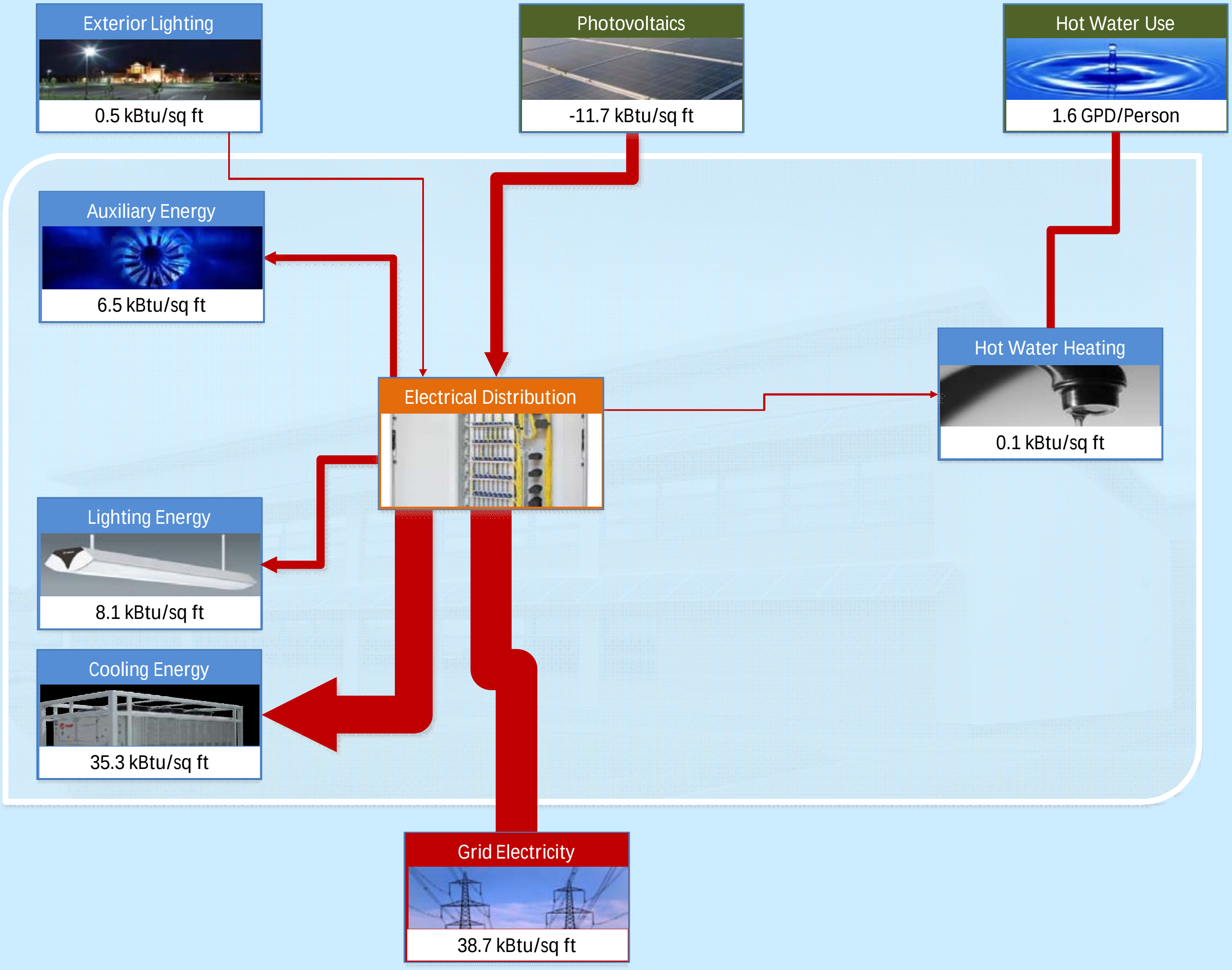

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.5 kBtu/sq ft

Photovoltaics
-11.7 kBtu/sq ft

Hot Water Use
1.6 GPD/Person

Auxiliary Energy
6.5 kBtu/sq ft

Electrical Distribution

Hot Water Heating
0.1 kBtu/sq ft

Lighting Energy
8.1 kBtu/sq ft

Cooling Energy
35.3 kBtu/sq ft

Grid Electricity
38.7 kBtu/sq ft

BUILDING DATA

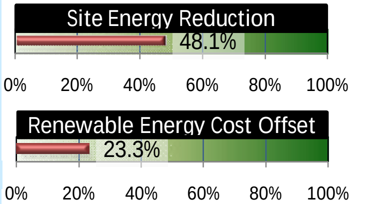
Organic Storage Warehouse
GJMMP, Guam
35,000 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Organic Storage Warehouse
Option B Energy Model Flows

PERFORMANCE INDICATORS



LEED

LEED-NC

EA1	19	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: 75.2% ✓

EPAct compliant ✓

ENERGY USE

38.7 kBtu/sqft

11.4 kWh/sqft

COST INFORMATION

$2.72/sq ft Energy Cost

15.2 yrs Disc. Payback from Standard

AECOM

OPTION A SCORECARD

Name	Organic Storage Warehouse
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Gold

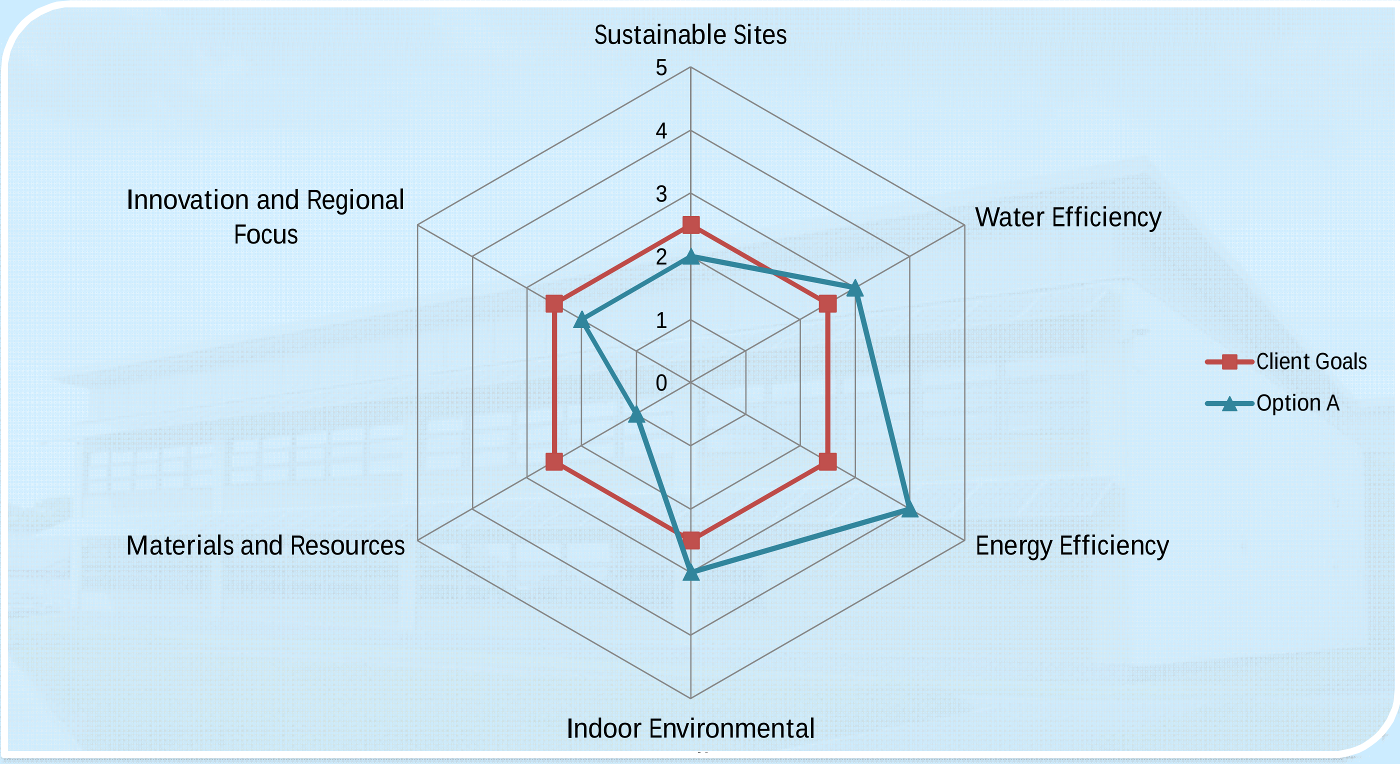
Y	?	N	
61	0	48	Project Totals (Pre-certification Estimate)

Y	?	N		
11	0	15	Sustainable Sites	
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
0	0	1	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3	Water Efficiency	
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction
29	0	6	Energy and Atmosphere	
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
19	0	0	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power
0	0	4	Regional Importance	
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

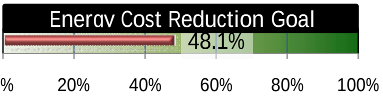
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

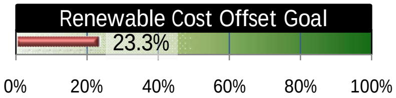
Y	?	N		
2	0	12	Materials and Resources	
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
0	0	1	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
9	0	6	Indoor Environmental Quality	
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces
4	0	2	Innovation in Design	
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



PERFORMANCE INDICATORS





LEED

LEED-NC

SS	11	out of 26 potential points
WE	6	out of 10 potential points
EA	29	out of 35 potential points
MR	2	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

Water Efficient Lanscaping Goal

100%

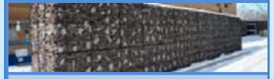
Water Use Reduction Goal

30%

Construction Waste Management Goal

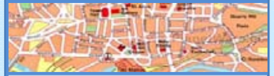
75%

Recycled Materials Goal



0%

Regional Materials Goal



0%

SUSTAINABILITY METRIC

LEED GOLD
USGBC

BUILDING DATA

Organic Storage Warehouse
Guam
35,000 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

Organic Storage Warehouse
Option A Sustainability KPIs

AECOM

Guam JMMP Sustainability Program Summary Report

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the Workshop, in line with the approved requirements of the overall sustainability program. For the Workshop, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Workshop	31.0%	9.0%	Baseline

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Baseline). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
Workshop	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design t**eam** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

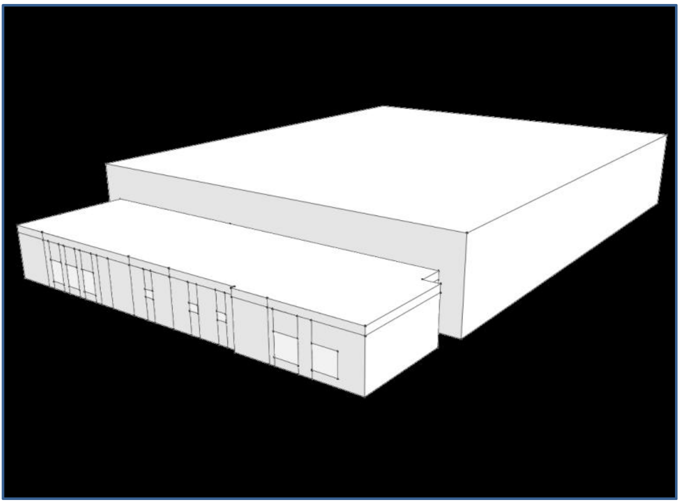
Building Name:	Workshop
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Workshop in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

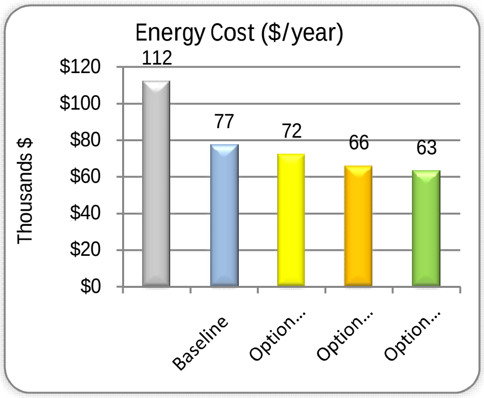
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

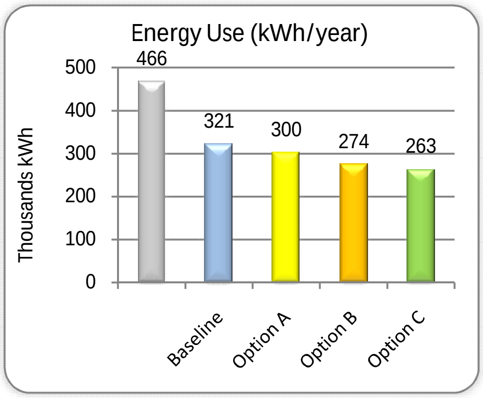


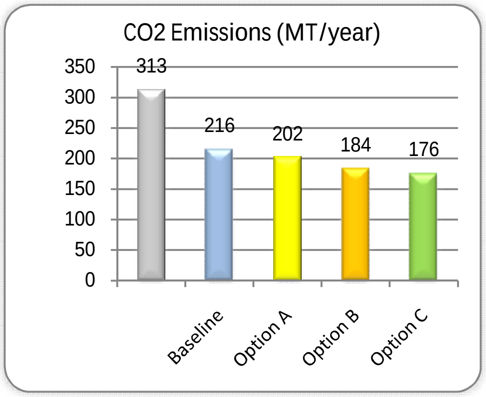
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 84.9 kBtu/sq ft of energy per year.   Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 313.1 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $5.98/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



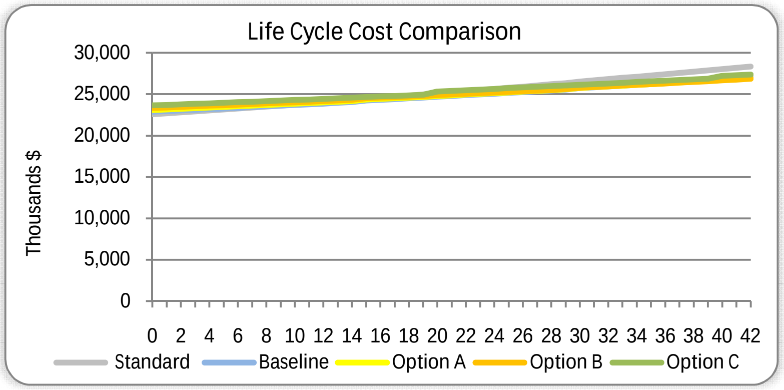




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 8.3 years for the Baseline scenario, 12.1 years for Option A, 15.6 years for Option B and 18.5 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

	Standard	Baseline	Option A	Option B	Option C
Options Summary					
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	28W T5 Fixtures	28W T5 Fixtures	28W T5 Fixtures	28W T5 Fixtures
Reduction from Baseline	0%	13%	13%	13%	13%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	14.9	4.5
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Constant Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Baseline	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	17.9	29.9	44.9	44.9
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0
Energy Use Summary					
Lighting (kWh/year)	102337.0	89544.8	89544.8	89544.8	89544.8
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	223157.0	155215.5	155215.5	155215.5	144095.7
Auxiliary Energy (kWh/year)	51452.0	26396.9	26396.9	26396.9	26396.9
DHW (kWh/year)	2548.8	1955.1	1955.1	1955.1	1955.1
Exterior Lighting (kWh/year)	10490.1	3671.535	3671.535	3671.535	3671.535
Equipment (kWh/year)	76460.1	76460.1	76460.1	76460.1	76460.1
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-31755.2	-52925.3	-79388.0	-79388.0
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	466445.0	321488.8	300318.7	273856.0	262736.2
Reduction from Baseline (%)	0%	31%	36%	41%	44%
Energy Use by Fuel					
Grid Electricity Use (kWh)	466445.0	321488.8	300318.7	273856.0	262736.2
Reduction from Baseline (%)	0%	31%	36%	41%	44%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Source Energy Use					
Source Electricity Energy Use (kWh)	1557926.2	1073772.7	1003064.5	914679.2	877539.0
Reduction from Baseline (%)	0%	31%	36%	41%	44%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%
Total (kWh)	1557926.2	1073772.7	1003064.5	914679.2	877539.0
Reduction from Baseline (%)	0%	31%	36%	41%	44%
Renewables Offset					
PV Energy Cost ($/year)	0.0	-7621.2	-12702.1	-19053.1	-19053.1
% of Building Energy Cost	0%	9%	15%	22%	23%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	313.1	215.8	201.6	183.8	176.3
Reduction from Baseline (%)	0%	31%	36%	41%	44%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-21.3	-35.5	-53.3	-53.3
Proportion of Total (%)	0%	9%	15%	22%	23%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Baseline (%)	0%	0%	0%	0%	0%

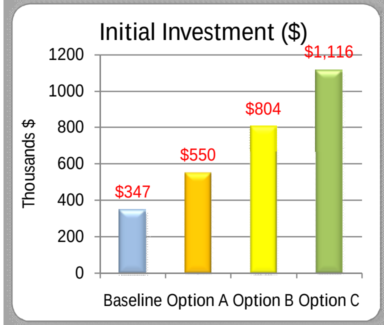
Total CO_2 Emissions (MT/yr)	313.1	215.8	201.6	183.8	176.3
Reduction from Baseline (%)	0%	31%	36%	41%	44%

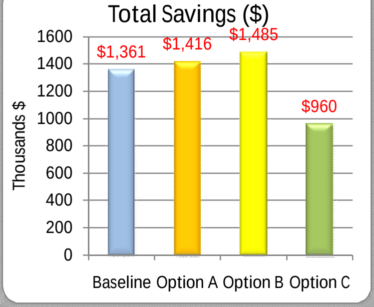
Energy Cost Summary

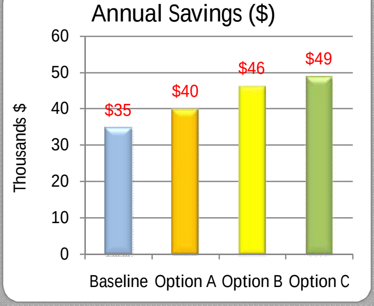
Electricity Cost ($/sq ft)	5.98	4.12	3.85	3.51	3.37
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	5.98	4.12	3.85	3.51	3.37
Reduction from Baseline (%)	0%	31%	36%	41%	44%
Simple Payback (Years)	-	10.0	13.8	17.4	22.8

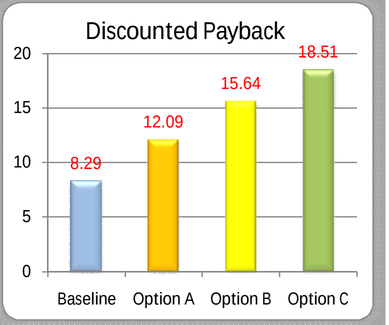
$/sq ft/kg of CO2 Emissions reduction	-	190.63	263.56	332.18	436.09

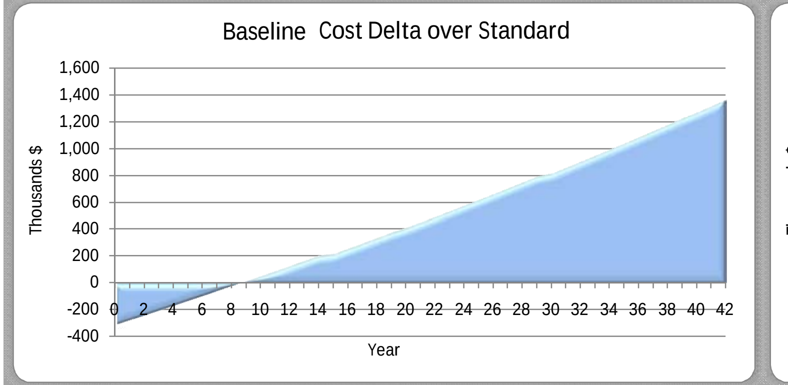
LIFE CYCLE COSTING

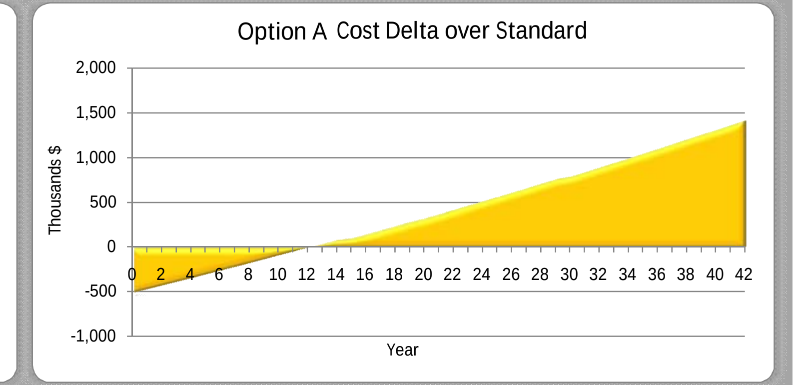

Initial Investment ($)

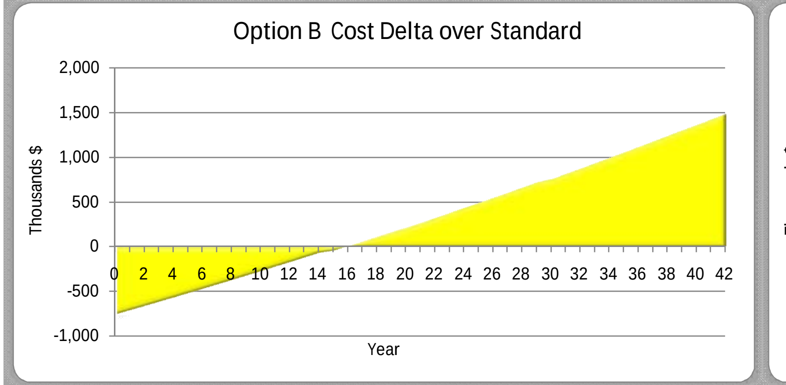

Total Savings ($)

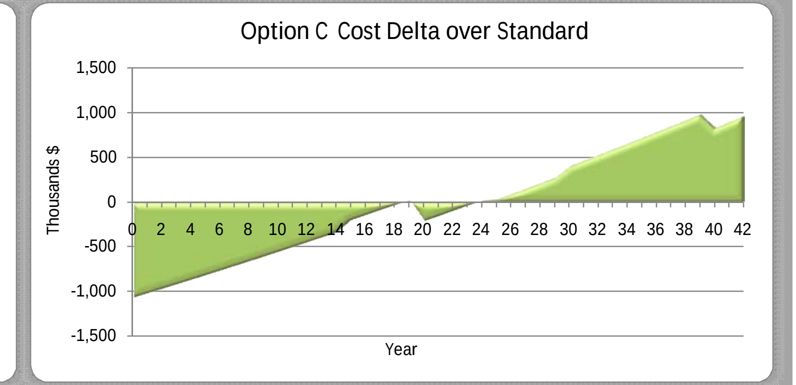

Annual Savings ($)

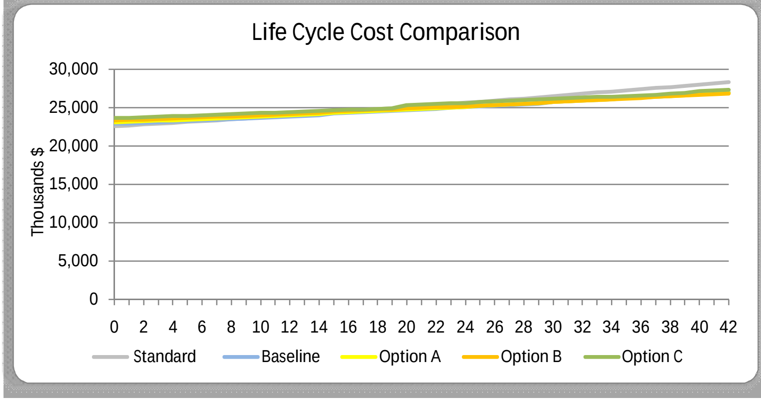

Discounted Payback

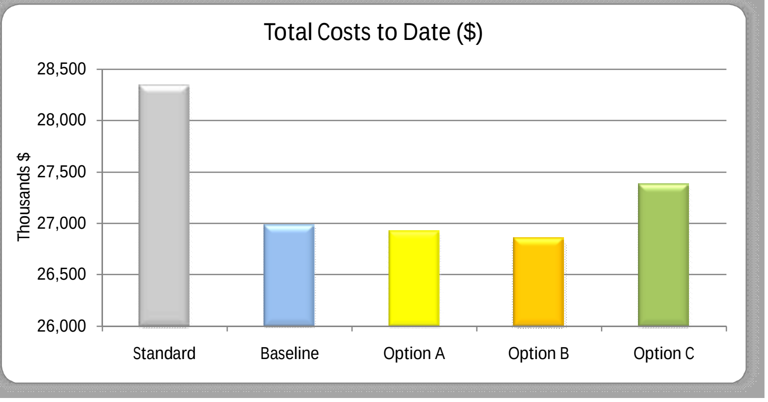

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

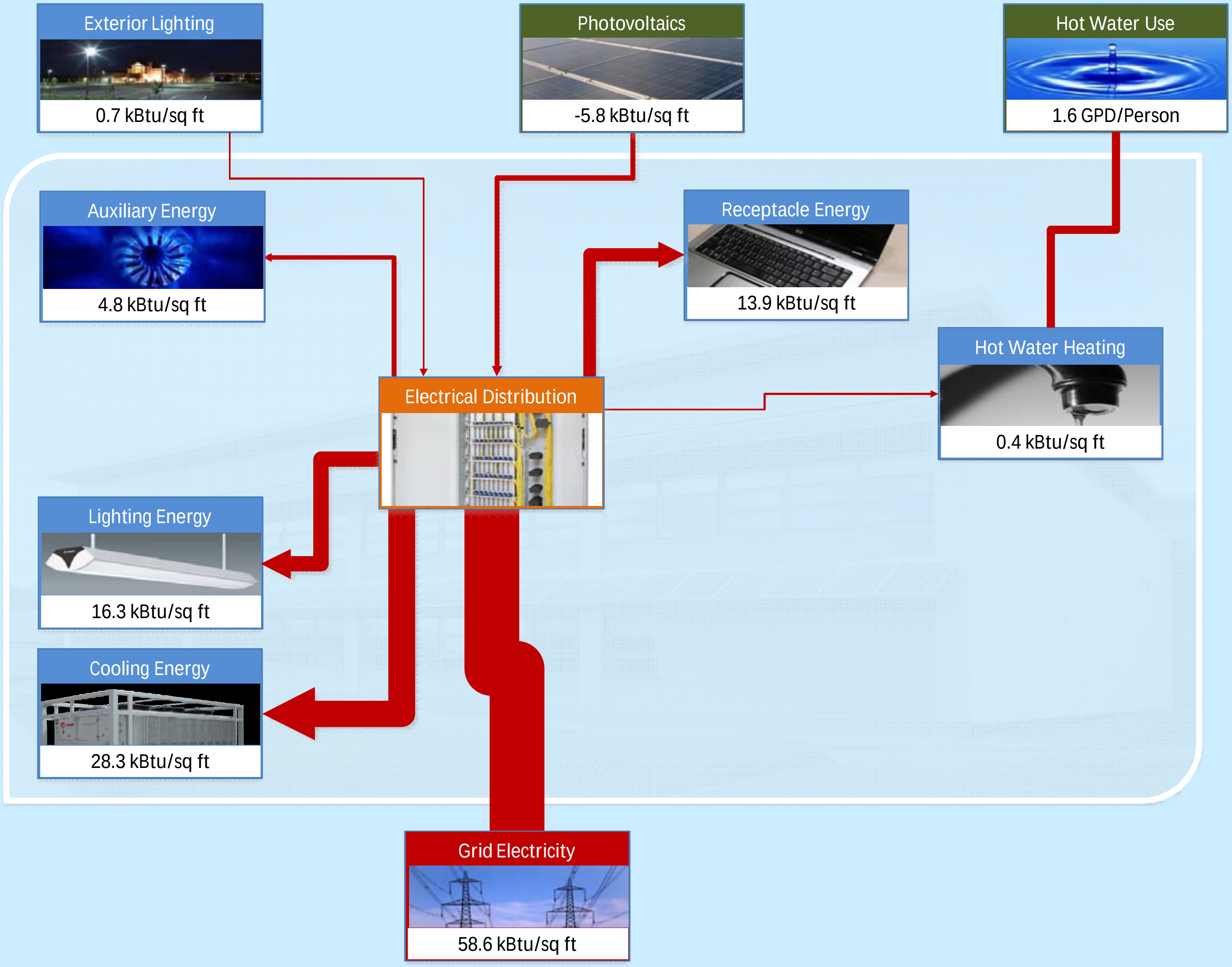

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.7 kBtu/sq ft

Photovoltaics
-5.8 kBtu/sq ft

Hot Water Use
1.6 GPD/Person

Auxiliary Energy
4.8 kBtu/sq ft

Receptacle Energy
13.9 kBtu/sq ft

Electrical Distribution

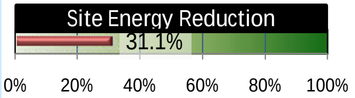
Hot Water Heating
0.4 kBtu/sq ft

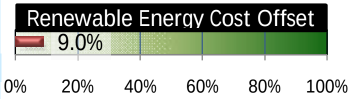
Lighting Energy
16.3 kBtu/sq ft

Cooling Energy
28.3 kBtu/sq ft

Grid Electricity
58.6 kBtu/sq ft

PERFORMANCE INDICATORS





LEED

LEED-NC

EA1 10 out of 19 potential points

EA2 4 out of 7 potential points

FEDERAL MANDATES

EISA Score: N/A

EPAct compliant ✓

ENERGY USE

58.6 kBtu/sqft

17.2 kWh/sqft

COST INFORMATION

$4.12/sq ft Energy Cost

8.3 yrs Disc. Payback from Standard

BUILDING DATA

Workshop
GJMMP, Guam
18,724 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Workshop
Baseline Energy Model Flows

AECOM

OPTION A SCORECARD

Name	Workshop
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver

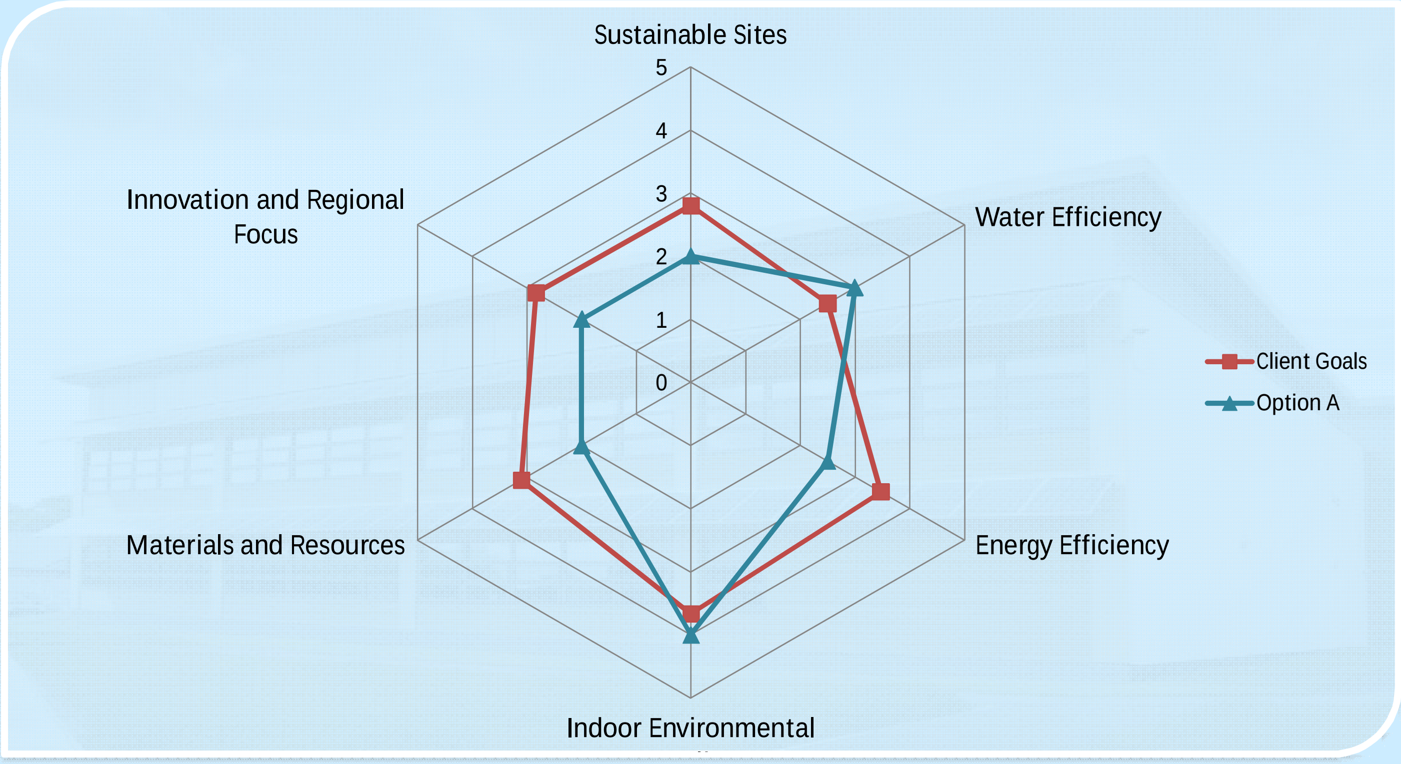
Y	?	N	
52	0	57	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Description
12	0	14	Sustainable Sites	
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3	Water Efficiency	
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction
18	0	17	Energy and Atmosphere	
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
10	0	9	EAc1	Optimize Energy Performance
5	0	2	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power
0	0	4	Regional Importance	
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

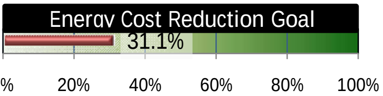
Y	?	N	Credit	Description
3	0	11	Materials and Resources	
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
9	0	6	Indoor Environmental Quality	
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces
4	0	2	Innovation in Design	
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs

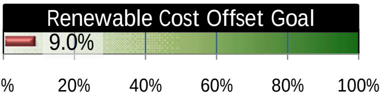


PERFORMANCE INDICATORS

Energy Cost Reduction Goal



Renewable Cost Offset Goal



LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	18	out of 35 potential points
MR	3	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

U.S. GREEN BUILDING COUNCIL LEED SILVER USGBC

Water Efficient Lanscaping Goal

100%

Water Use Reduction Goal

30%

Construction Waste Management Goal

75%

Recycled Materials Goal

10%

Regional Materials Goal

0%

BUILDING DATA

Workshop
Guam
18,724 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

Workshop
Option A Sustainability KPIs

AECOM

Guam JMMP Sustainability Program Summary Report

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the Day Center, in line with the approved requirements of the overall sustainability program. For the Day Center, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
Day Center	42.5%	13.0%	Option A

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option A). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
Day Center	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

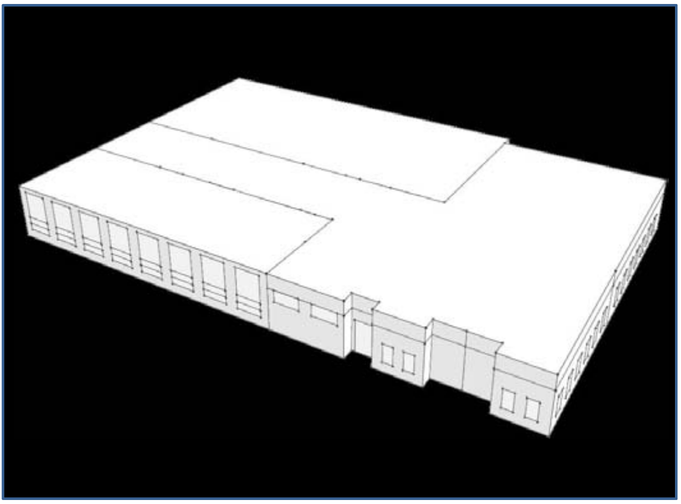
Building Name:	Day Center
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the Day Center in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

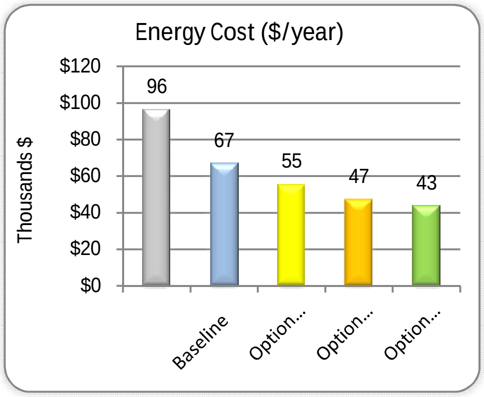
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

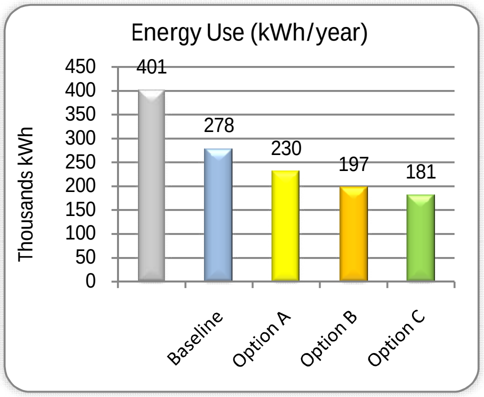


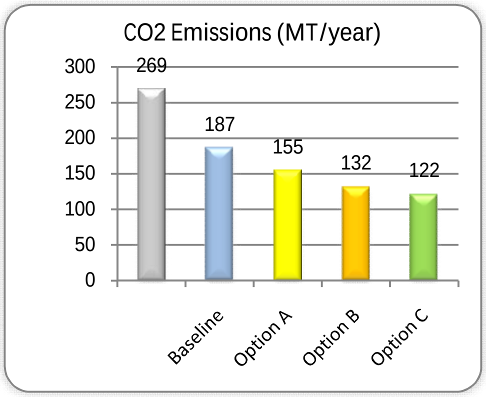
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 68.3 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 269.1 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $4.81/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



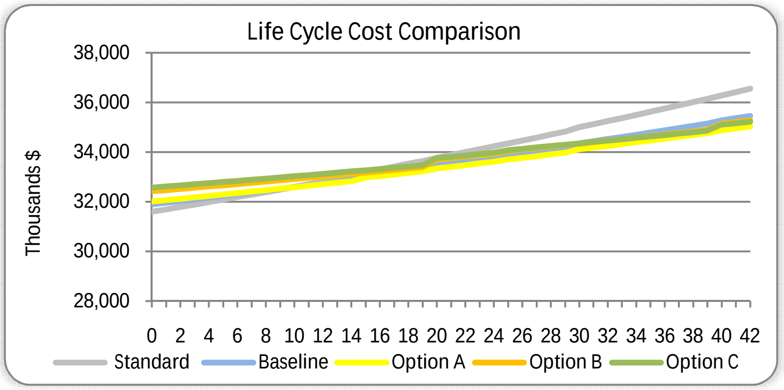




LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 9.3 years for the Baseline scenario, 9.5 years for Option A, 15.4 years for Option B and 16.2 years for Option C.



NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	ith Lighting Controls (Daylight and Motion)	ith Lighting Controls (Daylight and Motion)	ith Lighting Controls (Daylight and Motion)	ith Lighting Controls (Daylight and Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	4.5	4.5
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Constant Volume System	Constant Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	15.6	19.5	31.1	38.9
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	96767.2	76446.1	76446.1	76446.1	76446.1
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	209297.5	142697.2	137947.6	127294.3	125751.2
Auxiliary Energy (kWh/year)	56928.9	56424.8	20409.8	20409.8	20264.5
DHW (kWh/year)	4928.7	3780.8	3780.8	1323.3	1323.3
Exterior Lighting (kWh/year)	10621.5	3717.525	3717.525	3717.525	3717.525
Equipment (kWh/year)	22457.8	22457.8	22457.8	22457.8	22457.8
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-27552.2	-34440.2	-55104.4	-68880.5
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	401001.5	277971.9	230319.3	196544.4	181079.8
Reduction from Standard (%)	0%	31%	43%	51%	55%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	401001.5	277971.9	230319.3	196544.4	181079.8
Reduction from Standard (%)	0%	31%	43%	51%	55%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	1339345.0	928426.2	769266.5	656458.4	604806.5
Reduction from Standard (%)	0%	31%	43%	51%	55%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	1339345.0	928426.2	769266.5	656458.4	604806.5
Reduction from Standard (%)	0%	31%	43%	51%	55%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-6612.5	-8265.7	-13225.1	-16531.3
% of Building Energy Cost	0%	9%	13%	22%	27%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	-589.8	-589.8
% of Building Energy Cost	0%	0%	0%	1%	1%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	269.1	186.6	154.6	131.9	121.5
Reduction from Standard (%)	0%	31%	43%	51%	55%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-18.5	-23.1	-37.0	-46.2
Proportion of Total (%)	0%	9%	13%	22%	28%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

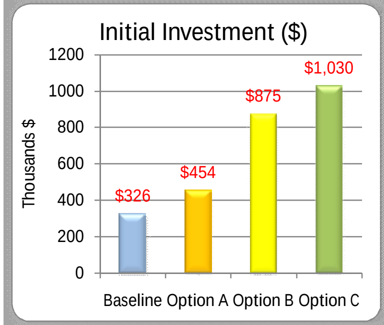
Total CO_2 Emissions (MT/yr)	269.1	186.6	154.6	131.9	121.5
Reduction from Standard (%)	0%	31%	43%	51%	55%

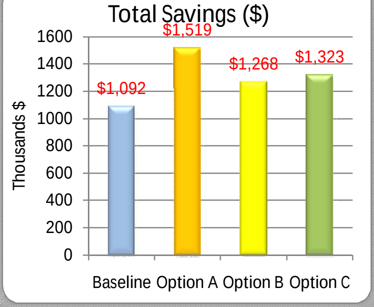
Energy Cost Summary

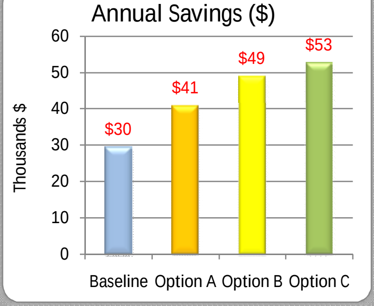
Electricity Cost ($/sq ft)	4.81	3.33	2.76	2.36	2.17
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	4.81	3.33	2.76	2.36	2.17
Reduction from Standard (%)	0%	31%	43%	51%	55%
Simple Payback (Years)	-	11.0	11.1	17.8	19.5

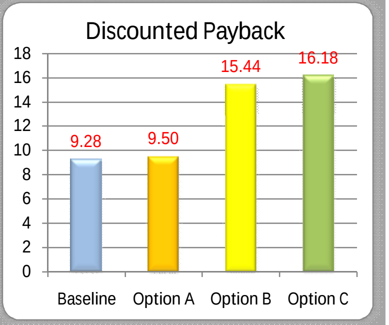
$/sq ft/kg of CO2 Emissions reduction	-	197.19	198.15	318.58	348.71

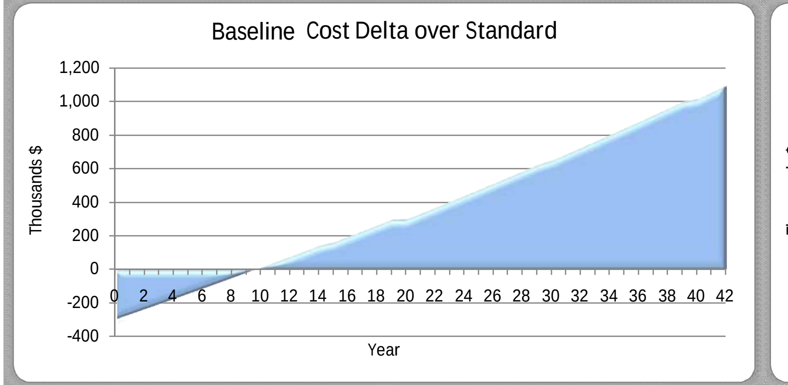
LIFE CYCLE COSTING

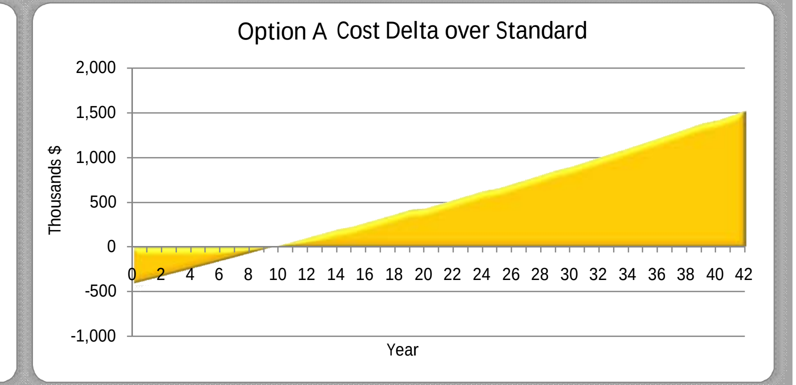

Initial Investment ($)

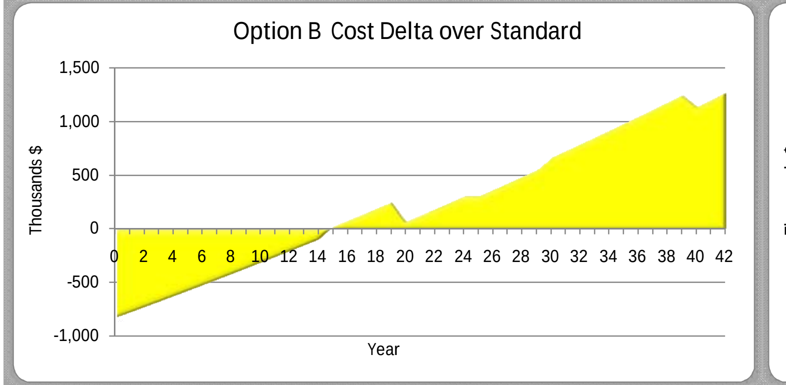

Total Savings ($)

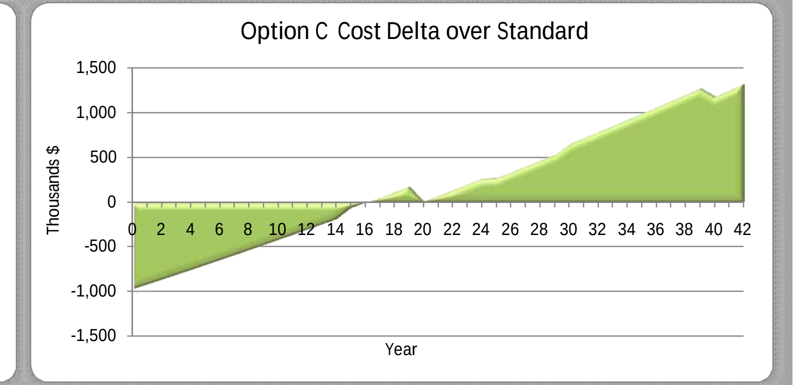

Annual Savings ($)

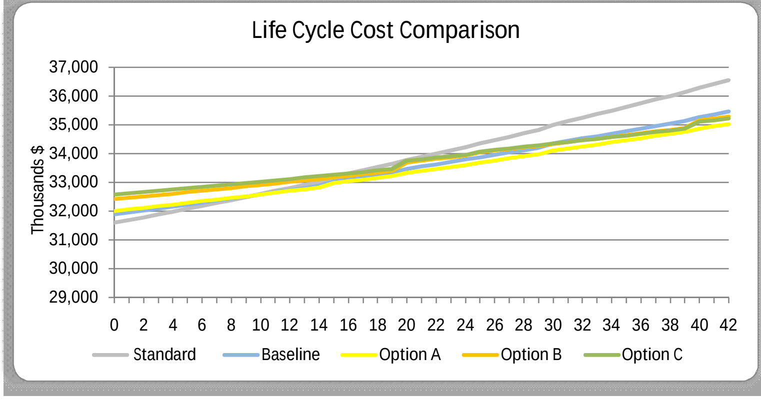

Discounted Payback

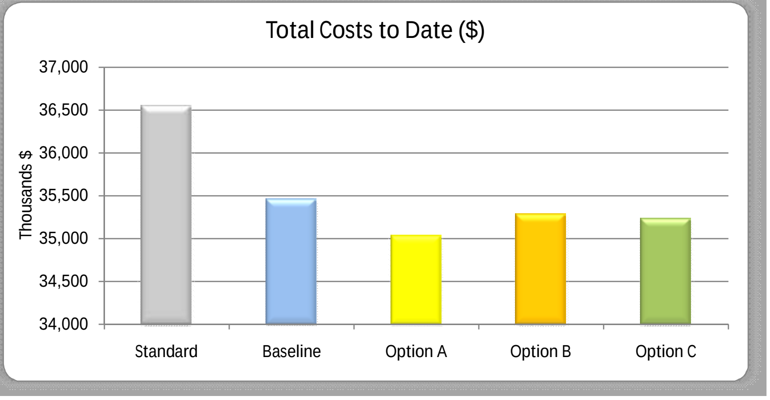

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

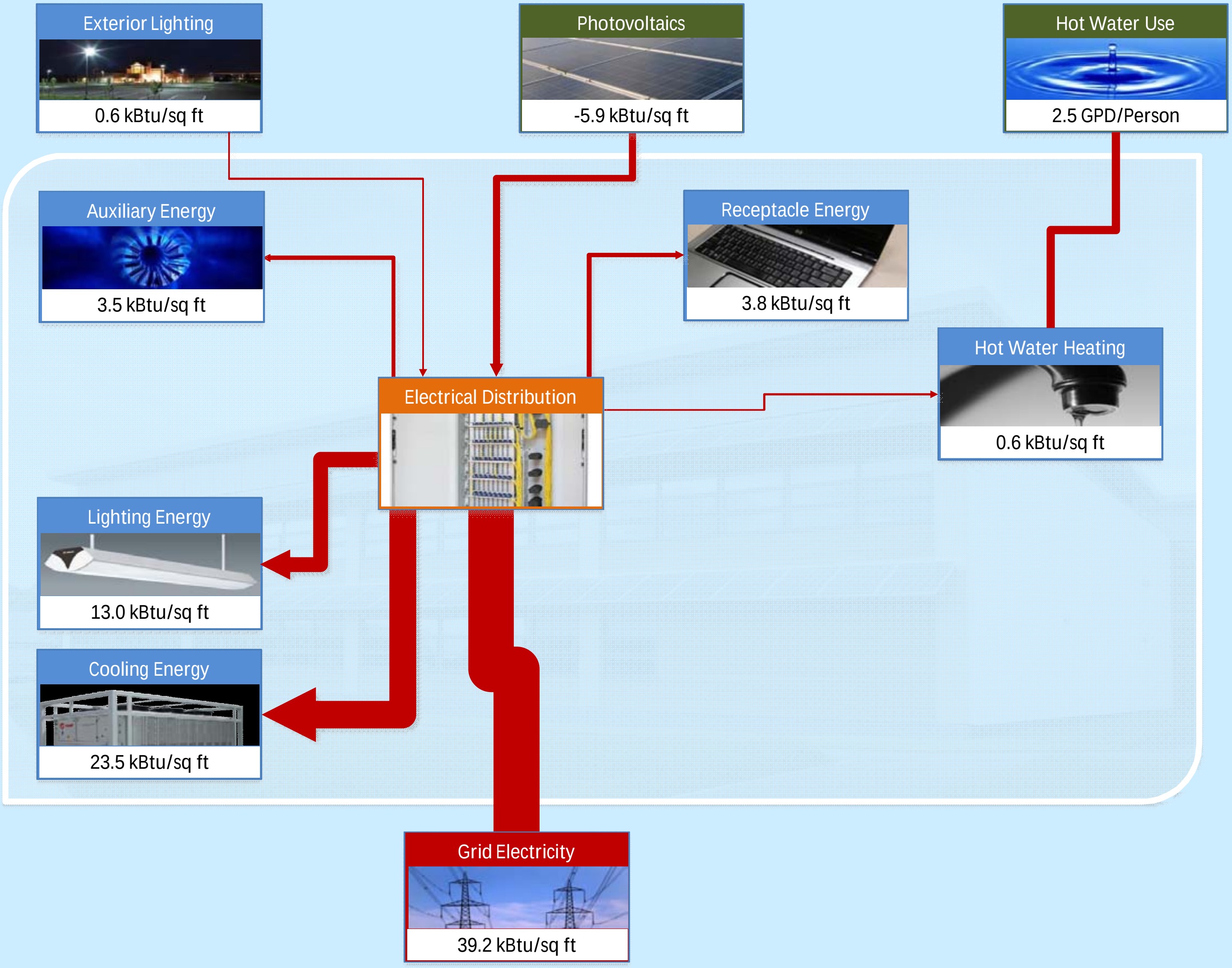

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.6 kBtu/sq ft

Photovoltaics
-5.9 kBtu/sq ft

Hot Water Use
2.5 GPD/Person

Auxiliary Energy
3.5 kBtu/sq ft

Receptacle Energy
3.8 kBtu/sq ft

Hot Water Heating
0.6 kBtu/sq ft

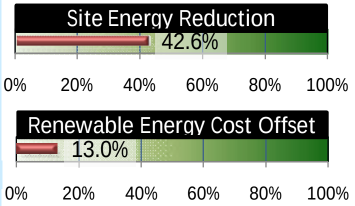
Electrical Distribution

Lighting Energy
13.0 kBtu/sq ft

Cooling Energy
23.5 kBtu/sq ft

Grid Electricity
39.2 kBtu/sq ft

PERFORMANCE INDICATORS



Site Energy Reduction
42.6%

Renewable Energy Cost Offset
13.0%

LEED

LEED-NC

EA1	16	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: 65.7% ✓

EPAct compliant ✓

ENERGY USE

39.2 kBtu/sqft

11.5 kWh/sqft

COST INFORMATION

$2.76/sq ft Energy Cost

9.5 yrs Disc. Payback

BUILDING DATA

Day Center
GJMMP, Guam
20,019 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

Day Center
Option A Energy Model Flows

AECOM

OPTION A SCORECARD

Name	Day Center
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver

Y	?	N	
59	0	50	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Sustainable Sites
11	0	15		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
0	0	1	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction

Y	?	N	Credit	Water Efficiency
6	0	3		Water Efficiency
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction

Y	?	N	Credit	Energy and Atmosphere
26	0	9		Energy and Atmosphere
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
16	0	3	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power

Y	?	N	Credit	Regional Importance
0	0	4		Regional Importance
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

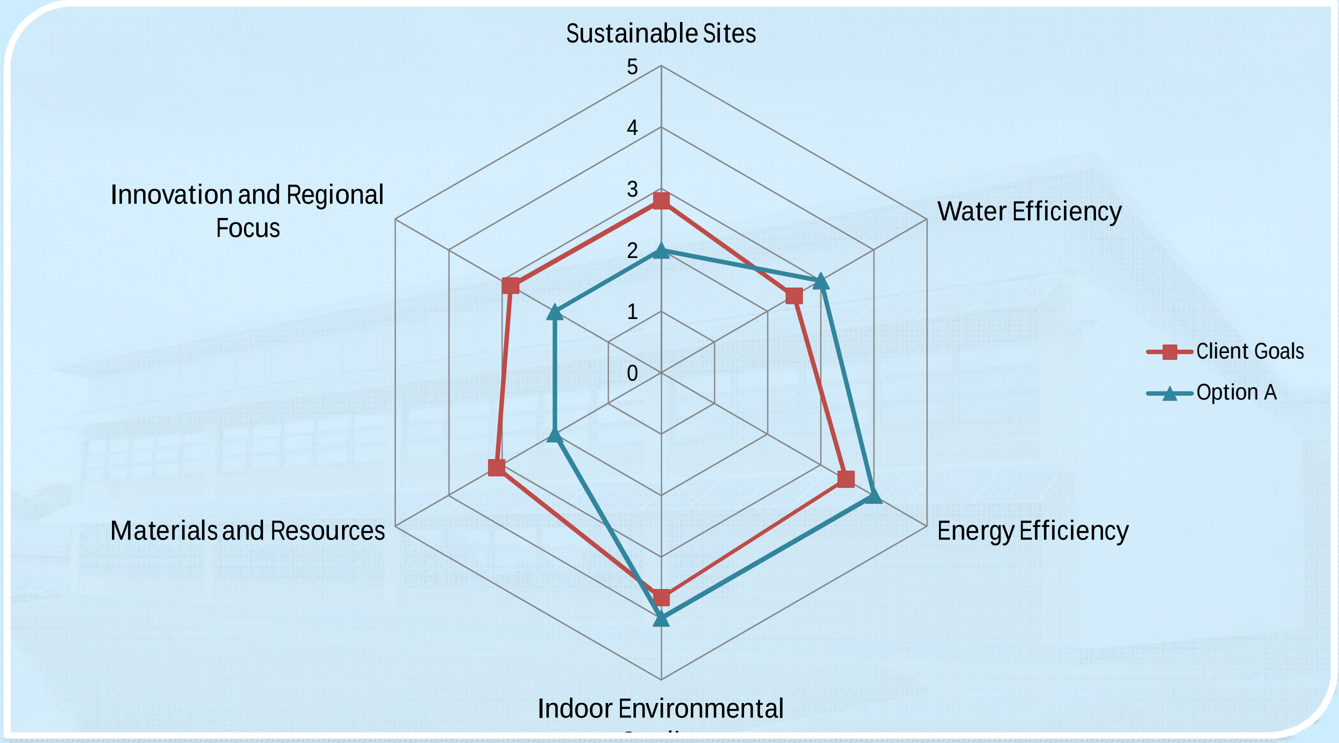
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

Y	?	N	Credit	Materials and Resources
3	0	11		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood

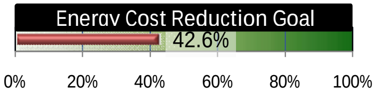
Y	?	N	Credit	Indoor Environmental Quality
9	0	6		Indoor Environmental Quality
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
0	0	1	EQc8.2	Daylight & Views, Views for 90% of Spaces

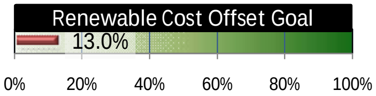
Y	?	N	Credit	Innovation in Design
4	0	2		Innovation in Design
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



PERFORMANCE INDICATORS





LEED

LEED-NC

SS	11	out of 26 potential points
WE	6	out of 10 potential points
EA	26	out of 35 potential points
MR	3	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

Water Efficient Lanscaping Goal

100%

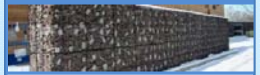
Water Use Reduction Goal

30%

Construction Waste Management Goal

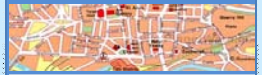
75%

Recycled Materials Goal



10%

Regional Materials Goal



0%

SUSTAINABILITY METRIC

U.S. GREEN BUILDING COUNCIL
LEED SILVER
USGBC

BUILDING DATA

Day Center
Guam
20,019 sqft GFA

CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

Day Center
Option A Sustainability KPIs

AECOM

As part of the Guam Sustainability Program, undertaken on the Joint Military Master Plan in Finegayan, Guam, an energy analysis has been conducted to assess the energy performance of the buildings to be constructed as part of the build-up. Additionally, for each building type a preliminary LEED Building Design and Construction (BD+C) analysis has been conducted to assess the LEED certification potential of the non-residential buildings.

Energy Requirements

The following document contains summary results for the School building, in line with the approved requirements of the overall sustainability program. For the School building, compliance with the energy use intensity and renewable energy requirements need to be met with at least the following:

	% Reduction	% Renewables	ECM Package
School	38.5%	15.5%	Option A

Based on the results of the analysis, packages of energy conservation measures (ECMs) are outlined including one possible route to compliance for meeting the targets of the overall sustainability Masterplan (Option B). In defining ECMs for each of the study packages, it is recognized that this is a master planning level study therefore the measures proposed may not be applicable to all buildings on the site and if implemented, are not guaranteed to attain the levels of energy performance outlined within the study.

LEED Certification Requirements

To ensure compliance with the overall installation wide sustainability goals, performance based language should be included within the design and build contracts for each facility mandating the minimum level of LEED certification performance that should be achieved, as follows:

	LEED Certification Level
School	Silver

The credit strategies proposed within can be used to demonstrate one solution to achieving compliance with the performance targets in a cost effective manner. However, as noted these should not be used as prescriptive requirements for achieving compliance in each building type.

Note

The results of this study do not represent a prescriptive LEED checklist or list of energy conservation measures that can be applied to each building type. As each building is designed and constructed, the individual design **team** will have responsibility for the selection of building systems and ECMs, as well as appropriate LEED strategies to ensure compliance with the federal mandates and sustainability goals for the base.

SSIMe SUMMARY REPORT

SSIMe Analysis Summary Report

BUILDING SUMMARY

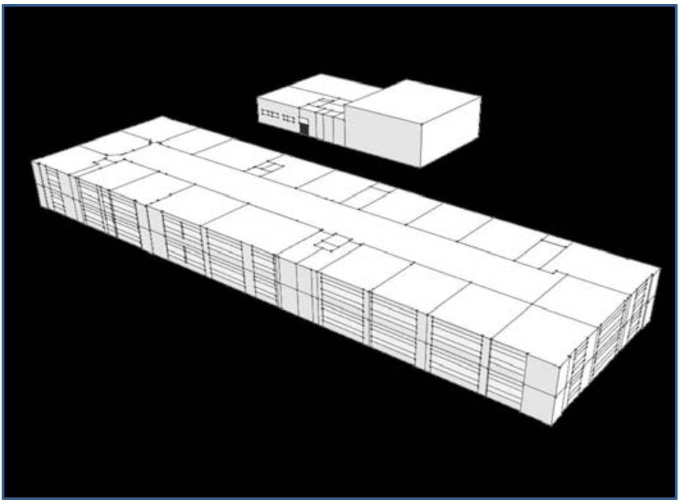
Building Name:	School
Location:	GJMMP, Guam
Date:	5/18/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the School in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

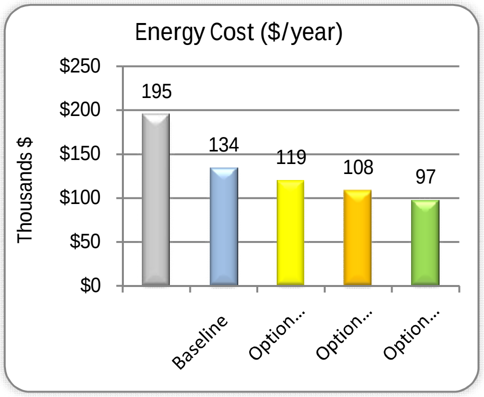
The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.



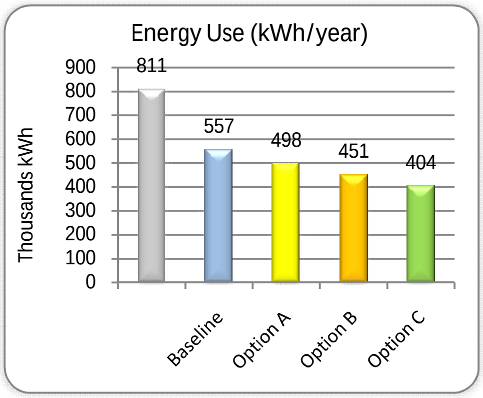
RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 59.9 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 544.1 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $4.22/sq ft per year.

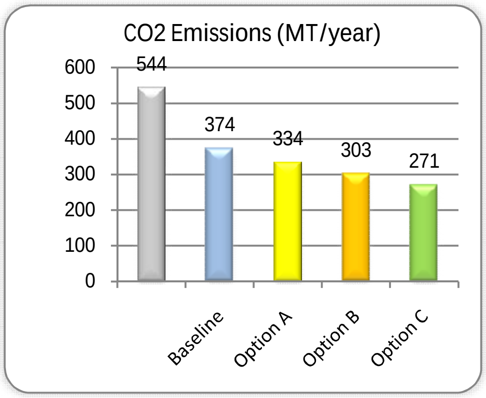
Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.



Energy Cost ($/year)



Energy Use (kWh/year)

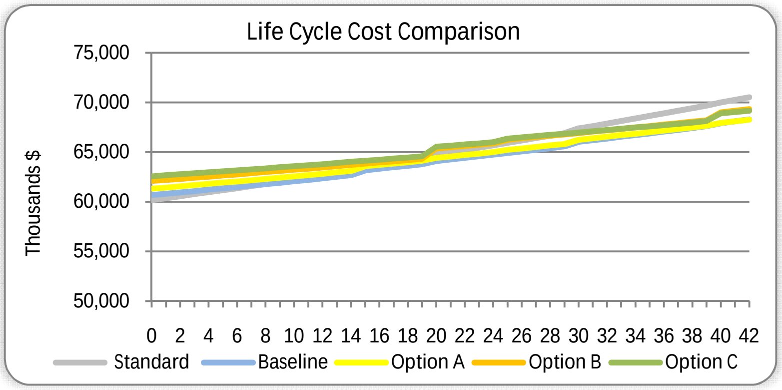


CO2 Emissions (MT/year)

LIFE CYCLE COST SUMMARY

Life cycle cost analysis was also undertaken of each package of ECMs. Results were assessed against the standard building scenerio.

Analysis indicates that discounted payback will be achieved in 7.4 years for the Baseline scenario, 14.2 years for Option A, 17.4 years for Option B and 28.6 years for Option C.



Life Cycle Cost Comparison

NOTES

The results within this document are for based on preliminary level analysis only and do not present a guarantee that the packaged of ECMs proposed will achieve the levels of energy performance identified within.

RESULTS

Options Summary

	Standard	Baseline	Option A	Option B	Option C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R13 Ins. U=0.1225	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045	ASHRAE 90.1 1A. R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R15 Ins. U=0.0633	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325	ASHRAE 90.1 1A. R30 Ins. U=0.0325
Fenestration U Value	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	1.00 (Whole assembly)	0.33 (Whole Assembly)
SHGC	0.25	0.25	0.25	0.25	0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting	32W T8 Fixtures. ASHRAE 90.1 LPD	ith Lighting Controls (Daylight and Motion)	ith Lighting Controls (Daylight and Motion)	ith Lighting Controls (Daylight and Motion)	ith Lighting Controls (Daylight and Motion)
Reduction from Standard	0%	21%	21%	21%	21%
Heating	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System	No Space Heating System
Heating Efficiency	100%	100%	100%	100%	100%
Heat Recovery Type	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery	No Heat Recovery
Heat Recovery Efficiency	0%	0%	0%	0%	0%
Cooling	Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Efficiency Packaged DX Cooling	High Eff. Air Cooled Chillers	High Eff. Air Cooled Chillers
SEER (If Packaged) COP (Central Plant)	11.1	14.9	14.9	4.5	4.5
Coolth Recovery Type	No Coolth Recovery	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers	Plate Coolth Exchangers
Coolth Recovery Efficiency	0%	60%	60%	60%	60%
Delivery Method	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System	Variable Volume System
CHP	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Absorption Chillers	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Hot Water Reduction Measure	LEED-NC v3 Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings	Low Flow Fixtures and Fittings
Reduction from Standard	0% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction	18% DHW Use Reduction
Hot Water Heating	Minimum Eff. Electric Storage	High Eff. Electric Storage	High Eff. Electric Storage	Solar Hot Water / High. Eff Electric Storage	Solar Hot Water / High. Eff Electric Storage
Heating Efficiency	87%	93%	93%	93%	93%
Exterior Lighting	HID Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting	LED Exterior Lighting
Exterior Lighting Density (W/sq ft)	5.00 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft	1.75 W/sq ft
Photovoltaics	No PV Generation	Amorphous	Amorphous	Amorphous	Amorphous
Installed Capacity (kW)	0.0	20.4	51.0	51.0	76.4
Building Integrated Wind	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation	No Wind Generation
Installed Capacity (kW)	0.0	0.0	0.0	0.0	0.0

Energy Use Summary

	Standard	Baseline	Option A	Option B	Option C
Lighting (kWh/year)	105952.2	83702.2	83702.2	83702.2	83702.2
Space Heating (kWh/year)	0.0	0.0	0.0	0.0	0.0
Space Cooling (kWh/year)	564748.4	390247.3	386843.0	352922.4	350272.8
Auxiliary Energy (kWh/year)	47063.8	44109.3	42579.4	42579.4	42590.2
DHW (kWh/year)	24563.6	18842.7	18842.7	6594.9	6594.9
Exterior Lighting (kWh/year)	19217.25	6726.0375	6726.0375	6726.0375	6726.0375
Equipment (kWh/year)	49124.6	49124.6	49124.6	49124.6	49124.6
Process Load (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Heating Energy (kWh/year)	0.0	0.0	0.0	0.0	0.0
CHP Electrical Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
PV Generation (kWh/year)	0.0	-36079.3	-90198.3	-90198.3	-135297.4
Wind Generation (kWh/year)	0.0	0.0	0.0	0.0	0.0
Total (kWh/year)	810670.0	556672.9	497619.7	451451.4	403713.4
Reduction from Standard (%)	0%	31%	39%	44%	50%

Energy Use by Fuel

	Standard	Baseline	Option A	Option B	Option C
Grid Electricity Use (kWh)	810670.0	556672.9	497619.7	451451.4	403713.4
Reduction from Standard (%)	0%	31%	39%	44%	50%
Gas Use (Therms)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomas Use (MMBtu)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Source Energy Use

	Standard	Baseline	Option A	Option B	Option C
Source Electricity Energy Use (kWh)	2707637.7	1859287.5	1662049.9	1507847.7	1348402.9
Reduction from Standard (%)	0%	31%	39%	44%	50%
Gas Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Biomass Use (kWh)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%
Total (kWh)	2707637.7	1859287.5	1662049.9	1507847.7	1348402.9
Reduction from Standard (%)	0%	31%	39%	44%	50%

Renewables Offset

	Standard	Baseline	Option A	Option B	Option C
PV Energy Cost ($/year)	0.0	-8659.0	-21647.6	-21647.6	-32471.4
% of Building Energy Cost	0%	6%	15%	16%	25%
Wind Generation Cost ($/year)	0.0	0.0	0.0	0.0	0.0
% of Building Energy Cost	0%	0%	0%	0%	0%
Solar Hot Water Generation Cost ($/year)	0.0	0.0	0.0	-2939.5	-2939.5
% of Building Energy Cost	0%	0%	0%	2%	2%

Carbon Summary

Net Electricity CO_2 Emissions (MT/yr)	544.1	373.6	334.0	303.0	271.0
Reduction from Standard (%)	0%	31%	39%	44%	50%

Gas CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

Biomass CO_2 Emissions (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

PV Gen CO_2 Offset (MT/yr)	0.0	-24.2	-60.5	-60.5	-90.8
Proportion of Total (%)	0%	6%	15%	17%	25%

Wind Gen CO_2 Offset (MT/yr)	0.0	0.0	0.0	0.0	0.0
Reduction from Standard (%)	0%	0%	0%	0%	0%

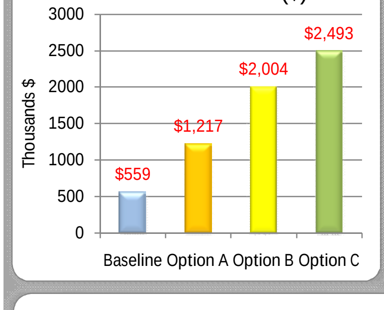
Total CO_2 Emissions (MT/yr)	544.1	373.6	334.0	303.0	271.0
Reduction from Standard (%)	0%	31%	39%	44%	50%

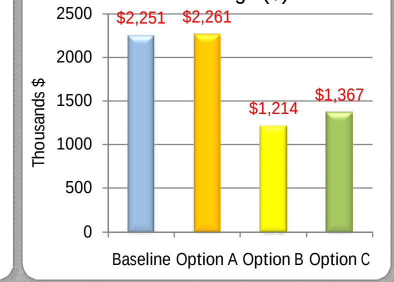
Energy Cost Summary

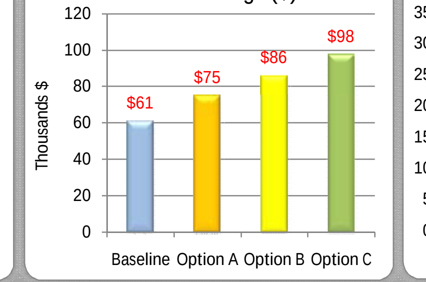
Electricity Cost ($/sq ft)	4.22	2.90	2.59	2.35	2.10
Gas Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Biomass Cost ($/sq ft)	0.00	0.00	0.00	0.00	0.00
Total Energy Cost ($/ sq ft)	4.22	2.90	2.59	2.35	2.10
Reduction from Standard (%)	0%	31%	39%	44%	50%
Simple Payback (Years)	-	9.2	16.2	23.2	25.5

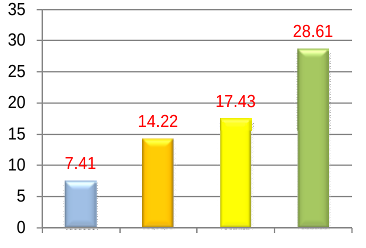
$/sq ft/kg of CO2 Emissions reduction	-	71.10	125.62	180.29	197.96

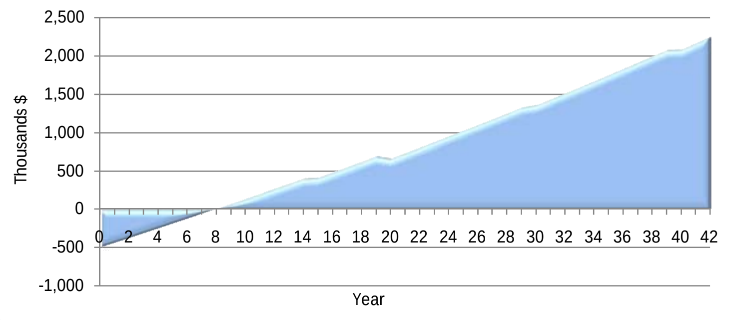
LIFE CYCLE COSTING

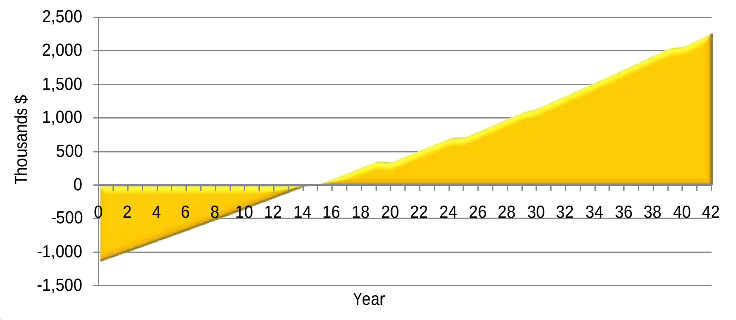

Initial Investment ($)

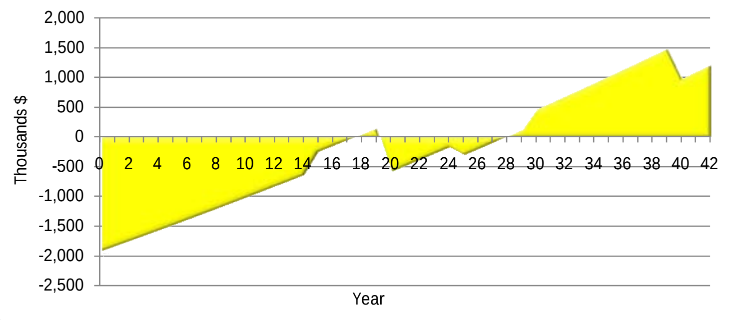

Total Savings ($)

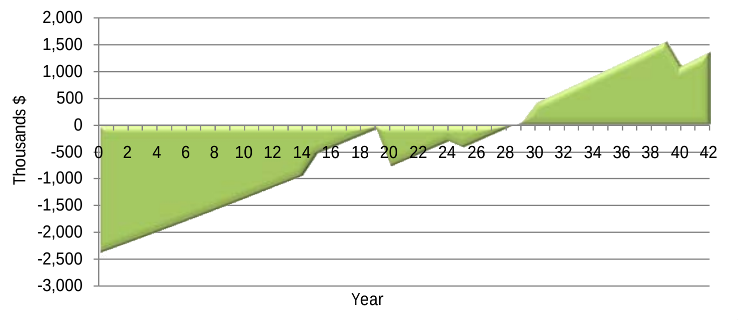

Annual Savings ($)

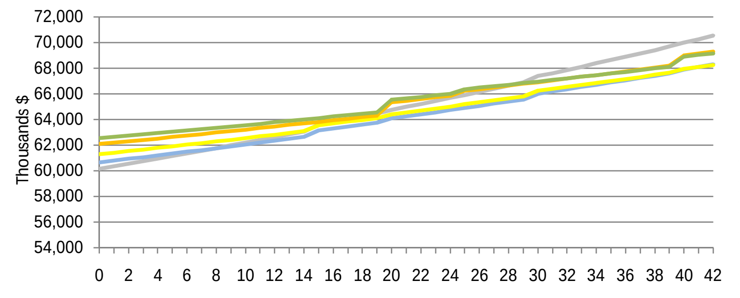

Discounted Payback

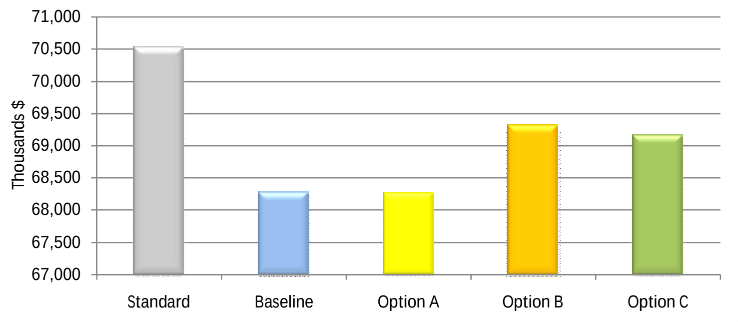

Baseline Cost Delta over Standard


Option A Cost Delta over Standard

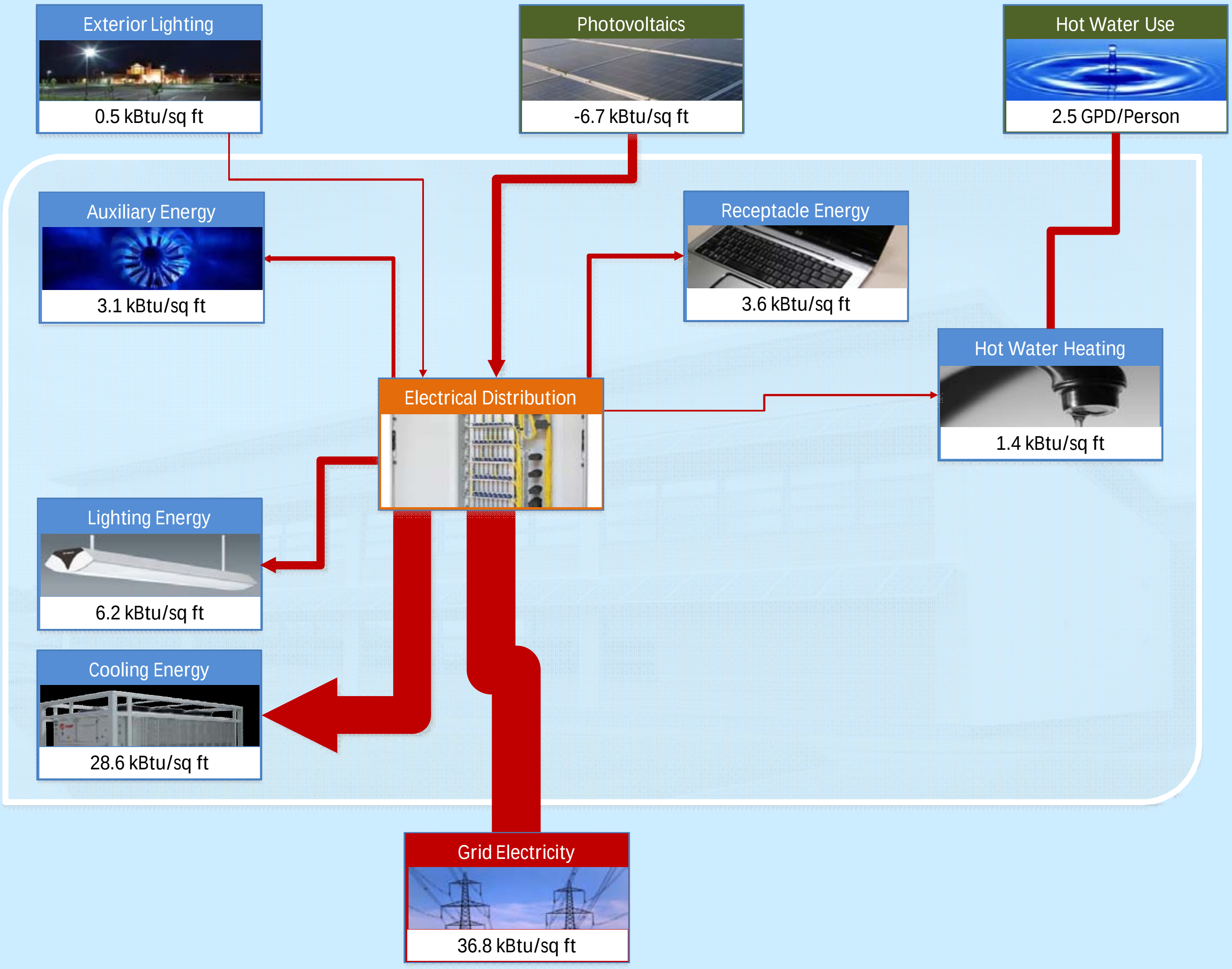

Option B Cost Delta over Standard


Option C Cost Delta over Standard


Life Cycle Cost Comparison


Total Costs to Date ($)

ENERGY FLOW DIAGRAM



Exterior Lighting
0.5 kBtu/sq ft

Photovoltaics
-6.7 kBtu/sq ft

Hot Water Use
2.5 GPD/Person

Auxiliary Energy
3.1 kBtu/sq ft

Receptacle Energy
3.6 kBtu/sq ft

Hot Water Heating
1.4 kBtu/sq ft

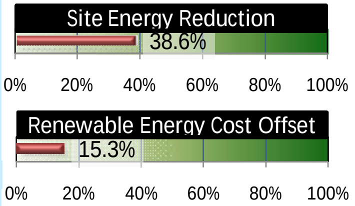
Electrical Distribution

Lighting Energy
6.2 kBtu/sq ft

Cooling Energy
28.6 kBtu/sq ft

Grid Electricity
36.8 kBtu/sq ft

PERFORMANCE INDICATORS



Site Energy Reduction
38.6%

Renewable Energy Cost Offset
15.3%

LEED

LEED-NC

EA1	14	out of 19 potential points
EA2	7	out of 7 potential points

FEDERAL MANDATES

EISA Score: N/A

EPAct compliant ✓

ENERGY USE

36.8 kBtu/sqft

10.8 kWh/sqft

COST INFORMATION

$2.59/sq ft Energy Cost

14.2 yrs Disc. Payback from Standard

BUILDING DATA

School
GJMMP, Guam
46,112 sqft GFA

SIMULATION WEATHER DATA

GUM_Anderson.AFB_TMY2.epw

School
Option A Energy Model Flows

AECOM

OPTION A SCORECARD

Name	School
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver

Y	?	N	
59	0	50	Project Totals (Pre-certification Estimate)

Y	?	N	Credit	Sustainable Sites
12	0	14		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction

Y	?	N	Credit	Water Efficiency
6	0	3		Water Efficiency
2	0	0	WE1.1	Water Efficient Landscaping Reduce by 50%
2	0	0	WE1.2	Water Efficient Landscaping No Potable Use or No Irrigation
0	0	2	WE2	Innovative Wastewater Technologies
2	0	0	WE3.1	Water Use Reduction, 30% Reduction
0	0	1	WE3.2	Water Use Reduction, 35% Reduction
0	0	1	WE3.3	Water Use Reduction 40% Reduction

Y	?	N	Credit	Energy and Atmosphere
24	0	11		Energy and Atmosphere
			EAp1	Fundamental Commissioning
			EAp2	Minimum Energy Performance
			EAp3	Fundamental Refrigerant Management
14	0	5	EAc1	Optimize Energy Performance
7	0	0	EAc2	On-Site Renewable Energy
0	0	2	EAc3	Enhanced Commissioning
0	0	2	EAc4	Enhanced Refrigerant Management
3	0	0	EAc5	Measurement & Verification
0	0	2	EAC6	Green Power

Y	?	N	Credit	Regional Importance
0	0	4		Regional Importance
0	0	1	RCc1.1	RC Credit 1.1 Regional Priority - WEc1.2
0	0	1	RCc1.2	RC Credit 1.2 Regional Priority - EAc1 (36%)
0	0	1	RCc1.3	RC Credit 1.3 Regional Priority - EAc2 (5%)
0	0	1	RCc1.4	RC Credit 1.4 Regional Priority - IEQc8.1

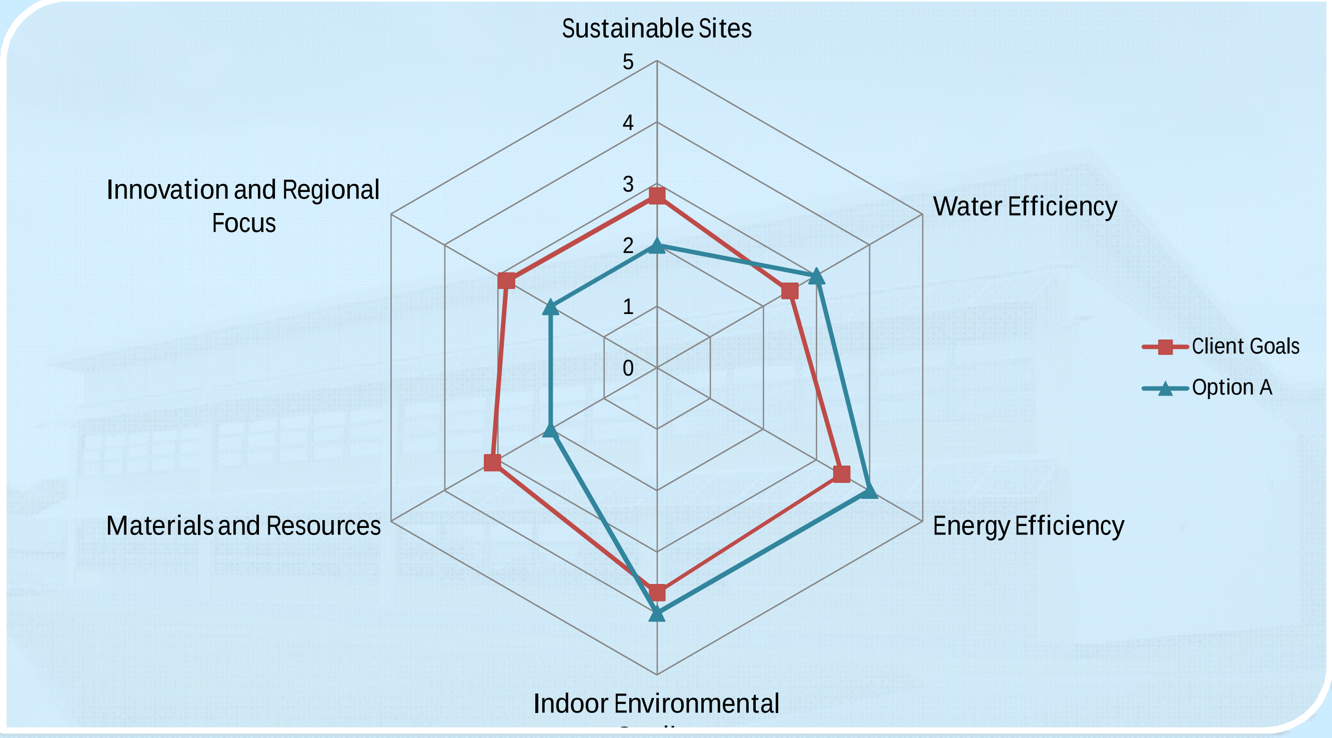
Strategy developed based upon the inclusion of the following credits:
Low Design Impact / Low Construciton Cost

Y	?	N	Credit	Materials and Resources
3	0	11		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood

Y	?	N	Credit	Indoor Environmental Quality
10	0	5		Indoor Environmental Quality
			EQp1	Minimum IAQ Performance
			EQp2	Environmental Tobacco Smoke (ETS) Control
1	0	0	EQc1	Outdoor Air Delivery Monitoring
0	0	1	EQc2	Increased Ventilation
1	0	0	EQc3.1	Construction IAQ Management Plan During Construction
0	0	1	EQc3.2	Construction IAQ Management Plan Before Occupancy
1	0	0	EQc4.1	Low-Emitting Materials Adhesives & Sealants
1	0	0	EQc4.2	Low-Emitting Materials Paints & Coatings
1	0	0	EQc4.3	Low-Emitting Materials Carpet Systems
0	0	1	EQc4.4	Low-Emitting Materials Composite Wood & Agrifiber Products
1	0	0	EQc5	Indoor Chemical & Pollutant Source Control
1	0	0	EQc6.1	Controllability of Systems Lighting
0	0	1	EQc6.2	Controllability of Systems, Thermal Comfort
1	0	0	EQc7.1	Thermal Comfort, Design
1	0	0	EQc7.2	Thermal Comfort, Verification
0	0	1	EQc8.1	Daylight & Views, Daylight 75% of Spaces
1	0	0	EQc8.2	Daylight & Views, Views for 90% of Spaces

Y	?	N	Credit	Innovation in Design
4	0	2		Innovation in Design
1	0	0	IDc1.1	ID Credit 1.1 Innovation in Design: Sustainable Education Program
0	0	1	IDc1.2	ID Credit 1.2 Innovation in Design: Green Cleaning program
1	0	0	IDc1.3	ID Credit 1.3 Innovation in Design: Integrated Pest Management Program
1	0	0	IDc1.4	ID Credit 1.4 Innovation in Design: SSc5.2 Exemplary Performance
0	0	1	IDc1.5	ID Credit 1.5 Innovation in Design: T.B.C.
1	0	0	IDc2	LEED Accredited Professional

SUSTAINABILITY KPIs



Water Efficient Lanscaping Goal

100%

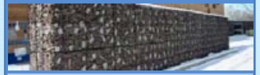
Water Use Reduction Goal

30%

Construction Waste Management Goal

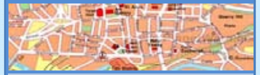
75%

Recycled Materials Goal



10%

Regional Materials Goal



0%

BUILDING DATA

School
Guam
36,856 sqft GFA

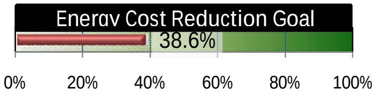
CREDIT STRATEGIES

Low Design Impact / Low Construction Cost
-
-

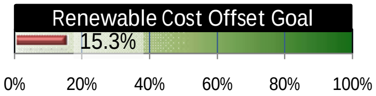
School
Option A Sustainability KPIs

PERFORMANCE INDICATORS

Energy Cost Reduction Goal



Renewable Cost Offset Goal



LEED

LEED-NC

SS	12	out of 26 potential points
WE	6	out of 10 potential points
EA	24	out of 35 potential points
MR	3	out of 14 potential points
EQ	10	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

SUSTAINABILITY METRIC

LEED SILVER

AECOM

Attachment B - Cost Assumptions

The following costs have been utilized as part of the SSIMe building energy study:

Building Envelope - Insulation

- Wall insulation costs based on a quote from JDH Constuction (a licensed Icynene insulation applicator) sent to Owen Igarashi at NAVFAC Pac, which indicated a cost of $2.25/sq ft for Guam for R13 spray insulation. Assuming a 30% cost increase for R21 insulation gives a cost of $2.93/sq ft.
- Roof deck insulation costs are based on the above, with a 25% cost increase used to account for the increased labor associated with installing roof deck insulation compared to wall insulation. Accounting for the increased thickness associated with the requirements for roof insulation, this gives a cost of $2.85/sq ft for an R15 equivalent and 3.93 (40% cost delta) for an R30 solution.
- It is assumed that insulation replacement will not take place during the normal lifespan of the building.

Building Envelope - Fenestration

- Fenestration costs are based on RSMeans 2005 costs escalated to 2010 @ 3% per year and escalated to Guam costs using the 2.64 Guam escalation factor. This produces a standard glazing cost of $103.49/sq ft.
- The high efficiency is assumes the use of a thermally broken frame with insulating glass @ $46.37/sq ft (2010) (including materials and labor). Escalating this to Guam prices gives a total cost for a high efficiency fenestration solution of $121.02/sq ft.
- The Fenestration price was range ($100 to $120/sq ft) was reviewed and approved by Owen Igarashi at NAVFAC Pac.
- Brise soleil cost based on green spec UK estimate of £180/m for a powder coated aluminum slat system with 1.2m projection. US (mainland) cost estimate is $131.67/lin ft based on a $1.60/£1 exchange rate. The Guam cost is calculated assuming a 50% cost increase for shipping and storage, thus giving a total cost of $197.50/lin ft.

Lighting

- Lighting costs are based upon information received from Bill Beery (Guam local cost consultant), as follows:
  - T8 2 x 4 flourescent recessed - Supply = $49.95 / fixture
  - T5 2 x 4 flourescent recessed - Supply = $100.50 / fixture
  - T8 w/ dimming ballast = $143.75 / fixture
  - T5 w/ dimming ballast = $307.00 / fixture
- All the above are FOB Guam (100 each quantity assumed for freight purposes). A labor installation cost of $95 per fixture has been used.

Space Heating Systems

- No space heating systems are required for the GJMMP buildings.

Space Cooling Systems

- Baseline packaged system costs are based upon a quote from Trane supplied to Bill Beery for Guam for a Trane Model SXHF Rooftop 50 ton Package Unit at $69,017 ($392.25/kw). A 20% cost increase has been assumed for a high efficiency alternative.
- The air cooled chiller “central plant” option cost is calculated using RSMeans 2005 costs, escalated to 2010 prices at 3% per year inflation rate and increased to Guam costs using a 1.42 shipping multiplier as advised by Bill Beery, giving the cost of an air cooled chiller as $216.01/kW (excluding the cost of air handling equipment).
- The water cooled “central plant” system is calculated based on a quote supplied to Bill Beery for a Trane Helical Rotor Water Cooled Chiller of 150 Tons Capacity at $109,576. Cooling tower costs are calculated using the NAVFAC Engineering Command Cost Data Book (January 2005) data escalated to 2010 costs at 3% inflation rate per year. Costs are based upon 110 ton draw through cooling tower. A 20% cost add on has been included for auxiliary equipment, giving the total cost of a water cooled central plant systems as $445.28/kW (excluding the cost of air handling equipment).

Delivery Method

- Constant air volume (CAV), VAV and minimum fresh air system costs from IEM Cost Consultants (California), which estimated the costa of typical CAV system to be $5.64/cfm, a VAV system to be $6.48/cfm and a minimum fresh air system to be $4.16/cfm. These costs have been escalated to Guam prices using the 2.64 Guam escalation factor, giving Guam costs for each system of $14.72/cfm $16.91/cfm and $10.86/cfm for each system respectively.

Service Hot Water Heating Systems

- Commercial service hot water heating electric storage system costs have been calculated based on NAVFAC Pac 2005 Guam Cost Book data for a 250MBH (~73kW system), escalated to 2010 costs at 3% inflation rate per year, giving a total cost $155.81/kW. The cost of a high efficiency electric storage system has been calculated assuming a 20% cost increase over the standard alternative.
- STHW system is assumed to be a flat plate collector type system yielding a whole system efficiency of around 52%. The cost is based on NAVFAC Pac 2005 Guam cost data book data for a 3 x 12sf solar collector system, escalated to 2010 prices at 3% inflation rate per year, giving a total system, cost of around $206.34/sq ft of required panel area.

Photovoltaics

- System and efficiency information for the amorphous PV panel system has been based upon a Solar Integrated SI-G1 864W panel, with an efficiency of 6.2%. The installed cost of BIPV is assumed to be $16.97/kW, based on Techval’s Technical Evaluation of BIPV Roof Technology study (August 2008) for a proposed rooftop amorphous PV system at Big Navy in Guam.
- Polycrystalline panel data is for a Sharp Solar ND-170 panel rated at 170W, 14.1sq ft size. The US mainland panel retail price (Sierra Solar Systems) is $3.21/W. The installed price is therefore calculated to be ~$7.13/W (45% of total), which yields a Guam price of $18.62/W, based on the 2.64 “Guam factor”. The percentage cost delta of the polycrystalline product compared to the amorphous product for Guam is in line with the percentage cost delta compared to amorphous PV for mainland costs using this calculation methodology.
- Monocrystalline panel data is for Sharp Solar NU-U235F1 panels rated at 235W, 17.54 sq ft size. US panel retail price (Sierra Solar Systems) $3.39/W. The installed price is ~$7.53/W (45% of total). Guam price is $19.67/W. The percentage cost delta of the monocrystalline product compared to the amorphous product for Guam is in line with the percentage cost delta compared to amorphous PV for mainland costs using this calculation methodology.

Wind Microgeneration

- Microwind generation cost is calculated from estimated turbine costs provided by the American Wind Association US Small Wind Turbine Industry Roadmap, which estimates the cost of small wind to be $4/W installed on the mainland Using the 2.64 "Guam factor", the Guam cost is estimated to be $10.44/W installed.

Residential Lighting

- Incandescent light cost based on SATCO-S2503 71W bulbs at $1.35 per 2 pack bulbs $0.00950/W). Lifespan = 750 hours. Assume 1900 hours use per year.
- CFL cost based on TCP 14W CFL (60W incadescent equal) at $1.90 per bulb ($0.0317/W cf 60W fixture). Lifespan = 10,000 hours

Residential Cooling

- Standard efficiency unit based on Carrier 24APA3 13 unit, retailing at $2796.50 (Air Stream Services GSA contract price) for a 5 ton unit. Escalated to Guam prices using a 1.42 shipping multiplier as advised by Bill Beery.
- High efficient unit based on Carrier 24ANA7 unit, retailing at $3440.02 (Air Stream Services Inc. GSA contract price) for a 5 ton unit. Escalated to Guam prices using a 1.42 shipping multiplier as advised by Bill Beery.

Indoor Fan Coil Unit

- AHU cost based on Carrier FE4 model, retailing at $1878.79 (Air Stream Services GSA contract price) for a 5 ton (~2800cfm) unit. Escalated to Guam prices using a 1.42 shipping multiplier as advised by Bill Beery.

Domestic Hot Water Heating

- The solar thermal hot water (STHW) system is assumed to be a flat plate collector type system yielding a whole system efficiency of around 52%. The cost is based on NAVFAC Pac 2005 Guam cost data book data for a 3 x 12sf solar collector system, escalated to 2010 prices at 3% inflation rate per year, giving a total system, cost of around $206.34/sq ft of required panel area.
- The cost of a minimum efficiency residential domestic electric water heater has been calculated based on Whirlpool E1F50RD045V electric water heater, retailing at $283 ($62.88/kW) in Guam. The high efficiency alternative is based upon the cost of a Whirlpool EE2H50RD045V model, retailing at $386.26 ($85.83/kW) in Guam.
- Electric tankless water heater system cost is based on PowerStar AE 125 26.85kW electric tankless hot water heater retailing at $649 (Home Depot Guam) (equivalent to 4.5kW, 50 gal storage system), therefore the equivalent cost of the system is calculated to be $144.22/kW. This cost is in line with the expected cost differential between the minimum and high efficiency storage solutions and tankless system

Dishwasher

- Purchase price based on Energy Star calculator estimates of $538 for a conventional unit and $550 for an Energy Star certified unit. Research indicates that there is little or no cost delta for appliances in Guam compared to the US mainland (Ref Home Depot).

Refrigerator

- Purchase price based on Energy Star calculator estimates of $1150 for a conventional unit and $1180 for an Energy Star certified unit. Research indicates that there is little or no cost delta for appliances in Guam compared to the US mainland (Ref Home Depot).

Washing Machine/Dryer

- Purchase price based on Energy Star calculator estimates of $1530 for a conventional unit and $1752 for an Energy Star certified unit. Research indicates that there is little or no cost delta for appliances in Guam compared to the US mainland (Ref Home Depot).

Cooking Range

- Electric range price based on GE 30” Freestanding CleanSteel Electric Range, retailing at $628 (Home Depot Guam)

Attachment C -

LEED Home Scorecard & Energy Star Checklist

LEED Home

Energy Star Qualified Home Themal Bypass Inspection Checklist

LEED for Homes Checklist

for Homes

LEED for Homes Project Checklist

Builder Name:

Project Team Leader:

Home Address (Street/City/State):

Project Description				**Adjusted Certification Thresholds**			
Building Type:		Project type:		Certified:	*45.0*	Gold:	*75.0*
# of Bedrooms:	*0*	Floor Area:	*0*	Silver:	*60.0*	Platinum:	*90.0*

Project Point Total		**Final Credit Category Point Totals**					
Prelim: *0 + 0 maybe pts*	Final: *0*	*ID: 0*	*SS: 0*	*EA: 0*	*EQ: 0*		
Certification Level		*LL: 0*	*WE: 0*	*MR: 0*	*AE: 0*		
Prelim: *Not Certified*	Final: *Not Certified*	*Min. Point Thresholds Not Met for Prelim. OR Final Rating*					

Date Most Recently Updated: *Updated by:*

✍ *Indicates that an Accountability Form is required.*

		Max Pts. Available	Preliminary Rating Y / Pts	Maybe	No	Notes	Project Points
Innovation & Design Process (ID)	(Minimum 0 ID Points Required)	*Max: 11*	*Y:0*	*M:0*		*Notes*	*Final: 0*
1. Integrated Project Planning							
1.1	Preliminary Rating	*Prereq.*					
	Target performance tier:						
1.2	Integrated Project Team *(meet all of the following)*	*1*	*0*	*0*			*0*
	☐ a) Individuals or organizations with necessary capabilities						
	☐ b) All team members involved in various project phases						
	☐ c) Regular meetings held with project team						
1.3	Professional Credentialed with Respect to LEED for Homes	*1*	*0*	*0*		*please see ID 01-06 for details*	*0*
1.4	Design Charrette	*1*	*0*	*0*			*0*
1.5	Building Orientation for Solar Design *(meet all of the following)*	*1*	*0*	*0*			*0*
	☐ a) Glazing area on north/south walls 50% greater than on east/west walls						
	☐ b) East-west axis is within 15 degrees of due east-west						
	☐ c) At least 450 sq. ft. of south-facing roof area, oriented for solar applications						
	☐ d) 90% of south-facing glazing is shaded in summer, unshaded in winter						
2. Quality Management for Durability							
2.1	Durability Planning *(meet all of the following)*	*Prereq.*					
	☐ a) Durability evaluation completed						
	☐ b) Strategies developed to address durability issues						
	☐ c) Moisture control measures from Table 1 incorporated						
	☐ d) Durability strategies incorporated into project documentation						
	☐ e) Durability measures listed in durability inspection checklist						
2.2	Durability Management *(meet one of the following)*	*Prereq.*					
	☐ Builder has a quality management process in place						
	☐ Builder conducted inspection using durability inspection checklist						
2.3	Third-Party Durability Management Verification	*3*	*0*	*0*			*0*

LEED for Homes Checklist Continued

3. Innovative or Regional Design							
	3.1	✍ Innovation 1 (ruling #):	*1*	*0*	*0*		*0*
	3.2	✍ Innovation 2 (ruling #):	*1*	*0*	*0*		*0*
	3.3	✍ Innovation 3 (ruling #):	*1*	*0*	*0*		*0*
	3.4	✍ Innovation 4 (ruling #):	*1*	*0*	*0*		*0*
Location & Linkages (LL)		(Minimum 0 LL Points Required)	***Max: 10***	***Y:0***	***M:0***	***Notes***	***Final: 0***
1. LEED for Neighborhood Development							
	1	LEED for Neighborhood Development	*10*	*0*	*0*		*0*
2. Site Selection							
	2	✍ Site Selection *(meet all of the following)*	*2*	*0*	*0*		*0*
		☐ **a) Built above 100-year floodplain defined by FEMA** ☐ **b) Not built on habitat for threatened or endangered species** ☐ **c) Not built within 100 ft of water, including wetlands** ☐ **d) Not built on land that was public parkland prior to acquisition** ☐ **e) Not built on land with prime soils, unique soils, or soils of state significance**					
3. Preferred Locations							
	3.1	Edge Development	*1*	*0*	*0*		*0*
OR	**3.2**	Infill	*2*	*0*	*0*		*0*
AND/OR	**3.3**	Previously Developed	*1*	*0*	*0*		*0*
4. Infrastructure							
	4	Existing Infrastructure	*1*	*0*	*0*		*0*
5. Community Resources / Transit							
	5.1	Basic Community Resources / Transit *(meet one of the following)*	*1*	*0*	*0*		*0*
		☐ **a) Within 1/4 mile of 4 basic community resources** ☐ **b) Within 1/2 mile of 7 basic community resources** ☐ **c) Within 1/2 mile of transit services providing 30 rides per weekday**					
OR	**5.2**	Extensive Community Resources / Transit *(meet one of the following)*	*2*	*0*	*0*		*0*
		☐ **a) Within 1/4 mile of 7 basic community resources** ☐ **b) Within 1/2 mile of 11 basic community resources** ☐ **c) Within 1/2 mile of transit services providing 60 rides per weekday**					
OR	**5.3**	Outstanding Community Resources / Transit *(meet one of the following)*	*3*	*0*	*0*		*0*
		☐ **a) Within 1/4 mile of 11 basic community resources** ☐ **b) Within 1/2 mile of 14 basic community resources** ☐ **c) Within 1/2 mile of transit services providing 125 rides per weekday**					
6. Access to Open Space							
	6	Access to Open Space	*1*	*0*	*0*		*0*

LEED for Homes Checklist Continued

		Sustainable Sites (SS) (Minimum 5 SS Points Required)	*Max: 22*	*Y:0*	*M:0*	**Notes**	*Final: 0*
1. Site Stewardship							
	1.1	Erosion Controls During Construction *(meet all of the following)*	*Prereq.*				
		☐ a) Stockpile and protect disturbed topsoil from erosion.					
		☐ b) Control the path and velocity of runoff with silt fencing or equivalent.					
		☐ c) Protect sewer inlets, streams, and lakes with straw bales, silt fencing, etc.					
		☐ d) Provide swales to divert surface water from hillsides					
		☐ e) Use tiers, erosion blankets, compost blankets, etc. on sloped areas.					
	1.2	Minimize Disturbed Area of Site *(meet the appropriate requirements)*	*1*	*0*	*0*		*0*
		Where the site is not previously developed, meet all the following:					
		☐ a) Develop tree / plant preservation plan with "no-disturbance" zones					
		☐ b) Leave 40% of buildable lot area, not including area under roof, undisturbed					
	OR	Where the site is previously developed, meet all the following:					
		☐ c) Develop tree / plant preservation plan with "no-disturbance" zones AND					
		☐ Rehabilitate lot; undo soil compaction and remove invasive plants AND					
		☐ Meet the requirements of SS 2.2					
	OR	☐ d) Build on a lot of 1/7 acre or less, or 7 units per acre.					
2. Landscaping							
	2.1	✍ No Invasive Plants	*Prereq.*				
	2.2	✍ Basic Landscaping Design *(meet all of the following)*	*2*	*0*	*0*		*0*
		☐ a) Any turf must be drought-tolerant.					
		☐ b) Do not use turf in densely shaded areas.					
		☐ c) Do not use turf in areas with slope of 25%					
		☐ d) Add mulch or soil amendments as appropriate.					
		☐ e) All compacted soil must be tilled to at least 6 inches.					
AND/OR	2.3	✍ Limit Conventional Turf	*3*	*0*	*0*		*0*
		☐ Percentage of designed landscape softscape area that is turf					
AND/OR	2.4	✍ Drought-Tolerant Plants	*2*	*0*	*0*		*0*
		☐ Percentage of installed plants that are drought-tolerant					
OR	2.5	✍ Reduce Overall Irrigation Demand by at Least 20%	*6*	*0*	*0*		*0*
		☐ Percentage reduction in estimated irrigation water demand	*(calculate)*				
3. Reduce Local Heat Island Effects							
	3	✍ Reduce Local Heat Island Effects *(meet one of the following)*	*1*	*0*	*0*		*0*
		☐ a) Locate trees / plantings to provide shade for 50% of hardscapes					
		☐ b) Install light-colored, high-albedo materials for 50% of hardscapes					

LEED for Homes Checklist Continued

4. Surface Water Management

	4.1	✍ Permeable Lot	4	0	0	0

☐ vegetative landscape
☐ permeable paving
☐ impermeable surfaces directed to infiltration features
☐ other impermeable surfaces (areas not counted towards credit)

	4.2	Permanent Erosion Controls *(meet one of the following)*	1	0	0	0

☐ a) For portions of lot on steep slope, use terracing and retaining walls
☐ b) Plant trees, shrubs, or groundcover

	4.3	✍ Management of Runoff from Roof *(meet any, see Rating System for pts)*	2	0	0	0

☐ a) Install permanent stormwater controls to manage runoff from the home
☐ b) Install vegetated roof to cover 50% of roof area
☐ c) Install vegetated roof to cover 100% of roof area
☐ d) Have lot designed by professional to manage runoff from home on-site

5. Nontoxic Pest Control

	5	Pest Control Alternatives *(meet any of the following, 1/2 pt each)*	2	0	0	0

☐ a) Keep all exterior wood at least 12" above soil
☐ b) Seal external cracks, joints, etc. with caulking and install pest-proof screens
☐ c) Include no wood-to-concrete connections, or separate connections with dividers
☐ d) Install landscaping so mature plants are 24" from home

e) In 'moderate' to 'very heavy' termite risk areas:
☐ i) Treat all cellulosic material with borate product to 3' above foundation
☐ ii) Install sand or diatomaceous earth barrier
☐ iii) Install steel mesh barrier termite control system
☐ iv) Install non-toxic termite bait system
☐ v) Use noncellulosic wall structure
☐ vi) Use solid concrete foundation walls or pest-proof masonry wall design

6. Compact Development

	6.1	Moderate Density	2	0	0	0

☐ # of total units on the lot ☐ lot size (acres) N/A density (units/acre)

OR	6.2	High Density	3	0	0	0
OR	6.3	Very High Density	4	0	0	0

Water Efficiency (WE) (Minimum 3 WE Points Required)

Max: 15 *Y:0* *M:0* *Notes* *Final: 0*

1. Water Reuse

	1.1	Rainwater Harvesting System	4	0	0	0

☐ Percentage of roof area used for harvesting
☐ Application

AND/OR	1.2	Graywater Reuse System	1	0	0	0
OR	1.3	Use of Municipal Recycled Water System	3	0	0	0

LEED for Homes Checklist Continued

2. Irrigation System

	2.1	✍ High-Efficiency Irrigation System *(meet any of the following, 1 pt each)*	*3*	*0*	*0*	*0*

☐ a) Irrigation system designed by EPA Water Sense certified professional
☐ b) Irrigation system with head-to-head coverage
☐ c) Install central shut-off valve
☐ d) Install submeter for the irrigation system
☐ e) Use drip irrigation for 50% of planting beds
☐ f) Create separate zones for each type of bedding
☐ g) Install timer or controller for each watering zone
☐ h) Install pressure-regulating devices
☐ i) High-efficiency nozzles with distribution uniformity of at least 0.70.
☐ j) Check valves in heads
☐ k) Install moisture sensor or rain delay controller

AND/OR	2.2	Third-party Inspection	*1*	*0*	*0*	*0*
OR	2.3	✍ Reduce Overall Irrigation Demand by at Least 45%	*4*	*0*	*0*	*0*

☐ Percentage reduction in estimated irrigation water demand (calculate)

3. Indoor Water Use

3.1	High-Efficiency Fixtures and Fittings *(meet any of the following, 1 pt each)*	*3*	*0*	*0*	*0*

☐ a) Average flow rate of lavatory faucets is ≤ 2.00 gpm
☐ b) Average flow rate for all showers is ≤ 2.00 gpm per stall
☐ c) Average flow rate for all toilets is ≤ 1.30 gpf; OR
☐ Toilets are dual-flush; OR
☐ Toilets meet the EPA Water Sense specification

3.2	Very High-Efficiency Fixtures and Fittings *(meet any, 2 pts each)*	*6*	*0*	*0*	*0*

☐ a) Average flow rate of lavatory faucets is ≤ 1.50 gpm; OR
☐ Lavatory faucets meet the EPA Water Sense specification
☐ b) Average flow rate for all showers ≤ 1.75 gpm per stall
☐ c) Average flow rate for all toilets is ≤ 1.10 gpf

Energy & Atmosphere (EA) (Minimum 0 EA Points Required)	***Max: 38***	***Y:0***	***M:0***	***Notes***	***Final: 0***

1. Optimize Energy Performance

1.1	Performance of ENERGY STAR for Homes	***Prereq.***			
1.2	Exceptional Energy Performance	*34*	*0*	*0*	*0*

☐ IECC climate zone ☐ HERS Index

7. Water Heating

7.1	✍ Efficient Hot Water Distribution System *(meet one of the following)*	*2*	*0*	*0*	*0*

☐ a) Structured plumbing system
☐ b) Central manifold distribution system
☐ c) Compact design of conventional system

7.2	Pipe Insulation	*1*	*0*	*0*	*0*

11. Residential Refrigerant Management

11.1	Refrigerant Charge Test	***Prereq.***			
11.2	Appropriate HVAC Refrigerants *(meet one of the following)*	*1*	*0*	*0*	*0*

☐ a) Use no refrigerants
☐ b) Use non-HCFC refrigerants
☐ c) Use refrigerants that complies with global warming potential equation

LEED for Homes Checklist Continued

		Materials & Resources (MR) (Minimum 2 MR Points Required)	***Max: 16***	***Y:0***	*M:0*	***Notes***	***Final: 0***
1. Material-Efficient Framing							
	1.1	Framing Order Waste Factor	*Prereq.*				
	1.2	Detailed Framing Documents	*1*	*0*	*0*		*0*
	1.3	Detailed Cut List and Lumber Order	*1*	*0*	*0*		*0*
		☐ Requirements of MR 1.2 have been met	☐ Detailed cut list and lumber order corresponding to framing plans or scopes				
AND/OR	1.4	Framing Efficiencies *(meet any of the following, see Rating System for pts)*	*3*	*0*	*0*		*0*
		☐ Precut framing packages	☐ Stud spacing greater than 16" on center				
		☐ Open-web floor trusses	☐ Ceiling joist spacing greater than 16" on center				
		☐ Structural insulated panel walls	☐ Floor joist spacing greater than 16" on center				
		☐ Structural insulated panel roof	☐ Roof rafter spacing greater than 16" on center				
		☐ Structural insulated panel floors	☐ Two of the following: Size headers for loads; ladder blocking; drywall clips; 2-				
OR	1.5	Off-site Fabrication *(meet one of the following)*	*4*	*0*	*0*		*0*
		☐ a) Panelized construction	☐ b) Modular, prefabricated construction				
2. Environmentally Preferable Products							
	2.1	✍ FSC Certified Tropical Wood *(meet all of the following)*	*Prereq.*				
		☐ a) Provide suppliers with a notice of preference for FSC products; AND	☐ b) All purchased wood is either not tropical, FSC-certified, or reclaimed				
		☐ Request country of manufacture for each wood product					
	2.2	✍ Environmentally Preferable Products *(meet any, 1/2 pt each)*	*8*	*0*	*0*		*0*

Assembly : component	***(a) EPP***			***(b) Low emission***		***(c) Local production***	
Exterior wall: framing	☐		type: ________			☐	
Exterior wall: siding or masonry	☐		type: ________			☐	
Floor: flooring	☐	(45%)	type: ________	☐	90% hard flooring	☐	(45%)
Floor: flooring	☐	(90%)	type: ________	☐	SCS FloorScore	☐	(90%)
Floor: carpet				☐	Green Label Plus	☐	
Floor: framing	☐		type: ________			☐	
Foundation: aggregate	☐		type: ________			☐	
Foundation: cement	☐		type: ________			☐	
Interior wall: framing	☐		type: ________			☐	
Interior wall, ceiling: gypsum board	☐		type: ________			☐	
Interior wall, ceiling, millwork: paint	☐		type: ________	☐	type: ________		
Landscape: decking and patio	☐		type: ________			☐	
Other: cabinet	☐		type: ________			☐	
Other: counter	☐		type: ________			☐	
Other: door	☐		type: ________			☐	
Other : exterior trim	☐		type: ________			☐	
Other : adhesive, sealant				☐	type: ________		
Other : window frame	☐		type: ________			☐	
Roof: framing	☐		type: ________			☐	
Roof: roofing	☐		type: ________			☐	
Roof, floor, wall: cavity insulation	☐		type: ________	☐	type: ________	☐	

LEED for Homes Checklist Continued

3. Waste Management

3.1 Construction Waste Management Planning *(meet both of the following)* *Prereq.*

☐ **a) Investigate local options for waste diversion**
☐ **b) Document diversion rate for construction waste**

3.2 Construction Waste Reduction *(use one of the following methods)* ***3*** ***0*** *0* ***0***

☐ a) pounds waste / square foot
☐ cubic yards waste / 1,000 square feet
☐ b) percentage of waste diverted

Indoor Environmental Quality (EQ) (Minimum 6 EQ Points Required) *Max: 21* *Y:0* *M:0* *Notes* *Final: 0*

1. ENERGY STAR with Indoor Air Package

1 ENERGY STAR with Indoor Air Package ***13*** ***0*** *0* ***0***

2. Combustion Venting

2.1 Basic Combustion Venting Measures *(meet all of the following)* *Prereq.*

☐ **a) no unvented combustion appliances**
☐ **b) carbon monoxide monitors on each floor**
☐ **c) no fireplace installed, OR**
☐ **all fireplaces and woodstoves have doors**
☐ **d) space, water heating equipment designed with closed combustion; OR**
☐ **space and water heating equipment has power-vented exhaust; OR**
☐ **space and water heating equipment located in detached or open-air facilit**
☐ **no space- or water-heating equipment with combustion**

2.2 Enhanced Combustion Venting Measures *(meet one of the following)* ***2*** ***0*** *0* ***0***

Type of Fireplace or stove	***Better practice (1 pt)***	***Best practice (2 pts)*** ***(must also meet Better Practice)***
None		☐ granted automatically
Masonry wood-burning fireplace	☐ masonry heater	☐ back-draft potential test
Factory-built wood-burning fireplace	☐ listed by testing lab and meets EPA standards	☐ back-draft potential test
Woodstove and fireplace insert	☐ listed by testing lab and meets EPA standards	☐ back-draft potential test
Natural gas, propane, or alcohol stove	☐ listed, power- or direct-vented, fixed doors	☐ electronic pilot
Pellet stove	☐ EPA certified or meets safety requirements	☐ power- or direct-venting

3. Moisture Control

3 Moisture Load Control *(meet one of the following)* ***1*** ***0*** *0* ***0***

☐ **a) Additional dehumidification system**
☐ **b) Central HVAC system equipped with additional dehumidification mode**

4. Outdoor Air Ventilation

4.1 ✍ Basic Outdoor Air Ventilation *(meet one of the following)* *Prereq.*

☐ **a) Located in climate with ≤ 4,500 infiltration degree days.**
☐ **b) Continuous ventilation**
☐ **c) Intermittent ventilation**
☐ **d) Passive ventilation**

4.2 ✍ Enhanced Outdoor Air Ventilation *(meet one of the following)* ***2*** ***0*** *0* ***0***

☐ **a) In climates with ≤ 4,500 infiltration degree days, install active ventilation system**
☐ **b) Install heat recovery system**

4.3 Third-Party Performance Testing ***1*** ***0*** *0* ***0***

LEED for Homes Checklist Continued

5. Local Exhaust						
	5.1	✍ Basic Local Exhaust *(meet all of the following)*	*Prereq.*			
		☐ a) Bathroom and kitchen exhaust meets ASHRAE Std. 62.2 air flow requirement	☐ c) Air exhausted to outdoors			
		☐ b) Fans and ducts designed and installed to ASHRAE Std. 62.2	☐ d) ENERGY STAR labeled bathroom exhaust fans			
	5.2	Enhanced Local Exhaust *(meet one of the following)*	*1*	*0*	*0*	*0*
		☐ a) Occupancy sensor	☐ c) Automatic timer tied to switch			
		☐ b) Automatic humidistat controller	☐ d) Continuously operating exhaust fan			
	5.3	Third-Party Performance Testing	*1*	*0*	*0*	*0*
6. Distribution of Space Heating and Cooling						
	6.1	✍ Room-by-Room Load Calculations	*Prereq.*			
	6.2	Return Air Flow / Room-by-Room Controls *(meet one of the following)*	*1*	*0*	*0*	*0*
		A. Forced-Air Systems	B. Nonducted HVAC Systems			
		☐ a) Return air opening of 1 sq. inch per cfm of supply	☐ Flow control valves on every radiator			
		☐ b) Limited pressure differential between closed room and adjacent spaces				
	6.3	Third-Party Performance Test / Multiple Zones *(meet one of the following)*	*2*	*0*	*0*	*0*
		A. Forced-Air Systems	B. Nonducted HVAC Systems			
		☐ Have supply air flow rates in each room tested and confirmed	☐ Install at least two distinct zones with independent thermostat control			
7. Air Filtering						
	7.1	Good Filters	*Prereq.*			
	7.2	Better Filters	*1*	*0*	*0*	*0*
OR	7.3	Best Filters	*2*	*0*	*0*	*0*
8. Contaminant Control						
	8.1	✍ Indoor Contaminant Control during Construction	*1*	*0*	*0*	*0*
	8.2	Indoor Contaminant Control *(meet any of the following, 1 pt each)*	*2*	*0*	*0*	*0*
		☐ a) Design and install permanent walk-off mats at each entry	☐ c) Install central vacuum system with exhaust to ourdoors			
		☐ b) Design shoe removal and storage space near primary entryway				
	8.3	✍ Preoccupancy Flush	*1*	*0*	*0*	*0*
9. Radon Protection						
	9.1	✍ Radon-Resistant Construction in High-Risk Areas	*Prereq.*			
	9.2	✍ Radon-Resistant Construction in Moderate-Risk Areas	*1*	*0*	*0*	*0*

LEED for Homes Checklist Continued

10. Garage Pollutant Protection								
	10.1	No HVAC in Garage		*Prereq.*				
	10.2	Minimize Pollutants from Garage *(meet all of the following)*		*2*	*0*	*0*		*0*
		a) In conditioned spaces above garage:	b) In conditioned spaces next to garage					
		☐ Seal all penetrations and connecting floor and ceiling joist bays	☐ Weather-strip all doors ☐ carbon monoxide detectors in rooms that share a door with garage ☐ Seal all penetrations and cracks at the base of walls					
AND/OR	10.3	Exhaust Fan in Garage *(meet one of the following)*		*1*	*0*	*0*		*0*
		☐ a) Fan runs continuously	☐ b) Fan designed with automatic timer control					
OR	10.4	Detached Garage or No Garage		*3*	*0*	*0*		*0*
Awareness & Education (AE)		(Minimum 0 AE Points Required)		*Max: 3*	*Y:0*	*M:0*	*Notes*	*Final: 0*
1. Education of the Homeowner or Tenant								
	1.1	✍ Basic Operations Training *(meet both of the following)*		*Prereq.*				
		☐ a) Operations and training manual	☐ b) One-hour walkthrough with occupant(s)					
	1.2	✍ Enhanced Training		*1*	*0*	*0*		*0*
	1.3	Public Awareness *(meet three of the following)*		*1*	*0*	*0*		*0*
		☐ a) Open house on at least four weekends ☐ b) Website about features and benefits of LEED homes	☐ c) Newspaper article on the project ☐ d) Display LEED signage on the exterior of the home					
2. Education of the Building Manager								
	2	✍ Education of the Building Manager *(meet both of the following)*		*1*	*0*	*0*		*0*
		☐ a) Operations and training manual	☐ b) One-hour walkthrough with building manager					

LEED for Homes Checklist Continued

		Energy & Atmosphere (EA) (Minimum 0 EA Points Required)	***Max: 38***	***Y:0***	*M:0*	***Notes***	***Final: 0***
		2. Insulation					
	2.1	Basic Insulation *(meet both of the following)*	*Prereq.*				
		☐ a) Insulation meets R-value requirements of IECC ☐ b) Insulation meets HERS Grade II specifications for installation					
	2.2	Enhanced Insulation *(meet both of the following)*	*2*	*0*	*0*		*0*
		☐ a) Insulation exceeds R-value requirements of IECC by 5% ☐ b) Insulation meets HERS Grade I specifications for installation					
		3. Air Infiltration					
	3.1	Reduced Envelope Leakage	*Prereq.*				
		☐ Air leakage rate in ACH50					
	3.2	Greatly Reduced Envelope Leakage	*2*	*0*	*0*		*0*
OR	3.3	Minimal Envelope Leakage	*3*	*0*	*0*		*0*
		4. Windows					
	4.1	Good Windows *(meet all of the following)*	*Prereq.*				
		☐ a) Windows and glass doors meet ENERGY STAR BOP window specifications ☐ b) Skylight glazing area is ≤ 3% of floor area AND ☐ Skylights meet ENERGY STAR requirements for skylights					
	4.2	Enhanced Windows	*2*	*0*	*0*		*0*
OR	4.3	Exceptional Windows	*3*	*0*	*0*		*0*
		5. Heating and Cooling Distribution System					
	5.1	Reduced Distribution Losses *(meet all of the following, as appropriate)*	*Prereq.*				
		A. Forced-Air Systems ☐ a) Duct leakage of ≤ 4.0 CFM at 25 Pascals per 100 sq.ft. ☐ b) No ducts in exterior walls unless extra insulation is added ☐ c) At least R-6 insulation around ducts in unconditioned spaces B. Nonducted HVAC Systems ☐ At least R-3 insulation around pipes in unconditioned spaces					
	5.2	Greatly Reduced Distribution Losses *(meet the following, as appropriate)*	*2*	*0*	*0*		*0*
		A. Forced-Air Systems ☐ Duct leakage of ≤ 3.0 CFM at 25 Pascals per 100 sq.ft. B. Nonducted HVAC Systems ☐ Keep the boiler and pipes entirely within conditioned envelope					
OR	5.3	Minimal Distribution Losses *(meet one of the following, as appropriate)*	*3*	*0*	*0*		*0*
		A. Forced-Air Systems ☐ a) Duct leakage of ≤ 1.0 CFM at 25 Pascals per 100 sq.ft. ☐ b) Air-handler and all ductwork is within conditioned envelope and EA 3.3 is met ☐ c) Air-handler and all ductwork visibly within conditioned spaces (not in walls, etc.) B. Nonducted HVAC Systems ☐ Outdoor reset control to set distribution temp. based on outdoor temp.					

LEED for Homes Checklist Continued

6. Space Heating and Cooling Equipment

	6.1	✍ Good HVAC Design and Installation *(meet all of the following)*	*Prereq.*			

☐ a) Design and size HVAC equipment using ACCA Manual J or equivalent
☐ b) Install efficient heating AND cooling equipment (see Table)
☐ c) Install ENERGY STAR programmable thermostat OR
☐ Heat pump or hydronic installed and exempted from part (c)

Type of cooling system
Type of heating system
Cooling efficiency (SEER / EER)
Heating Efficiency (AFUE / HSPF / COP)

	6.2	High-Efficiency HVAC	*2*	*0*	*0*	*0*
OR	6.3	Very High Efficiency HVAC	*4*	*0*	*0*	*0*

7. Water Heating

	7.1	✍ Efficient Hot Water Distribution System *(meet one of the following)*	*2*	*0*	*0*	*0*

☐ a) Structured plumbing system
☐ b) Central manifold distribution system
☐ c) Compact design of conventional system

	7.2	Pipe Insulation	*1*	*0*	*0*	*0*
	7.3	Efficient Domestic Hot Water Equipment	*3*	*0*	*0*	*0*

Type of DHW system
Efficiency
Solar: Percentage of annual DHW load

8. Lighting

	8.1	ENERGY STAR Lights	*Prereq.*			
	8.2	Improved Lighting *(meet one of the following, see Rating System for pts)*	*1.5*	*0*	*0*	*0*

☐ a) Indoor lighting - 3 additional ENERGY STAR lights in high-use rooms
☐ b) Exterior lighting - motion sensor controls or integrated PV

OR	8.3	Advanced Lighting Package *(meet one of the following)*	*3*	*0*	*0*	*0*

☐ a) 60% of fixtures are ENERGY STAR fixtures
☐ b) 80% of lamps are ENERGY STAR CFLs

9. Appliances

	9.1	High-Efficiency Appliances *(meet any, see Rating System for pts)*	*2*	*0*	*0*	*0*

☐ a) ENERGY STAR labeled refrigerator
☐ b) ENERGY STAR labeled ceiling fans in living/family room and all bedrooms
☐ c) ENERGY STAR labeled dishwasher using 6.0 gallons per cycle or less
☐ d) ENERGY STAR clothes washer

	9.2	Water-Efficiency Clothes Washer	*1*	*0*	*0*	*0*

10. Renewable Energy

	10	✍ Renewable Energy System	*10*	*0*	*0*	*0.0*

Reference electric load, kWh/yr (based on HERS model)
Electricity supplied by renewable system, kWh/yr
0.0% Percentage of annual reference electric load met by renewable system

11. Residential Refrigerant Management

	11.1	Refrigerant Charge Test	*Prereq.*			
	11.2	Appropriate HVAC Refrigerants *(meet one of the following)*	*1*	*0*	*0*	*0*

☐ a) Use no refrigerants
☐ b) Use non-HCFC refrigerants
☐ c) Use refrigerants that complies with global warming potential equation

ENERGY STAR Qualified Homes
Thermal Bypass Inspection Checklist

The Thermal Bypass Inspection Checklist must be completed for homes to earn the ENERGY STAR label. The Checklist requires visual inspection of framing areas where air barriers are commonly missed and inspection of insulation to ensure proper alignment with air barriers, thus serving as an extra check that the air and thermal barriers are continuous and complete. State, local, and regional codes, as well as regional ENERGY STAR program requirements, supersede the items specified in this Checklist.

Guidance on Completing the Thermal Bypass Inspection Checklist:

1. Accredited HERS Providers and certified home energy raters shall use their experience and discretion in verifying that each Inspection Checklist item is installed per the inspection guidelines (e.g., identifying minor defects that the Provider or rater deems acceptable versus identifying major defects that undermine the intent of the Checklist item).

2. Alternative methods of meeting the Checklist requirements may be used in completing the Checklist, if the Provider deems them to be equivalent, or more stringent, than the Inspection Checklist guidelines.

3. In the event an item on the Checklist cannot be verified by the rater, the home cannot be qualified as ENERGY STAR, unless the builder assumes responsibility for verifying that the item has met the requirements of the Checklist. This option is available at the discretion of the Provider or rater but may not be used to verify more than six (6) items on the Inspection Checklist. This responsibility will be formally acknowledged by the builder signing-off on the Checklist for the item(s) that they verified. The column titled “N/A” should be used when the checklist item is not present in the home or when local code requirements take precedent.

4. The Checklist may be completed for a batch of homes using a RESNET-approved sampling protocol when qualifying homes as ENERGY STAR. For example, if the approved sampling protocol requires rating one in seven homes, then the Checklist will be completed for the one home which was rated.

5. In the event that a Provider or rater finds an item that is inconsistent with the Checklist Inspection guidelines, the home cannot be qualified as ENERGY STAR until the item is corrected in a manner that meets the ENERGY STAR requirements. If correction of the item is not possible, the home cannot earn the ENERGY STAR label.

6. The Provider or rater is required to keep a hard copy record of the completed and signed Checklist. The signature of a builder employee is also required if the builder verified compliance with any item on the Checklist.

7. For purposes of this Checklist, an air barrier is defined as any solid material that blocks air flow between a conditioned space and an unconditioned space, including necessary sealing to block excessive air flow at edges and seams. Additional information on proper air sealing of thermal bypasses can be found on the Building America Web site (www.eere.energy.gov/buildings/building_america) and in the EEBA Builder’s Guides (www.eeba.org). These references include guidance on identifying and sealing air barriers, as well as details on many of the items included in the Checklist.

ENERGY STAR Qualified Homes
Thermal Bypass Inspection Checklist

Home Address:____City:________________________State:_______

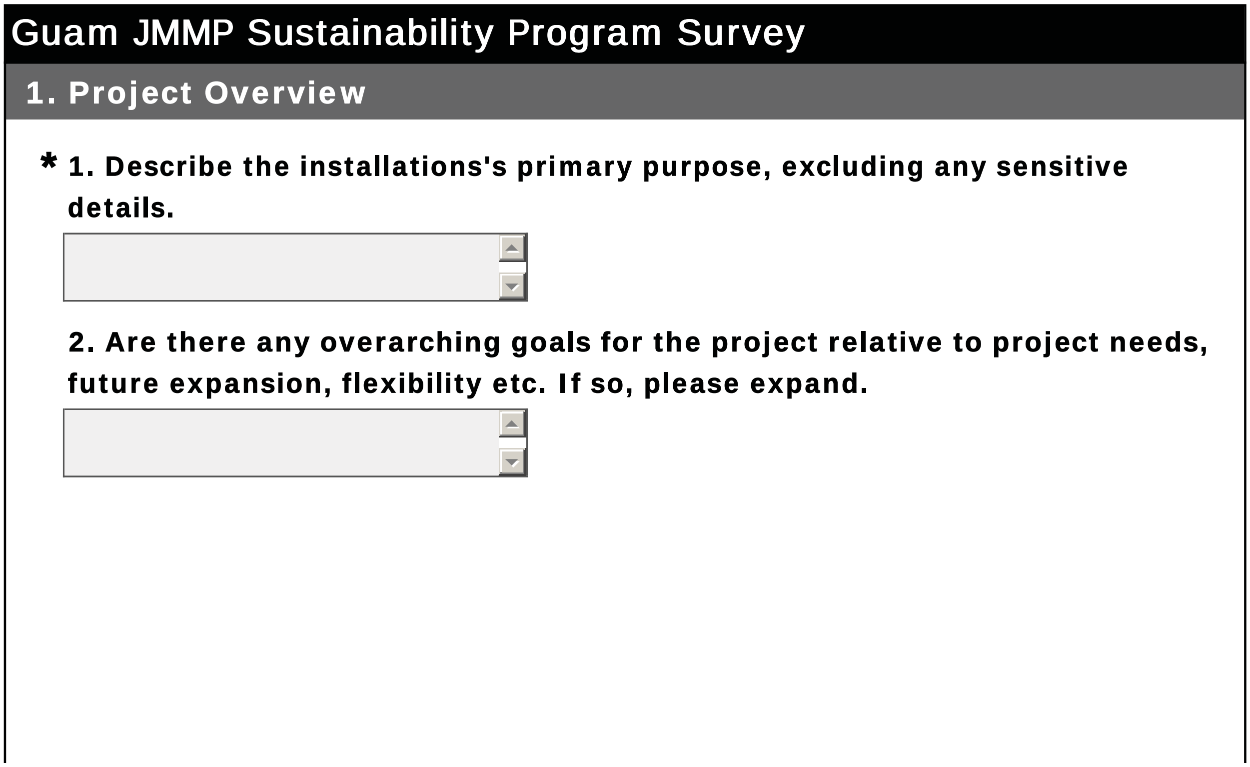
Thermal Bypass	Inspection Guidelines	Corrections Needed	Builder Verified	Rater Verified	N/A
1. Overall Air Barrier and Thermal Barrier Alignment	**Requirements:** Insulation shall be installed in full contact with sealed interior and exterior air barrier except for alternate to interior air barrier under item no. 2 *(Walls Adjoining Exterior Walls or Unconditioned Spaces)*				
	All Climate Zones:				
	1.1 Overall Alignment Throughout Home	☐	☐	☐	☐
	1.2 Garage Band Joist Air Barrier (at bays adjoining conditioned space)	☐	☐	☐	☐
	1.3 Attic Eave Baffles Where Vents/Leakage Exist	☐	☐	☐	☐
	Only at Climate Zones 4 and Higher:				
	1.4 Slab-edge Insulation (A maximum of 25% of the slab edge may be uninsulated in Climate Zones 4 and 5.)	☐	☐	☐	☐
	Best Practices Encouraged, Not Req'd.:				
	1.5 Air Barrier At All Band Joists (Climate Zones 4 and higher)	☐	☐	☐	☐
	1.6 Minimize Thermal Bridging (e.g., OVE framing, SIPs, ICFs)	☐	☐	☐	☐
2. Walls Adjoining Exterior Walls or Unconditioned Spaces	**Requirements:** • Fully insulated wall aligned with air barrier at both interior and exterior, **OR** • Alternate for **Climate Zones 1 thru 3**, sealed exterior air barrier aligned with RESNET Grade 1 insulation fully supported • Continuous top and bottom plates or sealed blocking				
	2.1 Wall Behind Shower/Tub	☐	☐	☐	☐
	2.2 Wall Behind Fireplace	☐	☐	☐	☐
	2.3 Insulated Attic Slopes/Walls	☐	☐	☐	☐
	2.4 Attic Knee Walls	☐	☐	☐	☐
	2.5 Skylight Shaft Walls	☐	☐	☐	☐
	2.6 Wall Adjoining Porch Roof	☐	☐	☐	☐
	2.7 Staircase Walls	☐	☐	☐	☐
	2.8 Double Walls	☐	☐	☐	☐
3. Floors between Conditioned and Exterior Spaces	**Requirements:** • Air barrier is installed at any exposed fibrous insulation edges • Insulation is installed to maintain permanent contact with sub-floor above including necessary supports (e.g., staves for blankets, netting for blown-in) • Blanket insulation is verified to have no gaps, voids or compression. • Blown-in insulation is verified to have proper density with firm packing				
	3.1 Insulated Floor Above Garage	☐	☐	☐	☐
	3.2 Cantilevered Floor	☐	☐	☐	☐
4. Shafts	**Requirements:** Openings to unconditioned space are fully sealed with solid blocking or flashing and any remaining gaps are sealed with caulk or foam (provide fire-rated collars and caulking where required)				
	4.1 Duct Shaft	☐	☐	☐	☐
	4.2 Piping Shaft/Penetrations	☐	☐	☐	☐
	4.3 Flue Shaft	☐	☐	☐	☐
5. Attic/ Ceiling Interface	**Requirements:** • All attic penetrations and dropped ceilings include a full interior air barrier aligned with insulation with any gaps fully sealed with caulk, foam or tape • Movable insulation fits snugly in opening and air barrier is fully gasketed				
	5.1 Attic Access Panel (fully gasketed and insulated)	☐	☐	☐	☐
	5.2 Attic Drop-down Stair (fully gasketed and insulated)	☐	☐	☐	☐
	5.3 Dropped Ceiling/Soffit (full air barrier aligned with insulation)	☐	☐	☐	☐
	5.4 Recessed Lighting Fixtures (ICAT labeled and sealed to drywall)	☐	☐	☐	☐
	5.5 Whole-house Fan (insulated cover gasketed to the opening)	☐	☐	☐	☐
6. Common Walls Between Dwelling Units	**Requirements:** Gap between drywall shaft wall (i.e., common wall) and the structural framing between units is fully sealed at all exterior boundary conditions				
	6.1 Common Wall Between Dwelling Units	☐	☐	☐	☐

Home Energy Rating Provider: _______________________ Rater Inspection Date: _______________ Builder Inspection Date: _______________
Home Energy Rater Company Name: ___________________________ Builder Company Name: _______________________________________
Home Energy Rater Signature: ________________________________ Builder Employee Signature:_____________________________________

Attachment D -

GJMMP Sustainability Program Survey Questions and Responses

Survey Questions



Guam JMMP Sustainability Program Survey

1. Project Overview

*** 1. Describe the installations's primary purpose, excluding any sensitive details.**

2. Are there any overarching goals for the project relative to project needs, future expansion, flexibility etc. If so, please expand.

Survey Questions - Continued

Guam JMMP Sustainability Program Survey

2. Project Drivers

The following questions will enable us to better understand the key client drivers and goals with respect to general Sustainability

1. Which of the following best describes the GUAM JMMP's sustainable goals from an initial Capital Cost perspective?

○ Lowest Capital Cost is the primary driver

○ Achieve sustainable design enhancement within a strict Internal Rate of Return (IRR) framework

○ Achieve current Federal Mandate best practices for sustainability at the least initial capital cost

○ Look to exceed Federal Mandate energy and water best practices

○ Fully optimize the sustainability potential

2. Which of the following best describes the GUAM JMMP's sustainable goals from an Operational Cost perspective?

○ Energy rates are such that ongoing energy costs are not a primary driver

○ Meet current industry best practices for energy costs

○ Exceed current industry best practices for energy costs

○ Fully optimize the sustainable potential and minimize the ongoing energy costs

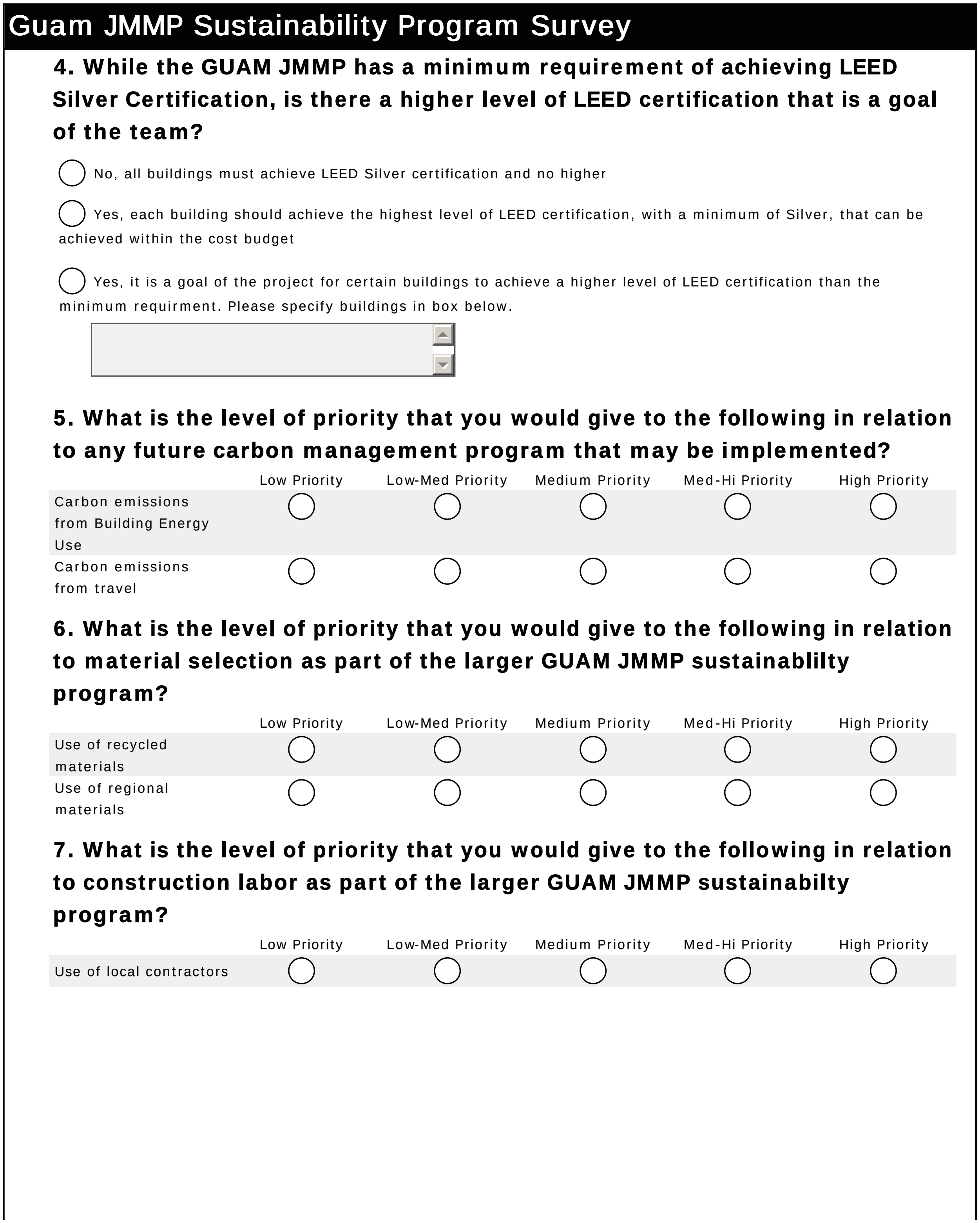
3. Which of the following best describe the project's overall sustainability goals?

○ Embrace sustainability sufficiently to achieve the minimum required for Federal Mandates

○ Achieve maximum sustainability within limited / set capital budget and IRR criteria

○ Fully embrace sustainability and maximize the sustainability potential

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

4. While the GUAM JMMP has a minimum requirement of achieving LEED Silver Certification, is there a higher level of LEED certification that is a goal of the team?

○ No, all buildings must achieve LEED Silver certification and no higher

○ Yes, each building should achieve the highest level of LEED certification, with a minimum of Silver, that can be achieved within the cost budget

○ Yes, it is a goal of the project for certain buildings to achieve a higher level of LEED certification than the minimum requirment. Please specify buildings in box below.

5. What is the level of priority that you would give to the following in relation to any future carbon management program that may be implemented?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority
Carbon emissions from Building Energy Use	○	○	○	○	○
Carbon emissions from travel	○	○	○	○	○

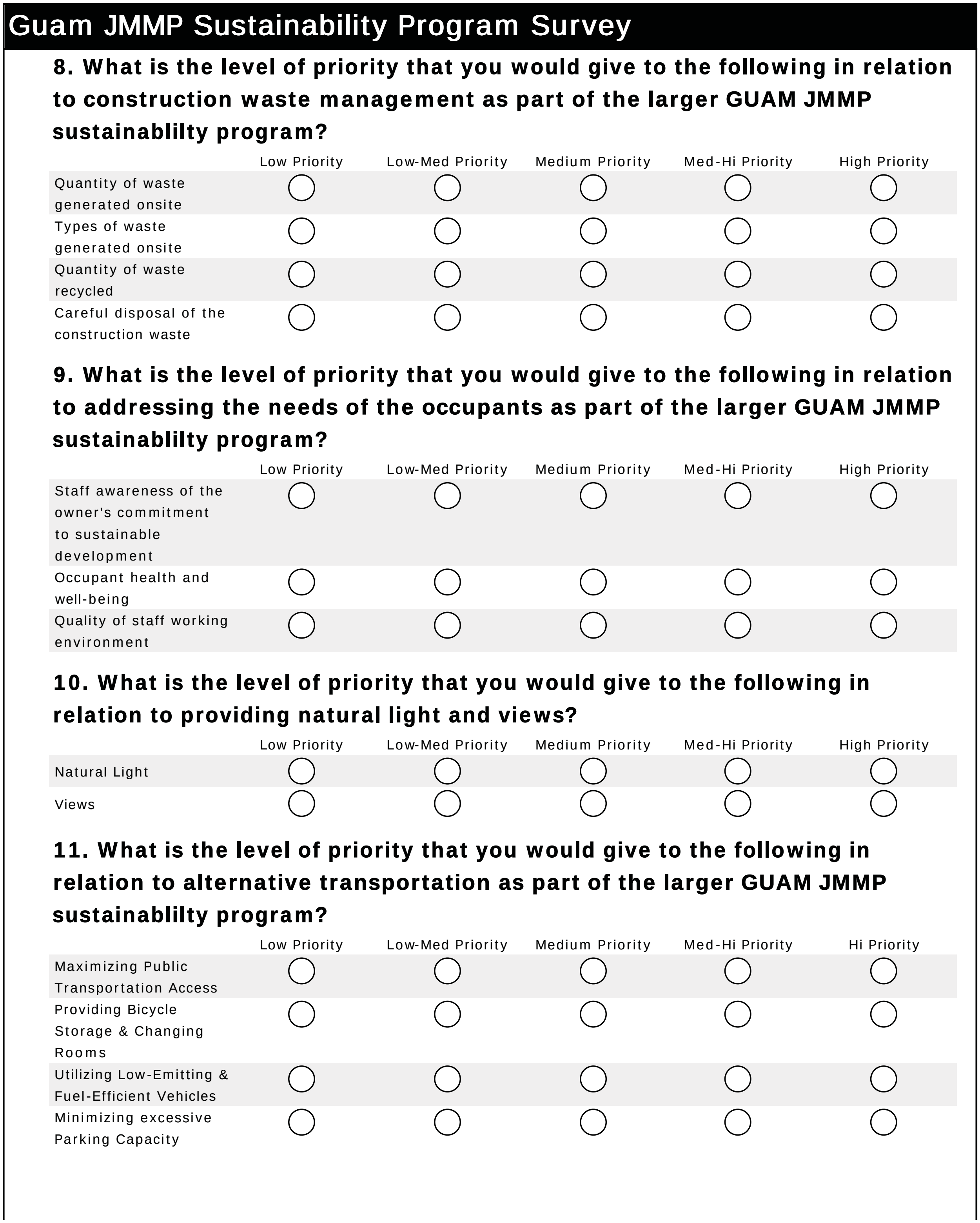
6. What is the level of priority that you would give to the following in relation to material selection as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority
Use of recycled materials	○	○	○	○	○
Use of regional materials	○	○	○	○	○

7. What is the level of priority that you would give to the following in relation to construction labor as part of the larger GUAM JMMP sustainabilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority
Use of local contractors	○	○	○	○	○

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

8. What is the level of priority that you would give to the following in relation to construction waste management as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority
Quantity of waste generated onsite	○	○	○	○	○
Types of waste generated onsite	○	○	○	○	○
Quantity of waste recycled	○	○	○	○	○
Careful disposal of the construction waste	○	○	○	○	○

9. What is the level of priority that you would give to the following in relation to addressing the needs of the occupants as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority
Staff awareness of the owner's commitment to sustainable development	○	○	○	○	○
Occupant health and well-being	○	○	○	○	○
Quality of staff working environment	○	○	○	○	○

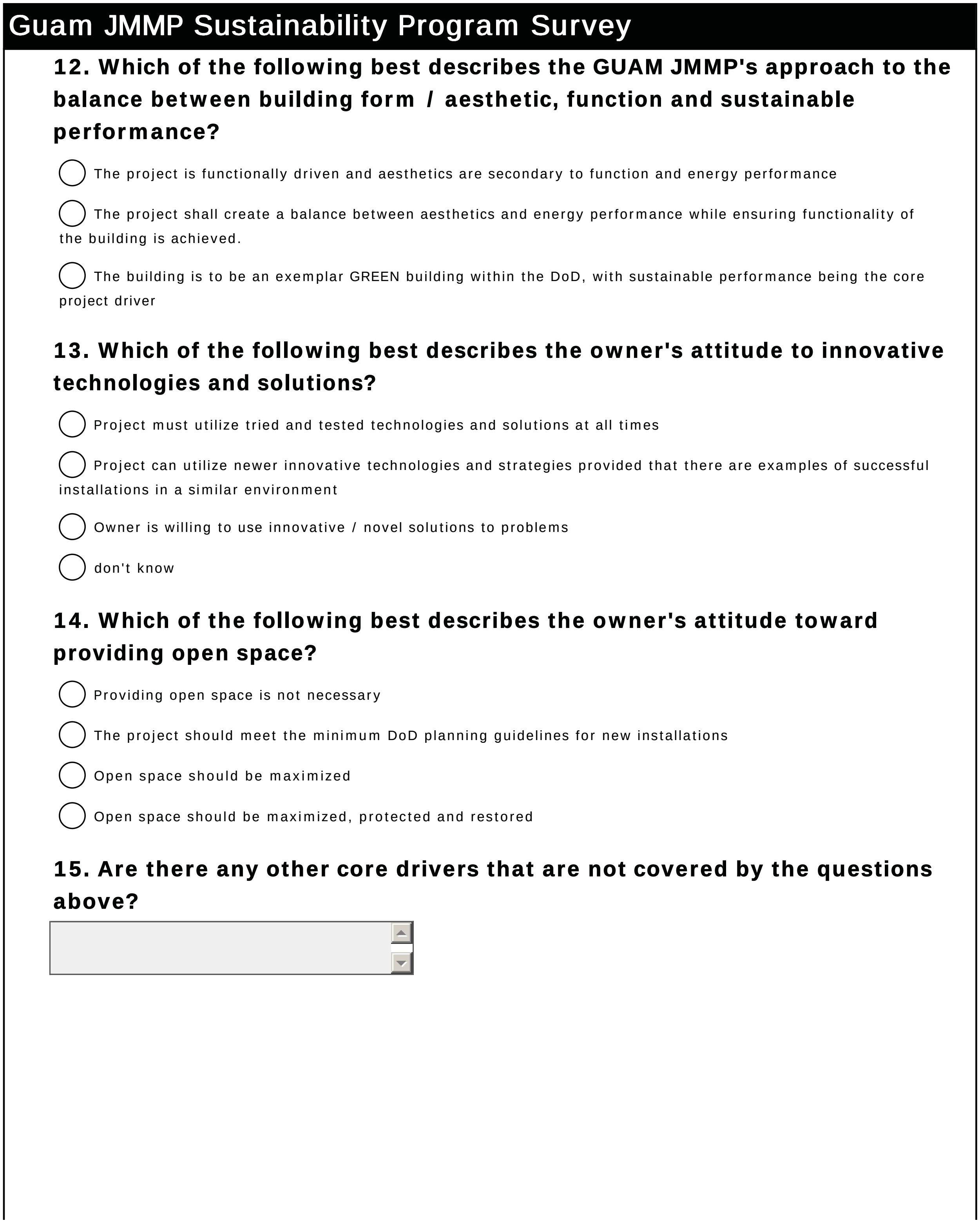
10. What is the level of priority that you would give to the following in relation to providing natural light and views?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority
Natural Light	○	○	○	○	○
Views	○	○	○	○	○

11. What is the level of priority that you would give to the following in relation to alternative transportation as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	Hi Priority
Maximizing Public Transportation Access	○	○	○	○	○
Providing Bicycle Storage & Changing Rooms	○	○	○	○	○
Utilizing Low-Emitting & Fuel-Efficient Vehicles	○	○	○	○	○
Minimizing excessive Parking Capacity	○	○	○	○	○

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

12. Which of the following best describes the GUAM JMMP's approach to the balance between building form / aesthetic, function and sustainable performance?

○ The project is functionally driven and aesthetics are secondary to function and energy performance

○ The project shall create a balance between aesthetics and energy performance while ensuring functionality of the building is achieved.

○ The building is to be an exemplar GREEN building within the DoD, with sustainable performance being the core project driver

13. Which of the following best describes the owner's attitude to innovative technologies and solutions?

○ Project must utilize tried and tested technologies and solutions at all times

○ Project can utilize newer innovative technologies and strategies provided that there are examples of successful installations in a similar environment

○ Owner is willing to use innovative / novel solutions to problems

○ don't know

14. Which of the following best describes the owner's attitude toward providing open space?

○ Providing open space is not necessary

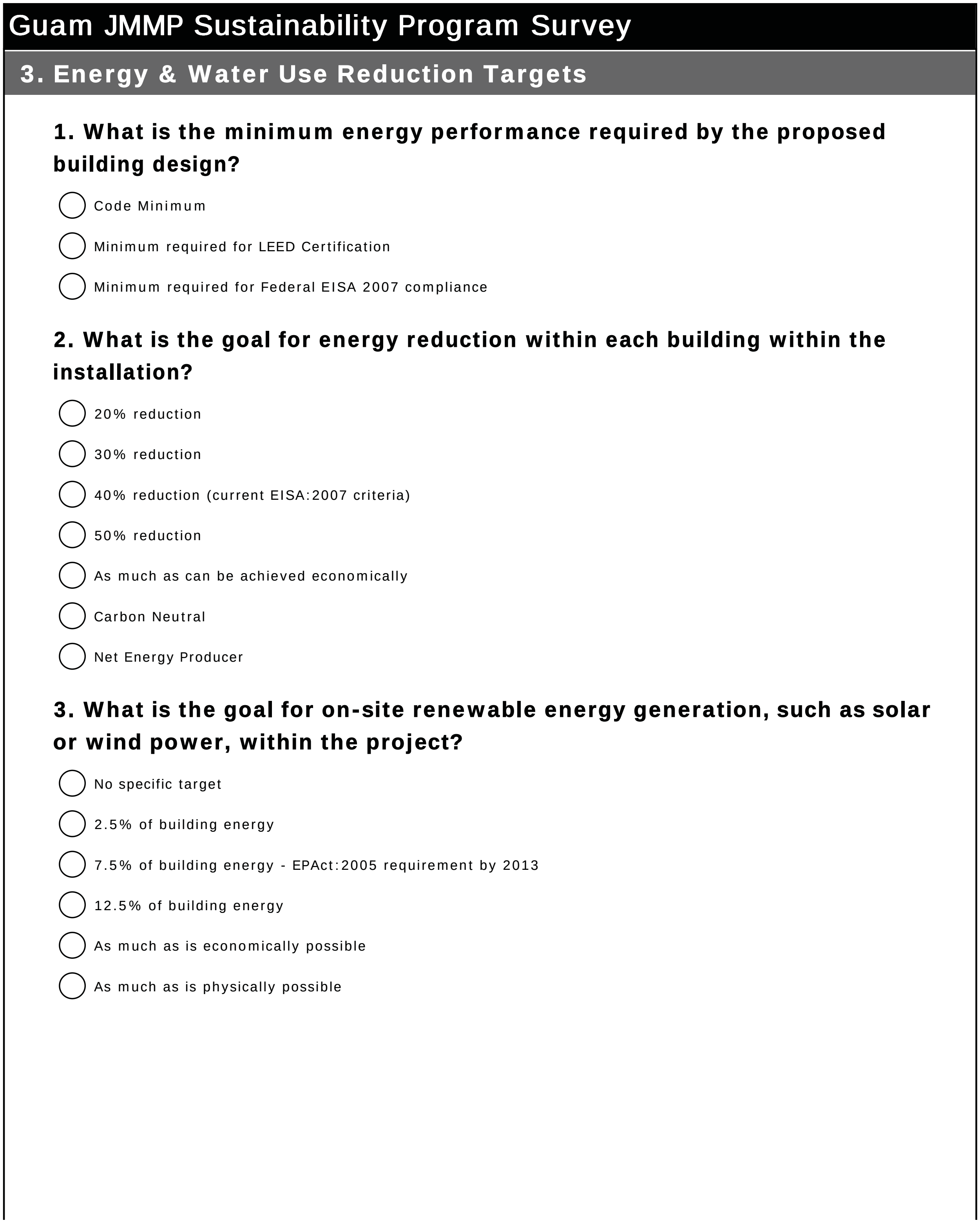
○ The project should meet the minimum DoD planning guidelines for new installations

○ Open space should be maximized

○ Open space should be maximized, protected and restored

15. Are there any other core drivers that are not covered by the questions above?

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

3. Energy & Water Use Reduction Targets

1. What is the minimum energy performance required by the proposed building design?

○ Code Minimum

○ Minimum required for LEED Certification

○ Minimum required for Federal EISA 2007 compliance

2. What is the goal for energy reduction within each building within the installation?

○ 20% reduction

○ 30% reduction

○ 40% reduction (current EISA:2007 criteria)

○ 50% reduction

○ As much as can be achieved economically

○ Carbon Neutral

○ Net Energy Producer

3. What is the goal for on-site renewable energy generation, such as solar or wind power, within the project?

○ No specific target

○ 2.5% of building energy

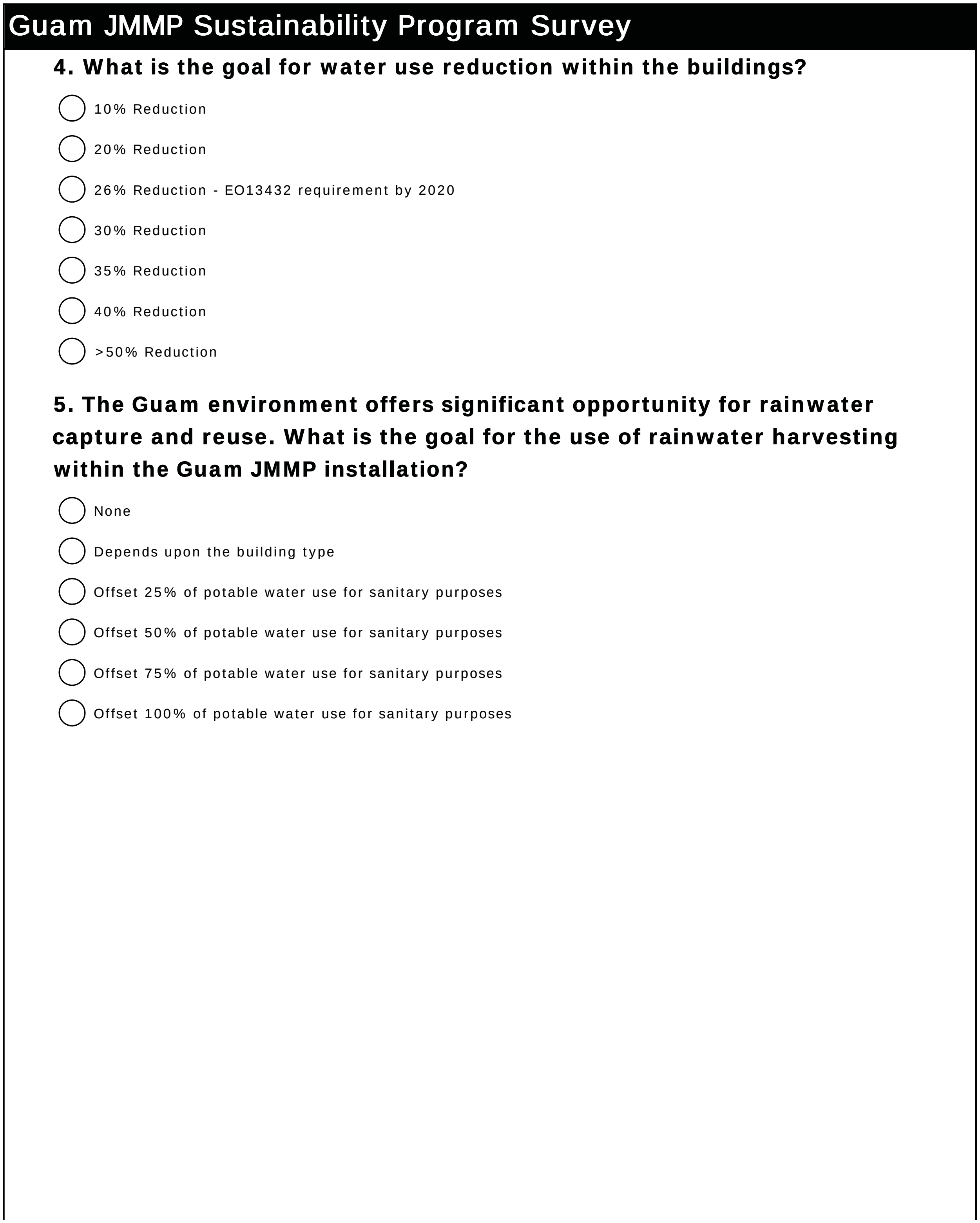
○ 7.5% of building energy - EPAct:2005 requirement by 2013

○ 12.5% of building energy

○ As much as is economically possible

○ As much as is physically possible

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

4. What is the goal for water use reduction within the buildings?

○ 10% Reduction

○ 20% Reduction

○ 26% Reduction - EO13432 requirement by 2020

○ 30% Reduction

○ 35% Reduction

○ 40% Reduction

○ >50% Reduction

5. The Guam environment offers significant opportunity for rainwater capture and reuse. What is the goal for the use of rainwater harvesting within the Guam JMMP installation?

○ None

○ Depends upon the building type

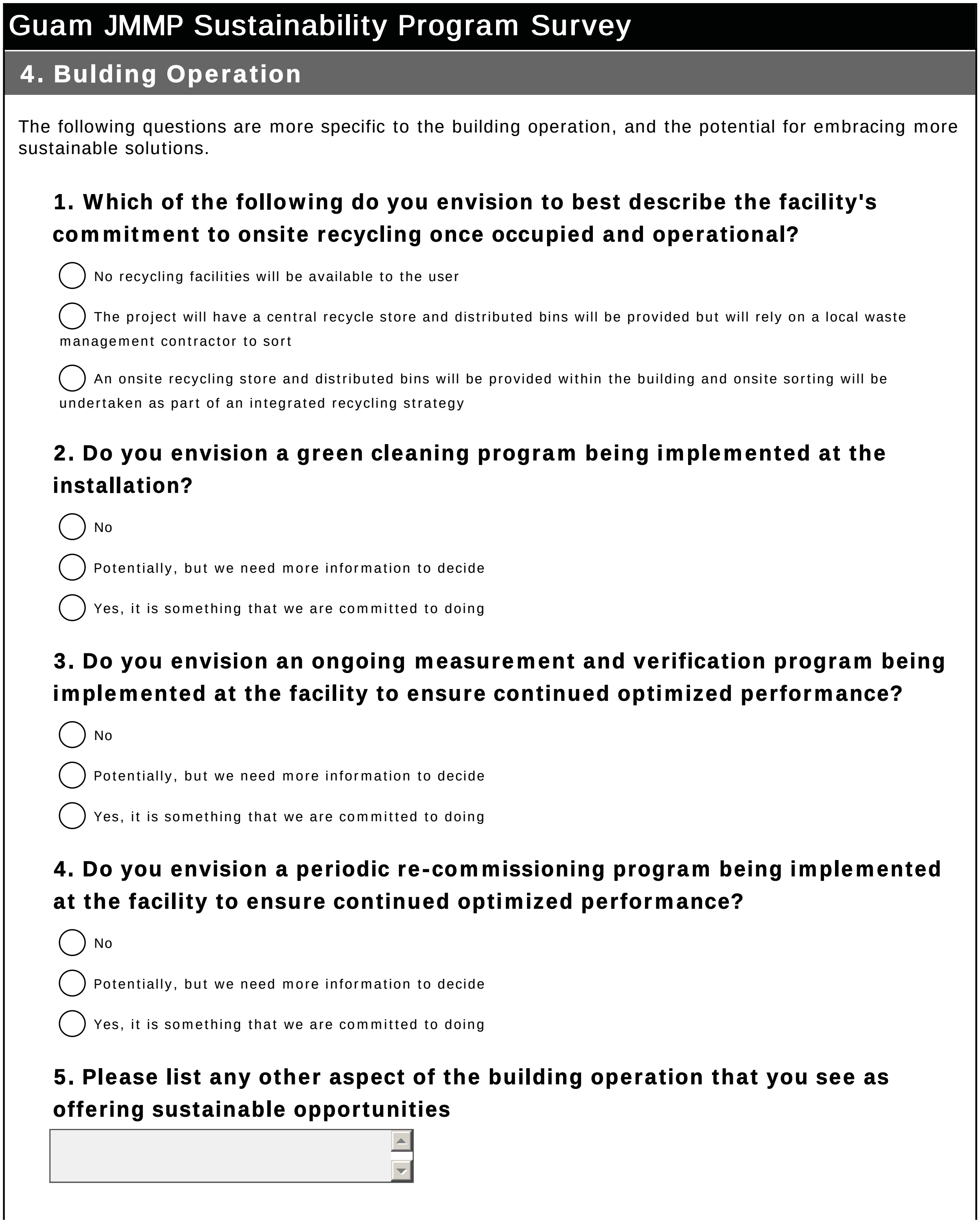
○ Offset 25% of potable water use for sanitary purposes

○ Offset 50% of potable water use for sanitary purposes

○ Offset 75% of potable water use for sanitary purposes

○ Offset 100% of potable water use for sanitary purposes

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

4. Bulding Operation

The following questions are more specific to the building operation, and the potential for embracing more sustainable solutions.

1. Which of the following do you envision to best describe the facility's commitment to onsite recycling once occupied and operational?

○ No recycling facilities will be available to the user

○ The project will have a central recycle store and distributed bins will be provided but will rely on a local waste management contractor to sort

○ An onsite recycling store and distributed bins will be provided within the building and onsite sorting will be undertaken as part of an integrated recycling strategy

2. Do you envision a green cleaning program being implemented at the installation?

○ No

○ Potentially, but we need more information to decide

○ Yes, it is something that we are committed to doing

3. Do you envision an ongoing measurement and verification program being implemented at the facility to ensure continued optimized performance?

○ No

○ Potentially, but we need more information to decide

○ Yes, it is something that we are committed to doing

4. Do you envision a periodic re-commissioning program being implemented at the facility to ensure continued optimized performance?

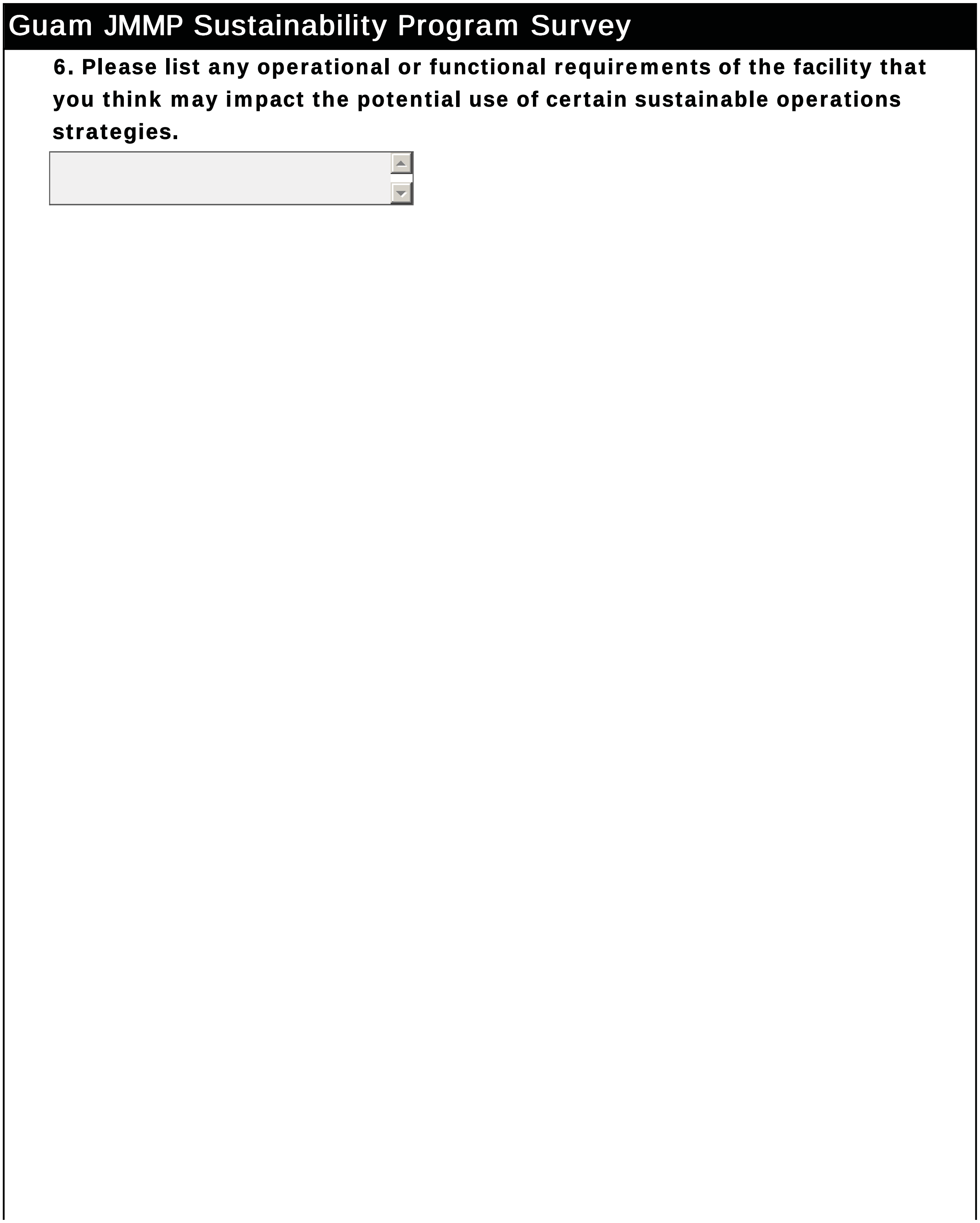
○ No

○ Potentially, but we need more information to decide

○ Yes, it is something that we are committed to doing

5. Please list any other aspect of the building operation that you see as offering sustainable opportunities

Survey Questions - Continued



Guam JMMP Sustainability Program Survey

6. Please list any operational or functional requirements of the facility that you think may impact the potential use of certain sustainable operations strategies.

Survey Responses

Guam JMMP Sustainability Program Survey

1. Describe the installations's primary purpose, excluding any sensitive details.		
		Response Count
		7
	answered question	**7**
	skipped question	**0**

2. Are there any overarching goals for the project relative to project needs, future expansion, flexibility etc. If so, please expand.		
		Response Count
		6
	answered question	**6**
	skipped question	**1**

Survey Responses - Continued

3. Which of the following best describes the GUAM JMMP's sustainable goals from an initial Capital Cost perspective?

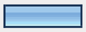
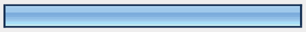
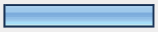
	Response Percent	Response Count
Lowest Capital Cost is the primary driver	0.0%	0
Achieve sustainable design enhancement within a strict Internal Rate of Return (IRR) framework	28.6%	2
Achieve current Federal Mandate best practices for sustainability at the least initial capital cost	**57.1%**	**4**
Look to exceed Federal Mandate energy and water best practices	0.0%	0
Fully optimize the sustainability potential	14.3%	1
	answered question	**7**
	skipped question	**0**

4. Which of the following best describes the GUAM JMMP's sustainable goals from an Operational Cost perspective?

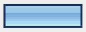
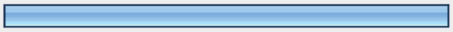
	Response Percent	Response Count
Energy rates are such that ongoing energy costs are not a primary driver	0.0%	0
Meet current industry best practices for energy costs	**57.1%**	**4**
Exceed current industry best practices for energy costs	14.3%	1
Fully optimize the sustainable potential and minimize the ongoing energy costs	28.6%	2
	answered question	**7**
	skipped question	**0**

Survey Responses - Continued

5. Which of the following best describe the project's overall sustainability goals?

		Response Percent	Response Count
Embrace sustainability sufficiently to achieve the minimum required for Federal Mandates		14.3%	1
Achieve maximum sustainability within limited / set capital budget and IRR criteria		**57.1%**	**4**
Fully embrace sustainability and maximize the sustainability potential		28.6%	2
		answered question	**7**
		skipped question	**0**

6. While the GUAM JMMP has a minimum requirement of achieving LEED Silver Certification, is there a higher level of LEED certification that is a goal of the team?

		Response Percent	Response Count
No, all buildings must achieve LEED Silver certification and no higher		14.3%	1
Yes, each building should achieve the highest level of LEED certification, with a minimum of Silver, that can be achieved within the cost budget		**85.7%**	**6**
Yes, it is a goal of the project for certain buildings to achieve a higher level of LEED certification than the minimum requirment. Please specify buildings in box below.		0.0%	0
		answered question	**7**
		skipped question	**0**

Survey Responses - Continued

7. What is the level of priority that you would give to the following in relation to any future carbon management program that may be implemented?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority	Response Count
Carbon emissions from Building Energy Use	**28.6% (2)**	14.3% (1)	14.3% (1)	14.3% (1)	**28.6% (2)**	7
Carbon emissions from travel	28.6% (2)	0.0% (0)	**42.9% (3)**	28.6% (2)	0.0% (0)	7
					answered question	**7**
					skipped question	**0**

8. What is the level of priority that you would give to the following in relation to material selection as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority	Response Count
Use of recycled materials	0.0% (0)	**28.6% (2)**	**28.6% (2)**	**28.6% (2)**	14.3% (1)	7
Use of regional materials	14.3% (1)	28.6% (2)	0.0% (0)	0.0% (0)	**57.1% (4)**	7
					answered question	**7**
					skipped question	**0**

9. What is the level of priority that you would give to the following in relation to construction labor as part of the larger GUAM JMMP sustainabilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority	Response Count
Use of local contractors	0.0% (0)	**33.3% (2)**	16.7% (1)	**33.3% (2)**	16.7% (1)	6
					answered question	**6**
					skipped question	**1**

Survey Responses - Continued

10. What is the level of priority that you would give to the following in relation to construction waste management as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority	Response Count
Quantity of waste generated onsite	0.0% (0)	0.0% (0)	0.0% (0)	42.9% (3)	**57.1% (4)**	7
Types of waste generated onsite	0.0% (0)	0.0% (0)	**33.3% (2)**	**33.3% (2)**	**33.3% (2)**	6
Quantity of waste recycled	14.3% (1)	0.0% (0)	14.3% (1)	14.3% (1)	**57.1% (4)**	7
Careful disposal of the construction waste	0.0% (0)	0.0% (0)	0.0% (0)	**57.1% (4)**	42.9% (3)	7
					answered question	**7**
					skipped question	**0**

11. What is the level of priority that you would give to the following in relation to addressing the needs of the occupants as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority	Response Count
Staff awareness of the owner's commitment to sustainable development	0.0% (0)	0.0% (0)	28.6% (2)	**42.9% (3)**	28.6% (2)	7
Occupant health and well-being	0.0% (0)	0.0% (0)	14.3% (1)	28.6% (2)	**57.1% (4)**	7
Quality of staff working environment	0.0% (0)	0.0% (0)	28.6% (2)	**42.9% (3)**	28.6% (2)	7
					answered question	**7**
					skipped question	**0**

Survey Responses - Continued

12. What is the level of priority that you would give to the following in relation to providing natural light and views?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	High Priority	Response Count
Natural Light	0.0% (0)	14.3% (1)	14.3% (1)	28.6% (2)	**42.9% (3)**	7
Views	14.3% (1)	**42.9% (3)**	28.6% (2)	14.3% (1)	0.0% (0)	7
	answered question					**7**
	skipped question					**0**

13. What is the level of priority that you would give to the following in relation to alternative transportation as part of the larger GUAM JMMP sustainablilty program?

	Low Priority	Low-Med Priority	Medium Priority	Med-Hi Priority	Hi Priority	Response Count
Maximizing Public Transportation Access	0.0% (0)	**42.9% (3)**	14.3% (1)	28.6% (2)	14.3% (1)	7
Providing Bicycle Storage & Changing Rooms	0.0% (0)	**42.9% (3)**	14.3% (1)	28.6% (2)	14.3% (1)	7
Utilizing Low-Emitting & Fuel-Efficient Vehicles	0.0% (0)	28.6% (2)	0.0% (0)	28.6% (2)	**42.9% (3)**	7
Minimizing excessive Parking Capacity	14.3% (1)	**42.9% (3)**	0.0% (0)	0.0% (0)	**42.9% (3)**	7
	answered question					**7**
	skipped question					**0**

Survey Responses - Continued

14. Which of the following best describes the GUAM JMMP's approach to the balance between building form / aesthetic, function and sustainable performance?

	Response Percent	Response Count
The project is functionally driven and aesthetics are secondary to function and energy performance	14.3%	1
The project shall create a balance between aesthetics and energy performance while ensuring functionality of the building is achieved.	**57.1%**	**4**
The building is to be an exemplar GREEN building within the DoD, with sustainable performance being the core project driver	28.6%	2
	answered question	**7**
	skipped question	**0**

15. Which of the following best describes the owner's attitude to innovative technologies and solutions?

	Response Percent	Response Count
Project must utilize tried and tested technologies and solutions at all times	0.0%	0
Project can utilize newer innovative technologies and strategies provided that there are examples of successful installations in a similar environment	**71.4%**	**5**
Owner is willing to use innovative / novel solutions to problems	14.3%	1
don't know	14.3%	1
	answered question	**7**
	skipped question	**0**

Survey Responses - Continued

16. Which of the following best describes the owner's attitude toward providing open space?

		Response Percent	Response Count
Providing open space is not necessary		0.0%	0
The project should meet the minimum DoD planning guidelines for new installations		**57.1%**	**4**
Open space should be maximized		14.3%	1
Open space should be maximized, protected and restored		28.6%	2
	answered question		**7**
	skipped question		**0**

17. Are there any other core drivers that are not covered by the questions above?

		Response Count
		2
	answered question	**2**
	skipped question	**5**

18. What is the minimum energy performance required by the proposed building design?

		Response Percent	Response Count
Code Minimum		14.3%	1
Minimum required for LEED Certification		0.0%	0
Minimum required for Federal EISA 2007 compliance		**85.7%**	**6**
	answered question		**7**
	skipped question		**0**

Survey Responses - Continued

19. What is the goal for energy reduction within each building within the installation?

		Response Percent	Response Count
20% reduction		14.3%	1
30% reduction		0.0%	0
40% reduction (current EISA:2007 criteria)		14.3%	1
50% reduction		0.0%	0
As much as can be achieved economically		**57.1%**	**4**
Carbon Neutral		0.0%	0
Net Energy Producer		14.3%	1
	answered question		**7**
	skipped question		**0**

20. What is the goal for on-site renewable energy generation, such as solar or wind power, within the project?

		Response Percent	Response Count
No specific target		14.3%	1
2.5% of building energy		0.0%	0
7.5% of building energy - EPAct:2005 requirement by 2013		0.0%	0
12.5% of building energy		0.0%	0
As much as is economically possible		**71.4%**	**5**
As much as is physically possible		14.3%	1
	answered question		**7**
	skipped question		**0**

Survey Responses - Continued

21. What is the goal for water use reduction within the buildings?

		Response Percent	Response Count
10% Reduction		0.0%	0
20% Reduction		0.0%	0
26% Reduction - EO13432 requirement by 2020		**100.0%**	**6**
30% Reduction		0.0%	0
35% Reduction		0.0%	0
40% Reduction		0.0%	0
>50% Reduction		0.0%	0
	answered question		**6**
	skipped question		**1**

22. The Guam environment offers significant opportunity for rainwater capture and reuse. What is the goal for the use of rainwater harvesting within the Guam JMMP installation?

		Response Percent	Response Count
None		0.0%	0
Depends upon the building type		**85.7%**	**6**
Offset 25% of potable water use for sanitary purposes		0.0%	0
Offset 50% of potable water use for sanitary purposes		0.0%	0
Offset 75% of potable water use for sanitary purposes		0.0%	0
Offset 100% of potable water use for sanitary purposes		14.3%	1
	answered question		**7**
	skipped question		**0**

Survey Responses - Continued

23. Which of the following do you envision to best describe the facility's commitment to onsite recycling once occupied and operational?			
		Response Percent	**Response Count**
No recycling facilities will be available to the user		0.0%	0
The project will have a central recycle store and distributed bins will be provided but will rely on a local waste management contractor to sort		**50.0%**	**3**
An onsite recycling store and distributed bins will be provided within the building and onsite sorting will be undertaken as part of an integrated recycling strategy		**50.0%**	**3**
	answered question		**6**
	skipped question		**1**

24. Do you envision a green cleaning program being implemented at the installation?			
		Response Percent	**Response Count**
No		14.3%	1
Potentially, but we need more information to decide		**85.7%**	**6**
Yes, it is something that we are committed to doing		0.0%	0
	answered question		**7**
	skipped question		**0**

Survey Responses - Continued

25. Do you envision an ongoing measurement and verification program being implemented at the facility to ensure continued optimized performance?

		Response Percent	**Response Count**
No		28.6%	2
Potentially, but we need more information to decide		**42.9%**	**3**
Yes, it is something that we are committed to doing		28.6%	2
	answered question		**7**
	skipped question		**0**

26. Do you envision a periodic re-commissioning program being implemented at the facility to ensure continued optimized performance?

		Response Percent	**Response Count**
No		28.6%	2
Potentially, but we need more information to decide		**57.1%**	**4**
Yes, it is something that we are committed to doing		14.3%	1
	answered question		**7**
	skipped question		**0**

27. Please list any other aspect of the building operation that you see as offering sustainable opportunities

		Response Count
		3
	answered question	**3**
	skipped question	**4**

Survey Responses - Continued

23. Which of the following do you envision to best describe the facility's commitment to onsite recycling once occupied and operational?			
		Response Percent	**Response Count**
No recycling facilities will be available to the user		0.0%	0
The project will have a central recycle store and distributed bins will be provided but will rely on a local waste management contractor to sort		**50.0%**	**3**
An onsite recycling store and distributed bins will be provided within the building and onsite sorting will be undertaken as part of an integrated recycling strategy		**50.0%**	**3**
	answered question		**6**
	skipped question		**1**

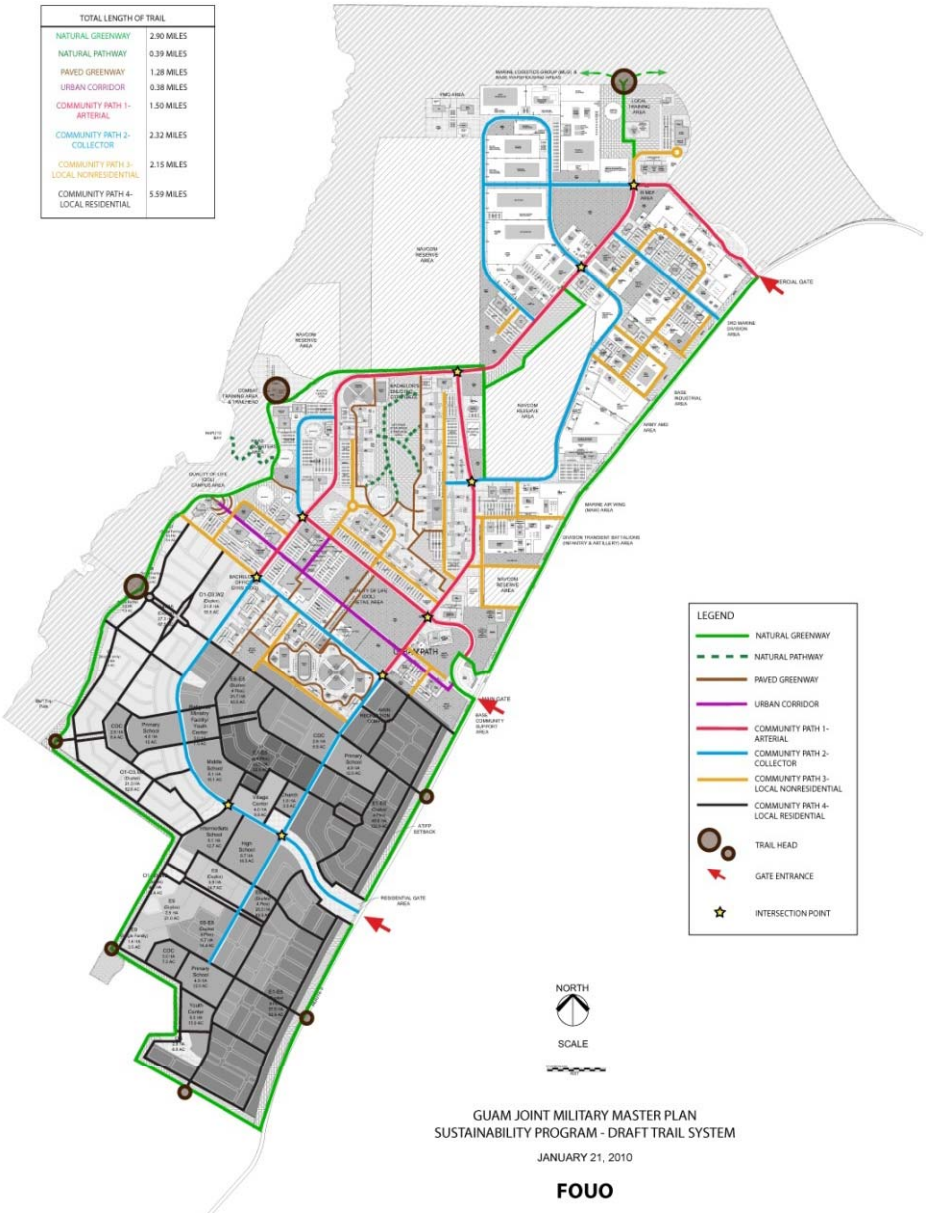
24. Do you envision a green cleaning program being implemented at the installation?			
		Response Percent	**Response Count**
No		14.3%	1
Potentially, but we need more information to decide		**85.7%**	**6**
Yes, it is something that we are committed to doing		0.0%	0
	answered question		**7**
	skipped question		**0**

Attachment E -

GJMMP Conceptual Master Trail Plan and Sections

GJMMP DRAFT Trails Plan

DRAFT



TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
URBAN CORRIDOR	0.38 MILES
COMMUNITY PATH 1-ARTERIAL	1.50 MILES
COMMUNITY PATH 2-COLLECTOR	2.32 MILES
COMMUNITY PATH 3-LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4-LOCAL RESIDENTIAL	5.59 MILES

GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM

JANUARY 21, 2010

FOUO

GJMMP DRAFT Trails Plan

LEGEND

- NATURAL GREENWAY
- NATURAL PATHWAY
- PAVED GREENWAY
- URBAN CORRIDOR
- COMMUNITY PATH 1- ARTERIAL
- COMMUNITY PATH 2- COLLECTOR
- COMMUNITY PATH 3- LOCAL NONRESIDENTIAL
- COMMUNITY PATH 4- LOCAL RESIDENTIAL
- ● TRAIL HEAD
- GATE ENTRANCE
- ☆ INTERSECTION POINT

TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
URBAN CORRIDOR	0.38 MILES
COMMUNITY PATH 1- ARTERIAL	1.50 MILES
COMMUNITY PATH 2- COLLECTOR	2.32 MILES
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

GJMMP DRAFT Trails Plan

LEGEND

- NATURAL GREENWAY
- NATURAL PATHWAY
- PAVED GREENWAY
- URBAN CORRIDOR
- COMMUNITY PATH 1- ARTERIAL
- COMMUNITY PATH 2- COLLECTOR
- COMMUNITY PATH 3- LOCAL NONRESIDENTIAL
- COMMUNITY PATH 4- LOCAL RESIDENTIAL
- TRAIL HEAD
- GATE ENTRANCE
- ☆ INTERSECTION POINT

TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
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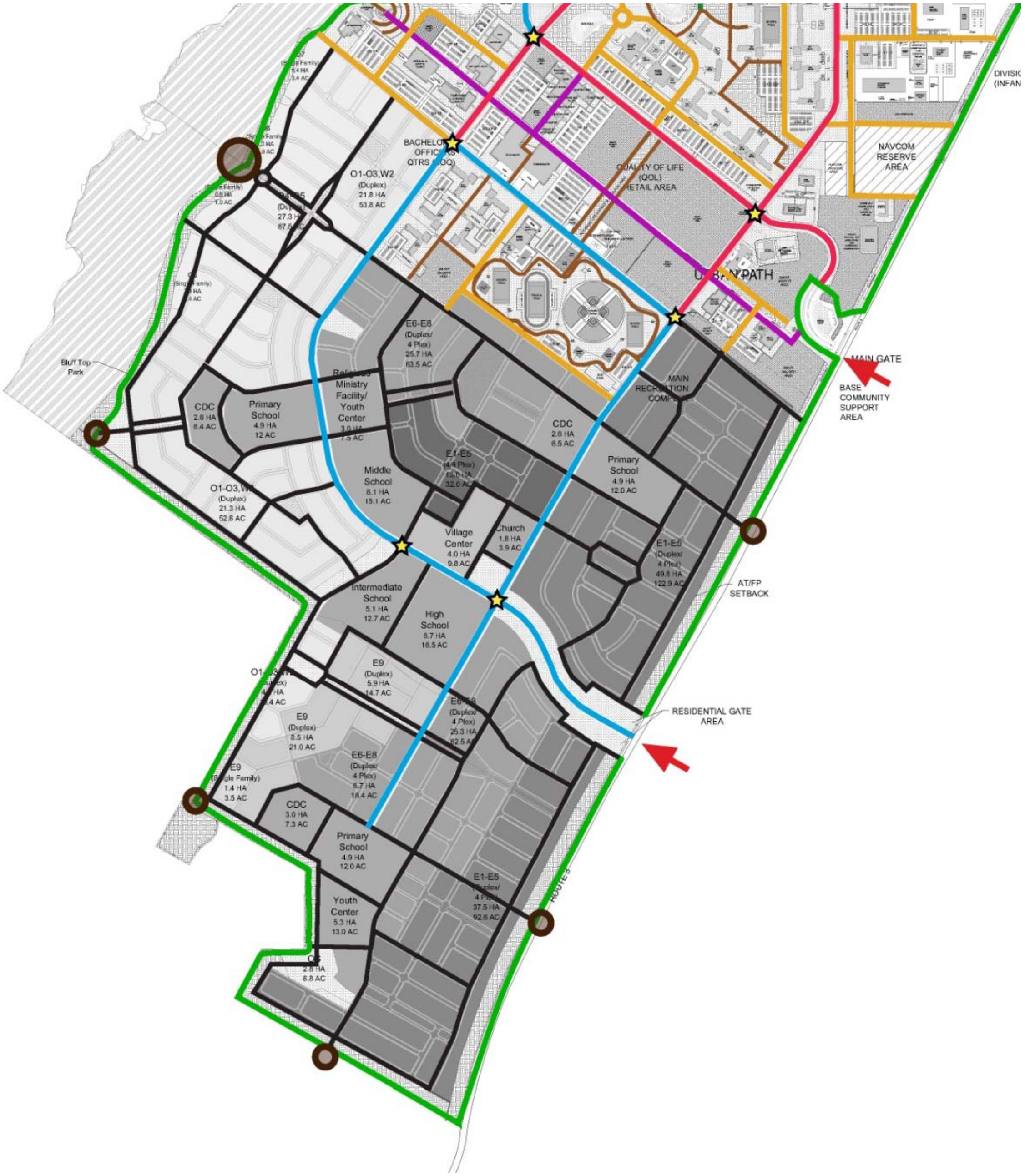
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

GJMMP DRAFT Trails Plan



LEGEND

- NATURAL GREENWAY
- NATURAL PATHWAY
- PAVED GREENWAY
- URBAN CORRIDOR
- COMMUNITY PATH 1- ARTERIAL
- COMMUNITY PATH 2- COLLECTOR
- COMMUNITY PATH 3- LOCAL NONRESIDENTIAL
- COMMUNITY PATH 4- LOCAL RESIDENTIAL
- TRAIL HEAD
- GATE ENTRANCE
- ☆ INTERSECTION POINT

TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
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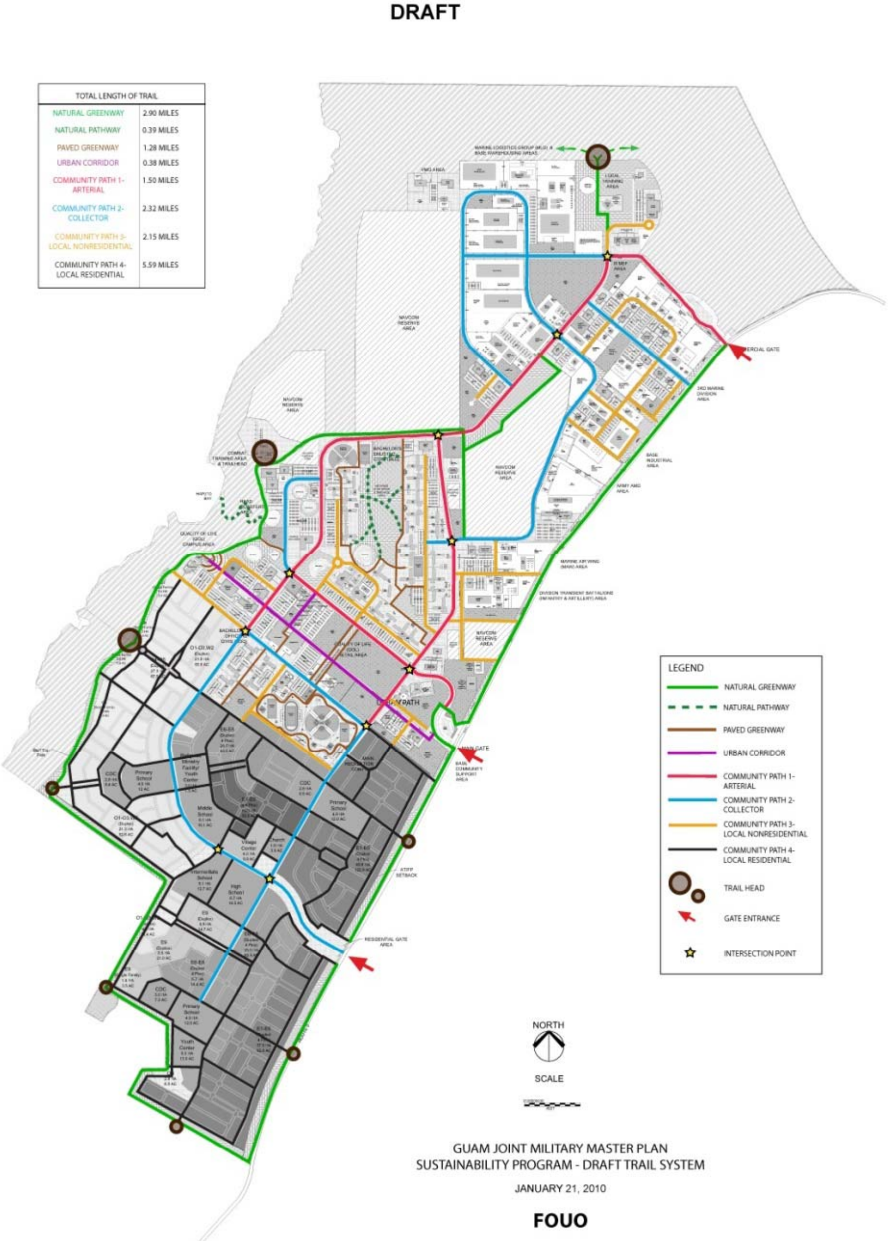
COMMUNITY PATH 1- ARTERIAL	1.50 MILES
COMMUNITY PATH 2- COLLECTOR	2.32 MILES
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

GJMMP DRAFT Trails Plan- CROSS SECTIONS



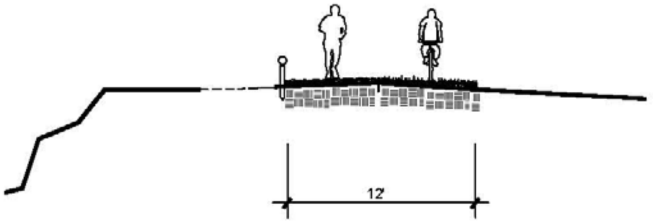
TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
URBAN CORRIDOR	0.38 MILES
COMMUNITY PATH 1- ARTERIAL	1.50 MILES
COMMUNITY PATH 2- COLLECTOR	2.32 MILES
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM

JANUARY 21, 2010

🟩 TYPE 1- NATURAL GREENWAY (NOT TO SCALE)

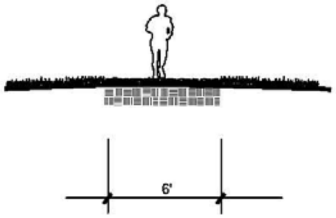
i.e. UNPAVED RECREATIONAL PATH (12 FT WIDE)



MULTI-PURPOSE TRAIL
(FOR PEDESTRIAN & BICYCLE ONLY)

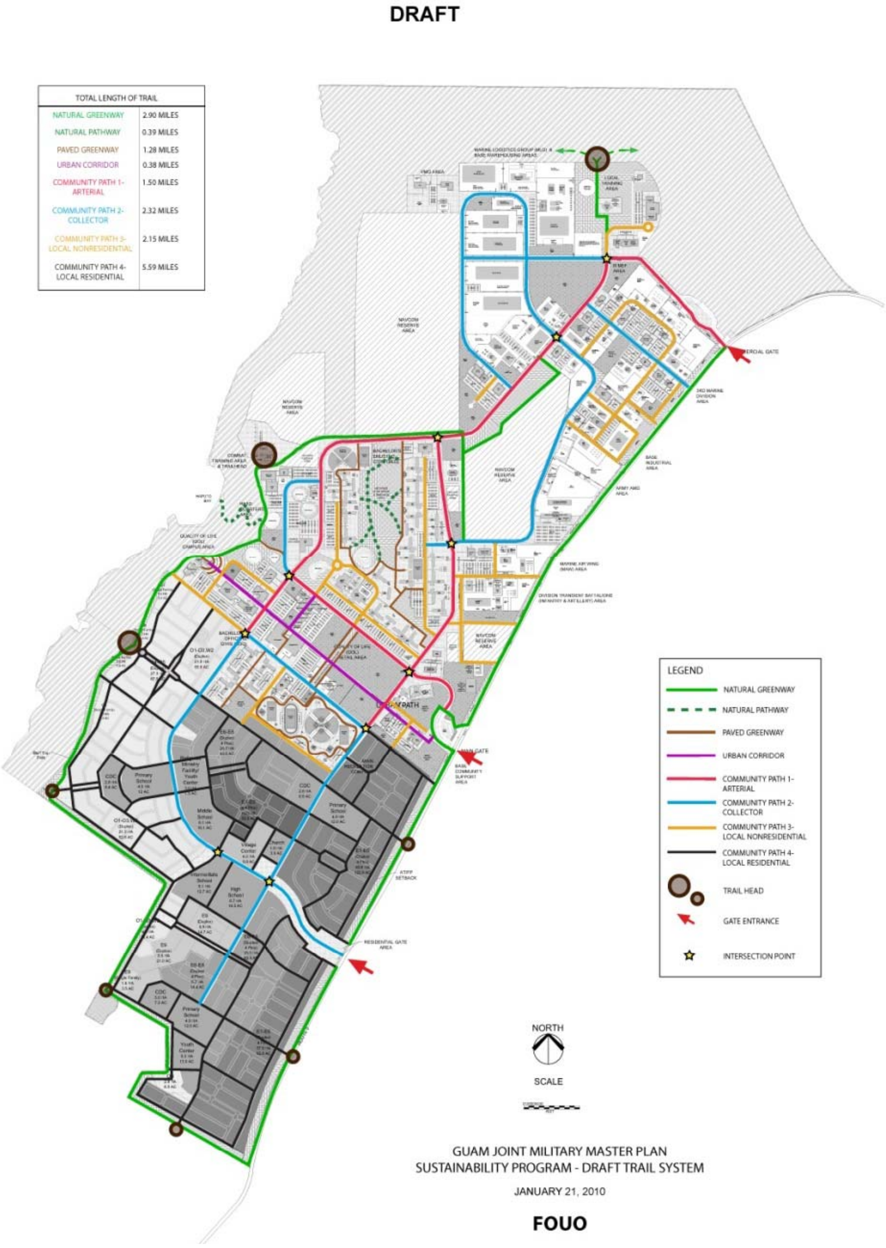
🟩 🟩 🟩 🟩 TYPE 2- NATURAL PATHWAY (NOT TO SCALE)

i.e. UNPAVED RECREATIONAL PATH (6 FT WIDE)



MULTI-PURPOSE TRAIL
(FOR PEDESTRIAN & BICYCLE ONLY)

GJMMP DRAFT Trails Plan- CROSS SECTIONS



TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
URBAN CORRIDOR	0.38 MILES
COMMUNITY PATH 1- ARTERIAL	1.50 MILES
COMMUNITY PATH 2- COLLECTOR	2.32 MILES
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

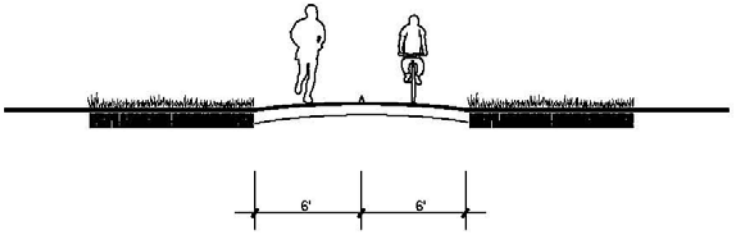
GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM

JANUARY 21, 2010

FOUO

TYPE 3- PAVED GREENWAY (NOT TO SCALE)

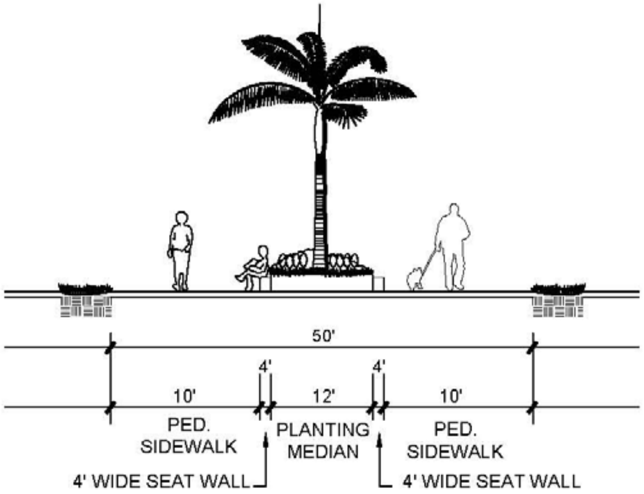
i.e. PAVED RECREATIONAL PATH



MULTI-PURPOSE TRAIL
(FOR PEDESTRIAN & BICYCLE ONLY)

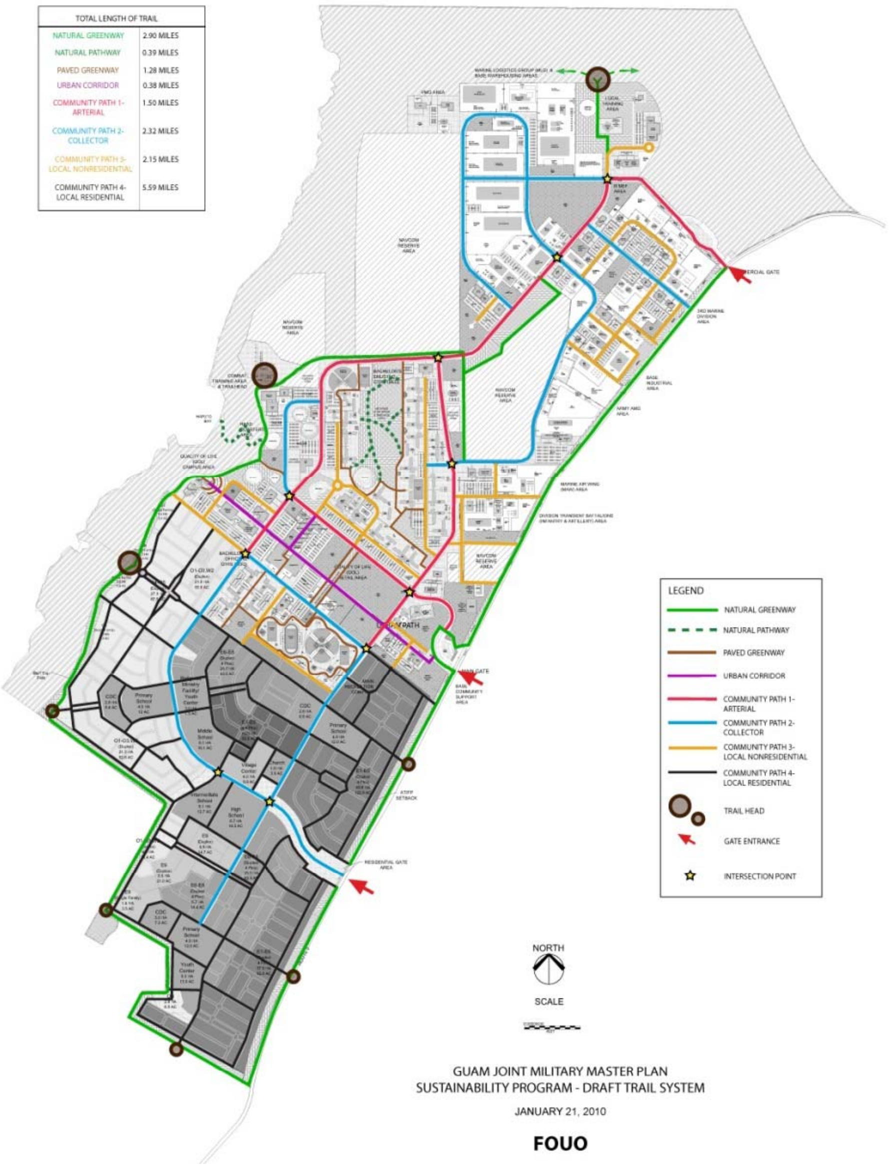
TYPE 4- URBAN CORRIDOR (NOT TO SCALE)

i.e. PEDESTRIAN MALL



GJMMP DRAFT Trails Plan- CROSS SECTIONS

DRAFT



TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
URBAN CORRIDOR	0.38 MILES
COMMUNITY PATH 1- ARTERIAL	1.50 MILES
COMMUNITY PATH 2- COLLECTOR	2.32 MILES
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

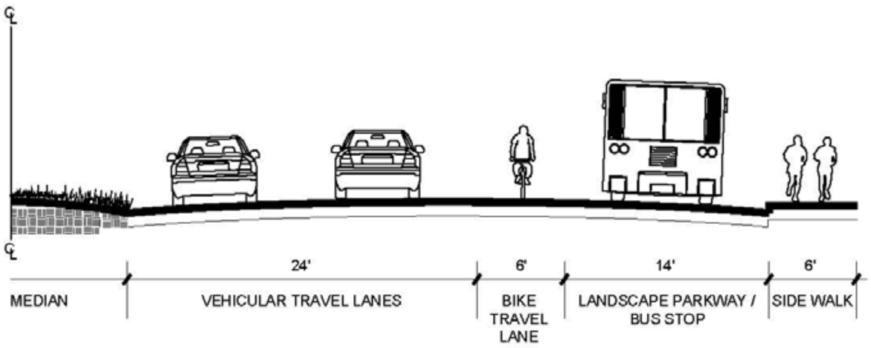
GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM
JANUARY 21, 2010

FOUO

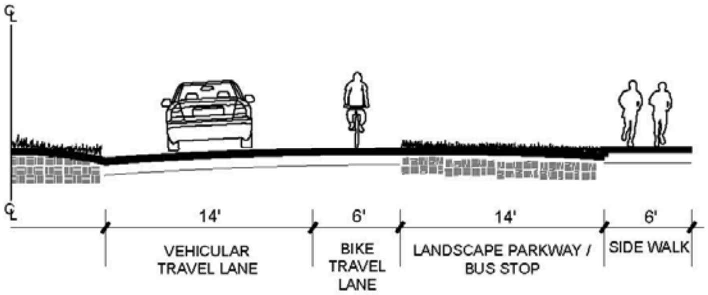
TYPE 5- COMMUNITY PATH (NOT TO SCALE)

i.e. VECULAR TRAVEL LANE + BIKE LANE + PARKWAY + WIDEWALK

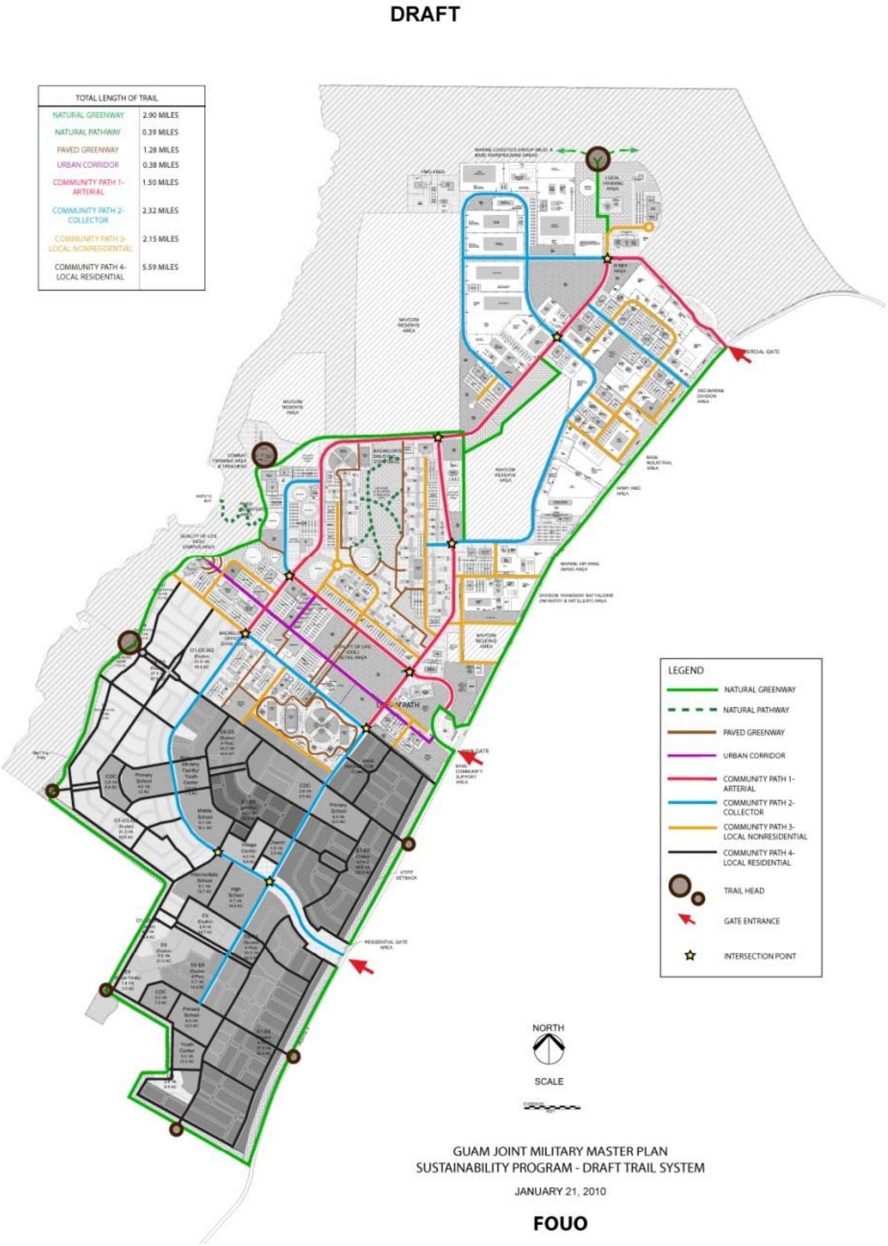
🟥 A) 5.1- ARTERIAL



🟦 B) 5.2- COLLECTOR



GJMMP DRAFT Trails Plan- CROSS SECTIONS



TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
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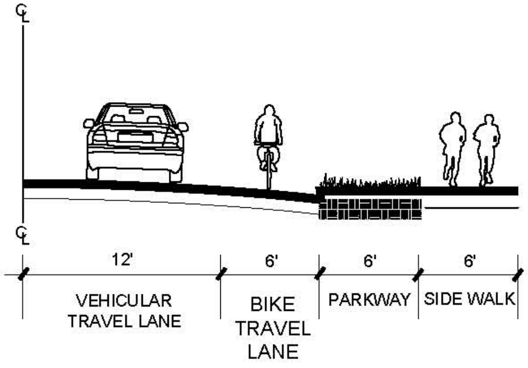
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

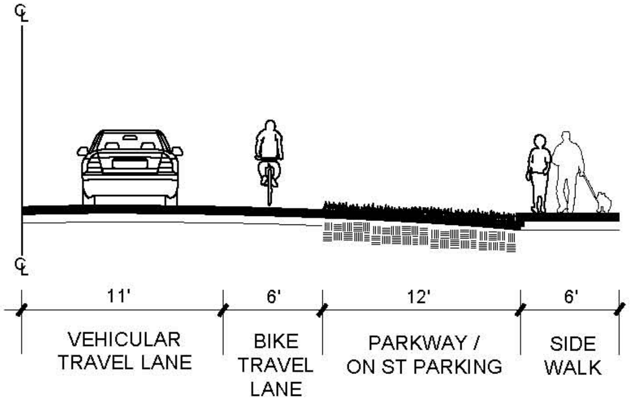
GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM

JANUARY 21, 2010

C) 5.3- LOCAL NONRESIDENTIAL



D) 5.4- LOCAL RESIDENTIAL

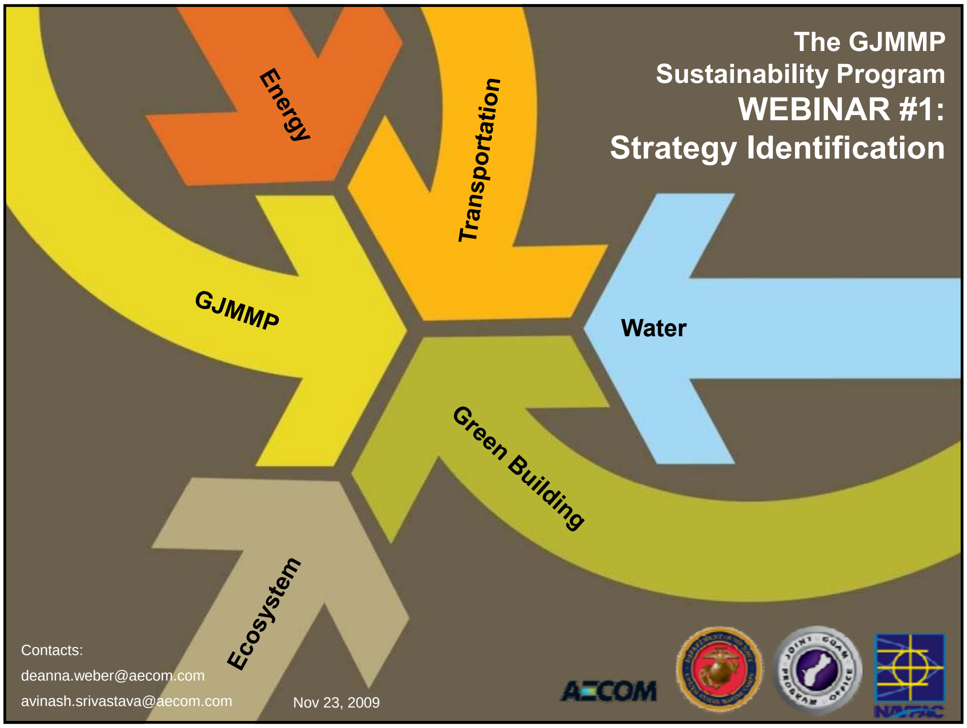


Attachment F -

GJMMP Sustainability Program Presentation

List of Webinars/Presentations:

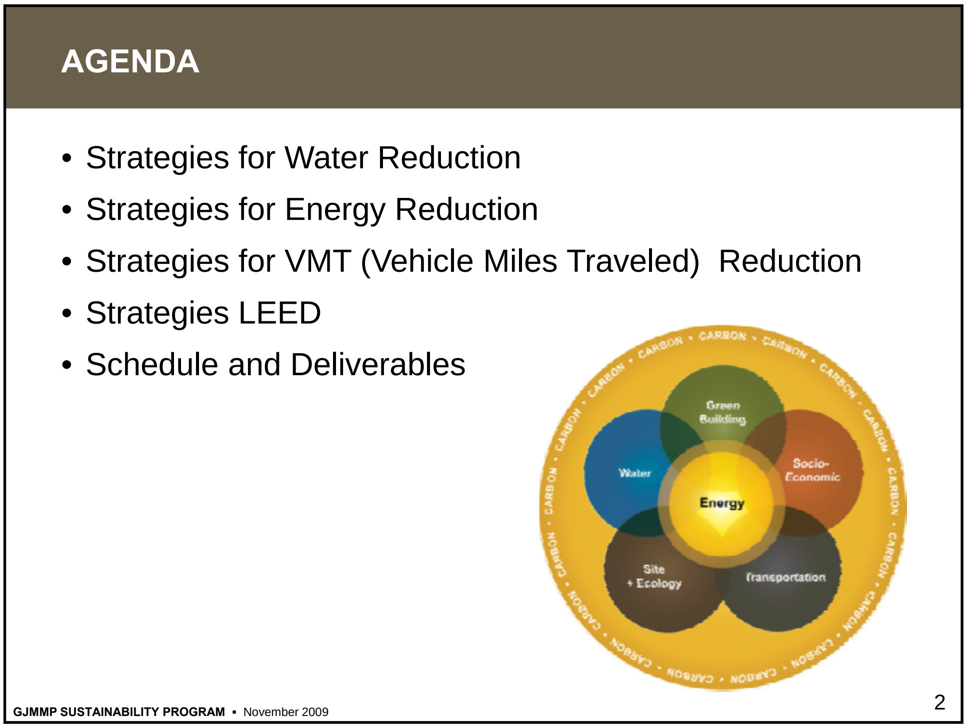
- Webinar #1, Nov. 29, 2009 Strategy Identification
- Webinar #2, Dec. 17, 2009 Energy and LEED Approach
- Webinar #3, Jan. 21, 2010 Transportation, Water, Ecosystem & LEED
- Webinar #4, Feb. 17, 2010 Transportation, LEED & Ecosystem Services
- Webinar #5, Feb. 18, 2010 Water & Energy
- Webinar #6, March 22, 2010 Water and Transportation
- Webinar #7, March 23, 2010 Energy, LEED & Ecosystem Services
- Webinar #8, May 5, 2010 GJMMP Sustainability Program Decision Briefing



The GJMMP Sustainability Program WEBINAR #1: Strategy Identification

Contacts:
deanna.weber@aecom.com
avinash.srivastava@aecom.com

Nov 23, 2009

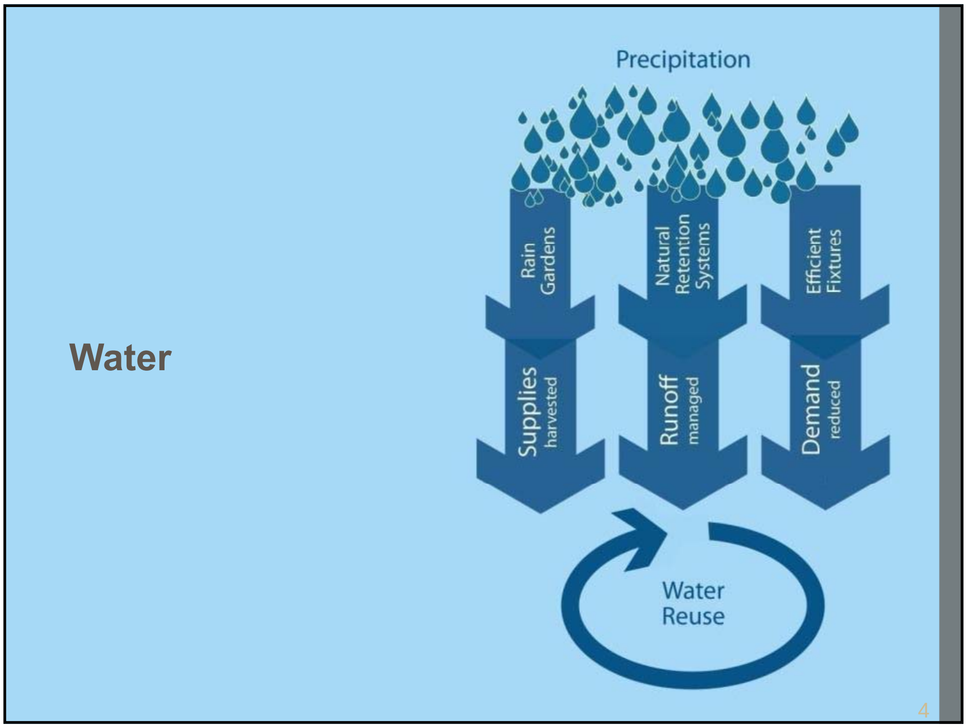


AGENDA

- Strategies for Water Reduction
- Strategies for Energy Reduction
- Strategies for VMT (Vehicle Miles Traveled) Reduction
- Strategies LEED
- Schedule and Deliverables

Water Balance Planning

establishes an equilibrium between natural water supplies and human demand.



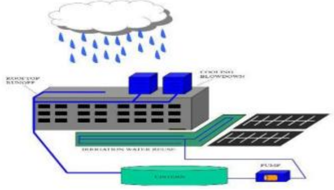
Water

Water Overall Goals

- **Conservation** – Reduce demand
- **Collection and reuse** - Harvesting
- **Protection of the aquifer** – Stormwater quality
- **Protection of coastal resources** – Stormwater quality
- **Meet and exceed Federal mandates** – LEED and Executive Order
- **Simple systems** – Ability to construct and monitor

Water Reduction Strategies

- **Low flow fixtures in all buildings** – Water Sense (EPS) recommendations resulting in about 20-30% reduction in interior water use
- **Rooftop rainfall harvesting as water supply for toilet flushing (residential) and incidental irrigation** – reduction in additional 25% of potable water, and reduction of 25% in wastewater requiring treatment
- **Use condensate as supplemental water supply** for cisterns for toilet flushing (commercial/industrial)

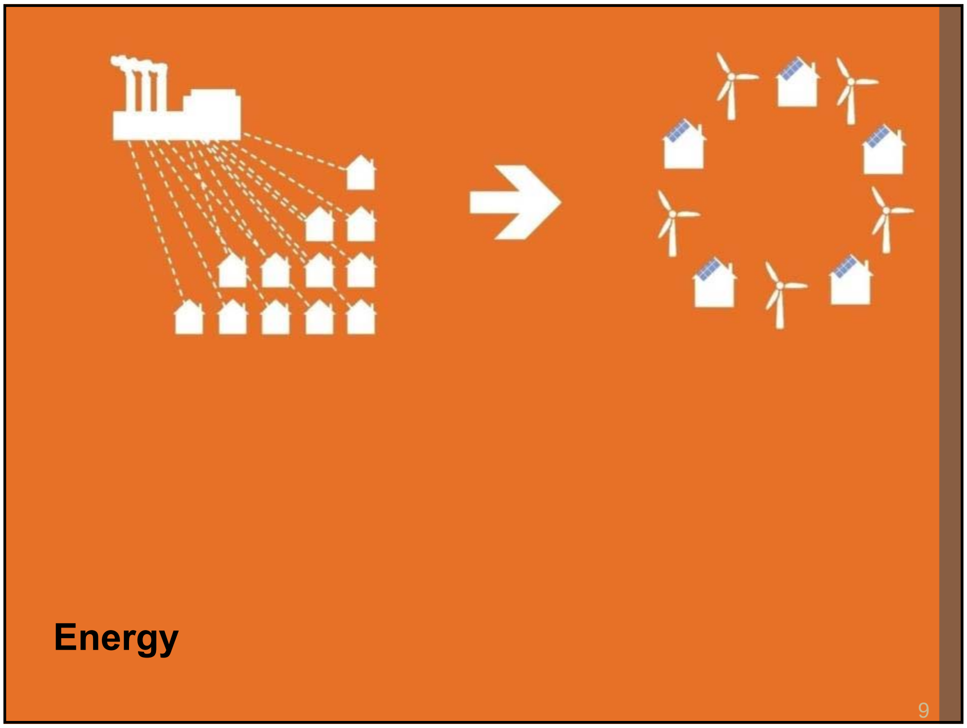


Water Reduction Strategies Cont.

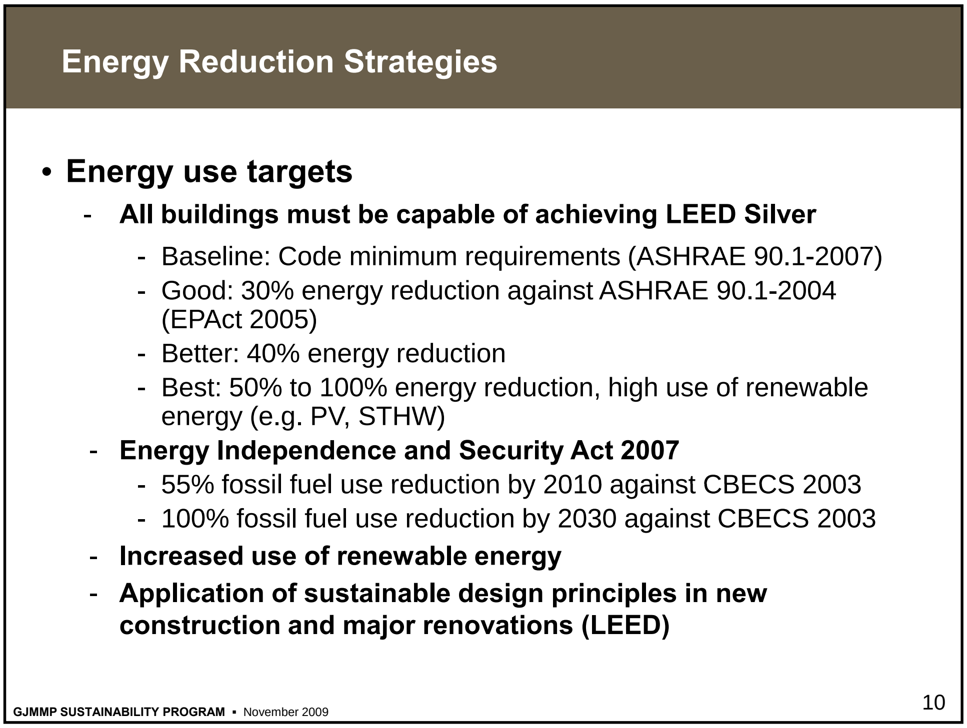
- **Stormwater management using natural means (Low Impact Development - LID)** to minimize sediment runoff into the ocean – treat up to 2-year, 24 hour storm
- **Consider graywater use in cisterns as additional water supply**

Energy Systems

will strive for efficiency of energy delivery in the transition to renewable resources.



Energy



Energy Reduction Strategies

- **Energy use targets**
  - **All buildings must be capable of achieving LEED Silver**
    - Baseline: Code minimum requirements (ASHRAE 90.1-2007)
    - Good: 30% energy reduction against ASHRAE 90.1-2004 (EPAct 2005)
    - Better: 40% energy reduction
    - Best: 50% to 100% energy reduction, high use of renewable energy (e.g. PV, STHW)
  - **Energy Independence and Security Act 2007**
    - 55% fossil fuel use reduction by 2010 against CBECS 2003
    - 100% fossil fuel use reduction by 2030 against CBECS 2003
  - **Increased use of renewable energy**
  - **Application of sustainable design principles in new construction and major renovations (LEED)**

Energy Reduction Strategies

- **First consider measures to make the building work harder:**
  - **Utilize increased levels of insulation of ASHRAE 90.2007 baseline case to reduce heat transfer through the building envelope (depending on building type)**
  - **Include high performance fenestration systems to reduce solar gain and minimize cooling demand**
  - **Assess the effectiveness of the use of solar shading with ASHRAE standard and high performance fenestration systems**

Energy Reduction Strategies

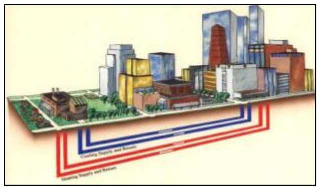
- **Secondly install efficient plant and controls including:**
  - **Use of high efficiency packaged units or chillers and cooling towers**
  - **Use of high efficiency lighting (including LED lighting) to reduce lighting energy and reduce the cooling demand**
  - **Utilize natural daylighting with daylight control**
  - **Include Energy Star appliances in homes**
  - **Low flow water fixtures reduce water heating demand**

Energy Reduction Strategies

- **Thirdly consider the most cost effective renewable systems that are suitable for the site:**
  - **Guam enjoys an excellent, year round solar resource**
  - **Amorphous PV (roof integrated) and Polycrystalline PV panels (roof mounted) have both been successfully used at the Navy base in Guam**
  - **Solar thermal hot water systems can reduce hot water demand by over 50%**
  - **Small wind generation may be viable, where correctly sighted**

Energy Reduction Strategies

- **Fourthly, assess district wide energy systems**
  - **Use of high efficiency, central chiller plants with distributed chiller water generation to buildings using pre-insulated pipe work**
  - **There is potential to make use of combined cooling, heat and power plant to reduce the energy use associated with cooling**
    - Central plants reduce maintenance requirements
    - Helps to future proof the cooling system for use with new technologies
    - Increased system efficiency
    - Ties into development density

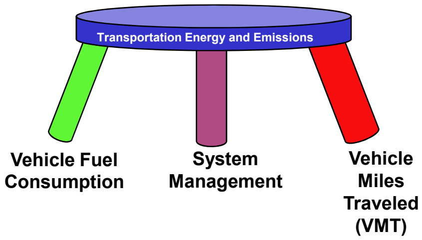


Transportation Systems

will quantify cost versus benefit of VMT (Vehicle Mile Traveled) reduction

Trip and VMT (Vehicle Miles Traveled) Reduction Strategies

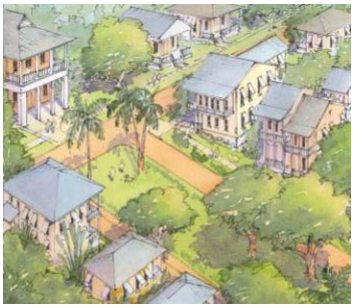
- **Three focus areas for trip and VMT reduction:**
  - **Land use and form *(Density, Diversity, Design, Distance to Transit, Destinations, etc.)***
  - **Internal measures and programs**
  - **External linkages**



- **Ultimately will develop “Good” and “Better” packages for evaluation**
  - **Measures will be identified as basic and enhanced**

Trip and VMT Reduction Strategies Cont.

- Land Use and Form
  - **Compact/walkable neighborhoods with short blocks**
  - **Transit-ready planning**
  - **Mixed-use core in the family housing area with coffee shop, food, family housing welcome center, ATM or satellite bank, satellite post office and units above**
  - **Wider sidewalks for higher traffic areas**
  - **Integrated trail system**



Trip and VMT Reduction Strategies Cont.

- Base Measures and Programs
  - **Internal and external shuttle buses**
  - **Trail system (connect with open space & recreation)**
  - **Centralized and reduced parking supplies (land bank to meet UFC req's)**
  - **Pedestrian & on-street bike system**
  - **Transportation Demand Management coordinator**
  - **Neighborhood Electric Vehicle (NEV system)**
  - **Car share program**
  - **Bike share program**
  - **Incentivize reduced car ownership**

Trip and VMT Reduction Strategies Cont.

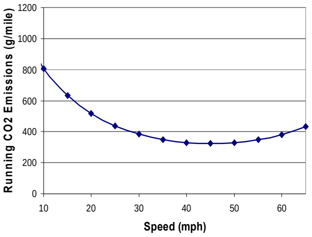
- **Off Base (External) Linkages**
  - **Coordination with Guam transit**
  - **Frequent and convenient shuttle service between bases/employment areas**
  - **Possibly restrict parking at North Ramp to encourage transit use**
  - **Consider bicycle path connectivity along Route 3**

Transportation Benchmarks Matrix

BASELINE	GOOD	BETTER	BEST
• UFC standard	• UFC standard aligned with latest federal mandates	• Basic TDM (Transportation Demand Management) program	• Enhanced TDM program
• No shuttle	• No shuttle	• Basic shuttle system	• Enhanced shuttle system
• Basic trail system	• Basic trail system	• Enhanced trail system • Basic bike/car share program • Transit-ready	• Robust trail system • Enhanced bike/car share program
±4.0 DU/acre	±5.0 DU/acre	±6.0 DU/acre	±7.0 DU/acre
• Motor pool: gasoline	• Motor pool: gasoline/natural gas	• Motor pool XX% electric or hybrid	• Motor pool: high % electric or hybrid
		• Basic NEV system	• Advanced NEV system
		• Education program	• Limit car ownership

Transportation Modeling

- **Review survey data if available**
- **Estimate reduction in:**
    - **Vehicle trips**
    - **Vehicle Miles of Travel (VMT)**
    - **Parking**
- **Estimate costs of measures**
- **Calculation reduction in GHGs from mobile sources**
- **Refine initial study findings**



Deliverables & Schedule

NEXT STEPS:

- **Establish Baseline or Business as Usual (BaU) Condition**
    - No shuttle, UFC parking criteria, basic bicycle and pedestrian facilities
- **Create Good and Better Transportation Programs**
    - Make recommendations to meet federal mandate and identify enhanced measures
- **Review Unit Costs w/ NAVFAC staff to Adjust for Guam**
    - Minimize maintenance and capital costs

Green Building

integrates systems at the building level and expands efficiency across the base

Green Building

HOMES

NEIGHBORHOOD DEVELOPMENT

NEW CONSTRUCTION

SCHOOLS, HEALTHCARE, RETAIL

LEED Overall Strategies

"LEED for Military Base"

Family Housing Area

- Mixed Use Town Center (potential)
- "Representative" Homes to be certified
- Major public buildings in Family Housing Area

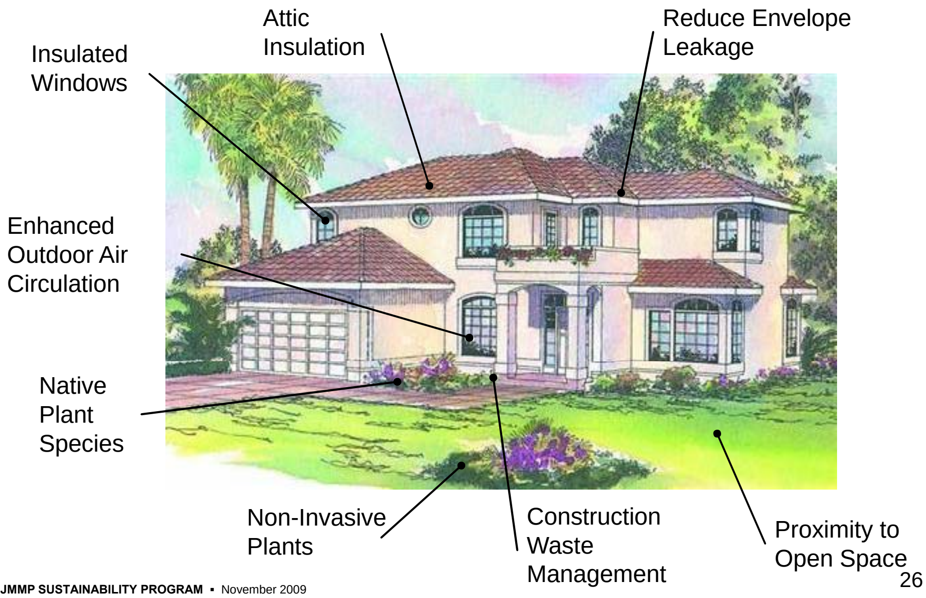
LEED for Schools
LEED for Retail
LEED for New Construction

Base Operational Area

- BEQ Housing Area (potential)
- LEED Silver Buildings with campus approach

LEED for New Construction
Multiple Buildings

LEED Home Strategies



Attic Insulation

Reduce Envelope Leakage

Insulated Windows

Enhanced Outdoor Air Circulation

Native Plant Species

Non-Invasive Plants

Construction Waste Management

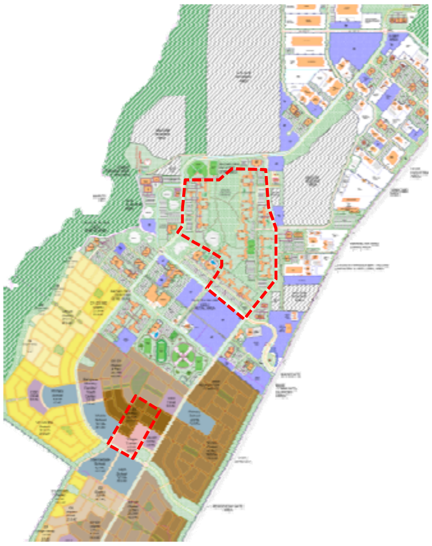
Proximity to Open Space

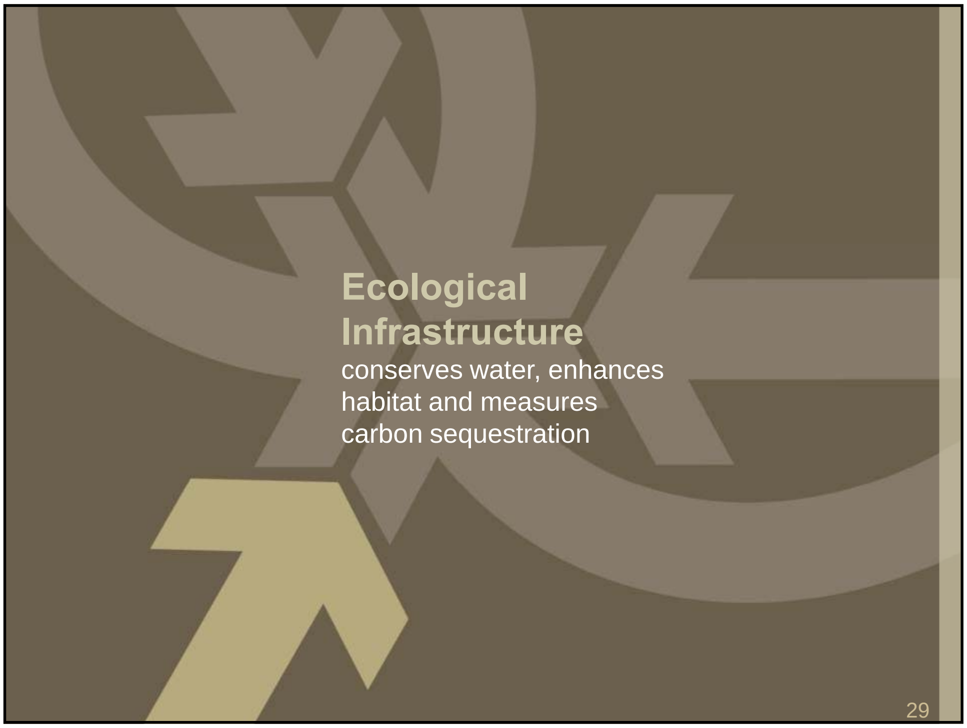
LEED Home Strategies

- Integrated Project Team
- Access to Open Space
- Reduce Overall Irrigation
- Reduce Heat Island Effect
- Pest Control Alternatives
- High Efficiency Fixtures
- Increased Air Infiltration
- Heating/Cooling Distribution Systems
- Efficient Hot Water Distribution
- Pipe Insulation
- Energy Efficient Lighting
- Indoor Contaminant Control
- Minimize Pollutants in Garage
- Education of Home Owners
- High Efficiency HVAC
- High Efficiency Appliances
- Water Efficient Clothes Washer

LEED ND (Neighborhood Development) Potential Strategies

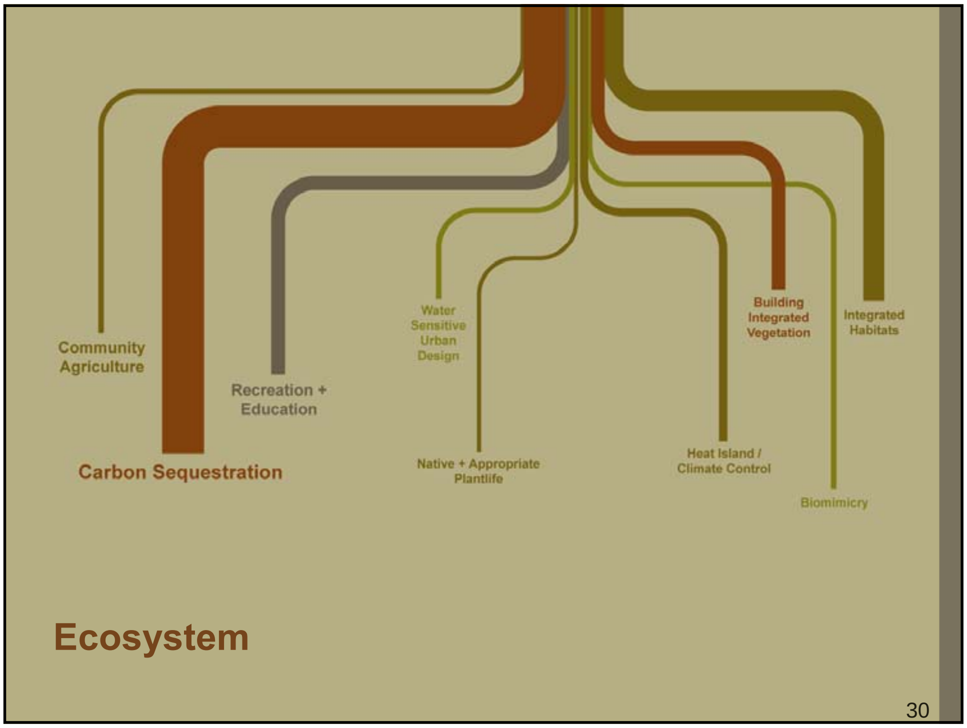
- Mixed use village in the family housing area
- Enhanced trail System connecting housing to "Quality of Life" services
- Base-wide shuttle system linking family housing area with base operation area
- Enhanced Green/Open Space Connectivity
- Onsite Tree Preservation





Ecological Infrastructure

conserves water, enhances habitat and measures carbon sequestration



Ecosystem

Community Agriculture

Carbon Sequestration

Recreation + Education

Water Sensitive Urban Design

Native + Appropriate Plantlife

Heat Island / Climate Control

Building Integrated Vegetation

Integrated Habitats

Biomimicry

Ecosystem Strategies Overview

- Local Food Production
- Carbon Sequestration
- Guam Native Landscape Design Guidelines
- Guam Habitat Friendly Design Strategy
- Education & Recreation

Ecosystem Services Strategy – Local Food Production

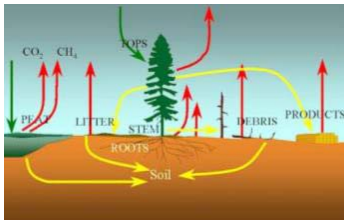
- Local food/fruit purchase opportunity with local farmers
- Farmers market at Town Center of the Family Housing area
- Native fruit garden on base

Ecosystem Services Strategy – Carbon Sequestration

- "**Carbon Sequestration** is the process by which atmospheric carbon dioxide is absorbed by trees [and vegetation] through photosynthesis and stored as carbon in biomass and soils."
  - -USDA Forest Service
- Factors
  - Tree type: Hardwood or Conifer
  - Growth rate, Tree age
  - Soil type
  - Regional climate
  - Topography
  - Sequestration rate

Ecosystem Services Strategy – Carbon Sequestration

- Modeling Tools
  - SSIM (Sustainable Systems Integration Method)
  - CUFR Tree Carbon Calculator
  - APPA



CUFR Tree Carbon Calculator

Developed by the Center for Urban Forest Research
Pacific Southwest Research Station
US Forest Service

In partnership with the California Department of
Forestry and Fire Protection

1 See user Help for details.

2 Worksheet 'Data Template' is an optional form that can be used to organize input data before it is input into Carbon Calculator

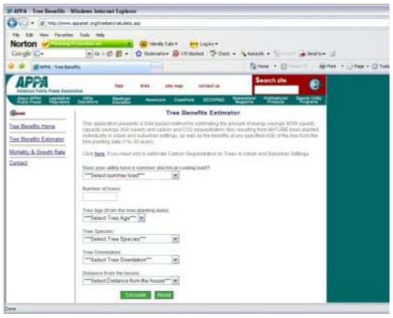
3 Worksheet 'CTCC' is where data are entered and results displayed, tree by tree. Only values in shaded cells can be changed in this worksheet
Enter 1 for Flag1 to compute values based on dbh input, enter 0 for age input
Enter 1 for Flag2 to compute values based on shade and climate effects, enter 0 for shade effects only
For 'DBH_or_age', enter 1 for Adjacent, 2 for Near, 3 for Far and 4 for > 60 ft from a conditioned building
For 'Air conditioned', enter 1 for central air conditioning/heat pump, 2 for evaporative cooler, 3 for window/wall unit, and 0 if not air conditioned
For 'Heated' enter 1 for natural gas heat, 2 for heat pump, 3 for electric resistance heat, 4 for fuel oil or other fossil fuel, and 0 for not heated
For 'Tree distance class' enter 1 for Adjacent (<20 ft), 2 for Near (20-40 ft), 3 for Far (40-60 ft), or 4 for > 60 ft

4 Worksheet Output Template is and optional form that can be used to save results for individual trees for later analysis.

5 Address questions not answered in the user Help or associated Frequently Asked Questions to psw_cufr@fs.fed.us

CTCC version 1 revision 1.6 notes
1 When loading workbooks, select the "enable macros" button if asked.
2 The popup box that appears when some input cells are selected may be dragged and dropped to another area of the workbook. Any change will be in effect is temporary, and will not be saved when the workbook is closed
3 Ignore any zeros that may appear at the bottom of the species drop down menu

NOTE: See Help Section for credits and disclaimers.



Tree Benefits Estimator

Does your utility have a summer electrical cooling load?
Select summer load

Number of trees:

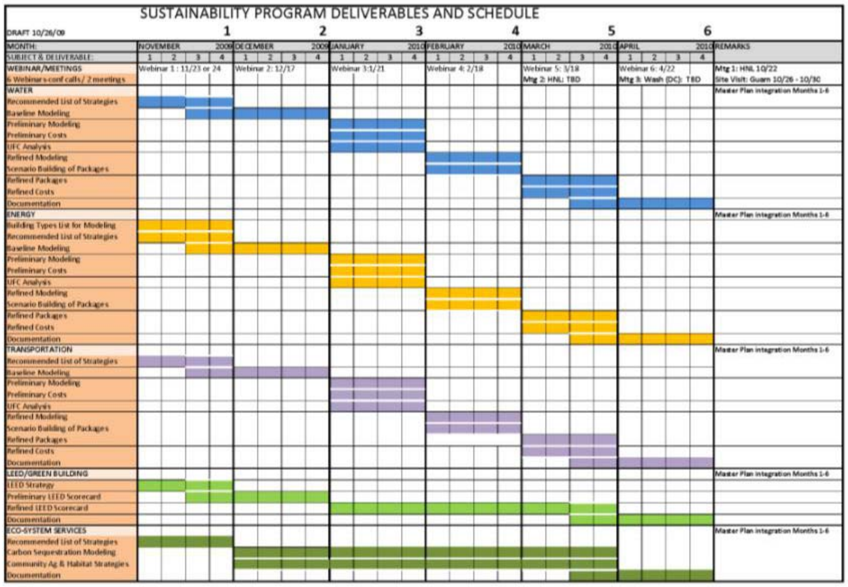
Tree Age (from the tree planting date):
Select Tree Age

Tree Species:
Select Tree Species

Tree Orientation:
Select Tree Orientation

Distance from the house:
Select Distance from the house

Deliverables & Schedule



SUSTAINABILITY PROGRAM DELIVERABLES AND SCHEDULE

DRAFT 10/26/09				1				2				3				4				5				6	
MONTH:	NOVEMBER 2009				DECEMBER 2009				JANUARY 2010				FEBRUARY 2010				MARCH 2010				APRIL 2010				REMARKS
SUBJECT & DELIVERABLE:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
WEBINAR/MEETINGS	Webinar 1 : 11/23 or 24				Webinar 2: 12/17				Webinar 3:1/21				Webinar 4: 2/18				Webinar 5: 3/18				Webinar 6: 4/22				Mtg 1: HNL 10/22
6 Webinars-conf calls / 2 meetings																	Mtg 2: HNL: TBD				Mtg 3: Wash (DC): TBD				Site Visit: Guam 10/26 - 10/30
WATER																									Master Plan integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
ENERGY																									Master Plan integration Months 1-6
Building Types List for Modeling	■	■	■	■																					
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
TRANSPORTATION																									Master Plan integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
LEED/GREEN BUILDING																									Master Plan integration Months 1-6
LEED Strategy	■	■	■	■																					
Preliminary LEED Scorecard			■	■	■	■	■	■																	
Refined LEED Scorecard									■	■	■	■	■	■	■	■	■	■	■	■					
Documentation																			■	■	■	■	■	■	
ECO-SYSTEM SERVICES																									Master Plan integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Carbon Sequestration Modeling					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Community Ag & Habitat Strategies					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Documentation																			■	■	■	■	■	■	

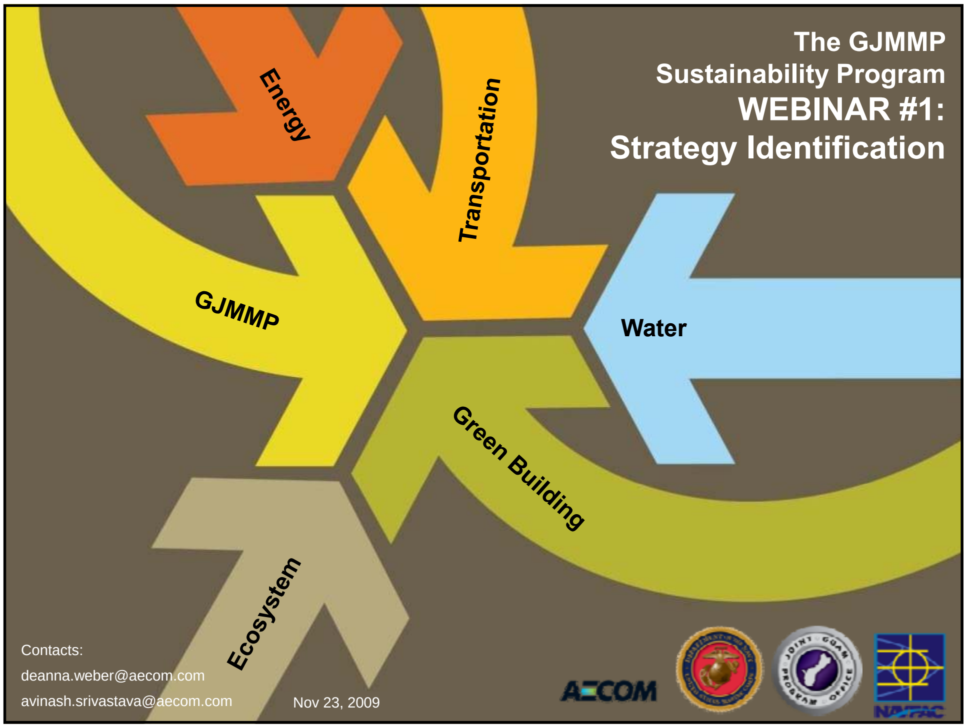
Deliverables & Schedule

DELIVERABLES:

- Full SSIM Cost Benefit Analysis
  - Water, Energy, Transportation, Green Building and Ecosystem Services
- Integration of LEED NC and ND into the Master Plan
- Additional Sustainable Integration into the Master Plan
- UFC analysis
  - Water, Energy, Transportation and Green Building

SCHEDULE:

- 6-7 month process
  - Mid-Oct 2009 to Mid-April, 2010

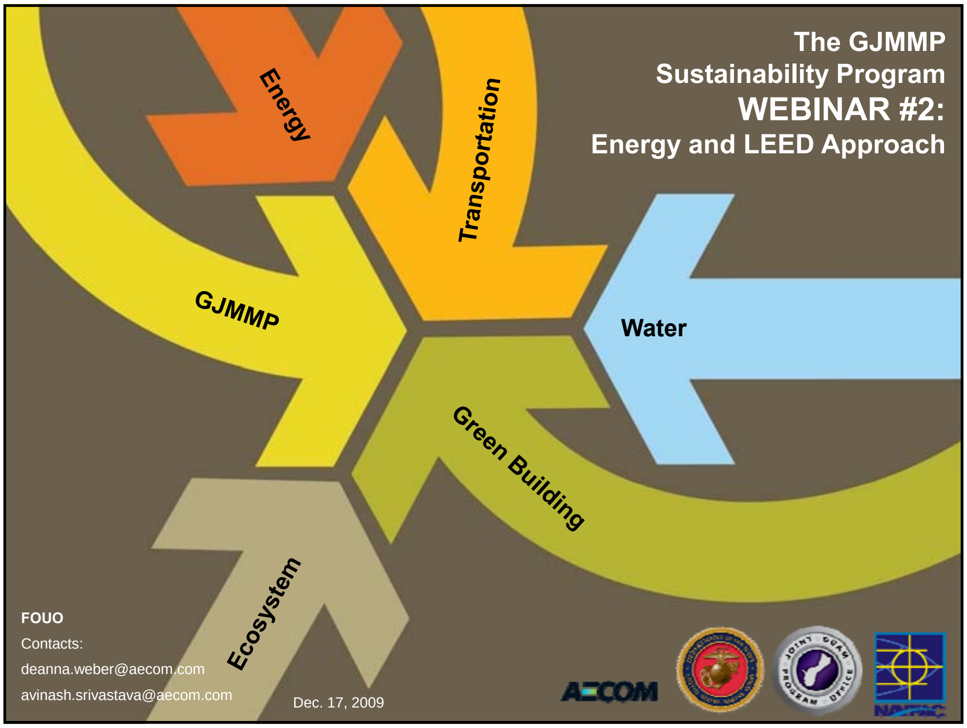


The GJMMP Sustainability Program

WEBINAR #1: Strategy Identification

Contacts:
deanna.weber@aecom.com
avinash.srivastava@aecom.com

Nov 23, 2009



The GJMMP Sustainability Program
WEBINAR #2:
Energy and LEED Approach

FOUO

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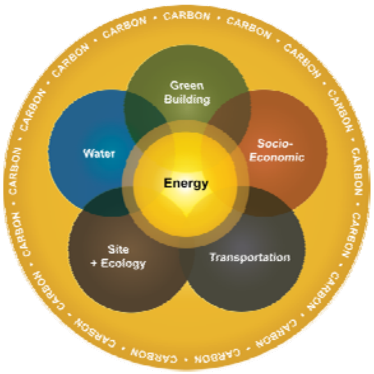
Dec. 17, 2009

AECOM

AGENDA

- Baseline SSIMe (Sustainable Systems Integration Modeling) Energy Modeling
- Update on Meeting with USGBC on LEED
- LEED NC and ND Strategy
- Schedule and Deliverables:
  - Next webinar Jan 21, 2009, focused on Water and Transportation



Energy Systems

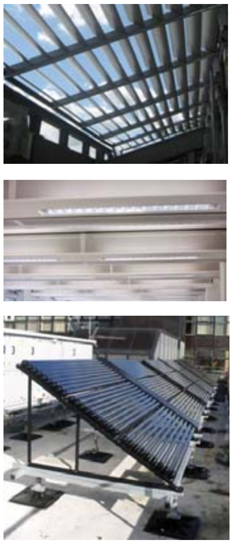
will strive for efficiency of energy delivery in the transition to renewable resources.

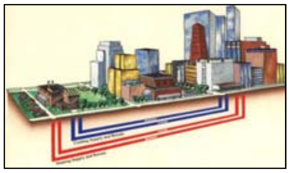
Energy Reduction Strategies (Summary from Webinar #1)

- **Energy use targets**
  - **All buildings must be capable of achieving LEED Silver**
    - Baseline: Code minimum requirements (ASHRAE 90.1-2007)
    - Good: 30% energy reduction against ASHRAE 90.1-2004 (EPAct 2005)
    - Better: 40% energy reduction
    - Best: 50% to 100% energy reduction, high use of renewable energy (e.g. PV, STHW)
  - **Energy Independence and Security Act 2007**
    - 55% fossil fuel use reduction by 2010 against CBECS 2003
    - 100% fossil fuel use reduction by 2030 against CBECS 2003
  - **Increased use of renewable energy**
  - **Application of sustainable design principles in new construction and major renovations (LEED Silver)**

Energy Reduction Strategies (Summary from Webinar #1)

- **First,** consider measures to make the building work harder
- **Second,** install efficient plant and controls
- **Third,** consider the most cost effective renewable systems that are suitable for the site
- **Fourth,** assess district wide energy systems

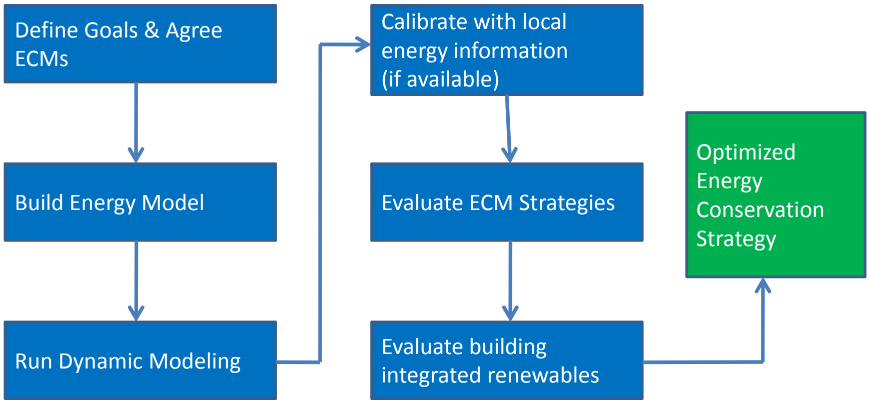




GJMMP – SSIMe Analysis

- SSIMe analysis to be conducted on 12 non-residential building types and 2 residential types
- Baseline modeling now carried out on 10 of the non residential building types and 2 residential
- Calibration to local Guam conditions has already taken place as part of the baseline modeling process
- Further calibration based on meeting feedback prior to development of the ECM (Energy Conservation Measures) packages
- Production of cost calibrated packages of ECMs, with LCC (Life Cycle Costing) analysis including equipment replacement costs, maintenance costs and energy costs

GJMMP – SSIMe Analysis


Define Goals & Agree ECMs

Build Energy Model

Run Dynamic Modeling

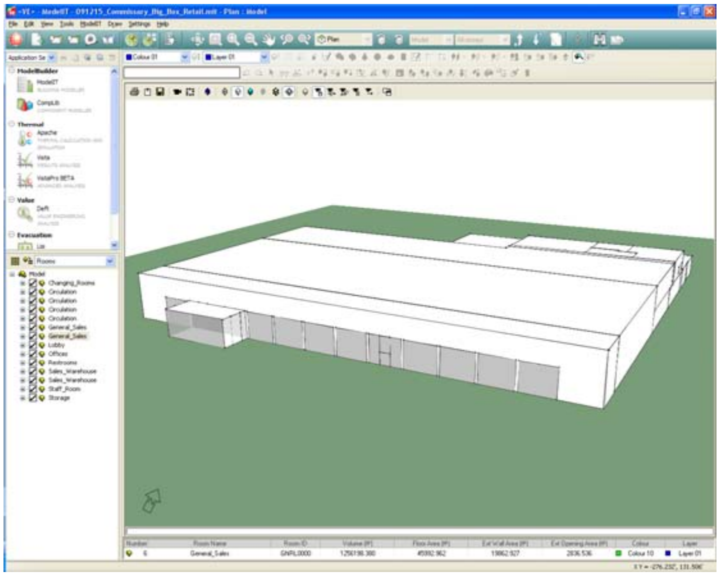
Calibrate with local energy information (if available)

Evaluate ECM Strategies

Evaluate building integrated renewables

Optimized Energy Conservation Strategy

GJMMP – SSIMe Analysis



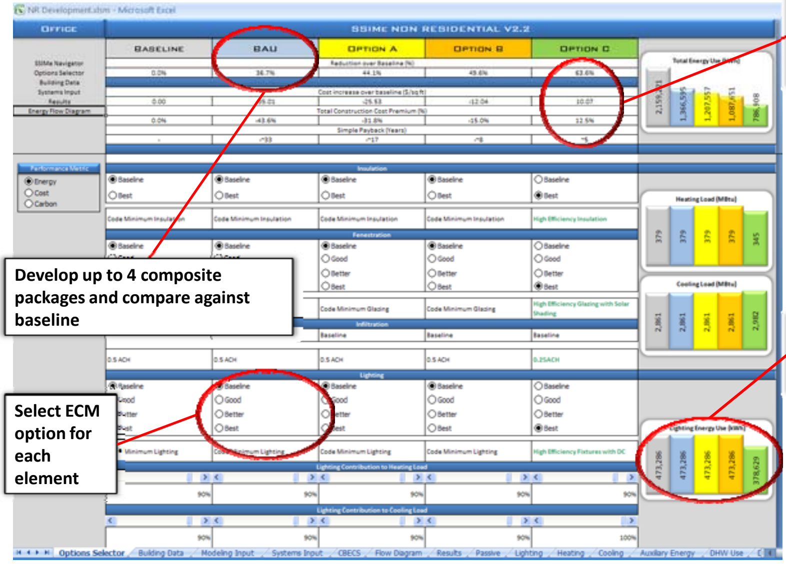
- Create a 3D model of each building type to be assessed using IES-VE

- Energy and loads calculations at 6-min intervals

- Calibrated to baseline construction and energy data

- Calibrated to the local climate (Anderson AFB weather tape)

GJMMP – SSIMe Analysis



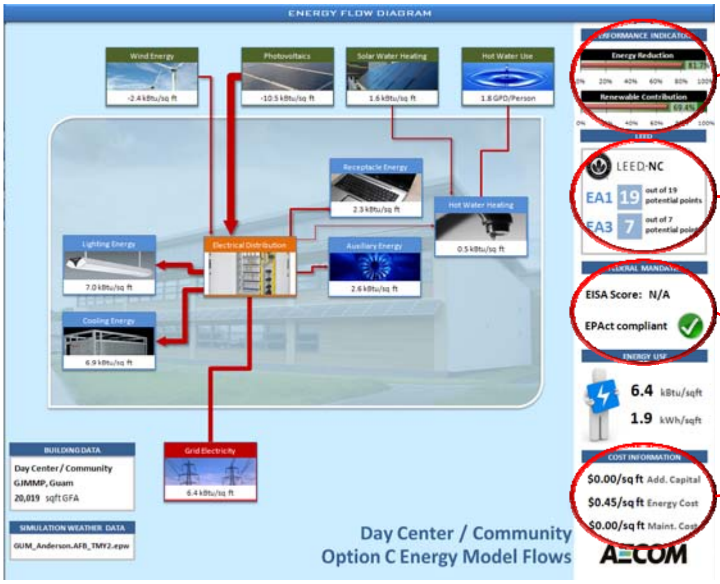
Realtime assessment of package performance

Develop up to 4 composite packages and compare against baseline

Compare energy benefit of selected options

Select ECM option for each element

GJMMP – SSIMe Analysis



Real time summary of package performance

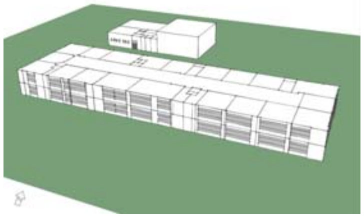
Real time assessment of anticipated LEED points

Real time assessment of federal mandates

Real time energy and capital cost data

Building Data Summary

- 2 and 3 Story Headquarters Office
- 1 Story Small Office
- 6 Story BEQ
- Climate Controlled Warehouse
- Unconditioned Warehouse
- Conditioned Auto/ Maintenance Workshop



SSIMe Non Residential Models	Construction Data	GFA (sq ft)	Number of Stories	Cooling Setpoint (°F)	Cooling Profile (°F)	Maximum RH (%)	Notes
3 Storey Headquarters Office (90,000 sq ft)	ASHRAE 90.1-2007: Climate Zone 1A	89,972	3	76/90	7am to 7pm with Setback, M to F	70	40% glazing distributed equally across all facades. Occupied and fully conditioned 5 days per week, with 'set back' occupancy and cooling during nightimes and weekends.
2 Storey Headquarters Office (30,000 sq ft)	ASHRAE 90.1-2007: Climate Zone 1A	30,277	2	76/90	7am to 7pm with Setback, M to F	70	40% glazing distributed equally across all facades. Occupied and fully conditioned 5 days per week, with 'set back' occupancy and cooling during nightimes and weekends.
1 Storey Small Office (15,000 sq ft)	ASHRAE 90.1-2007: Climate Zone 1A	15,138	1	76/90	7am to 7pm with Setback, M to F	70	40% glazing distributed equally across all facades. Occupied and fully conditioned 5 days per week, with 'set back' occupancy and cooling during nightimes and weekends.
6 Storey 300 Occupant BEQ	ASHRAE 90.1-2007: Climate Zone 1A	197,028	6	76/90	ASHRAE 24hr	70	Occupied and fully conditioned 7 days per week, 24 hours per day. 20 GPPPD DHW use. 2 soldiers per room.
Climate Controlled Warehouse	ASHRAE 90.1-2007: Climate Zone 1A	35,000	0	65	ASHRAE 24hr	40/60	No natural daylight. Fully conditioned and humidity controlled (40% to 60%) 7 days per week, 24 hours per day. Occupied between 7am and 7pm, 7 days per week.
Unconditioned Warehouse	ASHRAE 90.1-2007: Climate Zone 1A	35,000	0	-	-	100	No natural daylight. Unconditioned. Occupied between 7am and 7pm, 7 days per week.
Conditioned Auto / Maintenance Workshop	ASHRAE 90.1-2007: Climate Zone 1A						

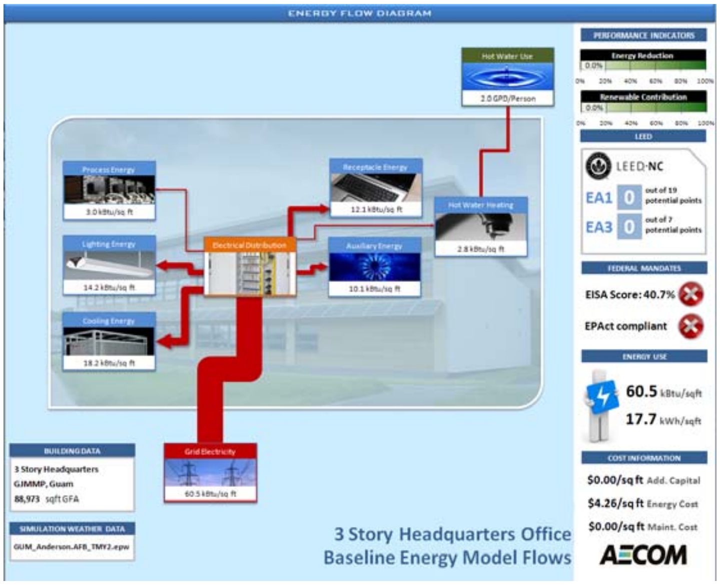
Building Data Summary cont.

- School
- Retail/Commissary
- Simulator Building (need architecture)
- Dining Facility
- Community Center
- Residential: Duplex and Single Family Home

School	ASHRAE 90.1-2007: Climate Zone 1A	46,112	0	76/90	6am to 6pm with Setback	70	Setback conditioning only is provided during weekends and vacation periods.
Retail / Commissary	ASHRAE 90.1-2007: Climate Zone 1A	67,823	1	72	ASHRAE 24hr	70	Occupied between 7am and 7pm, 7 days a week with setback conditioning at all other times, based on ASHRAE standard retail occupancy profiles.
Simulator Building	ASHRAE 90.1-2007: Climate Zone 1A						
Dining Facility	ASHRAE 90.1-2007: Climate Zone 1A	36,856	1	76/90	6am to 8pm with Setback	70	Includes 25,700 sq ft of dining space and 7,300 sq ft of kitchen space. Occupied between 6am and 8pm, 7 days a week with setback conditioning at all other times. Cooled to 76°F and humidified to 70% with 90°F setback.
Community Building / Day Centre	ASHRAE 90.1-2007: Climate Zone 1A	20,019	1	76/90	7am to 7pm with Setback, M to F	70	Occupied and fully conditioned between 6am and 9pm Monday to Friday.

SSIMe Residential Models							Notes
Duplex	ASHRAE 90.1-2007: Climate Zone 1A	1,633 per DU	2	78	ASHRAE 24hr	70	Occupied and fully conditioned 24/7.
SFD	ASHRAE 90.1-2007: Climate Zone 1A	1,936 per DU	2	78	ASHRAE 24hr	70	Occupied and fully conditioned 24/7.

3 Story Headquarters Building



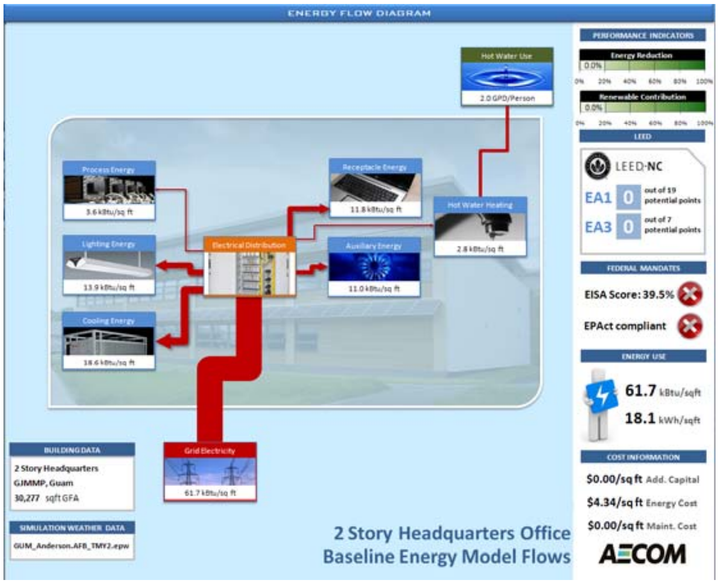
3 Story Headquarters Office
Baseline Energy Model Flows

3 Story HQ
88,973 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
57.5 kBtu/sq ft

2 Story Headquarters Building



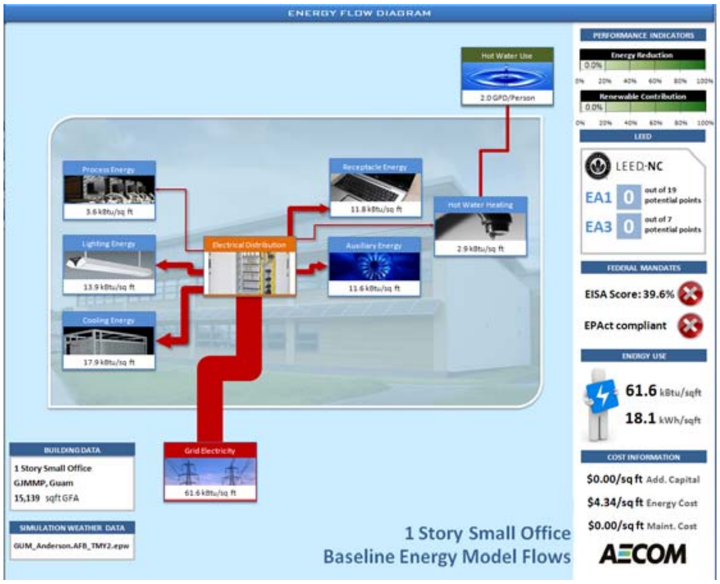
2 Story Headquarters Office
Baseline Energy Model Flows

2 Story HQ
30,277 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
61.7 kBtu/sq ft

1 Story Small Office

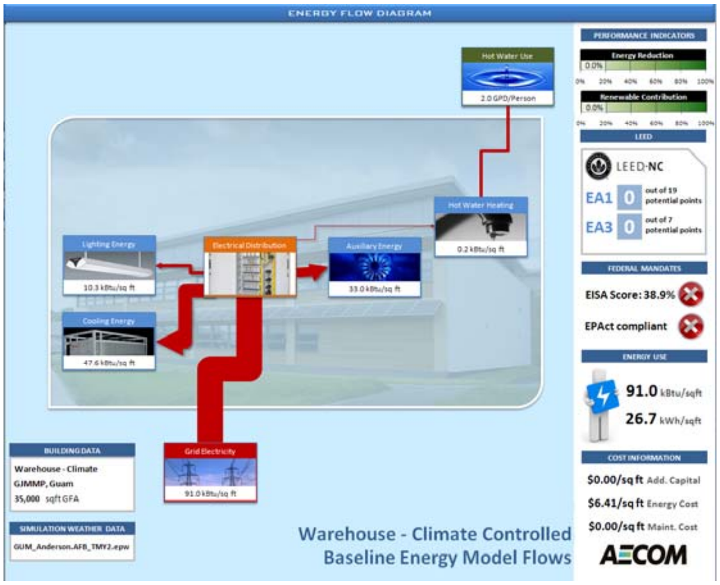


1 Story Office
15,139 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
61.6 kBtu/sq ft

Climate Controlled Warehouse



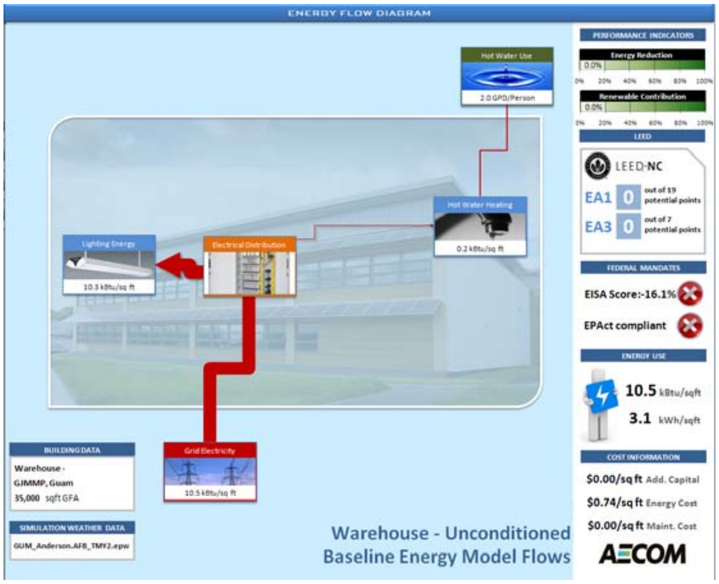
Climate Controlled Warehouse
35,000 sq ft GFA

65°F / 40/60 RH

ASHRAE 90.1-2007 Baseline

Energy Use:
91.0 kBtu/sq ft

Unconditioned Warehouse

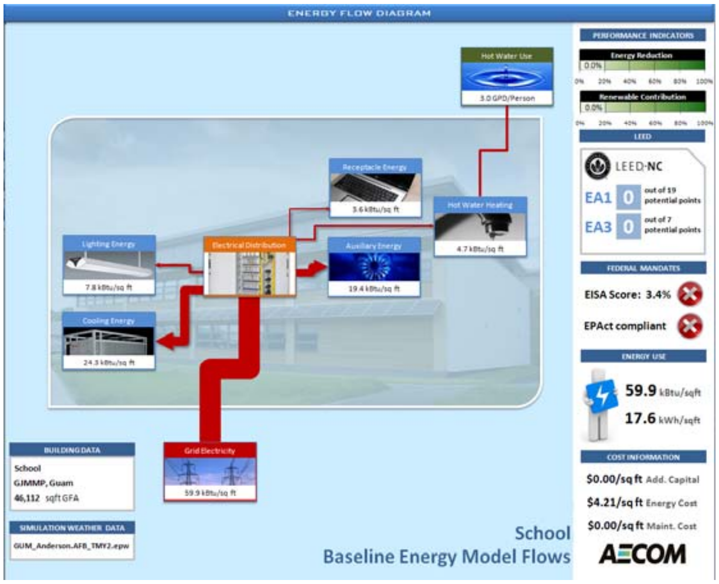


Unconditioned Warehouse
35,000 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
10.5 kBtu/sq ft

School

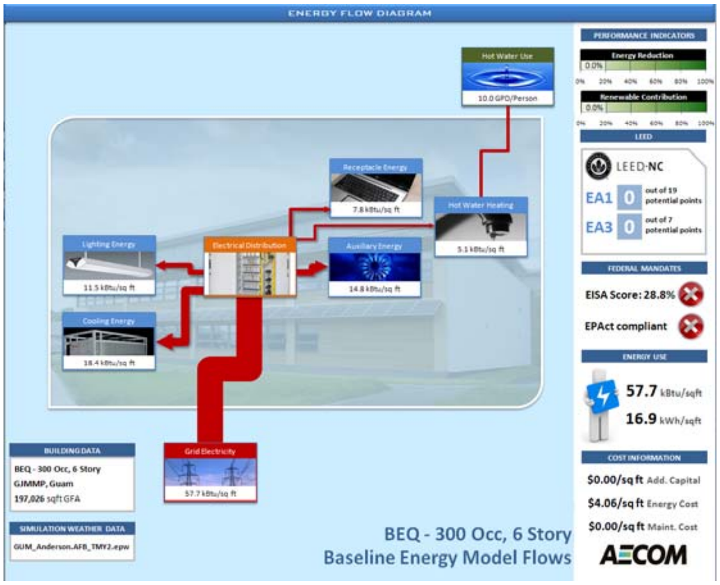


School
46,112 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
59.9 kBtu/sq ft

6 Story, 300 Occupant, Bachelor Enlisted Quarters

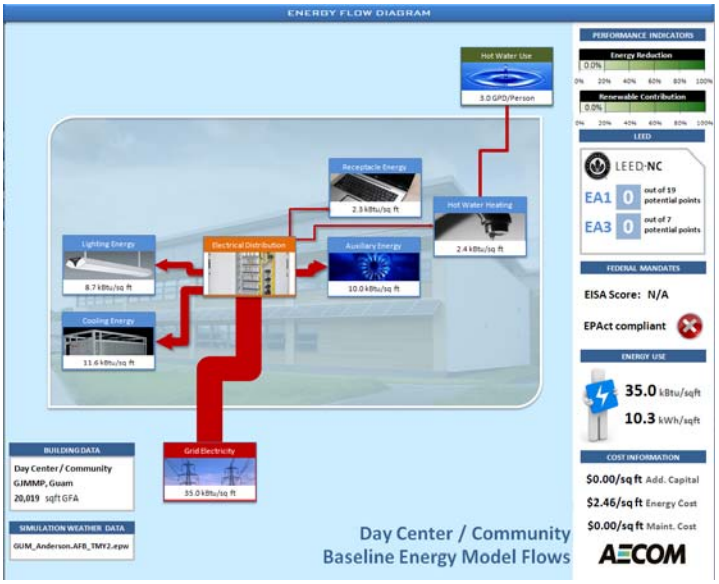


BEQ
197,026 sq ft GFA
300 Occupants

ASHRAE 90.1-2007 Baseline

Energy Use:
57.7 kBtu/sq ft

Day Center / Community Center

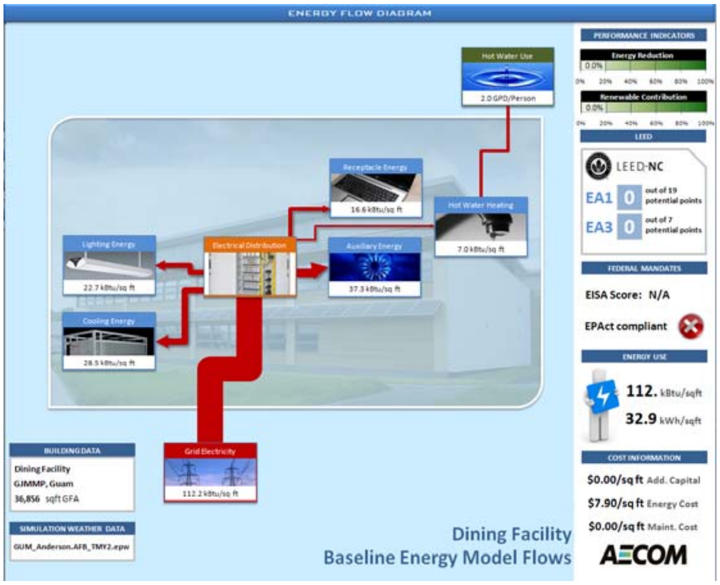


Day Center / Community Center
20,019 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
35.0 kBtu/sq ft

Dining Facility

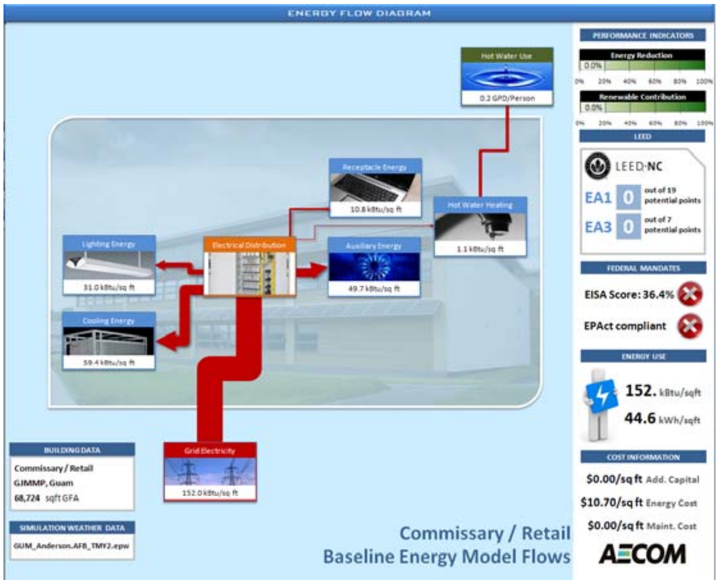


Dining Facility
36,856 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
112 kBtu/sq ft

Commissary / Retail

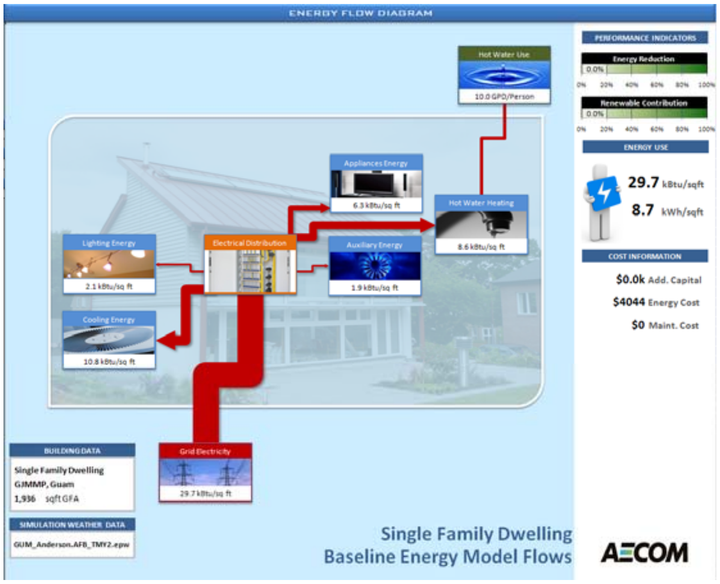


Commissary
68,724 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
152 kBtu/sq ft

Single Family Dwelling

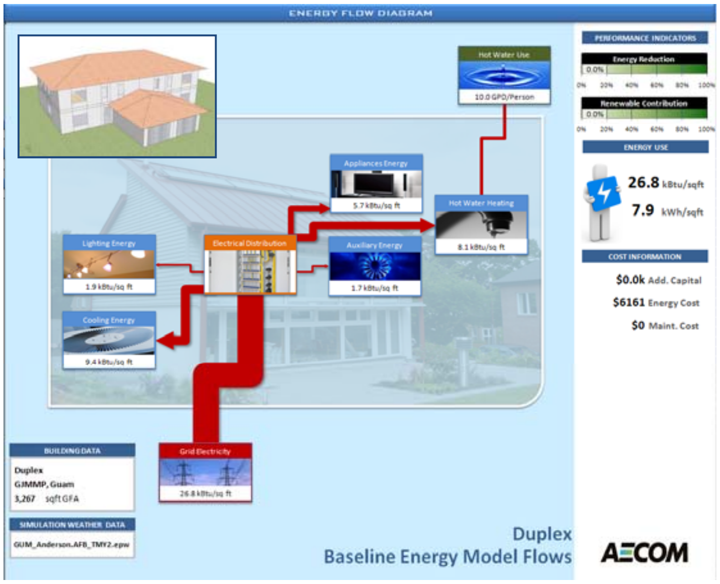


Single Family
1,936 sq ft GFA

ASHRAE 90.1-2007 Baseline

Energy Use:
29.7 kBtu/sq ft

Duplex



Duplex
3,267 sq ft GFA
2 DUs

ASHRAE 90.1-2007 Baseline

Energy Use:
26.8 kBtu/sq ft

SSIMe Analysis – Next Steps

- Development of the Simulator and Workshop building baseline models (information needed!)
- Further calibration of the baseline energy models based on meeting feedback
- Cost calibration of SSIMe model based on local ECM (Energy Conservation Measure) cost data

Green Building

integrates systems at the building level and expands efficiency across the base

HOMES

NEIGHBORHOOD DEVELOPMENT

NEW CONSTRUCTION

SCHOOLS, HEALTHCARE, RETAIL

LEED Overall Strategies

LEED Strategy for GJMMP

Family Housing Area

Mixed Use Town Center (potential)

“Representative” Homes to be certified

Public buildings in Family Housing Area

LEED 3.0 for NC including Schools, Community Buildings and Retail

Base Operational Area

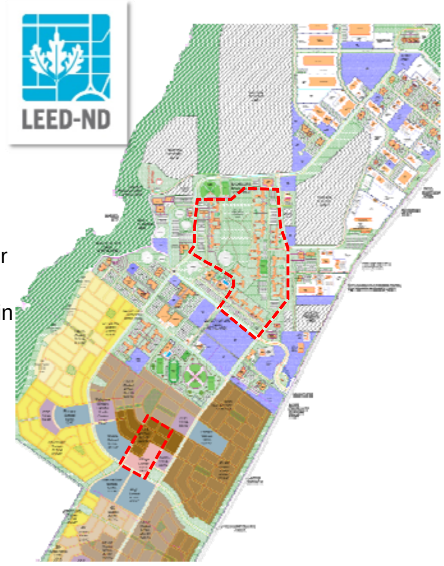
BEQ Housing Area (potential)

LEED Silver Buildings with “campus”/”block” approach

LEED 3.0 for New Construction Multiple Buildings

Summary of Meeting with USGBC (Dec.7, 2009)

- LEED ND contact: Sophie Lambert
- LEED NC contact: Mellissa Gallagher
- LEED Homes contact: Courtney Baker
- LEED GBCI contact: Sarah Alexander
- Pre-Requisites (Pre-Reqs) will continue to be difficult to meet
- We will continue to target testing LEED ND for the Family Housing Village Center and BEQs
    - (However, with BEQs subject to change in design, we will hold on calculations for now)
- LEED ND Examples
    - Hawaii Regional Housing PPV Increment 2 Kaneohe, HI, Stage 2, Certified, 7/17/09, Contact: Irwin Tamura irwintamura@forestcity.net
    - Simpson Wisser Fort Shafter Honolulu, HI, Stage 1, Certified,11/7/08, Contact: James Sullivan james.sullivan@actuslendlease.com



Summary of Meeting with USGBC (Dec.7, 2009)

- LEED ND points
- Pre-Requisites

ND

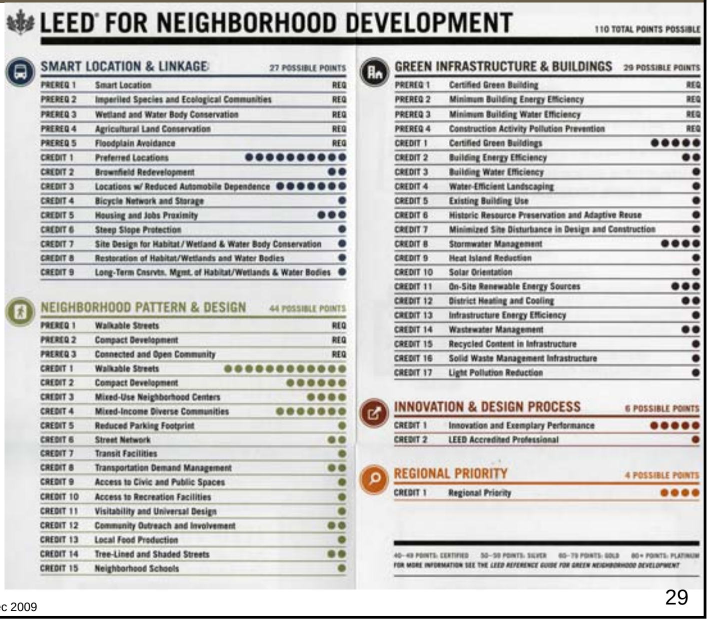
LEED® 2009
for Neighborhood
Development

Total Possible Points**	110*
Smart Location & Linkages	27
Neighborhood Pattern & Design	44
Green Infrastructure & Buildings	29

* Out of a possible 100 points + 10 bonus points

** Certified 40+ points, Silver 50+ points, Gold 60+ points, Platinum 80+ points

Innovation & Design Process	6
Regional Priority	4



LEED® FOR NEIGHBORHOOD DEVELOPMENT

110 TOTAL POINTS POSSIBLE

SMART LOCATION & LINKAGE

27 POSSIBLE POINTS

PREREQ 1	Smart Location	REQ
PREREQ 2	Imperiled Species and Ecological Communities	REQ
PREREQ 3	Wetland and Water Body Conservation	REQ
PREREQ 4	Agricultural Land Conservation	REQ
PREREQ 5	Floodplain Avoidance	REQ
CREDIT 1	Preferred Locations	●●●●●●●●●●
CREDIT 2	Brownfield Redevelopment	●●
CREDIT 3	Locations w/ Reduced Automobile Dependence	●●●●●●●
CREDIT 4	Bicycle Network and Storage	●
CREDIT 5	Housing and Jobs Proximity	●●●
CREDIT 6	Steep Slope Protection	●
CREDIT 7	Site Design for Habitat / Wetland & Water Body Conservation	●
CREDIT 8	Restoration of Habitat/Wetlands and Water Bodies	●
CREDIT 9	Long-Term Cnsrvtn. Mgmt. of Habitat/Wetlands & Water Bodies	●

NEIGHBORHOOD PATTERN & DESIGN

44 POSSIBLE POINTS

PREREQ 1	Walkable Streets	REQ
PREREQ 2	Compact Development	REQ
PREREQ 3	Connected and Open Community	REQ
CREDIT 1	Walkable Streets	●●●●●●●●●●●●
CREDIT 2	Compact Development	●●●●●●
CREDIT 3	Mixed-Use Neighborhood Centers	●●●●
CREDIT 4	Mixed-Income Diverse Communities	●●●●●●●
CREDIT 5	Reduced Parking Footprint	●
CREDIT 6	Street Network	●●
CREDIT 7	Transit Facilities	●
CREDIT 8	Transportation Demand Management	●●
CREDIT 9	Access to Civic and Public Spaces	●
CREDIT 10	Access to Recreation Facilities	●
CREDIT 11	Visitability and Universal Design	●
CREDIT 12	Community Outreach and Involvement	●●
CREDIT 13	Local Food Production	●
CREDIT 14	Tree-Lined and Shaded Streets	●●
CREDIT 15	Neighborhood Schools	●

GREEN INFRASTRUCTURE & BUILDINGS

29 POSSIBLE POINTS

PREREQ 1	Certified Green Building	REQ
PREREQ 2	Minimum Building Energy Efficiency	REQ
PREREQ 3	Minimum Building Water Efficiency	REQ
PREREQ 4	Construction Activity Pollution Prevention	REQ
CREDIT 1	Certified Green Buildings	●●●●●
CREDIT 2	Building Energy Efficiency	●●
CREDIT 3	Building Water Efficiency	●
CREDIT 4	Water-Efficient Landscaping	●
CREDIT 5	Existing Building Use	●
CREDIT 6	Historic Resource Preservation and Adaptive Reuse	●
CREDIT 7	Minimized Site Disturbance in Design and Construction	●
CREDIT 8	Stormwater Management	●●●●
CREDIT 9	Heat Island Reduction	●
CREDIT 10	Solar Orientation	●
CREDIT 11	On-Site Renewable Energy Sources	●●●
CREDIT 12	District Heating and Cooling	●●
CREDIT 13	Infrastructure Energy Efficiency	●
CREDIT 14	Wastewater Management	●●
CREDIT 15	Recycled Content in Infrastructure	●
CREDIT 16	Solid Waste Management Infrastructure	●
CREDIT 17	Light Pollution Reduction	●

INNOVATION & DESIGN PROCESS

6 POSSIBLE POINTS

CREDIT 1	Innovation and Exemplary Performance	●●●●●
CREDIT 2	LEED Accredited Professional	●

REGIONAL PRIORITY

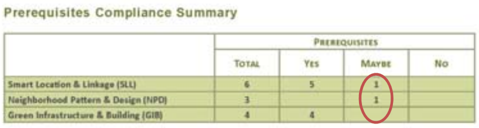
4 POSSIBLE POINTS

CREDIT 1	Regional Priority	●●●●

40–49 POINTS: CERTIFIED 50–59 POINTS: SILVER 60–79 POINTS: GOLD 80+ POINTS: PLATINUM

FOR MORE INFORMATION SEE THE *LEED REFERENCE GUIDE FOR GREEN NEIGHBORHOOD DEVELOPMENT*

LEED ND Test Results for Family Housing Area



Prerequisites Compliance Summary

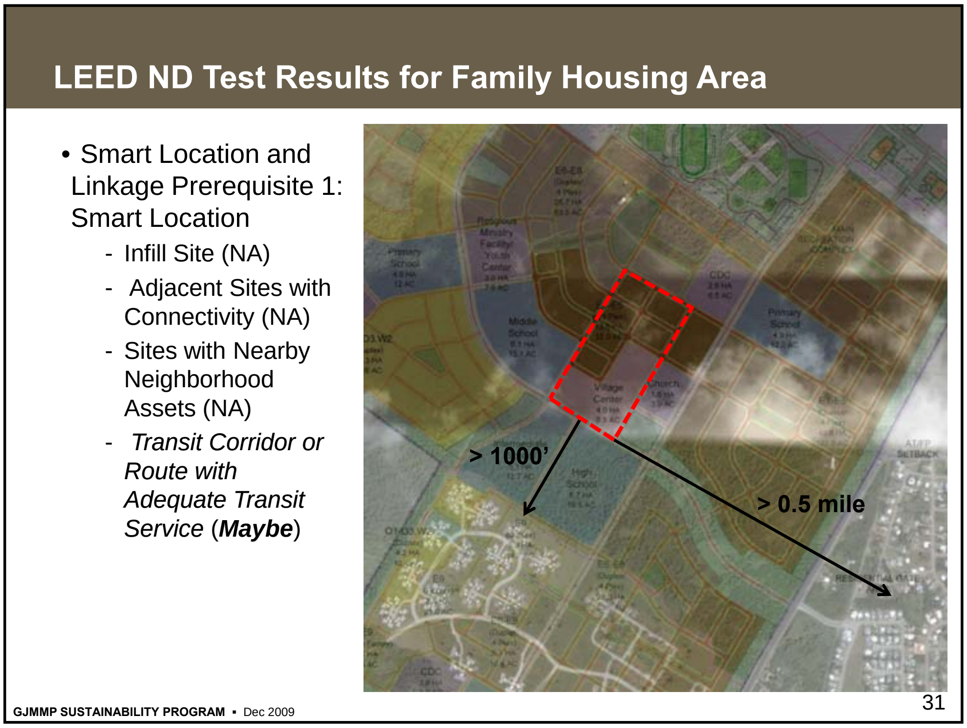
	PREREQUISITES			
	TOTAL	YES	MAYBE	NO
Smart Location & Linkage (SLL)	6	5	1	
Neighborhood Pattern & Design (NPD)	3		1	
Green Infrastructure & Building (GIB)	4	4		

Total Achievable Score Summary

	YES	MAYBE
Smart Location & Linkage (SLL)	3	3-9
Neighborhood Pattern & Design (NPD)	6-21	6-7
Green Infrastructure & Building (GIB)	10-19	5-8
Innovation & Design Process (ID)	1	
Total	20-44	14-24

LEED ND 2009 Certification Level

Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80 points & above

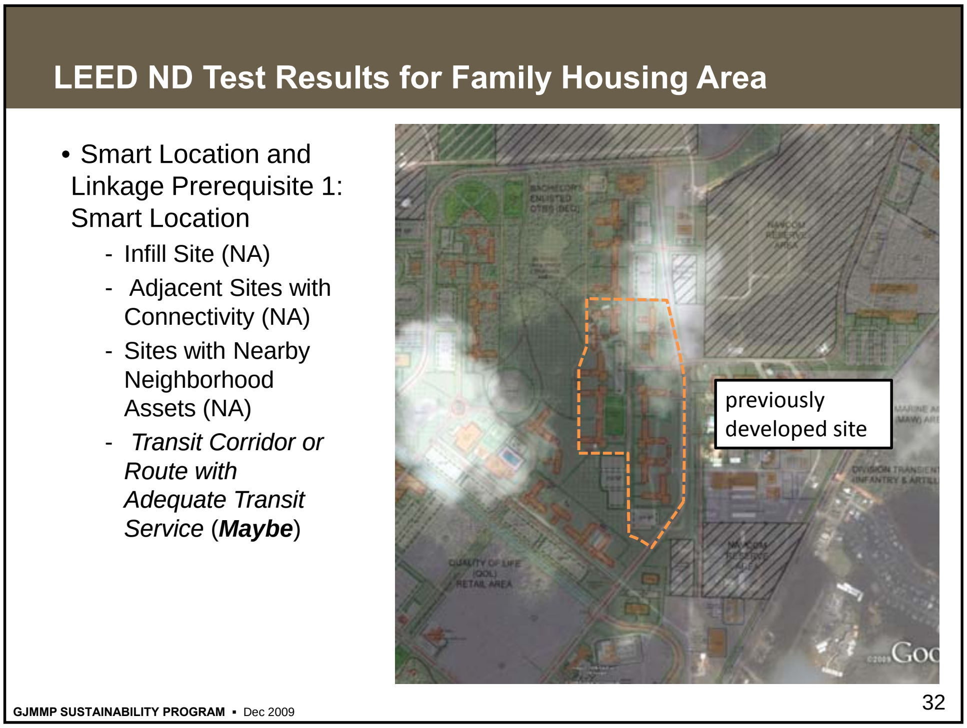


LEED ND Test Results for Family Housing Area

- Smart Location and Linkage Prerequisite 1: Smart Location
  - Infill Site (NA)
  - Adjacent Sites with Connectivity (NA)
  - Sites with Nearby Neighborhood Assets (NA)
  - *Transit Corridor or Route with Adequate Transit Service* (***Maybe***)

> 1000'

> 0.5 mile



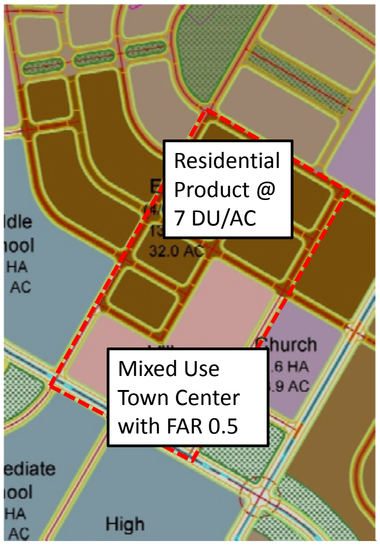
LEED ND Test Results for Family Housing Area

- Smart Location and Linkage Prerequisite 1: Smart Location
  - Infill Site (NA)
  - Adjacent Sites with Connectivity (NA)
  - Sites with Nearby Neighborhood Assets (NA)
  - *Transit Corridor or Route with Adequate Transit Service* (***Maybe***)

previously developed site

LEED ND Test Results for Family Housing Area

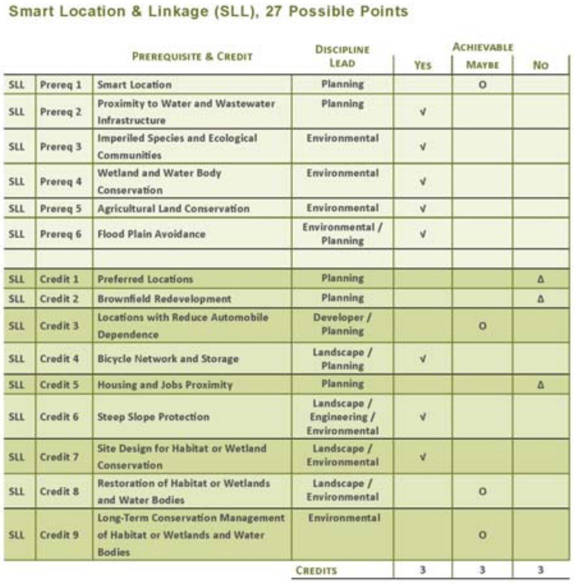
- Neighborhood Pattern and Design Prerequisite 2: Compact Development
  - Residential Density 7 DU/AC or above
  - Nonresidential FAR 0.5 or greater



Residential Product @ 7 DU/AC

Mixed Use Town Center with FAR 0.5

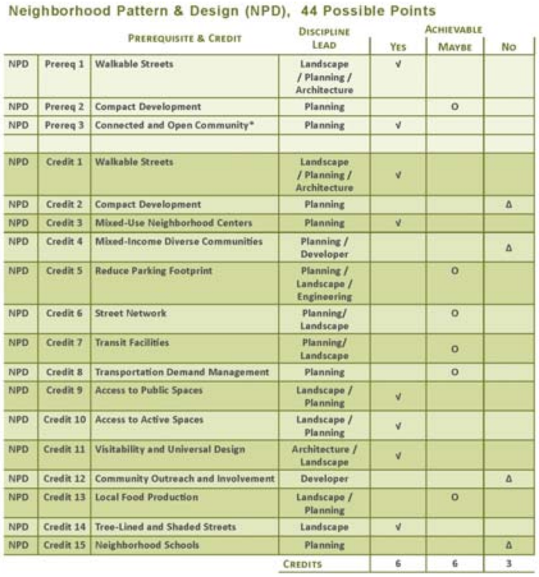
LEED ND Test Results for Family Housing Area



Smart Location & Linkage (SLL), 27 Possible Points

		PREREQUISITE & CREDIT	DISCIPLINE LEAD	ACHIEVABLE YES	 MAYBE	 NO
SLL	Prereq 1	Smart Location	Planning		O	
SLL	Prereq 2	Proximity to Water and Wastewater Infrastructure	Planning	√		
SLL	Prereq 3	Imperiled Species and Ecological Communities	Environmental	√		
SLL	Prereq 4	Wetland and Water Body Conservation	Environmental	√		
SLL	Prereq 5	Agricultural Land Conservation	Environmental	√		
SLL	Prereq 6	Flood Plain Avoidance	Environmental / Planning	√		
SLL	Credit 1	Preferred Locations	Planning			Δ
SLL	Credit 2	Brownfield Redevelopment	Planning			Δ
SLL	Credit 3	Locations with Reduce Automobile Dependence	Developer / Planning		O	
SLL	Credit 4	Bicycle Network and Storage	Landscape / Planning	√		
SLL	Credit 5	Housing and Jobs Proximity	Planning			Δ
SLL	Credit 6	Steep Slope Protection	Landscape / Engineering / Environmental	√		
SLL	Credit 7	Site Design for Habitat or Wetland Conservation	Landscape / Environmental	√		
SLL	Credit 8	Restoration of Habitat or Wetlands and Water Bodies	Landscape / Environmental		O	
SLL	Credit 9	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies	Environmental		O	
			CREDITS	3	3	3

LEED ND Test Results for Family Housing Area



Neighborhood Pattern & Design (NPD), 44 Possible Points

Prerequisite & Credit			Discipline Lead	Achievable		
				Yes	Maybe	No
NPD	Prereq 1	Walkable Streets	Landscape / Planning / Architecture	√		
NPD	Prereq 2	Compact Development	Planning		O	
NPD	Prereq 3	Connected and Open Community*	Planning	√		
NPD	Credit 1	Walkable Streets	Landscape / Planning / Architecture	√		
NPD	Credit 2	Compact Development	Planning			Δ
NPD	Credit 3	Mixed-Use Neighborhood Centers	Planning	√		
NPD	Credit 4	Mixed-Income Diverse Communities	Planning / Developer			Δ
NPD	Credit 5	Reduce Parking Footprint	Planning / Landscape / Engineering		O	
NPD	Credit 6	Street Network	Planning/ Landscape		O	
NPD	Credit 7	Transit Facilities	Planning/ Landscape		O	
NPD	Credit 8	Transportation Demand Management	Planning		O	
NPD	Credit 9	Access to Public Spaces	Landscape / Planning	√		
NPD	Credit 10	Access to Active Spaces	Landscape / Planning	√		
NPD	Credit 11	Visitability and Universal Design	Architecture / Landscape	√		
NPD	Credit 12	Community Outreach and Involvement	Developer			Δ
NPD	Credit 13	Local Food Production	Landscape / Planning		O	
NPD	Credit 14	Tree-Lined and Shaded Streets	Landscape	√		
NPD	Credit 15	Neighborhood Schools	Planning			Δ
			Credits	6	6	3

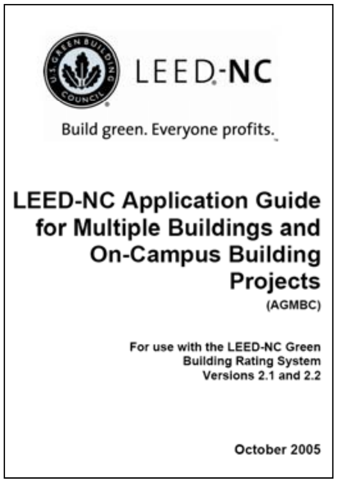
LEED ND Test Results for Family Housing Area

Green Infrastructure & Buildings (GIB), 29 Possible Points

Prerequisite & Credit			Discipline Lead	Achievable		
				Yes	Maybe	No
GIB	Prereq 1	Certified Green Building	Construction Mngt.	√		
GIB	Prereq 2	Minimum Building Energy Efficiency	Architecture / Engineer / Landscape	√		
GIB	Prereq 3	Minimum Building Water Efficiency	Engineering / Architecture	√		
GIB	Prereq 4	Construction Activity Pollution Prevention	Architecture / Engineer Landscape	√		
GIB	Credit 1	Certified Green Buildings	Architecture	√		
GIB	Credit 2	Building Energy Efficiency	Architecture	√		
GIB	Credit 3	Building Water Efficiency	Architecture	√		
GIB	Credit 4	Water Efficiency Landscaping	Landscape	√		
GIB	Credit 5	Existing Building Reuse	Planning Contractor Environmental	√		
GIB	Credit 6	Historic Resource Preservation and Adaptive Use	Engineering			Δ
GIB	Credit 7	Minimize Site Disturbance in Design and Construction	Engineering Landscape			Δ
GIB	Credit 8	Stormwater Management	Landscape / Planning / Engineering	√		
GIB	Credit 9	Heat Island Reduction	Architecture / Planning / Landscape / Engineering	√		
GIB	Credit 10	Solar Orientation	Engineering/ Landscape	√		
GIB	Credit 11	On-Site Renewable Energy Sources	Engineering		O	
GIB	Credit 12	District Heating & Cooling	Architecture / Engineering		O	
GIB	Credit 13	Infrastructure Energy Efficiency	Engineering/ Landscape /Architecture		O	
GIB	Credit 14	Wastewater Management	Architecture/ Engineering	√		
GIB	Credit 15	Recycled Content in Infrastructure	Engineering / Architecture		O	
GIB	Credit 16	Solid Waste Management Infrastructure	Construction Mgmt.	√		
GIB	Credit 17	Light Pollution Reduction	Construction Mgmt./ Planning, Landscape		O	
			Credits	10	5	2

Summary of Meeting with USGBC (Dec.7, 2009)

- Campus Guide will be re-written in 2010, the current guide will change!
- **Each building must have individual project registration**
- A “block” approach for 5-10 buildings may be used to get same reviewer (as long a you use the same LEED version)
- Important issues discussed:
    - All site work to be LEED compliant
    - Full documentation of site work to be used at a later date when building applications are submitted
    - Challenges with phased project and newer versions of LEED coming out in 2012 and 2015



LEED-NC

Build green. Everyone profits.

LEED-NC Application Guide for Multiple Buildings and On-Campus Building Projects
(AGMBC)

For use with the LEED-NC Green Building Rating System Versions 2.1 and 2.2

October 2005

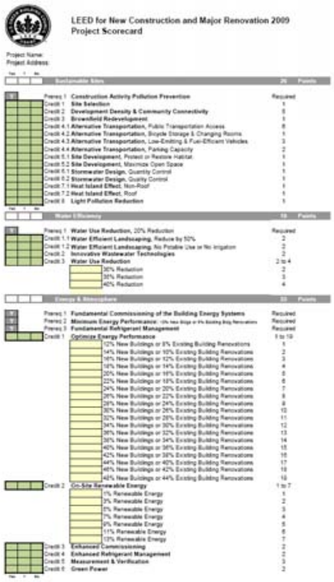
Summary of Meeting with USGBC (Dec.7, 2009)

- Exempt Buildings from LEED?
    - **NAVFAC Bulletin dated Dec 13, 2007 says under FY09 Projects and Beyond:** “All projects must be registered with USGBC and have the required LEED submittal documentation certified by USGBC to meet the required LEED Silver-level rating.”
- Discussion on “hangars”—Do they need to be LEED Silver?
    - See the USGBC website: Minimum project requirements
    - See also definitions including: “Normally occupied areas”
- Some structures will be exempt (i.e. pump houses and entry gate structures). Others will need to address “the intent” of LEED when not feasible for certification

Summary of Meeting with USGBC (Dec.7, 2009)

Summary Points:

- **Each building will require an application**
- The “block” approach will allow for requesting the same reviewer and using some of the documentation provided by earlier projects
- Site work compliance and documentation will be crucial to the success of each building application
- Application fees double in 2010 to $900 registration fee for each building
- See forthcoming new “campus” approach in 2010



LEED for New Construction and Major Renovation 2009 Project Scorecard

LEED ND Application Strategy

LEED Strategy:

- **Step One:** Establish categories based on building types and building energy modeling
- **Step Two:** Group “like” buildings together
- **Step Three:** Based on phasing, develop “blocks” of 2-10 buildings to get the same USGBC reviewer

LEED Building Applications:

- Burden is on the first applicant to fully document the project
- Full site documentation for future buildings is critical

LEED NC Application Strategy

LEED NC Building Types:

- 3 Story Headquarters Office (90,000 sq ft)
- 2 Story Headquarters Office (30,000 sq ft)
- 1 Story Small Office (15,000 sq ft)
- 6 Story BEQ
- Climate Controlled Warehouse
- Unconditioned Warehouse
- Conditioned Auto / Maintenance Workshop
- School
- Retail / Commissary
- Simulator
- Dining Facility
- Community Building/Daycare
- Duplex (Attached Home)
- Detached Home

LEED NC Application Strategy

GJMMP Building Summary:

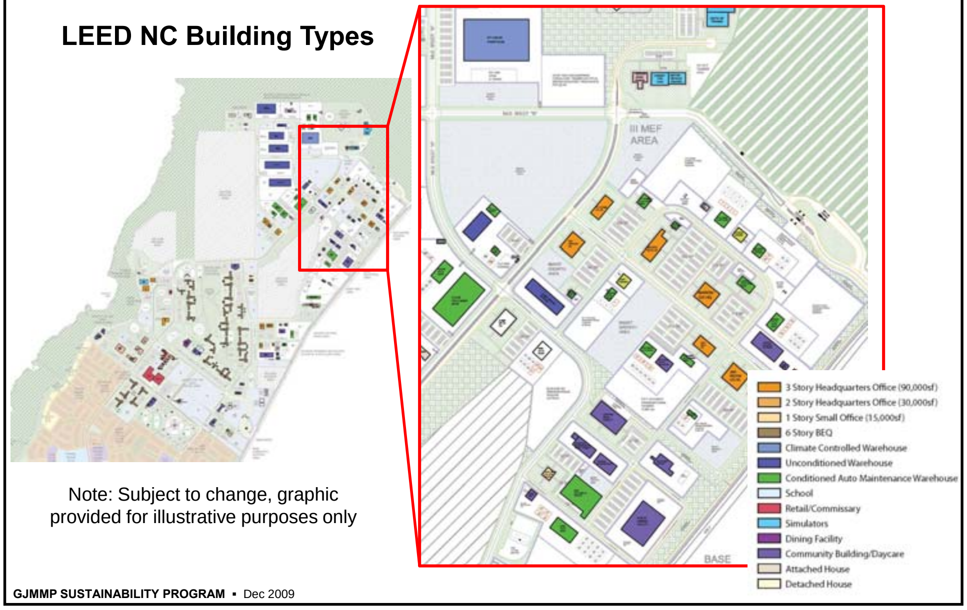
- +/- 174 Non-residential buildings
- 14 different building “types” being modeled for energy
- +/- 14 million total non-residential square feet
- +/- 2,740 residential dwelling units

BUILDING NAME	CCN	FACILITY DESCRIPTION	Estimated Building Area (sf)	Assumed Bldg Height (Floors)	Assumed Bldg Height (Feet)	Building/Area Footprint (Sq Ft)	No. of Occupants	SSIMe Building Types
Area 1								
BRIG	73015	Brig, Confinement Facility, MCB Guam	19,500	1	15	19,500	UNK	Brig
REHAB CENTER	73081	Rehabilitation Center	45,100	1	15	45,100	170	Rehab
PMO KENNEL	73076	Military Working Dog Kennel, MCB Guam	5,560	1	15	5,560	13	Kennel
Area 2								
3D MED BN WAREHOUSE	44112	Organic Unit Storage, 3D Med Bn	23,920	1	25	23,920	UNK	Unconditioned Warehouse
3D MED BN WAREHOUSE	44120	Controlled Humidity Warehouse, 3D Med Bn	7,800	1	25	7,800	UNK	Climate Controlled Warehouse
BASE-DSSA WAREHOUSE	44113	Base/DSSA Warehouse	145,425	1	25	145,425	UNK	Unconditioned Warehouse
PMO-TMO STORAGE	44113	PMO/TMO Storage	116,870	1	25	116,870	UNK	Unconditioned Warehouse
CRSP WAREHOUSE	44113	Combat Ready Storage Point Warehouse	200,000	1	45	200,000	UNK	Unconditioned Warehouse
CORROSION CONTROL FACILITY (PAINT & RELATED OPS STRUCTURE)	21931	Paint & Related Ops Structure, MCB Guam	35,000	1	45	35,000	UNK	-
9TH ESB ADMIN	61073	Company/Battalion Headquarters 9th ESB	10,333	1	15	10,333	62	1 Story Small Office (15,000 sq ft)
9TH ESB AUTO MAINTENANCE SHOP	21451	Auto Organizational Shop, H&S Co, 9th Engineer Support BN	15,395	1	25	15,395	UNK	Conditioned Auto / Maintenance Workshop
9TH ESB AUTO MAINTENANCE SHOP	21440	Vehicle Holding Shed, 9th Engineer Support BN	2,520	1	25	2,520	UNK	Unconditioned Warehouse
9TH ESB WAREHOUSE	44120	Controlled Humidity Warehouse, Engr Support Co, 9th ESB	100,315	1	25	100,315	UNK	Climate Controlled Warehouse
9TH ESB WAREHOUSE	44112	Organic Unit Storage, 9th Engineer Support BN	65,350	1	25	65,350	UNK	Unconditioned Warehouse
9TH ESB ELEC-COMM SHOP	21710	Electronic/Comm Maint Shop, H&S Co, 9th ESB	7,950	1	15	7,950	UNK	Conditioned Auto / Maintenance Workshop
9TH ESB WOODWORKING SHOP	21356	Woodworking Shop, H&S Co, 9th ESB	6,620	1	15	6,620	UNK	Conditioned Auto / Maintenance Workshop
9TH ESB OPERATIONAL VEHICLE GARAGE	14311	Operational Vehicle Garage, 9th Engineering Support BN	23,100	1	15	23,100	UNK	Conditioned Auto / Maintenance Workshop
OPERATIONAL HAZ/FLAM STORAGE	14378	Operational Haz/Flam Storage, 9th ESB, 3D MLG	8,070	1	15	8,070	UNK	-
Area 3								
MLG HQ ADMIN	61070	MLG Headquarters	74,380	3	45	24,793	326	3 Story Headquarters Office (90,000 sq ft)
CLR-37 CO ADMIN	61073	Headquarters Company, CLR-37	27,970	2	30	13,985	172	2 Story Headquarters Office (30,000 sq ft)
3D MED BN ADMIN	61072	Bn/Co HQ, 3D Med BN	10,980	1	15	10,980	66	1 Story Small Office (15,000 sq ft)

Orig. Source: GJMMP Site Development Plan, Main Cantonment building List, Alt. 2, Sept 18, 2009

LEED NC Application Strategy

LEED NC Building Types



Note: Subject to change, graphic provided for illustrative purposes only

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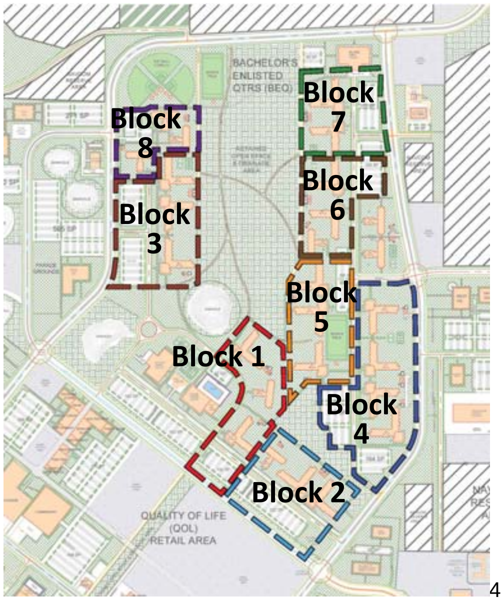
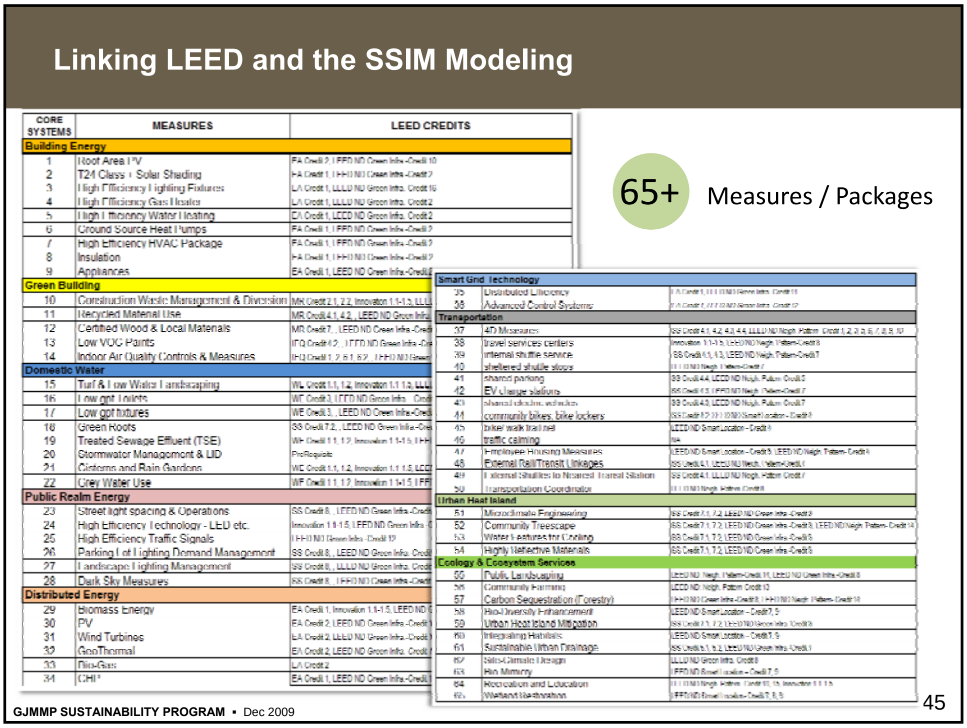
LEED NC Application Strategy

LEED NC "Block" Strategy

- Group 2-10 similar building types in the same phase together called a "block"
- First phase (or block) applies for LEED certification and completes full documentation
- Subsequent blocks can utilize former documentation that applies and can request the same LEED representative to review the same building types



Note: Subject to change, graphic provided for illustrative purposes only

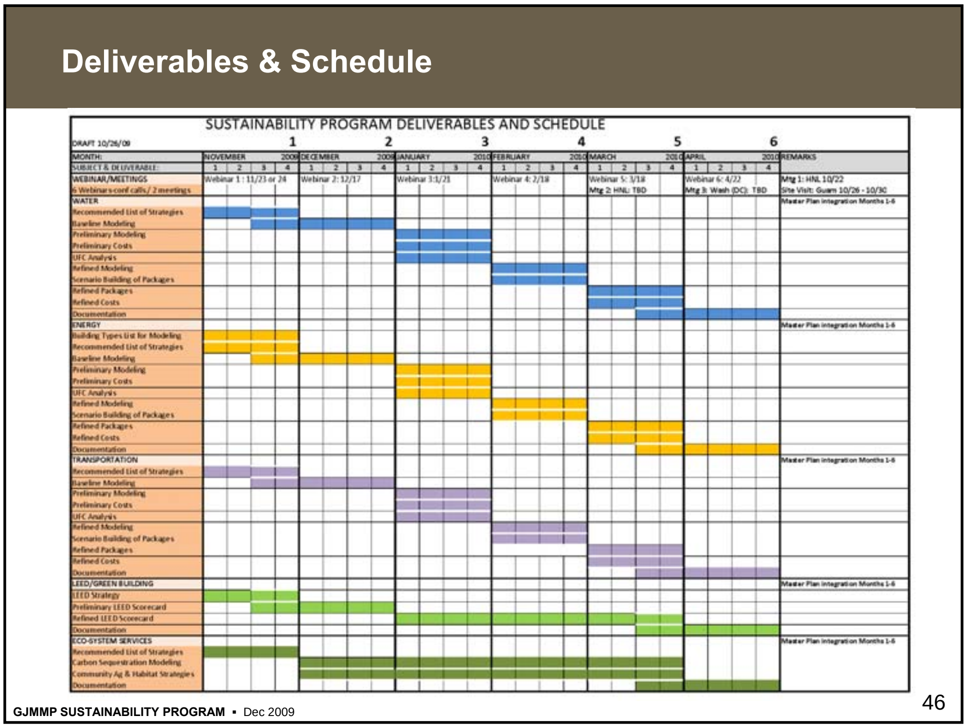


Linking LEED and the SSIM Modeling

CORE SYSTEMS	MEASURES	LEED CREDITS
Building Energy		
1	Roof Area PV	EA Credit 2, LEED ND Green Infra -Credit 10
2	T24 Class + Solar Shading	EA Credit 1, LEED ND Green Infra -Credit 2
3	High Efficiency Lighting Fixtures	EA Credit 1, LEED ND Green Infra. Credit 16
4	High Efficiency Gas Heater	EA Credit 1, LEED ND Green Infra. Credit 2
5	High Efficiency Water Heating	EA Credit 1, LEED ND Green Infra. Credit 2
6	Ground Source Heat Pumps	EA Credit 1, LEED ND Green Infra -Credit 2
7	High Efficiency HVAC Package	EA Credit 1, LEED ND Green Infra -Credit 2
8	Insulation	EA Credit 1, LEED ND Green Infra -Credit 2
9	Appliances	EA Credit 1, LEED ND Green Infra -Credit 2
Green Building		
10	Construction Waste Management & Diversion	MR Credit 2.1, 2.2, Innovation 1.1-1.5, LEE
11	Recycled Material Use	MR Credit 4.1, 4.2, , LEED ND Green Infra.
12	Certified Wood & Local Materials	MR Credit 7, , LEED ND Green Infra -Credi
13	Low VOC Paints	IEQ Credit 4.2, , LEED ND Green Infra -Cre
14	Indoor Air Quality Controls & Measures	IEQ Credit 1, 2, 6.1, 6.2, , LEED ND Green
Domestic Water		
15	Turf & Low Water Landscaping	WE Credit 1.1, 1.2, Innovation 1.1 1.5, LEE
16	Low gpf Toilets	WE Credit 3, LEED ND Green Infra. Credi
17	Low gpf fixtures	WE Credit 3, , LEED ND Green Infra -Credi
18	Green Roofs	SS Credit 7.2, , LEED ND Green Infra -Cre
19	Treated Sewage Effluent (TSE)	WE Credit 1.1, 1.2, Innovation 1.1-1.5, LEE
20	Stormwater Management & LID	PreRequisite
21	Cisterns and Rain Gardens	WE Credit 1.1, 1.2, Innovation 1.1 1.5, LEED
22	Grey Water Use	WE Credit 1.1, 1.2, Innovation 1.1-1.5, LEE
Public Realm Energy		
23	Street light spacing & Operations	SS Credit 8, , LEED ND Green Infra -Credit
24	High Efficiency Technology - LED etc.	Innovation 1.1-1.5, LEED ND Green Infra -C
25	High Efficiency Traffic Signals	LEED ND Green Infra -Credit 12
26	Parking Lot Lighting Demand Management	SS Credit 8, , LEED ND Green Infra -Credit
27	Landscape Lighting Management	SS Credit 8, , LEED ND Green Infra. Credi
28	Dark Sky Measures	SS Credit 8, , LEED ND Green Infra -Credit
Distributed Energy		
29	Biomass Energy	EA Credit 1, Innovation 1.1-1.5, LEED ND G
30	PV	EA Credit 2, LEED ND Green Infra -Credit 1
31	Wind Turbines	EA Credit 2, LEED ND Green Infra -Credit 1
32	GeoThermal	EA Credit 2, LEED ND Green Infra. Credit 1
33	Bio-Gas	EA Credit 2
34	CHP	EA Credit 1, LEED ND Green Infra -Credit 1

Smart Grid Technology		
35	Distributed Efficiency	EA Credit 1, LEED ND Green Infra. Credit 11
36	Advanced Control Systems	EA Credit 1, LEED ND Green Infra. Credit 12
Transportation		
37	4D Measures	SS Credit 4.1, 4.2, 4.3, 4.4, LEED ND Neigh. Pattern Credit 1, 2, 3, 5, 6, 7, 8, 9, 10
38	travel services centers	Innovation 1.1-1.5, LEED ND Neigh. Pattern-Credit 8
39	internal shuttle service	SS Credit 4.1, 4.3, LEED ND Neigh. Pattern-Credit 7
40	sheltered shuttle stops	LEED ND Neigh. Pattern-Credit 7
41	shared parking	SS Credit 4.4, LEED ND Neigh. Pattern Credit 5
42	EV charge stations	SS Credit 4.3, LEED ND Neigh. Pattern-Credit 7
43	shared electric vehicles	SS Credit 4.3, LEED ND Neigh. Pattern Credit 7
44	community bikes, bike lockers	SS Credit 4.2, LEED ND Smart Location - Credit 4
45	bike/ walk trail net	LEED ND Smart Location - Credit 4
46	traffic calming	NA
47	Employee Housing Measures	LEED ND Smart Location - Credit 5, LEED ND Neigh. Pattern- Credit 4
48	External Rail/Transit Linkages	SS Credit 4.1, LEED ND Neigh. Pattern-Credit 7
49	External Shuttles to Nearest Transit Station	SS Credit 4.1, LEED ND Neigh. Pattern Credit 7
50	Transportation Coordinator	LEED ND Neigh. Pattern Credit 8
Urban Heat Island		
51	Microclimate Engineering	SS Credit 7.1, 7.2, LEED ND Green Infra -Credit 9
52	Community Treescape	SS Credit 7.1, 7.2, LEED ND Green Infra -Credit 8, LEED ND Neigh. Pattern- Credit 14
53	Water Features for Cooling	SS Credit 7.1, 7.2, LEED ND Green Infra -Credit 8
54	Highly Reflective Materials	SS Credit 7.1, 7.2, LEED ND Green Infra -Credit 8
Ecology & Ecosystem Services		
55	Public Landscaping	LEED ND Neigh. Pattern-Credit 11, LEED ND Green Infra -Credit 8
56	Community Farming	LEED ND: Neigh. Pattern Credit 13
57	Carbon Sequestration (Forestry)	LEED ND Green Infra -Credit 8, LEED ND Neigh. Pattern- Credit 14
58	Bio-Diversity Enhancement	LEED ND Smart Location - Credit 7, 9
59	Urban Heat Island Mitigation	SS Credit 7.1, 7.2, LEED ND Green Infra. Credit 8
60	Integrating Habitats	LEED ND Smart Location - Credit 7, 9
61	Sustainable Urban Drainage	SS Credit 6.1, 6.2, LEED ND Green Infra -Credit 1
62	Site-Climate Design	LEED ND Green Infra. Credit 8
63	Bio Mimicry	LEED ND Smart Location - Credit 7, 9
64	Recreation and Education	LEED ND Neigh. Pattern Credit 10, 15, Innovation 1.1 1.5
65	Wetland Restoration	LEED ND Smart Location - Credit 7, 8, 9

65+ Measures / Packages

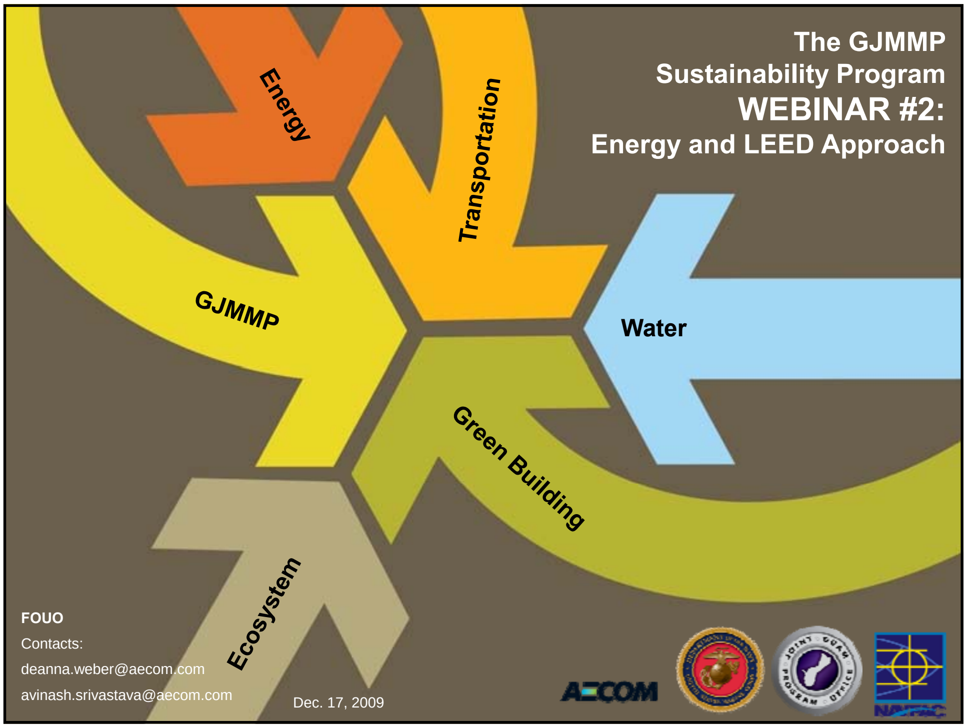


Deliverables & Schedule

SUSTAINABILITY PROGRAM DELIVERABLES AND SCHEDULE

DRAFT 10/26/09

	1				2				3				4				5				6				
MONTH:	NOVEMBER 2009				DECEMBER 2009				JANUARY 2010				FEBRUARY 2010				MARCH 2010				APRIL 2010				REMARKS
SUBJECT & DELIVERABLE:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
WEBINAR/MEETINGS	Webinar 1 : 11/23 or 24				Webinar 2: 12/17				Webinar 3:1/21				Webinar 4: 2/18				Webinar 5: 3/18				Webinar 6: 4/22				Mtg 1: HNL 10/22
6 Webinars-conf calls/ 2 meetings																	Mtg 2: HNL: TBD				Mtg 3: Wash (DC): TBD				Site Visit: Guam 10/26 - 10/30
WATER																									Master Plan integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
ENERGY																									Master Plan integration Months 1-6
Building Types List for Modeling	■	■	■	■																					
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
TRANSPORTATION																									Master Plan integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
LEED/GREEN BUILDING																									Master Plan integration Months 1-6
LEED Strategy	■	■	■	■																					
Preliminary LEED Scorecard			■	■	■	■	■	■																	
Refined LEED Scorecard									■	■	■	■	■	■	■	■	■	■	■	■					
Documentation																			■	■	■	■	■	■	
ECO-SYSTEM SERVICES																									Master Plan integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Carbon Sequestration Modeling					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Community Ag & Habitat Strategies					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Documentation																			■	■	■	■	■	■	



The GJMMP Sustainability Program
WEBINAR #2:
Energy and LEED Approach

Energy

Transportation

GJMMP

Water

Green Building

Ecosystem

FOUO

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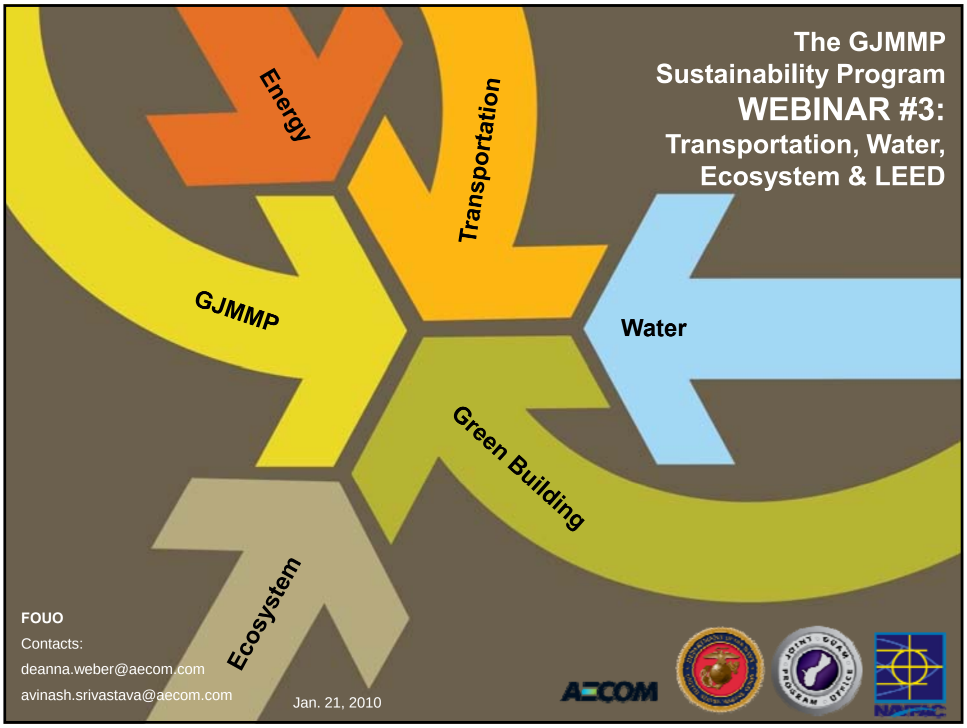
Dec. 17, 2009



The GJMMP Sustainability Program
WEBINAR #3:
Transportation, Water, Ecosystem & LEED

FOUO

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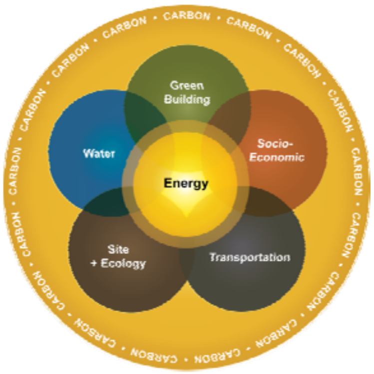
Jan. 21, 2010

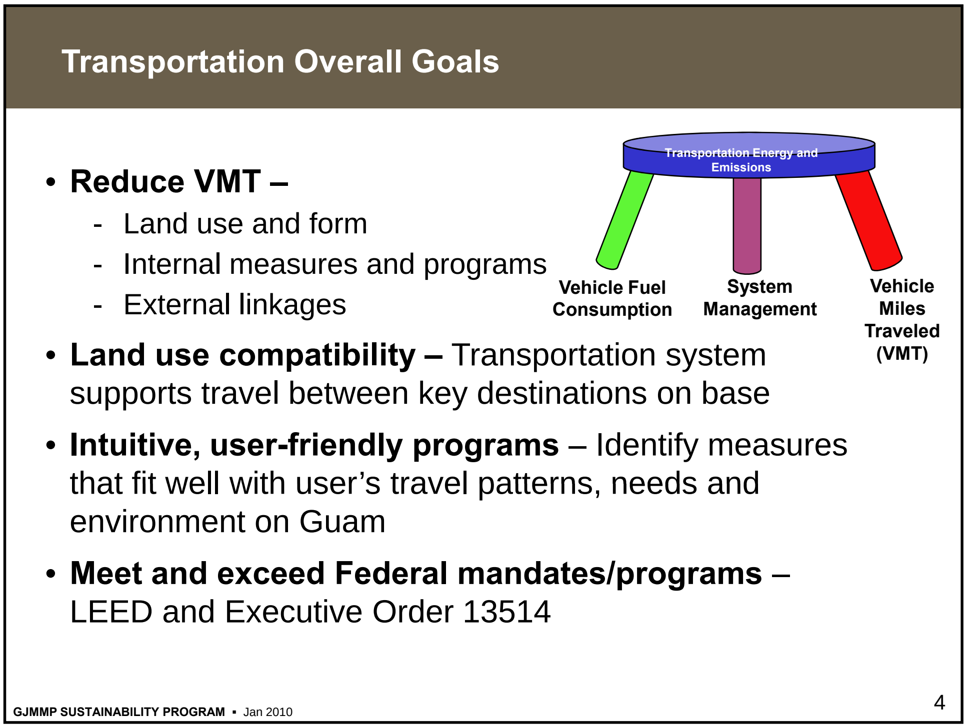
AGENDA

- Sustainable Transportation Summary of Work to Date
- Baseline SSIMw (Sustainable Systems Integration Modeling) Water Modeling
- Ecosystem Services Update
  - Local Food Production
  - Carbon Sequestration
- Update on Conference Calls with LEED Strategy
- Schedule and Deliverables:
  - Next webinar Feb. 18, 2010, Prelim. Modeling Results



Transportation Systems

will quantify cost versus benefit of VMT (Vehicle Mile Traveled) reduction



Transportation Overall Goals

- **Reduce VMT –**
  - Land use and form
  - Internal measures and programs
  - External linkages
- **Land use compatibility –** Transportation system supports travel between key destinations on base
- **Intuitive, user-friendly programs** – Identify measures that fit well with user’s travel patterns, needs and environment on Guam
- **Meet and exceed Federal mandates/programs** – LEED and Executive Order 13514

VMT Reduction Strategies (Summary from Webinar #1)

- **Benchmarks**
  - Baseline: Survey to help define
  - Option A: Good
  - Option B: Better
- **Executive Order 13514 Mandates**
  - Reduce use of fossil fuels via alternative fuels and optimizing the agency's vehicle fleet
  - Implement strategies and accommodations for transit, travel, training, and conferencing that actively support lower-carbon commuting and travel by agency staff
  - Consider sites that are pedestrian-friendly, near existing employment centers, and accessible to public transit

VMT Reduction Strategies (Summary from Webinar #1)

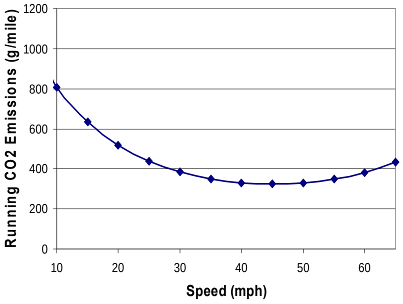
•Land Use and Form

•On-Base Measures and Programs
- •Shuttle buses
- •Trail system
- •Centralized and reduced parking supplies
- •Pedestrian & on-street bike system
- •Transportation Demand Management coordinator
- •Car, NEV, and bike share programs
- •Incentivize reduced car ownership

•Off-Base (External) Linkages
- •Coordination with Guam transit
- •Frequent and convenient transit service
- •Possibly restrict parking at North Ramp
- •Consider bicycle path along Route 3

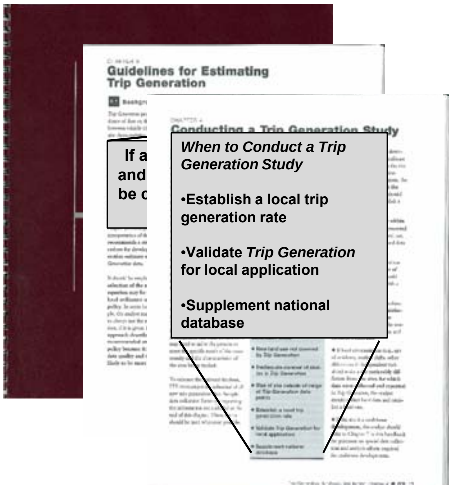
GJMMP – SSIM Transportation Analysis

- **Baseline to be determined by transportation survey**
  - **Surveying other Guam bases and Kanoehe Marine Base to determine travel patterns and preferences**
- **Estimate reduction in:**
  - **Vehicle trips**
  - **Vehicle Miles of Travel (VMT)**
  - **Parking supply need**
- **Estimate costs of measures**
- **Calculation reduction in GHGs from mobile sources**
- **Refine initial study findings**



VMT Baseline Methodology: Survey Purpose

- Survey to help characterize travel patterns typical to the base
- ITE recommended practice to supplement national database when a ***local*** rate is needed



Guidelines for Estimating Trip Generation

Conducting a Trip Generation Study

If a
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When to Conduct a Trip Generation Study

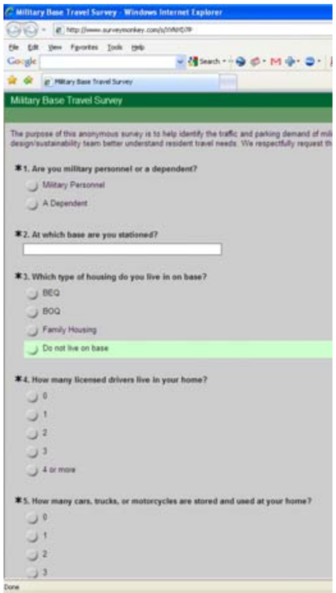
•Establish a local trip generation rate

•Validate *Trip Generation* for local application

•Supplement national database

VMT Baseline Methodology: Survey

- Limited existing information on travel patterns and trip-making characteristics for military personnel and dependents
- National data is limited:
  - based on 7 studies from Air Force bases
  - provides external trip information only
  - all located in CONUS
- Current draft of transportation study includes national ITE data and some local information for model
- Recommended survey intended to:
  - provide quick response to help validate/refine ITE information
  - on-line format easy for respondent and simplifies tabulation/data reduction
  - Provide data for future base planning/expansion



Military Base Travel Survey

The purpose of this anonymous survey is to help identify the traffic and parking demand of mil
design/sustainability team better understand resident travel needs. We respectfully request th

*1. Are you military personnel or a dependent?

○ Military Personnel
○ A Dependent

*2. At which base are you stationed?

*3. Which type of housing do you live in on base?

○ BEQ
○ BOQ
○ Family Housing
○ Do not live on base

*4. How many licensed drivers live in your home?

○ 0
○ 1
○ 2
○ 3
○ 4 or more

*5. How many cars, trucks, or motorcycles are stored and used at your home?

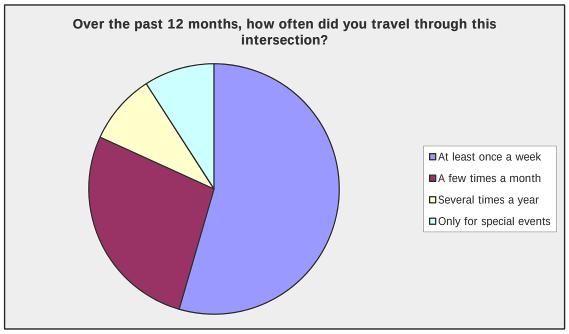
○ 0
○ 1
○ 2
○ 3

VMT Baseline Methodology: Sample Survey Output

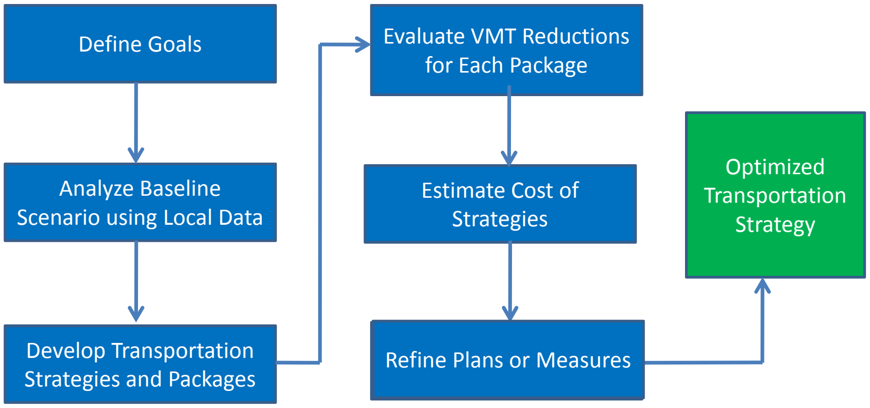
DRAFT Unser and Central Survey

Over the past 12 months, how often did you travel through this intersection?

Answer Options	**Response Percent**	**Response Count**
At least once a week	54.5%	6
A few times a month	27.3%	3
Several times a year	9.1%	1
Only for special events	9.1%	1
Other (please specify)		3
	answered question	**11**
	skipped question	**0**



GJMMP – SSIM Transportation Analysis



Define Goals

Analyze Baseline Scenario using Local Data

Develop Transportation Strategies and Packages

Evaluate VMT Reductions for Each Package

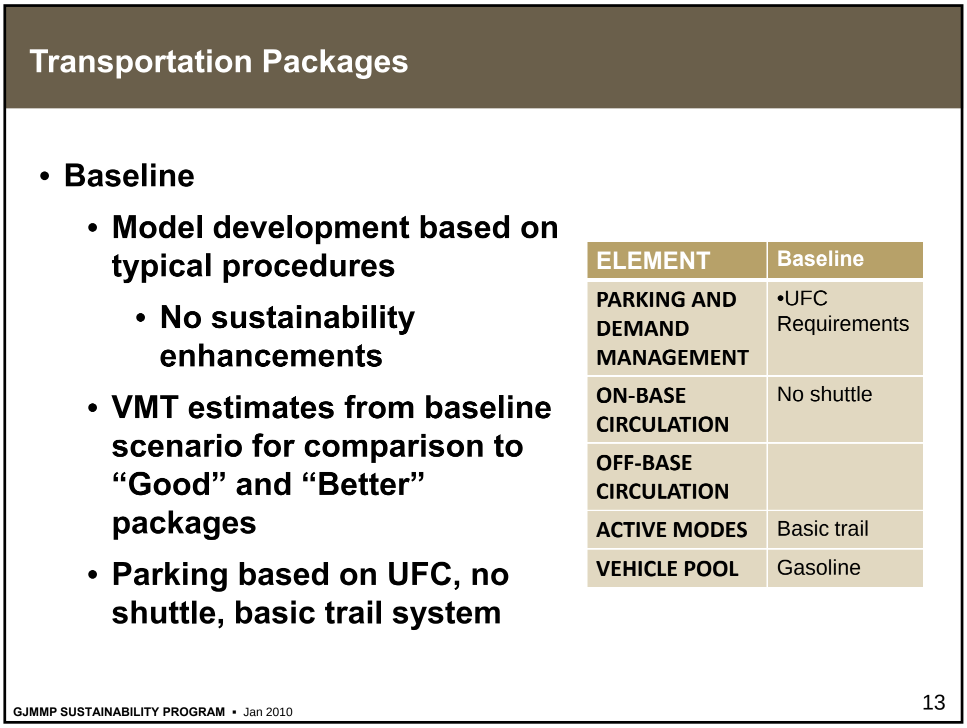
Estimate Cost of Strategies

Refine Plans or Measures

Optimized Transportation Strategy

Transportation Packages Overview

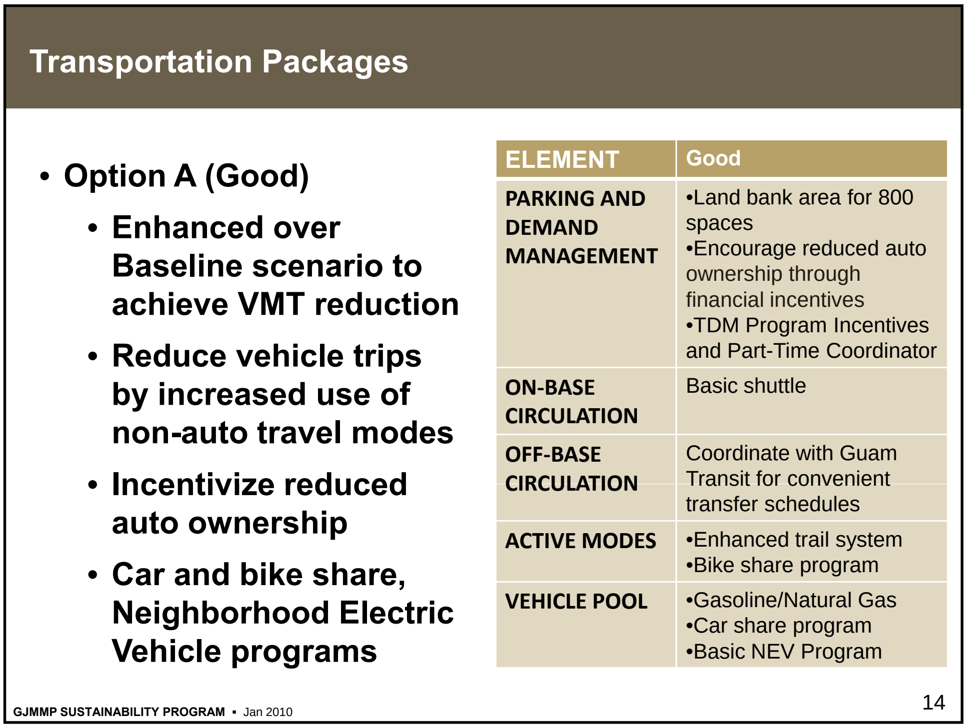
ELEMENT	Baseline	Good	Better
PARKING AND DEMAND MANAGEMENT	•UFC Requirements	•Land bank area for 800 spaces •Encourage reduced auto ownership through financial incentives •TDM Program Incentives and Part-Time Coordinator	•15% parking reduction •Centrally located parking facility •Limit auto ownership by rank •TDM Program Incentives and Disincentives and Full-Time Coordinator
ON-BASE CIRCULATION	No shuttle	Basic shuttle	Enhanced shuttle frequency, transfers, demand-responsive
OFF-BASE CIRCULATION	No	Coordinate with Guam Transit for convenient transfer schedules	Coordinate with Guam Transit for transfers, bike access, enhanced frequency and operating hours
ACTIVE MODES	Basic trail	•Enhanced trail system •Bike share program	•Robust trail system •Enhanced bike share •Context -sensitive street design and pedestrian amenities
VEHICLE POOL	Gasoline	•Gasoline/Natural Gas •Car share program •Basic NEV Program	•10% Electric,10% Hybrid •Enhanced car share •Enhanced NEV Program



Transportation Packages

- Baseline
  - Model development based on typical procedures
    - No sustainability enhancements
  - VMT estimates from baseline scenario for comparison to “Good” and “Better” packages
  - Parking based on UFC, no shuttle, basic trail system

ELEMENT	Baseline
PARKING AND DEMAND MANAGEMENT	•UFC Requirements
ON-BASE CIRCULATION	No shuttle
OFF-BASE CIRCULATION	
ACTIVE MODES	Basic trail
VEHICLE POOL	Gasoline



Transportation Packages

- Option A (Good)
  - Enhanced over Baseline scenario to achieve VMT reduction
  - Reduce vehicle trips by increased use of non-auto travel modes
  - Incentivize reduced auto ownership
  - Car and bike share, Neighborhood Electric Vehicle programs

ELEMENT	Good
PARKING AND DEMAND MANAGEMENT	•Land bank area for 800 spaces •Encourage reduced auto ownership through financial incentives •TDM Program Incentives and Part-Time Coordinator
ON-BASE CIRCULATION	Basic shuttle
OFF-BASE CIRCULATION	Coordinate with Guam Transit for convenient transfer schedules
ACTIVE MODES	•Enhanced trail system •Bike share program
VEHICLE POOL	•Gasoline/Natural Gas •Car share program •Basic NEV Program

Transportation Packages

- Option B (Better)
  - Good Package plus additional enhancements
  - Reduce parking provided and limit auto ownership
  - Emphasize transit connectivity and convenience
  - Robust active transportation network

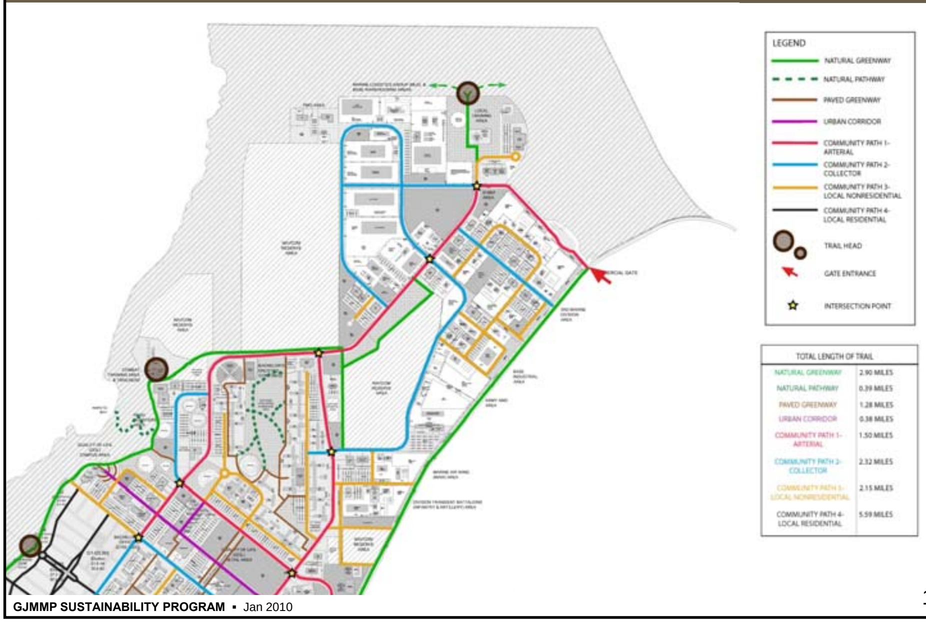
ELEMENT	Better
PARKING AND DEMAND MANAGEMENT	•15% parking reduction •Centrally located parking facility •Limit auto ownership by rank •TDM Program Incentives and Disincentives and Full-Time Coordinator
ON-BASE CIRCULATION	Enhanced shuttle frequency, transfers, demand-responsive
OFF-BASE CIRCULATION	Coordinate with Guam Transit for transfers, bike access, enhanced frequency and operating hours
ACTIVE MODES	•Robust trail system •Enhanced bike share •Context Sensitive Street Design and Pedestrian Amenities
VEHICLE POOL	•10% Electric,10% Hybrid •Enhanced car share •Enhanced NEV Program

SSIM Transportation Analysis – Next Steps

- **Validate Baseline Condition**
  - Using survey data
  - No shuttle, UFC parking criteria, basic bicycle and pedestrian facilities
- **Feedback on Good and Better Transportation Packages**
  - Make recommendations to meet federal mandate and identify enhanced measures
- **Review Unit Costs w/ NAVFAC staff to Adjust for Guam**
  - Minimize maintenance and capital costs

GJMMP DRAFT Trails Plan

GJMMP DRAFT Trails Plan



TOTAL LENGTH OF TRAIL	
NATURAL GREENWAY	2.90 MILES
NATURAL PATHWAY	0.39 MILES
PAVED GREENWAY	1.28 MILES
URBAN CORRIDOR	0.38 MILES
COMMUNITY PATH 1- ARTERIAL	1.50 MILES
COMMUNITY PATH 2- COLLECTOR	2.32 MILES
COMMUNITY PATH 3- LOCAL NONRESIDENTIAL	2.15 MILES
COMMUNITY PATH 4- LOCAL RESIDENTIAL	5.59 MILES

GJMMP DRAFT Trails Plan

TOTAL LENGTH OF TRAIL	
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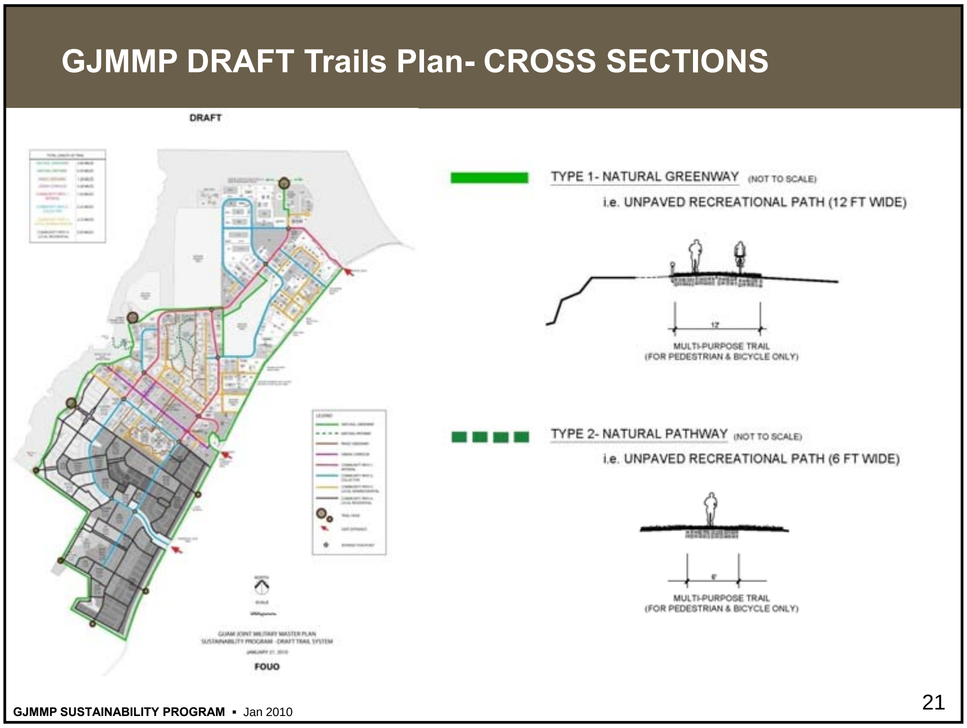


GJMMP DRAFT Trails Plan- CROSS SECTIONS

DRAFT

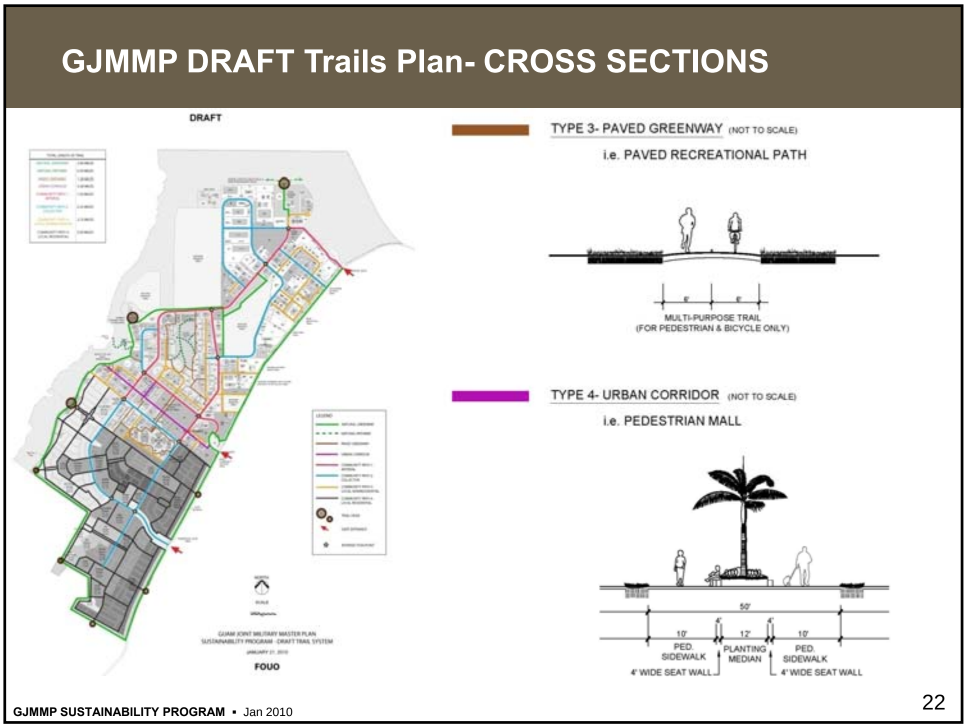
🟩 TYPE 1- NATURAL GREENWAY (NOT TO SCALE)

i.e. UNPAVED RECREATIONAL PATH (12 FT WIDE)

▪▪▪▪ TYPE 2- NATURAL PATHWAY (NOT TO SCALE)

i.e. UNPAVED RECREATIONAL PATH (6 FT WIDE)

GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM
JANUARY 21, 2010
FOUO



GJMMP DRAFT Trails Plan- CROSS SECTIONS

DRAFT

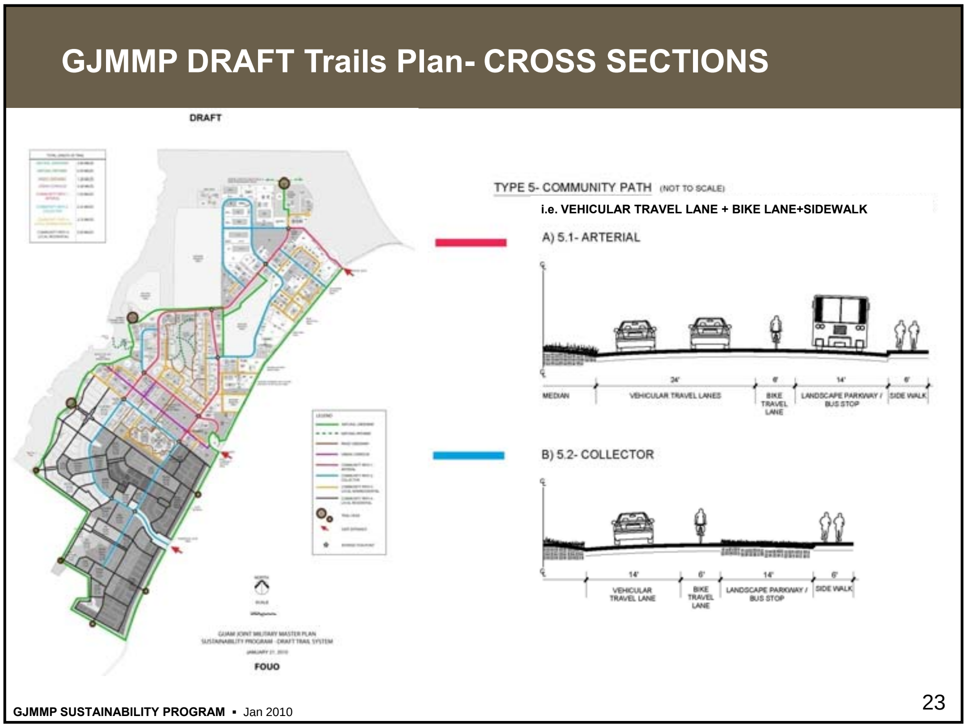
🟫 TYPE 3- PAVED GREENWAY (NOT TO SCALE)

i.e. PAVED RECREATIONAL PATH

🟪 TYPE 4- URBAN CORRIDOR (NOT TO SCALE)

i.e. PEDESTRIAN MALL

GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM
JANUARY 21, 2010
FOUO



GJMMP DRAFT Trails Plan- CROSS SECTIONS

DRAFT

GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM
JANUARY 21, 2010

FOUO

TYPE 5- COMMUNITY PATH (NOT TO SCALE)

i.e. VEHICULAR TRAVEL LANE + BIKE LANE+SIDEWALK

A) 5.1- ARTERIAL

B) 5.2- COLLECTOR

GJMMP SUSTAINABILITY PROGRAM ▪ Jan 2010

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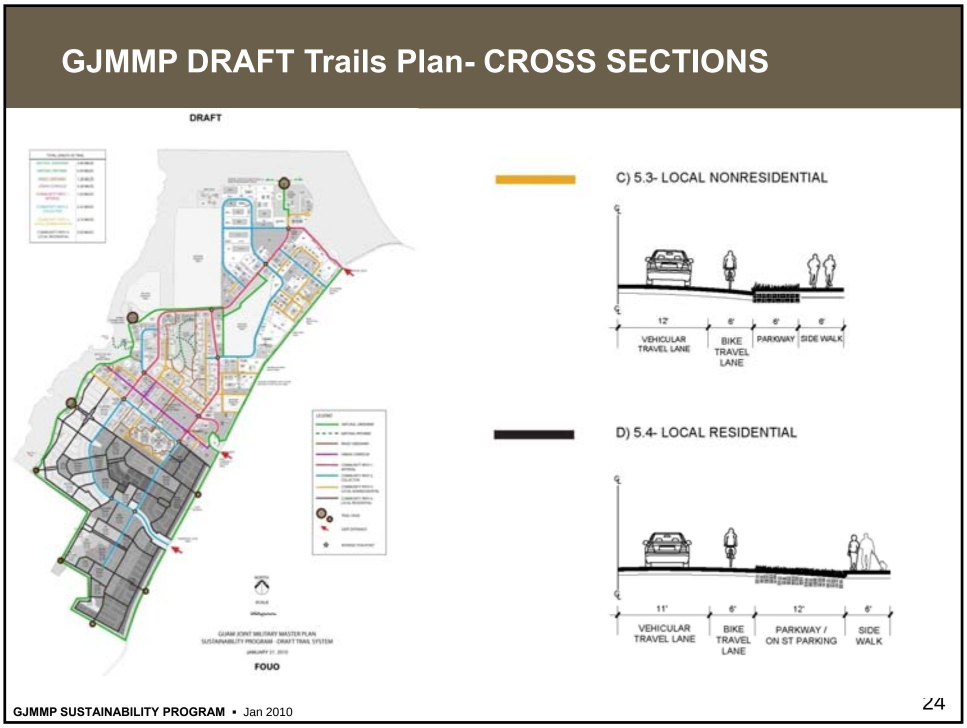

GJMMP DRAFT Trails Plan- CROSS SECTIONS

DRAFT

GUAM JOINT MILITARY MASTER PLAN
SUSTAINABILITY PROGRAM - DRAFT TRAIL SYSTEM
JANUARY 21, 2010

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C) 5.3- LOCAL NONRESIDENTIAL

D) 5.4- LOCAL RESIDENTIAL

GJMMP SUSTAINABILITY PROGRAM ▪ Jan 2010

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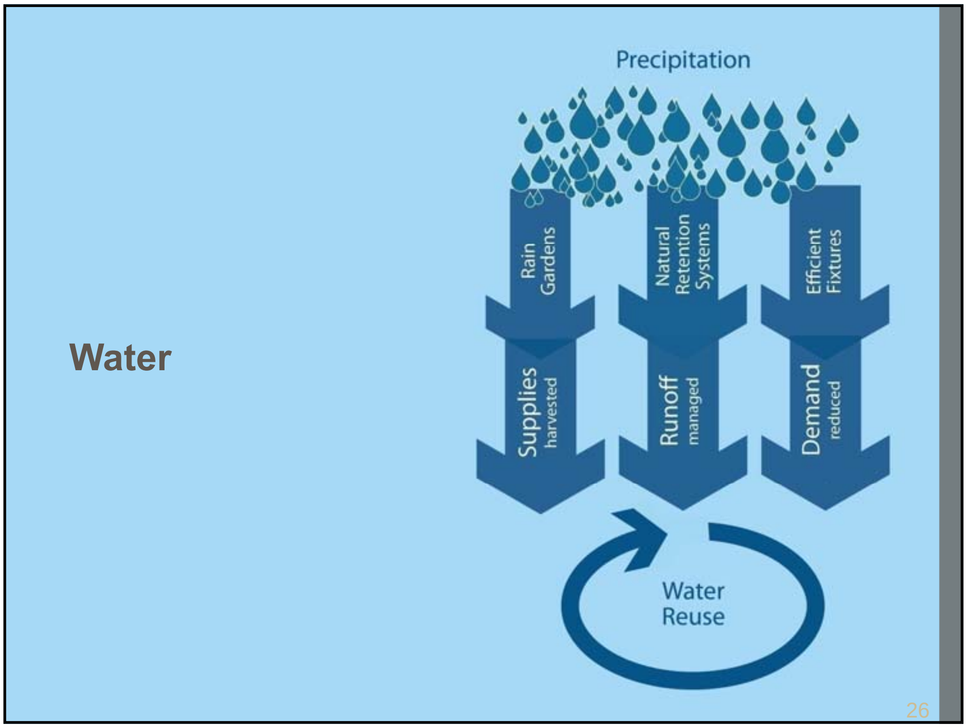
Water Balance Planning

establishes an equilibrium between natural water supplies and human demand.



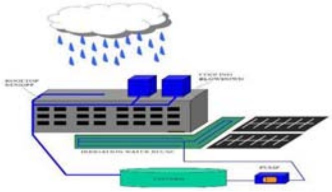
Water

Water Overall Goals (Summary from Webinar #1)

- **Conservation** – Reduce demand
- **Collection and reuse** - Harvesting
- **Protection of the aquifer** – Stormwater quality
- **Protection of coastal resources** – Stormwater quality
- **Meet and exceed Federal mandates** – LEED and Executive Order
- **Simple systems** – Ability to construct and monitor

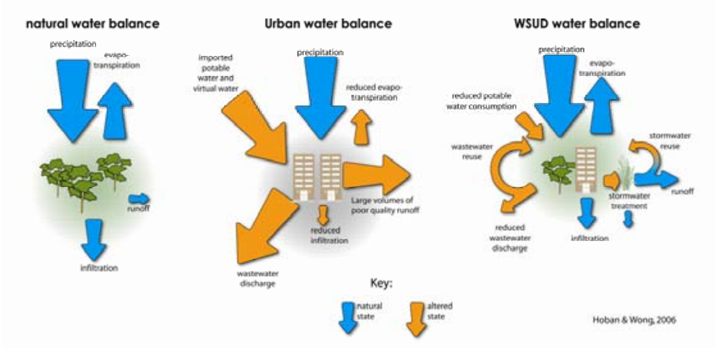
Water Reduction Strategies (Summary from Webinar #1)

- **Low flow fixtures in all buildings** – Water Sense (EPS) recommendations resulting in about 20-30% reduction in interior water use
- **Rooftop rainfall harvesting as water supply for toilet flushing (residential) and incidental irrigation** – reduction in additional 25% of potable water
- **Use condensate as supplemental water supply** for cisterns for toilet flushing (commercial/industrial)



Water Reduction Strategies Cont.

- **Stormwater management using natural means (Low Impact Development - LID)** to minimize sediment runoff into the ocean – treat up to 2-year, 24 hour storm
- **Consider graywater use in cisterns as additional water supply**



Hoban & Wong, 2006

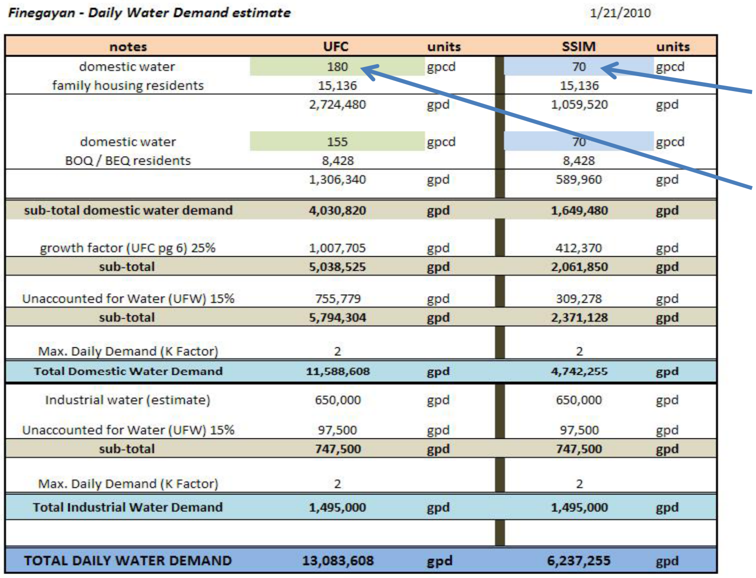
Water Federal Mandates

- **Federal Mandates and Executive Order 13514 (Oct 8, 2009)**
  - **Water reduction of 2%/year through 2013**
- **EISA 438 –**
  - **Incorporation of LID to all buildings greater than 5,000 gross square feet**
- **EPAct 2005**
- **LEED NC 2009 Version 3.0**

Water Reduction Strategies

- **Interior Water Use**
  - **Benchmarks – Housing example**
    - UFC – 180 gpcd
    - Option A - Adjusted UFC for EIS – 155 gpcd
    - Option B - Baseline EPA SSIM – 70 gpcd
    - Option C – Water Sense SSIM – 50 gpcd
  - **Reduction from UFC**
    - Option A - 14%
    - Option B - 61%
    - Option C - 72%

Water Reduction Strategies



Finegayan - Daily Water Demand estimate 1/21/2010

notes	UFC	units	SSIM	units
domestic water	180	gpcd	70	gpcd
family housing residents	15,136		15,136	
	2,724,480	gpd	1,059,520	gpd
domestic water	155	gpcd	70	gpcd
BOQ / BEQ residents	8,428		8,428	
	1,306,340	gpd	589,960	gpd
sub-total domestic water demand	**4,030,820**	**gpd**	**1,649,480**	**gpd**
growth factor (UFC pg 6) 25%	1,007,705	gpd	412,370	gpd
sub-total	**5,038,525**	**gpd**	**2,061,850**	**gpd**
Unaccounted for Water (UFW) 15%	755,779	gpd	309,278	gpd
sub-total	**5,794,304**	**gpd**	**2,371,128**	**gpd**
Max. Daily Demand (K Factor)	2		2	
Total Domestic Water Demand	**11,588,608**	**gpd**	**4,742,255**	**gpd**
Industrial water (estimate)	650,000	gpd	650,000	gpd
Unaccounted for Water (UFW) 15%	97,500	gpd	97,500	gpd
sub-total	**747,500**	**gpd**	**747,500**	**gpd**
Max. Daily Demand (K Factor)	2		2	
Total Industrial Water Demand	**1,495,000**	**gpd**	**1,495,000**	**gpd**
TOTAL DAILY WATER DEMAND	**13,083,608**	**gpd**	**6,237,255**	**gpd**

SSIM gpcd housing

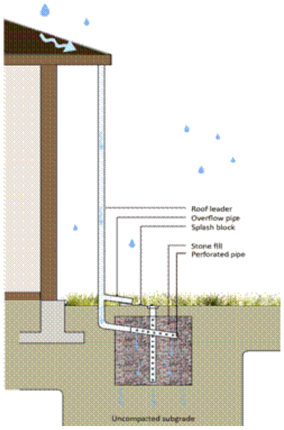
UFC gpcd housing

Water Reduction Strategies

- **Stormwater Management**
  - **Benchmarks**
    - **Maintain predevelopment hydrology to maximum extent technically feasible (METF)**
    - **Total volume of rainfall from 95th percentile storm to be managed on-site**
      - Bio-retention areas
      - Permeable pavements
      - Cisterns-recycling
      - Green roofs

Water Reduction Strategies

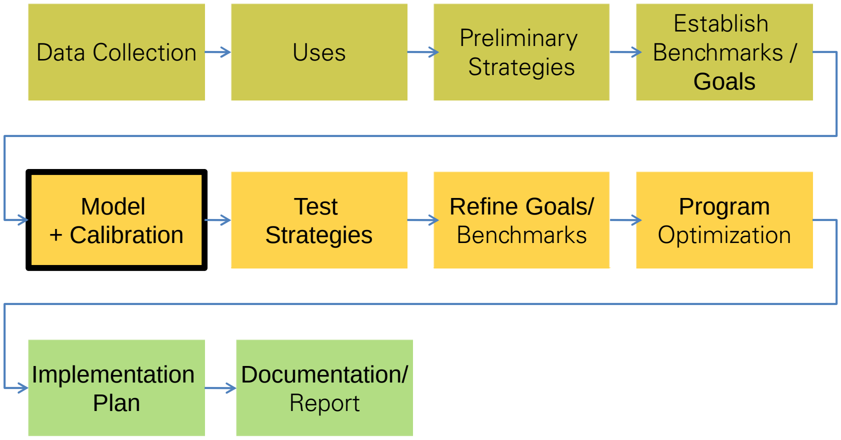
- **Synergies – Indoor/Outdoor**
  - **Rooftop harvesting for indoor water use**
    - Reduced potable demand (up to 20%) using harvested water
    - Reduced stormwater volume and treatment with harvesting
  - **Rainfall collection for equipment washing**



GJMMP – SSIM Water Analysis

- Baseline modeling begun for overall installation, identification of other water uses underway
- Calibration to local Guam conditions has already taken place as part of the baseline modeling process
- Further calibration to occur based on client feedback prior to development of the water conservation strategies

GJMMP – SSIM Water Analysis



Data Collection

Uses

Preliminary Strategies

Establish Benchmarks / Goals

Model + Calibration

Test Strategies

Refine Goals/ Benchmarks

Program Optimization

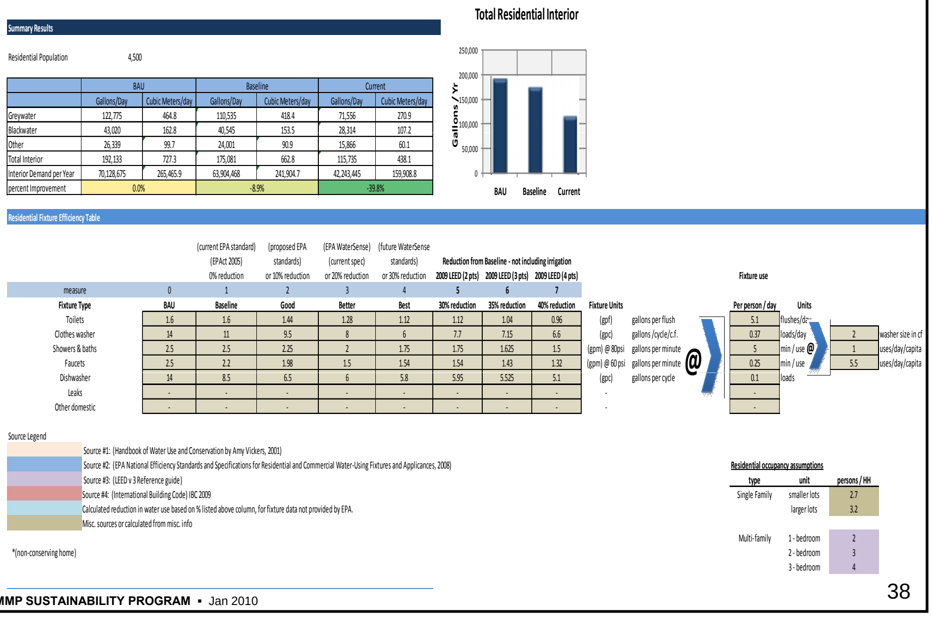
Implementation Plan

Documentation/ Report

GJMMP – SSIM Water Analysis

- **Water items for analysis**
  - **Demand by use – residential, institutional, warehouse, etc.**
  - **Interior potable water demand**
    - Toilets, dish and clothes washers, showers, lavatories, sinks
    - Cooling towers
  - **Exterior water demand**
    - Equipment washing
    - Construction
  - **Supply**
    - Groundwater
    - Rainfall harvesting
    - Greywater
    - Treated effluent
    - Condensate

GJMMP – Water Analysis



Summary Results

Residential Population 4,500

	BAU		Baseline		Current	
	Gallons/Day	Cubic Meters/day	Gallons/Day	Cubic Meters/day	Gallons/Day	Cubic Meters/day
Greywater	122,775	464.8	110,535	418.4	71,556	270.9
Blackwater	43,020	162.8	40,545	153.5	28,314	107.2
Other	26,339	99.7	24,001	90.9	15,866	60.1
Total Interior	192,133	727.3	175,081	662.8	115,735	438.1
Interior Demand per Year	70,128,675	265,465.9	63,904,468	241,904.7	42,243,445	159,908.8
percent Improvement	0.0%		-8.9%		-39.8%	

Residential Fixture Efficiency Table

		(current EPA standard) (EPAct 2005) 0% reduction	(proposed EPA standards) or 10% reduction	(EPA WaterSense) (current spec) or 20% reduction	(future WaterSense standards) or 30% reduction	**Reduction from Baseline - not including irrigation** **2009 LEED (2 pts)**	**2009 LEED (3 pts)**	**2009 LEED (4 pts)**			**Fixture use**			
measure	0	1	2	3	4	5	6	7						
Fixture Type	**BAU**	**Baseline**	**Good**	**Better**	**Best**	**30% reduction**	**35% reduction**	**40% reduction**	**Fixture Units**		**Per person / day**	**Units**		
Toilets	1.6	1.6	1.44	1.28	1.12	1.12	1.04	0.96	(gpf)	gallons per flush	5.1	flushes/day		
Clothes washer	14	11	9.5	8	6	7.7	7.15	6.6	(gpc)	gallons /cycle/c.f.	0.37	loads/day	2	washer size in cf
Showers & baths	2.5	2.5	2.25	2	1.75	1.75	1.625	1.5	(gpm) @ 80psi	gallons per minute	5	min / use @	1	uses/day/capita
Faucets	2.5	2.2	1.98	1.5	1.54	1.54	1.43	1.32	(gpm) @ 60 psi	gallons per minute	0.25	min / use	5.5	uses/day/capita
Dishwasher	14	8.5	6.5	6	5.8	5.95	5.525	5.1	(gpc)	gallons per cycle	0.1	loads		
Leaks	-	-	-	-	-	-	-	-	-		-			
Other domestic	-	-	-	-	-	-	-	-	-		-			

@

Source Legend

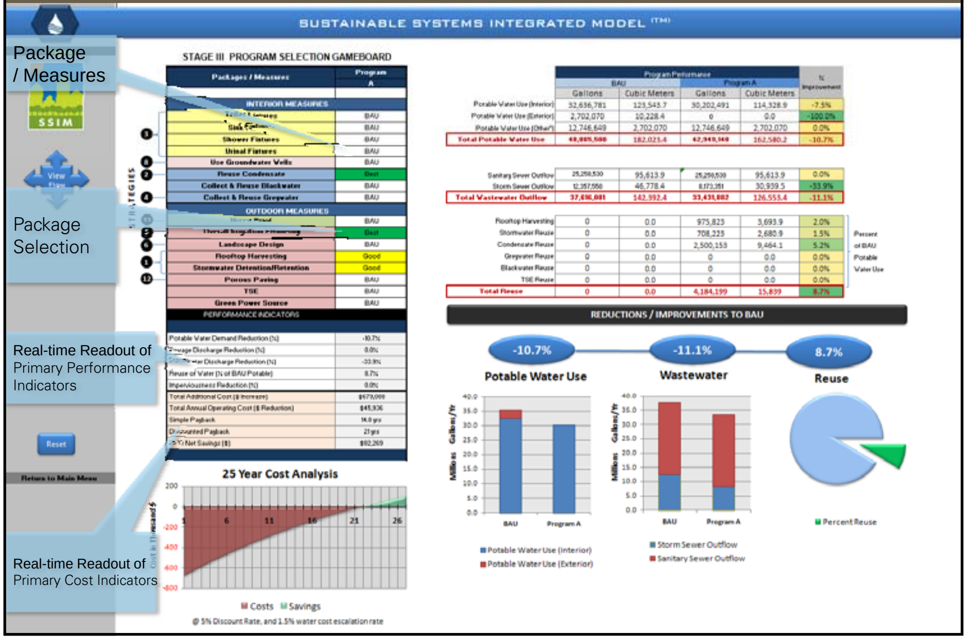
🟧	Source #1: (Handbook of Water Use and Conservation by Amy Vickers, 2001)
🟦	Source #2: (EPA National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Applicances, 2008)
🟪	Source #3: (LEED v 3 Reference guide)
🟥	Source #4: (International Building Code) IBC 2009
🟦	Calculated reduction in water use based on % listed above column, for fixture data not provided by EPA.
🟫	Misc. sources or calculated from misc. info

*(non-conserving home)

Residential occupancy assumptions

type	unit	persons / HH
Single Family	smaller lots	2.7
	larger lots	3.2
Multi-family	1 - bedroom	2
	2 - bedroom	3
	3 - bedroom	4

GJMMP – SSIM Water Analysis



Package / Measures

Package Selection

Real-time Readout of Primary Performance Indicators

Real-time Readout of Primary Cost Indicators

STAGE III PROGRAM SELECTION GAMEBOARD

Packages / Measures	Program A
INTERIOR MEASURES	
Toilet Fixtures	BAU
Sink Fixtures	BAU
Shower Fixtures	BAU
Urinal Fixtures	BAU
Use Groundwater Wells	BAU
Reuse Condensate	Best
Collect & Reuse Blackwater	BAU
Collect & Reuse Greywater	BAU
OUTDOOR MEASURES	
Green Roof	BAU
Overall Irrigation Efficiency	Best
Landscape Design	BAU
Rooftop Harvesting	Good
Stormwater Detention/Retention	Good
Porous Paving	BAU
TSE	BAU
Green Power Source	BAU

PERFORMANCE INDICATORS

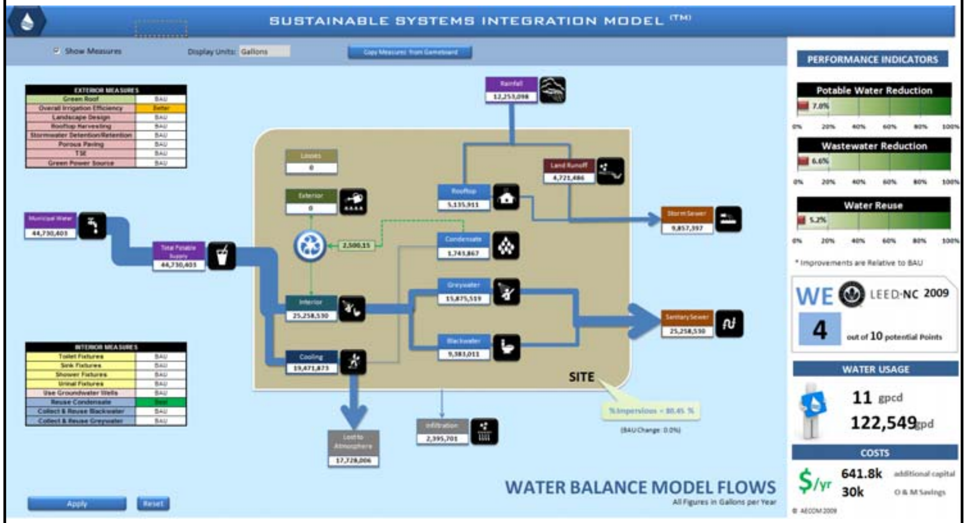
Potable Water Demand Reduction (%)	-10.7%
Sewage Discharge Reduction (%)	0.0%
Stormwater Discharge Reduction (%)	-33.9%
Reuse of Water (% of BAU Potable)	8.7%
Imperviousness Reduction (%)	0.0%
Total Additional Cost ($ Increase)	$673,000
Total Annual Operating Cost ($ Reduction)	$45,936
Simple Payback	14.0 yrs
Discounted Payback	21 yrs
25 Yr Net Savings ($)	$102,269

@ 5% Discount Rate, and 1.5% water cost escalation rate

	Program Performance				% Improvement
	BAU		Program A		
	Gallons	Cubic Meters	Gallons	Cubic Meters	
Potable Water Use (Interior)	32,636,781	123,543.7	30,202,491	114,328.9	-7.5%
Potable Water Use (Exterior)	2,702,070	10,228.4	0	0.0	-100.0%
Potable Water Use (Other*)	12,746,649	2,702,070	12,746,649	2,702,070	0.0%
Total Potable Water Use	48,085,500	182,023.4	42,949,140	162,580.2	-10.7%
Sanitary Sewer Outflow	25,258,530	95,613.9	25,258,530	95,613.9	0.0%
Storm Sewer Outflow	12,357,550	46,778.4	8,173,351	30,939.5	-33.9%
Total Wastewater Outflow	37,616,081	142,392.4	33,431,882	126,553.4	-11.1%
Rooftop Harvesting	0	0.0	975,823	3,693.9	2.0%
Stormwater Reuse	0	0.0	708,223	2,680.9	1.5%
Condensate Reuse	0	0.0	2,500,153	9,464.1	5.2%
Greywater Reuse	0	0.0	0	0.0	0.0%
Blackwater Reuse	0	0.0	0	0.0	0.0%
TSE Reuse	0	0.0	0	0.0	0.0%
Total Reuse	0	0.0	4,184,199	15,839	8.7%

Percent of BAU Potable Water Use

GJMMP – SSIM Water Analysis



☑ Show Measures Display Units: Gallons

EXTERIOR MEASURES	
Green Roof	BAU
Overall Irrigation Efficiency	Better
Landscape Design	BAU
Rooftop Harvesting	BAU
Stormwater Detention/Retention	BAU
Porous Paving	BAU
TSE	BAU
Green Power Source	BAU

INTERIOR MEASURES	
Toilet Fixtures	BAU
Sink Fixtures	BAU
Shower Fixtures	BAU
Urinal Fixtures	BAU
Use Groundwater Wells	BAU
Reuse Condensate	Best
Collect & Reuse Blackwater	BAU
Collect & Reuse Greywater	BAU

WATER BALANCE MODEL FLOWS

All Figures in Gallons per Year

PERFORMANCE INDICATORS

Potable Water Reduction: 7.0%

Wastewater Reduction: 6.6%

Water Reuse: 5.2%

* Improvements are Relative to BAU

4 out of 10 potential Points

WATER USAGE

11 gpcd

122,549 gpd

COSTS

$/yr

641.8k additional capital

30k O & M Savings

© AECOM 2009

Water Packages

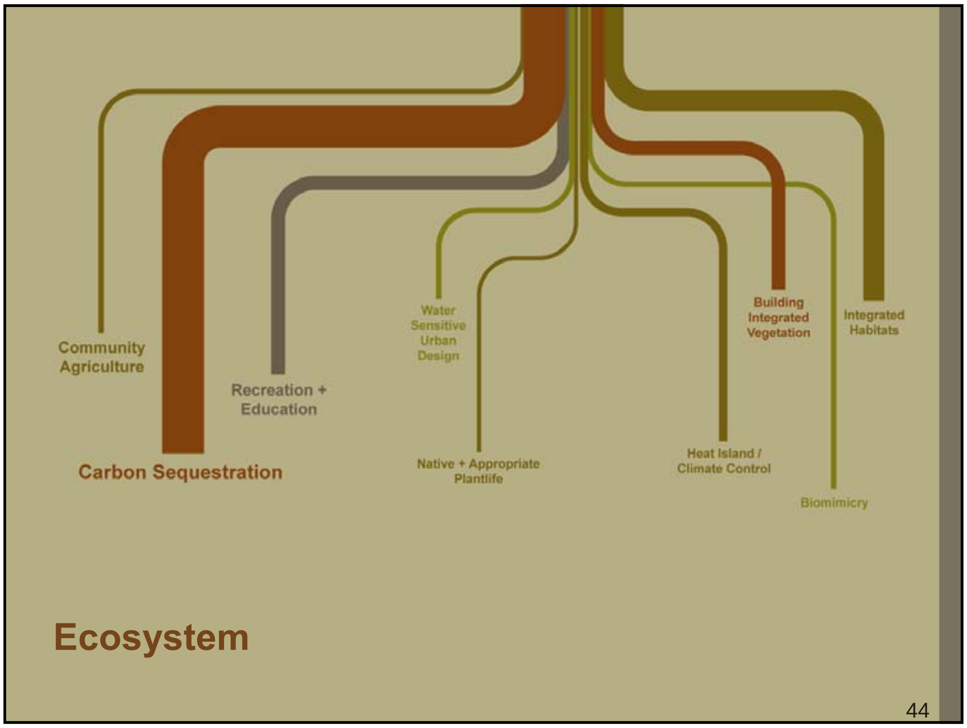
- **Initial water strategies for evaluation**
  - Efficient indoor fixtures
  - Rooftop harvesting/cisterns
  - Neighborhood harvesting
  - LID/stormwater management
  - Stormwater harvesting for non-potable water use
  - Condensate water use
  - Reduced flows/energy reduction
  - Reduced flows/cost reductions

SSIM Water Analysis – Next Steps

- Stormwater calibration with current LID study
- Further calibration of the baseline water model based on client feedback
- Development of water supply and demand balance/monthly
- Development of initial cistern sizing for rooftop harvesting and interior demand

Ecological Infrastructure

mitigates greenhouse gas emissions, protects biodiversity, conserves water and enhances quality of life.



Community Agriculture

Carbon Sequestration

Recreation + Education

Water Sensitive Urban Design

Native + Appropriate Plantlife

Heat Island / Climate Control

Building Integrated Vegetation

Integrated Habitats

Biomimicry

Ecosystem

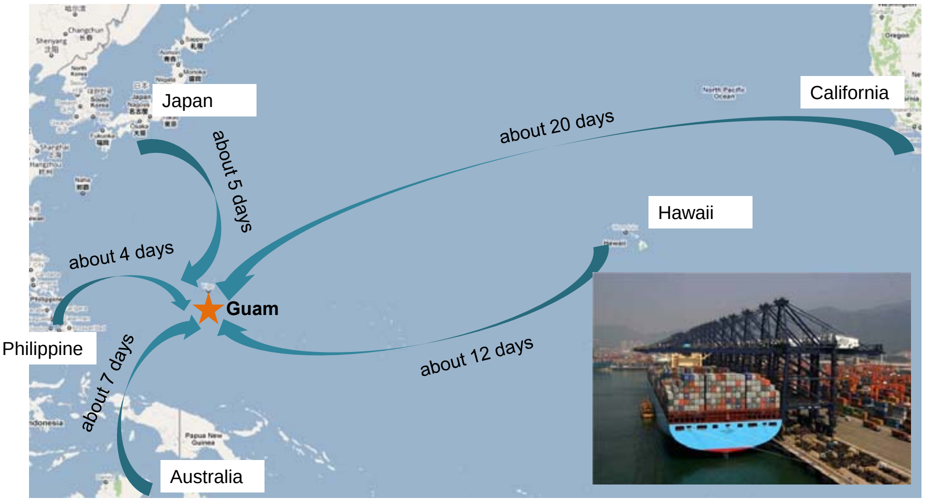
Ecosystem Strategies Overview

- Local Food Production
- Carbon Sequestration
- Guam Native Landscape Design Guidelines
- Guam Habitat Friendly Design Strategy
- Education & Recreation

Local Food Production – Gets National Attention !

Local Food Production – Existing Conditions

Do you realize how far food travels to Guam?

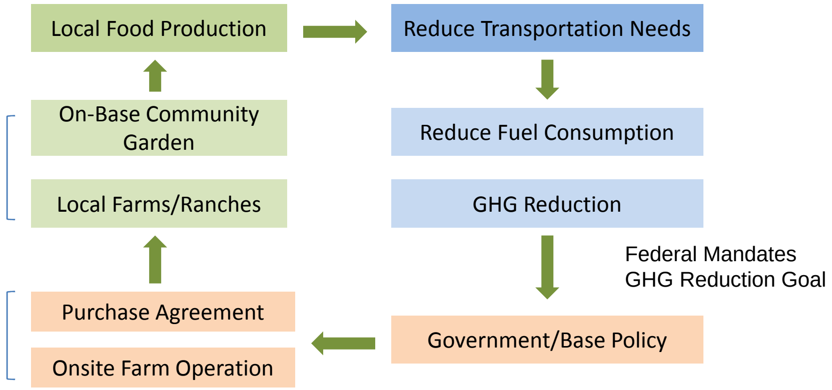


Local Food Production – Challenges & Opportunities

- GHG Emissions from Maritime Transportation
  - International Shipping Contributed to 2.7% of total global CO_2 emissions in 2007 (Source: International Maritime Organization)
  - Large amount of fruits and vegetables are shipped from CONUS, 40 days round trip to Guam
- Invasive Species
  - Imported agricultural products also increase the risk of bringing invasive species that endanger local ecological system

Local Food Production – Carbon Reduction Model

- Goal
  - To estimate GHG reduction from local food production
  - To make recommendation on master planning level and policy level
- Methodology



Local Food Production

Reduce Transportation Needs

On-Base Community Garden

Reduce Fuel Consumption

Local Farms/Ranches

GHG Reduction

Federal Mandates
GHG Reduction Goal

Purchase Agreement

Onsite Farm Operation

Government/Base Policy

Local Food Production – Preliminary Results

DRAFT

		Option A	Option B	Option C
Scenario	On-Base Community Garden(acres)	2	4	8
	Local Fruit/Vegetable Purchase (% of weekly consumption)	10%	15%	20%
Saving on Ship Fuel Oil Per Year (Tons)		12.67	19.15	27.02
GHG Reduction Per Year (Metric Tons)		76.9	115.8	158.9

*Population based on current master plan program

- Next Step
  - Verify key assumptions
  - Research on the cost information for policy recommendation

Local Food Production – Key Assumptions

DRAFT

- Local farm/agricultural data
  - Length of Season – year round (12 months) (Source: interview with Farmer's Cooperative Association of Guam)
  - Fruits and vegetables consumed per person: 13.6 lb/week (Source: USDA)
- Maritime transportation and emission data
  - Maritime transport vessel: 4000 TEU container ship
  - Avg. fuel consumption: 28000 tons per year
  - Days on the sea: 250 days per year
  - Fuel CO_2 Equivalent Factor: 3.06 MT/Ton (Source: <Greenhouse Gas Emission from Ships>, International Maritime Organization, 2008)
  - Avg. shipping days to Guam from Various location: 12.7 days one way (Source: desktop research and assumptions)

Local Food Production – More Benefits

- Significant Social Value of Local Food Production
- Fresh food for locals
- Enhance quality of life and promote healthy lifestyle in local community
- Boost local economy and job opportunities
- Educational program

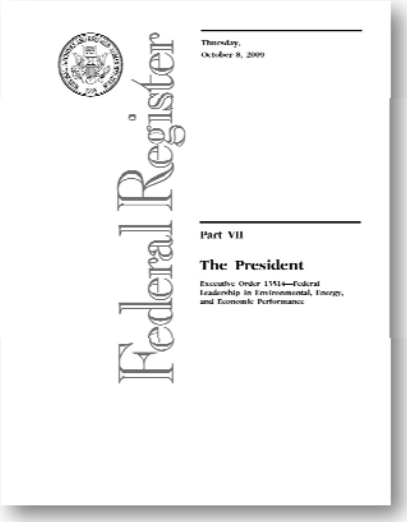
Local Food Production Strategy

- **Exploring the opportunity for an on-base community garden**
  - Incorporate with landscape design in the family housing area
  - Other potential sites on the base
- **Promoting local food purchase agreement with local farms and ranches**
  - Schools
  - Dining facilities/Cafeterias
  - Commissary

Executive Order 13514

This Executive Order sets sustainability goals for Federal agencies and focuses on making improvements in their environmental, energy and economic performance.

…requires Federal agencies to set a 2020 greenhouse gas emissions reduction target within 90 days; increase energy efficiency; reduce fleet petroleum consumption; conserve water; reduce waste; support sustainable communities; and ***leverage Federal purchasing power to promote environmentally-responsible products and technologies.***



Federal Register

Thursday,
October 8, 2009

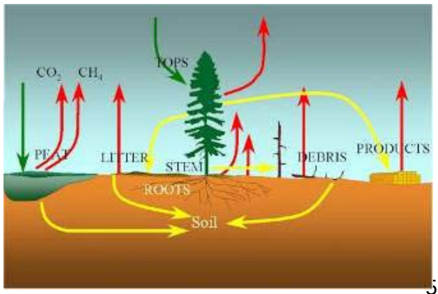
Part VII

The President

Executive Order 13514—Federal Leadership in Environmental, Energy, and Economic Performance

Carbon Sequestration – Definition

- “**Carbon Sequestration** is the process by which atmospheric carbon dioxide is absorbed by trees [and vegetation] through photosynthesis and stored as carbon in biomass and soils.”
  - -USDA Forest Service
- Factors
  - Tree type: Hardwood or Conifer
  - Growth rate, Tree age
  - Soil type
  - Regional climate
  - Topography
  - Sequestration rate



Carbon Sequestration – Identify Landscaped Area Types

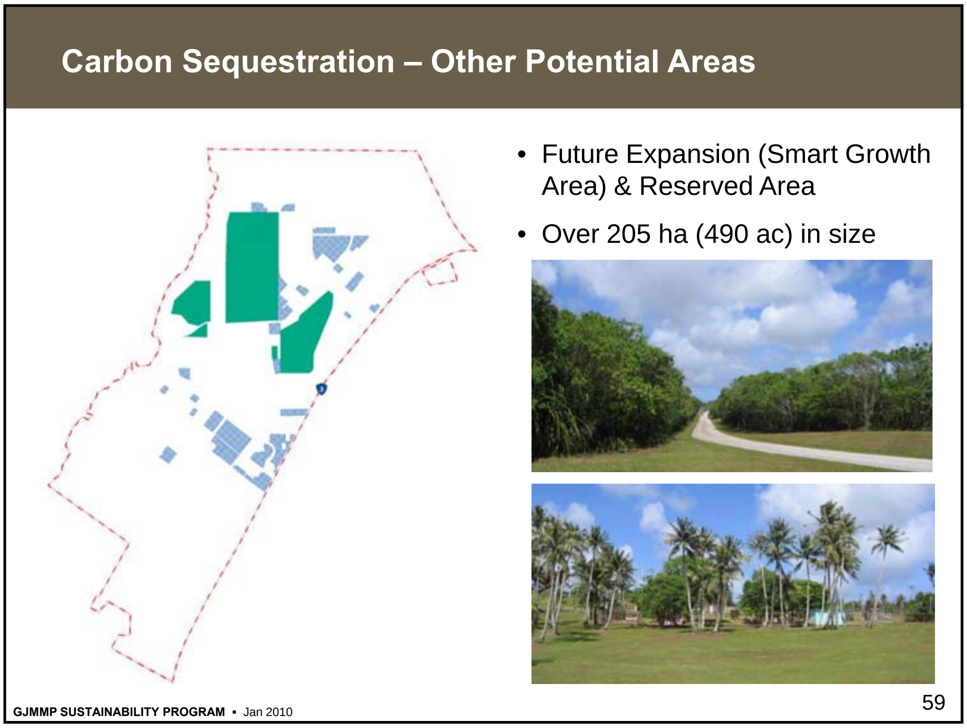
- Preserved/Protect Forest/Landscape
- Over 230 ha (550 ac) total

Carbon Sequestration - Identify Landscaped Area Types

- Landscaped Open Space & Parks
- Over 260 ha (620 ac) in size

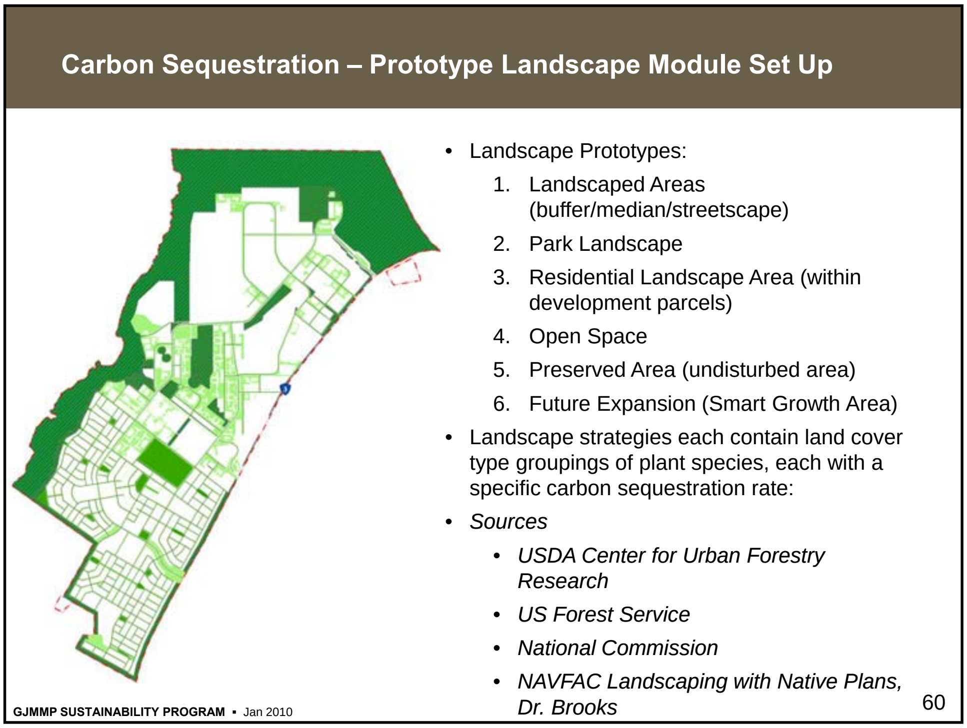
Carbon Sequestration - Identify Landscaped Area Types

- Street Trees and Parkways
- Over 68,000 meters (223,000 feet) in total length



Carbon Sequestration – Other Potential Areas

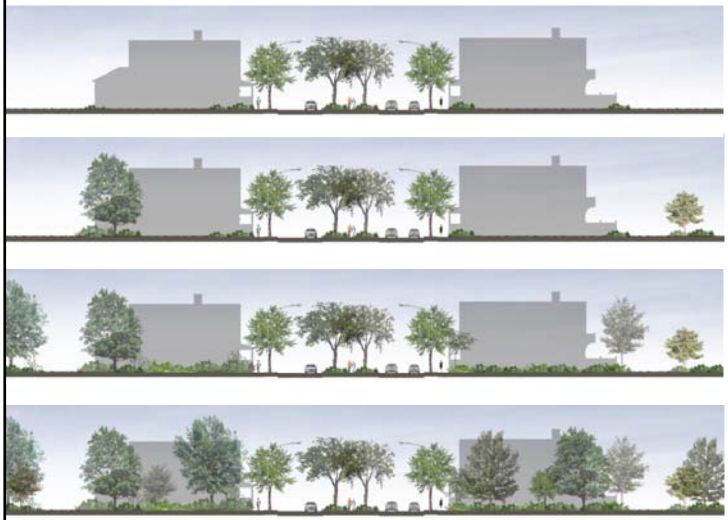
- Future Expansion (Smart Growth Area) & Reserved Area
- Over 205 ha (490 ac) in size



Carbon Sequestration – Prototype Landscape Module Set Up

- Landscape Prototypes:
  1. Landscaped Areas (buffer/median/streetscape)
  2. Park Landscape
  3. Residential Landscape Area (within development parcels)
  4. Open Space
  5. Preserved Area (undisturbed area)
  6. Future Expansion (Smart Growth Area)
- Landscape strategies each contain land cover type groupings of plant species, each with a specific carbon sequestration rate:
- *Sources*
  - *USDA Center for Urban Forestry Research*
  - *US Forest Service*
  - *National Commission*
  - *NAVFAC Landscaping with Native Plans, Dr. Brooks*

Carbon Sequestration – Sample Module Scenarios



Baseline

(13 trees per acre)

Option A

(16 trees per acre)

Option B

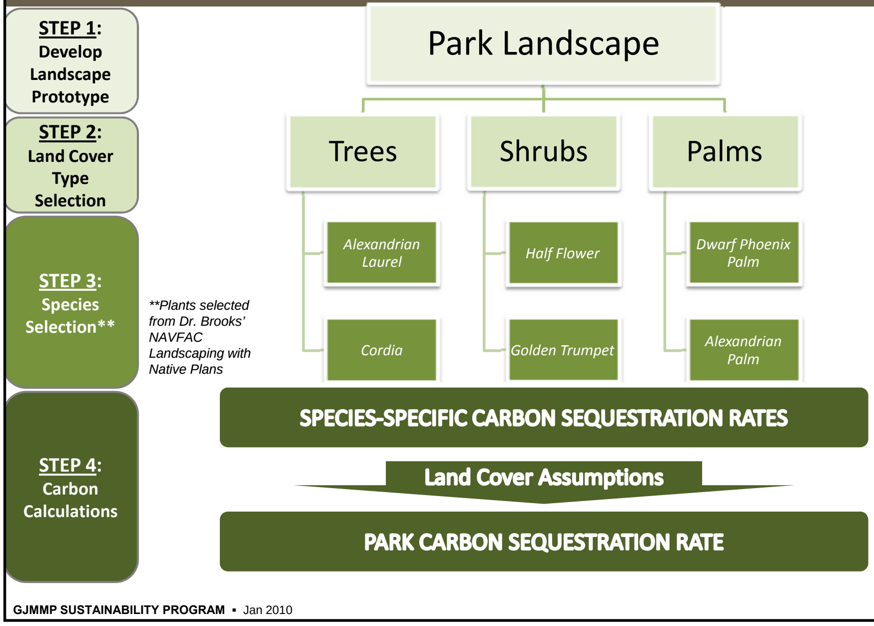
(20 trees per acre)

Option C

(25 trees per acre)

* Conceptual landscape alternatives only, Guam local landscape palette will be applied for this study.

Carbon Sequestration – Methodology and Modeling Approach



STEP 1: Develop Landscape Prototype

STEP 2: Land Cover Type Selection

STEP 3: Species Selection**

STEP 4: Carbon Calculations

Park Landscape

- Trees
  - *Alexandrian Laurel*
  - *Cordia*
- Shrubs
  - *Half Flower*
  - *Golden Trumpet*
- Palms
  - *Dwarf Phoenix Palm*
  - *Alexandrian Palm*

***Plants selected from Dr. Brooks' NAVFAC Landscaping with Native Plans*

SPECIES-SPECIFIC CARBON SEQUESTRATION RATES

Land Cover Assumptions

PARK CARBON SEQUESTRATION RATE

Carbon Sequestration – Methodology and Modeling Approach

DRAFT

BASELINE SCENARIO: *PRELIMINARY*

- Baseline scenario was developed assuming land cover distribution in site area similar to overall district
  - Overall district contains over 1,980 acres (800 hectares) of green space
  - Assumed distribution of current green space across prototypical landscapes
  - Landscape assumptions: coconut palm with turf

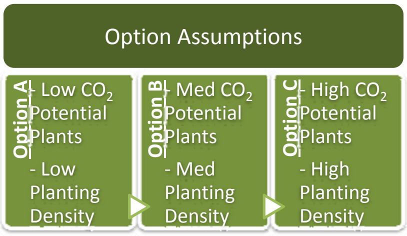
Carbon Sequestration	**Baseline**		
Prototype Landscapes	*CO_2 Sequestration Rate (kg/ha/yr)*	*Prototype Landscape Area (ha)*	*CO_2 Sequestration (kg/yr)*
Landscaped Areas (buffer/median/streetscape)	6,372	143.9	917,214
Park Landscape	14,868	28.1	418,241
Residential Landscape Area (within development parcel)	7,434	141.0	1,047,956
Open Space	10,620	94.8	1,007,039
Preserved Area - Undisturbed Areas	49,300	327.4	16,140,495
Future Expansion	7,434	66.7	495,618
Totals		**801.9**	**20,026,563**

Carbon Sequestration – Methodology and Modeling Approach

DRAFT

OPTIONS ANALYSIS: *PRELIMINARY*

- Options were developed based on varying landscape coverage, planting density, and the amount of land allocated for each prototypical landscape
- Carbon sequestration rates were developed for each prototypical landscape in each alternative, using land use program, overall carbon sequestration potential was generated.



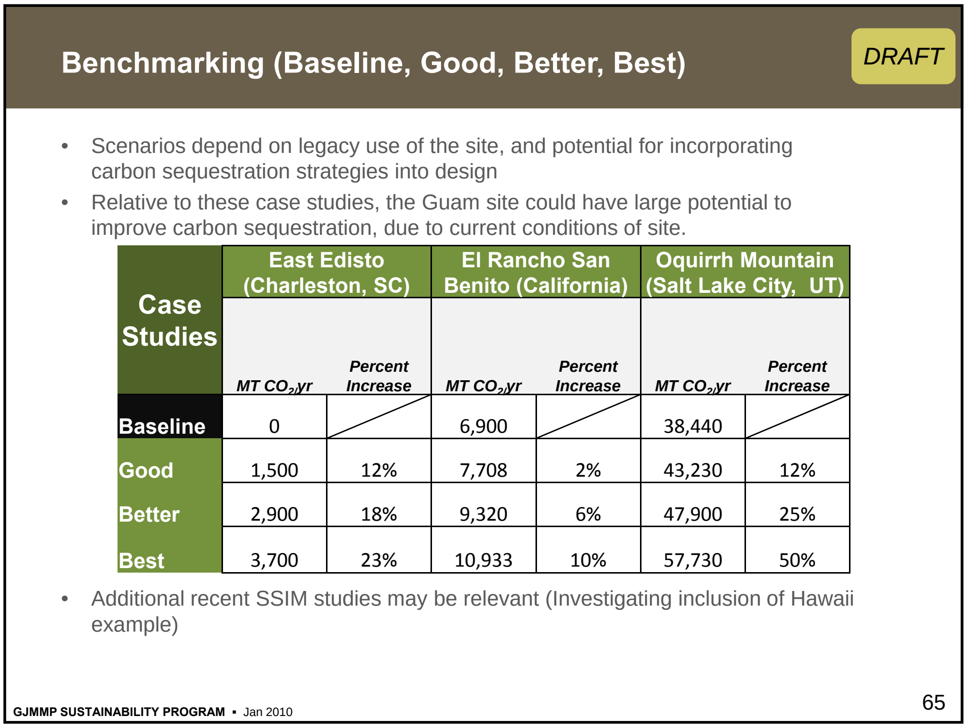
Option Assumptions

Option A
- Low CO_2 Potential Plants
- Low Planting Density

Option B
- Med CO_2 Potential Plants
- Med Planting Density

Option C
- High CO_2 Potential Plants
- High Planting Density

Carbon Sequestration (kg/yr)	**Baseline**	**Option A**	**Option B**	**Option C**
Prototype Landscapes				
Landscaped Areas (buffer/median/streetscape)	917,214	1,636,151	3,089,643	4,635,341
Park Landscape	418,241	746,070	1,408,850	2,113,674
Residential Landscape Area (within development parcel)	1,047,956	1,869,373	3,530,050	5,296,076
Open Space	1,007,039	1,796,385	3,392,222	5,089,294
Preserved Area - Undisturbed Areas	16,140,495	16,140,495	16,140,495	16,140,495
Future Expansion	495,618	884,097	1,669,494	2,504,715
Totals	**20,026,563**	**23,072,571**	**29,230,754**	**35,779,595**
Percent Change	**N/A**	**15.2%**	**46.0%**	**78.7%**



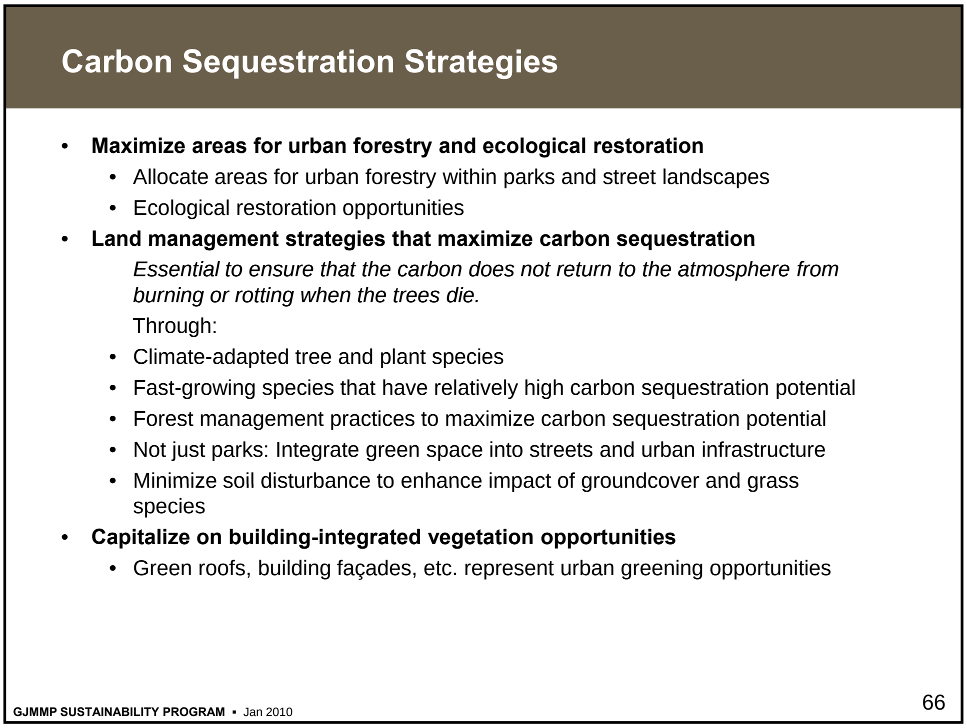
Benchmarking (Baseline, Good, Better, Best)

DRAFT

- Scenarios depend on legacy use of the site, and potential for incorporating carbon sequestration strategies into design
- Relative to these case studies, the Guam site could have large potential to improve carbon sequestration, due to current conditions of site.

Case Studies	East Edisto (Charleston, SC)		El Rancho San Benito (California)		Oquirrh Mountain (Salt Lake City, UT)	
	MT CO_2*/yr*	*Percent Increase*	*MT* CO_2*/yr*	*Percent Increase*	*MT* CO_2*/yr*	*Percent Increase*
Baseline	0		6,900		38,440	
Good	1,500	12%	7,708	2%	43,230	12%
Better	2,900	18%	9,320	6%	47,900	25%
Best	3,700	23%	10,933	10%	57,730	50%

- Additional recent SSIM studies may be relevant (Investigating inclusion of Hawaii example)

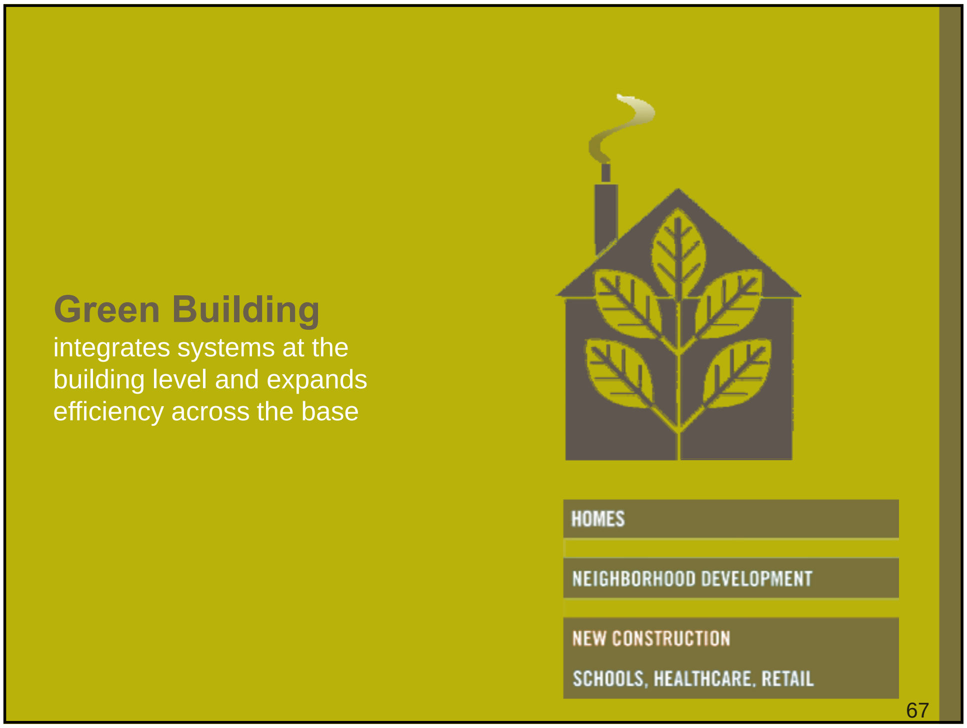


Carbon Sequestration Strategies

- **Maximize areas for urban forestry and ecological restoration**
  - Allocate areas for urban forestry within parks and street landscapes
  - Ecological restoration opportunities
- **Land management strategies that maximize carbon sequestration**

  Essential to ensure that the carbon does not return to the atmosphere from burning or rotting when the trees die.

  Through:
  - Climate-adapted tree and plant species
  - Fast-growing species that have relatively high carbon sequestration potential
  - Forest management practices to maximize carbon sequestration potential
  - Not just parks: Integrate green space into streets and urban infrastructure
  - Minimize soil disturbance to enhance impact of groundcover and grass species
- **Capitalize on building-integrated vegetation opportunities**
  - Green roofs, building façades, etc. represent urban greening opportunities



Green Building

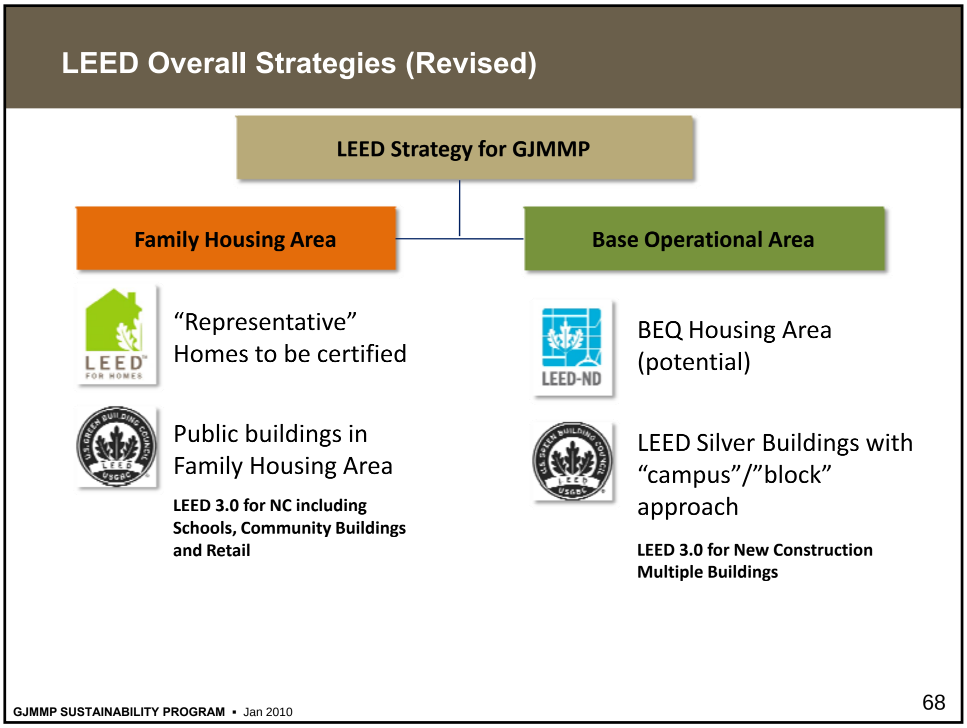
integrates systems at the building level and expands efficiency across the base

HOMES

NEIGHBORHOOD DEVELOPMENT

NEW CONSTRUCTION

SCHOOLS, HEALTHCARE, RETAIL



LEED Overall Strategies (Revised)

LEED Strategy for GJMMP

Family Housing Area

“Representative” Homes to be certified

Public buildings in Family Housing Area

LEED 3.0 for NC including Schools, Community Buildings and Retail

Base Operational Area

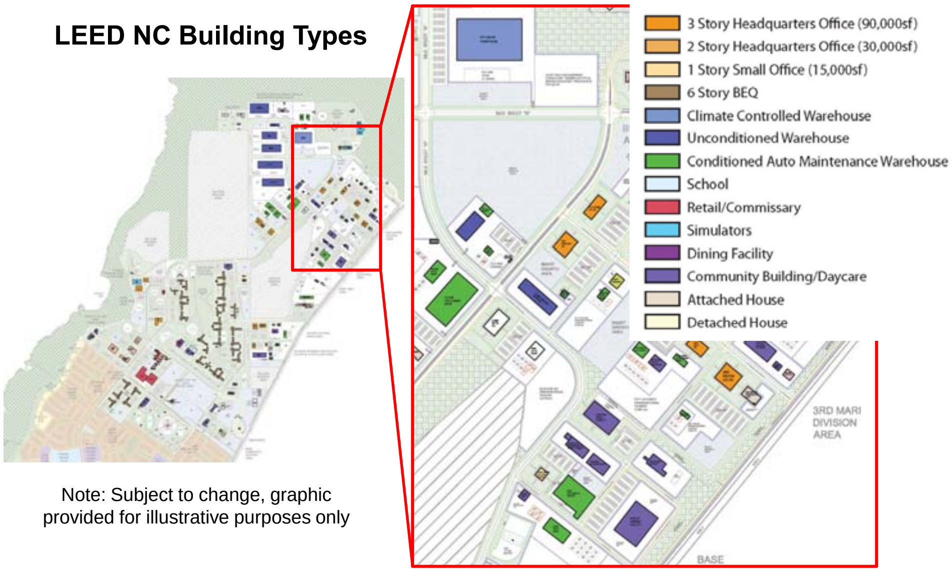
BEQ Housing Area (potential)

LEED Silver Buildings with “campus”/”block” approach

LEED 3.0 for New Construction Multiple Buildings

LEED NC Strategy: *Step One*
Establish Building Categories

LEED NC Building Types



Note: Subject to change, graphic provided for illustrative purposes only

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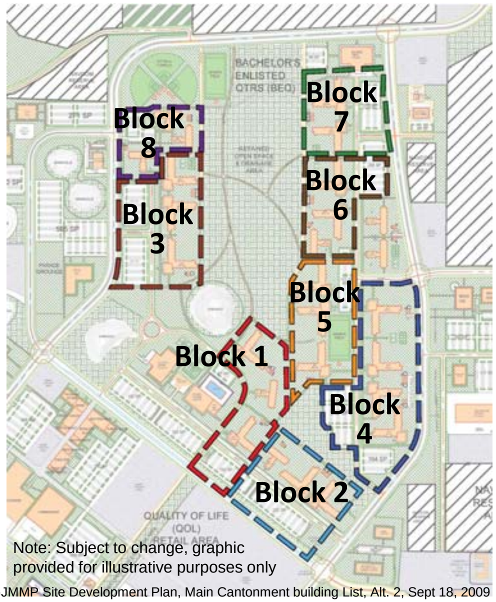
LEED NC Strategy: *Step Two*
Identify "Like" Building Types for "Blocks"/Campus

- **Like Building Types Include:**
  - BEQs
  - BOQs
  - Family Housing
- **USGBC should have updates to on-line guidance for LEED "Multiple buildings" approach by end of first quarter 2010**
- **"Blocks" are arranged by:**
  - Design Build Contractor
  - Building type
  - Phase
  - Geographical location



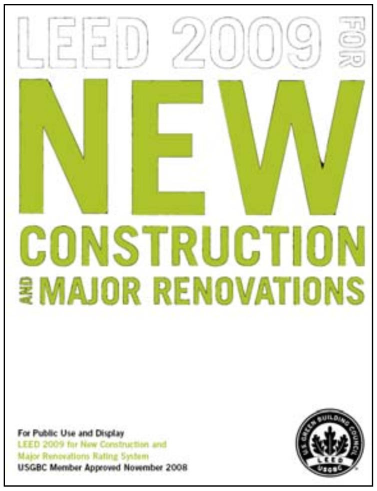
Note: Subject to change, graphic provided for illustrative purposes only

Orig. Source: GJMMP Site Development Plan, Main Cantonment building List, Alt. 2, Sept 18, 2009

LEED NC Strategy: *Step Three*
Individual Application is Required for each Building

Individual LEED NC Applications may be able to utilize a “Multiple Buildings” approach for certain credits such as:

- SSc6: Storm water Design
- EAc2: On-Site Renewable Energy (central renewable energy system)
- EAc4: Enhanced Refrigerant Management (if central chilled water system)
- MRp1: Storage and Collection of Recyclables
- MRc2: Construction Waste Management


LEED 2009 FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS

For Public Use and Display
LEED 2009 for New Construction and Major Renovations Rating System
USGBC Member Approved November 2008

LEED Home Strategy:

LEED Home Requires:

- Completion of all Prerequisites
- A “LEED for Home Provider” also referred to as a Green Rater
- Coordination with a Green Rater to establish which LEED points will be used to submitted in “Batch” of homes (Similar to a Block Approach). Typically 1 in 7 similar homes are tested in a Batch Approach
- The Green Rater to conduct a final inspection of the green measures once the home is completed
- The Green Rater to complete the required documentation

LEED™ FOR HOMES

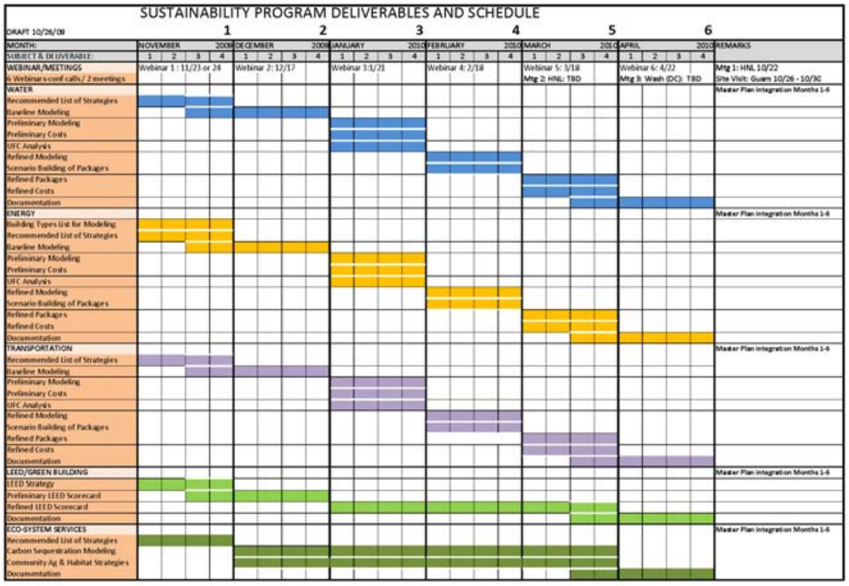
LEED NC and Home Strategy: *ongoing*

GJMMP LEED Strategy Implementation:

- NAVFAC LEED Coordinator reviews applications for consistencies where appropriate
- Develop LEED “Database” for all LEED “Letter Templates” by building type
- LEED Coordinator to pursue “Regional Credits” for Guam with local USGBC chapter and USGBC (an opportunity to receive extra credits! Puerto Rico has Regional Credits established)

Orig. Source: GJMMP Site Development Plan, Main Cantonment building List, Alt. 2, Sept 18, 2009

Deliverables & Schedule



SUSTAINABILITY PROGRAM DELIVERABLES AND SCHEDULE

DRAFT 10/26/09	1				2				3				4				5				6				
MONTH:	NOVEMBER 2009				DECEMBER 2009				JANUARY 2010				FEBRUARY 2010				MARCH 2010				APRIL 2010				REMARKS
SUBJECT & DELIVERABLE:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
WEBINAR/MEETINGS	Webinar 1 : 11/23 or 24				Webinar 2: 12/17				Webinar 3:1/21				Webinar 4: 2/18				Webinar 5: 3/18				Webinar 6: 4/22				Mtg 1: HNL 10/22
6 Webinars-conf calls/ 2 meetings																	Mtg 2: HNL: TBD				Mtg 3: Wash (DC): TBD				Site Visit: Guam 10/26 - 10/30
WATER																									Master Plan Integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
ENERGY																									Master Plan Integration Months 1-6
Building Types List for Modeling	■	■	■	■																					
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
Refined Modeling													■	■	■	■									
Scenario Building of Packages													■	■	■	■									
Refined Packages																	■	■	■	■					
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
TRANSPORTATION																									Master Plan Integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Baseline Modeling			■	■	■	■	■	■																	
Preliminary Modeling									■	■	■	■													
Preliminary Costs									■	■	■	■													
UFC Analysis									■	■	■	■													
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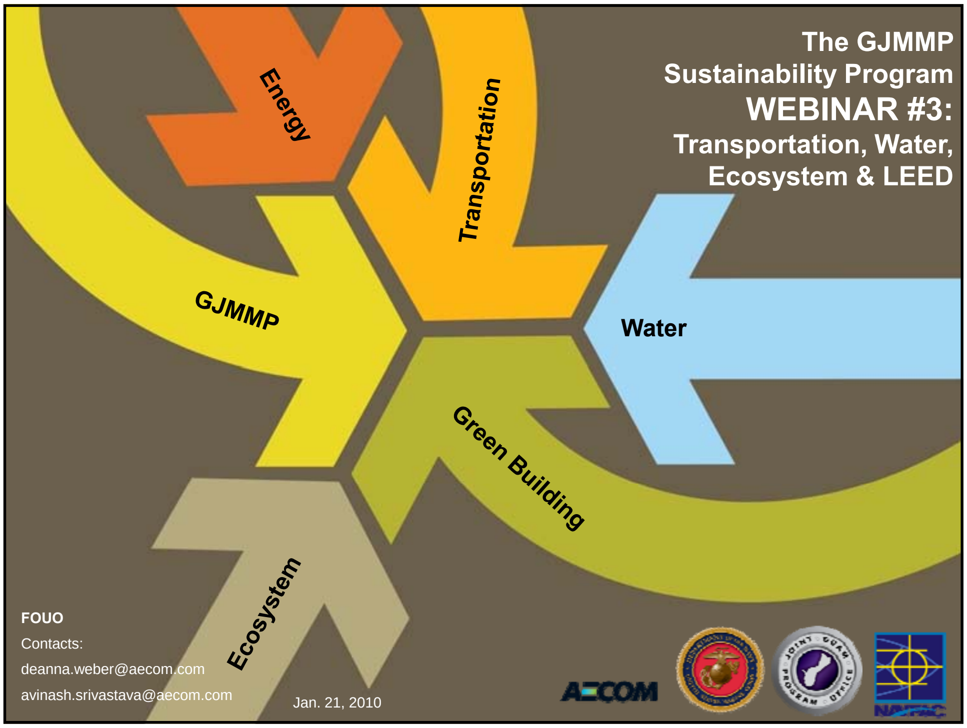
Refined Costs																	■	■	■	■					
Documentation																			■	■	■	■	■	■	
LEED/GREEN BUILDING																									Master Plan Integration Months 1-6
LEED Strategy	■	■	■	■																					
Preliminary LEED Scorecard			■	■	■	■	■	■																	
Refined LEED Scorecard									■	■	■	■	■	■	■	■	■	■	■	■					
Documentation																			■	■	■	■	■	■	
ECO-SYSTEM SERVICES																									Master Plan Integration Months 1-6
Recommended List of Strategies	■	■	■	■																					
Carbon Sequestration Modeling					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Community Ag & Habitat Strategies					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Documentation																			■	■	■	■	■	■	



The GJMMP Sustainability Program

WEBINAR #3:

Transportation, Water, Ecosystem & LEED

Energy

Transportation

GJMMP

Water

Green Building

Ecosystem

FOUO

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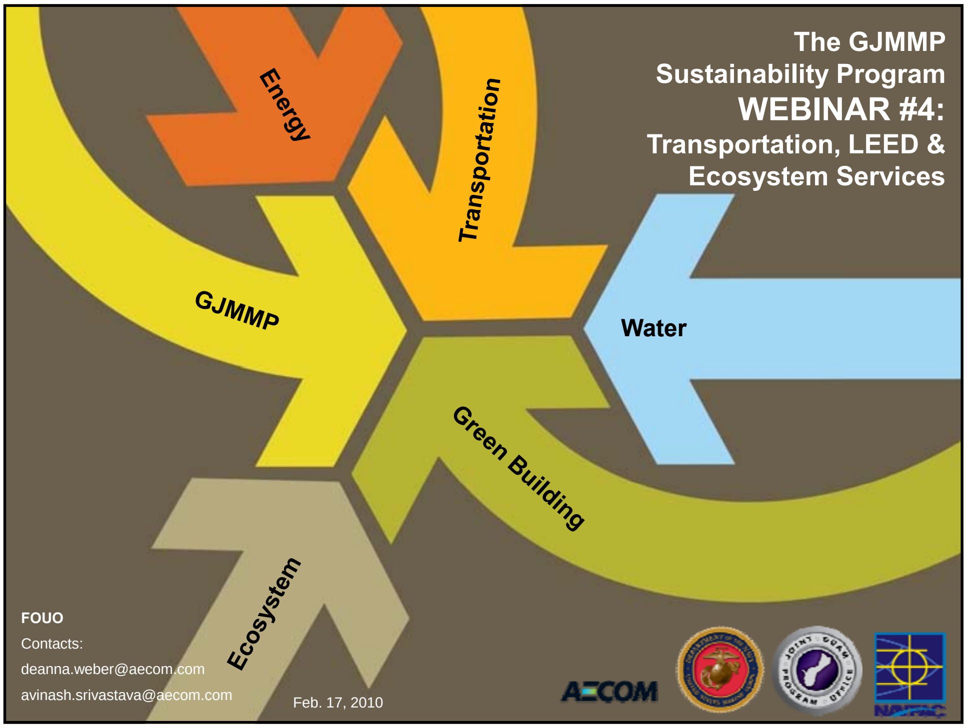
Jan. 21, 2010



The GJMMP Sustainability Program

WEBINAR #4:

Transportation, LEED & Ecosystem Services

Energy

Transportation

GJMMP

Water

Green Building

Ecosystem

FOUO

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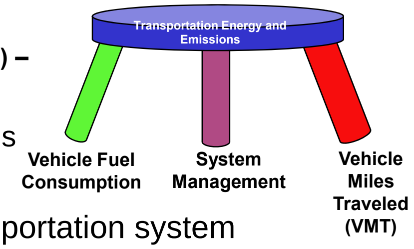
Feb. 17, 2010

Transportation Systems

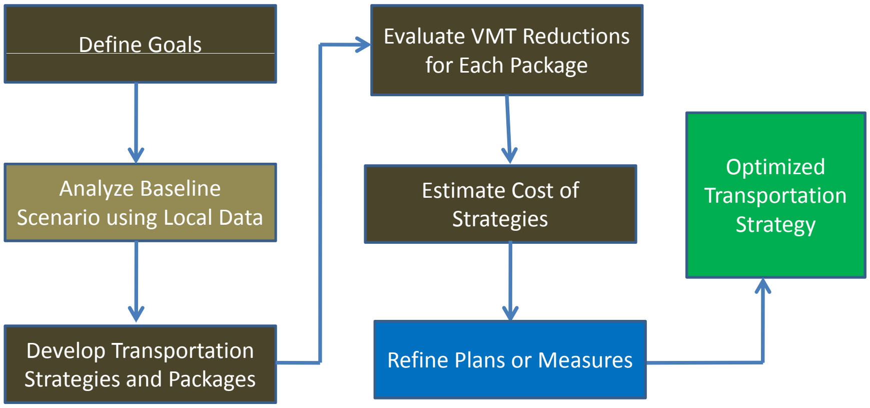
will quantify cost versus benefit of VMT (Vehicle Mile Traveled) reduction

Transportation Key Elements



- **Reduce VMT (Vehicle Miles Traveled) –**
  - Land use and form
  - Internal measures and programs
  - External linkages
- **Land use compatibility –** Transportation system supports travel between key destinations on base
- **Intuitive, user-friendly programs** – Identify measures that fit well with user's travel patterns, needs and environment on Guam
- **Meet and/or exceed Federal mandates/programs** – LEED-ND and Executive Order 13514

GJMMP – SSIM Transportation Analysis



VMT: Vehicle Miles Traveled

VMT Reduction Strategies (Summary from Webinar #1)

- **Benchmarks**
  - Baseline: Survey to help define
  - Option A (Good)
  - Option B (Better)
- **Quantified on- and off-base reductions separately**
- **On-Base Strategies**
  - Many strategies to reduce on-base trips
  - Shorter trip lengths
- **Off-Base Strategies**
  - More challenging to target off-base reductions
  - Longer trip lengths

DRAFT Transportation Packages Overview (Slide 1 of 3)

ELEMENT	Baseline	Option A	Option B
PARKING AND DEMAND MANAGEMENT	UFC Parking	Land bank area for 800 spaces	15% parking reduction Centrally located parking facility
	Limit Transient Auto Ownership	Limit auto ownership for E1-E3 (4,137 Marines)	20% of Military Staff choose not to ship a vehicle to base for $2000 “cash out”
	No Transportation Demand Management (TDM) Program	TDM Program Incentives and Part-Time (20 hrs/wk) Coordinator	TDM Program Incentives / Disincentives and Full-Time Coordinator (40 hrs/wk)
ON-BASE CIRCULATION	No shuttle	Shuttle: 30-minute headways	Shuttle:15-minute headways during peak periods, 30-minutes other hours
		Shuttle: Operates 12 hours/day (6am to 6pm)	Shuttle: Operates 18 hours/day (6am to 12am)
			Demand-responsive van outside peak periods

DRAFT Transportation Packages Overview (Slide 2 of 3)

ELEMENT	Baseline	Option A	Option B
OFF-BASE CIRCULATION	No off-base Circulation	Operates during peak hours (6 round trips/day)	All-day and late-night service, 6am – 12am (30 round trips/day)
		Hourly headways	30-minute headways during 6am – 6pm; hourly otherwise
		Shuttle and Guam Transit have convenient transfer schedules	Shuttle and Guam Transit have convenient transfer schedules
ACTIVE MODES	2.90 miles of Trail	2.90 miles of Trail, 0.39 miles of Pathway	2.90 miles of Trail, 0.39 miles of Pathway, 1.28 miles of Paved Greenway
	No Bike Sharing	One central bike share station with 50 bikes	One central bike share station with 50 bikes plus five satellite pods with 25 bikes/each
	Standard Street Design	30% of roadway network are speed managed, “Complete Streets”	60% of roadway network are speed managed, “Complete Streets”
	Limited Pedestrian Improvements	Pedestrian improvements at 15 intersections	Pedestrian improvements at 30 intersections

DRAFT Transportation Packages Overview (Slide 3 of 3)

ELEMENT	Baseline	Option A	Option B
VEHICLE POOL	Gasoline	10% Electric/ 10% Hybrid	25% Electric/25% Hybrid
	No car share	One central car share location with 100 cars	One central (100 cars) and five satellite (25 cars/each) car share locations
	No Neighborhood Electric Vehicle (NEV) Program	One central NEV location with 150 NEVs	One central (150 NEVs) and five satellite (25 NEVs/each) NEV locations

DRAFT Transportation Packages Options

ELEMENT	Option A			Option B		
	On-Base	Off-Base	Total	On-Base	Off-Base	Total
PARKING AND DEMAND MANAGEMENT	2%	3%	5%	5%	8%	13%
ON-BASE CIRCULATION	1%	-	1%	1%	-	1%
OFF-BASE CIRCULATION	-	1%	1%	-	3%	3%
ACTIVE MODES	1%	-	1%	1%	-	1%
VEHICLE POOL	1%	1%	2%	1%	2%	3%
TOTAL	**5%**	**5%**	**10%**	**8%**	**13%**	**21%**

DRAFT Transportation Packages: Implementation Costs

ELEMENT	Option A	Option B
PARKING AND DEMAND MANAGEMENT	$0	$0
ON-BASE CIRCULATION	$1,410,000	$2,180,000
OFF-BASE CIRCULATION	$200,000	$510,000
ACTIVE MODES	$710,000	$1,550,000
VEHICLE POOL	$4,240,000	$6,000,000
TOTAL	**$6,560,000**	**$10,240,000**

Note: All costs are preliminary and will be reviewed by NAVFAC, Marines, etc.

DRAFT Transportation Packages: Annual Operating Costs

ELEMENT	Option A	Option B
PARKING AND DEMAND MANAGEMENT	$300,000	$980,000
ON-BASE CIRCULATION	$640,000	$1,210,000
OFF-BASE CIRCULATION	$10,000	$30,000
ACTIVE MODES	$180,000	$320,000
VEHICLE POOL	$1,250,000	$1,510,000
TOTAL	**$2,380,000**	**$4,050,000**

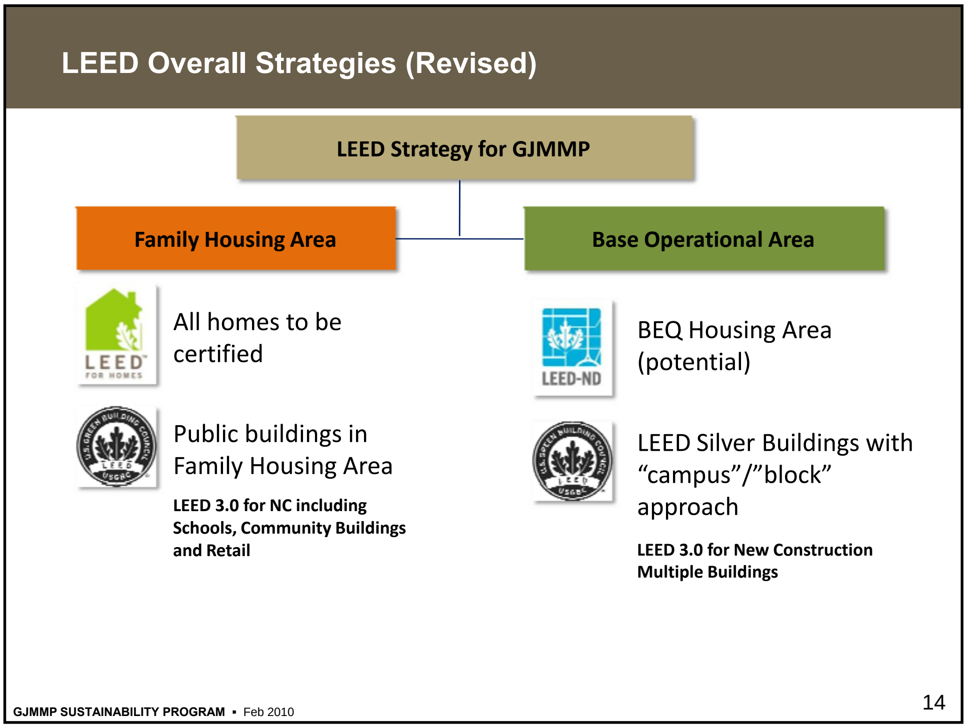
Note: All costs are preliminary and will be reviewed by NAVFAC, Marines, etc.

SSIM Transportation Analysis – Next Steps

- **Validate Baseline Condition**
  - Using survey data
  - No shuttle, UFC parking criteria, basic bicycle and pedestrian facilities
- **Feedback on Reductions and Unit Costs**
  - Make recommendations to meet federal mandate and identify enhanced measures
  - Minimize maintenance and capital costs
- **Refine Reductions and Unit Costs**
- **Documentation**

LEED Certification

Developing an optimized LEED Silver Certification of all new non-residential buildings



LEED Overall Strategies (Revised)

LEED Strategy for GJMMP

Family Housing Area

All homes to be certified

Public buildings in Family Housing Area

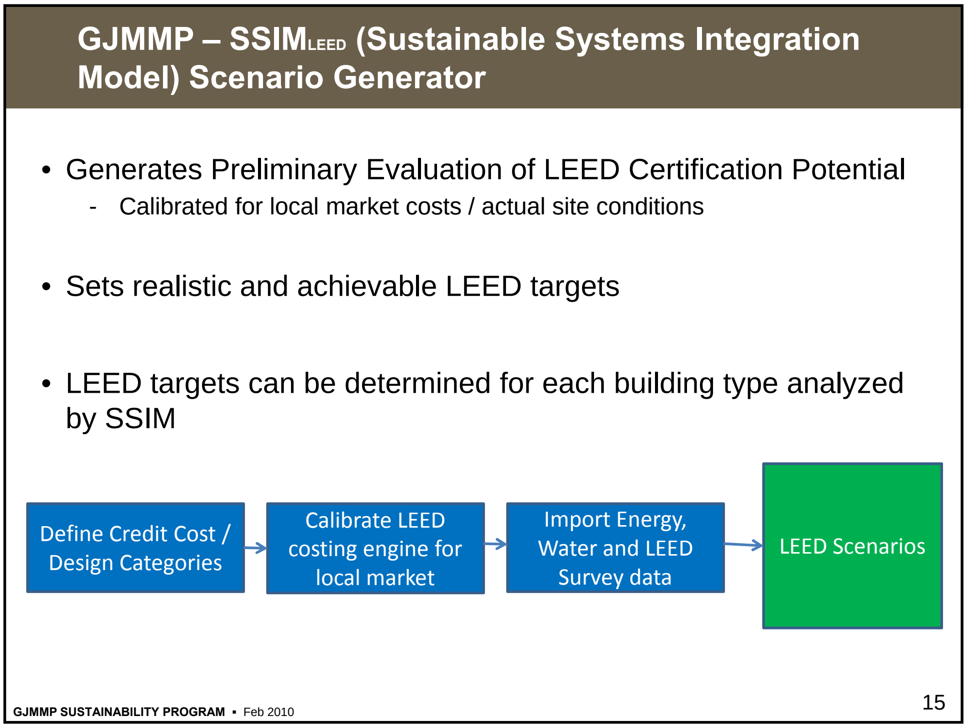
LEED 3.0 for NC including Schools, Community Buildings and Retail

Base Operational Area

BEQ Housing Area (potential)

LEED Silver Buildings with “campus”/”block” approach

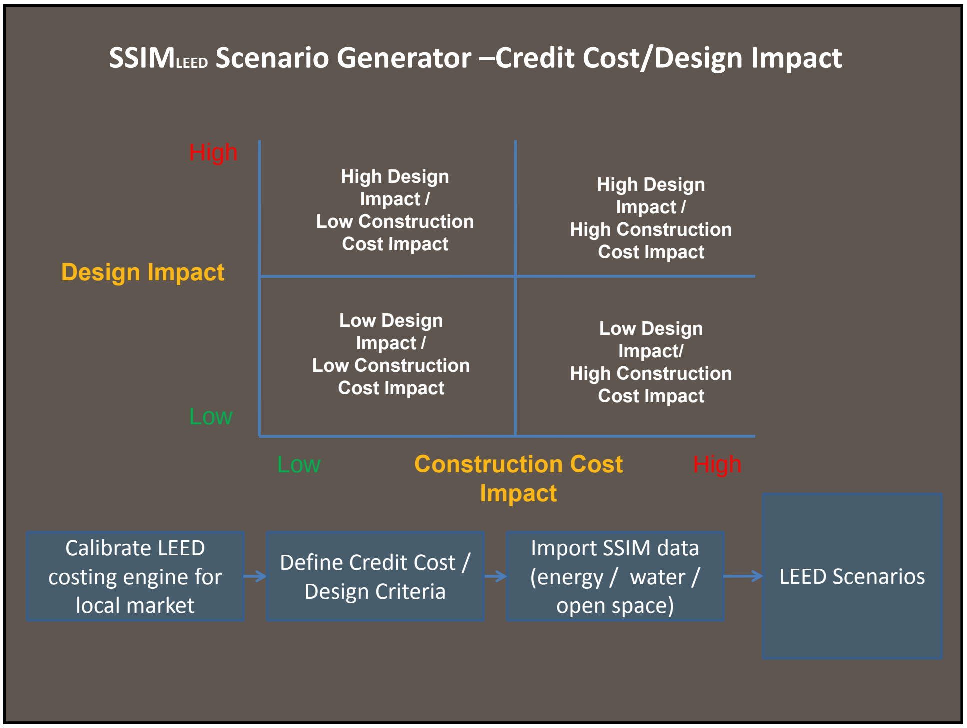
LEED 3.0 for New Construction Multiple Buildings



GJMMP – SSIM_{LEED} (Sustainable Systems Integration Model) Scenario Generator

- Generates Preliminary Evaluation of LEED Certification Potential
  - Calibrated for local market costs / actual site conditions
- Sets realistic and achievable LEED targets
- LEED targets can be determined for each building type analyzed by SSIM

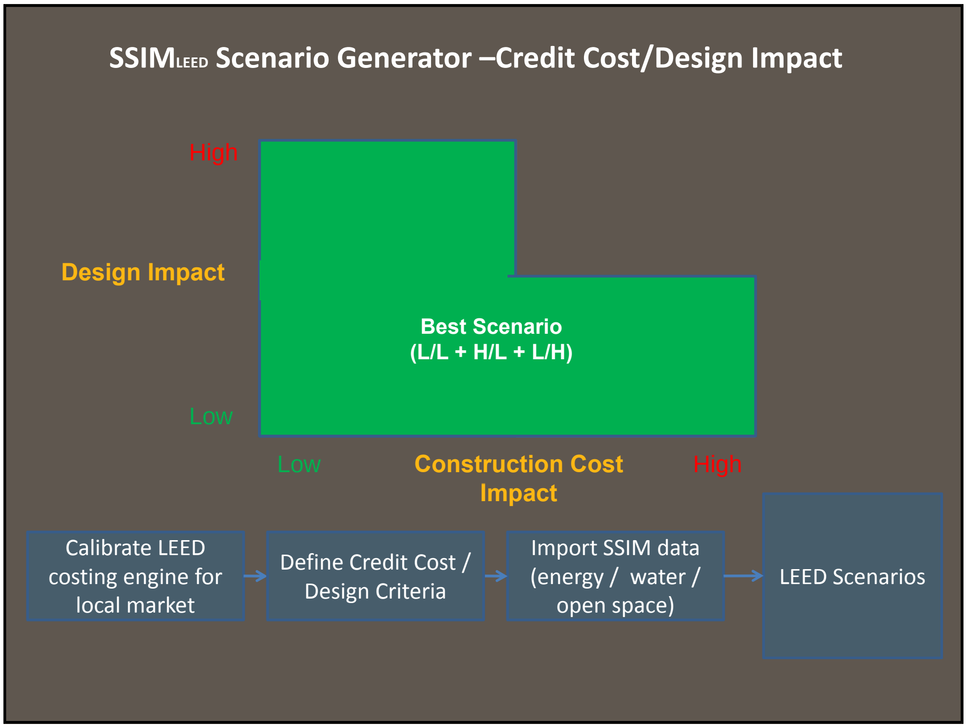
Define Credit Cost / Design Categories → Calibrate LEED costing engine for local market → Import Energy, Water and LEED Survey data → LEED Scenarios



SSIM_{LEED} Scenario Generator –Credit Cost/Design Impact

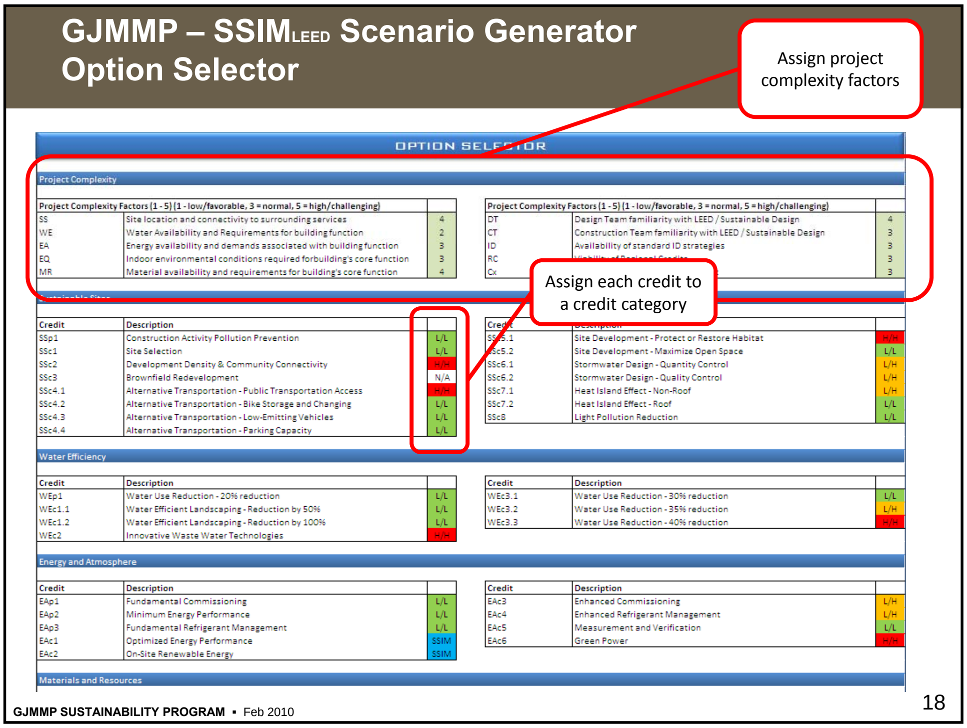
Design Impact		
High	High Design Impact / Low Construction Cost Impact	High Design Impact / High Construction Cost Impact
Low	Low Design Impact / Low Construction Cost Impact	Low Design Impact/ High Construction Cost Impact
	Low	High
	Construction Cost Impact	

Calibrate LEED costing engine for local market → Define Credit Cost / Design Criteria → Import SSIM data (energy / water / open space) → LEED Scenarios



SSIMLEED Scenario Generator –Credit Cost/Design Impact

Calibrate LEED costing engine for local market → Define Credit Cost / Design Criteria → Import SSIM data (energy / water / open space) → LEED Scenarios



GJMMP – SSIMLEED Scenario Generator Option Selector

Assign project complexity factors

Assign each credit to a credit category

OPTION SELECTOR

Project Complexity

Project Complexity Factors (1 - 5) (1 - low/favorable, 3 = normal, 5 = high/challenging)		
SS	Site location and connectivity to surrounding services	4
WE	Water Availability and Requirements for building function	2
EA	Energy availability and demands associated with building function	3
EQ	Indoor environmental conditions required forbuilding's core function	3
MR	Material availability and requirements for building's core function	4

Project Complexity Factors (1 - 5) (1 - low/favorable, 3 = normal, 5 = high/challenging)		
DT	Design Team familiarity with LEED / Sustainable Design	4
CT	Construction Team familiarity with LEED / Sustainable Design	3
ID	Availability of standard ID strategies	3
RC	Visibility of Regional Credits	3
Cx		3

Sustainable Sites

Credit	Description	
SSp1	Construction Activity Pollution Prevention	L/L
SSc1	Site Selection	L/L
SSc2	Development Density & Community Connectivity	H/H
SSc3	Brownfield Redevelopment	N/A
SSc4.1	Alternative Transportation - Public Transportation Access	H/H
SSc4.2	Alternative Transportation - Bike Storage and Changing	L/L
SSc4.3	Alternative Transportation - Low-Emitting Vehicles	L/L
SSc4.4	Alternative Transportation - Parking Capacity	L/L

Cred t		
SS 5.1	Site Development - Protect or Restore Habitat	H/H
Sc5.2	Site Development - Maximize Open Space	L/L
SSc6.1	Stormwater Design - Quantity Control	L/H
SSc6.2	Stormwater Design - Quality Control	L/H
SSc7.1	Heat Island Effect - Non-Roof	L/H
SSc7.2	Heat Island Effect - Roof	L/L
SSc8	Light Pollution Reduction	L/L

Water Efficiency

Credit	Description	
WEp1	Water Use Reduction - 20% reduction	L/L
WEc1.1	Water Efficient Landscaping - Reduction by 50%	L/L
WEc1.2	Water Efficient Landscaping - Reduction by 100%	L/L
WEc2	Innovative Waste Water Technologies	H/H

Credit	Description	
WEc3.1	Water Use Reduction - 30% reduction	L/L
WEc3.2	Water Use Reduction - 35% reduction	L/H
WEc3.3	Water Use Reduction - 40% reduction	H/H

Energy and Atmosphere

Credit	Description	
EAp1	Fundamental Commissioning	L/L
EAp2	Minimum Energy Performance	L/L
EAp3	Fundamental Refrigerant Management	L/L
EAc1	Optimized Energy Performance	SSIM
EAc2	On-Site Renewable Energy	SSIM

Credit	Description	
EAc3	Enhanced Commissioning	L/H
EAc4	Enhanced Refrigerant Management	L/H
EAc5	Measurement and Verification	L/L
EAc6	Green Power	H/H

Materials and Resources

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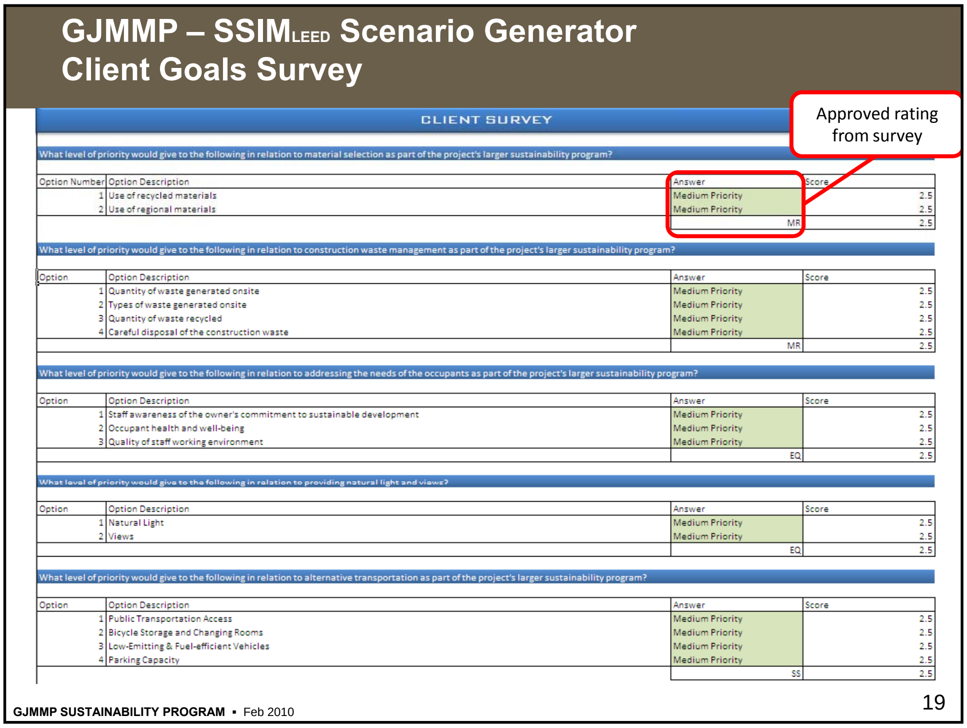

GJMMP – SSIM_{LEED} Scenario Generator
Client Goals Survey

CLIENT SURVEY

Approved rating from survey

What level of priority would give to the following in relation to material selection as part of the project's larger sustainability program?

Option Number	Option Description	Answer	Score
1	Use of recycled materials	Medium Priority	2.5
2	Use of regional materials	Medium Priority	2.5
		MR	2.5

What level of priority would give to the following in relation to construction waste management as part of the project's larger sustainability program?

Option	Option Description	Answer	Score
1	Quantity of waste generated onsite	Medium Priority	2.5
2	Types of waste generated onsite	Medium Priority	2.5
3	Quantity of waste recycled	Medium Priority	2.5
4	Careful disposal of the construction waste	Medium Priority	2.5
		MR	2.5

What level of priority would give to the following in relation to addressing the needs of the occupants as part of the project's larger sustainability program?

Option	Option Description	Answer	Score
1	Staff awareness of the owner's commitment to sustainable development	Medium Priority	2.5
2	Occupant health and well-being	Medium Priority	2.5
3	Quality of staff working environment	Medium Priority	2.5
		EQ	2.5

What level of priority would give to the following in relation to providing natural light and views?

Option	Option Description	Answer	Score
1	Natural Light	Medium Priority	2.5
2	Views	Medium Priority	2.5
		EQ	2.5

What level of priority would give to the following in relation to alternative transportation as part of the project's larger sustainability program?

Option	Option Description	Answer	Score
1	Public Transportation Access	Medium Priority	2.5
2	Bicycle Storage and Changing Rooms	Medium Priority	2.5
3	Low-Emitting & Fuel-efficient Vehicles	Medium Priority	2.5
4	Parking Capacity	Medium Priority	2.5
		SS	2.5

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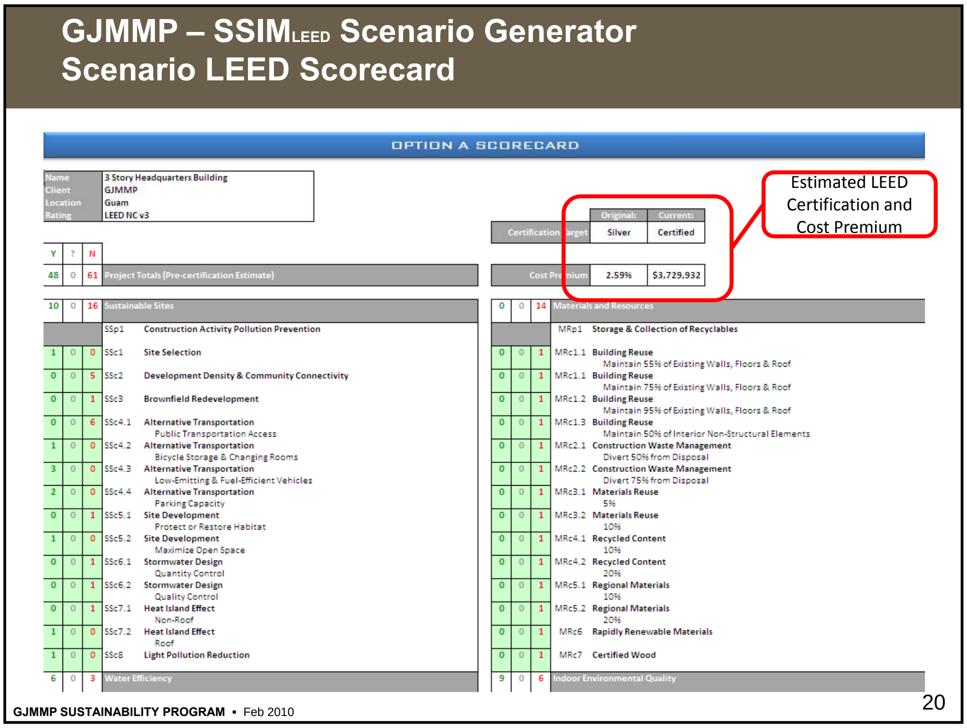

GJMMP – SSIM_{LEED} Scenario Generator
Scenario LEED Scorecard

OPTION A SCORECARD

Name	3 Story Headquarters Building
Client	GJMMP
Location	Guam
Rating	LEED NC v3

Estimated LEED Certification and Cost Premium

	Original:	Current:
Certification Target	Silver	Certified
Cost Premium	2.59%	$3,729,932

Y	?	N			
48	0	61	Project Totals (Pre-certification Estimate)		
10	0	16	Sustainable Sites		
			SSp1	Construction Activity Pollution Prevention	
1	0	0	SSc1	Site Selection	
0	0	5	SSc2	Development Density & Community Connectivity	
0	0	1	SSc3	Brownfield Redevelopment	
0	0	6	SSc4.1	Alternative Transportation	Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation	Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation	Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation	Parking Capacity
0	0	1	SSc5.1	Site Development	Protect or Restore Habitat
1	0	0	SSc5.2	Site Development	Maximize Open Space
0	0	1	SSc6.1	Stormwater Design	Quantity Control
0	0	1	SSc6.2	Stormwater Design	Quality Control
0	0	1	SSc7.1	Heat Island Effect	Non-Roof
1	0	0	SSc7.2	Heat Island Effect	Roof
1	0	0	SSc8	Light Pollution Reduction	
6	0	3	Water Efficiency		

Y	?	N			
0	0	14	Materials and Resources		
			MRp1	Storage & Collection of Recyclables	
0	0	1	MRc1.1	Building Reuse	Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse	Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse	Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse	Maintain 50% of Interior Non-Structural Elements
0	0	1	MRc2.1	Construction Waste Management	Divert 50% from Disposal
0	0	1	MRc2.2	Construction Waste Management	Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse	5%
0	0	1	MRc3.2	Materials Reuse	10%
0	0	1	MRc4.1	Recycled Content	10%
0	0	1	MRc4.2	Recycled Content	20%
0	0	1	MRc5.1	Regional Materials	10%
0	0	1	MRc5.2	Regional Materials	20%
0	0	1	MRc6	Rapidly Renewable Materials	
0	0	1	MRc7	Certified Wood	
9	0	6	Indoor Environmental Quality		

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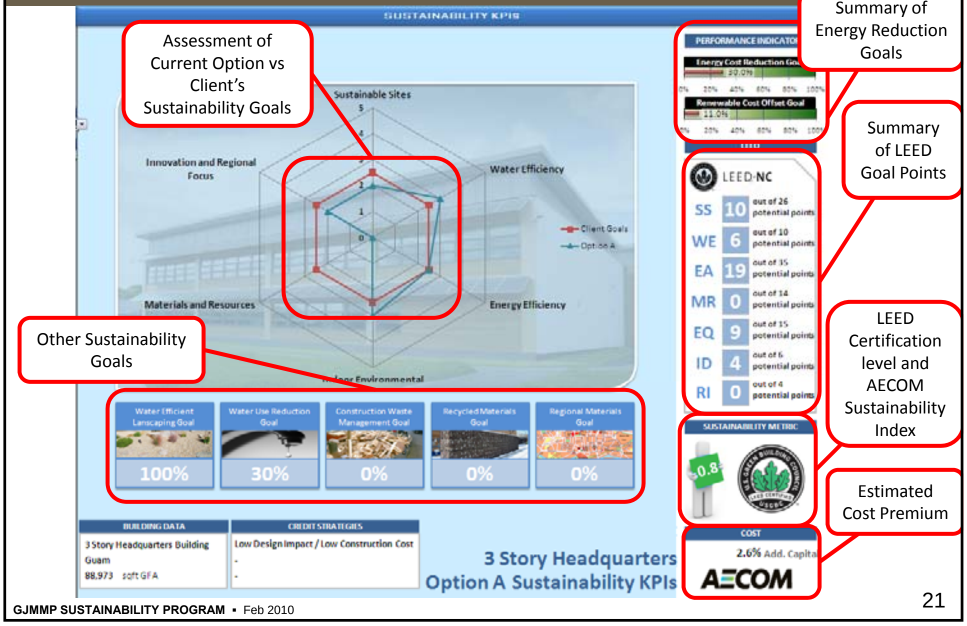
GJMMP – SSIMLEED Scenario Generator
Scenario Key Performance Indicators Summary (KPI)



SUSTAINABILITY KPIS

PERFORMANCE INDICATOR

Energy Cost Reduction Goal: 30.0%

Renewable Cost Offset Goal: 11.0%

LEED-NC

SS	10	out of 26 potential points
WE	6	out of 10 potential points
EA	19	out of 35 potential points
MR	0	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
100%	30%	0%	0%	0%

SUSTAINABILITY METRIC

0.8

COST

2.6% Add. Capital

AECOM

BUILDING DATA	CREDIT STRATEGIES
3 Story Headquarters Building Guam 88,973 sqft GFA	Low Design Impact / Low Construction Cost - -

3 Story Headquarters
Option A Sustainability KPIs

Assessment of Current Option vs Client's Sustainability Goals

Other Sustainability Goals

Summary of Energy Reduction Goals

Summary of LEED Goal Points

LEED Certification level and AECOM Sustainability Index

Estimated Cost Premium

GJMMP – SSIMLEED Scenario Generator
Work to Date

- Generated SSIMLEED Scenarios on the following building types:
  - 3 Story HQ Office
  - 2 Story HQ Office
  - 1 Story Small Office
  - Conditioned Warehouse
  - Unconditioned Warehouse
  - Day Care Center
  - Dining Facility
  - Commissary
  - BEQ
  - School
  - Workshop
- Preliminary ground truthing of scenarios based on existing LEED scorecard data from Guam:
  - Joint region Marianas Headquarters
  - BEQ Naval Base
  - Fitness Center

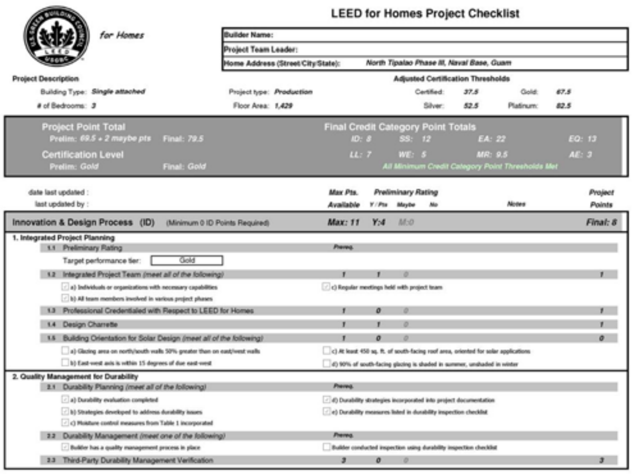
GJMMP – SSIM$_{LEED}$ Scenario Generator Initial Assumptions

- Preliminary costing information has been collated, based on mainland equipment prices, escalated using the “Guam Factor” (2.64)
- Credits that would form part of baseline specification (such as low VOC paints etc) are deemed to have zero additional cost premium due to economies of scale.
- Costing metrics used in initial models based upon our mainland experience. Needs additional input from local expertise to further calibrate.

LEED for Homes

Background Information Sources:

- Meetings/Calls with USGBC Conference call with LEED for Homes Provider
- Obtained North Tipalao Family Housing Phase III LEED Analysis



LEED for Homes Project Checklist

for Homes

Builder Name:
Project Team Leader:
Home Address (Street/City/State): North Tipalao Phase III, Naval Base, Guam

Project Description
Building Type: Single attached
# of Bedrooms: 3
Project type: Production
Floor Area: 1,429

Adjusted Certification Thresholds
Certified: 37.5
Silver: 52.5
Gold: 67.5
Platinum: 82.5

Project Point Total
Prelim: 69.5 + 2 maybe pts
Final: 79.5

Certification Level
Prelim: Gold
Final: Gold

Final Credit Category Point Totals
ID: 8
SS: 12
EA: 22
EQ: 13
LL: 7
WE: 5
MR: 9.5
AE: 3
All Minimum Credit Category Point Thresholds Met

date last updated :
last updated by :

	Max Pts. Available	Preliminary Rating Y / Pts	Maybe	No	Notes	Project Points
Innovation & Design Process (ID) (Minimum 0 ID Points Required)	Max: 11	Y:4	M:0			Final: 8
1. Integrated Project Planning						
1.1 Preliminary Rating	Prereq.					
Target performance tier: Gold						
1.2 Integrated Project Team *(meet all of the following)*	1	1	0			1
☑ a) Individuals or organizations with necessary capabilities ☑ b) All team members involved in various project phases ☑ c) Regular meetings held with project team						
1.3 Professional Credentialed with Respect to LEED for Homes	1	0	0			1
1.4 Design Charrette	1	1	0			1
1.5 Building Orientation for Solar Design *(meet all of the following)*	1	0	0			0
☐ a) Glazing area on north/south walls 50% greater than on east/west walls ☐ b) East-west axis is within 15 degrees of due east-west ☐ c) At least 450 sq. ft. of south-facing roof area, oriented for solar applications ☐ d) 90% of south-facing glazing is shaded in summer, unshaded in winter						
2. Quality Management for Durability						
2.1 Durability Planning *(meet all of the following)*	Prereq.					
☑ a) Durability evaluation completed ☑ b) Strategies developed to address durability issues ☑ c) Moisture control measures from Table 1 incorporated ☑ d) Durability strategies incorporated into project documentation ☑ e) Durability measures listed in durability inspection checklist						
2.2 Durability Management *(meet one of the following)*	Prereq.					
☑ Builder has a quality management process in place ☐ Builder conducted inspection using durability inspection checklist						
2.3 Third-Party Durability Management Verification	3	0	0			3

LEED Home Strategy:

LEED Home Requires:

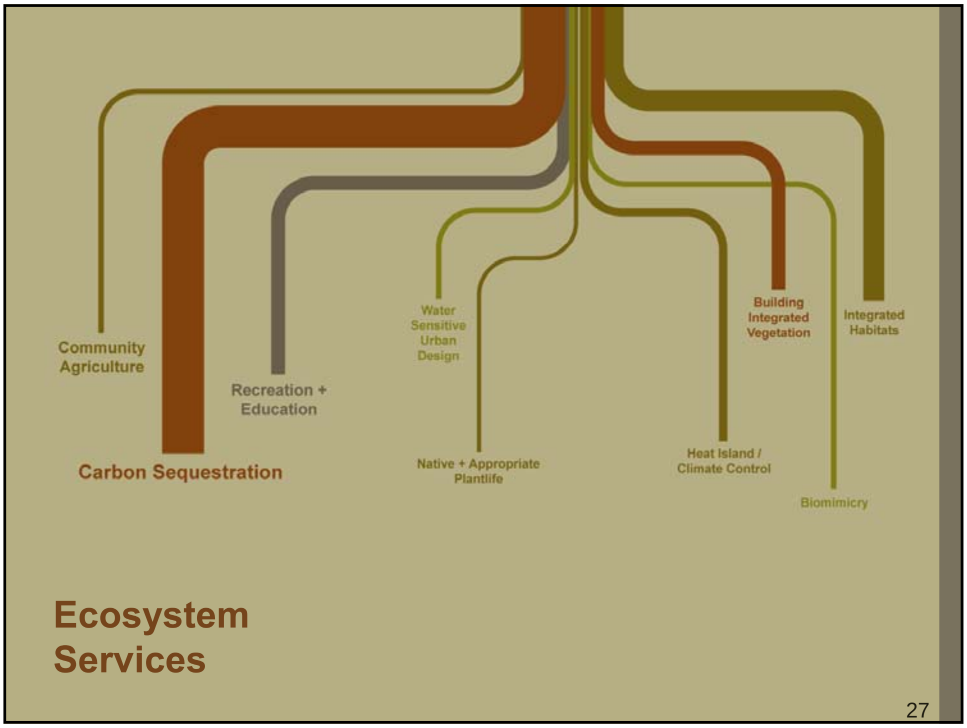
- A “LEED for Home Provider” also referred to as a Green Rater completes required documentation
- Coordination with a Green Rater to establish which LEED points will be used to submitted in “Batch” of homes (Similar to a Block Approach). **Typically 1 in 7 similar homes are tested on site in a batch approach.**
- **The Green Rater to conduct a final inspection of the green measures once the home is completed.**

Orig. Source: GJMMP Site Development Plan Alt. 2, Sept 18, 2009

LEED NC and Home Strategy: *ongoing*

GJMMP LEED Strategy Implementation:

- NAVFAC LEED Coordinator reviews applications for consistencies where appropriate
- NAVFAC LEED Coordinator to develop “Database” for all LEED info by building type
- LEED Coordinator to pursue “Regional Credits” for Guam with local USGBC chapter and USGBC



Community Agriculture

Carbon Sequestration

Recreation + Education

Water Sensitive Urban Design

Native + Appropriate Plantlife

Heat Island / Climate Control

Building Integrated Vegetation

Integrated Habitats

Biomimicry

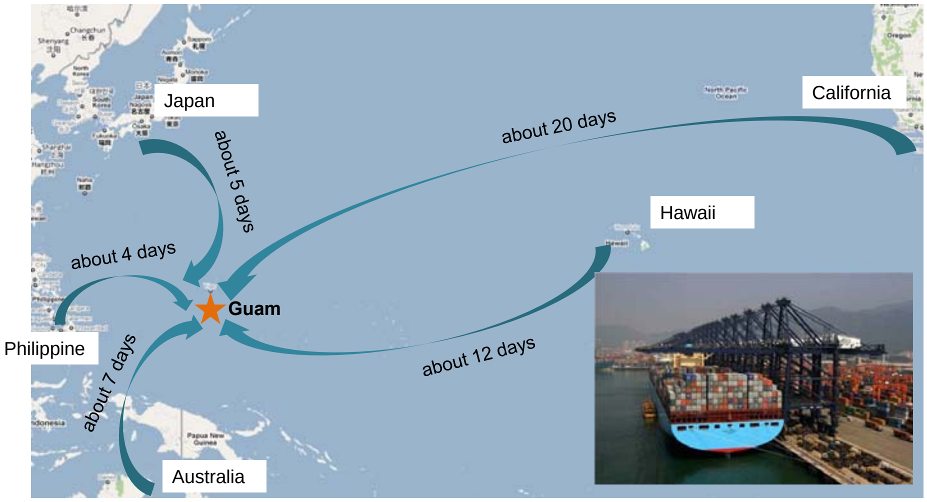
Ecosystem Services

Ecosystem Strategies Overview

- Local Food Production
- Carbon Sequestration
- Guam Native Landscape Design Guidelines
- Education & Recreation Opportunities

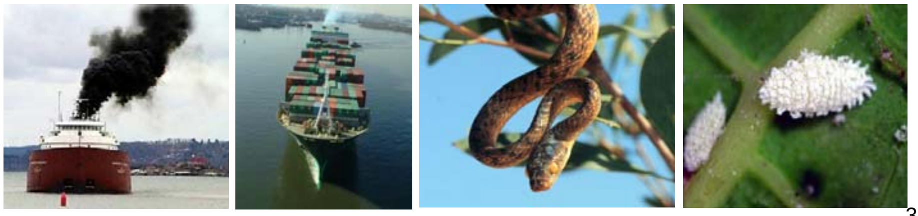
Local Food Production – Existing Conditions

Do you realize how far food travels to Guam?

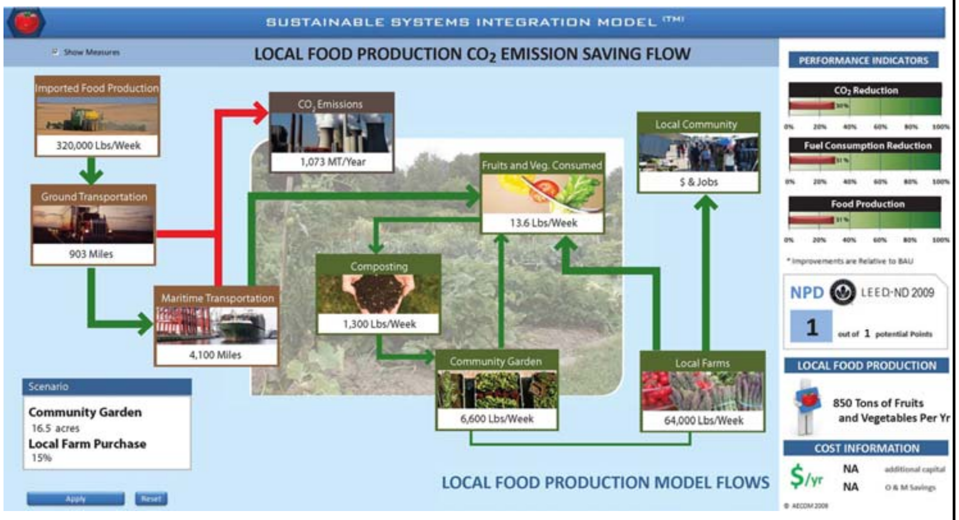


Local Food Production – Challenges & Opportunities

- GHG Emissions from Maritime Transportation
  - Large amount of fruits and vegetables are shipped from CONUS, 40 days round trip to Guam
- Invasive Species
  - Imported agricultural products also increase the risk of bringing invasive species that endanger local ecological system
- Opportunity to be a “Good Neighbor”
  - Supports local business

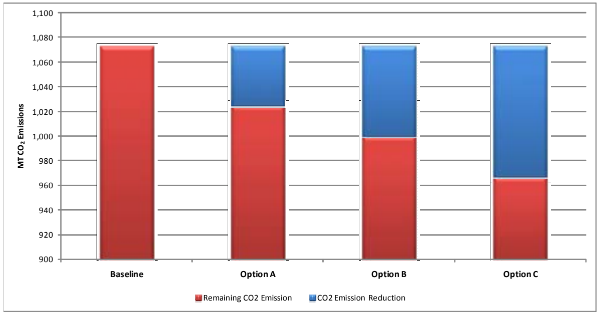


DRAFT Local Food Production – Carbon Reduction Model



DRAFT Local Food Production – Carbon Reduction Model

	Baseline	Option A	Option B	Option C
Community Garden	0 acres	2 acres	4 acres	16.5 acres
Additional Local Food Purchase (Percentage of Total Fruit & Vegetable Consumption)	0%	10%	15%	20%
Total Reduction in Fruit & Vegetable Importation	**0 lbs**	**776,655 lbs**	**1,168,583 lbs**	**1,697,311 lbs**
Total CO_2 Equivalent Reduction Per Year	**0 MT**	**48 MT**	**73 MT**	**106 MT**
Remaining CO_2 Emission From Fruit & Vegetable Importation	**1,073 MT**	**1,024 MT**	**1,000 MT**	**967 MT**
Percent Reduction in CO_2 Emissions	N/A	4.5%	6.8%	9.9%



- Next Steps
  - Validate the food production and cost information

Local Food Production – More Benefits

- Significant Social Value of Local Food Production
- Fresh food for locals
- Enhance quality of life and promote healthy lifestyle in local community
- Boost local economy and job opportunities
- Educational program

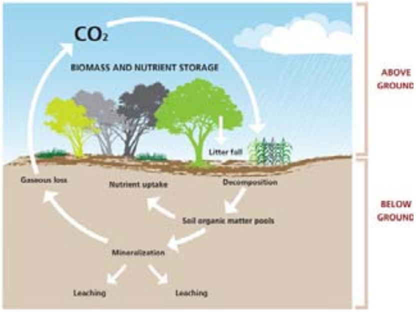
Carbon Sequestration – Definition

“**Carbon Sequestration** is the process by which atmospheric carbon dioxide is absorbed by trees [and vegetation] through photosynthesis and stored as carbon in biomass and soils.”

- USDA Forest Service

Factors

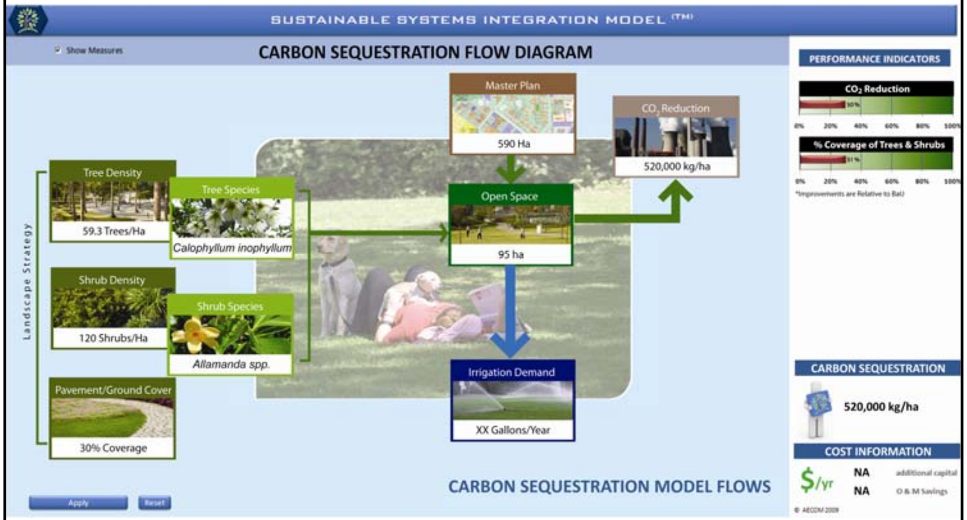
- Tree type
- Growth rate & Tree age
- Soil type
- Regional climate
- Topography
- Sequestration rate



Carbon Sequestration – Prototype Landscape Module Set Up

- Landscape Prototypes:
  1. Landscaped Areas (buffer/median/streetscape)
  2. Park Landscape
  3. Residential Landscape Area
  4. Open Space
  5. Preserved Area
- Landscape strategies each contain land cover type groupings of plant species, each with a specific carbon sequestration rate:
- *Sources*
  - *NAVFAC Landscaping with Native Plans, Dr. Brooks*
  - *USDA Center for Urban Forestry Research*
  - *US Forest Service*

DRAFT Carbon Sequestration Model



SUSTAINABLE SYSTEMS INTEGRATION MODEL (TM)

☑ Show Measures

CARBON SEQUESTRATION FLOW DIAGRAM

Landscape Strategy

Tree Density: 59.3 Trees/Ha

Tree Species: *Calophyllum inophyllum*

Shrub Density: 120 Shrubs/Ha

Shrub Species: *Allamanda spp.*

Pavement/Ground Cover: 30% Coverage

Master Plan: 590 Ha

Open Space: 95 ha

CO_2 Reduction: 520,000 kg/ha

Irrigation Demand: XX Gallons/Year

CARBON SEQUESTRATION MODEL FLOWS

PERFORMANCE INDICATORS

CO_2 Reduction: 30%

% Coverage of Trees & Shrubs: 31%

*Improvements are Relative to BaU

CARBON SEQUESTRATION

520,000 kg/ha

COST INFORMATION

$/yr

NA additional capital

NA O & M Savings

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Carbon Sequestration – Scenarios

DRAFT Carbon Sequestration – Methodology and Modeling Approach

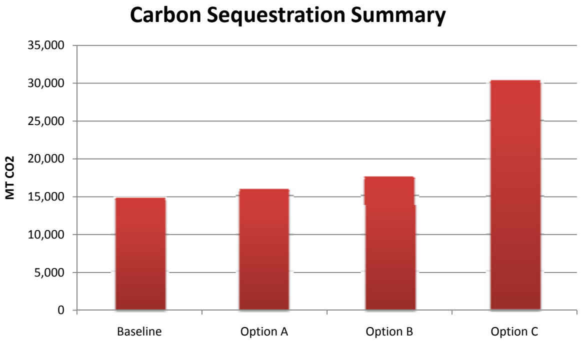
- Baseline scenario was developed assuming land coverage similar to overall district
  - Overall district contains over **1,460 acres** (~590 hectares) of green space with **52 miles** (84 km) of roads
  - Assumed distribution of current green space across prototypical landscapes
  - Baseline landscape assumptions: coconut palm with turf in disturbed areas
- Options were developed based on varying **plant species and planting density**, keeping the planting coverage and land program constant
- Carbon sequestration values were developed for each prototypical landscape in each alternative

Carbon Sequestration (MT CO_2)	Baseline	Option A	Option B	Option C
Prototype Landscapes				
Landscaped Areas (buffer/median/streetscape)	306	528	807	1,614
Park Landscape	175	334	568	994
Residential Landscape Area (within development parcel)	236	487	830	1,452
Open Space	519	1,072	1,823	3,190
Preserved Area - Undisturbed Areas	13,607	13,607	13,607	23,170
Totals	**14,843**	**16,028**	**17,635**	**30,420**
Percent Change	**N/A**	**8.0%**	**18.8%**	**104.9%**

DRAFT Carbon Sequestration – Methodology and Modeling Approach

Baseline and Option Comparison of Carbon Sequestration

Comparison	Baseline	Option A	Option B	Option C
Carbon Sequestration (MT CO_2)	14,843	16,028	17,634	30,420
Percent Change	N/A	8.0%	18.8%	104.9%



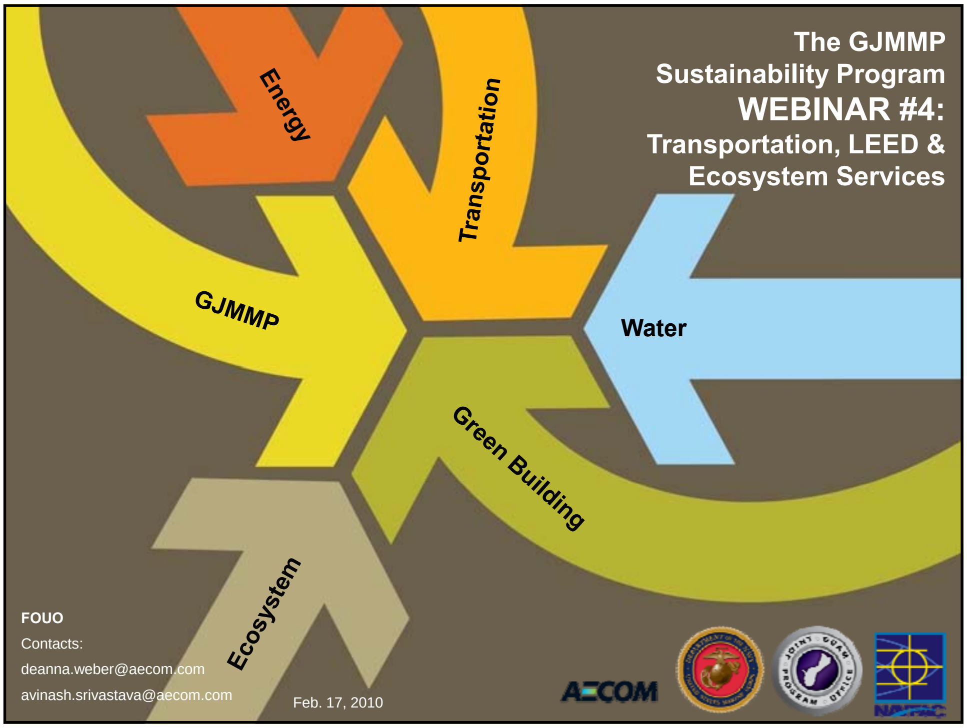
- Installation and O&M costs still being evaluated
- Hypothesis that options with higher carbon sequestration values are generally more cost effective.

Carbon Sequestration Strategies

- **Maximize areas for urban forestry and ecological restoration**
  - Allocate areas for urban forestry within parks and street landscapes
  - Ecological restoration opportunities
- **Land management strategies that maximize carbon sequestration**

  Essential to ensure that the carbon does not return to the atmosphere from burning or rotting when the trees die.

  Through:
  - Climate-adapted tree and plant species
  - Typhoon- and heavy storm tolerant- tree and plant species
  - Fast-growing species that have relatively high carbon sequestration potential
  - Forest management practices to maximize carbon sequestration potential
  - Not just parks: Integrate green space into streets and urban infrastructure
  - Minimize soil disturbance to enhance impact of groundcover and grass species *(this is not a quantified component of the carbon sequestration mode*



The GJMMP Sustainability Program

WEBINAR #4:

Transportation, LEED & Ecosystem Services

FOUO

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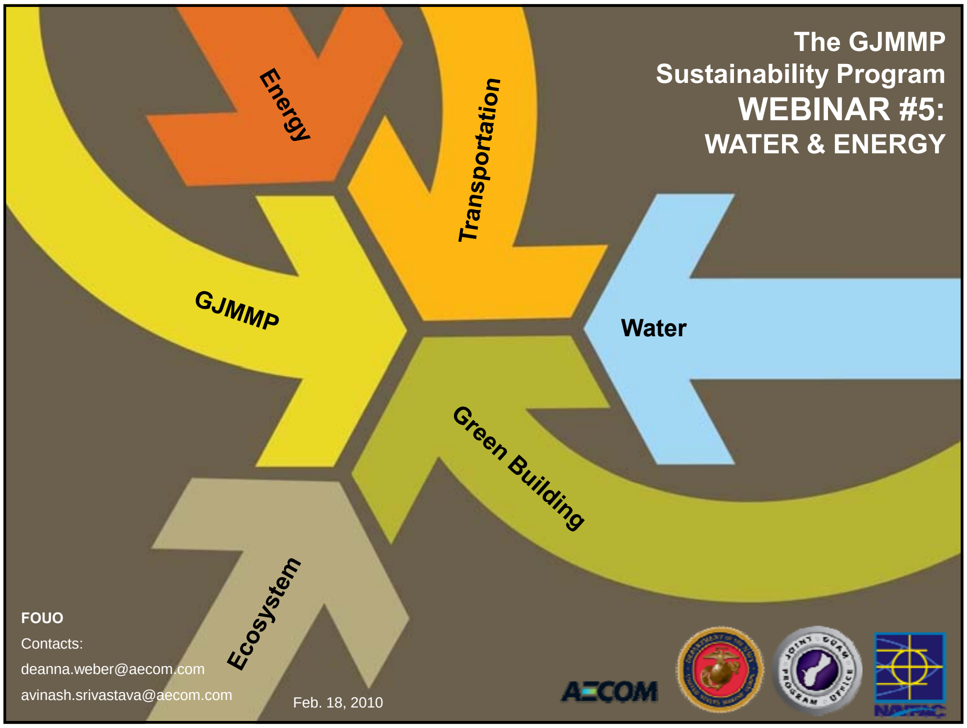
avinash.srivastava@aecom.com

Feb. 17, 2010



The GJMMP Sustainability Program
WEBINAR #5:
WATER & ENERGY

Energy

Transportation

GJMMP

Water

Green Building

Ecosystem

FOUO

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Feb. 18, 2010

Water Balance Planning

establishes an equilibrium between natural water supplies and human demand.

DRAFT Water ~ Overall Goals

- **Meet and Exceed Federal Mandates to Reduce Water Consumption**
  - Executive Order 13514 (water reduction 2% per year to FY 2020)
  - EISA 438 (Incorporate LID for all buildings greater than 5,000 gross s.f.)
  - EPAct 1992 & 2005 (Use of efficient fixtures)
  - LEED NC 2009, Version 3 (Silver certification)
- **Use Simple Systems** – Ease of Construction, Maintenance and Monitoring
- **Protection of the Aquifer & Coastal Resources** – Stormwater quality
  - Water Sensitive Urban Design
  - Low Impact Development

The use of Bioswales and Created Wetlands is critical to providing stormwater quality.

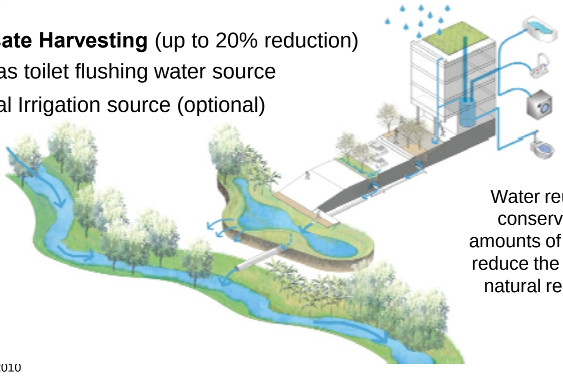
DRAFT Water ~ Reduction Strategies

Indoor Reduction

- **Low Flow Fixtures** (up to 30% reduction)

Outdoor Capture / Indoor Reuse

- **Rooftop Rainwater Harvesting** (up to 20% reduction)
  - Reuse as toilet flushing water source
  - Reduce stormwater treatment by capture
- **AC Condensate Harvesting** (up to 20% reduction)
  - Reuse as toilet flushing water source
  - Potential Irrigation source (optional)



Water reuse can conserve large amounts of water and reduce the impact on natural resources.

DRAFT Water ~ Reduction Strategies

Interior Water Use

Benchmarks – Housing water use example

- UFC = 180 gpcd (interior and exterior use U.S. National Avg.)
- BAU = 100 gpcd (interior and exterior use on Guam)
- Baseline = current EPA standard ~ 70 gpcd
- Option A = improved EPA standard ~ 63 gpcd
- Option B = EPA Water Sense ~ 56 gpcd
- Option C = improved Water Sense ~ 49 gpcd

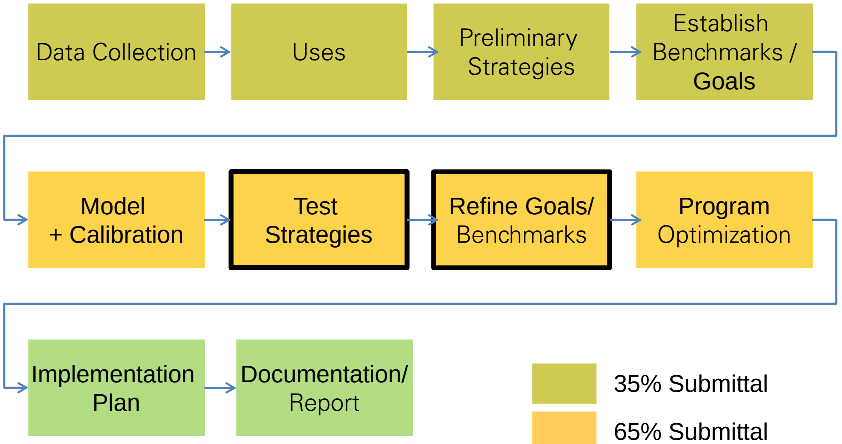
Waterless Urinals

Reduction from Baseline

- Option A = 10%
- Option B = 20+%
- Option C = 30+%

Low Flow Fixtures

DRAFT Water ~ SSIM Process Outline



Data Collection → Uses → Preliminary Strategies → Establish Benchmarks / Goals

Model + Calibration → Test Strategies → Refine Goals/ Benchmarks → Program Optimization

Implementation Plan → Documentation/ Report

🟨 35% Submittal

🟧 65% Submittal

🟩 95% Submittal

DRAFT Water ~ SSIM Process Update

- Model contains program details, water use and reuse options.
- Conservation strategies have been identified and defined in model.
- Further calibration to occur based on client feedback.
- Gaming option refinement is currently underway.

LAND USE and BUILDING PROGRAM

Residential

Land Use Type	Land Area (acres)	Dwelling Units	Bldg. Footprint SF	HHSize	Residents
BEQ & BOQ	85.0	8,428	2,718,108	1.0	8,428
Family housing (duplex)	443.9	3,505	5,413,659	4.3	15,072
Family housing (single family)	15.3	15	266,831	4.3	65

Cascading Reuse System - BEQ - BOQ Residential

Water Source	**Rooftop Water**	**Condensate**	**Greywater**	**TSE**	**-**	**-**
Reuse Priority	System	System	System	System	System	System
1	Toilets	Toilets	Irrigation	-	-	-
2	Non-Toilet Interior	Cooling	-	-	-	-
3	Cooling	Irrigation	-	-	-	-
4	Irrigation	-	-	-	-	-
Overflow	Storm Sewer	Storm Sewer	Sanitary Sewer	Sanitary Sewer	-	-

DRAFT Water ~ SSIM Model Input

Water use evaluation and gaming by facility and land use type

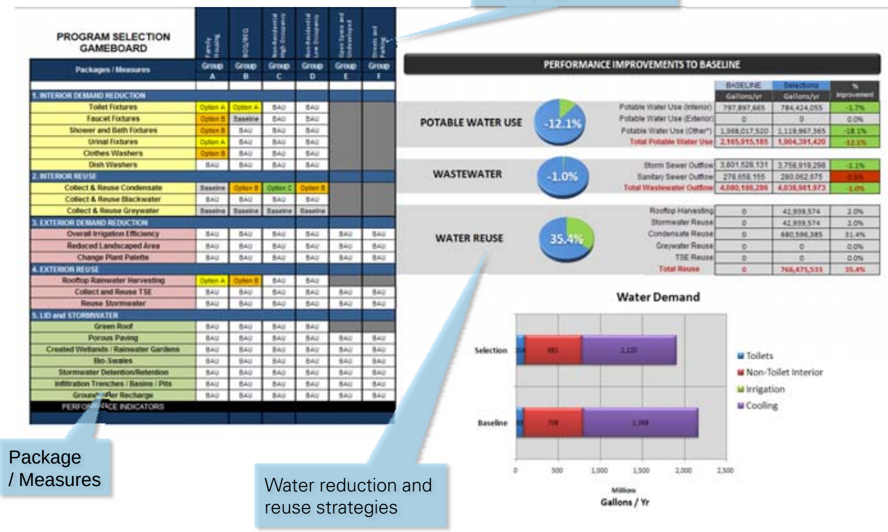
- Single Family Residential
- BEQ / BOQ Residential
- High Occupancy Non-Residential
- Low Occupancy Non-Residential
- Landscape and Open Space

Water Supply options for evaluation

- Groundwater Aquifer
- Rainfall Harvesting
- Condensate Harvesting
- Graywater (optional)
- TSE (optional)

With 100" of rainfall annually, rainwater capture is an important strategy to reduce water demand.

DRAFT Water ~ SSIM Analysis



Facility Type Selection

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Group A	Group B	Group C	Group D	Group E	Group F
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option A	Option A	BAU	BAU		
Faucet Fixtures	Option B	Baseline	BAU	BAU		
Shower and Bath Fixtures	Option B	BAU	BAU	BAU		
Urinal Fixtures	Option A	BAU	BAU	BAU		
Clothes Washers	Option B	BAU	BAU	BAU		
Dish Washers	BAU	BAU	BAU	BAU		
2. INTERIOR REUSE						
Collect & Reuse Condensate	Baseline	Option B	Option C	Option B		
Collect & Reuse Blackwater	BAU	BAU	BAU	BAU		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	BAU	BAU	BAU	BAU	BAU	BAU
Reduced Landscaped Area	BAU	BAU	BAU	BAU	BAU	BAU
Change Plant Palette	BAU	BAU	BAU	BAU	BAU	BAU
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option A	Option B	BAU	BAU		
Collect and Reuse TSE	BAU	BAU	BAU	BAU	BAU	BAU
Reuse Stormwater	BAU	BAU	BAU	BAU	BAU	BAU
5. LID and STORMWATER						
Green Roof	BAU	BAU	BAU	BAU		
Porous Paving	BAU	BAU	BAU	BAU	BAU	BAU
Created Wetlands / Rainwater Gardens	BAU	BAU	BAU	BAU	BAU	BAU
Bio-Swales	BAU	BAU	BAU	BAU	BAU	BAU
Stormwater Detention/Retention	BAU	BAU	BAU	BAU	BAU	BAU
Infiltration Trenches / Basins / Pits	BAU	BAU	BAU	BAU	BAU	BAU
Groundwater Recharge	BAU	BAU	BAU	BAU	BAU	BAU

PERFORMANCE INDICATORS

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
POTABLE WATER USE (-12.1%)	Potable Water Use (Interior)	797,897,665	784,424,055	-1.7%
	Potable Water Use (Exterior)	0	0	0.0%
	Potable Water Use (Other*)	1,368,017,520	1,119,967,365	-18.1%
	Total Potable Water Use	2,165,915,185	1,904,391,420	-12.1%
WASTEWATER (-1.0%)	Storm Sewer Outflow	3,801,528,131	3,758,919,298	-1.1%
	Sanitary Sewer Outflow	278,658,155	280,062,675	0.5%
	Total Wastewater Outflow	4,080,186,286	4,038,981,973	-1.0%
WATER REUSE (35.4%)	Rooftop Harvesting	0	42,939,574	2.0%
	Stormwater Reuse	0	42,939,574	2.0%
	Condensate Reuse	0	680,596,385	31.4%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	766,475,533	35.4%

Package / Measures

Water reduction and reuse strategies

DRAFT Water ~ SSIM Analysis

Residential Interior Water Use

Usage per Capita per Fixture per Day

Fixture Type	US Avg.*	% of total	BAU	Baseline	Option A	Option B	Option C
Toilets	18.5	27.3%	17.5	8.0	7.2	6.4	5.6
Clothes washer	15.0	22.2%	28.0	15.4	13.3	11.2	8.4
Showers & baths	12.8	18.9%	33.8	28.1	25.3	22.5	19.7
Faucets	8.7	12.9%	6.3	5.5	5.0	3.8	3.9
Faucets	2.2	3.2%	13.2	13.2	13.2	13.2	13.2
Dishwasher	1.0	1.5%	1.0	0.9	0.7	0.6	0.6
Avg. GPCD	**58.2**	100%	**99.7**	**71.1**	**64.6**	**57.7**	**51.3**
% Reduction from BAU			**0.0%**	**28.7%**	**35.2%**	**42.2%**	**48.5%**
% Reduction from Baseline				**0.0%**	**10.0%**	**23.3%**	**38.5%**
Greywater GPCD	36.5	62.7%	68.0	49.0	43.6	37.5	31.9
Blackwater GPCD	18.5	31.8%	18.5	8.9	7.9	7.0	6.2

Fixture Type	BAU	Baseline	Option A	Option B	Option C	Fixture Units
Toilets	3.50	1.60	1.44	1.28	1.12	(gpf)
Clothes washer	20.00	11.00	9.50	8.00	6.00	(gpc)
Showers & baths	3.00	2.50	2.25	2.00	1.75	(gpm) @ 80psi
Bathroom Faucets	2.50	2.20	1.98	1.50	1.54	(gpm) @ 60 psi
Kitchen Faucet	2.20	2.20	2.20	2.20	2.20	(gpm) @ 60 psi
Dishwasher	10.00	8.50	6.50	6.00	5.80	(gpc)

Per person / day	Units		
5	flushes/day		
0.7	loads/day	2	washer size in cf
7.5	min / use	1.5	uses/day/capita
0.5	min / use	5	uses/day/capita
1.5	min / use	4	uses/day/capita
0.1	loads		

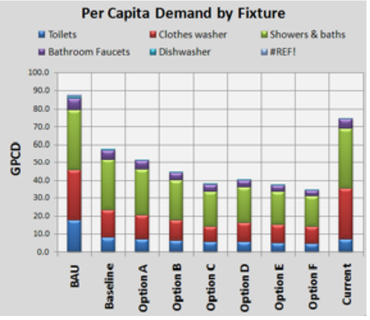
DRAFT Water ~ SSIM Analysis

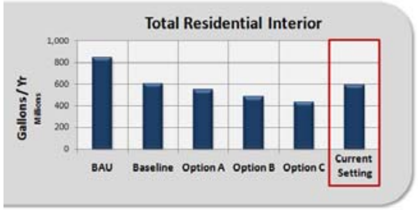
Summary Results

Residential Population **23,564**

	BAU	**Baseline**	**Option A**	**Option B**	**Option C**	**Current**
	Gallons/Day	Gallons/Day	Gallons/Day	Gallons/Day	Gallons/Day	Gallons/Day
Total Interior Demand	2,328,594	1,654,074	1,501,793	1,337,728	1,188,509	1,617,160
Interior Demand per Year	849,936,810	603,737,010	548,154,445	488,270,720	433,805,785	590,263,400
percent Improvement	**0.0%**	**-29.0%**	**-35.5%**	**-42.6%**	**-49.0%**	**-30.6%**

BEQ/BOQ Facility





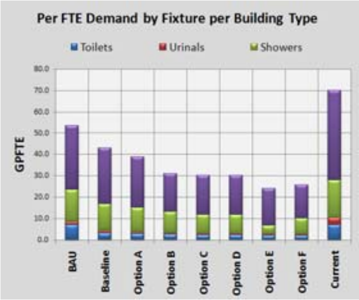
DRAFT Water ~ SSIM Analysis

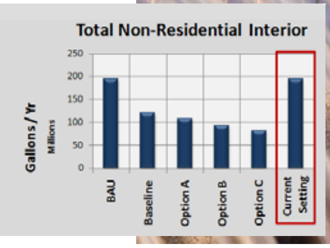
Summary Results

Non-Residential Full Time Equivalent Population **13,554**

	BAU	Baseline	Option A	Option B	Option C	Current
	Gallons/Day	Gallons/Day	Gallons/Day	Gallons/Day	Gallons/Day	Gallons/Day
Total Interior Demand	531,947	332,542	297,314	256,407	226,202	531,947
Interior Demand per Year	194,160,655	121,377,830	108,519,610	93,588,555	82,563,730	194,160,655
percent Improvement	**0.0%**	**-37.5%**	**-44.1%**	**-51.8%**	**-57.5%**	**0.0%**

Office / Admin Facility





DRAFT Water ~ SSIM Analysis

Interactions and Reuse Processes : Facility Group A Family Housing

Cascading Reuse System

Order	1	2	3	4	5	6
Water Source	**Rooftop Water**	**Condensate**	**Greywater**	**TSE**	**Site Stormwater**	**Blackwater**
Reuse Priority	System	System	System	System	System	System
1	Toilets	Toilets	-	-	-	-
2	Non-Toilet Interior	Non-Toilet Interior	-	-	-	-
3	Irrigation	Irrigation	-	-	-	-
Overflow	Storm Sewer	Storm Sewer	Sanitary Sewer	Sanitary Sewer	Storm Sewer	Sanitary Sewer

Interactions and Reuse Processes : Facility Group C Non-Residential High Occupancy

Cascading Reuse System

Order	1	2	3	4	5	6
Water Source	**Rooftop Water**	**Condensate**	**Greywater**	**TSE**	**Site Stormwater**	**Blackwater**
Reuse Priority	System	System	System	System	System	System
1	Toilets	Toilets	-	-	-	-
2	Non-Toilet Interior	Non-Toilet Interior	-	-	-	-
3	Cooling	Cooling	-	-	-	-
Overflow	Storm Sewer	Storm Sewer	Sanitary Sewer	Sanitary Sewer	Storm Sewer	Sanitary Sewer

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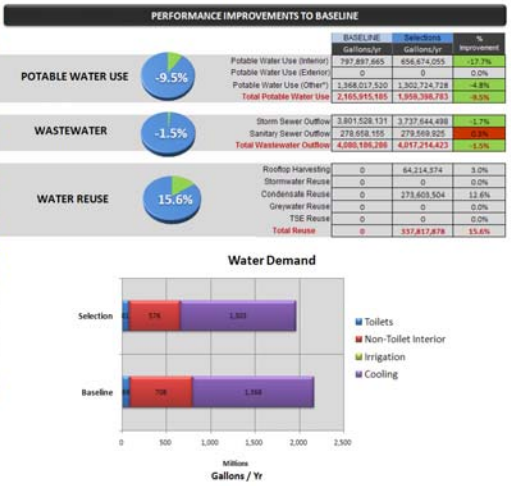
DRAFT Water ~ SSIM Analysis

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option A	Option A	Option A	Option A		
Faucet Fixtures	Option A	Option A	Option A	Option A		
Shower and Bath Fixtures	Option A	Option A	Option A	Option A		
Urinal Fixtures	Option A	Option A	Option A	Option A		
Clothes Washers	Option A	Option A	Option A	Option A		
Dish Washers	Option A	Option A	Option A	Option A		
2. INTERIOR REUSE						
Collect & Reuse Condensate	Option A	Option A	Option A	Option A		
Collect & Reuse Blackwater	Option A	Option A	Option A	Option A		
Collect & Reuse Greywater	Option A	Option A	Option A	Option A		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	BAU	BAU	BAU	BAU	BAU	BAU
Reduced Landscaped Area	BAU	BAU	BAU	BAU	BAU	BAU
Change Plant Palette	BAU	BAU	BAU	BAU	BAU	BAU
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option A	Option A	Option A	Option A		
Collect and Reuse TSE	Option A	Option A	Option A	Option A	Option A	Option A
Reuse Stormwater	BAU	BAU	BAU	BAU	BAU	BAU
5. LID and STORMWATER						
Green Roof	BAU	BAU	BAU	BAU		
Porous Paving	BAU	BAU	BAU	BAU	BAU	BAU
Created Wetlands / Rainwater Gardens	BAU	BAU	BAU	BAU	BAU	BAU
Bio-Swales	BAU	BAU	BAU	BAU	BAU	BAU
Stormwater Detention/Retention	BAU	BAU	BAU	BAU	BAU	BAU
Infiltration Trenches / Basins / Pits	BAU	BAU	BAU	BAU	BAU	BAU
Groundwater Recharge	BAU	BAU	BAU	BAU	BAU	BAU
PERFORMANCE INDICATORS						

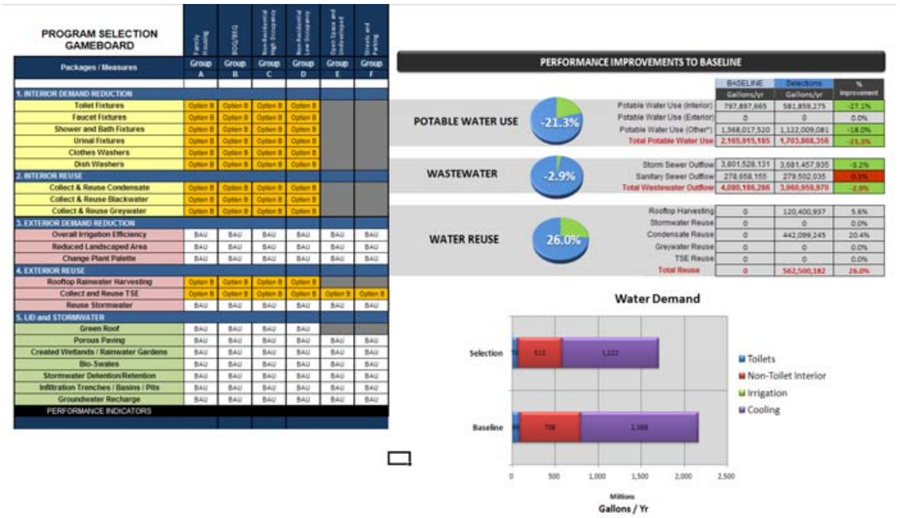


PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
POTABLE WATER USE	Potable Water Use (Interior)	797,897,665	656,674,055	-17.7%
-9.5%	Potable Water Use (Exterior)	0	0	0.0%
	Potable Water Use (Other*)	1,368,017,520	1,302,724,728	-4.8%
	Total Potable Water Use	2,165,915,185	1,959,398,783	-9.5%
WASTEWATER	Storm Sewer Outflow	3,801,528,131	3,737,644,498	-1.7%
-1.5%	Sanitary Sewer Outflow	278,658,155	279,569,925	0.3%
	Total Wastewater Outflow	4,080,186,286	4,017,214,423	-1.5%
WATER REUSE	Rooftop Harvesting	0	64,214,374	3.0%
15.6%	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	273,603,504	12.6%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	337,817,878	15.6%

Water Demand

DRAFT Water ~ SSIM Analysis



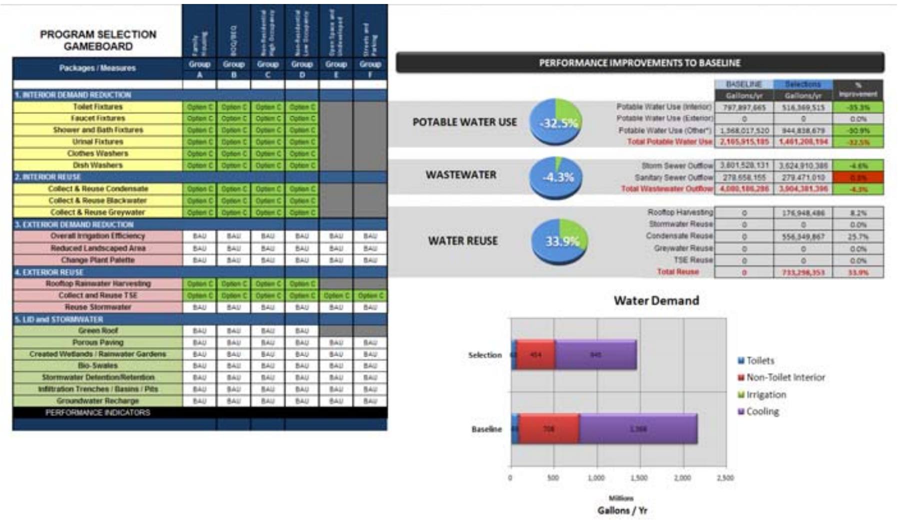
PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option B	Option B	Option B	Option B		
Faucet Fixtures	Option B	Option B	Option B	Option B		
Shower and Bath Fixtures	Option B	Option B	Option B	Option B		
Urinal Fixtures	Option B	Option B	Option B	Option B		
Clothes Washers	Option B	Option B	Option B	Option B		
Dish Washers	Option B	Option B	Option B	Option B		
2. INTERIOR REUSE						
Collect & Reuse Condensate	Option B	Option B	Option B	Option B		
Collect & Reuse Blackwater	Option B	Option B	Option B	Option B		
Collect & Reuse Greywater	Option B	Option B	Option B	Option B		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	BAU	BAU	BAU	BAU	BAU	BAU
Reduced Landscaped Area	BAU	BAU	BAU	BAU	BAU	BAU
Change Plant Palette	BAU	BAU	BAU	BAU	BAU	BAU
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option B	Option B	Option B	Option B		
Collect and Reuse TSE	Option B	Option B	Option B	Option B	Option B	Option B
Reuse Stormwater	BAU	BAU	BAU	BAU	BAU	BAU
5. LID and STORMWATER						
Green Roof	BAU	BAU	BAU	BAU		
Porous Paving	BAU	BAU	BAU	BAU	BAU	BAU
Created Wetlands / Rainwater Gardens	BAU	BAU	BAU	BAU	BAU	BAU
Bio-Swales	BAU	BAU	BAU	BAU	BAU	BAU
Stormwater Detention/Retention	BAU	BAU	BAU	BAU	BAU	BAU
Infiltration Trenches / Basins / Pits	BAU	BAU	BAU	BAU	BAU	BAU
Groundwater Recharge	BAU	BAU	BAU	BAU	BAU	BAU
PERFORMANCE INDICATORS						

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
POTABLE WATER USE -21.3%	Potable Water Use (Interior)	797,897,665	581,859,275	-27.1%
	Potable Water Use (Exterior)	0	0	0.0%
	Potable Water Use (Other*)	1,368,017,520	1,122,009,081	-18.0%
	Total Potable Water Use	2,165,915,185	1,703,868,356	-21.3%
WASTEWATER -2.9%	Storm Sewer Outflow	3,801,528,131	3,681,457,935	-3.2%
	Sanitary Sewer Outflow	278,658,155	279,502,035	0.3%
	Total Wastewater Outflow	4,080,186,286	3,960,959,970	-2.9%
WATER REUSE 26.0%	Rooftop Harvesting	0	120,400,937	5.6%
	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	442,099,245	20.4%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	562,500,182	26.0%

DRAFT Water ~ SSIM Analysis



PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option C	Option C	Option C	Option C		
Faucet Fixtures	Option C	Option C	Option C	Option C		
Shower and Bath Fixtures	Option C	Option C	Option C	Option C		
Urinal Fixtures	Option C	Option C	Option C	Option C		
Clothes Washers	Option C	Option C	Option C	Option C		
Dish Washers	Option C	Option C	Option C	Option C		
2. INTERIOR REUSE						
Collect & Reuse Condensate	Option C	Option C	Option C	Option C		
Collect & Reuse Blackwater	Option C	Option C	Option C	Option C		
Collect & Reuse Greywater	Option C	Option C	Option C	Option C		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	BAU	BAU	BAU	BAU	BAU	BAU
Reduced Landscaped Area	BAU	BAU	BAU	BAU	BAU	BAU
Change Plant Palette	BAU	BAU	BAU	BAU	BAU	BAU
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option C	Option C	Option C	Option C		
Collect and Reuse TSE	Option C	Option C	Option C	Option C	Option C	Option C
Reuse Stormwater	BAU	BAU	BAU	BAU	BAU	BAU
5. LID and STORMWATER						
Green Roof	BAU	BAU	BAU	BAU		
Porous Paving	BAU	BAU	BAU	BAU	BAU	BAU
Created Wetlands / Rainwater Gardens	BAU	BAU	BAU	BAU	BAU	BAU
Bio-Swales	BAU	BAU	BAU	BAU	BAU	BAU
Stormwater Detention/Retention	BAU	BAU	BAU	BAU	BAU	BAU
Infiltration Trenches / Basins / Pits	BAU	BAU	BAU	BAU	BAU	BAU
Groundwater Recharge	BAU	BAU	BAU	BAU	BAU	BAU
PERFORMANCE INDICATORS						

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
POTABLE WATER USE -32.5%	Potable Water Use (Interior)	797,897,665	516,369,515	-35.3%
	Potable Water Use (Exterior)	0	0	0.0%
	Potable Water Use (Other*)	1,368,017,520	944,838,679	-30.9%
	Total Potable Water Use	2,165,915,185	1,461,208,194	-32.5%
WASTEWATER -4.3%	Storm Sewer Outflow	3,801,528,131	3,624,910,386	-4.6%
	Sanitary Sewer Outflow	278,658,155	279,471,010	0.3%
	Total Wastewater Outflow	4,080,186,286	3,904,381,396	-4.3%
WATER REUSE 33.9%	Rooftop Harvesting	0	176,948,486	8.2%
	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	556,349,867	25.7%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	733,298,353	33.9%

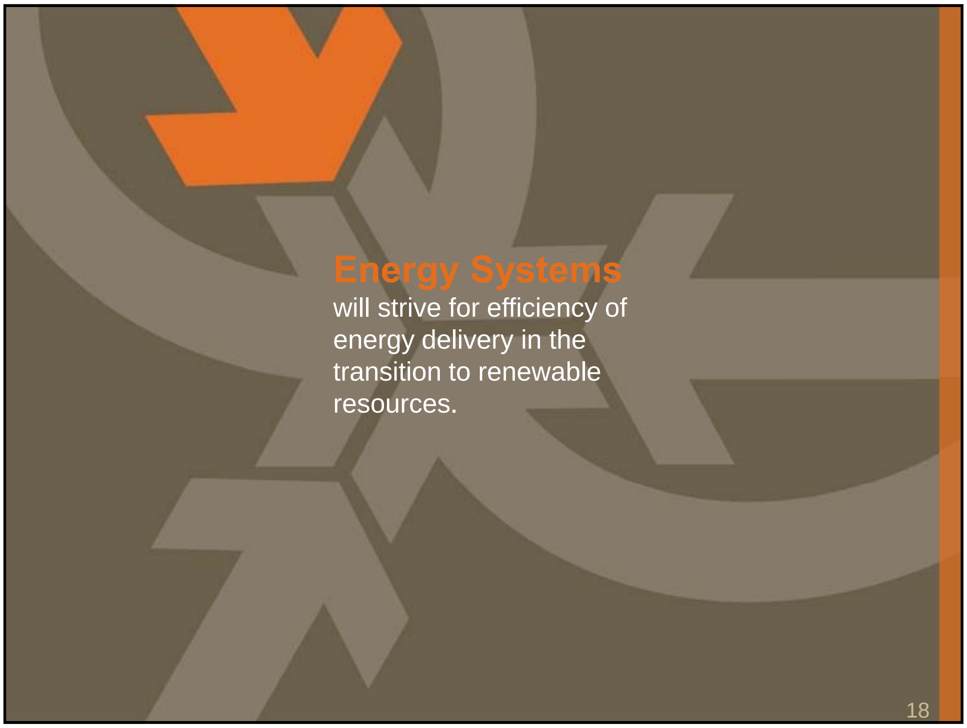
DRAFT Water ~ SSIM Next Steps

The next steps required with the SSIM model:

1. Further calibration of the baseline water model including client feedback and additional data, as requested.
2. Development of water supply, demand and reuse balance.
3. Development of initial cistern sizing for water harvesting and reuse demand.
4. Stormwater calibration with current LID study.

Additional Information Needs:

- Detailed water use for each facility type (to calibrate water demand)
- Existing water use on Marine Base in Okinawa (to compare use trends)
- Local Guam prices for labor and materials for Capital projects and O&M water and sewer costs (to update our cost assumptions)



Energy Systems

will strive for efficiency of energy delivery in the transition to renewable resources.

GJMMP – SSIMe Analysis

Work To Date

- Calibrated modeling has been undertaken on the following building types:
  - 3 Story HQ Office
  - 2 Story HQ Office
  - 1 Story Small Office
  - Conditioned Warehouse
  - Unconditioned Warehouse
  - Day Center
  - Commissary
  - Dining Facility
  - BEQ
  - School
  - Workshop
  - Single Family Dwelling
  - Duplex
- Ground truthing of models based on existing building energy use data in Guam:
  - Energy use data at “Big Navy” showed significant variance in the energy use for different building types (no “typical values”)
  - Limited availability of data for different building types

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GJMMP – SSIMe Analysis

Work To Date

- The Energy Star target finder was used to provide CEBCS “baseline” energy use information to help calibrate the models
  - Architecture 2030 estimates an energy improvement of around 25% is required to achieve Architecture 2030 compliance (analogous to EISA 2007)
  - Analysis indicates that this is in line with the baseline energy use of the majority of the building types modeled.
  - More specialist building types are not covered within the Energy Star target finder (which is used as the baseline for EISA compliance)

- Preliminary costing information has been collated, based on mainland equipment prices, escalated using the “Guam Factor” (2.64)

GJMMP – SSIMe Analysis

Definitions

- Baseline: ASHRAE 90.1-2007 baseline energy performance
- BAU: Prescriptive Navy / DoD policies (e.g. “high efficiency HVAC)
- Option A, Option B, Option C: Increasing levels of energy performance through system selection

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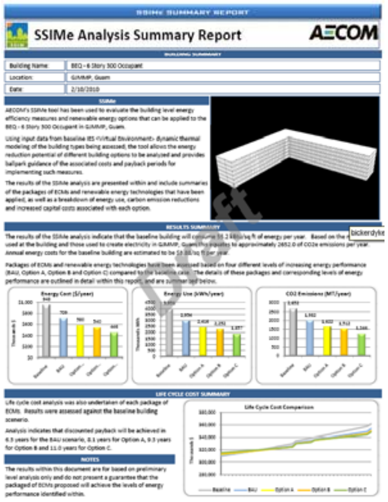
GJMMP – SSIMe Analysis (BY: not sure what this adds)

Example SSIMe Results Packages

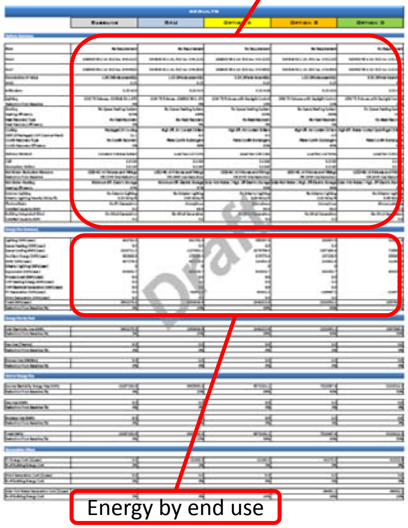


SSIMe Analysis Summary Report

AECOM

Building Name:	BEQ - 6 Story 300 Occupant
Location:	GJMMP, Guam
Date:	2/10/2010

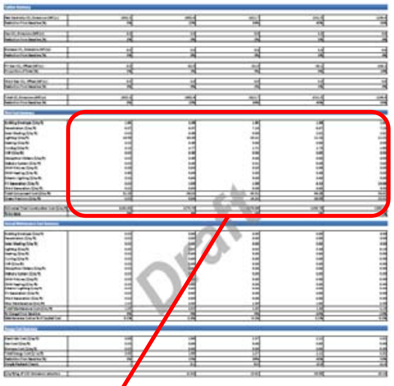
ECMs selected for each package



Energy by end use

GJMMP – SSIMe Analysis (BY: not readable at this scale, what are we trying to get across?)

Example SSIMe Results Packages

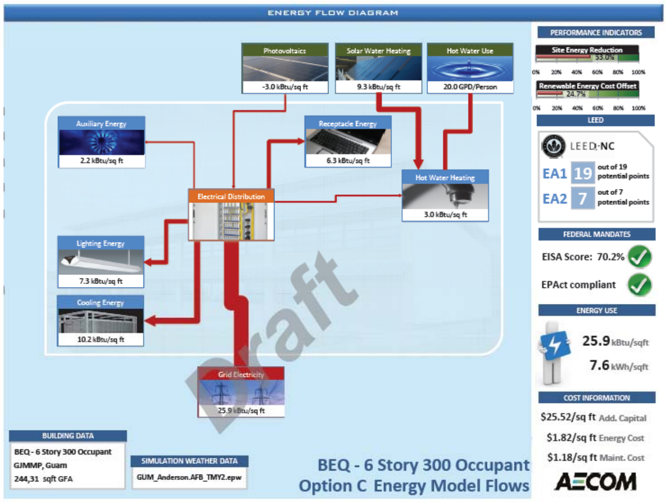


First cost summary

Life cycle cost summary
Based on 40 year analysis period
DoD LCC factors

GJMMP – SSIMe Analysis

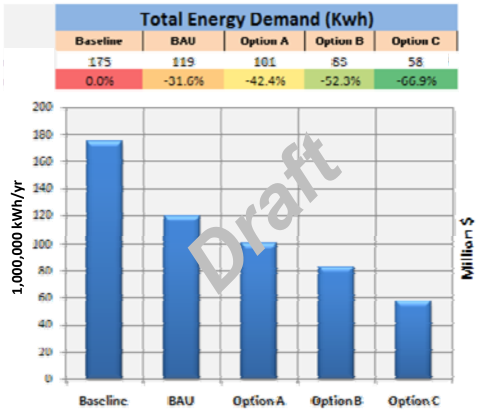
Example SSIMe Results Packages



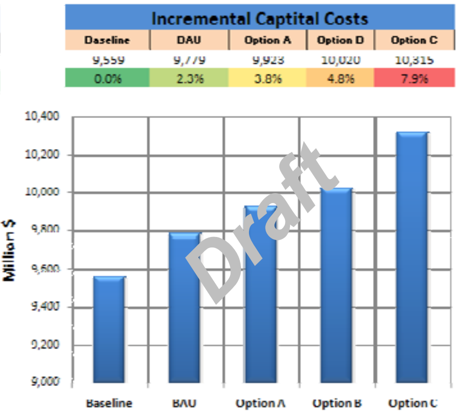
- Energy Flow Diagrams presented for each packaged of ECMs
- Includes anticipated LEED EA1 (energy cost reduction) and EA2 points (renewable energy cost offset) points.
- Additional capital cost requirements ($/sq ft) presented for each case.

GJMMP - SSIMe Analysis

Site Wide Energy Performance



Total Energy Demand (Kwh)				
Baseline	BAU	Option A	Option B	Option C
175	119	101	83	58
0.0%	-31.6%	-42.4%	-52.3%	-66.9%



Incremental Captital Costs				
Baseline	BAU	Option A	Option B	Option C
9,559	9,779	9,923	10,020	10,315
0.0%	2.3%	3.8%	4.8%	7.9%

GJMMP - SSIMe Analysis

PV

- The use of rooftop BIPV (amorphous PV) is currently considered a "BAU" strategy
- Greater energy savings can be achieved with conventional PV technologies (polycrystalline and monocrystalline) but at increased risk from typhoons
- The energy production increase from tilting panels is low (<1%) (maximum efficiency at ~9° tilt)
- Could flush mounted conventional PV technologies be used successfully?

GJMMP - SSIMe Analysis

Solar Thermal Hot Water

- Already used successfully in Guam
- Significant total energy savings can be achieved in buildings with high STHW demand (particularly dwellings and BEQs)
- Potential the same issues as PV with typhoon-proofing
- The Guam local energy code requires all new buildings to be STHW ‘ready’
  - Not specifically applicable to GJMMP
- Is STHW a strategy that should be aggressively pursued?
- Flat plate or evacuated tube?

GJMMP - SSIMe Analysis

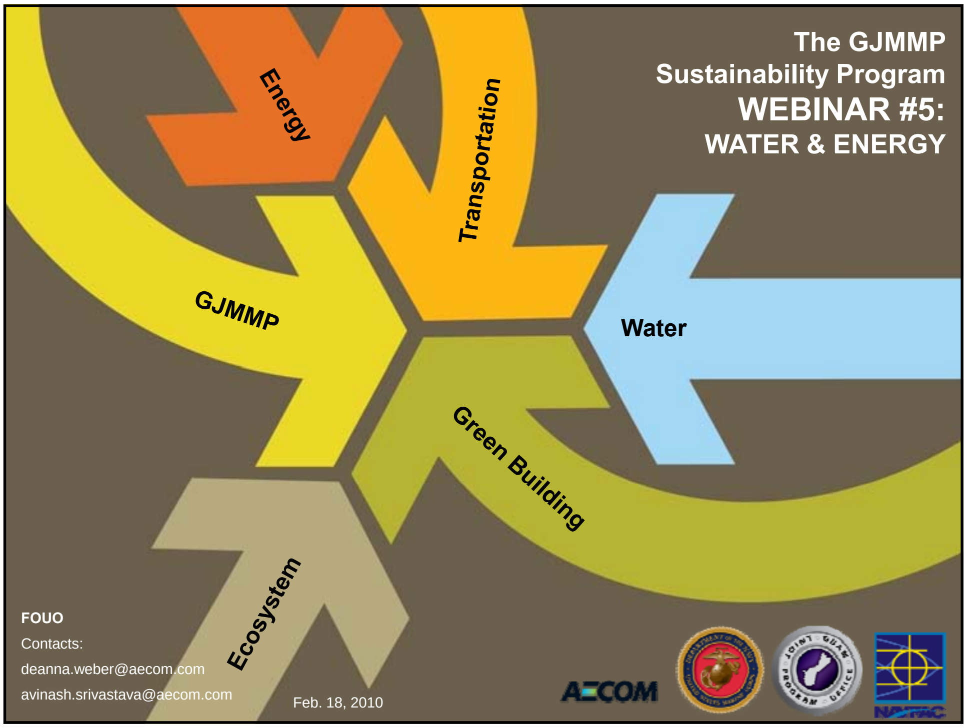
District Energy

- District energy strategies have been discussed in detail
- A full district wide system would be extremely expensive
- It is unlikely that significant energy savings could be garnered through the use of a district energy strategy
  - Alternate technologies e.g. biomass or CHP are not viable for the site
  - A district cooling system would therefore likely use water cooled chillers / cooling towers
  - The largest facilities (BEQs) are likely to use water cooled chillers and cooling towers regardless
- The use of central cooling systems on groups of buildings will have O&M benefits
- Consideration should be given to the use of central plant systems on buildings procured in packaged (e.g. BEQs)

GJMMP - SSIMe Analysis

Moving forward

- Review of the draft SSIMe analysis for each building type by the energy working group
- Feedback on the ECM packages that are currently proposed to the AECOM SSIMe team
- Decision on the ‘district systems strategy’
- Decision on renewable energy strategies
- Review of costs by the energy working group and SSIMe team green building cost consultant
- Refinement of ECM packages based on the above



The GJMMP
Sustainability Program
WEBINAR #5:
WATER & ENERGY

FOUO
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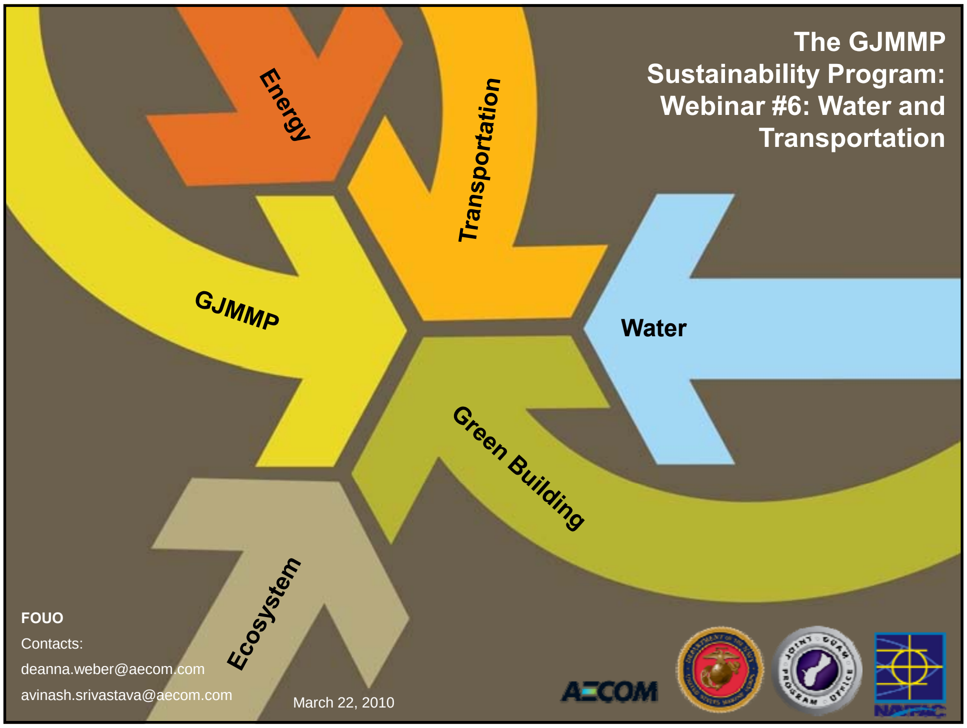
Feb. 18, 2010



The GJMMP Sustainability Program: Webinar #6: Water and Transportation

FOUO

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March 22, 2010

Transportation Systems

will quantify cost versus benefit of VMT (Vehicle Mile Traveled) reduction

Federal Mandates: Executive Order 13514 & DoD Directive

- Reduce use of fossil fuels via alternative fuels and optimizing the agency's vehicle fleet
  - 30% reduction in petroleum use by vehicle fleet over 2005 levels by 2020
- Reduce greenhouse gas emissions
  - 34% reduction in greenhouse gas emissions
- Implement strategies and accommodations for transit, travel, training, and conferencing that actively support lower-carbon commuting and travel by agency staff

Transportation Packages Overview (Slide 1 of 3) DRAFT

ELEMENT	Baseline	Option A	Option B	Option C
PARKING AND DEMAND MANAGEMENT	UFC Parking	Land bank area for 800 spaces or 4% of total and provide car share and NEV parking	Land bank area for 800 spaces or 4% of total and provide car share and NEV parking	15% parking reduction, plus Option B and provide car share and NEV parking Centrally located parking facility
	Limit Transient Auto Ownership	Limit auto ownership for E1-E3 (4,137 Marines)	Limit auto ownership for E1-E3 (4,137 Marines)	10% of Military Staff choose not to ship a vehicle to base for $2000 "cash out", plus Option B
	No **Transportation Demand Management (TDM)** Program	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator	TDM Program Incentives / Disincentives and two Full-Time Coordinators (two at 40 hrs/wk)

Note: TDM includes elements such as incentives/programs to encourage non-auto travel, transit subsidies, commute/travel assistance, preferential carpool parking, parking management, transportation surveys.

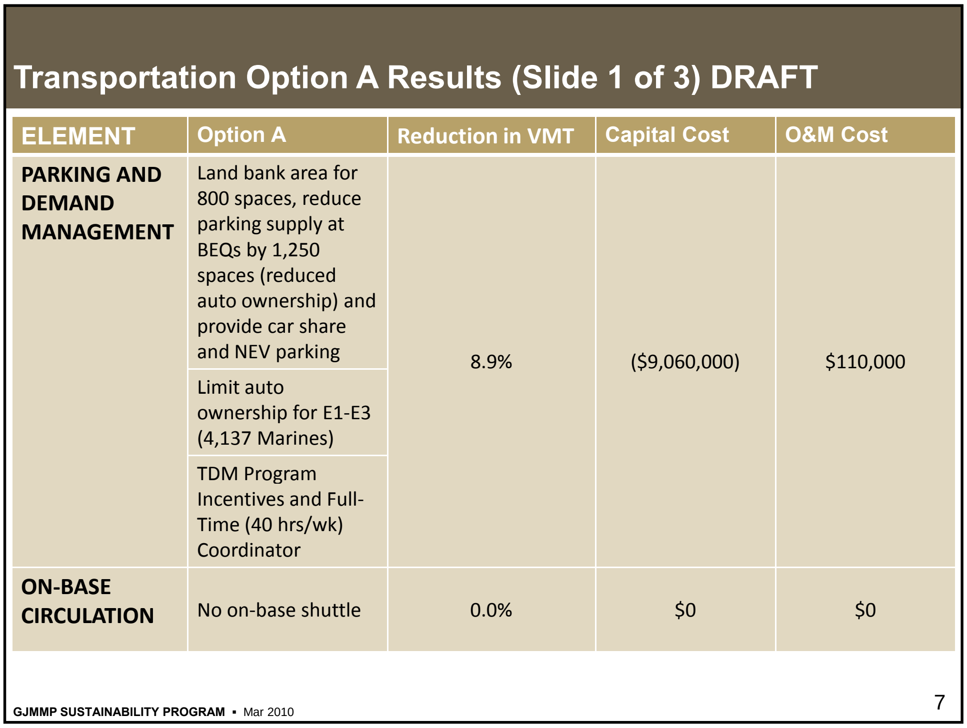
Transportation Packages Overview (Slide 2 of 3) DRAFT

ELEMENT	Baseline	Option A	Option B	Option C
ON-BASE CIRCULATION	No shuttle	No shuttle	Shuttle: 30-minute headways	Shuttle:15-minute headways during peak periods, 30-minutes other hours
			Shuttle: Operates 12 hours/day (6am to 6pm)	Shuttle: Operates 18 hours/day (6am to 12am)
				Demand-responsive van outside peak periods
OFF-BASE CIRCULATION	No off-base Circulation	Operates during peak hours (6 round trips/day)	Operates during peak hours (6 round trips/day)	All-day and late-night service, 6am – 12am (30 round trips/day)
		Hourly headways	Hourly headways	30-minute headways during 6am – 6pm; hourly otherwise
		Shuttle and Guam Transit have convenient transfers	Shuttle and Guam Transit have convenient transfers	Shuttle and Guam Transit have convenient transfer schedules

Transportation Packages Overview (Slide 3 of 3) DRAFT

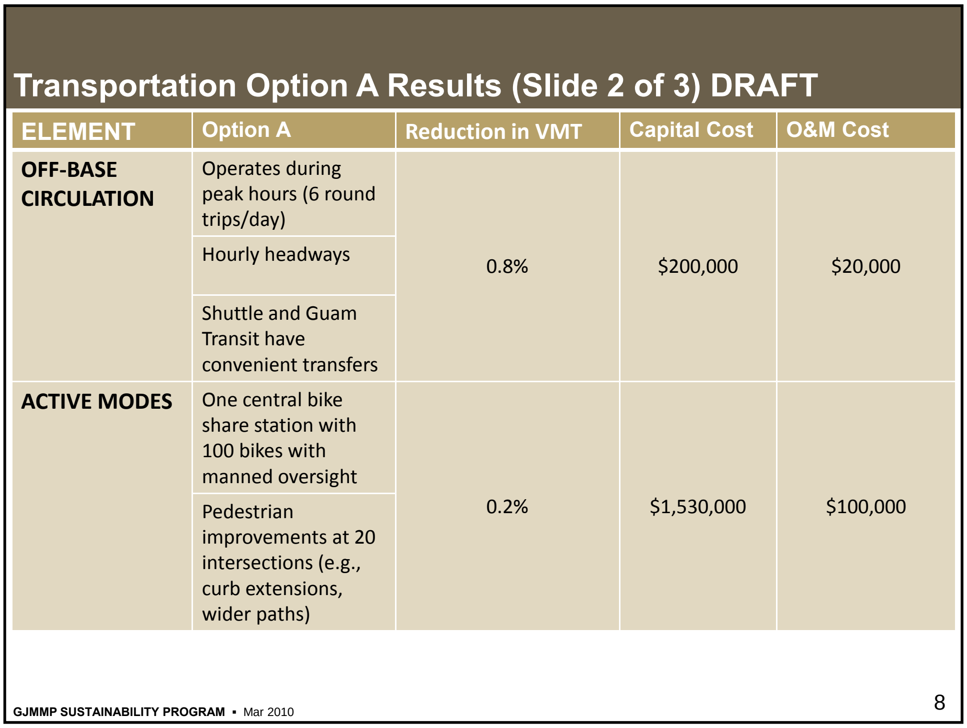
ELEMENT	Baseline	Option A	Option B	Option C
ACTIVE MODES	No Bike Sharing	One central bike share station with 100 bikes with manned oversight*	One central bike share station with 50 bikes with manned oversight*	One central bike share station with 50 bikes plus five satellite pods with 25 bikes/each*
	Limited Pedestrian Improvements	Pedestrian improvements at 20 intersections (e.g., curb extensions, wider paths)	Pedestrian improvements at 15 intersections (e.g., curb extensions, wider paths)	Pedestrian improvements at 30 intersections
VEHICLE POOL	Gasoline	20% Electric/ 20% Hybrid	20% Electric/ 20% Hybrid	30% Electric/ 30% Hybrid
	No car share	One central car share location with 100 cars*	One central car share location with 100 cars*	One central (100 cars) and five satellite (25 cars/each) car share locations*
	No Neighborhood Electric Vehicle (NEV) Program	One central NEV location with 300 NEVs	One central NEV location with 150 NEVs	One central (150 NEVs) and five satellite (25 NEVs/each) NEV locations

*Assumed military would operate to represent most conservative cost model, but public-private partnership may be considered for cost savings – possibly up to 50% or more. Assumed car share vehicles would not require an additional maintenance area.



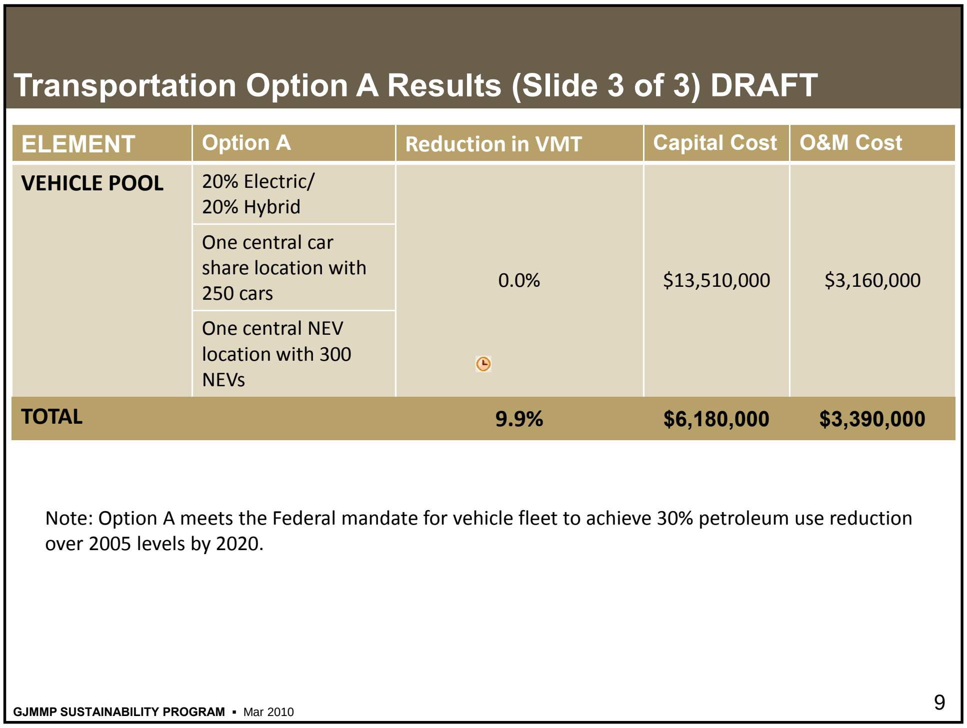
Transportation Option A Results (Slide 1 of 3) DRAFT

ELEMENT	Option A	Reduction in VMT	Capital Cost	O&M Cost
PARKING AND DEMAND MANAGEMENT	Land bank area for 800 spaces, reduce parking supply at BEQs by 1,250 spaces (reduced auto ownership) and provide car share and NEV parking	8.9%	($9,060,000)	$110,000
	Limit auto ownership for E1-E3 (4,137 Marines)			
	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator			
ON-BASE CIRCULATION	No on-base shuttle	0.0%	$0	$0



Transportation Option A Results (Slide 2 of 3) DRAFT

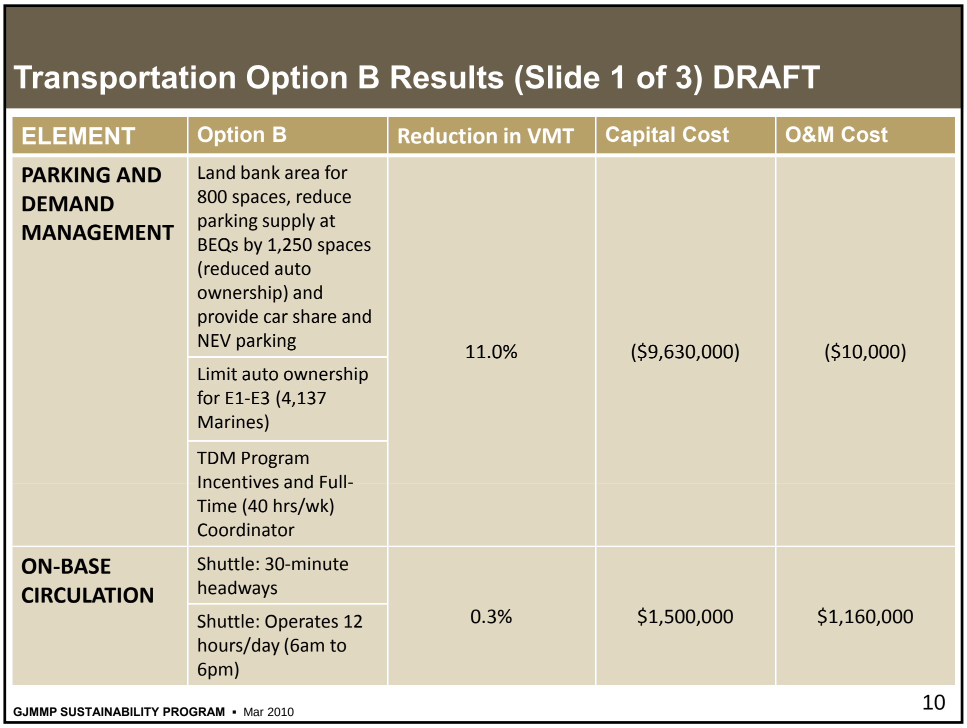
ELEMENT	Option A	Reduction in VMT	Capital Cost	O&M Cost
OFF-BASE CIRCULATION	Operates during peak hours (6 round trips/day)	0.8%	$200,000	$20,000
	Hourly headways			
	Shuttle and Guam Transit have convenient transfers			
ACTIVE MODES	One central bike share station with 100 bikes with manned oversight	0.2%	$1,530,000	$100,000
	Pedestrian improvements at 20 intersections (e.g., curb extensions, wider paths)			



Transportation Option A Results (Slide 3 of 3) DRAFT

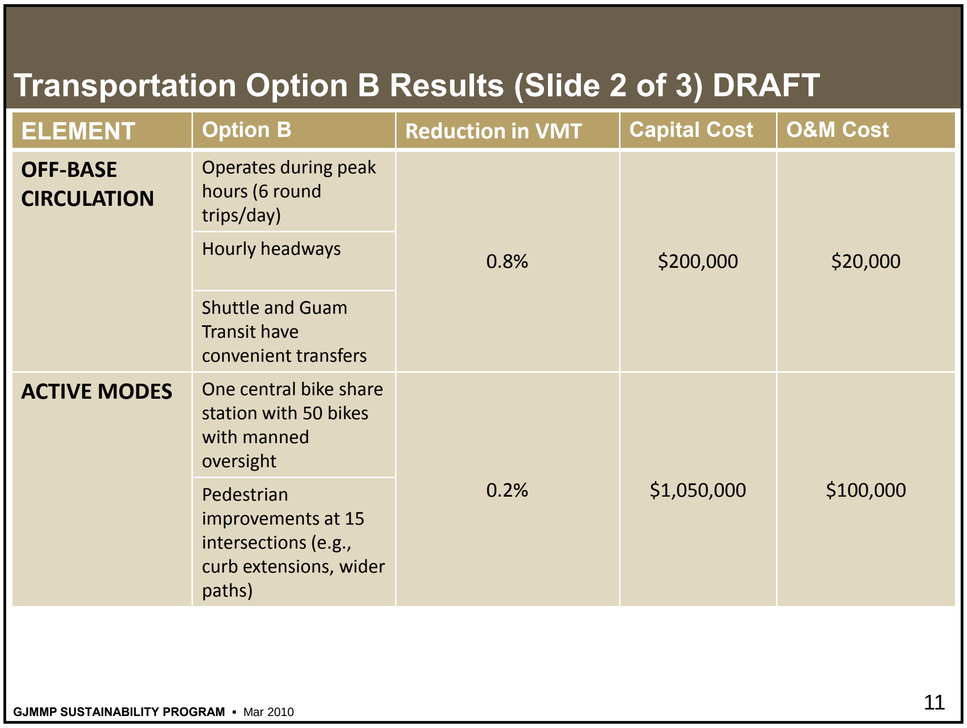
ELEMENT	Option A	Reduction in VMT	Capital Cost	O&M Cost
VEHICLE POOL	20% Electric/ 20% Hybrid	0.0%	$13,510,000	$3,160,000
	One central car share location with 250 cars			
	One central NEV location with 300 NEVs			
TOTAL		**9.9%**	**$6,180,000**	**$3,390,000**

Note: Option A meets the Federal mandate for vehicle fleet to achieve 30% petroleum use reduction over 2005 levels by 2020.



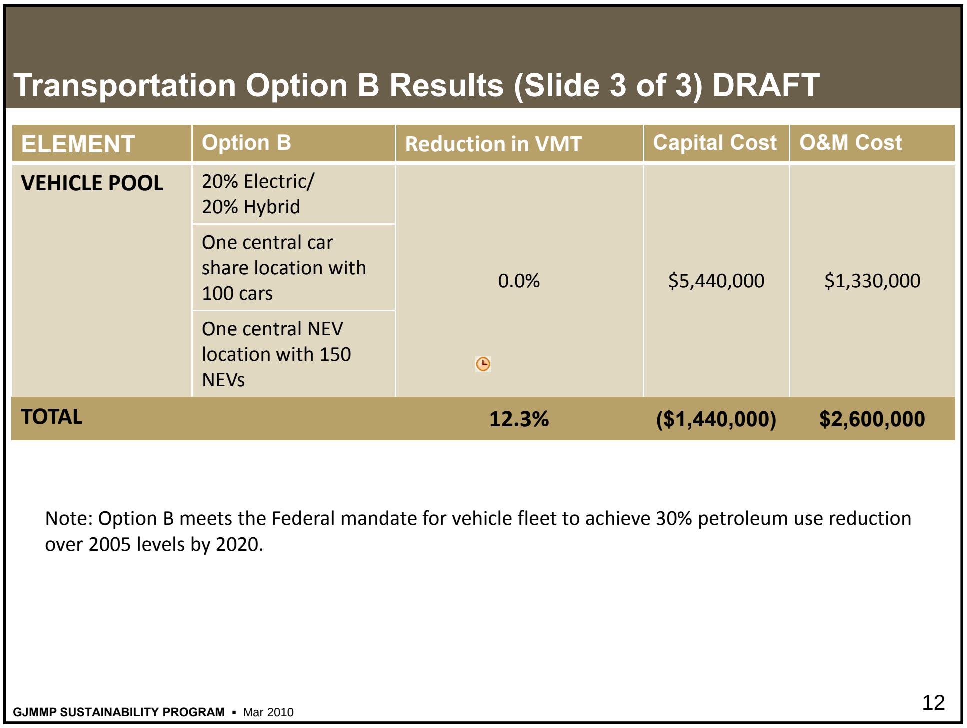
Transportation Option B Results (Slide 1 of 3) DRAFT

ELEMENT	Option B	Reduction in VMT	Capital Cost	O&M Cost
PARKING AND DEMAND MANAGEMENT	Land bank area for 800 spaces, reduce parking supply at BEQs by 1,250 spaces (reduced auto ownership) and provide car share and NEV parking	11.0%	($9,630,000)	($10,000)
	Limit auto ownership for E1-E3 (4,137 Marines)			
	TDM Program Incentives and Full-Time (40 hrs/wk) Coordinator			
ON-BASE CIRCULATION	Shuttle: 30-minute headways	0.3%	$1,500,000	$1,160,000
	Shuttle: Operates 12 hours/day (6am to 6pm)			



Transportation Option B Results (Slide 2 of 3) DRAFT

ELEMENT	Option B	Reduction in VMT	Capital Cost	O&M Cost
OFF-BASE CIRCULATION	Operates during peak hours (6 round trips/day)	0.8%	$200,000	$20,000
	Hourly headways			
	Shuttle and Guam Transit have convenient transfers			
ACTIVE MODES	One central bike share station with 50 bikes with manned oversight	0.2%	$1,050,000	$100,000
	Pedestrian improvements at 15 intersections (e.g., curb extensions, wider paths)			



Transportation Option B Results (Slide 3 of 3) DRAFT

ELEMENT	Option B	Reduction in VMT	Capital Cost	O&M Cost
VEHICLE POOL	20% Electric/ 20% Hybrid	0.0%	$5,440,000	$1,330,000
	One central car share location with 100 cars			
	One central NEV location with 150 NEVs			
TOTAL		**12.3%**	**($1,440,000)**	**$2,600,000**

Note: Option B meets the Federal mandate for vehicle fleet to achieve 30% petroleum use reduction over 2005 levels by 2020.

Transportation Option C Results (Slide 1 of 3) DRAFT

ELEMENT	Option C	Reduction in VMT	Capital Cost	O&M Cost
PARKING AND DEMAND MANAGEMENT	15% parking reduction, plus Option B, and provide car share and NEV parking Centrally located parking facility	18.8%	($12,770,000)	($720,000)
	10% of Military Staff choose not to ship a vehicle to base for $2000 “cash out”, plus Option A E1- E3 restriction			
	TDM Program Incentives / Disincentives and two Full-Time Coordinators (two at 40 hrs/wk)			
ON-BASE CIRCULATION	Shuttle:15-minute headways during peak periods, 30-minutes other hours	0.7%	$3,080,000	$4,000,000
	Shuttle: Operates 18 hours/day (6am to 12am)			
	Demand-responsive van outside peak periods			

Note: TDM includes elements such as incentives/programs to encourage non-auto travel, transit subsidies, commute/travel assistance, preferential carpool parking, parking management, transportation surveys.

Transportation Option C Results (Slide 2 of 3) DRAFT

ELEMENT	Option C	Performance	Capital Cost	O&M Cost
OFF-BASE CIRCULATION	All-day and late-night service, 6am – 12am (30 round trips/day)	3.0%	$500,000	$70,000
	30-minute headways during 6am – 6pm; hourly otherwise			
	Shuttle and Guam Transit have convenient transfer schedules			
ACTIVE MODES	One central bike share station with 50 bikes plus five satellite pods with 25 bikes/each	0.4%	$2,190,000	$210,000
	Pedestrian improvements at 30 intersections			

Transportation Option C Results (Slide 3 of 3) DRAFT

ELEMENT	Option C	Performance	Capital Cost	O&M Cost
VEHICLE POOL	30% Electric/ 30% Hybrid	0.0%	$11,530,000	$2,850,000
	One central (100 cars) and five satellite (25 cars/each) car share locations			
	One central (150 NEVs) and five satellite (25 NEVs/each) NEV locations			
TOTAL		**22.9%**	**($8,680,000)**	**$6,410,000**

Note: Option C exceeds the Federal mandate for vehicle fleet to achieve 30% petroleum use reduction over 2005 levels by 2020.

Transportation Results - DRAFT

		Baseline	Option A	Option B	Option c
VMT		73,192,355	65,946,312	64,189,695	56,431,306
	% of baseline		-9.9%	-12.3%	-22.9%
		Baseline	**Option A**	**Option B**	**Option c**
Gasoline (Gallons)		2,395,386	1,510,770	1,470,528	1,015,764
	% of baseline		-37%	-39%	-58%
Mobile Emissions (MTCo2eq)		45,687,307	35,612,322	34,663,715	28,098,588
	% of baseline		-22%	-24%	-38%

References

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- Fehr & Peers, Military Base Transportation Survey, distributed to Guam bases, March 2010.
- Guam Sustainability Charrette, held October 22-23, 2009.
- Institute of Transportation Engineers, *Trip Generation, 8th Edition,* 2009.
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- UFC Design Criteria.
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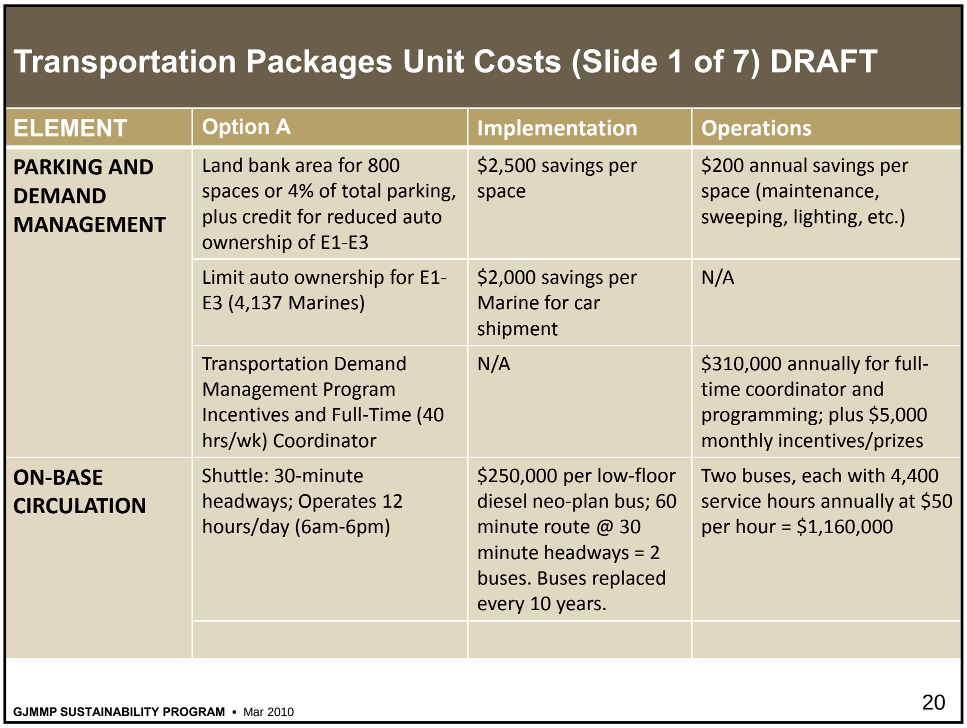
Transportation Survey Results - Preliminary Summary

- As of March 22, 109 responses received
  - Anderson AFB, Naval Base Guam
- 94% live in family housing
- 43% are dependents/57% military personnel

- I would walk, bike, or take the shuttle/bus more often if:
  - More walking paths: 57%
  - More bicycling paths and/or lanes: 48%
  - Safer places to walk or bike: 52%
  - Less traffic and congestion: 80%
  - Shorter waits on the shuttle/bus: 76%
  - A stop closer to my house: 63%
  - Cleaner or newer shuttles/buses: 89%
  - Shaded areas to wait for the shuttle/bus: 74%

Transportation Systems

will quantify cost versus benefit of VMT (Vehicle Mile Traveled) reduction



Transportation Packages Unit Costs (Slide 1 of 7) DRAFT

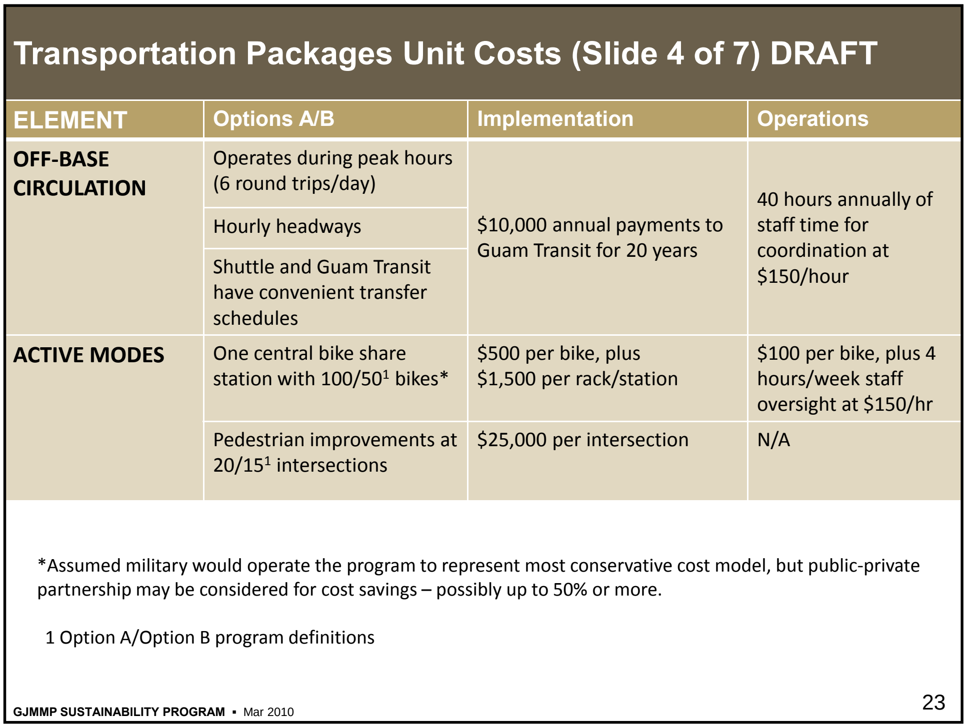
ELEMENT	Option A	Implementation	Operations
PARKING AND DEMAND MANAGEMENT	Land bank area for 800 spaces or 4% of total parking, plus credit for reduced auto ownership of E1-E3	$2,500 savings per space	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	Limit auto ownership for E1-E3 (4,137 Marines)	$2,000 savings per Marine for car shipment	N/A
	Transportation Demand Management Program Incentives and Full-Time (40 hrs/wk) Coordinator	N/A	$310,000 annually for full-time coordinator and programming; plus $5,000 monthly incentives/prizes
ON-BASE CIRCULATION	Shuttle: 30-minute headways; Operates 12 hours/day (6am-6pm)	$250,000 per low-floor diesel neo-plan bus; 60 minute route @ 30 minute headways = 2 buses. Buses replaced every 10 years.	Two buses, each with 4,400 service hours annually at $50 per hour = $1,160,000

Transportation Packages Unit Costs (Slide 2 of 7) DRAFT

ELEMENT	Option B	Implementation	Operations
PARKING AND DEMAND MANAGEMENT	Land bank area for 800 spaces or 4% of total parking, plus credit for reduced auto ownership of E1-E3	$2,500 savings per space	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	Limit auto ownership for E1-E3 (4,137 Marines)	$2,000 savings per Marine for car shipment	N/A
	Transportation Demand Management Program Incentives and Full-Time (40 hrs/wk) Coordinator	N/A	$310,000 annually for full-time coordinator and programming; plus $5,000 monthly incentives/prizes
ON-BASE CIRCULATION	No on-base shuttle	N/A	N/A

Transportation Packages Unit Costs (Slide 3 of 7) DRAFT

ELEMENT	Option C	Implementation	Operations
PARKING AND DEMAND MANAGEMENT	15% parking reduction Centrally located parking facility, plus Option A	$2,500 savings per space	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	10% of Military Staff choose not to ship a vehicle to base for $2000 "cash out", plus Option A	Net cost of $0 for car shipment and cash-out (775 Marines)	$200 annual savings per space (maintenance, sweeping, lighting, etc.)
	TDM Program Incentives / Disincentives and two Full-Time Coordinators (2 at 40 hrs/wk)	N/A	$620,000 annually for full-time coordinator & programming; plus $7,500 monthly incentives/prizes
ON-BASE CIRCULATION	Shuttle: 15-minute headways during peaks, 30-minutes other hours; Operates 18 hours/day (6am to 12am)	$250,000 per bus; 60 minute route @ 15 minute headways = 4 buses. Buses replaced every 10 years.	Four buses, each with 6,600 service hours annually at $50 per hour = $3,470,000
	Demand-responsive van outside peak periods (9am to 11am; 1pm to 3pm; 5pm to 12pm)	$25,000 per van (2 vans)	4,100 service hours annually at $50 per hour = $2,050,000

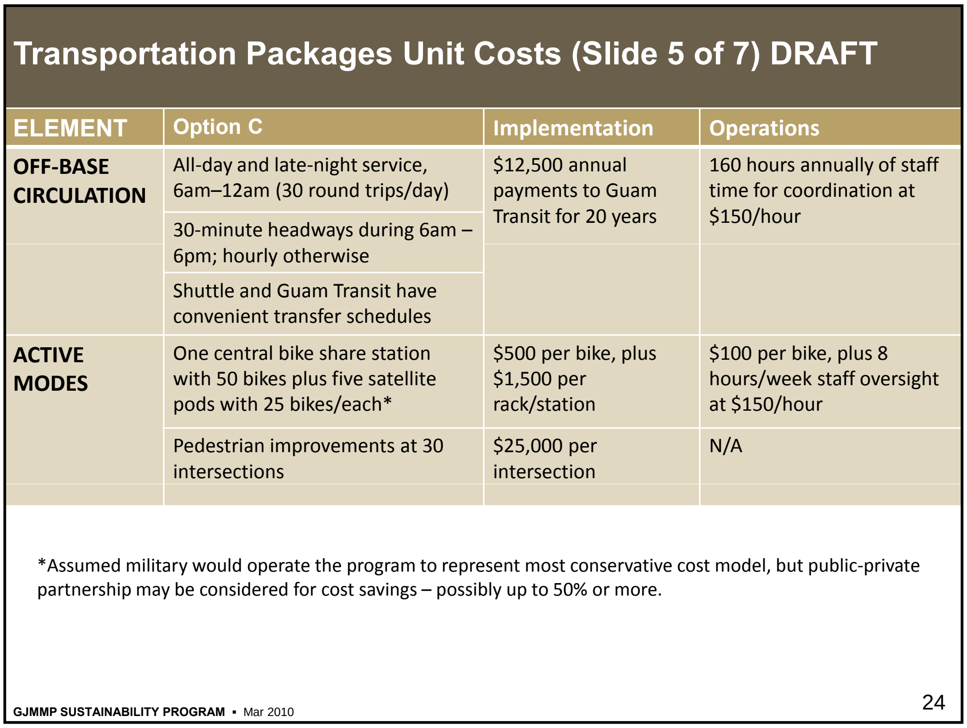


Transportation Packages Unit Costs (Slide 4 of 7) DRAFT

ELEMENT	Options A/B	Implementation	Operations
OFF-BASE CIRCULATION	Operates during peak hours (6 round trips/day)	$10,000 annual payments to Guam Transit for 20 years	40 hours annually of staff time for coordination at $150/hour
	Hourly headways		
	Shuttle and Guam Transit have convenient transfer schedules		
ACTIVE MODES	One central bike share station with 100/50[1] bikes*	$500 per bike, plus $1,500 per rack/station	$100 per bike, plus 4 hours/week staff oversight at $150/hr
	Pedestrian improvements at 20/15[1] intersections	$25,000 per intersection	N/A

*Assumed military would operate the program to represent most conservative cost model, but public-private partnership may be considered for cost savings – possibly up to 50% or more.

1 Option A/Option B program definitions



Transportation Packages Unit Costs (Slide 5 of 7) DRAFT

ELEMENT	Option C	Implementation	Operations
OFF-BASE CIRCULATION	All-day and late-night service, 6am–12am (30 round trips/day)	$12,500 annual payments to Guam Transit for 20 years	160 hours annually of staff time for coordination at $150/hour
	30-minute headways during 6am – 6pm; hourly otherwise		
	Shuttle and Guam Transit have convenient transfer schedules		
ACTIVE MODES	One central bike share station with 50 bikes plus five satellite pods with 25 bikes/each*	$500 per bike, plus $1,500 per rack/station	$100 per bike, plus 8 hours/week staff oversight at $150/hour
	Pedestrian improvements at 30 intersections	$25,000 per intersection	N/A

*Assumed military would operate the program to represent most conservative cost model, but public-private partnership may be considered for cost savings – possibly up to 50% or more.

Transportation Packages Unit Costs (Slide 6 of 7) DRAFT

ELEMENT	Options A/B	Implementation	Operations
VEHICLE POOL	20% Electric/ 20% Hybrid		
	One central car share location with 250/100[1] cars*	$25,000 per vehicle plus $2,000 per vehicle facility/infrastructure	$5,000 annual per vehicle (fuel, maintenance, operations)
	One central Neighborhood Electric Vehicles (NEV) location with 300/150[1] NEVs	$6,000 per NEV, plus $1,500 per NEV facility/infrastructure costs	$1,500 per NEV (maintenance, power supply, etc.)

*Assumed military would operate to represent most conservative cost model, but public-private partnership may be considered for cost savings – possibly up to 50% or more. Assumed car share vehicles would not require an additional maintenance area.

1 Option A/Option B program definitions

Transportation Packages Unit Costs (Slide 7 of 7) DRAFT

ELEMENT	Option C	Implementation	Operations
VEHICLE POOL	30% Electric/ 30% Hybrid		
	One central (100 cars) and five satellite (25 cars/ each) car share locations*	$25,000 per vehicle plus $2,000 per vehicle facility/infrastructure	$5,000 annual per vehicle (fuel, maintenance, operations)
	One central (150 NEVs) and five satellite (25 NEVs/each) NEV locations	$6,000 per NEV, plus $1,500 per NEV facility/infrastructure costs	$1,500 per NEV (maintenance, power supply, etc.)

*Assumed military would operate to represent most conservative cost model, but public-private partnership may be considered for cost savings – possibly up to 50% or more. Assumed car share vehicles would not require an additional maintenance area.

Water Balance Planning

establishes an equilibrium between natural water supplies and human demand.

Water ~ Overall Goals

- **Meet and Exceed Federal Mandates to Reduce Water Consumption**
  - Executive Order 13514 (water reduction 2% per year to FY 2020)
  - EISA 438 (Incorporate LID for all buildings greater than 5,000 gross s.f.)
  - EPAct 1992 & 2005 (Use of efficient water fixtures)
  - LEED NC 2009, Version 3 (Silver certification)
- **Use Simple Systems** – Ease of Construction, Maintenance and Monitoring
- **Protection of the Aquifer & Coastal Resources** – Stormwater quality
  - Water Sensitive Urban Design
  - Low Impact Development

The use of Bioswales and Created Wetlands is critical to providing stormwater quality.

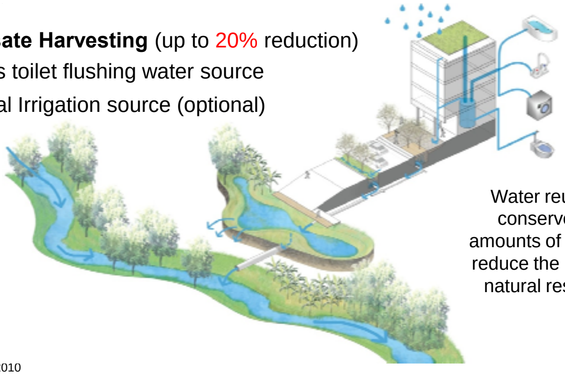
Water ~ Reduction Strategies

Indoor Reduction

- **Low Flow Fixtures** (up to 30% reduction)

Outdoor Capture / Indoor Reuse

- **Rooftop Rainwater Harvesting** (up to 20% reduction)
  - Reuse as toilet flushing water source
  - Reduce stormwater treatment by capture
- **AC Condensate Harvesting** (up to 20% reduction)
  - Reuse as toilet flushing water source
  - Potential Irrigation source (optional)



Water reuse can conserve large amounts of water and reduce the impact on natural resources.

Water ~ Reduction Strategies DRAFT

Interior Water Use

Benchmarks – Housing water use

- UFC = 180 gpcd (interior and exterior use U.S. National Avg.)
- BAU = 100 gpcd (interior and exterior use on Guam)
- Baseline = current EPA standard ~ 70 gpcd
- Option A = improved EPA standard ~ 63 gpcd
- Option B = EPA Water Sense ~ 56 gpcd
- Option C = improved Water Sense ~ 50 gpcd

Waterless Urinals

Reduction from Baseline

- Option A = 12%
- Option B = 24%
- Option C = 34%

Low Flow Fixtures

Water ~ SSIM Model Input

Water use evaluation and gaming by facility and land use type

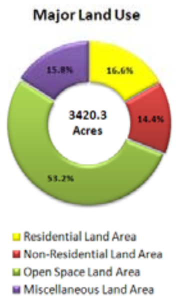
- Single Family Residential
- BEQ / BOQ Residential
- High Occupancy Non-Residential
- Low Occupancy Non-Residential
- Landscape and Open Space
- Pavement

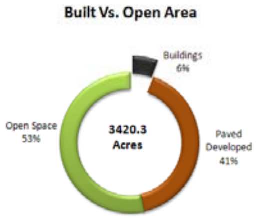
Water Supply options for evaluation

- Groundwater Aquifer
- Rainfall Harvesting
- Condensate Harvesting
- Graywater (optional)
- TSE (Treated Sewage Effluent)(optional)

With 100" of rainfall annually, rainwater capture is an important strategy to reduce water demand.

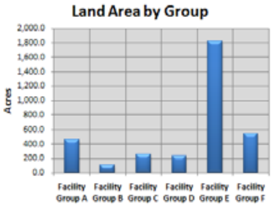
Water ~ Base Development Program Input DRAFT

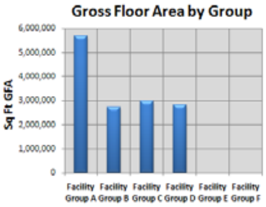




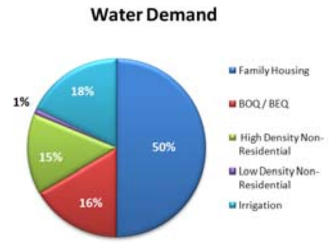
Site Area:	3420.3 Acres
Residents:	23,564
Workers*:	13,554 *Full-Time Equivalents
Total GFA :	14.2M sf
# Facilities :	1,330

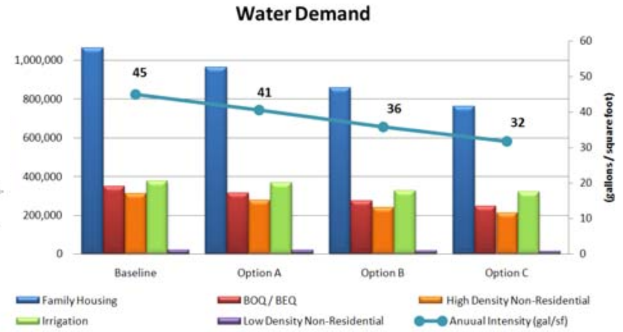
FACILITY GROUP CLASSIFICATION	
Facility Group A	Family Housing
Facility Group B	BOQ/BEQ
Facility Group C	Non-Residential High Occupancy
Facility Group D	Non-Residential Low Occupancy
Facility Group E	Open Space and Undeveloped
Facility Group F	Streets and Parking





Water ~ SSIM Analysis DRAFT

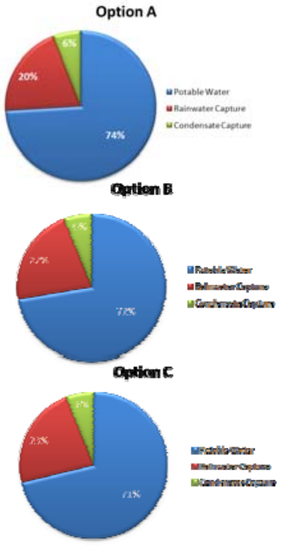


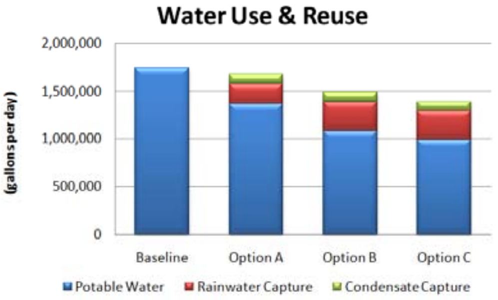


Water Demand (water use Gallons / day)

User	Baseline	Option A	Option B	Option C
Family Housing	1,062,471	964,655	859,270	763,422
BOQ / BEQ	350,816	315,734	275,174	245,571
High Density Non-Residential	310,962	278,108	240,256	211,948
Low Density Non-Residential	21,399	19,042	16,090	14,127
Irrigation	376,468	366,988	326,804	320,758
Daily total	**1,745,648**	**1,577,539**	**1,390,790**	**1,235,068**
Annual total	**637,161,520**	**575,801,735**	**507,638,350**	**450,799,820**
Anuual Intensity (gal/sf)	**45**	**41**	**36**	**32**

Water ~ SSIM Analysis DRAFT

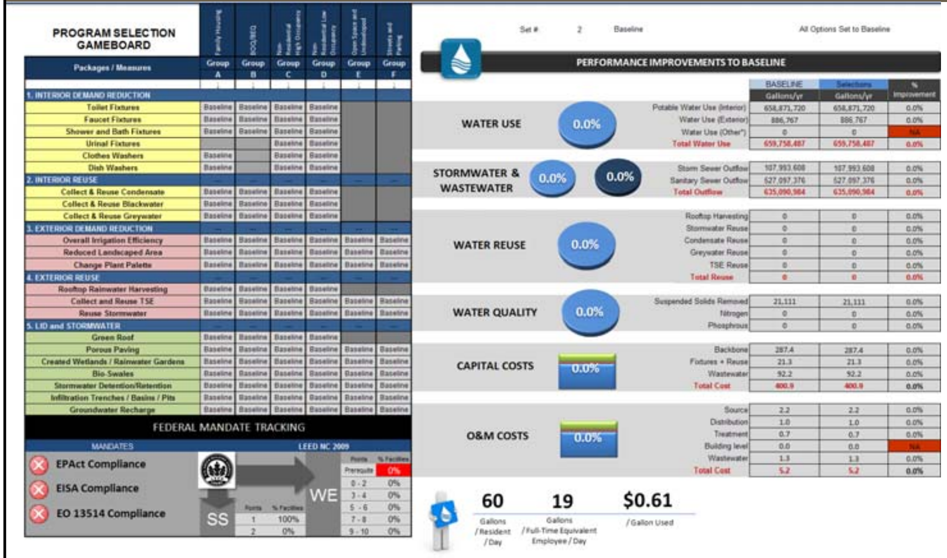




Water Reuse should come before stormwater
(water use Gallons / day)

Source	Baseline	Option A	Option B	Option C	
Potable Water	1,748,463	1,243,679	1,073,016	938,274	these numbers need to be verified
Rainwater Capture	0	336,394	319,943	298,765	these numbers need to be verified
Condensate Capture	0	100,000	90,000	80,000	these numbers need to be verified
totals	**1,748,463**	**1,577,539**	**1,390,790**	**1,235,068**	

Water ~ SSIM Analysis Baseline DRAFT



PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Baseline	Baseline	Baseline	Baseline		
Faucet Fixtures	Baseline	Baseline	Baseline	Baseline		
Shower and Bath Fixtures	Baseline	Baseline	Baseline	Baseline		
Urinal Fixtures			Baseline	Baseline		
Clothes Washers	Baseline		Baseline	Baseline		
Dish Washers	Baseline		Baseline	Baseline		
2. INTERIOR REUSE	—	—	—	—	—	—
Collect & Reuse Condensate	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION	—	—	—	—	—	—
Overall Irrigation Efficiency	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE	—	—	—	—	—	—
Rooftop Rainwater Harvesting	Baseline	Baseline	Baseline	Baseline		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	—	—	—	—	—	—
Green Roof	Baseline	Baseline	Baseline	Baseline		
Porous Paving	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Created Wetlands / Rainwater Gardens	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Bio-Swales	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Stormwater Detention/Retention	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Infiltration Trenches / Basins / Pits	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Groundwater Recharge	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline

FEDERAL MANDATE TRACKING

MANDATES

- ☒ EPAct Compliance
- ☒ EISA Compliance
- ☒ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequisite	0%
0 - 2	0%
3 - 4	0%
5 - 6	0%
7 - 8	0%
9 - 10	0%

Set # 2 Baseline All Options Set to Baseline

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
WATER USE	Potable Water Use (Interior)	658,871,720	658,871,720	0.0%
0.0%	Water Use (Exterior)	886,767	886,767	0.0%
	Water Use (Other*)	0	0	NA
	Total Water Use	659,758,487	659,758,487	0.0%
STORMWATER & WASTEWATER	Storm Sewer Outflow	107,993,608	107,993,608	0.0%
0.0% 0.0%	Sanitary Sewer Outflow	527,097,376	527,097,376	0.0%
	Total Outflow	635,090,984	635,090,984	0.0%
WATER REUSE	Rooftop Harvesting	0	0	0.0%
0.0%	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	0	0.0%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	0	0.0%
WATER QUALITY	Suspended Solids Removed	21,111	21,111	0.0%
0.0%	Nitrogen	0	0	0.0%
	Phosphrous	0	0	0.0%
CAPITAL COSTS	Backbone	287.4	287.4	0.0%
0.0%	Fixtures + Reuse	21.3	21.3	0.0%
	Wastewater	92.2	92.2	0.0%
	Total Cost	400.9	400.9	0.0%
O&M COSTS	Source	2.2	2.2	0.0%
0.0%	Distribution	1.0	1.0	0.0%
	Treatment	0.7	0.7	0.0%
	Building level	0.0	0.0	NA
	Wastewater	1.3	1.3	0.0%
	Total Cost	5.2	5.2	0.0%

60	19	$0.61
Gallons / Resident / Day	Gallons / Full-Time Equivalent Employee / Day	/ Gallon Used

Water ~ SSIM Analysis Option A DRAFT

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Family Housing Group A	BOQ/BEQ Group B	Non-Residential High Occupancy Group C	Non-Residential Low Occupancy Group D	Open Space and Undeveloped Group E	Streets and Parking Group F
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option A	Option A	Option A	Option A		
Faucet Fixtures	Option A	Option A	Option A	Option A		
Shower and Bath Fixtures	Option A	Option A	Option A	Option A		
Urinal Fixtures			Option A	Option A		
Clothes Washers	Option A		Option A	Option A		
Dish Washers	Option A		Option A	Option A		
2. INTERIOR REUSE					—	—
Collect & Reuse Condensate	Option A	Option A	Option A	Option A		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	Option A	Option A	Option A	Option A	Option A	Option A
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option A	Option A	Option A	Option A		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER	—	—	—	—	—	—
Green Roof	Option A	Option A	Option A	Option A		
Porous Paving	Option A	Option A	Option A	Option A	Option A	Option A
Created Wetlands / Rainwater Gardens	Option A	Option A	Option A	Option A	Option A	Option A
Bio-Swales	Option A	Option A	Option A	Option A	Option A	Option A
Stormwater Detention/Retention	Option A	Option A	Option A	Option A	Option A	Option A
Infiltration Trenches / Basins / Pits	Option A	Option A	Option A	Option A	Option A	Option A
Groundwater Recharge	Option A	Option A	Option A	Option A	Option A	Option A

FEDERAL MANDATE TRACKING

MANDATES

- ☒ EPAct Compliance
- ☒ EISA Compliance
- ☒ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequisite	12%
0 - 2	0%
3 - 4	2%
5 - 6	10%
7 - 8	0%
9 - 10	0%

Set # 3 Option A All Options Set to Option A

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
WATER USE	Potable Water Use (Interior)	658,871,720	579,521,243	-12.0%
-12.1%	Water Use (Exterior)	886,767	719,658	-18.8%
	Water Use (Other*)	0	0	NA
	Total Water Use	659,758,487	580,240,901	-12.1%
STORMWATER & WASTEWATER	Storm Sewer Outflow	107,771,128	103,769,677	-3.7%
-3.7% -9.6%	Sanitary Sewer Outflow	527,097,376	476,271,564	-9.6%
	Total Outflow	634,868,504	580,041,241	-8.6%
WATER REUSE	Rooftop Harvesting	0	3,335,052	0.5%
2.4%	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	12,483,160	1.9%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	15,818,212	2.4%
WATER QUALITY	Suspended Solids Removed	21,111	28,609	23.1%
23.1%	Nitrogen	0	0	0.0%
	Phosphrous	0	0	0.0%
CAPITAL COSTS	Backbone	287.4	279.7	-2.7%
4.4%	Fixtures + Reuse	21.3	57.9	172.0%
	Wastewater	92.2	81.1	-12.0%
	Total Cost	400.9	418.7	4.4%
O&M COSTS	Source	2.2	2.0	-11.2%
5.1%	Distribution	1.0	0.8	-11.2%
	Treatment	0.7	0.6	-11.2%
	Building level	0.0	0.9	NA
	Wastewater	1.3	1.2	-12.0%
	Total Cost	5.2	5.5	5.1%

54	16	$0.72
Gallons / Resident / Day	Gallons / Full-Time Equivalent Employee / Day	/ Gallon Used

Water ~ SSIM Analysis Option B DRAFT

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Group A (Family Housing)	Group B (BOQ/BEQ)	Group C (Non-Residential High Occupancy)	Group D (Non-Residential Low Occupancy)	Group E (Open Space and Undeveloped)	Group F (Streets and Parking)
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option B	Option B	Option B	Option B		
Faucet Fixtures	Option B	Option B	Option B	Option B		
Shower and Bath Fixtures	Option B	Option B	Option B	Option B		
Urinal Fixtures			Option B	Option B		
Clothes Washers	Option B		Option B	Option B		
Dish Washers	Option B		Option B	Option B		
2. INTERIOR REUSE						
Collect & Reuse Condensate	Option B	Option B	Option B	Option B		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	Option B	Option B	Option B	Option B	Option B	Option B
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option B	Option B	Option B	Option B		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER						
Green Roof	Option B	Option B	Option B	Option B		
Porous Paving	Option B	Option B	Option B	Option B	Option B	Option B
Created Wetlands / Rainwater Gardens	Option B	Option B	Option B	Option B	Option B	Option B
Bio-Swales	Option B	Option B	Option B	Option B	Option B	Option B
Stormwater Detention/Retention	Option B	Option B	Option B	Option B	Option B	Option B
Infiltration Trenches / Basins / Pits	Option B	Option B	Option B	Option B	Option B	Option B
Groundwater Recharge	Option B	Option B	Option B	Option B	Option B	Option B

FEDERAL MANDATE TRACKING

MANDATES

- ✓ EPAct Compliance
- ✓ EISA Compliance
- ☒ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequisite	25%
0 - 2	0%
3 - 4	2%
5 - 6	11%
7 - 8	12%
9 - 10	0%

Set # 4 Option B

All Options Set to Option B

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
WATER USE -24.3%	Potable Water Use (Interior)	658,871,720	498,798,000	-24.3%
	Water Use (Exterior)	886,767	662,639	-25.3%
	Water Use (Other*)	0	0	NA
	Total Water Use	659,758,487	499,460,639	-24.3%
STORMWATER & WASTEWATER -6.5% -20.5%	Storm Sewer Outflow	107,659,888	100,682,874	-6.5%
	Sanitary Sewer Outflow	527,097,376	418,800,124	-20.5%
	Total Outflow	634,757,264	519,482,998	-18.2%
WATER REUSE 3.7%	Rooftop Harvesting	0	5,977,415	0.9%
	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	18,724,740	2.8%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	24,702,155	3.7%
WATER QUALITY 23.1%	Suspended Solids Removed	21,111	28,609	23.1%
	Nitrogen	0	0	0.0%
	Phosphrous	0	0	0.0%
CAPITAL COSTS -0.5%	Backbone	287.4	271.8	-5.4%
	Fixtures + Reuse	21.3	57.4	[illegible]
	Wastewater	92.2	69.8	-24.3%
	Total Cost	400.9	399.0	-0.5%
O&M COSTS -7.0%	Source	2.2	1.7	-22.6%
	Distribution	1.0	0.7	-22.6%
	Treatment	0.7	0.5	-22.6%
	Building level	0.0	0.8	NA
	Wastewater	1.3	1.0	-24.3%
	Total Cost	5.2	4.9	-7.0%

47	13	$0.80
Gallons / Resident / Day	Gallons / Full-Time Equivalent Employee / Day	/ Gallon Used

Water ~ SSIM Analysis Option C DRAFT

PROGRAM SELECTION GAMEBOARD

Packages / Measures	Group A (Family Housing)	Group B (BOQ/BEQ)	Group C (Non-Residential High Occupancy)	Group D (Non-Residential Low Occupancy)	Group E (Open Space and Undeveloped)	Group F (Streets and Parking)
1. INTERIOR DEMAND REDUCTION						
Toilet Fixtures	Option C	Option C	Option C	Option C		
Faucet Fixtures	Option C	Option C	Option C	Option C		
Shower and Bath Fixtures	Option C	Option C	Option C	Option C		
Urinal Fixtures			Option C	Option C		
Clothes Washers	Option C		Option C	Option C		
Dish Washers	Option C		Option C	Option C		
2. INTERIOR REUSE						
Collect & Reuse Condensate	Option C	Option C	Option C	Option C		
Collect & Reuse Blackwater	Baseline	Baseline	Baseline	Baseline		
Collect & Reuse Greywater	Baseline	Baseline	Baseline	Baseline		
3. EXTERIOR DEMAND REDUCTION						
Overall Irrigation Efficiency	Option C	Option C	Option C	Option C	Option C	Option C
Reduced Landscaped Area	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Change Plant Palette	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
4. EXTERIOR REUSE						
Rooftop Rainwater Harvesting	Option C	Option C	Option C	Option C		
Collect and Reuse TSE	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Reuse Stormwater	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
5. LID and STORMWATER						
Green Roof	Option C	Option C	Option C	Option C		
Porous Paving	Option C	Option C	Option C	Option C	Option C	Option C
Created Wetlands / Rainwater Gardens	Option C	Option C	Option C	Option C	Option C	Option C
Bio-Swales	Option C	Option C	Option C	Option C	Option C	Option C
Stormwater Detention/Retention	Option C	Option C	Option C	Option C	Option C	Option C
Infiltration Trenches / Basins / Pits	Option C	Option C	Option C	Option C	Option C	Option C
Groundwater Recharge	Option C	Option C	Option C	Option C	Option C	Option C

FEDERAL MANDATE TRACKING

MANDATES

- ✓ EPAct Compliance
- ✓ EISA Compliance
- ✓ EO 13514 Compliance

LEED NC 2009

SS

Points	% Facilities
1	100%
2	0%

WE

Points	% Facilities
Prerequisite	92%
0 - 2	0%
3 - 4	67%
5 - 6	0%
7 - 8	25%
9 - 10	0%

Set # 5 Option C

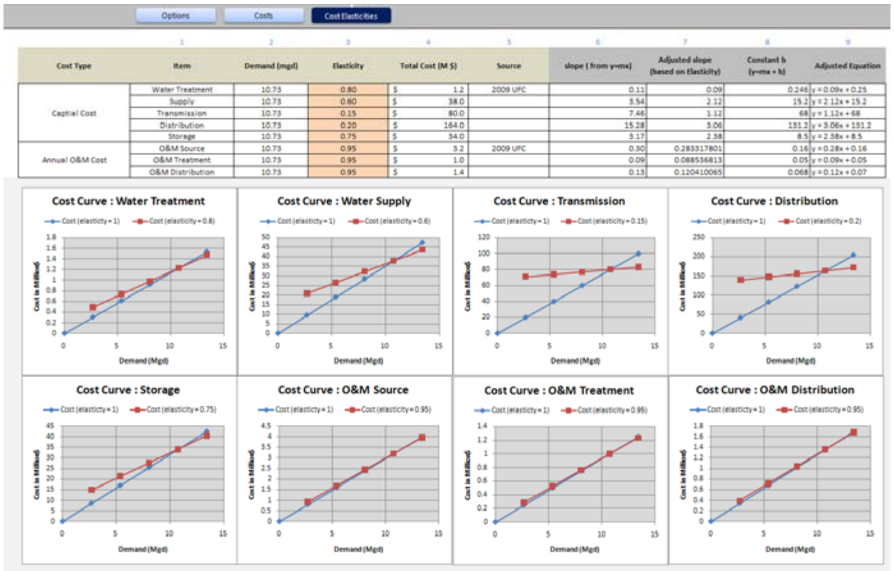
All Options Set to Option C

PERFORMANCE IMPROVEMENTS TO BASELINE

		BASELINE Gallons/yr	Selections Gallons/yr	% Improvement
WATER USE -34.2%	Potable Water Use (Interior)	658,871,720	433,661,403	-34.2%
	Water Use (Exterior)	886,767	615,308	-30.6%
	Water Use (Other*)	0	0	NA
	Total Water Use	659,758,487	434,276,710	-34.2%
STORMWATER & WASTEWATER -8.1% -29.3%	Storm Sewer Outflow	107,548,648	98,846,977	-8.1%
	Sanitary Sewer Outflow	527,097,376	372,797,276	-29.3%
	Total Outflow	634,646,024	471,644,253	-25.7%
WATER REUSE 4.9%	Rooftop Harvesting	0	7,368,872	1.1%
	Stormwater Reuse	0	0	0.0%
	Condensate Reuse	0	24,966,320	3.8%
	Greywater Reuse	0	0	0.0%
	TSE Reuse	0	0	0.0%
	Total Reuse	0	32,335,192	4.9%
WATER QUALITY 23.1%	Suspended Solids Removed	21,111	28,609	23.1%
	Nitrogen	0	0	0.0%
	Phosphrous	0	0	0.0%
CAPITAL COSTS -3.3%	Backbone	287.4	265.4	-7.6%
	Fixtures + Reuse	21.3	61.7	[illegible]
	Wastewater	92.2	60.7	-34.2%
	Total Cost	400.9	387.9	-3.3%
O&M COSTS -16.5%	Source	2.2	1.5	-31.7%
	Distribution	1.0	0.6	-31.7%
	Treatment	0.7	0.5	-31.7%
	Building level	0.0	0.8	NA
	Wastewater	1.3	0.9	-34.2%
	Total Cost	5.2	4.4	-16.5%

41	11	$0.89
Gallons / Resident / Day	Gallons / Full-Time Equivalent Employee / Day	/ Gallon Used

Water ~ Cost Analysis DRAFT



	1	2	3	4		5	6	7	8	9
Cost Type	Item	Demand (mgd)	Elasticity	Total Cost (M $)		Source	slope (from y=mx)	Adjusted slope (based on Elasticity)	Constant b (y=mx + b)	Adjusted Equation
Captial Cost	Water Treatment	10.73	0.80	$	1.2	2009 UFC	0.11	0.09	0.246	y = 0.09x + 0.25
	Supply	10.73	0.60	$	38.0		3.54	2.12	15.2	y = 2.12x + 15.2
	Transmission	10.73	0.15	$	80.0		7.46	1.12	68	y = 1.12x + 68
	Distribution	10.73	0.20	$	164.0		15.28	3.06	131.2	y = 3.06x + 131.2
	Storage	10.73	0.75	$	34.0		3.17	2.38	8.5	y = 2.38x + 8.5
Annual O&M Cost	O&M Source	10.73	0.95	$	3.2	2009 UFC	0.30	0.283317801	0.16	y = 0.28x + 0.16
	O&M Treatment	10.73	0.95	$	1.0		0.09	0.088536813	0.05	y = 0.09x + 0.05
	O&M Distribution	10.73	0.95	$	1.4		0.13	0.120410065	0.068	y = 0.12x + 0.07

Water ~ Cost Analysis DRAFT

	Water Cost per Gallon	Capital Cost change from Baseline	O&M Cost change from Baseline	% Water Reduction from Baseline
Baseline	**$0.61**	**0.0%**	**0.0%**	**0.0%**
Option A	**$0.72**	**4.4%**	**5.1%**	**-12.1%**
Option B	**$0.80**	**-0.5%**	**-7.0%**	**-24.3%**
Option C	**$0.89**	**-3.3%**	**-16.5%**	**-34.2%**

Water ~ Cost Analysis DRAFT

WATER SUPPLY

	BAU	Baseline	Current Options
Potable Water Demand (MGD)	2.63	1.81	1.19
+ Contingency 306%			
Total Potable Water Supply (MGD)	10.7	7.3	4.8

306

COST ANALYSIS

Guam Cost Adjustment Factors	Materials & Supply	Mid-Range	2.64
	Construction & Labor	Mid-Range	1
	Operations & Maintenance	Mid-Range	1

Cost in Million $

Cost Category		BAU	Baseline	Current Options
Backbone	Water Treatment	$ 1.2	$ 0.9	$ 0.7
	Supply	$ 37.9	$ 30.8	$ 25.4
	Transmission	$ 80.0	$ 76.2	$ 73.4
	Distribution	$ 163.9	$ 153.6	$ 145.9
	Storage	$ 33.9	$ 25.9	$ 20.0
	Total	**$ 316.9**	**$ 287.4**	**$ 265.4**
Fixtures	Fixture Costs - Group A	$ 13.0	$ 13.0	$ 22.2
	Fixture Costs - Group B	$ 6.2	$ 6.2	$ 6.7
	Fixture Costs - Group C	$ 1.6	$ 1.6	$ 2.8
	Fixture Costs - Group D	$ 0.6	$ 0.6	$ 1.1
	Total	**$ 21.3**	**$ 21.3**	**$ 32.8**
Reuse Infrastructure	Reuse Costs - Group A	$ -	$ -	$ 17.7
	Reuse Costs - Group B	$ -	$ -	$ 4.9
	Reuse Costs - Group C	$ -	$ -	$ 6.0
	Reuse Costs - Group D	$ -	$ -	$ 0.4
	Total	**$ -**	**$ -**	**$ 28.9**
Water Capital Costs ($M)		**$ 338.2**	**$ 308.7**	**$ 327.2**
Change Relative to BAU		0.0%	-8.7%	-3.2%
Change Relative to Baseline		9.5%	0.0%	6.0%
Change Relative to NAVFAC Study		0.0%	-8.7%	-3.3%

Operations & Maintenance	O&M Source	$ 3.2	$ 2.2	$ 1.5
	O&M Distribution	$ 1.4	$ 1.0	$ 0.6
	O&M Treatment	$ 1.0	$ 0.7	$ 0.5
	Building-Level Δ	$ -	$ -	$ 0.8
Water Annual O&M Costs ($M)		**$ 5.5**	**$ 3.9**	**$ 3.5**
Change Relative to BAU		0.0%	-29.8%	-37.2%
Change Relative to Baseline		42.5%	0.0%	-10.4%
Change Relative to NAVFAC Study		-0.1%	-29.9%	-37.2%

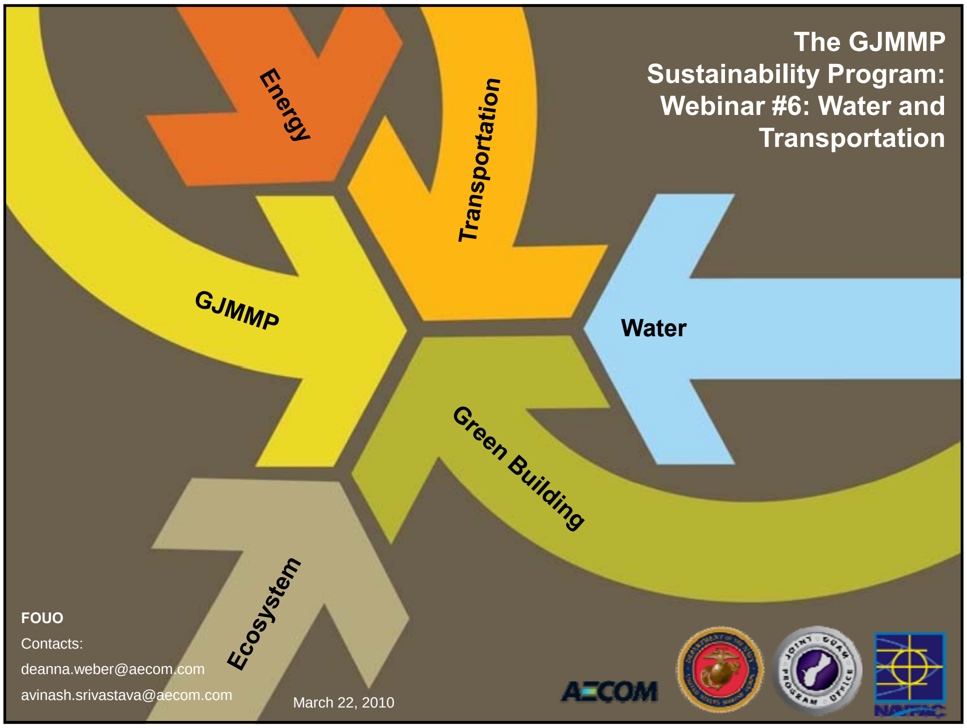
Wastewater Capital Costs ($M)	**$ 134.4**	**$ 92.2**	**$ 60.7**
Change Relative to BAU	0.0%	-31.4%	-54.9%
Change Relative to Baseline	45.8%	0.0%	-34.2%

Wastewater O&M Costs ($M)	**$ 2.0**	**$ 1.3**	**$ 0.9**
Change Relative to BAU	0.0%	-31.4%	-54.9%
Change Relative to Baseline	45.8%	0.0%	-34.2%

Water ~ SSIM Next Steps

The next steps required with the SSIM model:

- Live Gaming of conservation efforts and reuse strategies in SSIM water model.
- Final calibration with selected reuse strategies.
- Stormwater quality calibration with Final LID study.
- Final cost review of recommended strategies.



The GJMMP Sustainability Program: Webinar #6: Water and Transportation

FOUO

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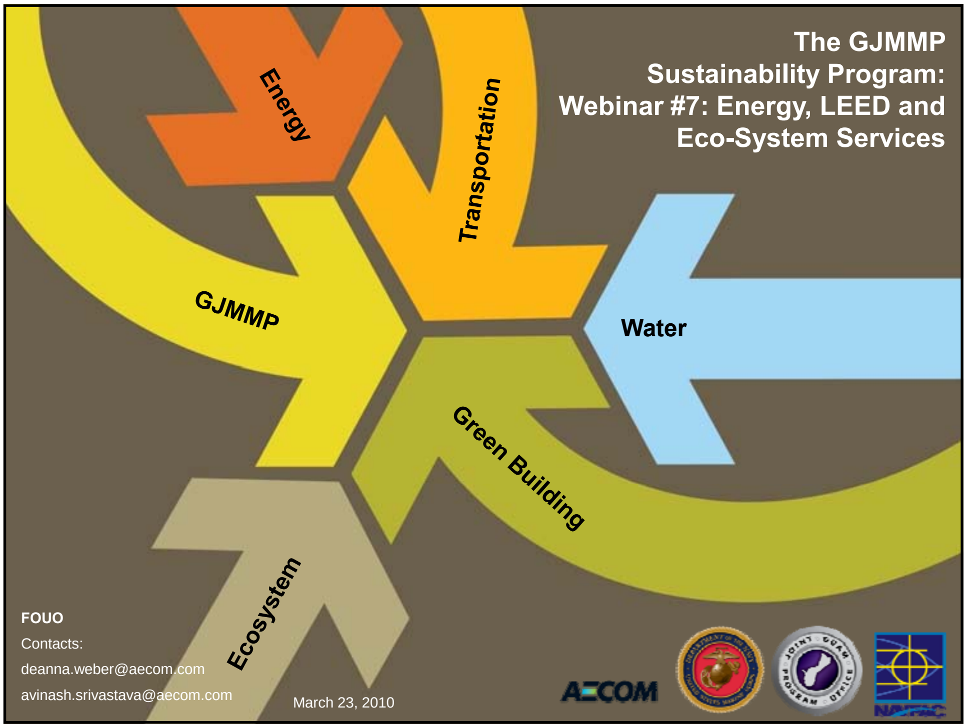
avinash.srivastava@aecom.com

March 22, 2010



The GJMMP Sustainability Program: Webinar #7: Energy, LEED and Eco-System Services

Energy
Transportation
GJMMP
Water
Green Building
Ecosystem

FOUO
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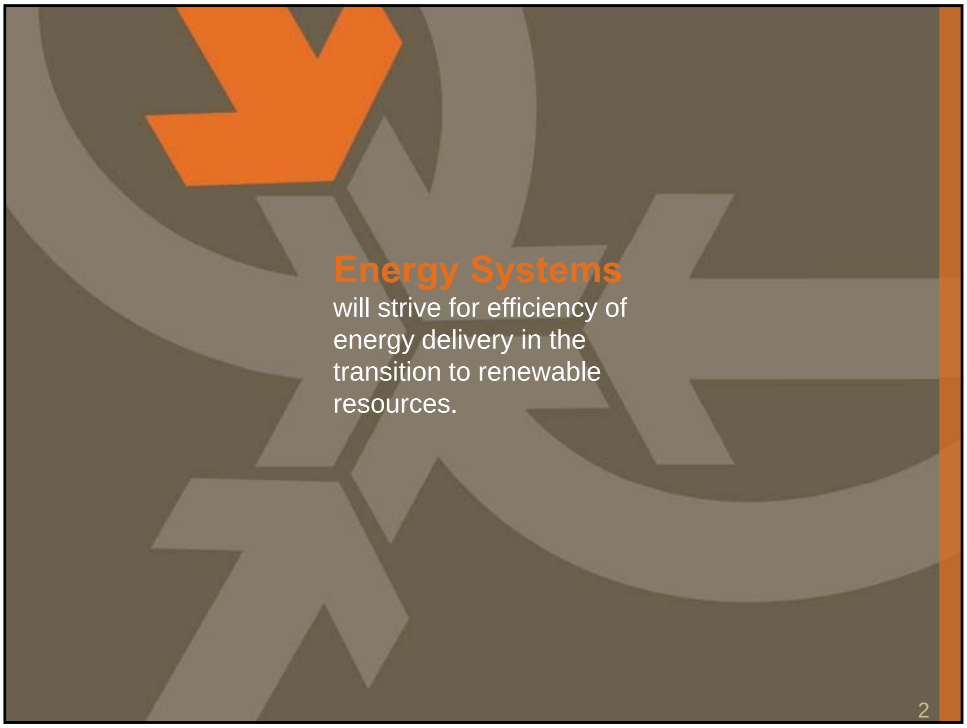
March 23, 2010



Energy Systems

will strive for efficiency of energy delivery in the transition to renewable resources.

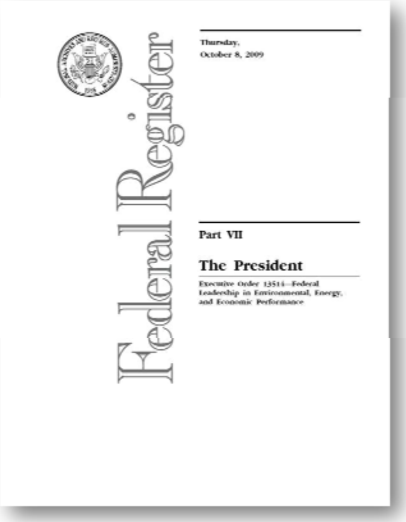
Building Energy: Federal Mandates

Energy Independence and Security Act (EISA) 2007

- 55% fossil fuel use reduction by 2010
- 100% fossil fuel use reduction by 2030
- 30% of hot water to be met by solar systems by 2015 where life cycle and cost efficient

Executive Order (EO) 13514:

- *"…reduce energy intensity in agency buildings; increasing agency use of renewable energy and implementing renewable energy generation projects on agency property…"*



Federal Register

Thursday,
October 8, 2009

Part VII

The President

Executive Order 13514—Federal Leadership in Environmental, Energy, and Economic Performance

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Building Energy: Federal Mandates

EPAct 2005

- Meter all buildings for electricity by 2012
- New buildings to be 30% more energy efficiency than the ASHRAE baseline, where life-cycle cost efficient
- Generate 7.5% in FY13 of all electricity consumed, where economically feasible and technically practicable
- All new construction must be LEED-Silver Certified

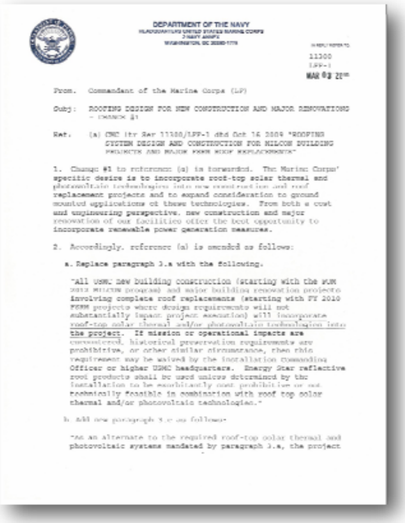
PUBLIC LAW 109-58—AUG. 8, 2005

ENERGY POLICY ACT OF 2005

Building Energy: Department of the Navy

Direction from Marine Corps (CMC ltr Ser 11300/LFF-1)

- *“All USMC new buildings construction… will incorporate roof-top solar thermal and/or photovoltaic technologies into the project”*
- *“As an alternate to the require roof top [systems]… also examine the technical feasibility of utilizing available land area to apply… ground mounted systems…”*



DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
2 NAVY ANNEX
WASHINGTON, DC 20380-1775

IN REPLY REFER TO:
11300
LFF-1
MAR 03 2010

From: Commandant of the Marine Corps (LF)

Subj: ROOFING DESIGN FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS – CHANGE #1

Ref: (a) CMC ltr Ser 11300/LFF-1 dtd Oct 16 2009 "ROOFING SYSTEM DESIGN AND CONSTRUCTION FOR MILCON BUILDING PROJECTS AND MAJOR FSRM ROOF REPLACEMENTS"

1. Change #1 to reference (a) is forwarded. The Marine Corps' specific desire is to incorporate roof-top solar thermal and photovoltaic technologies into new construction and roof replacement projects and to expand consideration to ground mounted applications of these technologies. From both a cost and engineering perspective, new construction and major renovation of our facilities offer the best opportunity to incorporate renewable power generation measures.

2. Accordingly, reference (a) is amended as follows:

a. Replace paragraph 3.a with the following.

"All USMC new building construction (starting with the FY 2012 MILCON program) and major building renovation projects involving complete roof replacements (starting with FY 2010 FSRM projects where design requirements will not substantially impact project execution) will incorporate roof-top solar thermal and/or photovoltaic technologies into the project. If mission or operational impacts are encountered, historical preservation requirements are prohibitive, or other similar circumstance, then this requirement may be waived by the installation Commanding Officer or higher USMC headquarters. Energy Star reflective roof products shall be used unless determined by the installation to be exorbitantly cost prohibitive or not technically feasible in combination with roof top solar thermal and/or photovoltaic technologies."

b. Add new paragraph 3.c as follows:

"As an alternate to the required roof-top solar thermal and photovoltaic systems mandated by paragraph 3.a, the project

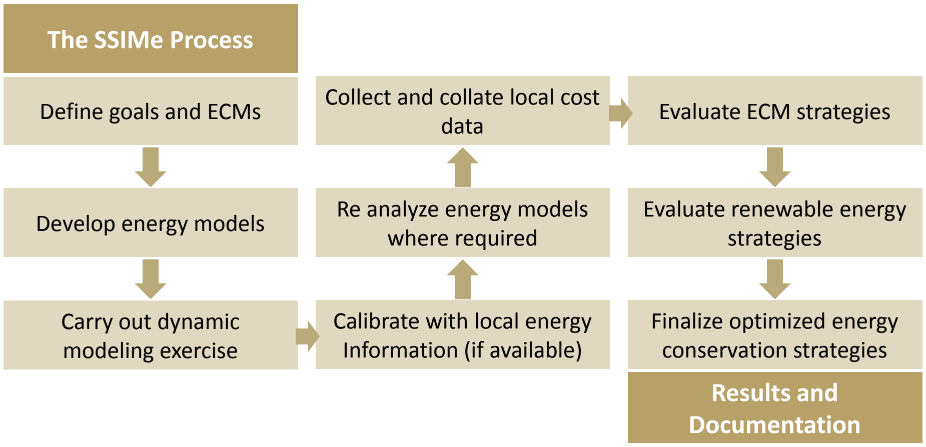
Sustainable Systems Integration Model Energy (SSIMe) Building Energy Study

- SSIMe Building Energy Study Building Types

Non Residential Building Type	Residential Building Type
3 Story Headquarters (Large) Office	Single Family (Detached Housing)
2 Story Headquarters Office	Duplex (Attached Housing)
Single Story Small Office	Bachelor Enlisted Quarters (BEQ)
Climate Controlled Warehouse (Organic)	
Semi Conditioned General Warehouse	
Day Center / Community Type Facility	
Commissary / Retail	
School	
Workshop	

Guam JMMP Building Energy Study

- SSIMe Building Energy Study Building Types



The SSIMe Process

Define goals and ECMs

Develop energy models

Carry out dynamic modeling exercise

Calibrate with local energy Information (if available)

Re analyze energy models where required

Collect and collate local cost data

Evaluate ECM strategies

Evaluate renewable energy strategies

Finalize optimized energy conservation strategies

Results and Documentation

Guam JMMP Building Energy Study – Key Strategies

Non Residential Building Key Strategies:

- High efficiency building envelope (including solar shading)
- High efficiency HVAC equipment (high efficiency packaged DX, air cooled chillers, and water cooled chillers)
- Rooftop amorphous **BIPV** (Building Integrated PV)
- Solar thermal hot water heating (where technically and functionally feasible)
- Use of variable volume fan controls (where appropriate)
- Use of lighting controls (daylighting dimming and motion controls) where appropriate

Guam JMMP Building Energy Study – Key Strategies

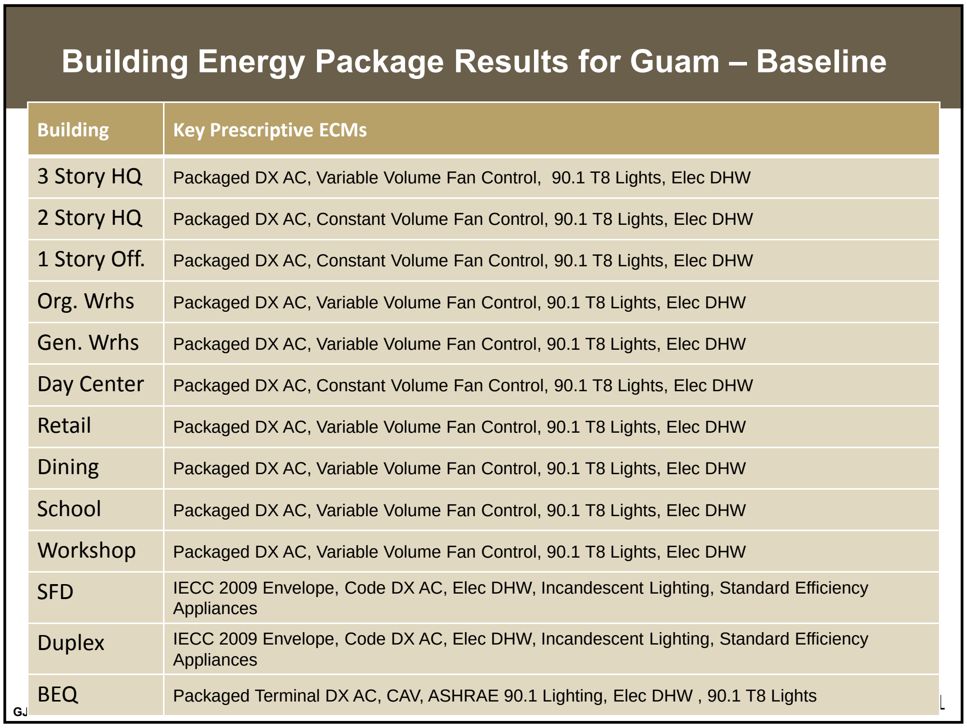
Residential Building Key Strategies:

- High efficiency building envelope (including solar shading)
- High efficiency cooling equipment
- Rooftop amorphous BIPV
- Solar thermal hot water heating
- Use of compact fluorescent lighting
- Energy Star rated appliances

SSIMe Building Energy Study – Key Strategies

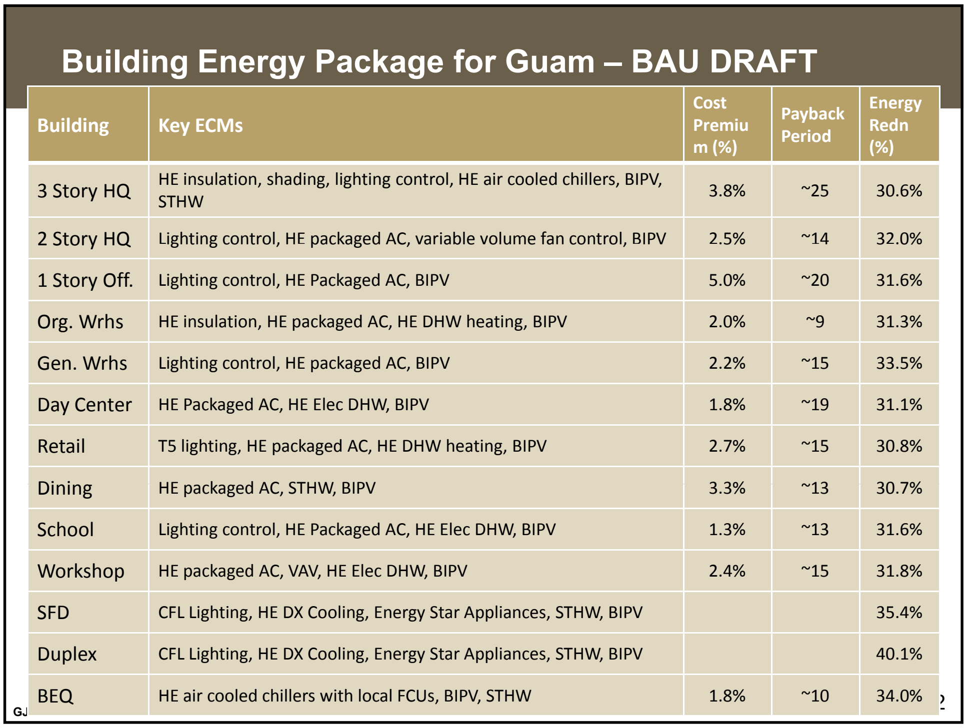
Acronyms:

- **IECC – International Energy Conservation Code**
- **90.1 – ASHRAE 90.1 (Baseline federal energy code standards)**
- **HE – High efficiency**
- **CAV – "Constant air volume" fan control system**
- **VAV - "Variable air volume" fan control system**
- **FCU – Fan coil unit**
- **DX – Direct expansion cooling**
- **T8 – "Baseline" type lighting system**
- **T5 – High efficiency lighting alternative**
- **DHW – "Domestic" hot water**
- **BIPV – Building integrated PV**
- **STHW – Solar thermal hot water**



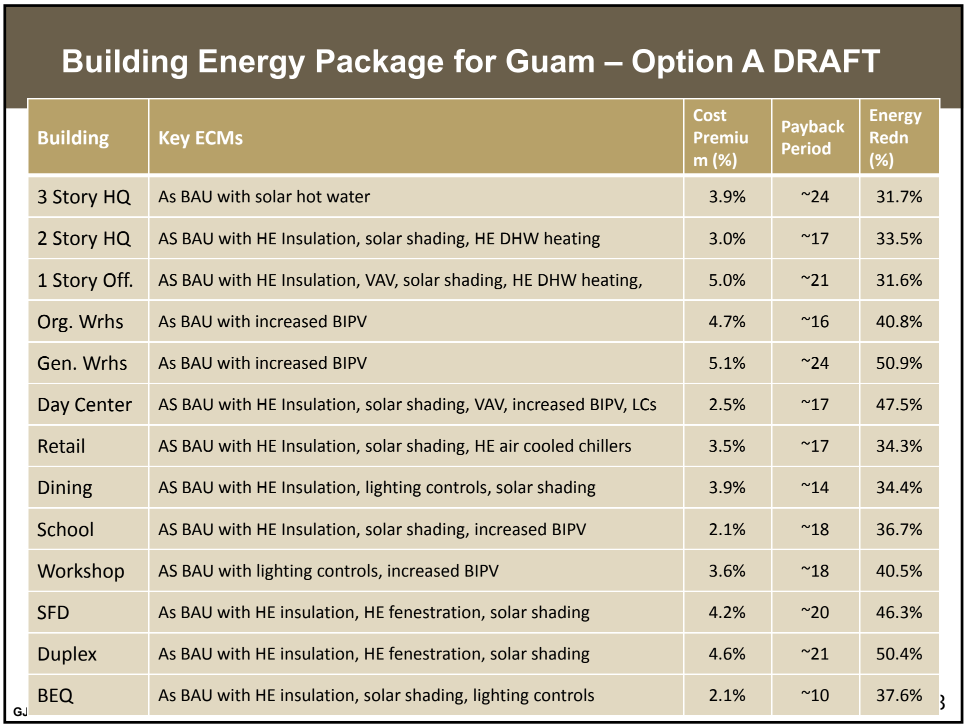
Building Energy Package Results for Guam – Baseline

Building	Key Prescriptive ECMs
3 Story HQ	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
2 Story HQ	Packaged DX AC, Constant Volume Fan Control, 90.1 T8 Lights, Elec DHW
1 Story Off.	Packaged DX AC, Constant Volume Fan Control, 90.1 T8 Lights, Elec DHW
Org. Wrhs	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
Gen. Wrhs	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
Day Center	Packaged DX AC, Constant Volume Fan Control, 90.1 T8 Lights, Elec DHW
Retail	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
Dining	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
School	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
Workshop	Packaged DX AC, Variable Volume Fan Control, 90.1 T8 Lights, Elec DHW
SFD	IECC 2009 Envelope, Code DX AC, Elec DHW, Incandescent Lighting, Standard Efficiency Appliances
Duplex	IECC 2009 Envelope, Code DX AC, Elec DHW, Incandescent Lighting, Standard Efficiency Appliances
BEQ	Packaged Terminal DX AC, CAV, ASHRAE 90.1 Lighting, Elec DHW , 90.1 T8 Lights



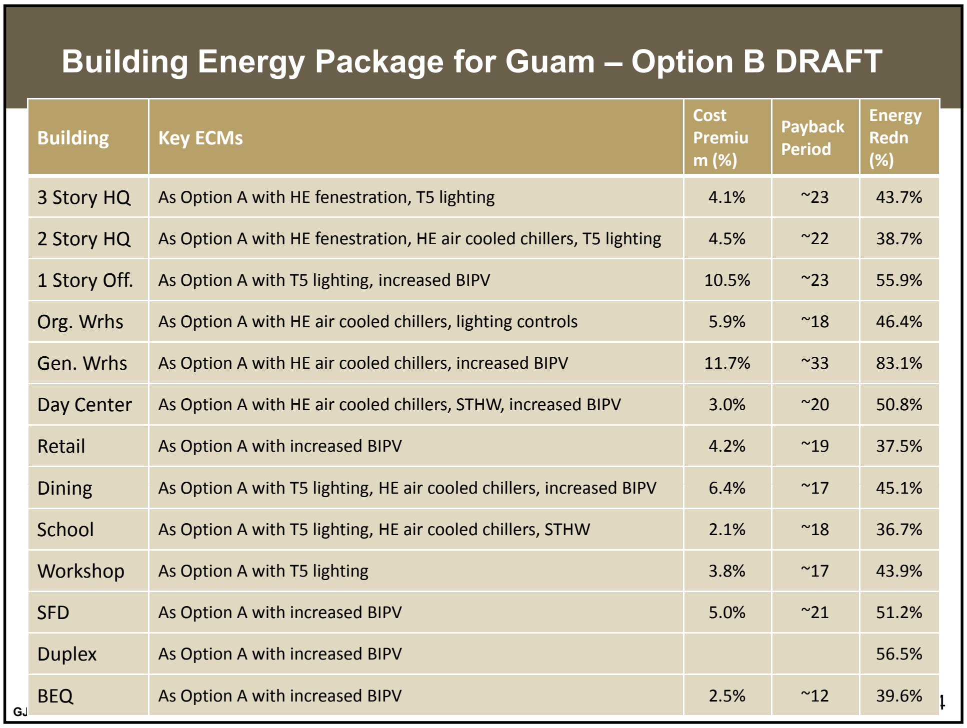
Building Energy Package for Guam – BAU DRAFT

Building	Key ECMs	Cost Premium (%)	Payback Period	Energy Redn (%)
3 Story HQ	HE insulation, shading, lighting control, HE air cooled chillers, BIPV, STHW	3.8%	~25	30.6%
2 Story HQ	Lighting control, HE packaged AC, variable volume fan control, BIPV	2.5%	~14	32.0%
1 Story Off.	Lighting control, HE Packaged AC, BIPV	5.0%	~20	31.6%
Org. Wrhs	HE insulation, HE packaged AC, HE DHW heating, BIPV	2.0%	~9	31.3%
Gen. Wrhs	Lighting control, HE packaged AC, BIPV	2.2%	~15	33.5%
Day Center	HE Packaged AC, HE Elec DHW, BIPV	1.8%	~19	31.1%
Retail	T5 lighting, HE packaged AC, HE DHW heating, BIPV	2.7%	~15	30.8%
Dining	HE packaged AC, STHW, BIPV	3.3%	~13	30.7%
School	Lighting control, HE Packaged AC, HE Elec DHW, BIPV	1.3%	~13	31.6%
Workshop	HE packaged AC, VAV, HE Elec DHW, BIPV	2.4%	~15	31.8%
SFD	CFL Lighting, HE DX Cooling, Energy Star Appliances, STHW, BIPV			35.4%
Duplex	CFL Lighting, HE DX Cooling, Energy Star Appliances, STHW, BIPV			40.1%
BEQ	HE air cooled chillers with local FCUs, BIPV, STHW	1.8%	~10	34.0%



Building Energy Package for Guam – Option A DRAFT

Building	Key ECMs	Cost Premium (%)	Payback Period	Energy Redn (%)
3 Story HQ	As BAU with solar hot water	3.9%	~24	31.7%
2 Story HQ	AS BAU with HE Insulation, solar shading, HE DHW heating	3.0%	~17	33.5%
1 Story Off.	AS BAU with HE Insulation, VAV, solar shading, HE DHW heating,	5.0%	~21	31.6%
Org. Wrhs	As BAU with increased BIPV	4.7%	~16	40.8%
Gen. Wrhs	As BAU with increased BIPV	5.1%	~24	50.9%
Day Center	AS BAU with HE Insulation, solar shading, VAV, increased BIPV, LCs	2.5%	~17	47.5%
Retail	AS BAU with HE Insulation, solar shading, HE air cooled chillers	3.5%	~17	34.3%
Dining	AS BAU with HE Insulation, lighting controls, solar shading	3.9%	~14	34.4%
School	AS BAU with HE Insulation, solar shading, increased BIPV	2.1%	~18	36.7%
Workshop	AS BAU with lighting controls, increased BIPV	3.6%	~18	40.5%
SFD	As BAU with HE insulation, HE fenestration, solar shading	4.2%	~20	46.3%
Duplex	As BAU with HE insulation, HE fenestration, solar shading	4.6%	~21	50.4%
BEQ	As BAU with HE insulation, solar shading, lighting controls	2.1%	~10	37.6%



Building Energy Package for Guam – Option B DRAFT

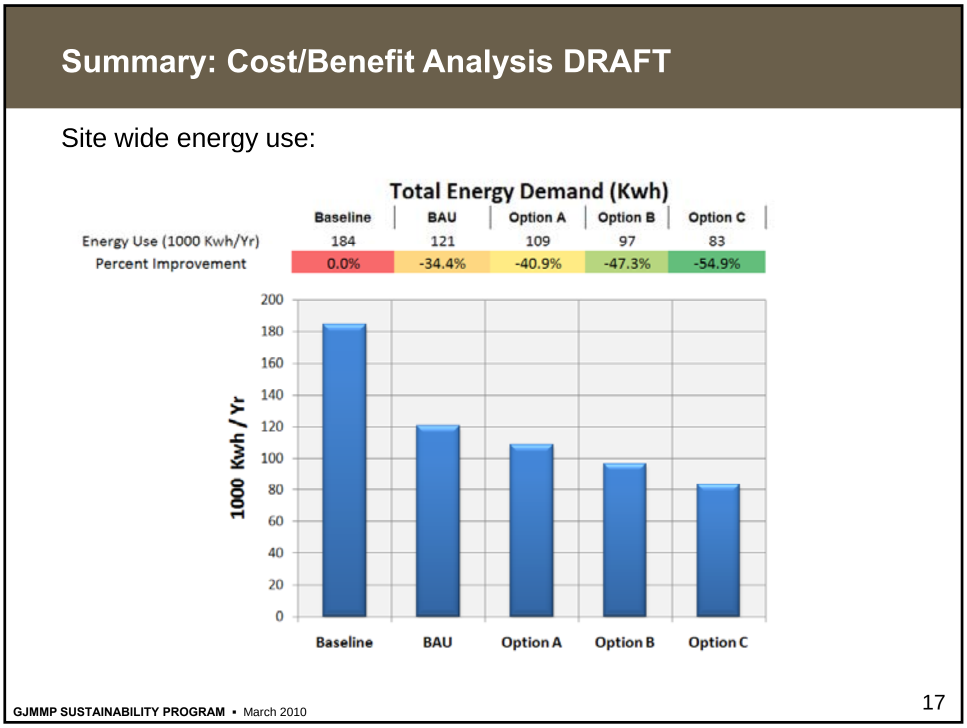
Building	Key ECMs	Cost Premium (%)	Payback Period	Energy Redn (%)
3 Story HQ	As Option A with HE fenestration, T5 lighting	4.1%	~23	43.7%
2 Story HQ	As Option A with HE fenestration, HE air cooled chillers, T5 lighting	4.5%	~22	38.7%
1 Story Off.	As Option A with T5 lighting, increased BIPV	10.5%	~23	55.9%
Org. Wrhs	As Option A with HE air cooled chillers, lighting controls	5.9%	~18	46.4%
Gen. Wrhs	As Option A with HE air cooled chillers, increased BIPV	11.7%	~33	83.1%
Day Center	As Option A with HE air cooled chillers, STHW, increased BIPV	3.0%	~20	50.8%
Retail	As Option A with increased BIPV	4.2%	~19	37.5%
Dining	As Option A with T5 lighting, HE air cooled chillers, increased BIPV	6.4%	~17	45.1%
School	As Option A with T5 lighting, HE air cooled chillers, STHW	2.1%	~18	36.7%
Workshop	As Option A with T5 lighting	3.8%	~17	43.9%
SFD	As Option A with increased BIPV	5.0%	~21	51.2%
Duplex	As Option A with increased BIPV			56.5%
BEQ	As Option A with increased BIPV	2.5%	~12	39.6%

Building Energy Package for Guam – Option C DRAFT

Building	Key ECMs	Cost Premium (%)	Payback Period	Energy Redn (%)
3 Story HQ	As Option B with water cooled chillers / cooling towers	4.1%	~19	43.7%
2 Story HQ	As Option B with solar DHW heating	5.6%	~23	44.5%
1 Story Off.	As Option B with HE fenestration, HE air cooled chillers	12.7%	~27	57.7%
Org. Wrhs	As Option B with T5 lighting, increased BIPV	8.1%	~21	56.0%
Gen. Wrhs	As Option B with increased BIPV	16.6%	~35	112.1%
Day Center	As Option B with HE fenestration, T5 lighting	3.1%	~19	54.9%
Retail	As Option B with HE fenestration, STHW	4.7%	~20	39.6%
Dining	As Option B with HE fenestration	6.6%	~18	45.5%
School	As Option B with HE fenestration, increased BIPV	4.0%	~24	50.3%
Workshop	As Option B with HE air cooled chillers	4.9%	~21	46.9%
SFD	As Option B with increased BIPV	5.8%	~23	56.1%
Duplex	As Option B with increased BIPV			62.5%
BEQ	As Option B with HE fenestration, water cooled chillers	2.6%	~10	48.7%

Baseline Construction Costs DRAFT

	Rev 1	Rev 2	*Rev 3 - By Beery (2010 Equiv.)*	Rev 4 (TBD)	*Building Project Referenced*	GC
Single Family Dwelling			**174 (201)**		Villa Carmen SFD 2005	5M / Maeda
Duplex			**244 (261)**		Tipalao @ Navy 2008	Watts
3 Story Headquarters Office	**1,618**	**807**	**525 (604)**		See BEQ Equiv +15%	
2 Story Headquarters Office	**1,618**	**807**	**525 (604)**		See BEQ Equiv +15%	
1 Story Small Office	**1,618**	**557**	**261 (261)**		See Duplex Equiv	
Warehouse - Conditioned	**755**	**336**	**190 (190)**		IDI Warehouse 2010	DCK
Warehouse - Semi Conditioned	**755**	**336**	**174 (205)**		WRM AAFB 2004	JA Jones
Day Center	**1,574**		**300 (300)**		See School Equiv	
Commissary	**1,334**		**186 (203)**		AAFB Exchange 2007	Watts
Dining Facility	**1,993**	**1,118**	**370 (392)**		Chili's Rest. 2008	Beery CM
BEQ - 6 Story 300 Occupant	**1,263**	**651**	**510 (525)**		Navy BEQ 2009	Hensel Phelps
School	**1,301**		**260 (275)**		Navy McCool 2008	DCK
School			**280 (300)**		Navy Guam High 2008	DCK
Workshop	**1,200**		**205 (205)**		See Whse - semi-cond.	



Summary: Cost/Benefit Analysis DRAFT

Site wide energy use:

Total Energy Demand (Kwh)

	Baseline	BAU	Option A	Option B	Option C
Energy Use (1000 Kwh/Yr)	184	121	109	97	83
Percent Improvement	0.0%	-34.4%	-40.9%	-47.3%	-54.9%

GJMMP SUSTAINABILITY PROGRAM ▪ March 2010

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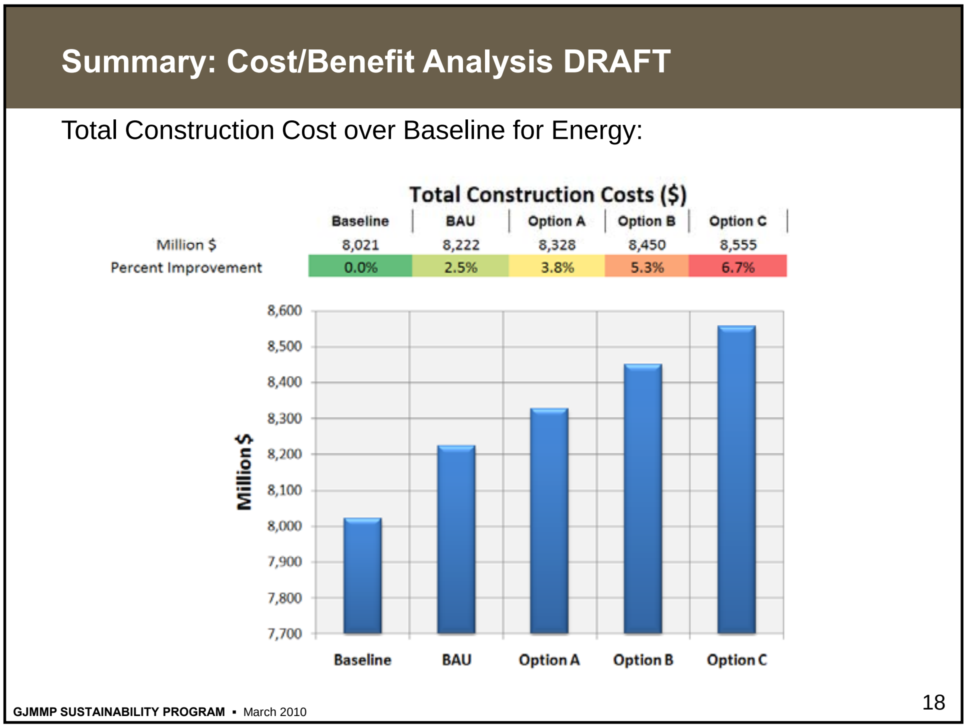

Summary: Cost/Benefit Analysis DRAFT

Total Construction Cost over Baseline for Energy:

Total Construction Costs ($)

	Baseline	BAU	Option A	Option B	Option C
Million $	8,021	8,222	8,328	8,450	8,555
Percent Improvement	0.0%	2.5%	3.8%	5.3%	6.7%

GJMMP SUSTAINABILITY PROGRAM ▪ March 2010

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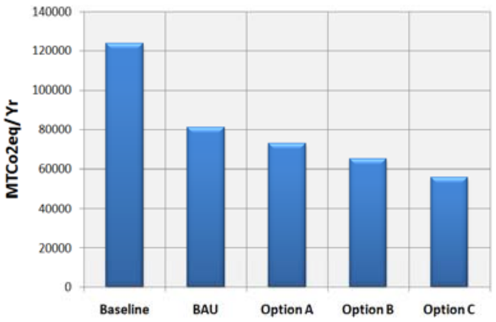
Summary: Cost/Benefit Analysis DRAFT

Building Carbon Emissions

	Baseline	BAU	Option A	Option B	Option C
Building Carbon Emissions (MTCo2eq/Yr)	123,582	81,082	73,043	65,082	55,779
Percent Improvement	0.0%	-34.4%	-40.9%	-47.3%	-54.9%



	Baseline	BAU	Option A	Option B	Option C
Carbon Reduction from Baseline	-	42,500	50,538	58,500	67,803
Incremental Initial cost from Baseline ($M)	-	$ 200.84	$ 306.44	$ 428.90	$ 534.19
Carbon Reduction Per $1000 Investment	-	0.21	0.16	0.14	0.13
Cost of per Ton Reduction	-	$ 4,725.67	$ 6,063.59	$ 7,331.62	$ 7,878.49

Background Information: Cost Sources

- AECOM team kick off workshops in Guam (October 2009)
- Techval Technical Evaluation of Building Integrated Photovoltaic (BIPV) Roof Technology (August 2008)
- Sierra Solar Systems
- Focus group calls with Energy team
- NAVFAC Pac Guam Cost Data Book (January 2005)
- RSMeans 2005
- Air Stream Services
- American Wind Association US Small Wind Turbine Industry Roadmap
- Energy Star
- Bill Berry, former GM of Watts Construction

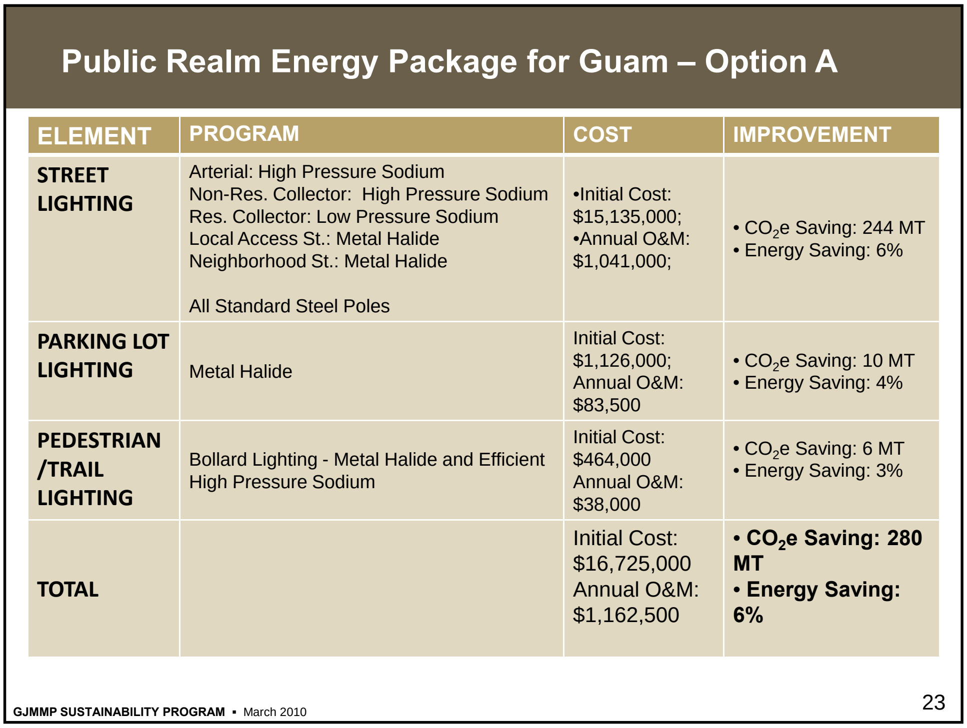
(Note: all costs have been reviewed by Bill Beery, Guam Contractor/Cost Estimator)

Public Realm Energy Strategy Introduction

- Public Realm Energy Includes
  - Street Lighting – over **84,000** meters (52 miles) long streets
  - Parking Lot Lighting – over **735,000** square meters (176 acres) in area
  - Pedestrian/Trail Lighting – over **5,800** meters (3.6 miles) long trails
- Public Realm Energy Factors
  - Fixture Spacing and Foot Candles
  - Dark Sky Concepts
  - Demand Management
  - Renewable Energy Option

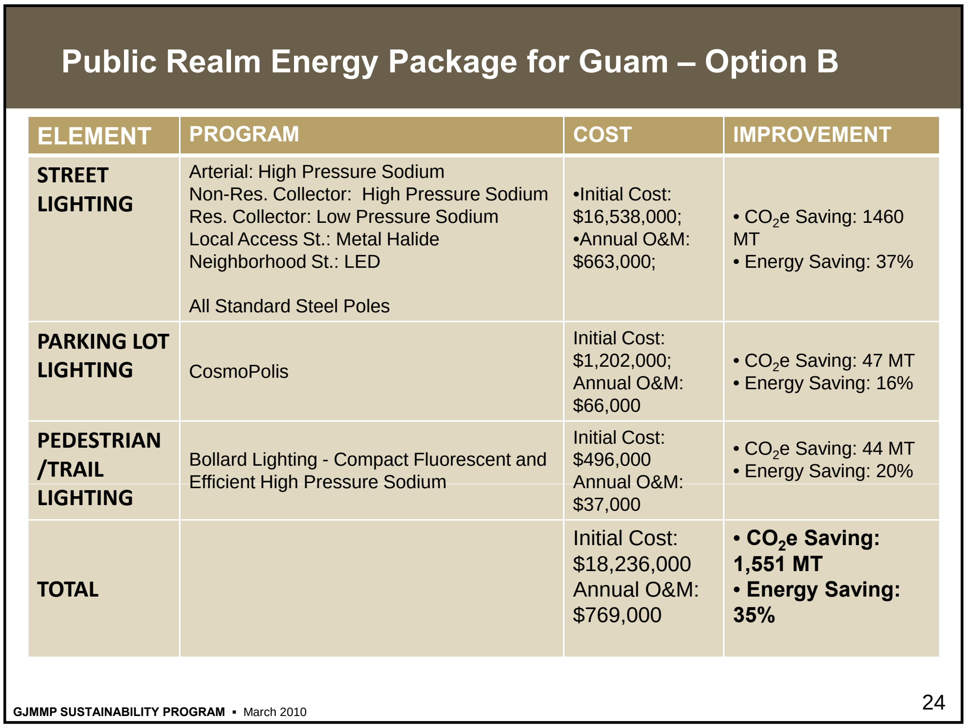
Public Realm Energy Package for Guam – Baseline

ELEMENT	PROGRAM	COST	IMPROVEMENT
STREET LIGHTING	Arterial: High Pressure Sodium Non-Res. Collector: High Pressure Sodium Res. Collector: Low Pressure Sodium Local Access St.: Low Pressure Sodium Neighborhood St.: Low Pressure Sodium All Standard Steel Poles	Initial Cost: $15,101,000; Annual O&M: $1,053,000;	Based on UFC Standard
PARKING LOT LIGHTING	High Pressure Sodium	Initial Cost: $1,093,000; Annual O&M: $77,000	Based on UFC Standards
PEDESTRIAN /TRAIL LIGHTING	Bollard Lighting - Compact Fluorescent & High Pressure Sodium	Initial Cost: $445,000 Annual O&M: $46,000	Based on UFC Standards
TOTAL		Initial Cost: $16,639,000 Annual O&M: $1,176,000	



Public Realm Energy Package for Guam – Option A

ELEMENT	PROGRAM	COST	IMPROVEMENT
STREET LIGHTING	Arterial: High Pressure Sodium Non-Res. Collector: High Pressure Sodium Res. Collector: Low Pressure Sodium Local Access St.: Metal Halide Neighborhood St.: Metal Halide All Standard Steel Poles	•Initial Cost: $15,135,000; •Annual O&M: $1,041,000;	• CO_2e Saving: 244 MT • Energy Saving: 6%
PARKING LOT LIGHTING	Metal Halide	Initial Cost: $1,126,000; Annual O&M: $83,500	• CO_2e Saving: 10 MT • Energy Saving: 4%
PEDESTRIAN /TRAIL LIGHTING	Bollard Lighting - Metal Halide and Efficient High Pressure Sodium	Initial Cost: $464,000 Annual O&M: $38,000	• CO_2e Saving: 6 MT • Energy Saving: 3%
TOTAL		Initial Cost: $16,725,000 Annual O&M: $1,162,500	**• CO_2e Saving: 280 MT** **• Energy Saving: 6%**



Public Realm Energy Package for Guam – Option B

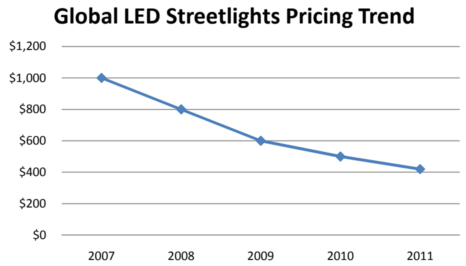
ELEMENT	PROGRAM	COST	IMPROVEMENT
STREET LIGHTING	Arterial: High Pressure Sodium Non-Res. Collector: High Pressure Sodium Res. Collector: Low Pressure Sodium Local Access St.: Metal Halide Neighborhood St.: LED All Standard Steel Poles	•Initial Cost: $16,538,000; •Annual O&M: $663,000;	• CO_2e Saving: 1460 MT • Energy Saving: 37%
PARKING LOT LIGHTING	CosmoPolis	Initial Cost: $1,202,000; Annual O&M: $66,000	• CO_2e Saving: 47 MT • Energy Saving: 16%
PEDESTRIAN /TRAIL LIGHTING	Bollard Lighting - Compact Fluorescent and Efficient High Pressure Sodium	Initial Cost: $496,000 Annual O&M: $37,000	• CO_2e Saving: 44 MT • Energy Saving: 20%
TOTAL		Initial Cost: $18,236,000 Annual O&M: $769,000	**• CO_2e Saving: 1,551 MT** **• Energy Saving: 35%**

Public Realm Energy Package for Guam – Option C

ELEMENT	PROGRAM	COST	IMPROVEMENT
STREET LIGHTING	Arterial: Cosmopolis Non-Res. Collector: Metal Halide Res. Collector: LED Local Access St.: LED Neighborhood St.: LED Solar Pole & Standard Steel Poles	•Initial Cost: $17,609,000; •Annual O&M: $560,000;	• CO$_2$e Saving: 2360 MT • Energy Saving: 60%
PARKING LOT LIGHTING	LED	Initial Cost: $1,765,000; Annual O&M: $37,000	• CO$_2$e Saving: 160 MT • Energy Saving: 53%
PEDESTRIAN /TRAIL LIGHTING	Bollard Lighting - LED	Initial Cost: $540,000 Annual O&M: $21,000	• CO$_2$e Saving: 104 MT • Energy Saving: 47%
TOTAL		Initial Cost: $19,914,000 Annual O&M: $618,000	**• CO$_2$e Saving: 2623 MT** **• Energy Saving: 59%**

High Efficient Lighting Technology & Products

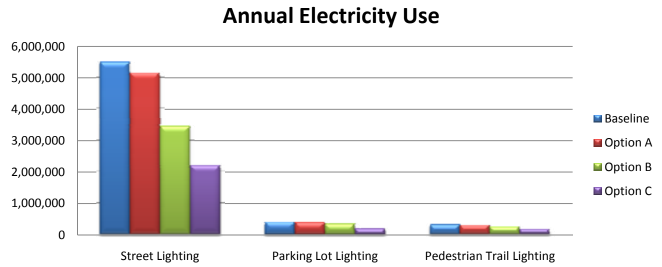
Great Potential of LED Lighting

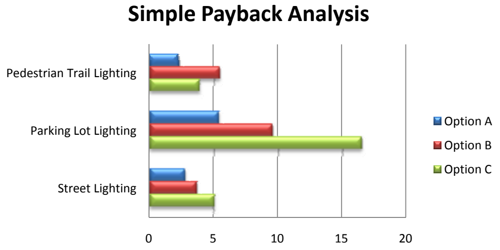


HPS

LED

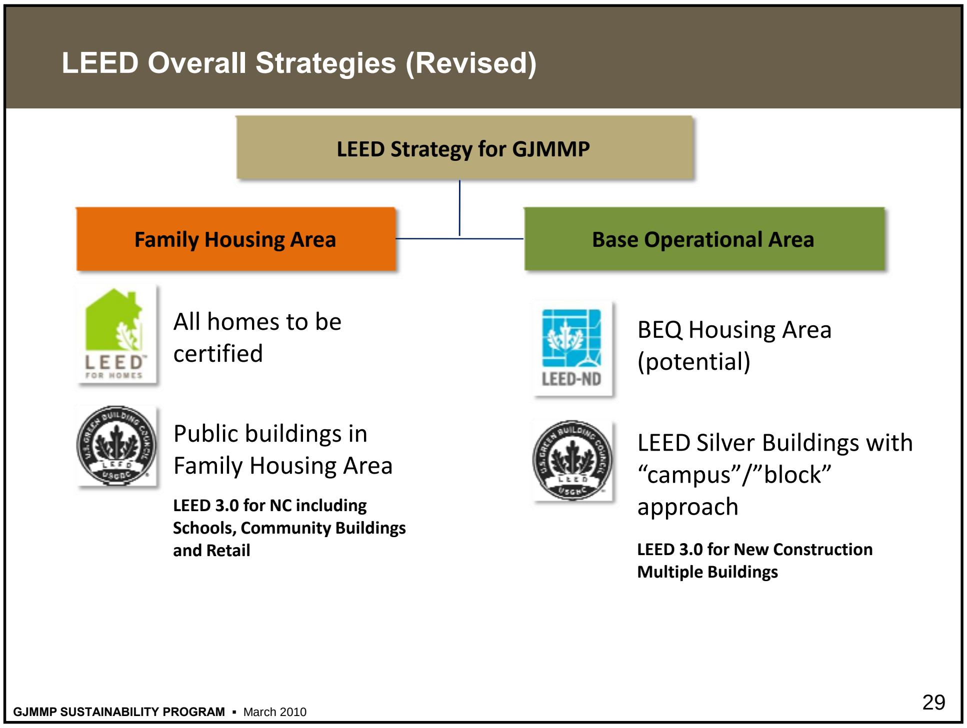
Summary DRAFT


Annual Electricity Use


Simple Payback Analysis

LEED Certification

Developing an optimized LEED Silver Certification for all buildings



LEED Overall Strategies (Revised)

LEED Strategy for GJMMP

Family Housing Area

All homes to be certified

Public buildings in Family Housing Area

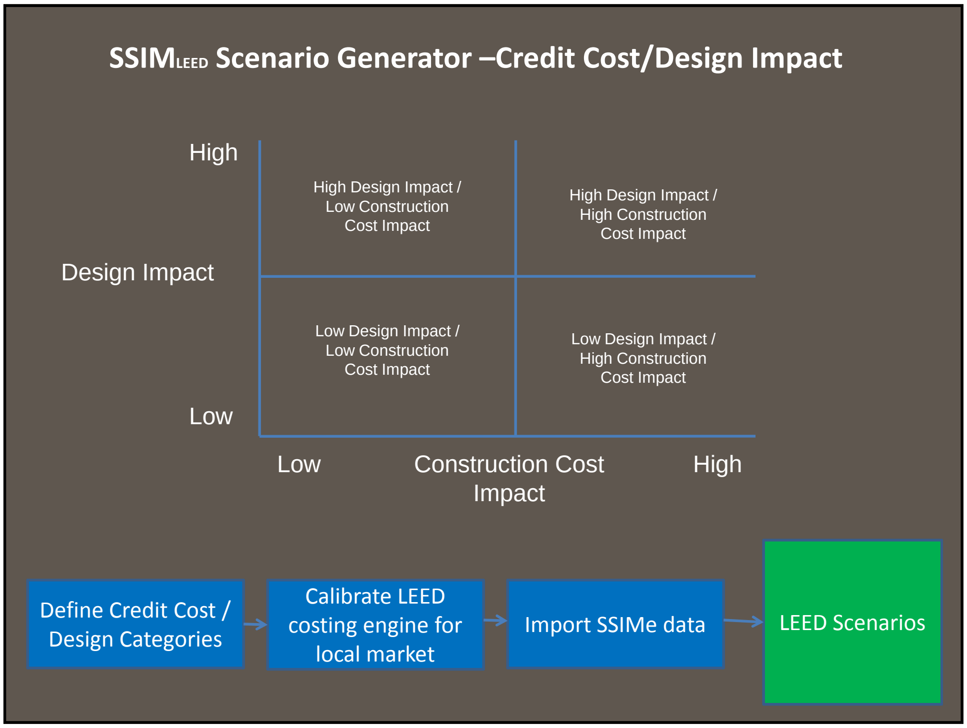
LEED 3.0 for NC including Schools, Community Buildings and Retail

Base Operational Area

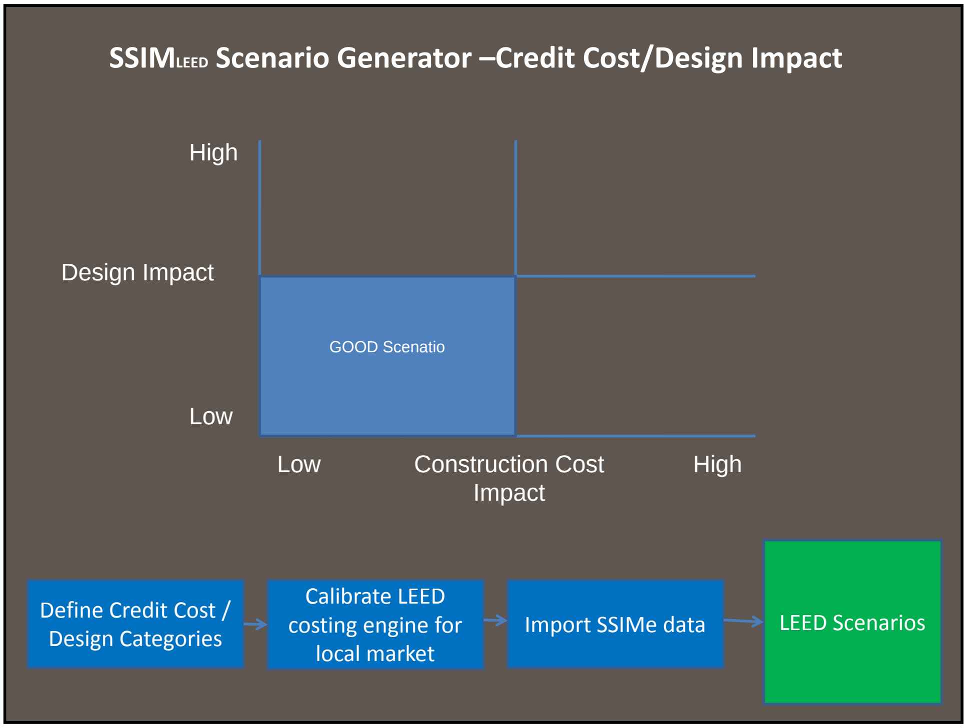
BEQ Housing Area (potential)

LEED Silver Buildings with "campus"/"block" approach

LEED 3.0 for New Construction Multiple Buildings



SSIM



SSIM$_{\text{LEED}}$ Scenario Generator –Credit Cost/Design Impact

High

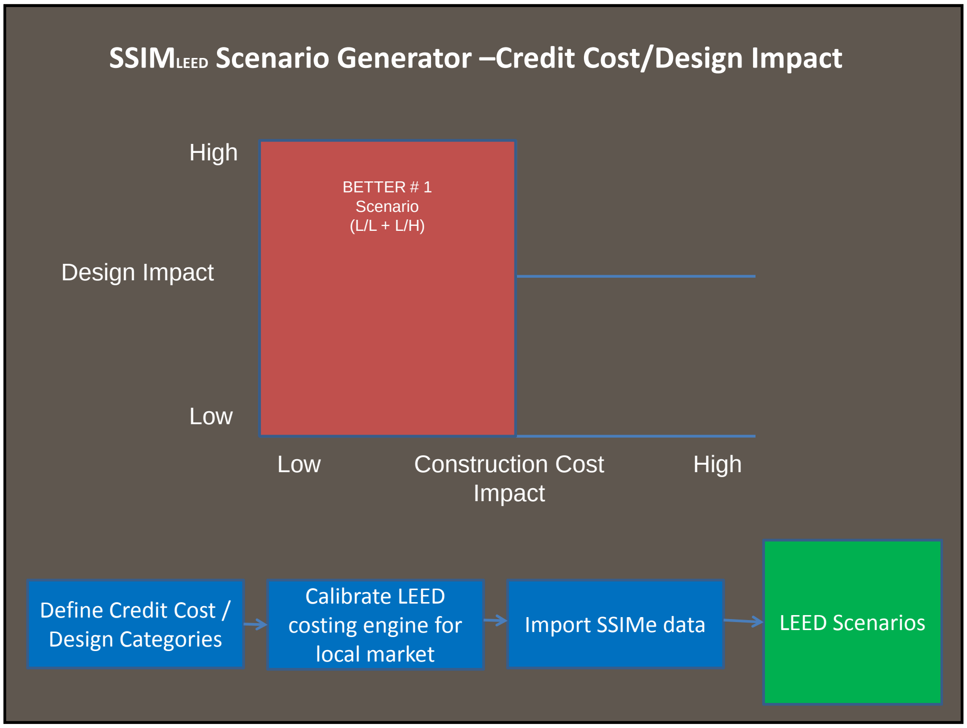
Design Impact

Low

GOOD Scenatio

Low Construction Cost Impact High

Define Credit Cost / Design Categories → Calibrate LEED costing engine for local market → Import SSIMe data → LEED Scenarios



SSIM$_{\text{LEED}}$ Scenario Generator –Credit Cost/Design Impact

High

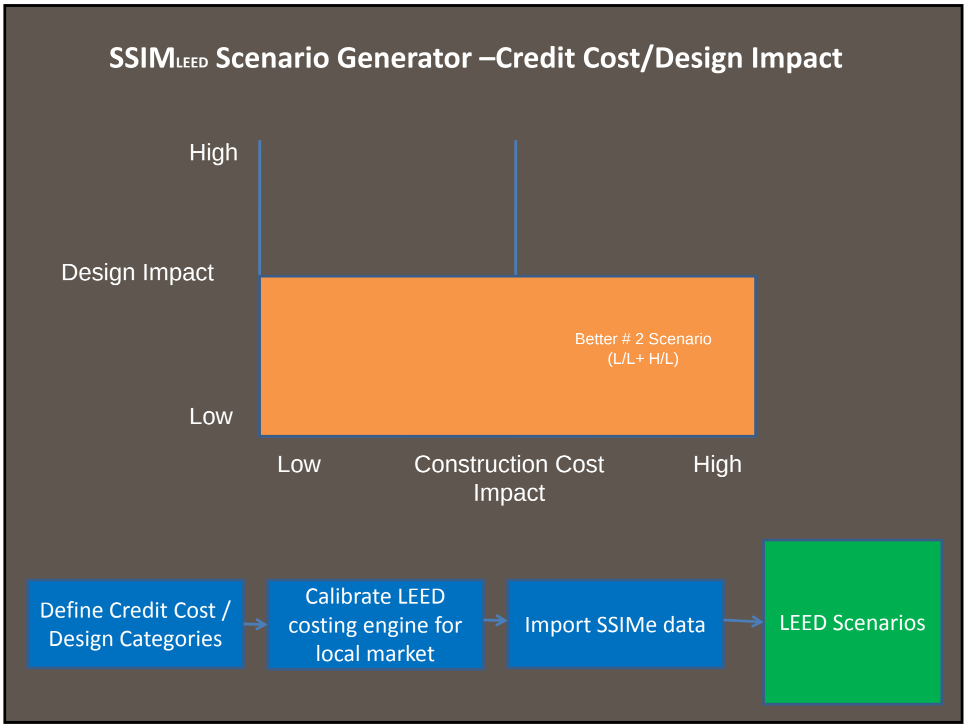
Design Impact

Low

BETTER # 1
Scenario
(L/L + L/H)

Low Construction Cost Impact High

Define Credit Cost / Design Categories → Calibrate LEED costing engine for local market → Import SSIMe data → LEED Scenarios



SSIM$_{LEED}$ Scenario Generator –Credit Cost/Design Impact

High

Design Impact

Low

Better # 2 Scenario
(L/L+ H/L)

Low

Construction Cost Impact

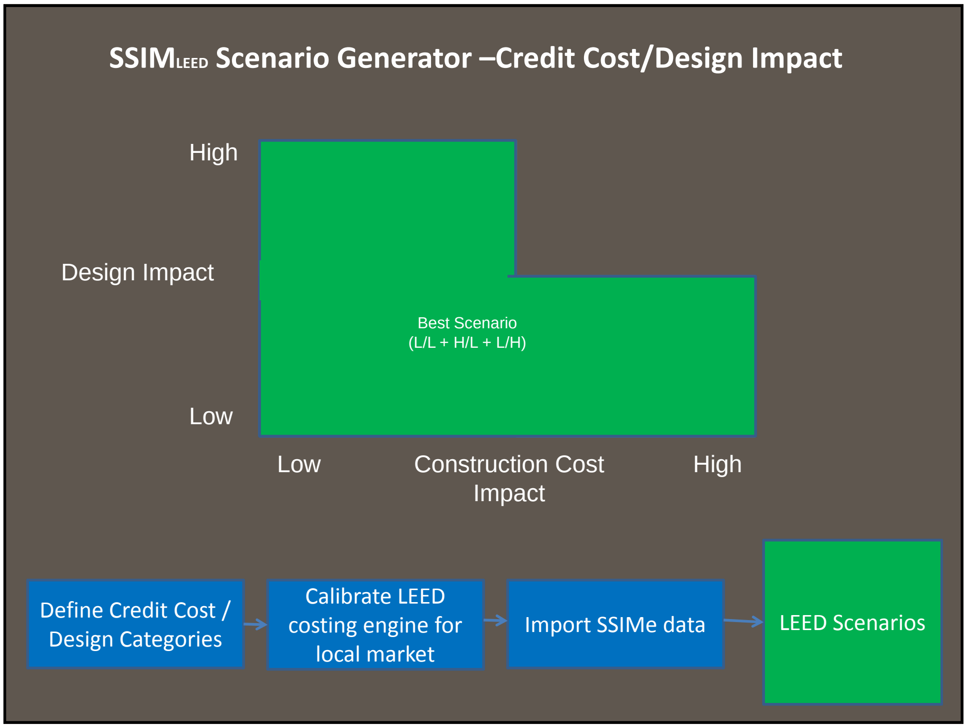
High

Define Credit Cost / Design Categories

Calibrate LEED costing engine for local market

Import SSIMe data

LEED Scenarios



SSIM$_{LEED}$ Scenario Generator –Credit Cost/Design Impact

High

Design Impact

Low

Best Scenario
(L/L + H/L + L/H)

Low

Construction Cost Impact

High

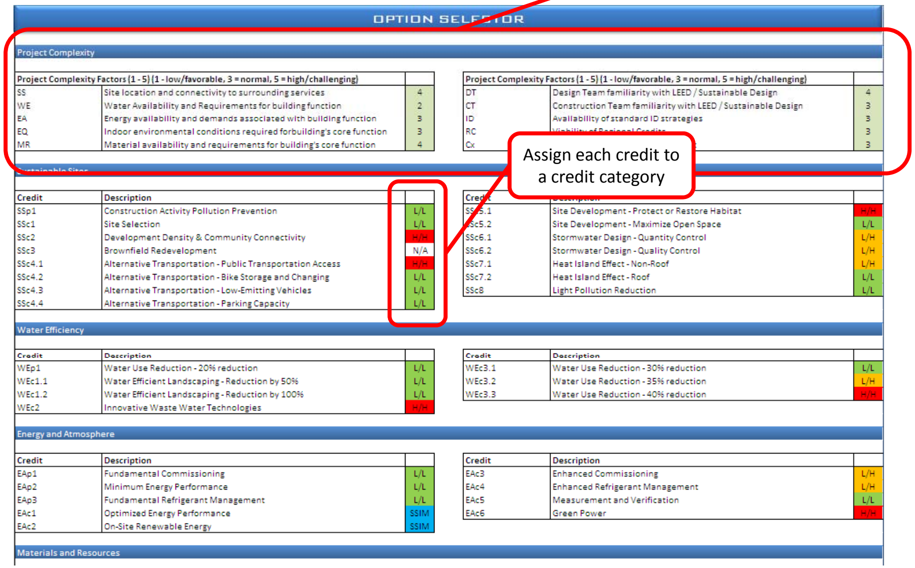
Define Credit Cost / Design Categories

Calibrate LEED costing engine for local market

Import SSIMe data

LEED Scenarios

GJMMP – SSIM$_{\text{LEED}}$ Scenario Generator Option Selector



Assign project complexity factors

Assign each credit to a credit category

OPTION SELECTOR

Project Complexity

Project Complexity Factors (1 - 5) (1 - low/favorable, 3 = normal, 5 = high/challenging)		
SS	Site location and connectivity to surrounding services	4
WE	Water Availability and Requirements for building function	2
EA	Energy availability and demands associated with building function	3
EQ	Indoor environmental conditions required forbuilding's core function	3
MR	Material availability and requirements for building's core function	4

Project Complexity Factors (1 - 5) (1 - low/favorable, 3 = normal, 5 = high/challenging)		
DT	Design Team familiarity with LEED / Sustainable Design	4
CT	Construction Team familiarity with LEED / Sustainable Design	3
ID	Availability of standard ID strategies	3
RC	Viability of Regional Credits	3
Cx		3

Sustainable Sites

Credit	Description	
SSp1	Construction Activity Pollution Prevention	L/L
SSc1	Site Selection	L/L
SSc2	Development Density & Community Connectivity	H/H
SSc3	Brownfield Redevelopment	N/A
SSc4.1	Alternative Transportation - Public Transportation Access	H/H
SSc4.2	Alternative Transportation - Bike Storage and Changing	L/L
SSc4.3	Alternative Transportation - Low-Emitting Vehicles	L/L
SSc4.4	Alternative Transportation - Parking Capacity	L/L

Credit	Description	
SSc5.1	Site Development - Protect or Restore Habitat	H/H
SSc5.2	Site Development - Maximize Open Space	L/L
SSc6.1	Stormwater Design - Quantity Control	L/H
SSc6.2	Stormwater Design - Quality Control	L/H
SSc7.1	Heat Island Effect - Non-Roof	L/H
SSc7.2	Heat Island Effect - Roof	L/L
SSc8	Light Pollution Reduction	L/L

Water Efficiency

Credit	Description	
WEp1	Water Use Reduction - 20% reduction	L/L
WEc1.1	Water Efficient Landscaping - Reduction by 50%	L/L
WEc1.2	Water Efficient Landscaping - Reduction by 100%	L/L
WEc2	Innovative Waste Water Technologies	H/H

Credit	Description	
WEc3.1	Water Use Reduction - 30% reduction	L/L
WEc3.2	Water Use Reduction - 35% reduction	L/H
WEc3.3	Water Use Reduction - 40% reduction	H/H

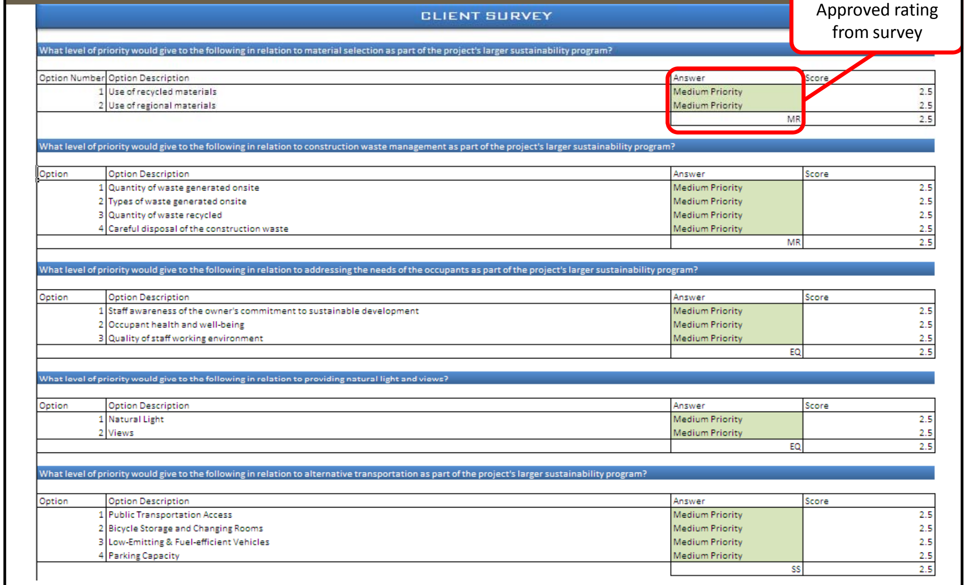
Energy and Atmosphere

Credit	Description	
EAp1	Fundamental Commissioning	L/L
EAp2	Minimum Energy Performance	L/L
EAp3	Fundamental Refrigerant Management	L/L
EAc1	Optimized Energy Performance	SSIM
EAc2	On-Site Renewable Energy	SSIM

Credit	Description	
EAc3	Enhanced Commissioning	L/H
EAc4	Enhanced Refrigerant Management	L/H
EAc5	Measurement and Verification	L/L
EAc6	Green Power	H/H

Materials and Resources

GJMMP – SSIM$_{\text{LEED}}$ Scenario Generator Client Goals Survey



Approved rating from survey

CLIENT SURVEY

What level of priority would give to the following in relation to material selection as part of the project's larger sustainability program?

Option Number	Option Description	Answer	Score
1	Use of recycled materials	Medium Priority	2.5
2	Use of regional materials	Medium Priority	2.5
		MR	2.5

What level of priority would give to the following in relation to construction waste management as part of the project's larger sustainability program?

Option	Option Description	Answer	Score
1	Quantity of waste generated onsite	Medium Priority	2.5
2	Types of waste generated onsite	Medium Priority	2.5
3	Quantity of waste recycled	Medium Priority	2.5
4	Careful disposal of the construction waste	Medium Priority	2.5
		MR	2.5

What level of priority would give to the following in relation to addressing the needs of the occupants as part of the project's larger sustainability program?

Option	Option Description	Answer	Score
1	Staff awareness of the owner's commitment to sustainable development	Medium Priority	2.5
2	Occupant health and well-being	Medium Priority	2.5
3	Quality of staff working environment	Medium Priority	2.5
		EQ	2.5

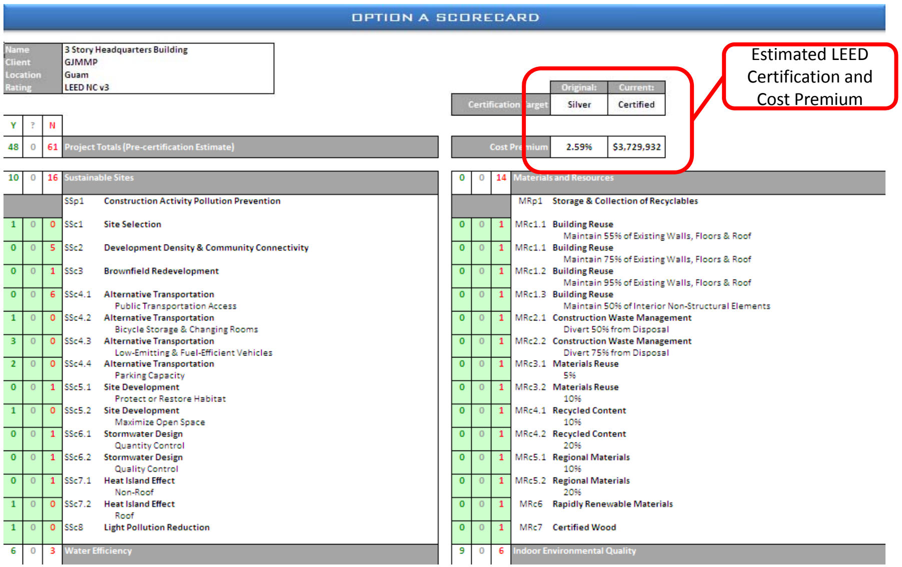
What level of priority would give to the following in relation to providing natural light and views?

Option	Option Description	Answer	Score
1	Natural Light	Medium Priority	2.5
2	Views	Medium Priority	2.5
		EQ	2.5

What level of priority would give to the following in relation to alternative transportation as part of the project's larger sustainability program?

Option	Option Description	Answer	Score
1	Public Transportation Access	Medium Priority	2.5
2	Bicycle Storage and Changing Rooms	Medium Priority	2.5
3	Low-Emitting & Fuel-efficient Vehicles	Medium Priority	2.5
4	Parking Capacity	Medium Priority	2.5
		SS	2.5

GJMMP – SSIM_{LEED} Scenario Generator Scenario LEED Scorecard



OPTION A SCORECARD

Name	3 Story Headquarters Building
Client	GJMMP
Location	Guam
Rating	LEED NC v3

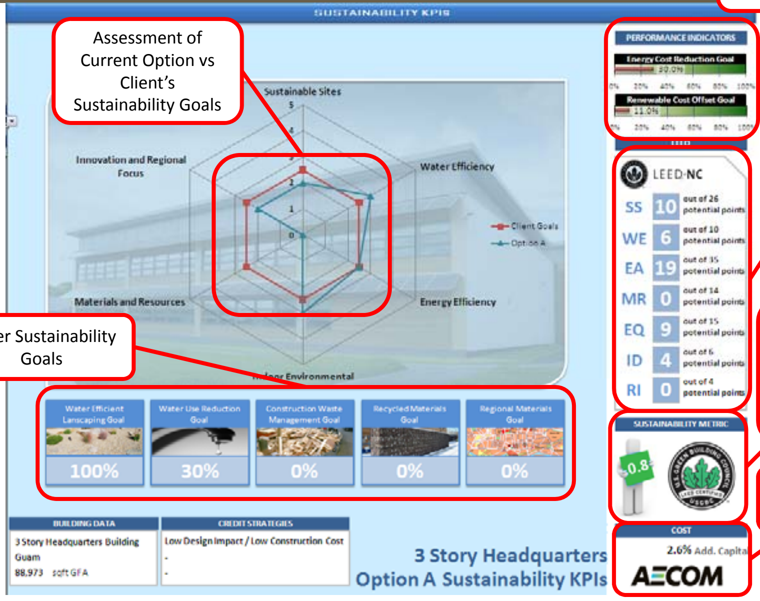
	Original:	Current:
Certification Target	Silver	Certified
Cost Premium	2.59%	$3,729,932

Y	?	N		
48	0	61		Project Totals (Pre-certification Estimate)
10	0	16		Sustainable Sites
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
0	0	1	SSc6.1	Stormwater Design Quantity Control
0	0	1	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect Roof
1	0	0	SSc8	Light Pollution Reduction
6	0	3		Water Efficiency

Y	?	N		
0	0	14		Materials and Resources
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
0	0	1	MRc2.1	Construction Waste Management Divert 50% from Disposal
0	0	1	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
0	0	1	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials
0	0	1	MRc7	Certified Wood
9	0	6		Indoor Environmental Quality

Estimated LEED Certification and Cost Premium

GJMMP – SSIM_{LEED} Scenario Generator Scenario KPI Summary



Water Efficient Lanscaping Goal	Water Use Reduction Goal	Construction Waste Management Goal	Recycled Materials Goal	Regional Materials Goal
100%	30%	0%	0%	0%

SS	10	out of 26 potential points
WE	6	out of 10 potential points
EA	19	out of 35 potential points
MR	0	out of 14 potential points
EQ	9	out of 15 potential points
ID	4	out of 6 potential points
RI	0	out of 4 potential points

2.6% Add. Capita

BUILDING DATA	CREDIT STRATEGIES
3 Story Headquarters Building	Low Design Impact / Low Construction Cost
Guam	-
88,973 sqft GFA	-

3 Story Headquarters
Option A Sustainability KPIs

Assessment of Current Option vs Client’s Sustainability Goals

Other Sustainability Goals

Summary of Energy Reduction Goals

Summary of LEED Goal Points

LEED Certification level and AECOM Sustainability Index

Estimated Cost Premium

GJMMP – SSIM$_{\text{LEED}}$ Scenario Generator Work to Date

- Generated SSIM$_{\text{LEED}}$ Scenarios on the following building types:

  - 3 Story HQ Office
  - 2 Story HQ Office
  - 1 Story Small Office
  - Conditioned Warehouse
  - Unconditioned Warehouse
  - Day Care Center
  - Dining Facility
  - Commissary
  - BEQ
  - School
  - Workshop

- “Ground truthing” of scenarios based on existing LEED scorecard data from Guam:
  - Joint region Marianas Headquarters
  - BEQ Naval Base
  - Fitness Center
  - North Tipalao Housing Project

GJMMP – SSIM$_{\text{LEED}}$ Scenario Generator Initial Assumptions

- Costing has been based upon the revised $/sf information provided.

- Credits that would form part of baseline specification (such as low VOC paints etc) are deemed to have zero additional cost premium due to economies of scale.

- Costing metrics used in initial models based upon our mainland experience of LEED NCv2.2, which calibration using local information where available.

GJMMP – SSIM$_{\text{LEED}}$ Scenario Generator Initial Results DRAFT

Building Type	Cost Premium to Silver	Cost Premium to Gold
3 Story HQ Office	5.4%	6.4%
2 Story HQ Office	4.7%	5.8%
1 Story Small Office	6.9%	11.2%
Conditioned Warehouse	6.3%	7.4%
Unconditioned Warehouse	4.4%	4.4%
Day Care Center	4.0%	5.0%
Commissary	5.1%	6.0%
Dining Facility	3.5%	4.5%
BEQ	3.2%	4.4%
School	3.1%	4.1%
Workshop	5.2%	6.3%
Average	4.8%	6.0%

GJMMP – SSIM$_{\text{LEED}}$ Scenario Generator USGBC Certification Costs DRAFT

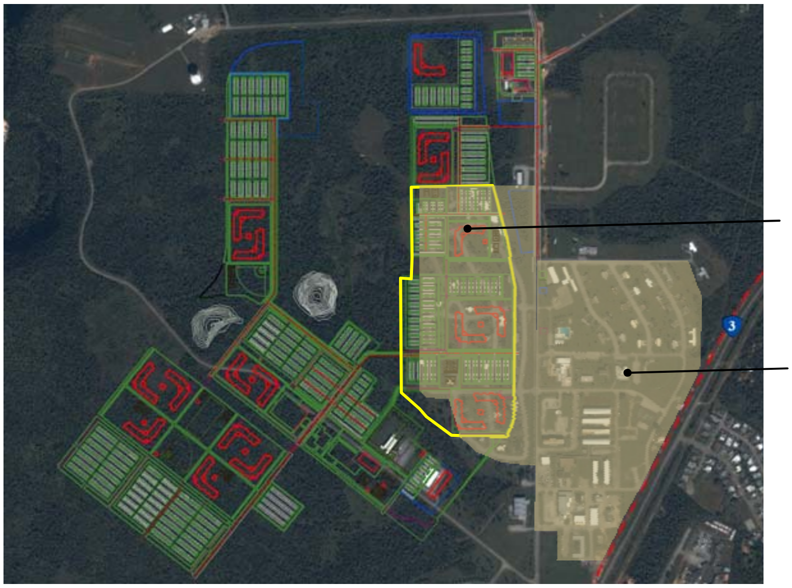
Building Type	Less than 50 ksq ft	50k – 500 ksqft	More than 500 kSqft
	Fixed Fee	Based upon Square Footage	Fixed Rate
Design Review	$2,000	$0.04 / sf	$20,000
Construction Review	$500	$0.01 / sf	$5,000
Appeal cost	$500/credit		

Assumes USGBC Member rates

LEED ND Analysis for BEQ Area

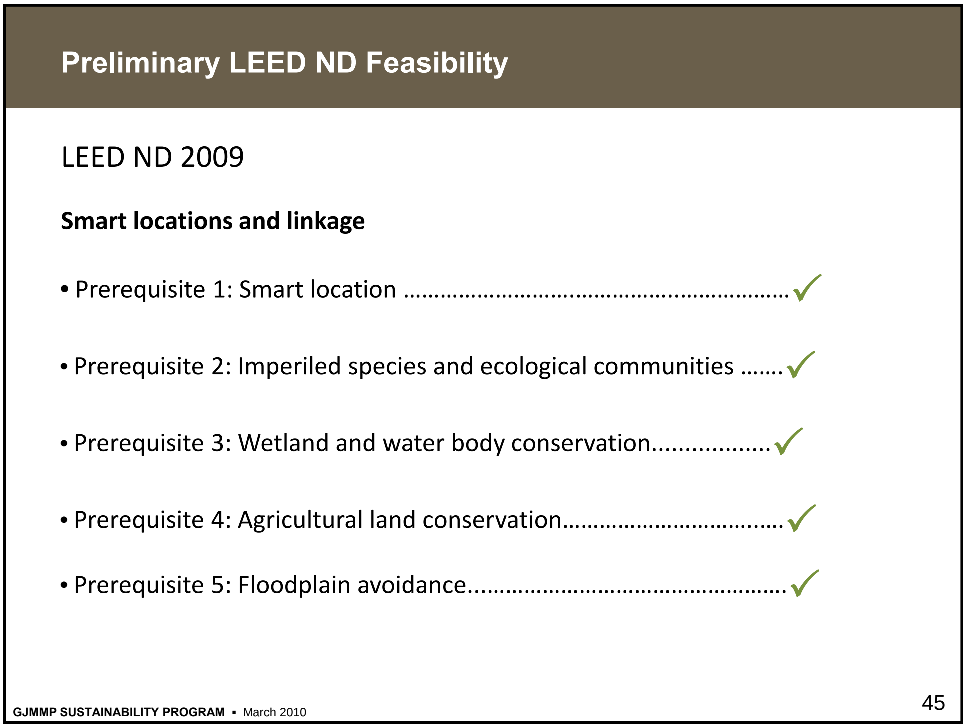
Updated BEQ
Area Plan

BEQ Plan and Existing Aerial Overlay



Potential
LEED ND
Project Area

Previous
Developed
Area

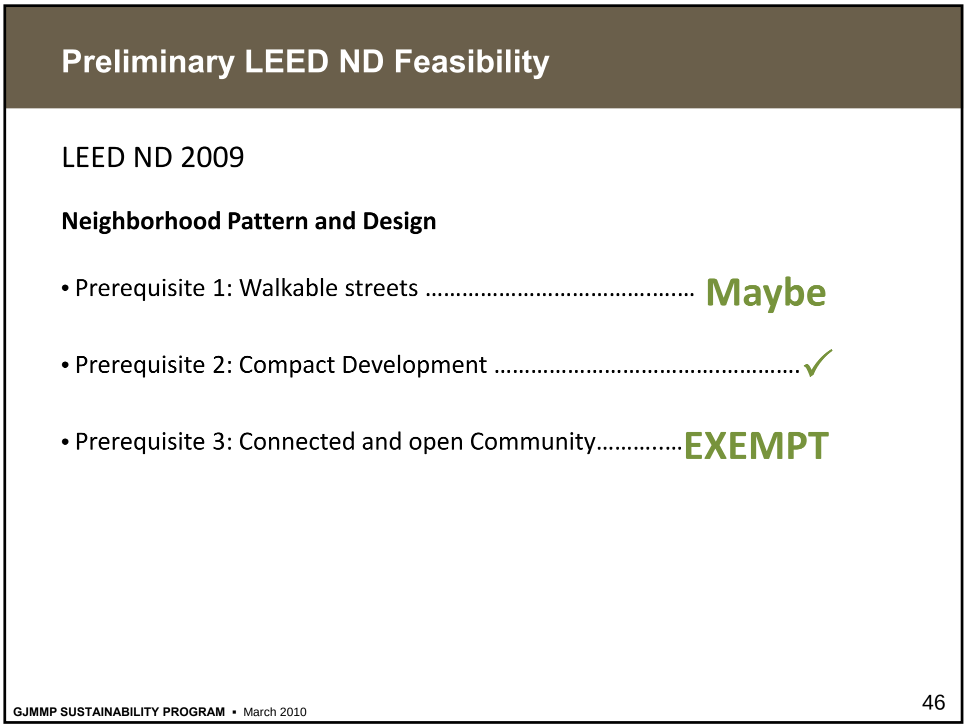


Preliminary LEED ND Feasibility

LEED ND 2009

Smart locations and linkage

- Prerequisite 1: Smart location ………………………………………………………✓
- Prerequisite 2: Imperiled species and ecological communities …….✓
- Prerequisite 3: Wetland and water body conservation……………..✓
- Prerequisite 4: Agricultural land conservation…………………………….✓
- Prerequisite 5: Floodplain avoidance…………………………………………..✓



Preliminary LEED ND Feasibility

LEED ND 2009

Neighborhood Pattern and Design

- Prerequisite 1: Walkable streets …………………………………… **Maybe**
- Prerequisite 2: Compact Development …………………………………………✓
- Prerequisite 3: Connected and open Community…………..**EXEMPT**

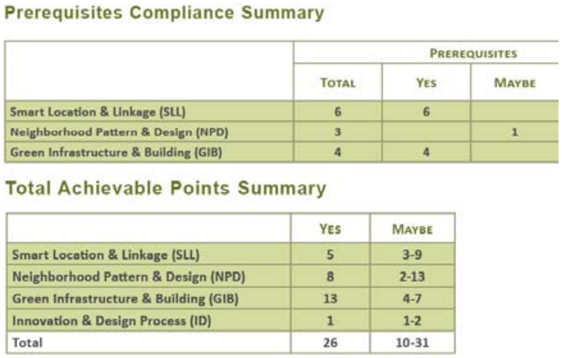
Preliminary LEED ND Feasibility

LEED ND 2009

Green infrastructure and buildings

- Prerequisite 1: Certified green building…………………………………………✓
- Prerequisite 2: Minimum building energy efficiency……………………..✓
- Prerequisite 3: Minimum building water efficiency ……………………..✓
- Prerequisite 4: Construction activity pollution prevention……………✓

Preliminary LEED ND Feasibility



Prerequisites Compliance Summary

	Prerequisites		
	Total	Yes	Maybe
Smart Location & Linkage (SLL)	6	6	
Neighborhood Pattern & Design (NPD)	3		1
Green Infrastructure & Building (GIB)	4	4	

Total Achievable Points Summary

	Yes	Maybe
Smart Location & Linkage (SLL)	5	3-9
Neighborhood Pattern & Design (NPD)	8	2-13
Green Infrastructure & Building (GIB)	13	4-7
Innovation & Design Process (ID)	1	1-2
Total	26	10-31

LEED ND 2009 Certification Level

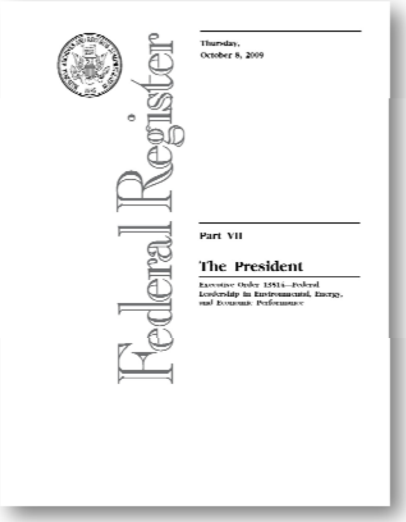
Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80 points & above

Carbon Sequestration: Executive Order 13514

- Reduce greenhouse gas emissions
  - 34% reduction in greenhouse gas emissions

"…pursuing opportunities with vendors and contractors to address and incorporate incentives to reduce greenhouse gas emissions."

"…greenhouse gas emission reductions associated with pursuing other relevant goals…"



Federal Register

Thursday,
October 8, 2009

Part VII

The President

Executive Order 13514—Federal Leadership in Environmental, Energy, and Economic Performance

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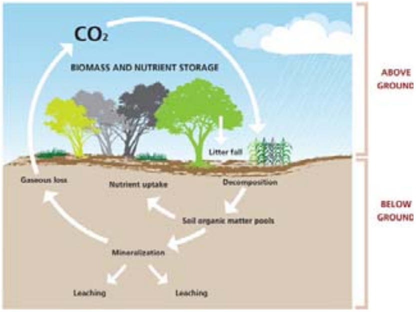
Carbon Sequestration – Introduction

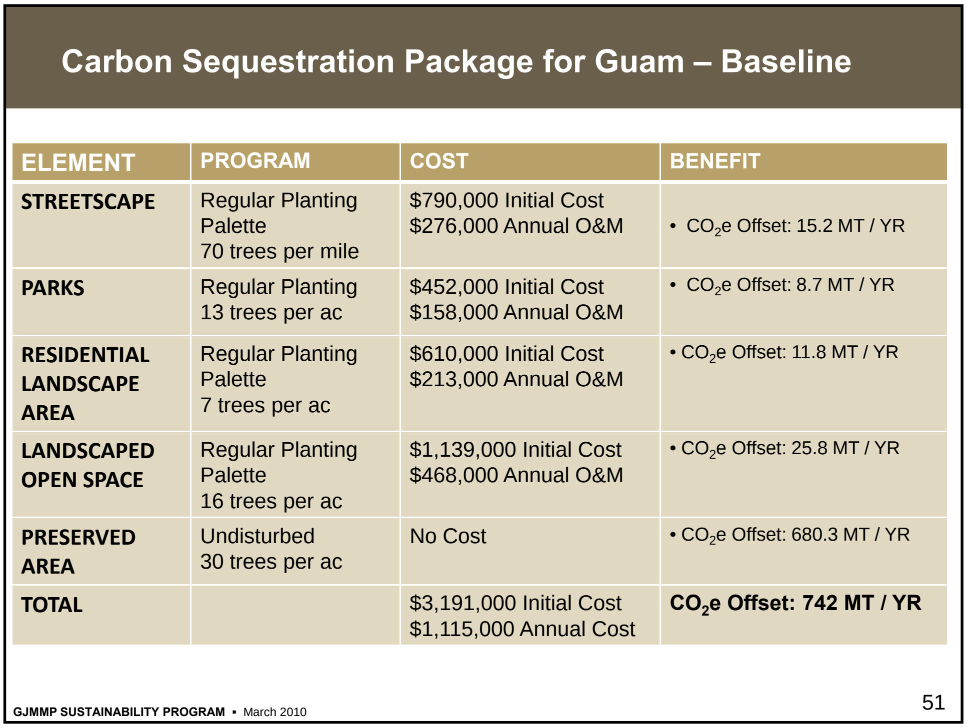
"**Carbon Sequestration** is the process by which atmospheric carbon dioxide is absorbed by trees [and vegetation] through photosynthesis and stored as carbon in biomass and soils."

- USDA Forest Service

Landscape Prototypes:

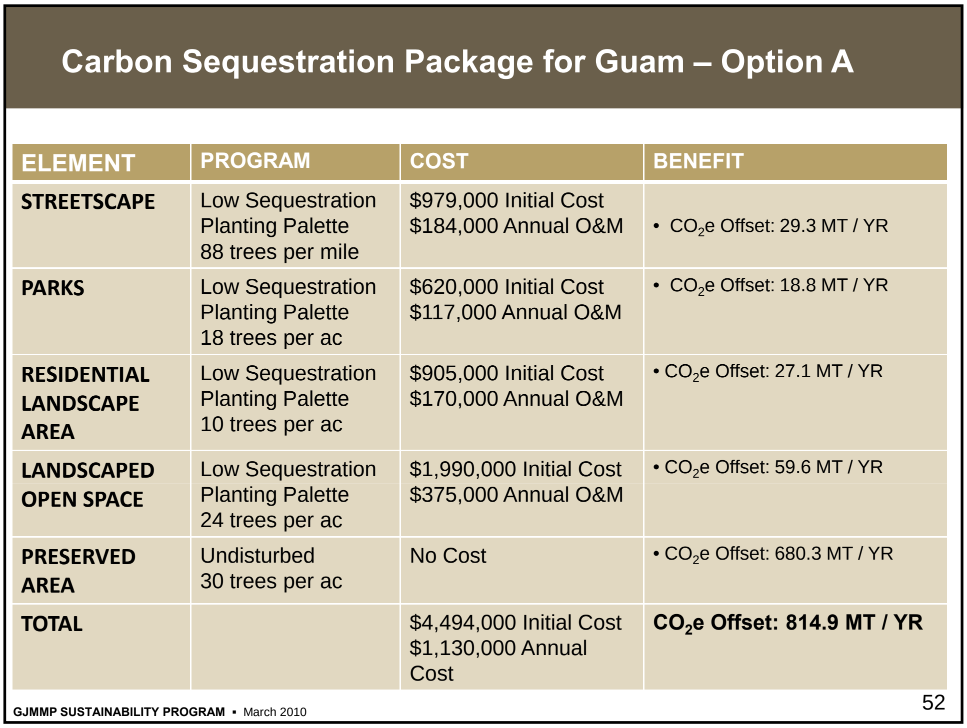
1. Landscaped Areas (buffer/median/streetscape)
2. Park Landscape
3. Residential Landscape Area
4. Open Space
5. Preserved Area





Carbon Sequestration Package for Guam – Baseline

ELEMENT	PROGRAM	COST	BENEFIT
STREETSCAPE	Regular Planting Palette 70 trees per mile	$790,000 Initial Cost $276,000 Annual O&M	• CO_2e Offset: 15.2 MT / YR
PARKS	Regular Planting 13 trees per ac	$452,000 Initial Cost $158,000 Annual O&M	• CO_2e Offset: 8.7 MT / YR
RESIDENTIAL LANDSCAPE AREA	Regular Planting Palette 7 trees per ac	$610,000 Initial Cost $213,000 Annual O&M	• CO_2e Offset: 11.8 MT / YR
LANDSCAPED OPEN SPACE	Regular Planting Palette 16 trees per ac	$1,139,000 Initial Cost $468,000 Annual O&M	• CO_2e Offset: 25.8 MT / YR
PRESERVED AREA	Undisturbed 30 trees per ac	No Cost	• CO_2e Offset: 680.3 MT / YR
TOTAL		$3,191,000 Initial Cost $1,115,000 Annual Cost	**CO_2e Offset: 742 MT / YR**



Carbon Sequestration Package for Guam – Option A

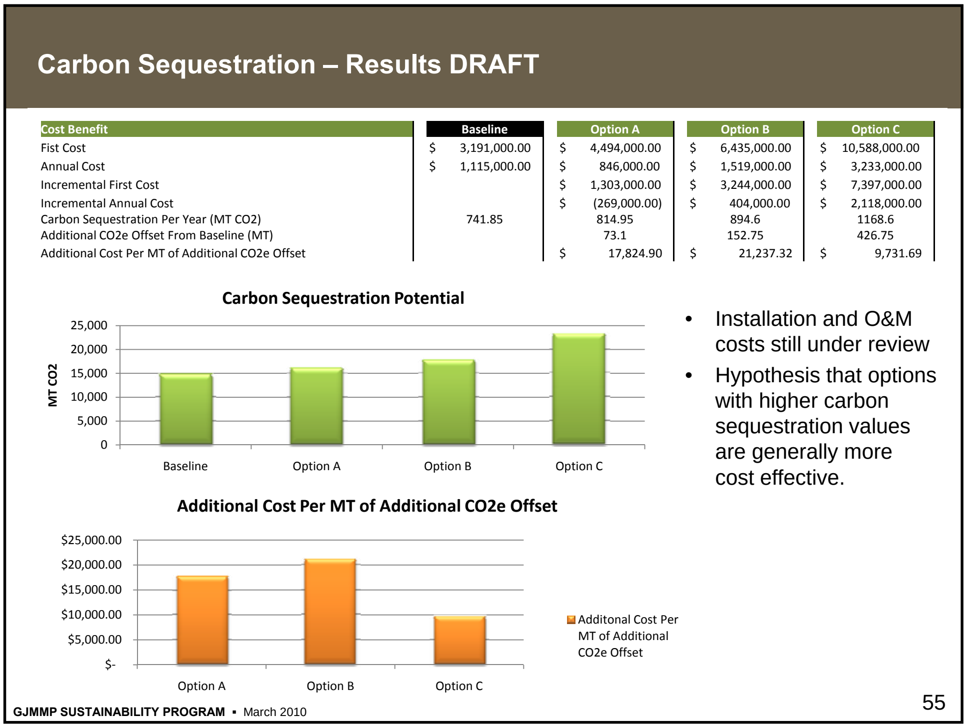
ELEMENT	PROGRAM	COST	BENEFIT
STREETSCAPE	Low Sequestration Planting Palette 88 trees per mile	$979,000 Initial Cost $184,000 Annual O&M	• CO_2e Offset: 29.3 MT / YR
PARKS	Low Sequestration Planting Palette 18 trees per ac	$620,000 Initial Cost $117,000 Annual O&M	• CO_2e Offset: 18.8 MT / YR
RESIDENTIAL LANDSCAPE AREA	Low Sequestration Planting Palette 10 trees per ac	$905,000 Initial Cost $170,000 Annual O&M	• CO_2e Offset: 27.1 MT / YR
LANDSCAPED OPEN SPACE	Low Sequestration Planting Palette 24 trees per ac	$1,990,000 Initial Cost $375,000 Annual O&M	• CO_2e Offset: 59.6 MT / YR
PRESERVED AREA	Undisturbed 30 trees per ac	No Cost	• CO_2e Offset: 680.3 MT / YR
TOTAL		$4,494,000 Initial Cost $1,130,000 Annual Cost	**CO_2e Offset: 814.9 MT / YR**

Carbon Sequestration Package for Guam – Option B

ELEMENT	PROGRAM	COST	BENEFIT
STREETSCAPE	Med Sequestration Planting Palette 105 trees per mile	$1,289,000 Initial Cost $304,000 Annual O&M	• CO_2e Offset: 42.9 MT / YR
PARKS	Med Sequestration Planting Palette 24 trees per ac	$907,000 Initial Cost $241,000 Annual O&M	• CO_2e Offset: 30.2 MT / YR
RESIDENTIAL LANDSCAPE AREA	Med Sequestration Planting Palette 14 trees per ac	$1,326,000 Initial Cost $313,000 Annual O&M	• CO_2e Offset: 44.2 MT / YR
LANDSCAPED OPEN SPACE	Med Sequestration Planting Palette 32 trees per ac	$2,913,000 Initial Cost $688,000 Annual O&M	• CO_2e Offset: 97.0 MT / YR
PRESERVED AREA	Undisturbed 30 trees per ac	No Cost	• CO_2e Offset: 680.3 MT / YR
TOTAL		$6,435,000 Initial Cost $1,519,000 Annual Cost	**CO_2e Offset: 894.6 MT / YR**

Carbon Sequestration Package for Guam – Option C

ELEMENT	PROGRAM	COST	BENEFIT
STREETSCAPE	High Sequestration Planting Palette 150 trees per mile	$2,133,000 Initial Cost $553,000 Annual O&M	• CO_2e Offset: 92.7 MT / YR
PARKS	High Sequestration Planting Palette 30 trees per ac	$1,313,000 Initial Cost $413,000 Annual O&M	• CO_2e Offset: 57.1 MT / YR
RESIDENTIAL LANDSCAPE AREA	High Sequestration Planting Palette 17 trees per ac	$1,918,000 Initial Cost $604,000 Annual O&M	• CO_2e Offset: 83.4 MT / YR
LANDSCAPED OPEN SPACE	High Sequestration Planting Palette 40 trees per ac	$4,216,000 Initial Cost $1,327,000 Annual O&M	• CO_2e Offset: 183.3 MT / YR
PRESERVED AREA	Restoration with High Sequestration Planting Palette where applicable 40 trees per ac	$1,008,000 Initial Cost $336,000 Annual Cost (Estimate 15% Area, 85% remain undisturbed)	• CO_2e Offset: 752.1 MT / YR
TOTAL		$10,588,000 Initial Cost $3,233,000 Annual Cost	**CO_2e Offset: 1168 MT / YR**



Carbon Sequestration – Results DRAFT

Cost Benefit	Baseline	Option A	Option B	Option C
Fist Cost	$ 3,191,000.00	$ 4,494,000.00	$ 6,435,000.00	$ 10,588,000.00
Annual Cost	$ 1,115,000.00	$ 846,000.00	$ 1,519,000.00	$ 3,233,000.00
Incremental First Cost		$ 1,303,000.00	$ 3,244,000.00	$ 7,397,000.00
Incremental Annual Cost		$ (269,000.00)	$ 404,000.00	$ 2,118,000.00
Carbon Sequestration Per Year (MT CO2)	741.85	814.95	894.6	1168.6
Additional CO2e Offset From Baseline (MT)		73.1	152.75	426.75
Additional Cost Per MT of Additional CO2e Offset		$ 17,824.90	$ 21,237.32	$ 9,731.69

Carbon Sequestration Potential

Additional Cost Per MT of Additional CO2e Offset

- Installation and O&M costs still under review
- Hypothesis that options with higher carbon sequestration values are generally more cost effective.

GJMMP SUSTAINABILITY PROGRAM ▪ March 2010

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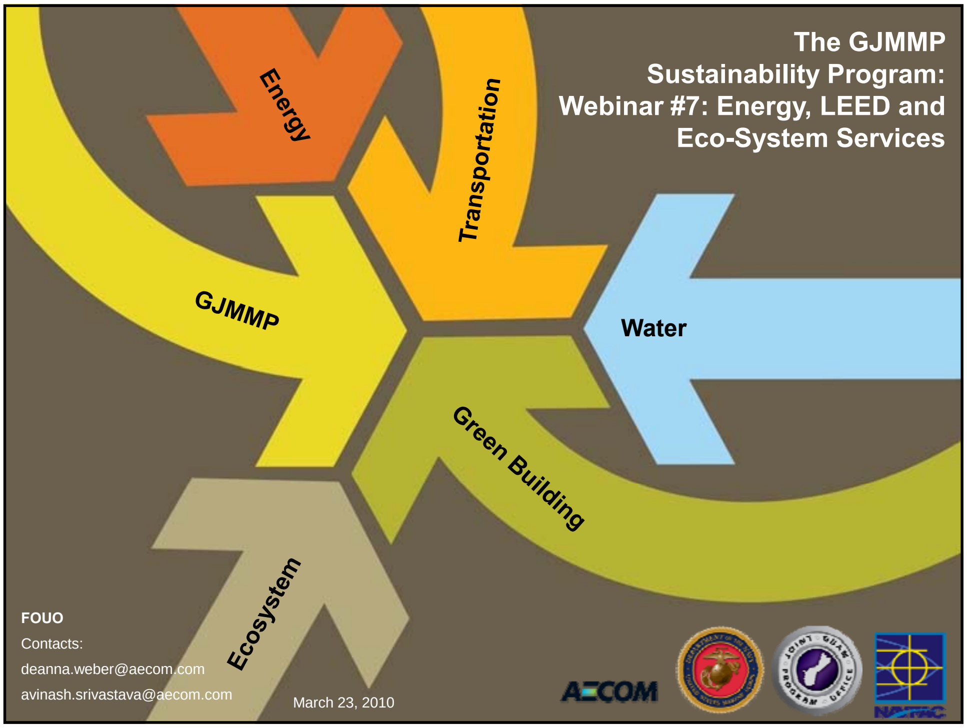

The GJMMP Sustainability Program: Webinar #7: Energy, LEED and Eco-System Services

FOUO

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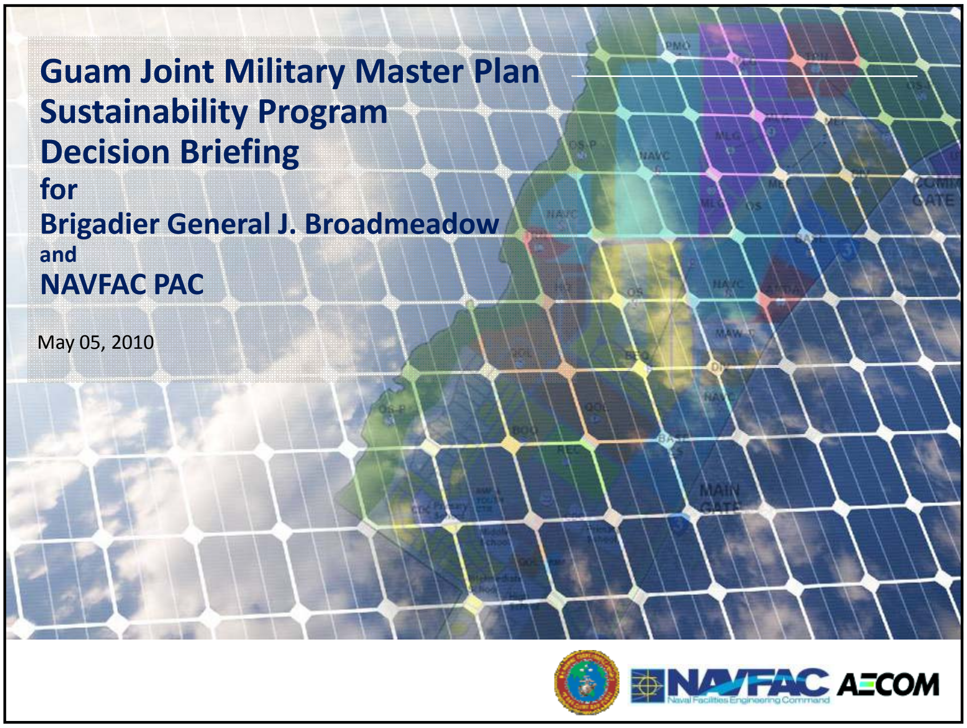
March 23, 2010



Guam Joint Military Master Plan
Sustainability Program
Decision Briefing

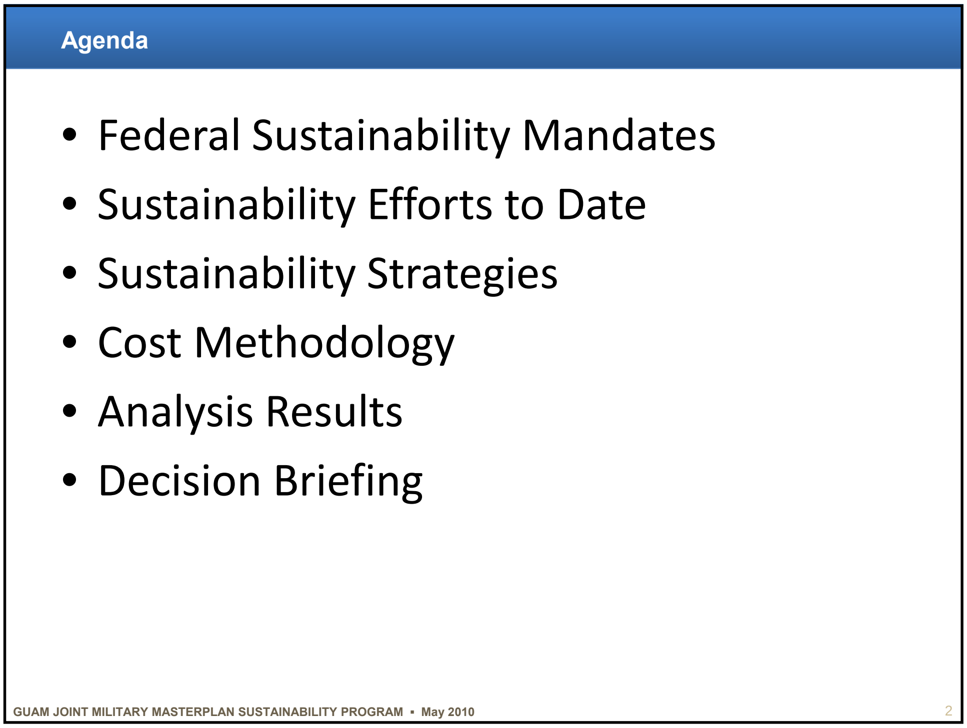
for

Brigadier General J. Broadmeadow

and

NAVFAC PAC

May 05, 2010



Agenda

- Federal Sustainability Mandates
- Sustainability Efforts to Date
- Sustainability Strategies
- Cost Methodology
- Analysis Results
- Decision Briefing

Guam JMMP Sustainability Program: Cost/Benefit Results

Baseline and Criteria Definitions:

Reference Standard:
Reference performance criteria to measure against (as defined by relevant regulation)

Baseline: Federal Mandate
Performance level to be achieved according to mandate. This is the minimum requirement to meet facility related mandates.

Agency/Installation Targets
Some regulations (such as Greenhouse Gas reductions) are set at the Agency level. The Guam JMMP has to assume a target that contributes to the overall Agency target.

Subject:	Reference Standard	Baseline: Federal Mandate
Facility Related Mandates		
Non-residential Energy	ASHRAE 90.1	30% reduction
Residential Energy	IECC[1]	30% reduction
LEED ®	LEED NC v. 3.0	Silver
Agency / Installation Wide Mandates		
Water	EPAct / EISA 2007[2]	26% reduction[3]
Transportation:	EO 13514	30% reduction of petroleum in fleet vehicles[4]
Fossil Fuels	EISA 2007[2]	100% Fossil Fuel Reduction by 2030
Renewable Energy	EPAct / EISA 2007[2]	7.5% of Total Energy (by 2013)
Agency / Installation Wide Targets		
Greenhouse Gas Emissions (overall site)	EO 13514/DoD	34% reduction[5]

[1] IECC: International Energy Conservation Code

[2] EPAct 1992 (active standard in 2007)

[3] (Executive Order 13514) performance based on year 2020. 26% potable water use intensity reduction from 2007 and 20% industrial water use reduction from 2010

[4] EO 13514: by 2020

[5] EO 13514 and DoD 1/29/10 by 2020

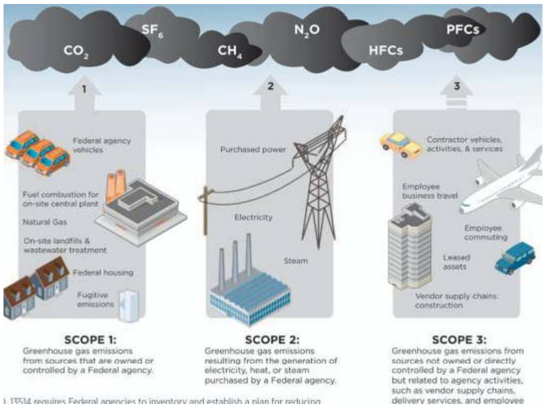
Guam JMMP Sustainability Program: Cost/Benefit Results

Greenhouse Gas (GHG) Emissions Target:

In accordance with Executive Order 13514, in January 2010, the Department of Defense has established an agency wide GHG target of **34% reduction** (from 2008 baseline).

EO 13514 requires that each Federal Agency establish a target for Scope 1 & 2 emissions by January 2010 and an additional Scope 3 target by June 2010. It is likely that the overall target for DoD **may** increase after June 2010.

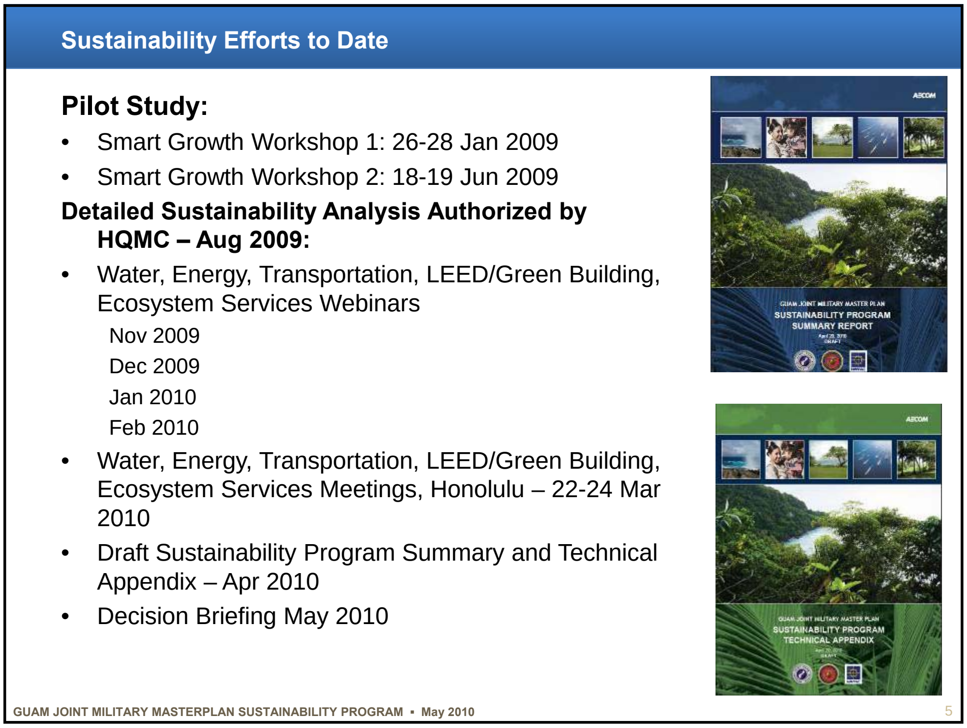
Assumed Target for Joint Military Base, Guam:
In the absence of any official specific installation level guidance on GHG targets, we recommend that the new development **adopt the overall agency target** in order to be positioned to comply with future, potentially more stringent GHG mandates.



34%
reduction from 2008

?? %
Due in June 2010

Department of Defense Targets



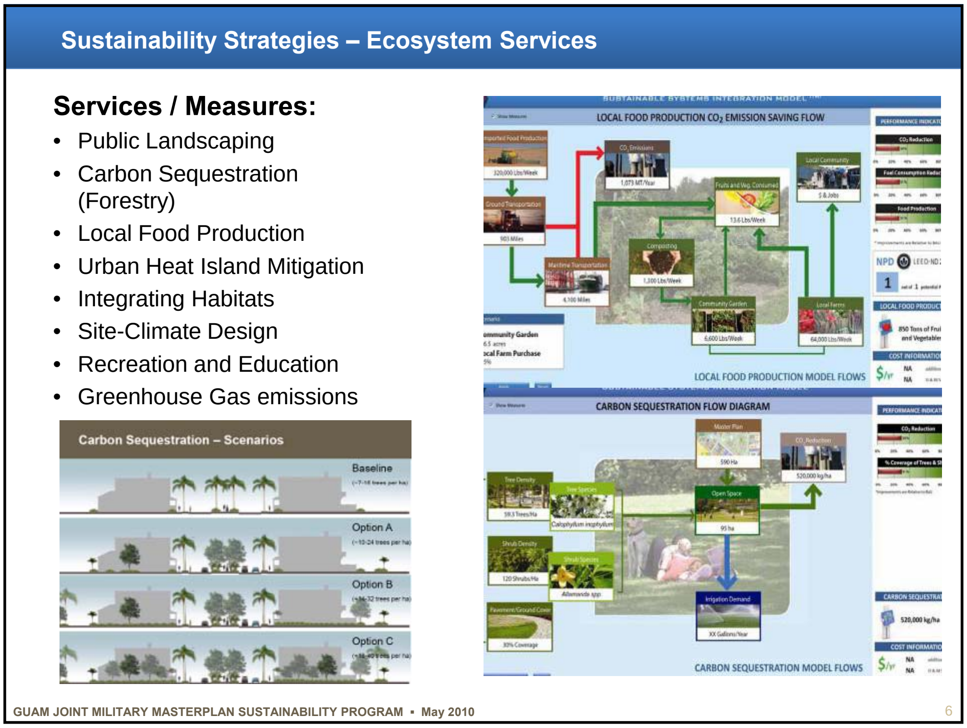
Sustainability Efforts to Date

Pilot Study:

- Smart Growth Workshop 1: 26-28 Jan 2009
- Smart Growth Workshop 2: 18-19 Jun 2009

Detailed Sustainability Analysis Authorized by HQMC – Aug 2009:

- Water, Energy, Transportation, LEED/Green Building, Ecosystem Services Webinars
  Nov 2009
  Dec 2009
  Jan 2010
  Feb 2010
- Water, Energy, Transportation, LEED/Green Building, Ecosystem Services Meetings, Honolulu – 22-24 Mar 2010
- Draft Sustainability Program Summary and Technical Appendix – Apr 2010
- Decision Briefing May 2010



Sustainability Strategies – Ecosystem Services

Services / Measures:

- Public Landscaping
- Carbon Sequestration (Forestry)
- Local Food Production
- Urban Heat Island Mitigation
- Integrating Habitats
- Site-Climate Design
- Recreation and Education
- Greenhouse Gas emissions

Sustainability Strategies – Energy Systems

ENERGY

Energy Items Overall:

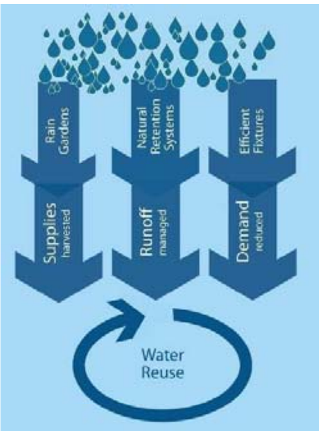
#	Priority	Action
1	High	LED for Streetlights, parking lot lights and path lights
2	High	All buildings (over 5000 SF) PV ready or have BIPV
Energy Items for Non-Residential Buildings:		
3	High	High efficiency HVAC equipment
4	High	Solar thermal hot water heating
5	High	Use of variable volume fan controls
6	High	High Efficiency T5 lighting in all buildings
7	High	Use of lighting controls
Energy Items for Residential Buildings:		
8	High	High efficiency cooling equipment
9	High	Solar thermal hot water heating
10	High	Use of compact fluorescent lighting
11	High	Energy star appliances

BIPV: Building Integrated PV

Sustainability Strategies – Water Systems

WATER

#	Priority	Action
1	High	Low flow fixtures (See water fixture flow rate table)
2	High	Roof top collection of water with cisterns (buried or incorporated into the structure if above ground)
3	High	Condensate capture (except for family housing)
4	High	Eliminate all irrigation use
5	Medium	Integration of Low Impact Development from LID study into SSIM™ for costing and LEED point evaluation
6	Medium	Curb and Gutter to be implemented by exception only (intersections may have curb and gutter for safety reasons)

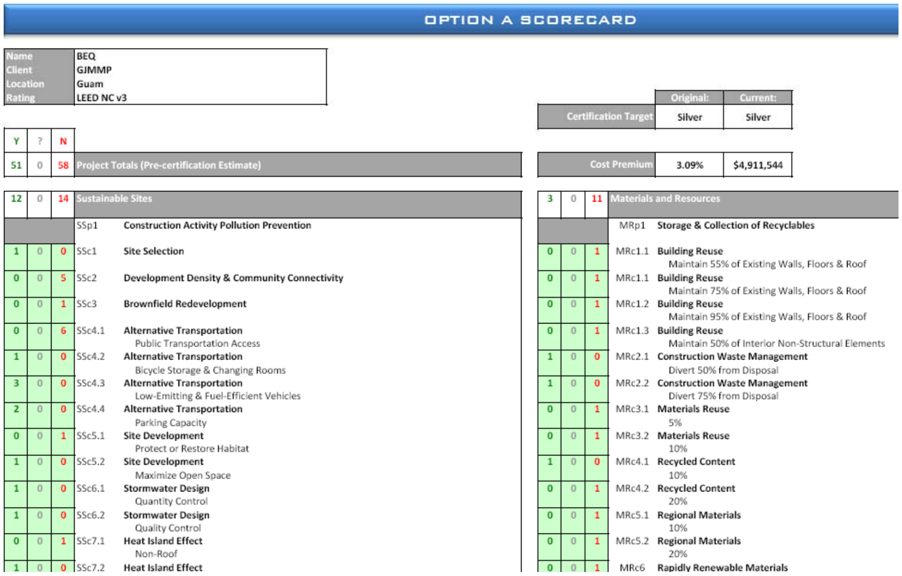


Facility Group #	Facility Group Description	Toilets (gpf)	Urinals (gpf)	Showers (gpm)	Bath Faucets (gpm)	Kitchen Faucets (gpm)	Clothes Washers (gpl/cf)	Dish-washer (gpl)
Group A	Family Housing	1.28	-	2.00	1.50	2.20	6.00	5.80
Group B	BEQ / BOQ	1.28	-	2.00	1.50	2.20	-	-
Group C	Non-Residential - High Occupancy	1.28	0.25	2.00	0.50	2.20	8.00	6.00
Group D	Non-Residential - Low Occupancy	1.28	0.25	2.00	0.50	2.20	8.00	6.00

Recommended LEED Cost Allowances for Each Building Type To Achieve the Overall Sustainability Goals

	LEED Silver	LEED Gold
5 Story HQ Office	5.00%	6.25%
3 Story HQ Office	5.00%	7.00%
2 Story HQ Office	5.00%	5.50%
1 Story Small Office	5.50%	7.75%
Organic Storage Warehouse	7.00%	7.60%
General Storage Warehouse	3.50%	0.00%
Day Center	3.25%	3.50%
Commissary	4.50%	6.00%
Dining Facility	3.50%	6.25%
BEQ - 6 Story 300 Occupant	3.50%	4.50%
School	3.00%	4.00%
Workshop	5.50%	7.00%

LEED Example



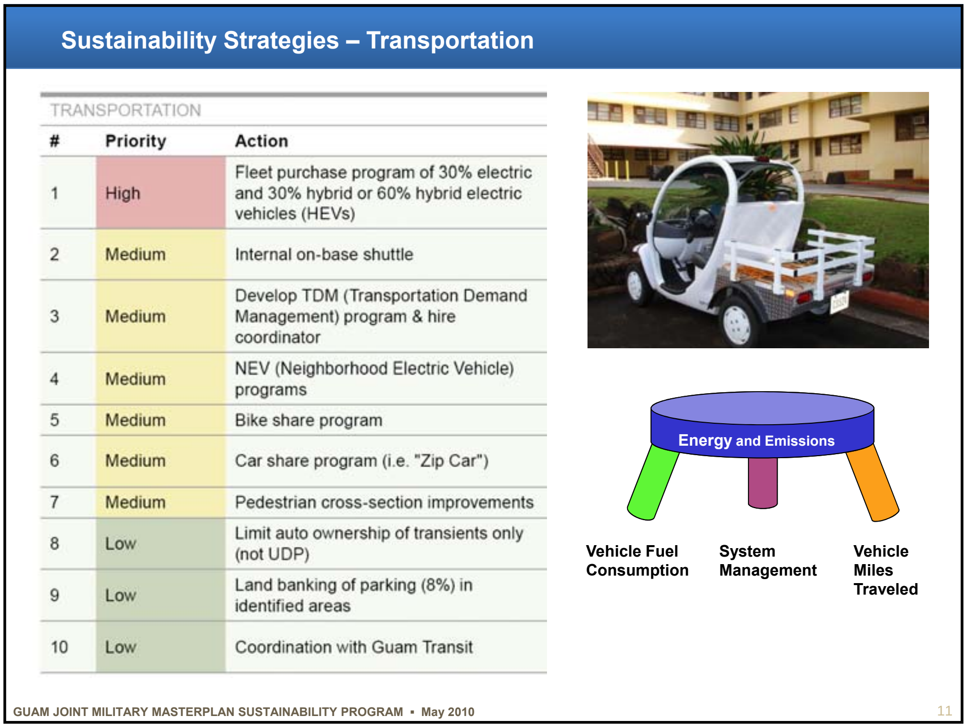
OPTION A SCORECARD

Name	BEQ
Client	GJMMP
Location	Guam
Rating	LEED NC v3

	Original:	Current:
Certification Target	Silver	Silver
Cost Premium	3.09%	$4,911,544

Y	?	N		
51	0	58	Project Totals (Pre-certification Estimate)	
12	0	14	Sustainable Sites	
			SSp1	Construction Activity Pollution Prevention
1	0	0	SSc1	Site Selection
0	0	5	SSc2	Development Density & Community Connectivity
0	0	1	SSc3	Brownfield Redevelopment
0	0	6	SSc4.1	Alternative Transportation Public Transportation Access
1	0	0	SSc4.2	Alternative Transportation Bicycle Storage & Changing Rooms
3	0	0	SSc4.3	Alternative Transportation Low-Emitting & Fuel-Efficient Vehicles
2	0	0	SSc4.4	Alternative Transportation Parking Capacity
0	0	1	SSc5.1	Site Development Protect or Restore Habitat
1	0	0	SSc5.2	Site Development Maximize Open Space
1	0	0	SSc6.1	Stormwater Design Quantity Control
1	0	0	SSc6.2	Stormwater Design Quality Control
0	0	1	SSc7.1	Heat Island Effect Non-Roof
1	0	0	SSc7.2	Heat Island Effect

3	0	11	Materials and Resources	
			MRp1	Storage & Collection of Recyclables
0	0	1	MRc1.1	Building Reuse Maintain 55% of Existing Walls, Floors & Roof
0	0	1	MRc1.1	Building Reuse Maintain 75% of Existing Walls, Floors & Roof
0	0	1	MRc1.2	Building Reuse Maintain 95% of Existing Walls, Floors & Roof
0	0	1	MRc1.3	Building Reuse Maintain 50% of Interior Non-Structural Elements
1	0	0	MRc2.1	Construction Waste Management Divert 50% from Disposal
1	0	0	MRc2.2	Construction Waste Management Divert 75% from Disposal
0	0	1	MRc3.1	Materials Reuse 5%
0	0	1	MRc3.2	Materials Reuse 10%
1	0	0	MRc4.1	Recycled Content 10%
0	0	1	MRc4.2	Recycled Content 20%
0	0	1	MRc5.1	Regional Materials 10%
0	0	1	MRc5.2	Regional Materials 20%
0	0	1	MRc6	Rapidly Renewable Materials



Sustainability Strategies – Transportation

TRANSPORTATION

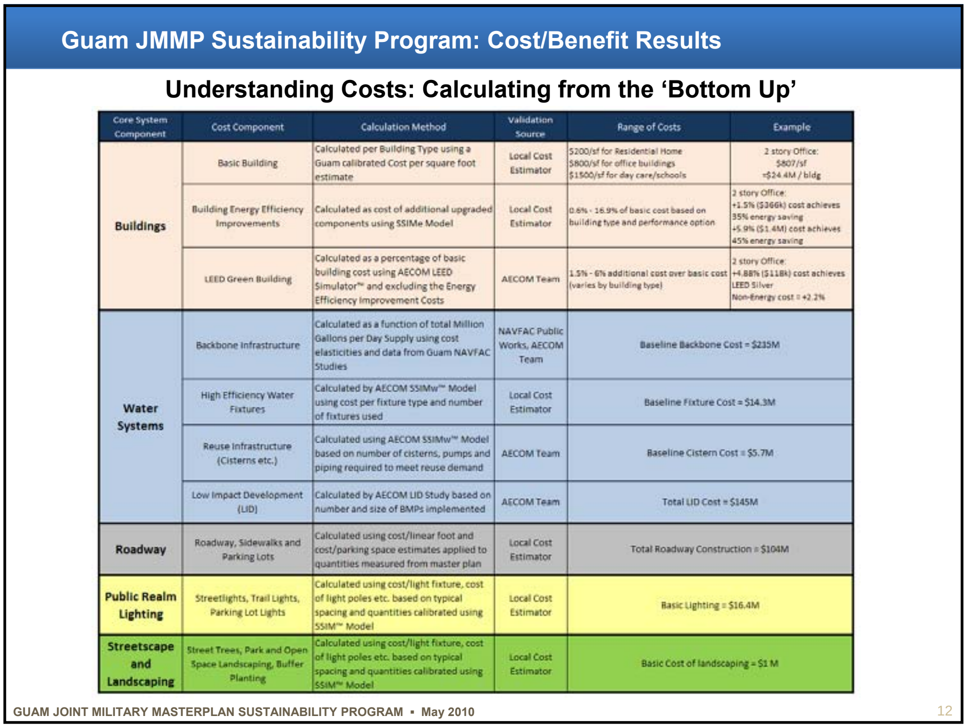
#	Priority	Action
1	High	Fleet purchase program of 30% electric and 30% hybrid or 60% hybrid electric vehicles (HEVs)
2	Medium	Internal on-base shuttle
3	Medium	Develop TDM (Transportation Demand Management) program & hire coordinator
4	Medium	NEV (Neighborhood Electric Vehicle) programs
5	Medium	Bike share program
6	Medium	Car share program (i.e. "Zip Car")
7	Medium	Pedestrian cross-section improvements
8	Low	Limit auto ownership of transients only (not UDP)
9	Low	Land banking of parking (8%) in identified areas
10	Low	Coordination with Guam Transit

Energy and Emissions

Vehicle Fuel Consumption

System Management

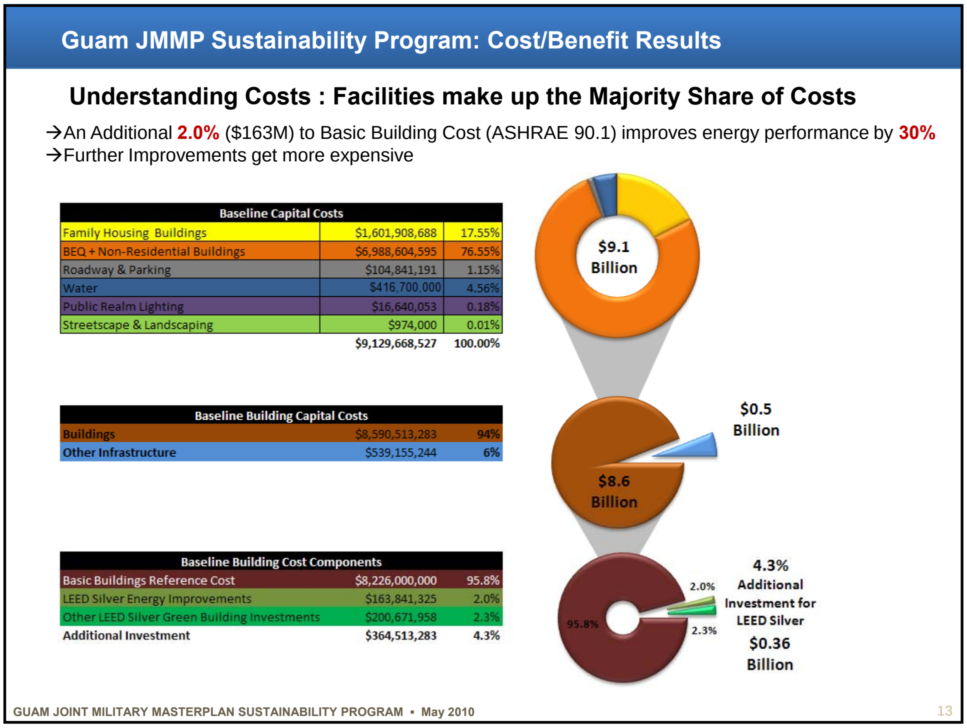
Vehicle Miles Traveled



Guam JMMP Sustainability Program: Cost/Benefit Results

Understanding Costs: Calculating from the 'Bottom Up'

Core System Component	Cost Component	Calculation Method	Validation Source	Range of Costs	Example
Buildings	Basic Building	Calculated per Building Type using a Guam calibrated Cost per square foot estimate	Local Cost Estimator	$200/sf for Residential Home $800/sf for office buildings $1500/sf for day care/schools	2 story Office: $807/sf =$24.4M / bldg
	Building Energy Efficiency Improvements	Calculated as cost of additional upgraded components using SSIMe Model	Local Cost Estimator	0.6% - 16.9% of basic cost based on building type and performance option	2 story Office: +1.5% ($366k) cost achieves 35% energy saving +5.9% ($1.4M) cost achieves 45% energy saving
	LEED Green Building	Calculated as a percentage of basic building cost using AECOM LEED Simulator™ and excluding the Energy Efficiency Improvement Costs	AECOM Team	1.5% - 6% additional cost over basic cost (varies by building type)	2 story Office: +4.88% ($118k) cost achieves LEED Silver Non-Energy cost = +2.2%
Water Systems	Backbone Infrastructure	Calculated as a function of total Million Gallons per Day Supply using cost elasticities and data from Guam NAVFAC Studies	NAVFAC Public Works, AECOM Team	Baseline Backbone Cost = $235M	
	High Efficiency Water Fixtures	Calculated by AECOM SSIMw™ Model using cost per fixture type and number of fixtures used	Local Cost Estimator	Baseline Fixture Cost = $14.3M	
	Reuse Infrastructure (Cisterns etc.)	Calculated using AECOM SSIMw™ Model based on number of cisterns, pumps and piping required to meet reuse demand	AECOM Team	Baseline Cistern Cost = $5.7M	
	Low Impact Development (LID)	Calculated by AECOM LID Study based on number and size of BMPs implemented	AECOM Team	Total LID Cost = $145M	
Roadway	Roadway, Sidewalks and Parking Lots	Calculated using cost/linear foot and cost/parking space estimates applied to quantities measured from master plan	Local Cost Estimator	Total Roadway Construction = $104M	
Public Realm Lighting	Streetlights, Trail Lights, Parking Lot Lights	Calculated using cost/light fixture, cost of light poles etc. based on typical spacing and quantities calibrated using SSIM™ Model	Local Cost Estimator	Basic Lighting = $16.4M	
Streetscape and Landscaping	Street Trees, Park and Open Space Landscaping, Buffer Planting	Calculated using cost/light fixture, cost of light poles etc. based on typical spacing and quantities calibrated using SSIM™ Model	Local Cost Estimator	Basic Cost of landscaping = $1 M	



Guam JMMP Sustainability Program: Cost/Benefit Results

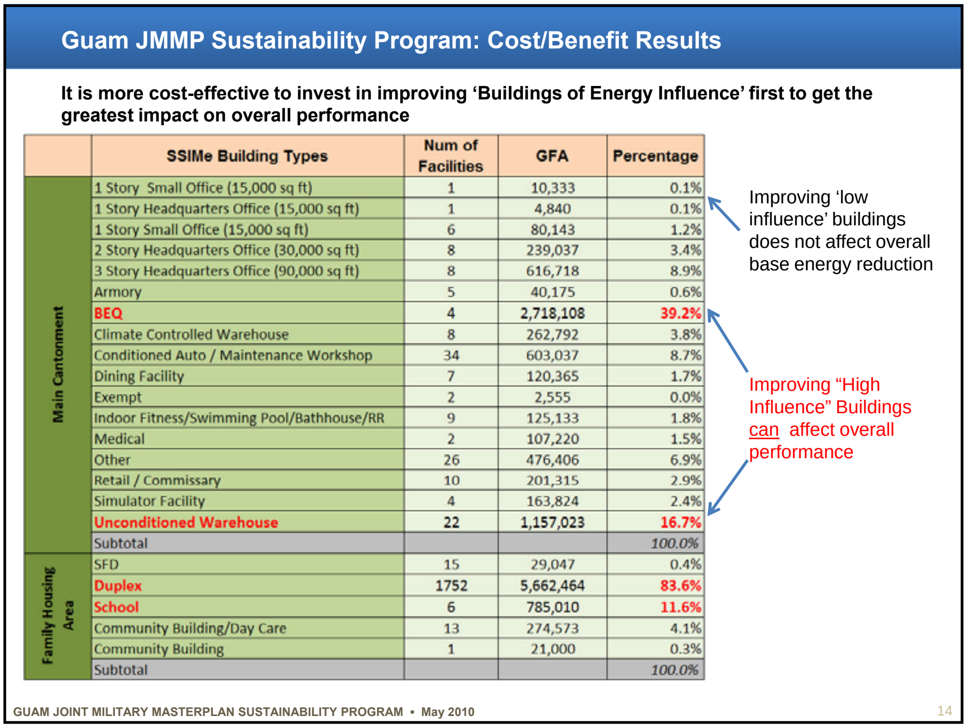
Understanding Costs : Facilities make up the Majority Share of Costs

→An Additional **2.0%** ($163M) to Basic Building Cost (ASHRAE 90.1) improves energy performance by **30%**
→Further Improvements get more expensive

Baseline Capital Costs		
Family Housing Buildings	$1,601,908,688	17.55%
BEQ + Non-Residential Buildings	$6,988,604,595	76.55%
Roadway & Parking	$104,841,191	1.15%
Water	$416,700,000	4.56%
Public Realm Lighting	$16,640,053	0.18%
Streetscape & Landscaping	$974,000	0.01%
	$9,129,668,527	**100.00%**

Baseline Building Capital Costs		
Buildings	$8,590,513,283	**94%**
Other Infrastructure	$539,155,244	**6%**

Baseline Building Cost Components		
Basic Buildings Reference Cost	$8,226,000,000	95.8%
LEED Silver Energy Improvements	$163,841,325	2.0%
Other LEED Silver Green Building Investments	$200,671,958	2.3%
Additional Investment	**$364,513,283**	**4.3%**



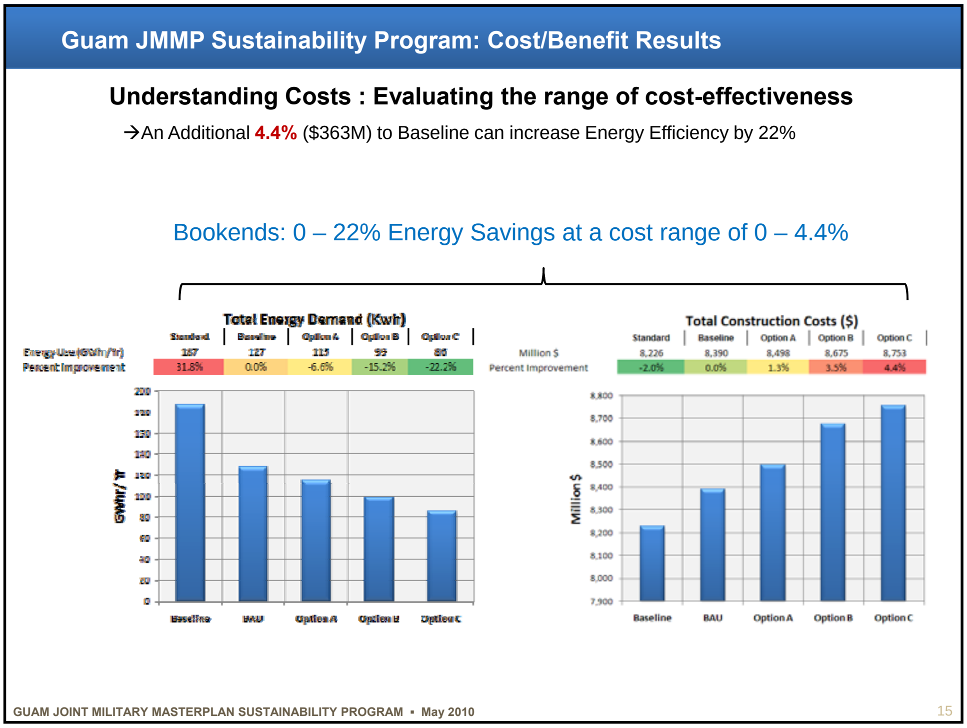
Guam JMMP Sustainability Program: Cost/Benefit Results

It is more cost-effective to invest in improving 'Buildings of Energy Influence' first to get the greatest impact on overall performance

	SSIMe Building Types	Num of Facilities	GFA	Percentage
Main Cantonment	1 Story Small Office (15,000 sq ft)	1	10,333	0.1%
	1 Story Headquarters Office (15,000 sq ft)	1	4,840	0.1%
	1 Story Small Office (15,000 sq ft)	6	80,143	1.2%
	2 Story Headquarters Office (30,000 sq ft)	8	239,037	3.4%
	3 Story Headquarters Office (90,000 sq ft)	8	616,718	8.9%
	Armory	5	40,175	0.6%
	BEQ	4	**2,718,108**	**39.2%**
	Climate Controlled Warehouse	8	262,792	3.8%
	Conditioned Auto / Maintenance Workshop	34	603,037	8.7%
	Dining Facility	7	120,365	1.7%
	Exempt	2	2,555	0.0%
	Indoor Fitness/Swimming Pool/Bathhouse/RR	9	125,133	1.8%
	Medical	2	107,220	1.5%
	Other	26	476,406	6.9%
	Retail / Commissary	10	201,315	2.9%
	Simulator Facility	4	163,824	2.4%
	Unconditioned Warehouse	**22**	**1,157,023**	**16.7%**
	Subtotal			*100.0%*
Family Housing Area	SFD	15	29,047	0.4%
	Duplex	1752	**5,662,464**	**83.6%**
	School	6	785,010	**11.6%**
	Community Building/Day Care	13	274,573	4.1%
	Community Building	1	21,000	0.3%
	Subtotal			*100.0%*

Improving 'low influence' buildings does not affect overall base energy reduction

Improving "High Influence" Buildings can affect overall performance



Guam JMMP Sustainability Program: Cost/Benefit Results

Understanding Costs : Evaluating the range of cost-effectiveness

→An Additional **4.4%** ($363M) to Baseline can increase Energy Efficiency by 22%

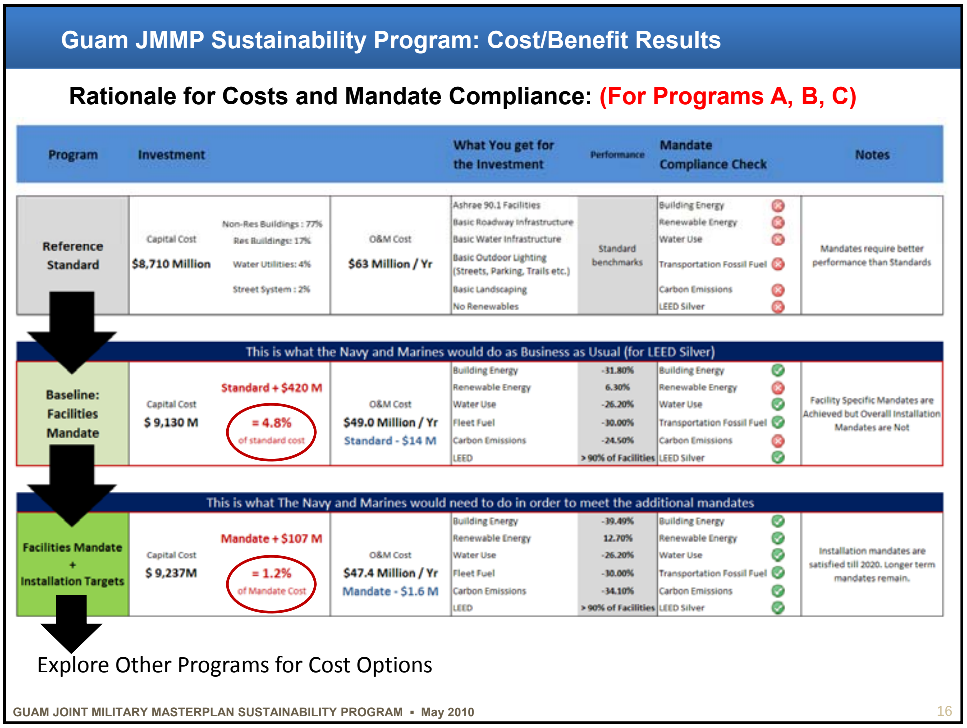
Bookends: 0 – 22% Energy Savings at a cost range of 0 – 4.4%

Total Energy Demand (Kwh)

	Standard	Baseline	Option A	Option B	Option C
Energy Use (GWh/Yr)	167	127	115	99	86
Percent Improvement	31.8%	0.0%	-6.6%	-15.2%	-22.2%

Total Construction Costs ($)

	Standard	Baseline	Option A	Option B	Option C
Million $	8,226	8,390	8,498	8,675	8,753
Percent Improvement	-2.0%	0.0%	1.3%	3.5%	4.4%



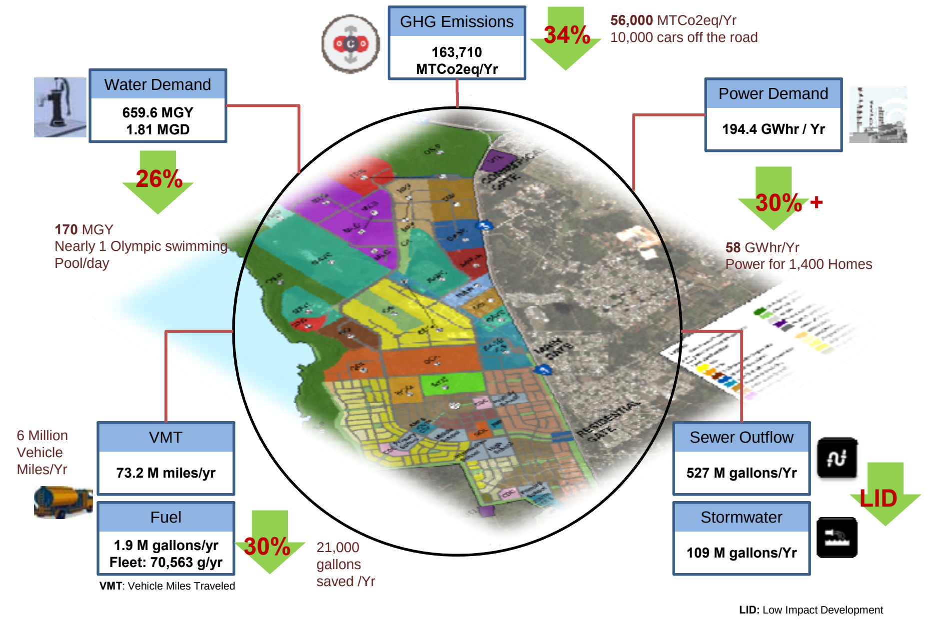
Guam JMMP Sustainability Program: Cost/Benefit Results

Rationale for Costs and Mandate Compliance: (For Programs A, B, C)

Program	Investment			What You get for the Investment	Performance	Mandate Compliance Check	Notes
Reference Standard	Capital Cost $8,710 Million	Non-Res Buildings : 77% Res Buildings: 17% Water Utilities: 4% Street System : 2%	O&M Cost $63 Million / Yr	Ashrae 90.1 Facilities Basic Roadway Infrastructure Basic Water Infrastructure Basic Outdoor Lighting (Streets, Parking, Trails etc.) Basic Landscaping No Renewables	Standard benchmarks	Building Energy ☒ Renewable Energy ☒ Water Use ☒ Transportation Fossil Fuel ☒ Carbon Emissions ☒ LEED Silver ☒	Mandates require better performance than Standards
This is what the Navy and Marines would do as Business as Usual (for LEED Silver)							
Baseline: Facilities Mandate	Capital Cost $ 9,130 M	Standard + $420 M = 4.8% of standard cost	O&M Cost $49.0 Million / Yr Standard - $14 M	Building Energy Renewable Energy Water Use Fleet Fuel Carbon Emissions LEED	-31.80% 6.30% -26.20% -30.00% -24.50% > 90% of Facilities	Building Energy ✓ Renewable Energy ☒ Water Use ✓ Transportation Fossil Fuel ✓ Carbon Emissions ☒ LEED Silver ✓	Facility Specific Mandates are Achieved but Overall Installation Mandates are Not
This is what The Navy and Marines would need to do in order to meet the additional mandates							
Facilities Mandate + Installation Targets	Capital Cost $ 9,237M	Mandate + $107 M = 1.2% of Mandate Cost	O&M Cost $47.4 Million / Yr Mandate - $1.6 M	Building Energy Renewable Energy Water Use Fleet Fuel Carbon Emissions LEED	-39.49% 12.70% -26.20% -30.00% -34.10% > 90% of Facilities	Building Energy ✓ Renewable Energy ✓ Water Use ✓ Transportation Fossil Fuel ✓ Carbon Emissions ✓ LEED Silver ✓	Installation mandates are satisfied till 2020. Longer term mandates remain.

Explore Other Programs for Cost Options

Guam JMMP Development Impact Mitigation / Targets:



GHG Emissions
163,710 MTCo2eq/Yr
34%
56,000 MTCo2eq/Yr
10,000 cars off the road

Water Demand
659.6 MGY
1.81 MGD
26%
170 MGY
Nearly 1 Olympic swimming Pool/day

Power Demand
194.4 GWhr / Yr
30% +
58 GWhr/Yr
Power for 1,400 Homes

6 Million Vehicle Miles/Yr
VMT
73.2 M miles/yr

Fuel
1.9 M gallons/yr
Fleet: 70,563 g/yr
30%
21,000 gallons saved /Yr

VMT: Vehicle Miles Traveled

Sewer Outflow
527 M gallons/Yr

Stormwater
109 M gallons/Yr

LID

LID: Low Impact Development

Guam JMMP Sustainability Program: Cost/Benefit Results

Preferred Program Selection Criteria:

******All Programs Meet Federal Mandates at Facility and Installation Level******

Program:	Total Cost Benefit Analysis for Entire Site (including Family Housing)
A	Least Capital Cost (First Costs)
B	Quickest Payback (Years)
C	Highest Life Cycle Cost Savings

For Reference Only – Housing investment costs are covered by the SPE, recovered through OHA

Program:	Total Cost Benefit Analysis (excluding Family Housing (SPE))
D	Least Capital Cost (First Costs)
E	Quickest Payback (Years)
F	Highest Life Cycle Cost Savings

[1] Federal Mandate EISA (Energy Independence Security Act) requires 42 year life cycle analysis
[2] Life Cycle Cost Savings in Net Present Value over 42 years

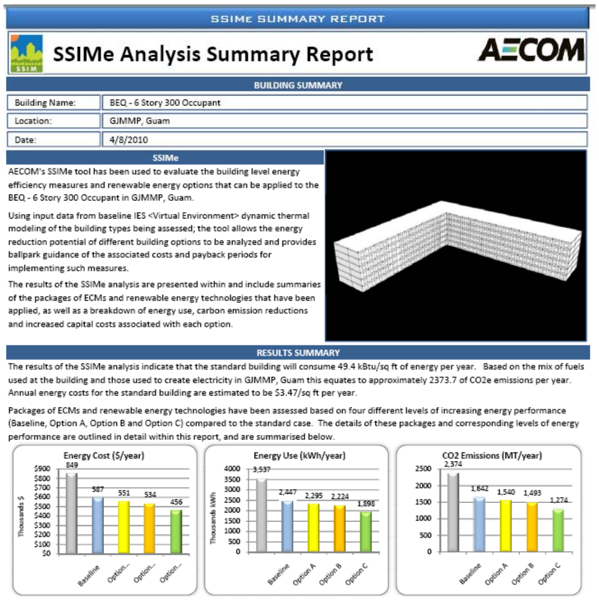
SPE: Special Purpose Entity

MARFORPAC Decision Guidance

- Request decision on which program to proceed for USMC Guam Construction Program
  - DPRI staff recommends quickest payback solution
  - Brigadier General Broadmeadow “concurs”

Program:	Entire Site (excluding Family Housing Capital Costs)[5]	Total Investment (Achieving All Mandates + Targets)[1]	Additional Investment (over Baseline)[1]	Total Savings (NPV) over 42 Years	Discounted Payback (Yrs)
D	Least Capital Investment	$7,639 M	$107 M (+1.4%)	$373 M	23.6 yrs
E	Quickest Payback	$7,651 M	$119 M (+1.6%)	$469 M	21.5 yrs
F	Highest Life Cycle Savings	$7,749 M	$217 M (+2.9%)	$497 M	23.0 yrs

What This Means for Building Energy…BEQ Example



SSIME SUMMARY REPORT

SSIMe Analysis Summary Report

AECOM

BUILDING SUMMARY

Building Name:	BEQ - 6 Story 300 Occupant
Location:	GJMMP, Guam
Date:	4/8/2010

SSIMe

AECOM's SSIMe tool has been used to evaluate the building level energy efficiency measures and renewable energy options that can be applied to the BEQ - 6 Story 300 Occupant in GJMMP, Guam.

Using input data from baseline IES <Virtual Environment> dynamic thermal modeling of the building types being assessed; the tool allows the energy reduction potential of different building options to be analyzed and provides ballpark guidance of the associated costs and payback periods for implementing such measures.

The results of the SSIMe analysis are presented within and include summaries of the packages of ECMs and renewable energy technologies that have been applied, as well as a breakdown of energy use, carbon emission reductions and increased capital costs associated with each option.

RESULTS SUMMARY

The results of the SSIMe analysis indicate that the standard building will consume 49.4 kBtu/sq ft of energy per year. Based on the mix of fuels used at the building and those used to create electricity in GJMMP, Guam this equates to approximately 2373.7 of CO2e emissions per year. Annual energy costs for the standard building are estimated to be $3.47/sq ft per year.

Packages of ECMs and renewable energy technologies have been assessed based on four different levels of increasing energy performance (Baseline, Option A, Option B and Option C) compared to the standard case. The details of these packages and corresponding levels of energy performance are outlined in detail within this report, and are summarised below.

What This Means for Building Energy…BEQ Example

RESULTS

Options Summary

	STANDARD	BASELINE	OPTION A	OPTION B	OPTION C
Floor	No Requirement	No Requirement	No Requirement	No Requirement	No Requirement
Walls	ASHRAE 90.1 1A, R13 Ins. U=0.1225	ASHRAE 90.1 1A, R13 Ins. U=0.1225	ASHRAE 90.1 1A, R21 ins. U=0.1045	ASHRAE 90.1 1A, R21 ins. U=0.1045	ASHRAE 90.1 1A, R21 ins. U=0.1045
Roof	ASHRAE 90.1 1A, R15 Ins. U=0.0633	ASHRAE 90.1 1A, R15 Ins. U=0.0633	ASHRAE 90.1 1A, R30 Ins. U=0.0325	ASHRAE 90.1 1A, R30 Ins. U=0.0325	ASHRAE 90.1 1A, R30 Ins. U=0.0325
Fenestration U Value SHGC	1.00 (Whole assembly) 0.25	1.00 (Whole assembly) 0.25	1.00 (Whole assembly) 0.25	1.00 (Whole assembly) 0.25	0.33 (Whole Assembly) 0.25
Infiltration	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH	0.25 ACH
Lighting Reduction from Standard	Compact T8 Fixtures. ASHRAE 90.1 LPD 0%	Compact T8 Fixtures. ASHRAE 90.1 LPD 0%	Compact T8 Fixtures. ASHRAE 90.1 LPD 0%	Compact T8 Fixtures. ASHRAE 90.1 LPD 0%	Compact T8 Fixtures. ASHRAE 90.1 LPD 0%
Heating Heating Efficiency Heat Recovery Type Heat Recovery Efficiency	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%	No Space Heating System 100% No Heat Recovery 0%
Cooling SEER (If Packaged) COP (Central Plant) Coolth Recovery Type Coolth Recovery Efficiency	PTAC Units with DX Cooling 11.1 No Coolth Recovery 0%	High Eff. Air Cooled Chillers 4.5 Plate Coolth Exchangers 60%	High Eff. Air Cooled Chillers 4.5 Plate Coolth Exchangers 60%	High Eff. Air Cooled Chillers 4.5 Plate Coolth Exchangers 60%	High Eff. Water Cooled Centrifugal Chillers 6.4 Plate Coolth Exchangers 60%
Delivery Method	Constant Volume System	Local Fan Coil Units	Local Fan Coil Units	Local Fan Coil Units	Local Fan Coil Units
CHP Absorption Chillers	0.0 kW 0.0 kW	0.0 kW 0.0 kW	0.0 kW 0.0 kW	0.0 kW 0.0 kW	0.0 kW 0.0 kW
Hot Water Reduction Measure Reduction from Standard	LEED-NC v3 Fixtures and Fittings 0% DHW Use Reduction	LEED-NC v3 Fixtures and Fittings 0% DHW Use Reduction	LEED-NC v3 Fixtures and Fittings 0% DHW Use Reduction	LEED-NC v3 Fixtures and Fittings 0% DHW Use Reduction	LEED-NC v3 Fixtures and Fittings 0% DHW Use Reduction
Hot Water Heating Heating Efficiency	Minimum Eff. Electric Storage 87%	Solar Hot Water / High. Eff Electric Storage 93%	Solar Hot Water / High. Eff Electric Storage 93%	Solar Hot Water / High. Eff Electric Storage 93%	Solar Hot Water / High. Eff Electric Storage 93%
Exterior Lighting Exterior Lighting Density (W/sq ft)	HID Exterior Lighting 5.00 W/sq ft	HID Exterior Lighting 5.00 W/sq ft	HID Exterior Lighting 5.00 W/sq ft	HID Exterior Lighting 5.00 W/sq ft	HID Exterior Lighting 5.00 W/sq ft
Photovoltaics Installed Capacity (kW)	No PV Generation 0.0	Amorphous 15.8	Amorphous 79.2	Amorphous 118.7	Amorphous 118.7
Building Integrated Wind Installed Capacity (kW)	No Wind Generation 0.0	No Wind Generation 0.0	No Wind Generation 0.0	No Wind Generation 0.0	No Wind Generation 0.0

Program E Summary

Actions

No Change from Baseline:
Family Housing, workshops and other buildings, Overall Water System, Overall Landscaping, On-base circulation, transportation active modes (pedestrian design), vehicle pool enhancements

First Level Upgrades (Option A):
1 story small offices, Day Center, Commissary, School, Off-base circulation, Parking and Travel Demand Management

Mid- Level Upgrades (Option B):
3 and 2 story offices, all warehouses, dining facilities,

High- Level Upgrades (Option C):
5-story flagship building, BEQ/BOQ, LED based street lighting

Performance

Carbon Footprint Reduction:
34.0%

Building Energy Reduction :
40.2%

Renewable Energy Component:
13.5%

VMT Reduction:
7.6%

Water Use Reduction:
26.2%

Fleet Fuel Savings:
30.0%

Total Transportation Fuel Reduction:
148,800 gallons/yr

Cost

Total Capital Cost:
$7,651 M

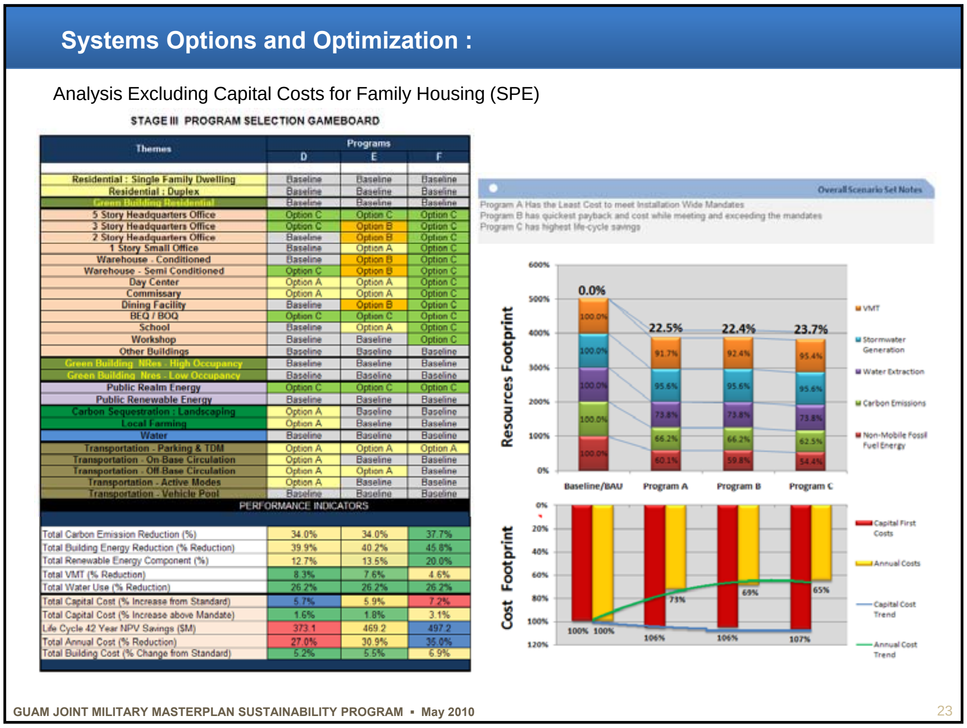
Additional Capital over Baseline:
$119 M (+ 1.5%)

Total O&M Cost:
$43.5 M (- 11.2%)

Lifecycle 42 yr Savings:
$469 M

Discounted Payback
21.5 yrs

* All percentages relative to Federal Mandate Baseline



Systems Options and Optimization :

Analysis Excluding Capital Costs for Family Housing (SPE)

STAGE III PROGRAM SELECTION GAMEBOARD

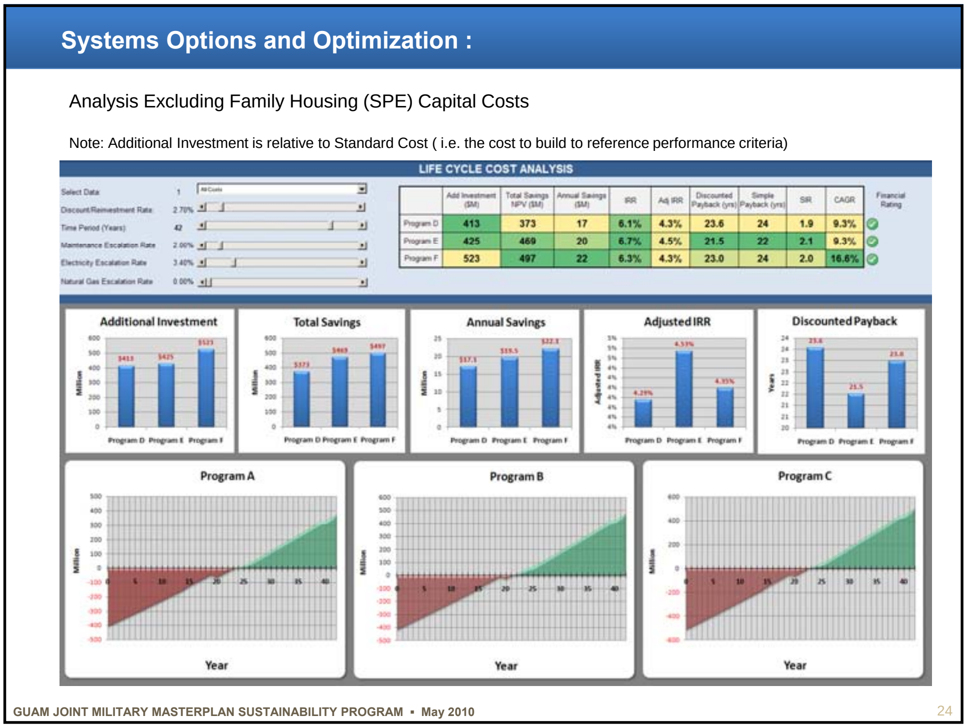
Themes	Programs D	Programs E	Programs F
Residential : Single Family Dwelling	Baseline	Baseline	Baseline
Residential : Duplex	Baseline	Baseline	Baseline
Green Building Residential	Baseline	Baseline	Baseline
5 Story Headquarters Office	Option C	Option C	Option C
3 Story Headquarters Office	Option C	Option B	Option C
2 Story Headquarters Office	Baseline	Option B	Option C
1 Story Small Office	Baseline	Option A	Option C
Warehouse - Conditioned	Baseline	Option B	Option C
Warehouse - Semi Conditioned	Option C	Option B	Option C
Day Center	Option A	Option A	Option C
Commissary	Option A	Option A	Option C
Dining Facility	Baseline	Option B	Option C
BEQ / BOQ	Option C	Option C	Option C
School	Baseline	Option A	Option C
Workshop	Baseline	Baseline	Option C
Other Buildings	Baseline	Baseline	Baseline
Green Building NRes - High Occupancy	Baseline	Baseline	Baseline
Green Building Nres - Low Occupancy	Baseline	Baseline	Baseline
Public Realm Energy	Option C	Option C	Option C
Public Renewable Energy	Baseline	Baseline	Baseline
Carbon Sequestration : Landscaping	Option A	Baseline	Baseline
Local Farming	Option A	Baseline	Baseline
Water	Baseline	Baseline	Baseline
Transportation - Parking & TDM	Option A	Option A	Option A
Transportation - On-Base Circulation	Option A	Baseline	Baseline
Transportation - Off-Base Circulation	Option A	Option A	Baseline
Transportation - Active Modes	Option A	Baseline	Baseline
Transportation - Vehicle Pool	Baseline	Baseline	Baseline
PERFORMANCE INDICATORS			
Total Carbon Emission Reduction (%)	34.0%	34.0%	37.7%
Total Building Energy Reduction (% Reduction)	39.9%	40.2%	45.8%
Total Renewable Energy Component (%)	12.7%	13.5%	20.0%
Total VMT (% Reduction)	8.3%	7.6%	4.6%
Total Water Use (% Reduction)	26.2%	26.2%	26.2%
Total Capital Cost (% Increase from Standard)	5.7%	5.9%	7.2%
Total Capital Cost (% Increase above Mandate)	1.6%	1.8%	3.1%
Life Cycle 42 Year NPV Savings ($M)	373.1	469.2	497.2
Total Annual Cost (% Reduction)	27.0%	30.9%	35.0%
Total Building Cost (% Change from Standard)	5.2%	5.5%	6.9%

Overall Scenario Set Notes

Program A Has the Least Cost to meet Installation Wide Mandates

Program B has quickest payback and cost while meeting and exceeding the mandates

Program C has highest life-cycle savings



Systems Options and Optimization :

Analysis Excluding Family Housing (SPE) Capital Costs

Note: Additional Investment is relative to Standard Cost (i.e. the cost to build to reference performance criteria)

LIFE CYCLE COST ANALYSIS

Select Data 1 All Costs
Discount/Reinvestment Rate 2.70%
Time Period (Years) 42
Maintenance Escalation Rate 2.00%
Electricity Escalation Rate 3.40%
Natural Gas Escalation Rate 0.00%

	Add Investment ($M)	Total Savings NPV ($M)	Annual Savings ($M)	IRR	Adj IRR	Discounted Payback (yrs)	Simple Payback (yrs)	SIR	CAGR	Financial Rating
Program D	413	373	17	6.1%	4.3%	23.6	24	1.9	9.3%	✓
Program E	425	469	20	6.7%	4.5%	21.5	22	2.1	9.3%	✓
Program F	523	497	22	6.3%	4.3%	23.0	24	2.0	16.6%	✓

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