Non-Roadway Development

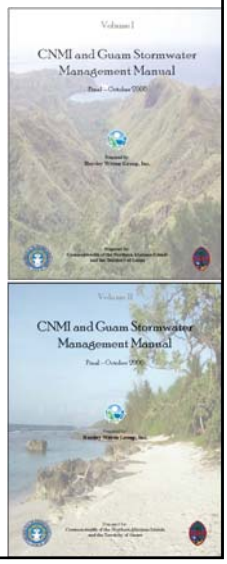
Guam Stormwater Workshop
July 28, 2011

Session Objectives

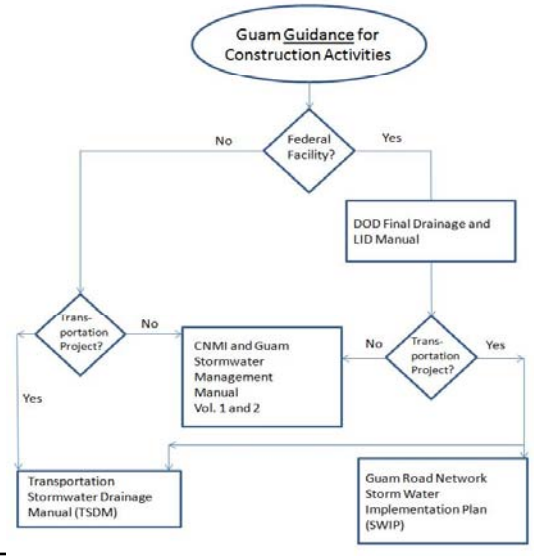
- Existing regulations work with the manual
- Purpose and overview of manuals
- Construction performance standards and acceptable BMPs
- Post-Construction performance standards and acceptable BMPs
- Selecting and locating BMPs
- Unified sizing criteria
- Summary points

Overview and Purpose of Manual

- The CNMI and Guam Storm Water Management Manual, Volume I & II, was prepared by Horsley Witten Group, Inc., and is dated October 2006
- Compiles information into a single comprehensive design handbook that is useful to engineers, plan reviewers and the regulated community
- This manual is intended to update and replace previous reference manuals in CNMI and Guam, most notably the *Guam Storm Drainage Manual (*U.S. Army Corps, 1980), *Storm Water Control Handbook* (Soil and Water Conservation Districts of CNMI, 1989), and the *Erosion and Sediment Control Manual* (GEPA, 2000)
- The purpose of the manual is to:
  1) Protect the waters of the CNMI and Guam from the adverse impacts of urban storm water runoff,
  2) to provide design guidance on the most effective best management practices (BMPs) for new development sites and redevelopment sites both during construction and post construction, and
  3) to improve the quality of BMPs that are constructed in CNMI and Guam, specifically in regard to their performance, longevity, safety, ease of maintenance, community acceptance and environmental benefit.



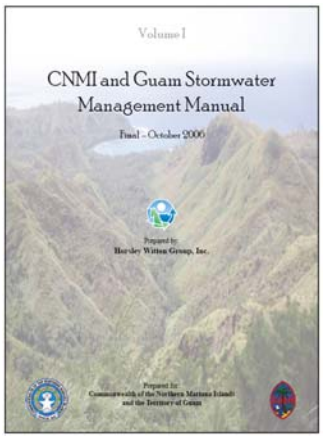
Construction and Post-Construction



2006 CNMI and Guam Storm Water Management Manual – Volume I

Volume I – General Overview

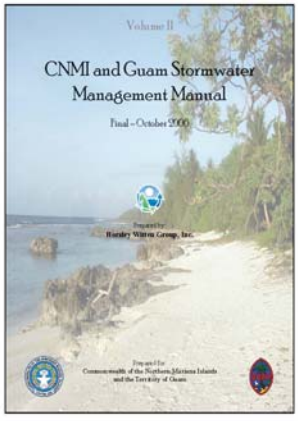
- Storm Water Treatment Practice Standards
- Acceptable Best Management Practices (BMPs)
- Construction and Post-construction



2006 CNMI and Guam Storm Water Management Manual – Volume II

Volume II – Detailed Information

- Select and locate BMPs
- Effective Landscaping
- BMP Construction Specifications
- Step-by-Step Design Examples



Supplement to the 2006 CNMI and Guam Storm Water Management Manual

- Modifies several of the designs to more typical island conditions (e.g., limestone recharge utilizing pretreatment and a filter cell prior to infiltration).
- Incorporates locally-available materials and design flexibility for wet and dry season conditions.
- Introduces additional LID practices that are recommended for the island environment.

Erosion and Sediment Control (E&SC) for Construction Sites

General Performance Standards

(Volume 1, Chapter 2, Section 2.1.1)

E&SC Standard 1:

Minimize clearing and grading, particularly during the wet season.

E&SC Standard 2:

Protect surface waters and limit clearing within the riparian corridor through the implementation of perimeter sediment controls.

E&SC Standard 3:

Construction shall be phased to limit active areas of disturbance.

Construction Storm Water General Performance Standards (contd.)

E&SC Standard 4:

Disturbed areas shall be stabilized as soon as possible after construction, but no longer than 14 days after completion of active construction.

E&SC Standard 5:

For steep slopes, defined as any slope over 20% (5:1) in grade over a length of 50 feet, the slopes shall be protected from erosion through the implementation of appropriate controls (i.e., run-on, slope stabilization, etc.).

E&SC Standard 6:

Perimeter sediment controls shall be applied to retain or filter concentrated runoff from disturbed areas before it leaves a construction site.

Construction Storm Water General Performance Standards (contd.)

E&SC Standard 7:

Adequate sediment trapping and settling devices shall be employed in lieu of ineffective perimeter sediment controls (e.g., silt fence).

E&SC Standard 8:

All construction site managers shall receive and document training in the application and maintenance of erosion and sediment control practices.

E&SC Standard 9:

All construction site managers must participate in a pre-construction meeting with the applicable authority to review the provisions of the erosion and sediment control plan.

Construction Storm Water General Performance Standards (contd.)

E&SC Standard 10:

Minimize active construction and soil exposure should in the rainy season (July 1st–Nov. 30th) and during periods of coral spawning.

E&SC Standard 11:

Adequate maintenance of erosion and sediment control practices shall occur throughout all phases of construction.

Note: Additional specifications and details for Construction Storm Water Treatment Criteria and Standards contained in Vol. I, Section 2.1.

Acceptable Erosion and Sediment Controls for Construction Sites

(Volume 1, Chapter 3, Section 3.1)

- Describes the general design, installation, and maintenance specifications for select E&SC BMPs that are acceptable for meeting the construction storm water criteria in Chapter 2
- "Toolbox" of acceptable E&SC practices not exhaustive
- Refers designers to other reference manuals to obtain E&SC practice specifications
  - Guam Soil E&SC Manual, May 1998
  - E&SC Manuals for New York and Oregon

Acceptable Erosion and Sediment Controls for Construction Sites

(Volume 1, Chapter 3, Section 3.1)

Table 3.1 Most Common Best Management Practices for Construction Sites, Detailed in Appendix A

Temporary Structural Practices	
A1:	Check Dam
A2:	Diversion Dike/Swale
A3:	Level Spreader
A4:	Perimeter Dike/Swale
A5:	Sediment Basin
A6:	Sediment Trap
A7:	Silt Fence
A8:	Stabilized Construction Entrance
A9:	Storm Drainage Inlet Protection
A10:	Turbidity Curtain
Permanent Structural Practices	
A11:	Vegetated and Lined Waterways
A12:	Rock Outlet Protection
Vegetative Practices (Temporary and/or Permanent)	
A13:	Erosion Control Blankets
A14:	Stabilization with Vegetation, Mulch, or Topsoil

Source: *CNMI and Guam Storm Water Management Manual*, October 2006.

Construction Treatment Criteria

2.1.2 Treatment Criteria

All construction site measures shall be designed to accommodate (safely convey without creating erosive conditions) the 10-year frequency storm. The 10-year frequency storm represents a large event that will generally produce significant runoff and yet has a relatively high chance of occurring in any given year (i.e., 10%). Thus, the 10-year frequency storm shall serve as the basis for channel and hydraulic design of all on-site erosion and sediment control measures.

All temporary sediment trapping devices shall be designed to retain runoff from a minimum of the 1.5" precipitation event. The 1.5-inch storm represents a frequent event that generates runoff and potential sediment load. On CNMI and Guam, the 1.5-inch event is equal to or greater than approximately 90% of precipitation events and therefore, a design criterion that requires the capture of this event will capture approximately 90% of the annual sediment load from construction sites. Thus, the 1.5-inch storm shall serve as the basis for retention design for construction site sediment trapping devices.

Post-construction Storm Water Management

General Performance Standards for Post-construction

(Volume 1, Chapter 2, Section 2.2.1)

Standard 1:

Site designers shall strive to reduce the generation of storm water runoff and utilize pervious areas for storm water treatment.

Standard 2:

Storm water management shall include a combination of structural and non-structural practices.

Standard 3:

All storm water runoff from new development shall be adequately treated prior to discharging into waters.

General Performance Standards for Post-construction (contd.)

Standard 4:

Pre-development annual groundwater recharge rates and runoff rates to coastal waters shall be maintained by promoting infiltration.

Standard 5:

For new development, structural BMPs shall be designed to remove 80% of the average annual post development total suspended solids (TSS) load and match or exceed predevelopment infiltration rates, as possible.

Standard 6:

The post-development peak discharge rate frequency shall not exceed the pre-development peak discharge rate for the 25-year frequency storm event.

General Performance Standards for Post-construction (contd.)

Standard 7:

To protect stream channels from degradation, a channel protection volume (Cpv) shall be provided by means of 24 hours of extended detention storage for the one-year frequency storm event.

Standard 8:

Storm water discharges to critical areas with sensitive resources (i.e., coral reefs, swimming beaches, wellhead protection areas, designated sensitive ecosystems) will be subject to additional performance criteria and BMPs.

Standard 9:

All BMPs shall have an enforceable operation and maintenance agreement to ensure the system functions as designed.

General Performance Standards for Post-construction (contd.)

Standard 10:

Redevelopment projects are governed by special storm water sizing criteria depending on impervious area created.

Standard 11:

For sites meeting the definition of an “infill development project,” the storm water management requirements contain important distinctions for the applicant.

Standard 12:

Certain industrial sites and all sites with disturbance over 1.0 acre are required to prepare and implement a SWPPP in accordance with the CGP.

General Performance Standards for Post-construction (contd.)

Standard 13:

Storm water discharges from land uses or activities with higher potential pollutant loadings, defined as hotspots (see Section 2.1.1.1), are required to use specific structural BMPs and pollution prevention practices.

Note: Additional details for Post-construction Storm Water Treatment Standards and Criteria contained in Vol. I, Section 2.2.

Acceptable Post-construction BMPs

(Volume 1, Chapter 3, Section 3.2)

- Describes the minimum design criteria for five groups of structural BMPs to meet:
  - Storm water quantity criteria (storage for Cp_v and Q_{p-25} and pretreatment)
  - Water quality treatment criteria (e.g., WQ_v and pollutant removal requirements)

Integrated Storm Water Management Site Design Process

The integrated design process is illustrated in **Figure 1.18**. Each concept or aspect of this process will be described in the subsequent chapters and in Volume II of the manual.

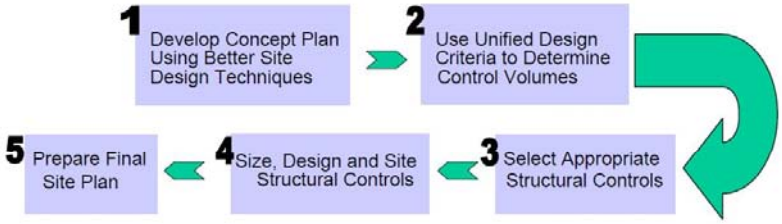


Figure 1.18 The Integrated Stormwater Management Site Design Process

Unified Sizing Criteria

Table 2.2 CNMI and Guam Required Unified Sizing Criteria for Stormwater Management Practices

Criteria	Requirement
Recharge (Re_v)	Limestone-Dominated Regions: Re_v = (1.5 in) (A) (I)/12 expressed in acre-feet where: I = Impervious area percentage of site area (decimal) A = Site area (acres) Volcanic-Dominated Regions: Re_v = (F) (A) (I)/12 expressed in acre-feet where: I = Impervious area percentage of site area (decimal) A = Site area (acres) Hydrologic Soil Group — Annual Recharge Volume Factor (F) A — 0.80 inches B — 0.50 inches C — 0.20 inches D — 0.10 inches Note: Stormwater runoff from hotspots should not infiltrate into groundwater without appropriate pretreatment equivalent to 100% of the water quality volume
Water Quality (WQ_v)	90% Rule (Discharge to High Quality Waters & Hotspot Land Uses): WQ_v = [(P)(A)(I)] / 12 expressed in acre-feet where: P = 1.5 inches[1] I = Impervious area percentage of site area (decimal) A = Site area (acres) 80% Rule (Discharge to Moderate Quality Waters): WQ_v = [(P)(A)(I)] / 12 expressed in acre-feet where: P = 0.8 inches[1] I = Impervious area percentage of site area (decimal) A = Site area (acres) Note: Minimum WQ_v = 0.0167ft*(A) in acre-feet (or 0.2 watershed inches)
Channel Protection (Cp_v) Overbank Flood Control (Q_{p-25})	Cp_v = 24 hours extended detention of post-developed 1-year, 24-hour rainfall event. Control the peak discharge from the 25-year storm to 25-year pre-development rates.

BMP Suitability Matrix – Land Use

Table 2.1 BMP Selection Matrix 1-Land Use

BMP Group	BMP Design	Rural	Residential	Roads and Highways	Commercial/ High Density	Hotspots	Ultra Urban
Pond	Micropool ED	○	○	○	◗	ⓐ	●
	Wet Pond	○	○	○	◗	ⓐ	●
	Wet ED Pond	○	○	○	◗	ⓐ	●
Wetland	Shallow Marsh	○	○	◗	◗	ⓐ	●
	ED Wetland	○	○	◗	◗	ⓐ	●
	Pocket Wetland/Pond	○	◗	○	◗	●	●
Infiltration	Infiltration Trench/Chambers	◗	◗	○	○	●*	◗
	Shallow I-Basin	◗	◗	◗	◗	●*	◗
Filters	Sand Filter	●	●	◗	○	ⓒ	○
	Organic Filter	●	◗	○	○	ⓒ	○
	Bioretention	◗	◗	○	○	ⓒ	○
Open Channels	Dry Swale	○	◗	○	◗	ⓒ	◗
	Wet Swale	○	●	○	●	●	●

○: Yes. Good option in most cases.
◗: Depends. Suitable under certain conditions, or may be used to treat a portion of the site.
●: No. Seldom or never suitable.
ⓐ: Acceptable option, but may require a pond liner to reduce risk of groundwater contamination.
ⓒ: Acceptable option, if not designed as an exfilter. (An exfilter is a conventional stormwater filter without an underdrain system. The filtered volume ultimately infiltrates into the underlying soils.)

* Infiltration practices may be used for quantity control at hotspots as long as 100% of water quality volume is treated prior to infiltration.

BMP Suitability Matrix - Feasibility

Table 2.2 BMP Selection Matrix 2-Physical Feasibility

BMP Group	BMP Design	Soils[1]	Water Table	Drainage Area (Ac)	Site Slope[2]	Head (Ft)
Pond	Micropool ED	Limestone and HSG A soils require pond liner	3 ft* separation if hotspot or aquifer	10 min**	No more than 15%	6 to 8 ft
	Wet Pond					
	Wet ED Pond			25 min**		
Wetland	Shallow Marsh	Limestone and HSG A, soils require liner	3 ft* separation if hotspot or aquifer	25 min	No more than 8%	3 to 5 ft
	ED Wetland					
	Pocket Wetland/Pond	OK	below WT	5 max***		4 ft
Infiltration	Infiltration Trench/Chamber	$f_c > 0.5$*[3] inch/hr	3 ft*	5 max	No more than 6%	1 ft
	Infiltration Basin			10 max		3 ft
Filters	Sand Filter	OK	2 ft	10 max ***	no more than 6%	2 to 7 ft
	Organic Filter			5 max***		2 to 4 ft
	Bioretention	Made Soil				5 ft
Open Channels	Dry Swale	Made Soil	2 ft	5 max	No more than 4%	3 to 5 ft
	Wet Swale	OK	below WT	5 max		1 ft

Notes: OK= not restricted, WT= water table, f_c =soil permeability
* denotes a required limit, other elements are planning level guidance and may vary somewhat depending on site conditions
** unless adequate water balance and anti-clogging device installed
***drainage area can be larger in some instances.

BMP Suitability Matrix - Watershed

Table 2.3 BMP Selection Matrix 3-Watershed

BMP Group	Critical Resource Area Specific Criteria				
	Groundwater	Freshwater Streams	Freshwater Ponds	Freshwater Wetlands	Coastal Waters
Ponds	Pre-treat hotspots. Provide 2 ft SD from seasonal high GW elevation, 3 ft SD if hotspot or aquifer. Pretreat hotspots at 100% of WQ_v.	Overland erosion and channel protection necessary (Cp_v).	Design for enhanced TP removal. Use ponds with wetlands to increase TP removal.	Design for enhanced TP removal. Use ponds with wetlands to increase TP removal.	Moderate bacteria removal. Good to moderate TN removal. Provide permanent pools
Wetlands	Same as ponds	Same as ponds.	Same as ponds. Use Ponds/wetlands to increase TP removal.	Same as ponds. Use Ponds/wetlands to increase TP removal.	Provide long ED (> 48 hrs) for maximum bacteria dieoff.
Infiltration	100 ft SD from water supply wells. Pre-treat runoff in limestone regions at 90% Rule for WQ_v.	OK, but soils overlaying volcanic dominated regions may limit application.	OK, if site has appropriate soils. Highest TP removal.	OK, if site has appropriate soils. Highest TP removal.	OK, but maintain 3 ft SD from seasonal high GW. TN removal is increased if placed within B soil horizon.
Filtering Systems	OK, ideal practice for pretreatment prior to infiltration.	Practices rarely can provide Cp_v or $Q_{p\text{-}25}$. other detention needed.	OK, moderate to high TP removal.	OK, moderate to high TP removal	OK, moderate to high bacteria and nitrogen removal
Open Channels	Pre-treat hotspots at 90% Rule for WQ_v.	OK, should be linked w/ basin to provide Cp_v or $Q_{p\text{-}25}$.	OK, Dry swale provides more TP removal than wet swale.	OK, Dry swale provides more TP removal than wet swale.	Poor bacteria removal.
Detention	Does not meet WQ_v pretreatment requirements.	Needed to provide Cp_v and $Q_{p\text{-}25}$.	Generally not necessary if directly discharging to large lake.		Generally not necessary, Cp_v and $Qp_{\text{-}25}$ not required.

SD = separation distance, ED = extended detention, GW = groundwater

Post-construction BMPs to Treat the WQ_v

Table 3.3 List of BMPs Acceptable for Water Quality

Group	Practice	Description
Ponds	Micropool[1] Extended Detention Pond	Pond that treats the majority of the water quality volume through extended detention[2], and incorporates a micropool at the outlet of the pond to prevent sediment resuspension.
	Wet Pond	Pond that provides storage for the entire water quality volume in the permanent pool.
	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.
Wetland	Shallow Marsh	A wetland that provides water quality treatment primarily in wet shallow marsh.
	Extended Detention Wetland	A wetland system that provides a portion of the water quality volume by detaining storm flows above the marsh surface.
	Pocket Wetland/Pond	A wetland or pond design adapted for treatment of runoff from small drainage areas, which has little or no baseflow available to maintain water elevations and relies on groundwater inputs to maintain a permanent pool.

[1] Micropool is the term to define a small permanent pool 4-8 feet deep, typically with a minimum storage of 0.1 inches per impervious acre of drainage.
[2] Extended detention involves providing temporary storage above the permanent pool or micropool for at least a portion of the WQv that is released over a specified period of time (i.e., 24 hours).

Source: *CNMI and Guam Storm Water Management Manual*, October 2006.

Post-construction BMPs to Treat the WQ_v Continued

Group	Practice	Description
Infiltration	Infiltration Trenches/Chambers	An infiltration practice that 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 Basin	An infiltration practice that stores the water quality volume in a shallow surface depression before it is infiltrated into the underlying soils within the B or C soil horizons.
Filtering Practices	Sand Filter	A filtering practice that treats stormwater by settling out larger particles in a sediment chamber, and then filtering stormwater through a surface, underground, or perimeter sand matrix.
	Organic Filter	A filtering practice that uses an organic medium such as compost in the filter, or incorporates organic material in addition to sand (e.g., peat/sand mixture).
	Bioretention	A shallow depression that treats stormwater as it flows through a soil matrix, and is returned to the storm drain system, or infiltrated into underlying soils or substratum.
Open Channels	Dry Swale	An open vegetated channel or depression explicitly designed to detain and promote filtration of stormwater runoff into an underlying fabricated soil matrix.
	Wet Swale	An open vegetated channel or depression designed to retain water or intercept groundwater for water quality treatment.

See **Volume II-Chapter 2** for presumed pollutant removals of the practice groups as guidance on appropriate BMP selection.

Source: *CNMI and Guam Storm Water Management Manual*, October 2006.

BMP Examples

Infiltration Practices

Description: Excavated trench or basin 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 or trench.

Design Options:
Infiltration Chambers/Trenches (I-1), Shallow Infiltration Basin (I-2)

KEY CONSIDERATIONS

FEASIBILITY

- Minimum soil infiltration rate of 0.5 inches per hour.
- Soils less than 20% clay, and 40% silt/clay.
- Natural slope less than 15%.
- Cannot accept hotspot runoff, except under the conditions outlined in **Section 2.1.1.1**.
- Separation from groundwater table of at least three (3) feet.

CONVEYANCE

- Flows exiting the practice through vegetation must be non-erosive (3.5 to 5.0 fps).
- Maximum dewatering time of 48 hours.
- Design off-line if stormwater is conveyed to the practice by a storm drain pipe.

PRETREATMENT

- Pretreatment of 25% of the WQv at all sites.
- 50% pretreatment if f_c >2.0 inches/hour.
- 100% pretreatment in areas with f_c >5.0 inches/hour.
- Exit velocities from pretreatment through vegetation must be non-erosive for the 2-year storm.

TREATMENT

- Water quality volume designed to exfiltrate through the floor of the practice.
- Construction sequence to maximize practice life.

STORMWATER MANAGEMENT SUITABILITY

- ☑ **Recharge**
- ☑ **Water Quality**
- ☑ **Channel Protection***
- ☑ **Overbank Flood Control***

* Infiltration basin only

Accepts Hotspot Runoff: *No*

IMPLEMENTATION CONSIDERATIONS

- H **Capital Cost**
- H **Maintenance Burden**

Residential/Subdivision Use: *Yes*
High Density/Ultra-Urban: *Yes*

Drainage Area: *10 acres max.*

Soils: *Pervious soils required (0.5 in/hr or greater)*

Other Considerations:

- *Ideally not placed under pavement or concrete for easy maintenance*

Key: L=Low M=Moderate H=High

BMP Schematics

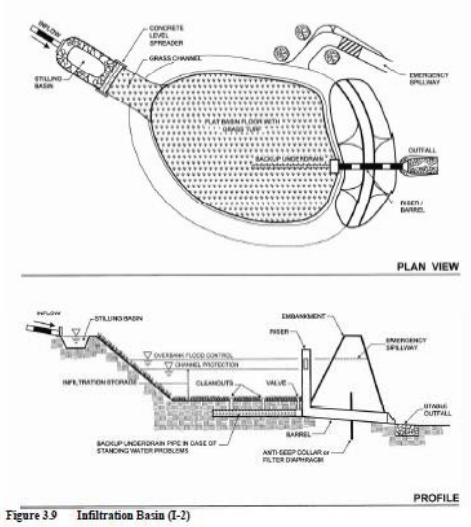


Figure 3.9 Infiltration Basin (I-2)

Volume II – Additional Information

- Chapter 3:
  - Better site design practices (i.e., non-structural an natural approaches) for new development and redevelopment projects.
- Chapter 4:
  - Step-by step design and case studies for Guam and CNMI.
- Chapter 5:
  - Landscaping guidance for effective BMPs.
- Chapter 6:
  - Additional standards and specifications for Volume I, Chapter 3; including construction checklist.
- Chapter 7:
  - Maintenance descriptions and guidance; including checklists.
- Chapter 8:
  - Soils information.
- Chapter 9:
  - Infiltration testing; additional BMP details; and hydrologic analysis tools.

Summary Points

- The 2006 CNMI and Guam Storm Water Management Manuals (Volume I & II) and the March 2010 Supplement "Island Storm Water Practice Design Specifications" builds on island-specific knowledge.
- Provides comprehensive Construction and Post-Construction standards for design, selection, and maintenance.
- Foundation of other manuals and the draft Guam Erosion and Sediment Control Regulations.

Questions?