

WORKSHOP OUTLINE

Module 1 Introduction

Module 2 Rules Relating to Storm Drainage Standards

Module 3 Electronic Resource Library

Module 4 Examples



MODULE 1

INTRODUCTION



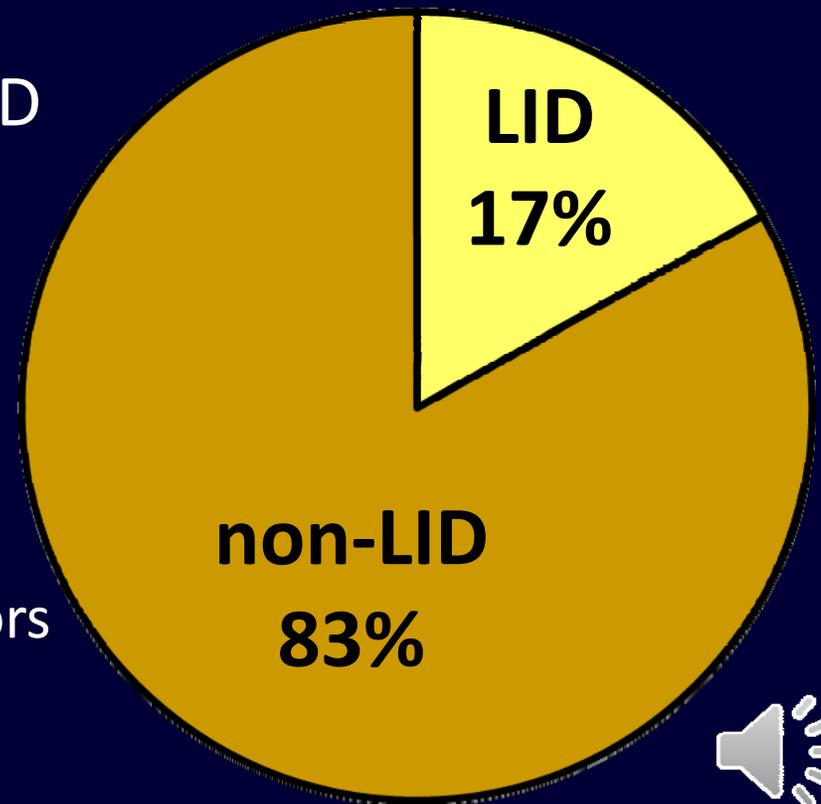
Reissued NPDES MS4 Permit requires stricter Water Quality standards for Post-Construction

- Low Impact Development (LID) standards must be added to the Rules Relating to Storm Drainage Standards
- LID standards must apply to all projects disturbing ≥ 1 acre, and smaller projects that have the potential to discharge pollutants to the City's MS4



LID is not an entirely new concept in Honolulu

- City BMP Database includes approx. 360 BMPs
- ~ 60 (17%) are considered LID
- ~ 300 (83%) are non-LID:
 - ~ 55 detention basins
 - ~ 115 catch basin inserts
 - ~ 130 hydrodynamic separators



INTRODUCTION

So the majority of the permanent treatment control BMPs in-place aren't considered LID



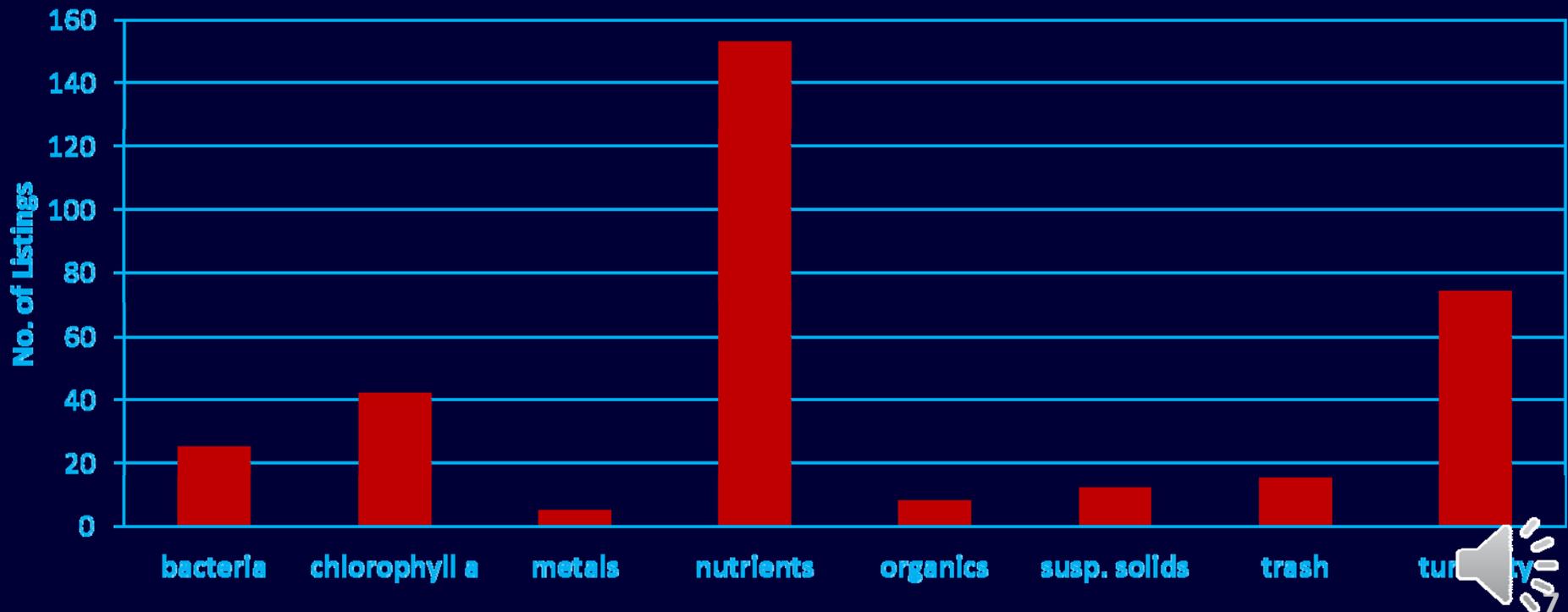
But they still improve water quality, right?



INTRODUCTION

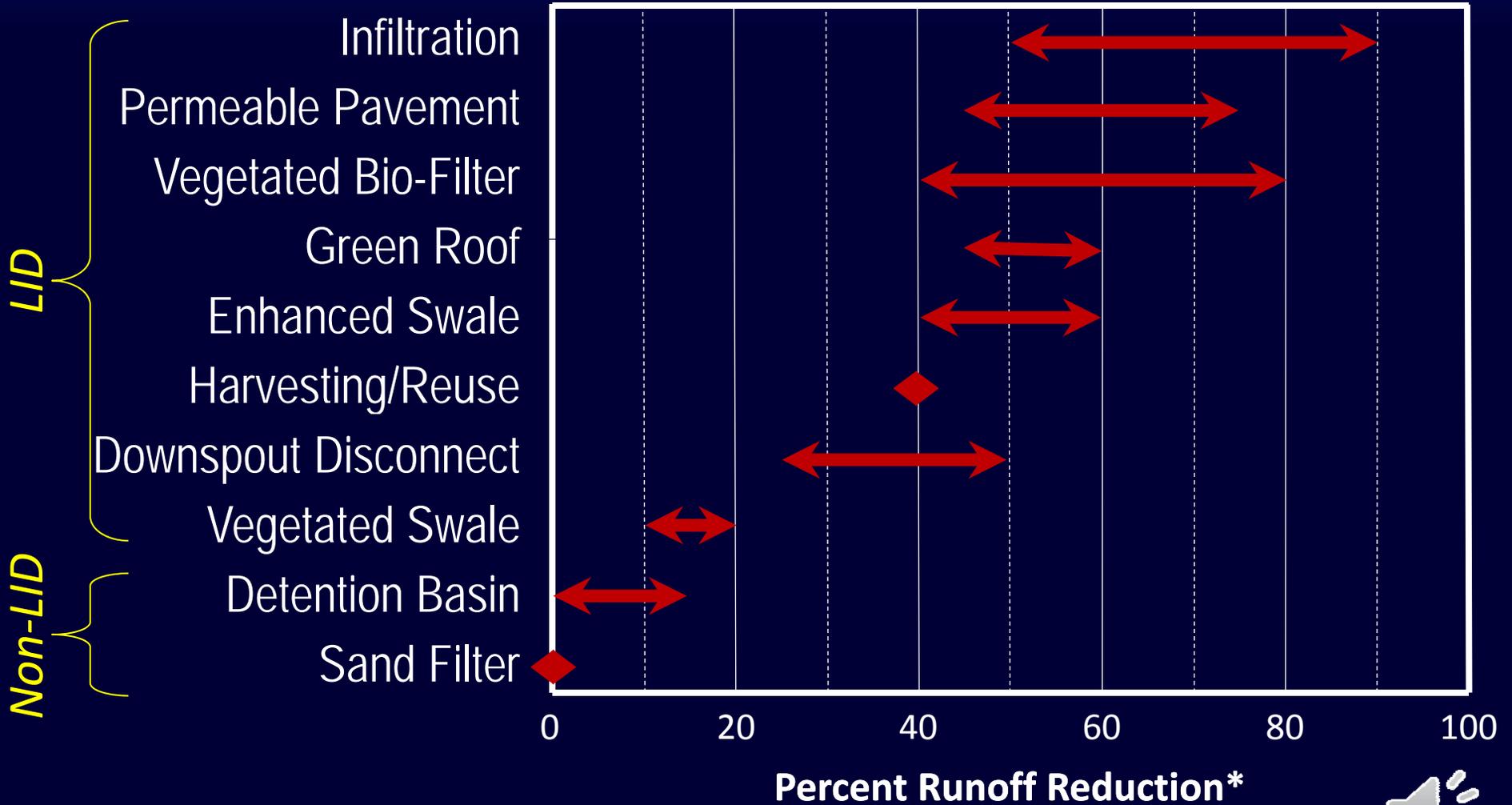
non-LID BMPs don't address all 303(d) pollutants

- 107 impaired waterbodies on Oahu
- 334 total pollutant listings
- non-LIDs address Susp. Solids, Trash, & Turbidity



INTRODUCTION

non-LID BMPs don't reduce Runoff Volumes



**Center for Watershed Protection, 2008*



INTRODUCTION



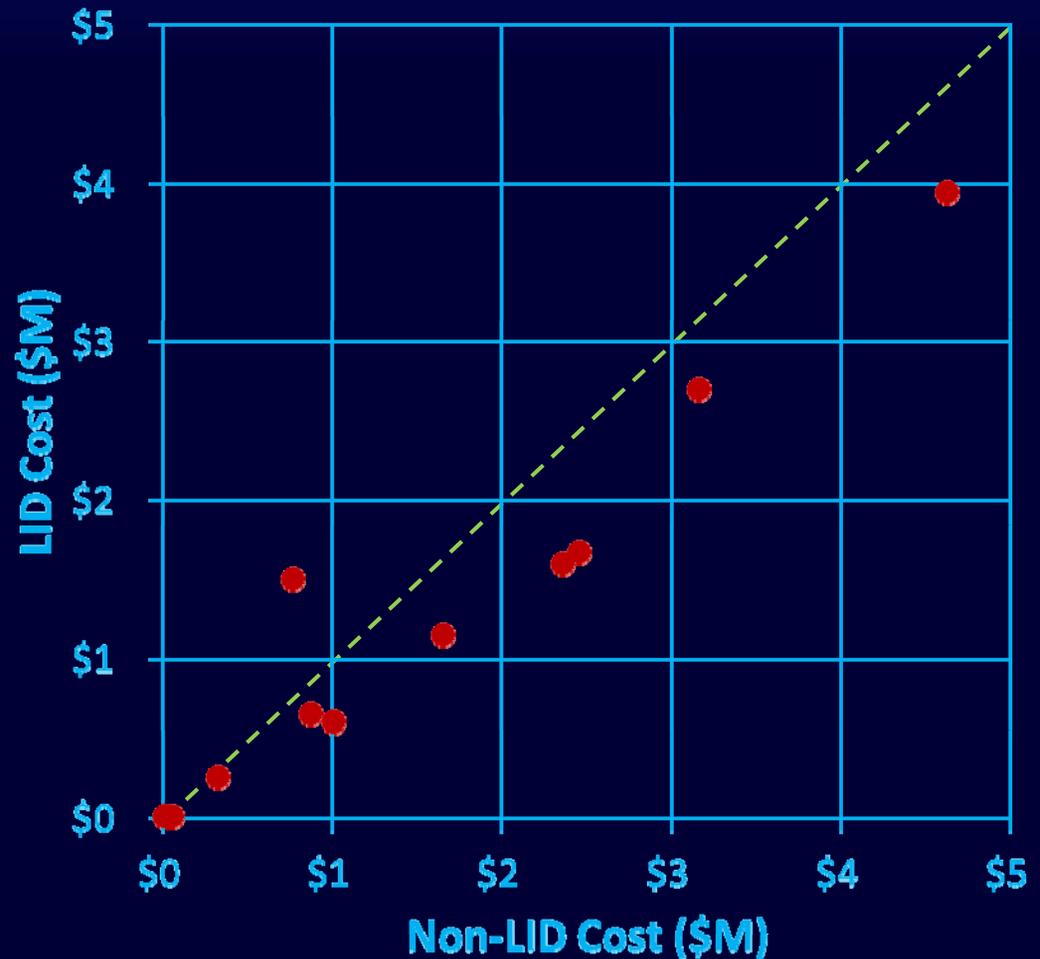
And, contrary to popular belief, LID practices are not necessarily more expensive than non-LID practices



INTRODUCTION

EPA Case Study Evaluation*

- 12 actual case studies comparing costs incurred/estimated for traditional treatment vs. LID
- 1 project had higher LID costs

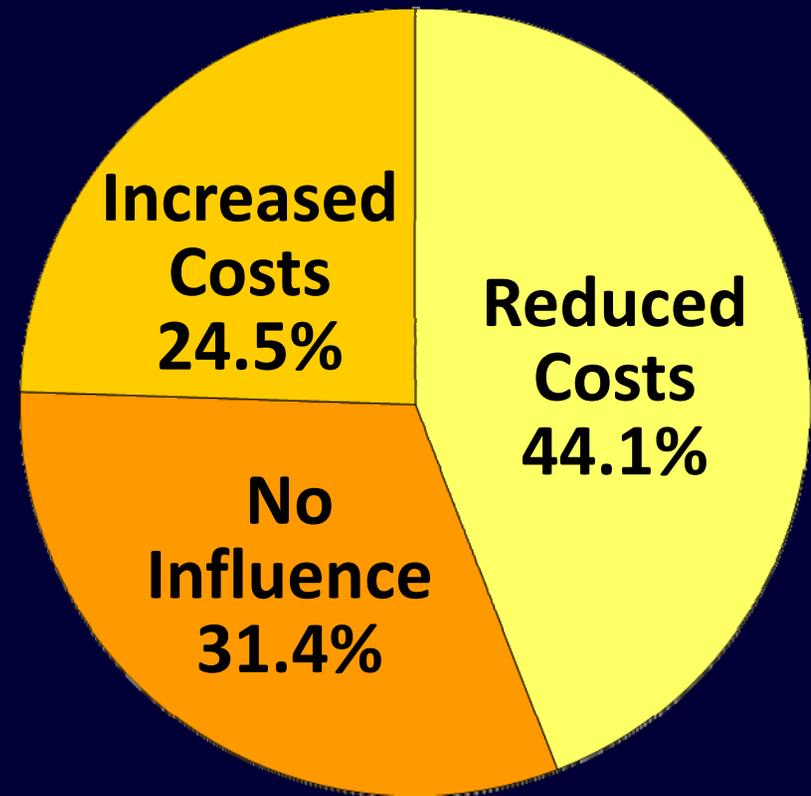


* *Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices. EPA 841-F-07-006. December 2007.*



American Society of Landscape Architect's (ASLA) Green Infrastructure Survey*

- 479 case studies from 43 states, D.C., and Canada
- Over 300 ASLA members and other practitioners were asked “Did use of green infrastructure increase costs?”



* *Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide, A Joint Report by American Rivers, WEF, ASLA, and ECONorthwest, 2012*



Technical Components of LID

Site Design Minimizing runoff volumes and preserving existing hydrology

Retention Keeping runoff on-site by infiltration and evapotranspiration

Biofiltration Removing pollutants from runoff by filtration, adsorption & biological uptake

Details for each are provided in the City's Storm Water BMP Guide



Approved LID Site Design Strategies

1. Conserve Natural Areas, Soils, and Vegetation
2. Minimize Disturbances to Natural Drainages
3. Minimize Soil Compaction
4. Minimize Impervious Surfaces
5. Direct Runoff to Landscaped Areas



Approved LID Retention & Biofiltration BMPs

Retention

1. Infiltration Basin
2. Infiltration Trench
3. Subsurface Infiltration
4. Dry Well
5. Bioretention Basin
6. Permeable Pavement

Biofiltration

1. Vegetated Bio-Filter
2. Green Roof
3. Enhanced Swale
4. Downspout Disconnection
5. Vegetated Swale
6. Vegetated Buffer Strip
7. Tree Box Filter



Module Summary



INTRODUCTION - SUMMARY

- Reissued Permit requires LID standards
- LID addresses more of Oahu's pollutants
- LID is better at reducing runoff volumes
- LID may save you money
- LID consists of Site Design, Retention, and Biofiltration



INTRODUCTION

For more information...

1. Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices, EPA, 2007.
2. Low Impact Development, A Practitioner's Guide, Hawaii Office of Planning, Coastal Zone Management Program, 2006.
3. County of Los Angeles Low Impact Development Standards Manual, County of Los Angeles, 2009.
4. Unified Facilities Criteria, Low Impact Development, US Department of Defense, 2010.
5. Low Impact Development Manual for Michigan, Southeast Michigan Council of Governments, 2008.
6. Low Impact Development Approaches Handbook, Clean Water Services, 2009.
7. California Stormwater Quality Association (CASQA), California LID Portal, <http://www.casqa.org/LID/tabid/240/Default.aspx>



End of Module 1



MODULE 2

RULES RELATING TO STORM DRAINAGE STANDARDS



MODULE 2

RULES RELATING TO STORM DRAINAGE STANDARDS



Sections that underwent revision

§1-1 PURPOSE

§1-2 MODIFICATIONS

§1-3 DEFINITIONS

§1-4 SECTION I – STANDARDS FOR FLOOD CONTROL

§1-5 SECTION II – STORM WATER QUALITY

§1-6 REPEAL



§1-1, PURPOSE

These Rules address requirements for both storm runoff quantities for flood control as well as storm runoff quality and reflect the most recent changes to Federal, State, and County requirements related to the quality of storm water discharges. By establishing criteria to address water quality, the City and County of Honolulu is satisfying Federal Regulatory requirements to control the discharge of pollutants in storm water as specified in the Clean Water Act as amended by the Water Quality Act of 1987.

These standards are not intended to limit the initiative and resourcefulness of the engineer in developing drainage plans, or be viewed as maximum limits in design criteria. More stringent criteria should be used where reasonable.



§1-2, MODIFICATIONS

A. The Director may modify provisions of these rules whenever:

1. The land to be developed is of such a size and shape or is affected by location or geological or topographical conditions, or is devoted to such uses that it is impractical or not economically achievable in the particular case to conform fully to these rules.

was changed to:

A. The Director may modify provisions of these rules whenever:

1. Full conformance to these rules is not achievable because of the size and shape, location or geological or topographical conditions, or land uses.



§1-3, DEFINITIONS

Terms Added

Biofiltration

Disturbed Area

Evapotranspiration

Impervious Surface

Infiltration

Low Impact Development

New Development

Site Design Strategies

Source Control BMPs

Treatment Control BMPs

Terms Revised

Redevelopment



DISTURBED AREA

The area of the project that is expected to undergo any disturbance, including, but not limited to excavation, grading, clearing, demolition, uprooting of vegetation, equipment staging, and storage



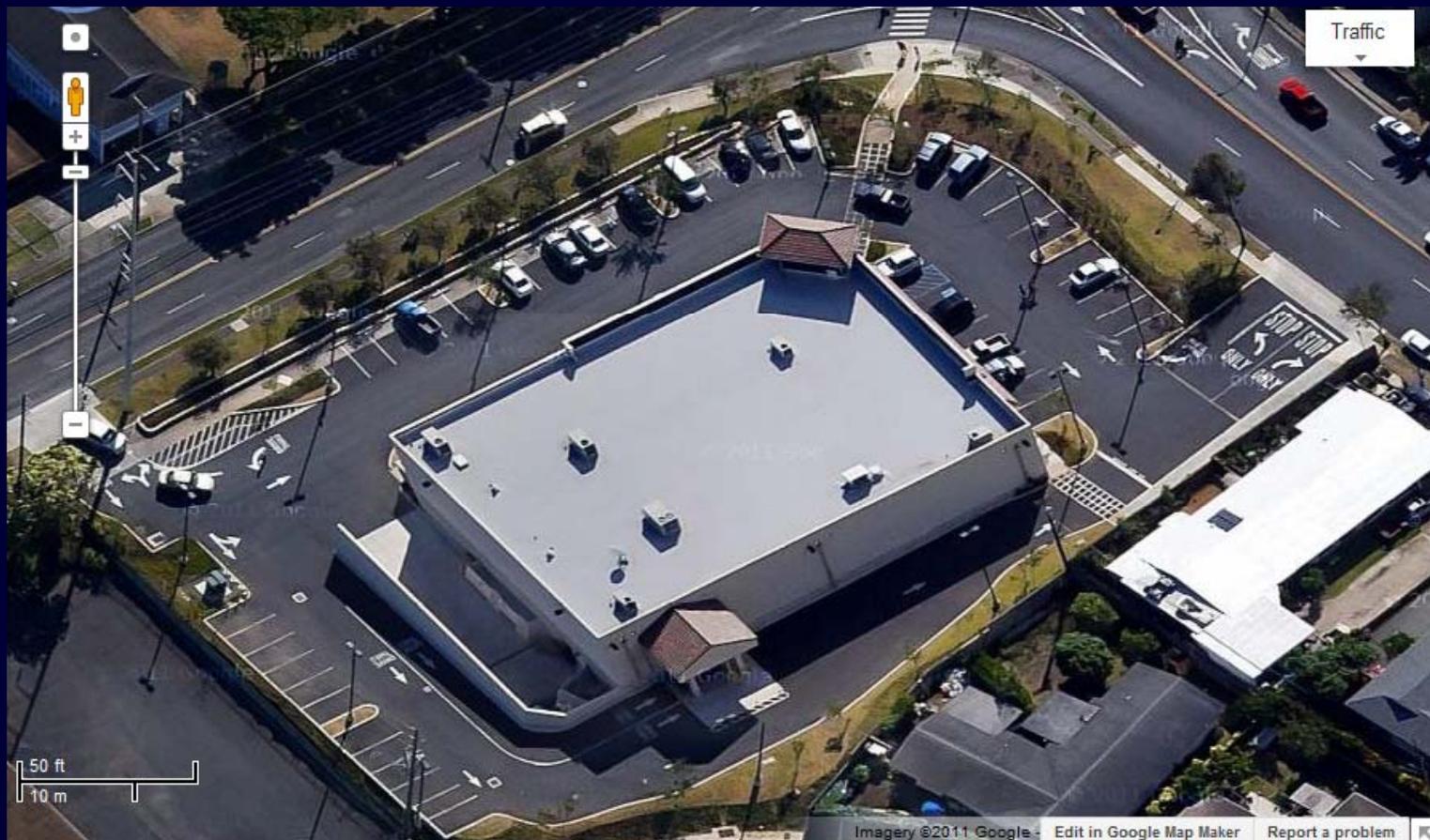
Areas not considered to be Disturbed

- Areas which are cleared, graded, and/or excavated for the sole purpose of landscape renovation
- Areas which are cleared, graded, and/or excavated for the sole purpose of growing crops



IMPERVIOUS SURFACE

A surface covering or pavement of a developed parcel of land that prevents the land's natural ability to absorb and infiltrate rainfall/storm water, including rooftops; walkways; patios; driveways; parking lots; storage areas; impervious concrete and asphalt; and any other continuous watertight pavement or covering



NEW DEVELOPMENT

Land disturbing activities; structural development, including construction or installation of a building or structure, the creation of impervious surfaces; and land subdivision



SOURCE CONTROL

Low-technology practices designed to prevent pollutants from contacting storm water runoff and/or prevent discharge of contaminated runoff to the MS4

- Stenciling storm drain inlets
- Grading dumpster, fueling, and storage areas to prevent run-on & runoff
- Using dumpsters with lids
- Paving high risk areas with concrete instead of asphalt
- Covering fueling and storage areas



Gas station, Kapolei, HI



Approved Source Control BMPs

- Landscaped areas
- Auto. irrigation systems
- Storm drain inlets
- Loading docks
- Parking areas
- Vehicle/equipment repair
- Vehicle/equipment fueling
- Vehicle/equipment washing/cleaning
- Outdoor trash storage
- Outdoor material storage
- Outdoor work areas
- Outdoor process equip. operations

Details for each are provided in Chapter 2 of the City's Storm Water BMP Guide



Vehicle/Equipment Fueling

- Cover with a roof or canopy
- Pave with Portland Cement Concrete
- Use fuel dispensing nozzles with automatic shutoffs
- Post signs warning against "topping off" of fuel tanks



Loading Docks

- Cover all areas, or design them to preclude run-on and runoff.
- Do not allow runoff from depressed loading docks (truck wells) to discharge into storm drains.
- Grade to a drain that is connected to a dead-end.
- Pave with concrete instead of asphalt.



Outdoor Material Storage

- Place materials in an enclosure to prevent contact with runoff
- Slope the storage area towards a dead-end sump
- Direct runoff from downspouts/roofs away from storage areas
- Cover the storage area with an awning



Outdoor Work Areas

- Create an impermeable surface or use a metal drip pan
- Cover the area with a roof to prevent run-on
- Berm around the area perimeter to prevent run-on from adjacent areas
- Locate the work area away from storm drains or catch basins



REDEVELOPMENT

Development that would create or add impervious surface area on an already developed site, including expansion of a building footprint; addition to or replacement of a structure; replacement of an impervious surface that is not part of a routine maintenance activity; and land disturbing activities related to structural or impervious surfaces



Activities not considered to be Redevelopment

- Routine maintenance activities to maintain original hydraulic capacity
- Routine maintenance activities to maintain original purpose of facility
- Emergency redevelopment activity required to protect public health and safety
- Impervious surface replacement, such as parking lot and roadway reconstruction, which does not disturb additional area
- Repaving of existing roads



Revised Subsections

- §1-5.1.B.1, Development & Redevelopment Included
- §1-5.1.B.3, Project Applicability
- §1-5.1.B.6, Management Practices to Meet Criteria
- §1-5.1.B.10, Storm Water Quality Facilities Review
- §1-5.1.B.11, Maintenance

Deleted Subsections

- §1-5.1.C, Detention Based WQ Control
- §1-5.1.D, Flow-Through Based WQ Control
- §1-5.1.E, Detention Combined with Flow-Through Treatment
- §1-5.1.F, Flow-Through Upstream of Detention Treatment

New Subsections

- §1-5.1.B.2, Regulated Projects



What the Rules now specify

- Rules apply to all projects as defined in §1-5.1.B.2
- BMP sizing requirements apply to all new development projects that disturb at least 1 acre during construction
- BMP sizing requirements apply to all redevelopment projects that disturb at least 1 acre during construction
- Rules only apply to the addition of the redevelopment



§1-5.1.B.2, REGULATED PROJECTS

Projects are classified as follows:

Priority	Description
A1	Disturb \geq 5 acres of land during construction
A2	Disturb 1 - 5 acres of land during construction
B	Disturb $<$ 1 acre during construction, create at least 10,000 sq-ft of total impervious surface, and is a Retail Gas Station, Auto Repair Shop, Restaurant, or Parking Lot



What the Rules now specify

The Director may exempt projects from the application of these rules if projects are determined to have submitted ~~substantially~~ completed construction drawings and ~~substantially~~ completed site-specific drainage reports prior to June 1, 2013.



What the Rules used to specify

- Post-Construction Treatment Control BMPs
- BMP at owner's discretion

What the Rules now specify

- Combination of multiple management practices based on the project's Priority
- BMP at owner's discretion (partially)



Priority A1 Projects (disturb ≥ 5 acres)

- All applicable Site Design Strategies
- All applicable Source Control BMPs
- Unless infeasible, retain with LID Retention BMPs, the Water Quality Volume (WQV)
- Unless infeasible, biofilter with LID Biofiltration BMPs, any portion of the WQV not retained
- Alternative Compliance if WQV is not retained or biofiltered



Priority A2 Projects (disturb 1 – 5 acres)

- All applicable Site Design Strategies
- All applicable Source Control BMPs
- Unless infeasible, retention or biofiltration of WQV
- Alternative Compliance if WQV is not retained or biofiltered

Priority B Projects

- Consider implementing LID Site Design Strategies
- All applicable Source Control BMPs



§1-5.1.B.6 references some other new terms:

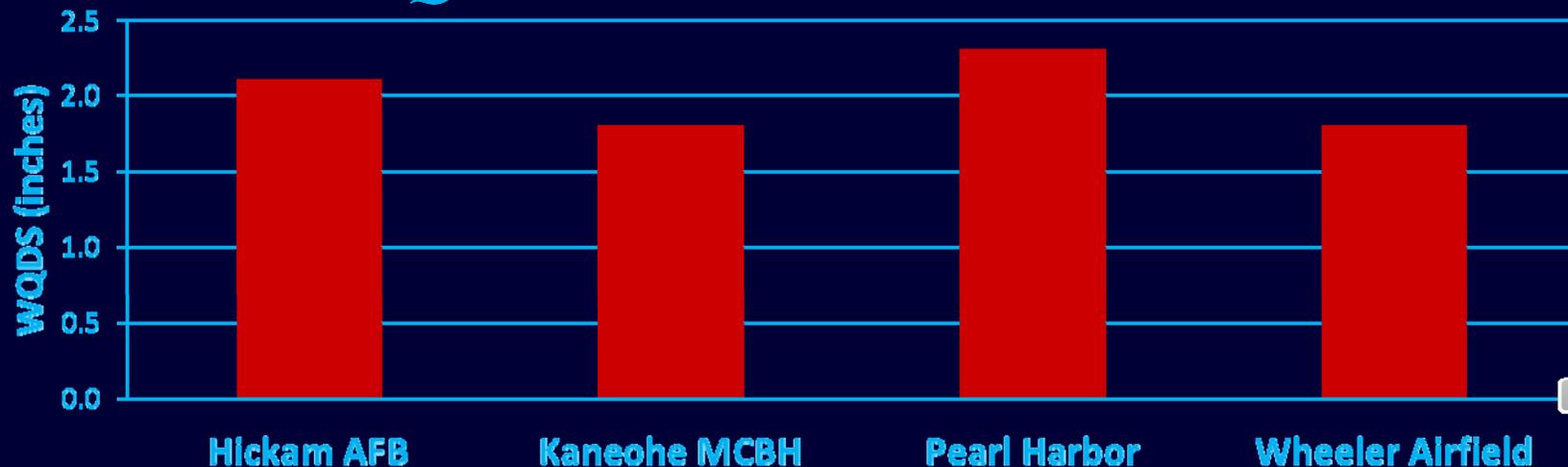
- Water Quality Volume
- Infeasible
- Alternative Compliance



Water Quality Volume (WQV)

- Volume of runoff generated by a pre-determined precipitation event (the Water Quality Design Storm, or WQDS) that must be managed for water quality
- The City selected 1 inch as the WQDS

WQDS at Oahu Federal Facilities



How is Infeasibility Determined?

- Pre-established criteria for all Retention and Biofiltration BMPs
- Based on a review and analysis of other municipalities and state/federal agencies
- Exemption from a specific LID BMP may be claimed if at least one criterion for the BMP is met
- Applicant may propose for City approval a criterion not listed



Alternative Compliance Options

1. Either Harvest/Reuse or Treat on-site with non-LID BMPs, any portion of the WQV that is not retained or biofiltered
 - Detention Basin
 - Sand Filter
 - Manufactured Treatment Device
2. Retain or biofilter at an offsite location, the volume of runoff equivalent to the portion of the WQV that was not retained and/or biofiltered on-site
 - Proposed location must be approved by City
 - Applicant responsible for all costs, including maintenance



What the Rules now specify

- SWQR (Storm Water Quality Report) required for Priority A1 Projects
 - A SWQR presents a project's storm water quality issues and storm water quality management strategy, in a standard report format
- SWQC (Storm Water Quality Checklist) required for Priority A2 & Priority B Projects
 - A SWQC presents a project's storm water quality management strategy, in a simple checklist format



SWQR & SWQC Specifics

- Signed by Owner & Licensed Architect/Engineer
- Submittal Requirements

	SWQR (Priority A1)	SWQC (Priority A2)	SWQC (Priority B)
Construction Plan Approvals	✓	✓	
Building Permit Applications			✓

- WQ management strategy must be included in Master Plan, Discretionary Land Use Permit, or EA/EIS
- More details in Module 3...



What the Rules now specify

- Maintenance details specified in SWQR/SWQC, as applicable
- Treatment Control BMPs must be maintained regularly and inspected annually prior to rainy season
- Maintenance Activity Log must be kept for 5 yrs



November 2013

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30



Subsections A-D replaced in their entirety with:

§1-5.2.A Volume Based Storm Water Quality Control Facilities

§1-5.2.B Flow Based Storm Water Quality Control Facilities

§1-5.2.C Area Based Storm Water Quality Control Facilities

§1-5.2.D Demand Based Storm Water Quality Control Facilities



§1-5.2.A, VOLUME BASED STORM WATER QUALITY CONTROL FACILITIES

Volume-based BMPs shall be sized for the WQV:

$$WQV = PCA \times 3630$$

Where:

WQV	=	water quality volume (cubic feet)
P	=	WQDS runoff depth (inches) = 1 inch
C	=	volumetric runoff coefficient (unitless)
A	=	drainage area (acres)

The volumetric runoff coefficient is calculated by:

$$C = 0.05 + 0.009I$$

Where:

C	=	volumetric runoff coefficient
I	=	% impervious cover, expressed as a percentage

Infiltration Basin
Infiltration Trench
Subsurface Infiltration
Dry Well

Bioretention Basin
Permeable Pavement
Green Roof
Vegetated Bio-Filter

Enhanced Swale
Tree Box Filter
Detention Basin
Sand Filter



§1-5.2.B, FLOW BASED STORM WATER QUALITY CONTROL FACILITIES

Flow-through based BMPs shall be sized for the WQF:

$$WQF = CiA$$

Where:

WQF	=	water quality flow rate (cubic feet per second)
C	=	runoff coefficient (unitless)
i	=	peak rainfall intensity (inches per hour)
A	=	total drainage area (acres)

- A Peak rainfall intensity of 0.4 in/hr shall be used
- For drainage areas containing multiple land uses, a composite weighted runoff coefficient should be used.

Vegetated Swale
Vegetated Buffer Strip

Tree Box Filter
Manufactured Treatment Device



§1-5.2.C, AREA BASED STORM WATER QUALITY CONTROL FACILITIES

Area based BMPs shall be sized such that:

- The size of the vegetated area receiving the roof runoff is at least 10% of the size of the roof area that drains to the downspout

or

- The flow path of the vegetated area receiving the roof runoff is at least as long as the flow path of the roof area that drains to the downspout

Downspout Disconnection



§1-5.2.D, DEMAND BASED STORM WATER QUALITY CONTROL FACILITIES

Demand based BMPs shall be sized such that:

- At least 80% of the total annual runoff is captured

and

- At least 80% of the total annual reuse demand is met

Harvesting / Reuse



Module Summary



SUMMARY – PROJECTS SUBJECT TO RULES

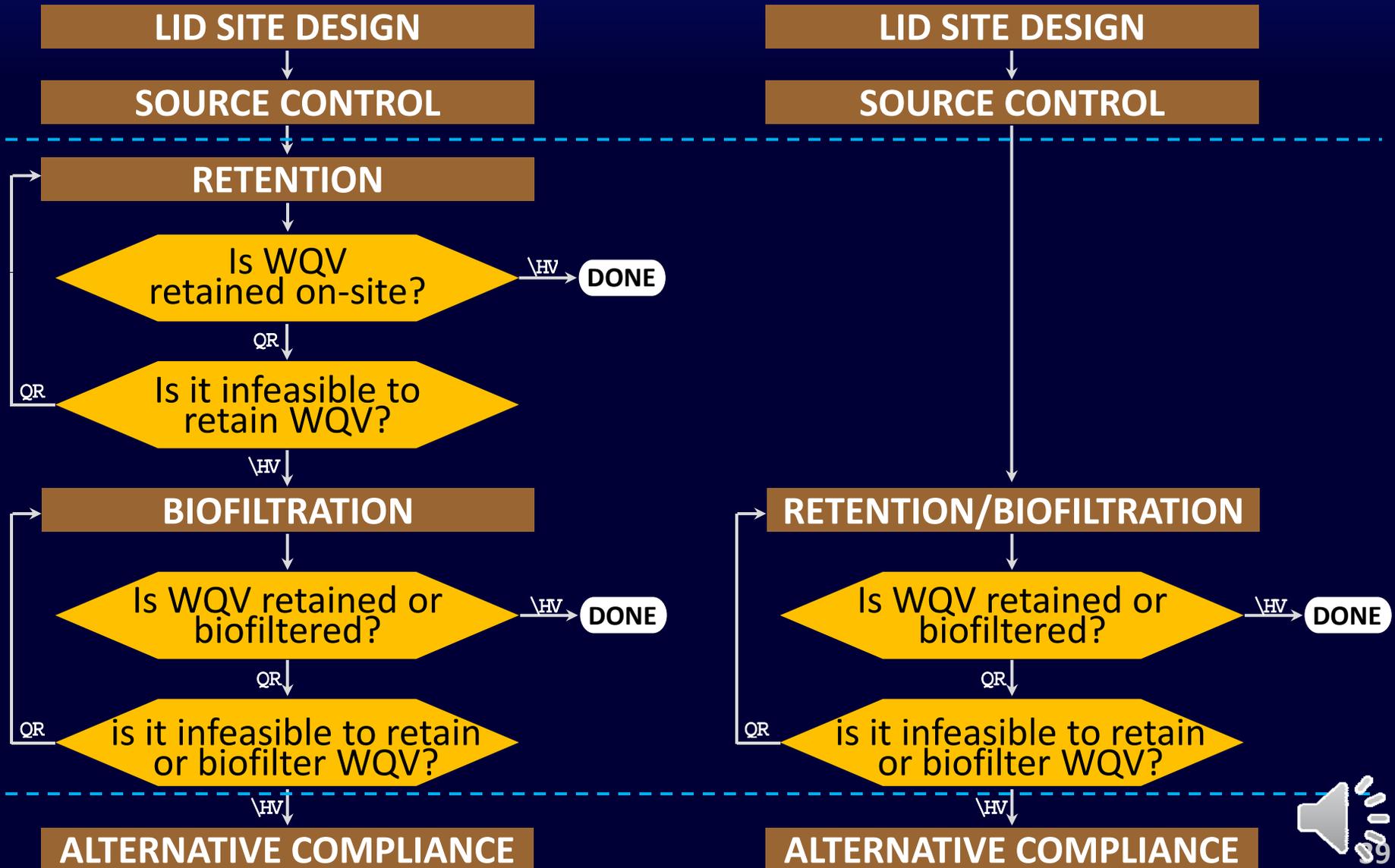
Priority	Description
A1	Disturb \geq 5 acres of land during construction
A2	Disturb 1 - 5 acres of land during construction
B	Disturb $<$ 1 acre during construction, create at least 10,000 sq-ft of total impervious surface, and is a Retail Gas Station, Auto Repair Shop, Restaurant, or Parking Lot



SUMMARY – STORM WATER MANAGEMENT REQUIREMENTS

Priority A1

Priority A2



SUMMARY – STORM WATER MANAGEMENT REQUIREMENTS

Priority B

CONSIDER LID SITE DESIGN



SOURCE CONTROL



DONE



SUMMARY – DOCUMENTATION REQUIREMENTS

Priority	Document	Submittal Requirements	
		Building Permit Apps.	Const. Plan Approvals
A1	SWQR		✓
A2	SWQC		✓
B	SWQC	✓	



SUMMARY – MAINTENANCE REQUIREMENTS

- Maintenance activities and responsibility specified in SWQR/SWQC, as applicable
- Treatment Control BMPs must be maintained regularly and inspected annually prior to rainy season (November 1)
- Maintenance Activity Log must be kept on file for 5 yrs



SUMMARY - WATER QUALITY DESIGN STANDARDS

BMP Sizing Criteria

BMP Type	Sizing Criteria
Volume Based	WQV with rainfall depth of 1 inch
Flow Based	WQF with rainfall intensity of 0.4 in/hr
Area Based	10% of contributing area or 100% of contributing flow path
Demand Based	80% of total annual runoff is captured and 80% of total annual reuse demand is met



End of Module 2



MODULE 3

ELECTRONIC RESOURCE LIBRARY



www.honolulu-dpp.org/ReportsNotices/StormWaterQualityPage.aspx

MODULE 3

ELECTRONIC RESOURCE LIBRARY

www.honolulu-dpp.org/ReportsNotices/StormWaterQualityPage.asp



Available Online Resources

- Storm Water Quality Report (SWQR) and Storm Water Quality Checklist (SWQC) Templates
- SWQR and SWQC Preparation Manuals
- LID Exemption Table Template
- Storm Water BMP Guide
- Treatment Control BMP Sizing Worksheets



SWQR & SWQC TEMPLATES

To make everyone's life a little easier, the City developed 6 Templates (MS Word®) to facilitate preparation and review, and to establish consistency

SWQR
Priority A1

SWQC
Priority A2

SWQC
Priority B,
Retail Gas Outlet

SWQC
Priority B,
Auto Repair Shop

SWQC
Priority B,
Restaurant

SWQC
Priority B,
Parking Lot

→ *Use of Templates is mandatory* ←



SWQR & SWQC TEMPLATES

Template Contents

	SWQR (A1)	SWQC (A2)	SWQC (B)
Project information (address, size, TMK, etc.)	✓	✓	✓
Project description	✓		
Site description	✓		
Hydrology and hydrogeology	✓		
Management practices to meet water quality criteria	✓	✓	✓
Inspection and O&M requirements for BMPs	✓		
Funding mechanism for inspection and O&M	✓		
Signature of owner and responsible architect/engineer	✓	✓	✓
Supporting attachments	✓	✓	



STORM WATER QUALITY REPORT TEMPLATE

IV. MANAGEMENT PRACTICES TO MEET CRITERIA

This section describes the management practices that will be taken to meet the Water Quality criteria specified in the Rules Relating to Storm Drainage Standards.

IV.1 LID Site Design

[Click here to begin typing](#)

IV.2 Source Control

[Click here to begin typing](#)

IV.3 Retention

[Click here to begin typing](#)

IV.4 Biofiltration

[Click here to begin typing](#)

IV.5 Alternative Compliance

[Click here to begin typing](#)



STORM WATER QUALITY CHECKLIST TEMPLATE (A2)

MANAGEMENT PRACTICES TO MEET WATER QUALITY CRITERIA

i. LID Site Design. The following strategies will be incorporated:

- | | |
|--|--|
| <input type="checkbox"/> Conserve natural areas, soils, and vegetation | <input type="checkbox"/> Minimize soil compaction |
| <input type="checkbox"/> Minimize disturbances to natural drainages | <input type="checkbox"/> Minimize impervious surface |
| <input type="checkbox"/> Direct Runoff to Landscaped Areas | <input type="checkbox"/> None (all infeasible) |

ii. Source Control. The following Source Control BMP(s) will be incorporated:

- | | | |
|---|---|--|
| <input type="checkbox"/> Automatic irrigation systems | <input type="checkbox"/> Landscaped areas | <input type="checkbox"/> Loading docks |
| <input type="checkbox"/> Outdoor trash storage | <input type="checkbox"/> Storm drain Inlets | <input type="checkbox"/> Parking areas |
| <input type="checkbox"/> None | | |

iii. Retention/Biofiltration. The following Treatment Control BMP(s) will be incorporated:

- | | | |
|--|--|--|
| <input type="checkbox"/> Bioretention Basin | <input type="checkbox"/> Vegetated Bio-Filter | <input type="checkbox"/> Dry Well |
| <input type="checkbox"/> Infiltration Basin | <input type="checkbox"/> Downspout Disconnection | <input type="checkbox"/> Green Roof |
| <input type="checkbox"/> Infiltration Trench | <input type="checkbox"/> Vegetated Swale | <input type="checkbox"/> Enhanced Swale |
| <input type="checkbox"/> Subsurface Infiltration | <input type="checkbox"/> Vegetated Filter Strip | <input type="checkbox"/> Tree Box Filter |
| <input type="checkbox"/> Permeable Pavement | | |

Alternative Compliance. The following alternative compliance is proposed:

- Incorporate the following Other Treatment Control BMP(s):
- | | | |
|--|--|--|
| <input type="checkbox"/> Detention Basin | <input type="checkbox"/> Manufactured Treatment Device | <input type="checkbox"/> Harvest/Reuse |
| <input type="checkbox"/> Sand Filter | <input type="checkbox"/> Other: | |
- Offsite Retention/Biofiltration (proposal attached)
- None. WQV retained and/or biofiltered



STORM WATER QUALITY CHECKLIST TEMPLATE (B)

ii. **Source Control.** The following BMPs were incorporated into the design

Storm Drains

- All storm drain inlets and catch basins include appropriate stenciling

Fuel Dispensing Areas

- Cover with a roof or canopy, pave with Portland Cement Concrete, and grade to prevent ponding and run-on, and to drain toward a dead-end sump
- Fit underground tanks with spill containment and overflow prevention systems
- Use fuel dispensing nozzles with automatic shutoffs ("hold-open latches")
- Post signs warning against "topping off" of fuel tanks

Dumpster Areas

- Graded and paved to prevent storm water run-on and runoff
- Includes a roof, awning, or attached lid over the dumpster area
- Includes a low containment berm around the dumpster area
- Includes drip pans underneath dumpsters

Air / Water Supply Areas

- Graded and paved to prevent runoff of storm water
- Covered with a roof or overhang
- Isolated with a perimeter low containment berm



SWQR & SWQC PREPARATION MANUALS

- 1 manual for SWQRs, 1 manual for SWQCs
- Step-by-step instructions
- Side-by-side format : template on left and instructions on right

Steps for completing the Management Practices section are as follows:

- i. LID Site Design
 1. Review the elements of each Site Design Strategy presented in the *City and County of Honolulu Storm Water BMP Guide*, and select those that were considered.
 2. Check the box next to each strategy that was considered. If none were considered, check the “None” box.
- ii. Source Control for Design
 1. Review each Source Control BMP for Design and check the box next to each one that will be incorporated. Although they are not mandatory, all are recommended.



LID EXEMPTION TABLE

- Checklist to claim an exemption from LID requirements
- MS Word® File
- Must be attached to SWQR and SWQC (A2)

Permeable Pavement
<input type="checkbox"/> Soils beneath reservoir layer invert have infiltration rates < 0.5 in/hr
<input type="checkbox"/> Unable to maintain a distance of at least 3 feet from pavement invert to seasonally high groundwater table
<input type="checkbox"/> Site has known man-made plumes or contaminated soils
<input type="checkbox"/> Site has high potential for concentrated pollutant/chemical spills
<input type="checkbox"/> Site has high potential for oil and/or grease spills
<input type="checkbox"/> Site is up-gradient of ephemeral streams (i.e. habitat type change downstream)
<input type="checkbox"/> Site is up-gradient of known shallow landslide-prone area
<input type="checkbox"/> Site has high potential to receive sand and/or sediment loads
<input type="checkbox"/> Unable to maintain a distance of at least 50 feet to the nearest groundwater well used for drinking water
<input type="checkbox"/> Unable to maintain a distance of at least 35 feet to the nearest septic system
<input type="checkbox"/> Unable to maintain a pavement slope no greater than 5%
<input type="checkbox"/> Pavement would be above a utility vault
<input type="checkbox"/> Pavement is expected to receive more than 1,000 average daily trips
<input type="checkbox"/> Other:



STORM WATER BMP GUIDE



Storm Water BMP Guide

FINAL

December 2012

By:
City and County of Honolulu
Department of Planning and Permitting



E Mālama I Ka Wai Ola
Protect our waters...
FOR LIFE

Ch. 1 LID Site Design

Ch. 2 Source Control

Ch. 3 Treatment Control

References



Fact Sheet Contents:

- Description
- Specific measures

MINIMIZE SOIL COMPACTION

Clearing, grading and compaction by construction traffic reduces the natural absorption and infiltration capacities of the native soils. Soil compaction damages soil structure, reduces infiltration rates, limits root growth and plant survivability, and destroys soil organisms. Subsequent tilling and/or addition of soil amendments such as compost can help, but will not restore the original infiltration capacity of the soils. By protecting native soils and vegetation in appropriate areas during the clearing and grading phase of development the site can retain some of its existing beneficial hydrologic function. Specific measures are:

- Protect soils against compaction and rutting in areas where traffic is unavoidable.
- Minimize the size of construction easements and material storage areas.
- Limit areas of heavy equipment
- Prohibit working on wet soils with heavy equipment.
- Restore compacted open space areas with tilling and soil amendments.
- Avoid extensive and unnecessary clearing and stockpiling of topsoil
- Avoid/minimize soil compaction in open space, landscaped, and proposed LID BMP areas
- Prepare soil amendments off-site



Strip next to drainage channel



Fact Sheet Contents:

- Description/Approach
- Design Guidelines
- O&M Recommendations

Source Control BMPs

LOADING DOCKS

Description / Approach

Several measures can be taken to prevent operations at loading docks from contributing a variety of toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to the storm water conveyance system. In designs for loading docks, containment is encouraged. Preventive measures include overflow containment structures and dead-end sumps.



Design Guidelines

Design requirements for vehicle maintenance and repair are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. The design requirements described hereon are meant to enhance and be consistent with these code requirements.

- Cover all loading dock areas, or design them to preclude run-on and runoff.
- Do not allow runoff from depressed loading docks (truck wells) to discharge into storm drains.
- Drain below-grade loading docks from grocery stores and warehouse/distribution centers of fresh food items through water quality inlets, an engineered infiltration system, or an equally effective alternative.
- Grade and/or berm the loading/unloading area to a drain that is connected to a dead-end.
- Pave loading areas with concrete instead of asphalt.

O&M Recommendations

- Develop an operations plan that describes procedures for loading and/or unloading.
- Conduct loading and unloading in dry weather if possible.
- Load and unload all materials and equipment in covered areas if feasible.
- Load/unload only at designated loading areas.
- Check loading and unloading equipment regularly for leaks.
- Look for dust or fumes during loading or unloading operations.
- Develop and implement a Spill Prevention Control and Countermeasure (SPCC) Plan.



Fact Sheet Contents:

- Description
- BMP Category
- Expected Pollutant Removals
- Minimum Design Criteria
- Feasibility Criteria
- Step-by-step Sizing Procedure
- Pretreatment Considerations
- Area Requirements
- Sizing Example
- Other Design Considerations
- Typical Schematic

Treatment Control BMPs

GREEN ROOF

Description

Sometimes referred to as a Vegetated Roof or Eco-roof, a green roof is a roof that is entirely or partially covered with vegetation and soils for the purpose of filtering, absorbing, evapotranspiring, and retaining/ detaining the rain that falls upon it.

BMP Category	
Retention	○
Biofiltration	●
Other	○



U. of Hawaii C-MORE Hale (hahana.soest.hawaii.edu)

Expected Pollutant Removals	
Nutrients	Medium
Sediment	High
Trash	High
Pathogens	Medium
Pesticides	Medium
Oil & Grease	High
Metals	Medium
Organic Compounds	Medium

Minimum Design Criteria

Design Parameter	Units	Value
Minimum Depth of Soil Media	inches	2
Minimum Depth of Drainage Layer	inches	2
Maximum slope on roof	%	20

Feasibility Criteria

See Table 10.

Sizing Procedure

1. Use the procedure presented previously to compute the Volumetric Runoff Coefficient and Water Quality Volume.
2. Select initial values for the soil media thickness (l_m), drainage layer thickness (l_d), and allowable ponding depth (d_p).
3. Calculate the total effective storage depth based on the instantaneous storage capacity using the void space in the soil media and drainage layer, and the allowable ponding:



Ch. 3 also includes requirements and recommendations for LID Retention BMPs to ensure long-term performance (i.e., to prevent an infiltration basin from becoming a wet pond)



Design requirements for LID Retention BMPs

- **Written opinion of a licensed professional engineer with geotechnical expertise**
- **Depth to Groundwater (minimum is 3 ft)**
- **Soil Infiltration Rate (minimum is 0.5 in/hr)**
- **A Correction Factor to convert soil infiltration rate to design infiltration rate**



Table 2 - Default Soil Infiltration Rates*

Texture Class	Hydrologic Soil Group (HSG)	Infiltration Rate (in/hr)
Sand	A	8.00
Loamy sand	A	2.00
Sandy loam	B	1.00
Loam	B	0.50
Silt loam	C	0.25
Sandy clay loam	C	0.15
Clay loam	D	0.09
Silty clay loam	D	< 0.09
Clay	D	< 0.05

Infiltration Feasible

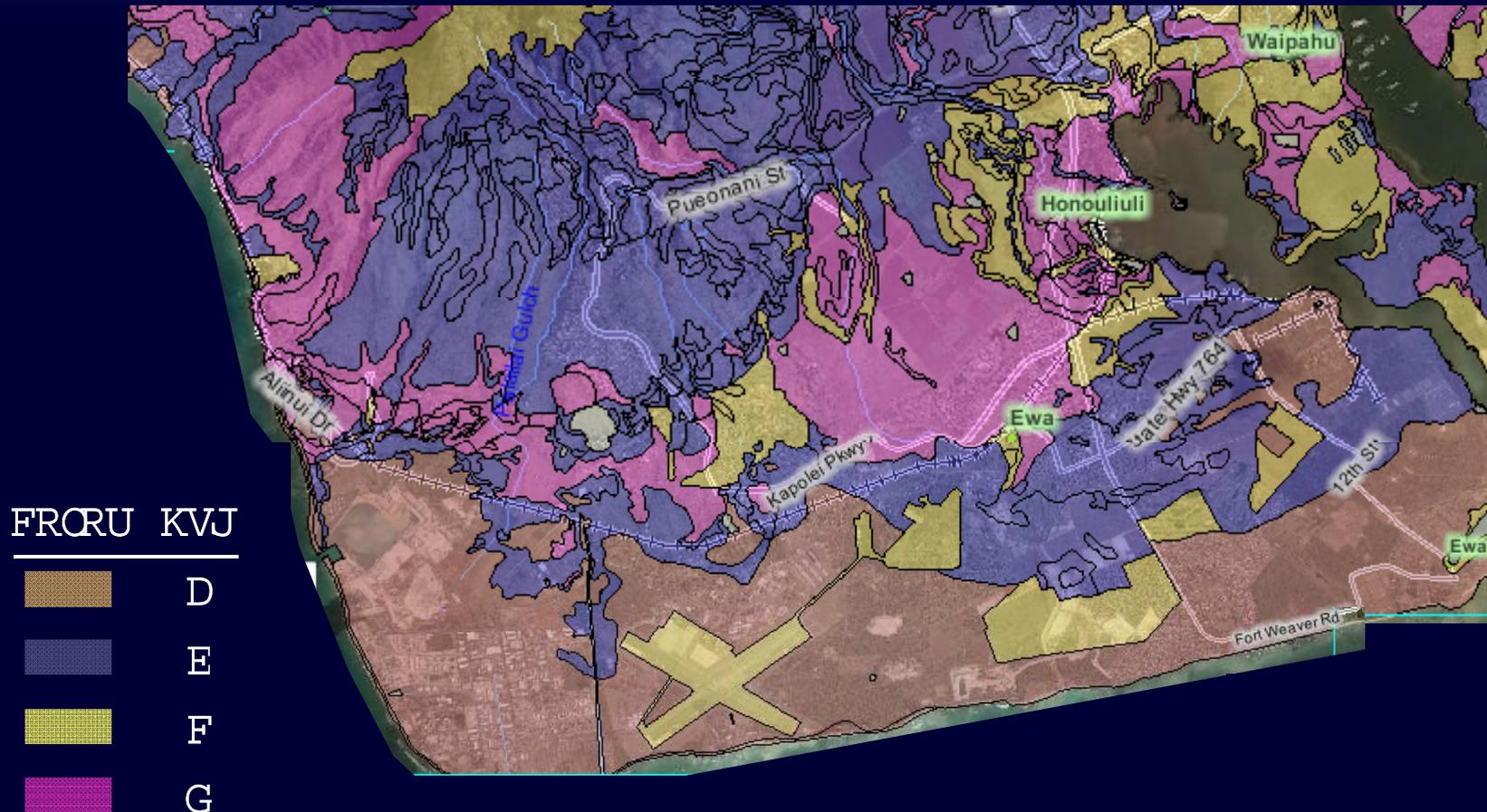
Infiltration Infeasible

* *Urban Runoff Quality Management, Manual and Report of Engineering Practice 87. ASCE. 1998*



CH. 3 – TREATMENT CONTROL

Hydrologic Soil Groups in Ewa Plain*

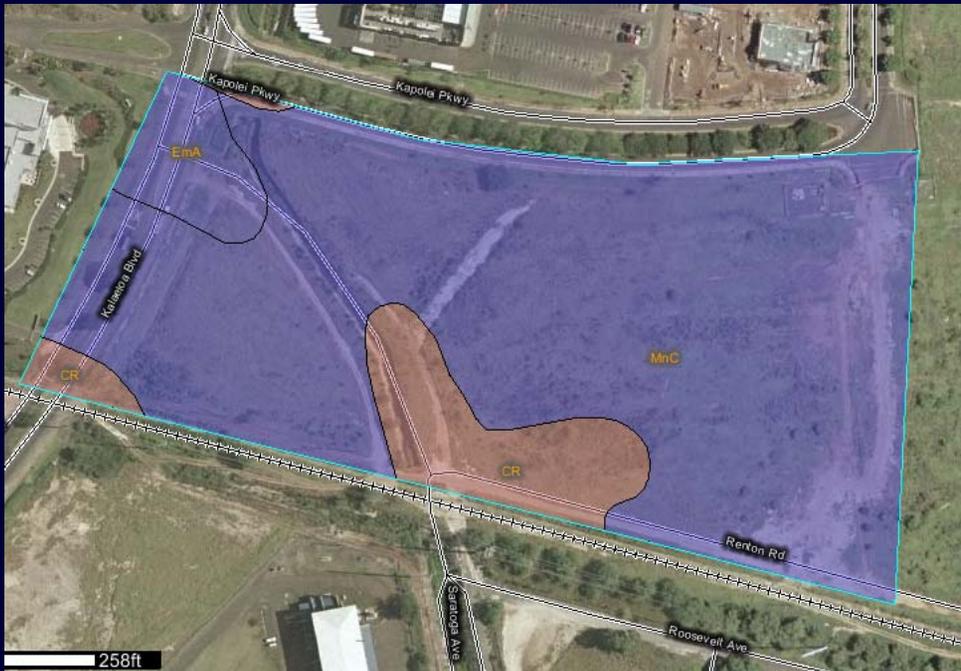


* US Dept. of Agriculture Natural Resources Conservation Service Web Soil Survey, websoilsurvey.nrcs.usda.gov



CH. 3 – TREATMENT CONTROL

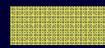
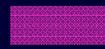
Comparison of 2 Big Box Retailers in Kapolei



Company A

FRQRU KVJ

Company B

-  D
-  E
-  F
-  G



CH. 3 – TREATMENT CONTROL

To account for uncertainties and inaccuracies in testing, a correction (i.e., safety) factor shall be applied to the soil infiltration rate to produce a design infiltration rate for BMP sizing calculations

Method	Factor (F_s)
Without recommended no. of Test Pits or recommended no. of Permeability Tests	5
With recommended no. of Test Pits only	4
With recommended no. of Permeability Tests only	3
With recommended no. of Test Pits and recommended no. of Permeability Tests	2

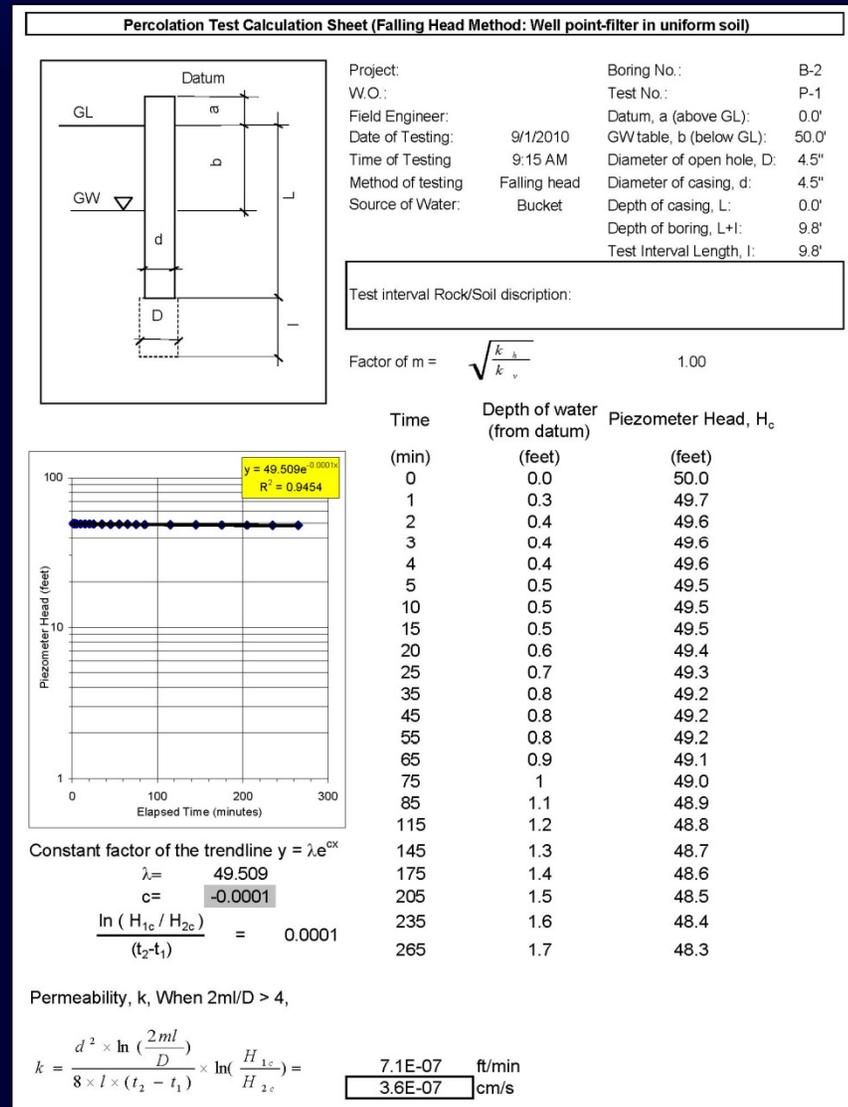
$$\text{Design Rate} = \text{Measured or Default Rate} / F_s$$



CH. 3 – TREATMENT CONTROL

Recommendations for Infiltration-based BMPs:

- Test Pits/Borings
- Permeability Tests



Test Pit/Boring Recommendations

BMP	Size	Recommended No. of Test Pits/Borings
Infiltration Basin, Subsurface Infiltration, Dry Well, Bioretention Basin, Permeable Pavement	< 2,500 sq-ft	1
	2,500 – 20,000 sq-ft	2
	20,000 – 30,000 sq-ft	3
	30,000 – 40,000 sq-ft	4
	> 40,000 sq-ft	1 per 10,000 sq-ft
Infiltration Trench	< 100 ft	1
	100 – 200 ft	2
	200 – 300 ft	3
	> 300 ft	1 per 100 ft



Permeability Test Recommendations

BMP	Presence of Manmade Soils	Recommended No. of Permeability Tests
Infiltration Basin, Subsurface Infiltration, Dry Well, Bioretention Basin, Permeable Pavement	not present	1 per 2,500 sq-ft
	present	1 per 1,000 sq-ft
Infiltration Trench	not present	1 per 100 ft
	present	1 per 50 ft



So, you have a choice:

Use the Web Soil Survey and Table 2 default values

or

Perform the test pits/borings and/or percolation tests

F_s	BMP Size Relative to $F_s = 5$
5	-
4	15% - 25% smaller
3	25% - 50% smaller
2	40% - 75% smaller



TREATMENT CONTROL BMP SIZING WORKSHEETS

- **Microsoft Excel[®] Spreadsheets**
- **Calculates BMP minimum size (footprint) consistent with formulas in Storm Water BMP Guide**
- **Color-coded cells**
 - **User-defined Design Parameter** 
 - **System-defined Design Parameter** 
 - **System Calculated Value** 
- **Data validation for user-defined design parameters**
- **Does not design the BMP (inlet, outlet, underdrain, energy dissipation, pretreatment, vegetation, etc.)**



TREATMENT CONTROL BMP SIZING WORKSHEETS

BMP Sizing Worksheet: Vegetated Bio-Filter

Project: 3.4 ac Commercial Development, DA 1a

Date: Dec-2012

1. Water Quality Volume

a. BMP Tributary Drainage Area, A	0.70	ac
b. % Impervious Area, I	80	%
c. Water Quality Design Storm Depth, P	1.0	in
d. Volumetric Runoff Coefficient, C	0.77	
e. Water Quality Volume, WQV	1,957	cu-ft

2. Filter Bed Surface Area

a. Planting Media Depth, I_m (2.0 - 5.0 ft)	2.0	ft
b. Maximum Ponding Depth, d_p (12 in)	4.0	in
c. Planting Media Coefficient of Permeability, k	1	ft/day
d. Filter Bed Drain Time, t	48	hrs
e. Filter Bed Surface Area, A_{BMP}	903	sq-ft

3. BMP Area

a. Side Slopes (length per unit height), z	0	
b. Freeboard, f	0.25	ft
c. Filter Bed Width, w_b	3.78	ft
d. Filter Bed Length, l_b	239	ft
e. Top Width, w_t	3.78	ft
f. Top Length, l_t	239	ft
g. Min. Top Surface Area excluding pretreatment, A_{BMP}	903	sq-ft

Worksheets:

LID Retention

Infiltration Basin
 Infiltration Trench
 Dry Well
 Bioretention Basin
 Permeable Pavement

LID Biofiltration

Green Roof
 Vegetated Bio-Filter
 Enhanced Swale
 Vegetated Swale
 Vegetated Buffer Strip

Other

Harvesting/Reuse
 Detention Basin
 Sand Filter



Module Summary



- Use the SWQR and SWQC templates - other forms will not be accepted
- Follow the instructions in the SWQR and SWQC Preparation Manuals
- Attach the LID Exemption Table to SWQR and SWQC (A2) if LID exemptions are being claimed
- Use the Storm Water BMP Guide to select and size management practices
- Attach applicable Treatment Control BMP Sizing Worksheets to SWQR and SWQC (A2)



End of Module 3



MODULE 4

EXAMPLES



MODULE 4

EXAMPLES



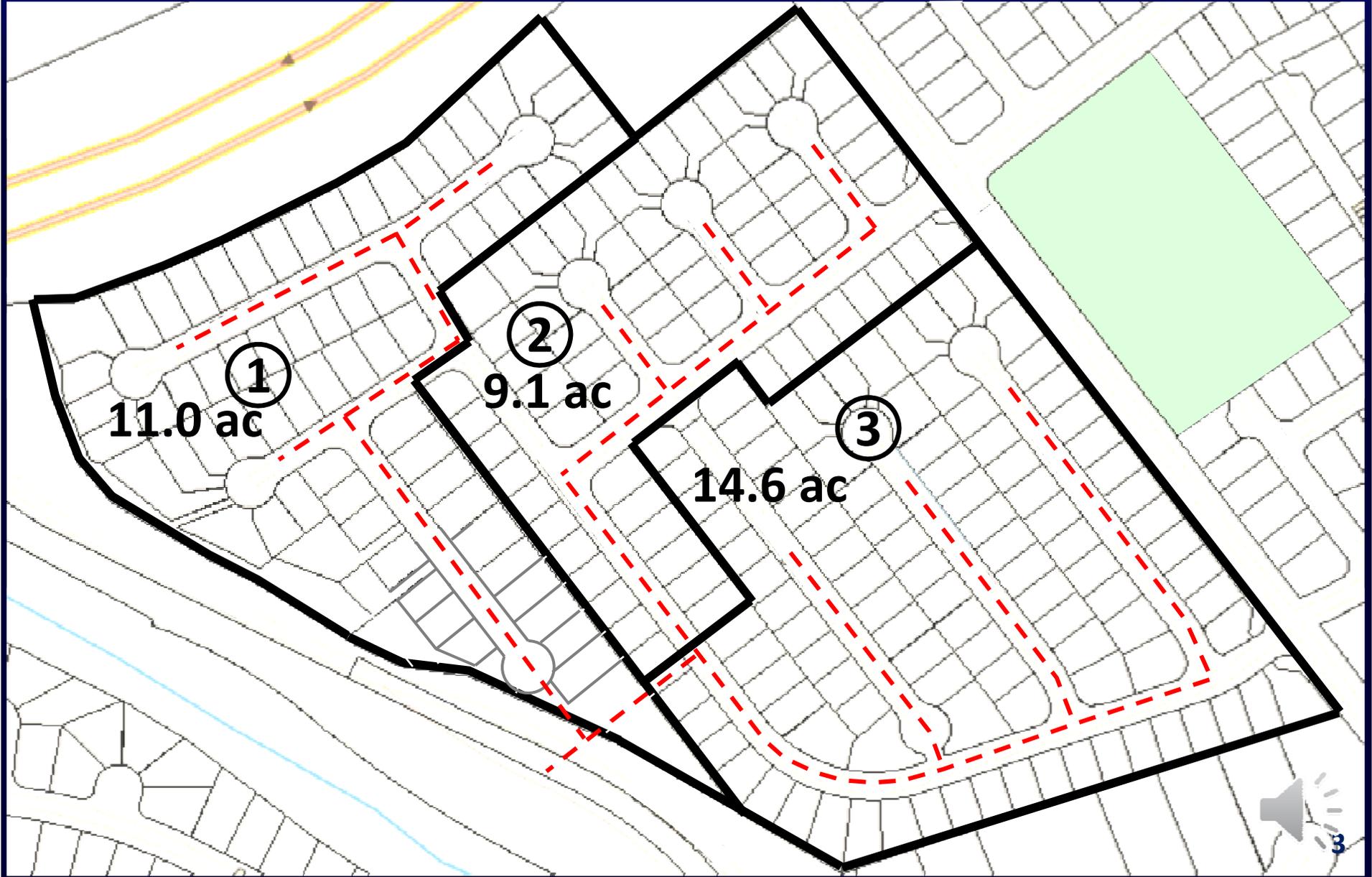
EXAMPLES

- A. 35 acre Residential Development
- B. 3.4 acre Commercial Development
- C. 4,000 sq-ft Restaurant on $\frac{3}{4}$ acre site
- D. 37 acre Residential Development



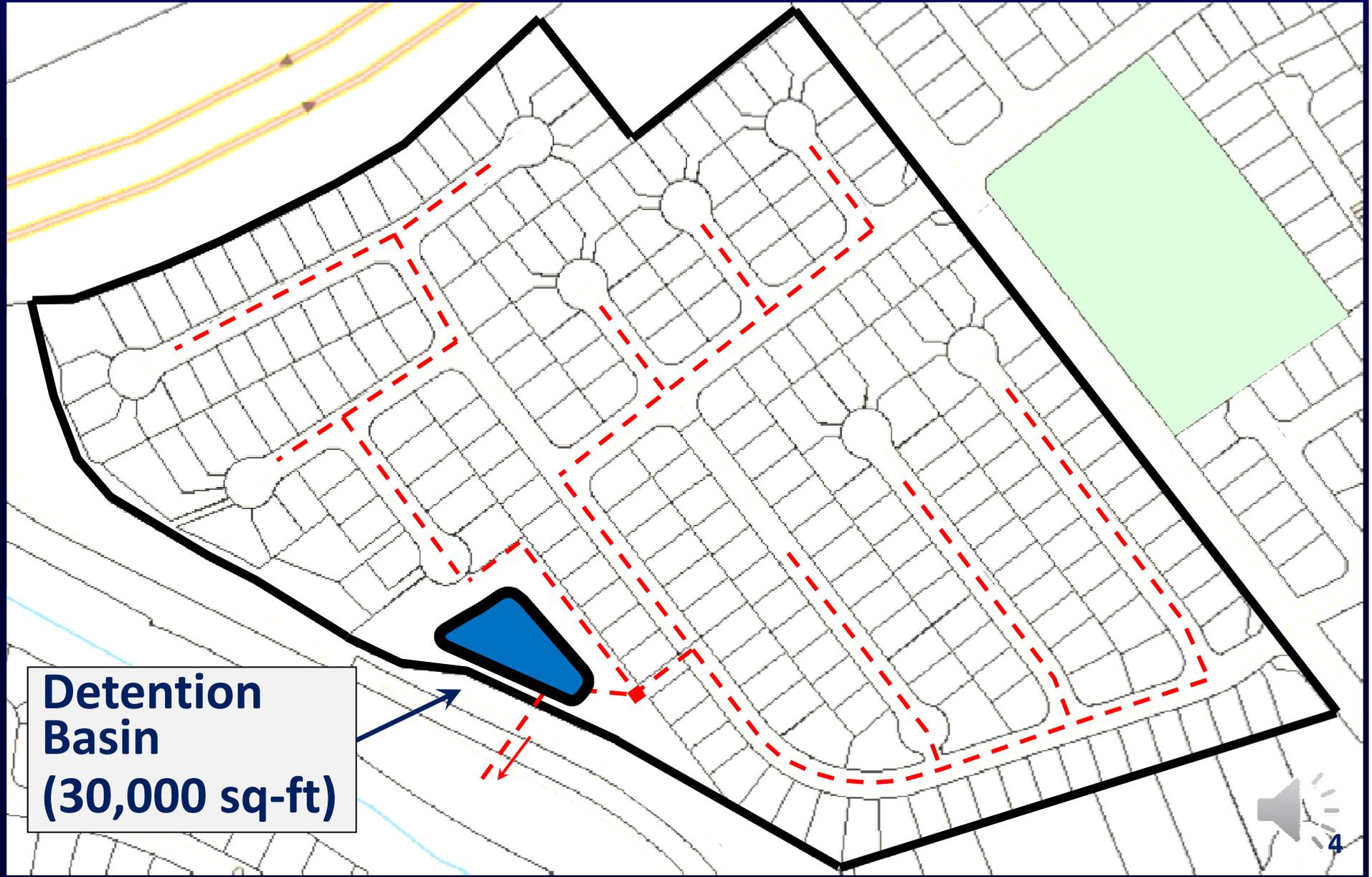
35 ACRE RESIDENTIAL DEVELOPMENT

Site & Drainage Plan



35 ACRE RESIDENTIAL DEVELOPMENT

WQ Management Scheme under Old Rules



Does this WQ Management Scheme
comply with the Retention & Biofiltration
requirements specified in the new Rules?

- Yes
- No
- Maybe
- I Don't Know



It depends...

If any Retention BMPs are feasible, then it doesn't comply.

If all Retention BMPs are infeasible, and any Biofiltration BMPs are feasible, then it doesn't comply.

If all Retention and Biofiltration BMPs are infeasible, then it complies.



What's the first step to get the answer?

Determine if the project soils support infiltration:

Use the NRCS Web Soil Survey and the ASCE default infiltration rates

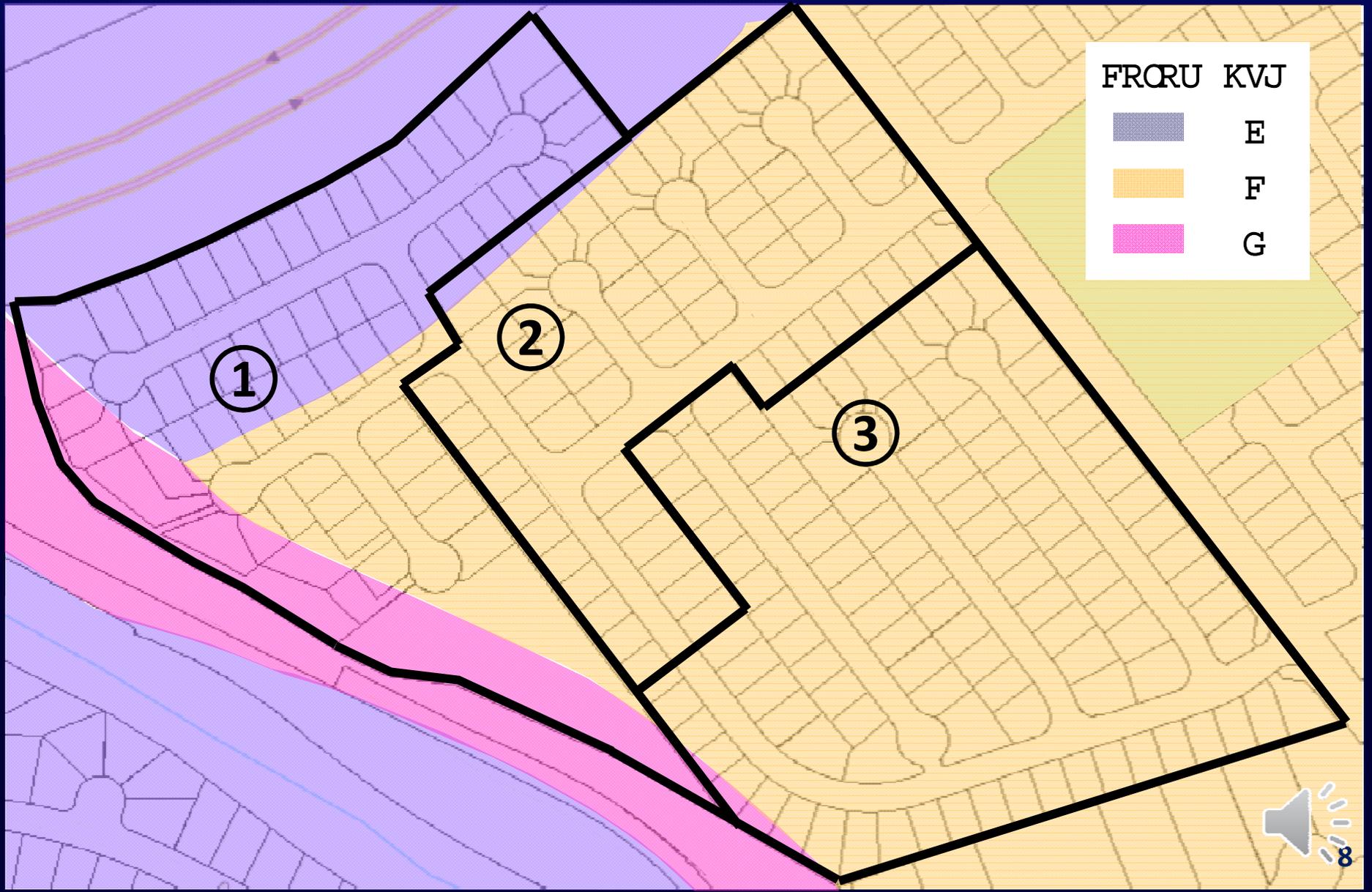
or

Perform field measurements



35 ACRE RESIDENTIAL DEVELOPMENT

Hydrologic Soil Groups (NRCS Web Soil Survey)



So, retention may be possible...

- An exemption from Retention may not be claimed in the HSG “B” area solely based on infiltration rates. As much of the WQV as possible must be retained here unless an exemption is claimed for another reason
- An exemption from all Retention BMPs may be claimed in the HSG “C” and “D” areas. Whatever part of the WQV not retained in “B” must be biofiltered where ever feasible (i.e., no exemption claimed)



35 ACRE RESIDENTIAL DEVELOPMENT

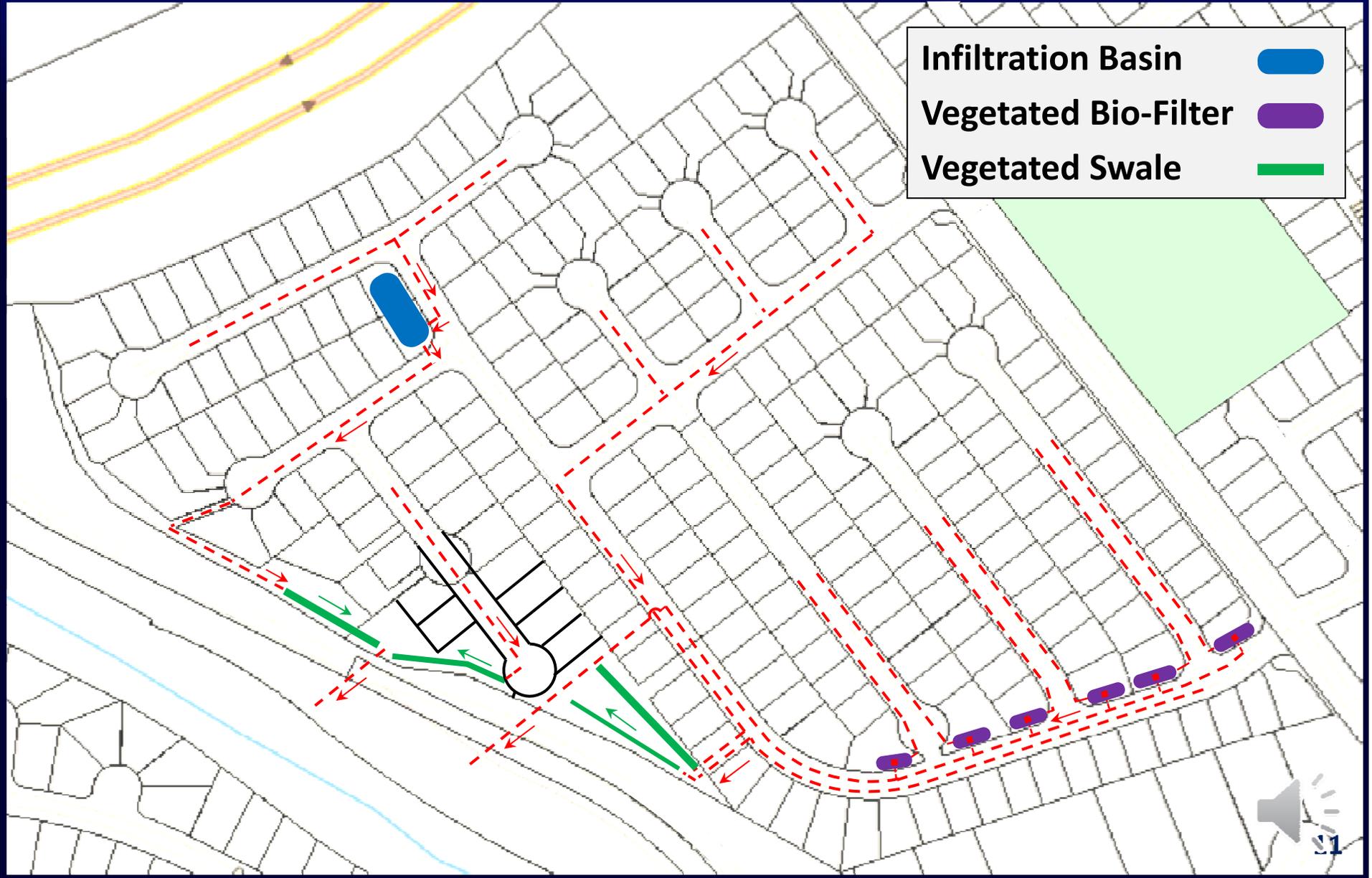
BMPs that could achieve compliance

	BMP	Drainage Area		
		1	2	3
<i>Retention</i>	Infiltration Basin	✓		
	Infiltration Trench	✓		
	Subsurface Infiltration	✓		
	Dry Well	✓		
	Bioretention Basin	✓		
	Permeable Pavement	✓		
<i>Biofiltration</i>	Green Roof			
	Bioretention Filter	✓	✓	✓
	Dry Swale	✓	✓	✓
	Downspout Disconnect	✓	✓	✓
	Vegetated Swale	✓	✓	✓
	Vegetated Buffer Strip			
	Tree Box Filter	✓	✓	✓



35 ACRE RESIDENTIAL DEVELOPMENT

One Possible WQ Management Scheme



35 ACRE RESIDENTIAL DEVELOPMENT

BMP Sizing Worksheet: Vegetated Bio-Filter

Project: 35 acre Residential Development

Date: Dec- 2012

1. Water Quality Volume

- | | | |
|---|--------------|-------|
| a. BMP Tributary Drainage Area, A | <u>1.70</u> | ac |
| b. % Impervious Area, I | <u>50</u> | % |
| c. Water Quality Design Storm Depth, P | <u>1.0</u> | in |
| d. Volumetric Runoff Coefficient, C | <u>0.5</u> | |
| e. Water Quality Volume, WQV | <u>3,083</u> | cu-ft |

2. Filter Bed Surface Area

- | | | |
|---|--------------|--------|
| a. Planting Media Depth, I_m (2.0 - 5.0 ft) | <u>2.0</u> | ft |
| b. Maximum Ponding Depth, d_p (12 in) | <u>6.0</u> | in |
| c. Planting Media Coefficient of Permeability, k | <u>1</u> | ft/day |
| d. Filter Bed Drain Time, t | <u>48</u> | hrs |
| e. Filter Bed Surface Area, A_{BMP} | <u>1,370</u> | sq-ft |

3. BMP Area

- | | | |
|---|--------------|-------|
| a. Side Slopes (length per unit height), z | <u>0</u> | |
| b. Freeboard, f | <u>1</u> | ft |
| c. Filter Bed Width, w_b | <u>20.00</u> | ft |
| d. Filter Bed Length, l_b | <u>69</u> | ft |
| e. Top Width, w_t | <u>20.00</u> | ft |
| f. Top Length, l_t | <u>69</u> | ft |
| g. Min. Top Surface Area excluding pretreatment, A_{BMP} | <u>1,370</u> | sq-ft |



35 ACRE RESIDENTIAL DEVELOPMENT

WQ Management Scheme Comparison

BMP	BMP Qty	Footprint (sq-ft)	Lots Lost	Approx. Cost ¹ (\$1000)
Detention Basin <i>(Old Rules)</i>	1	30,000	8	\$125 - \$250
Infiltration Basin Vegetated Bio-Filters Vegetated Swales	11	20,000 - 40,000	4	\$100 - \$300
Infiltration Basin Tree Box Filters	80	5,000 – 25,000 ²	2	\$650 - \$800

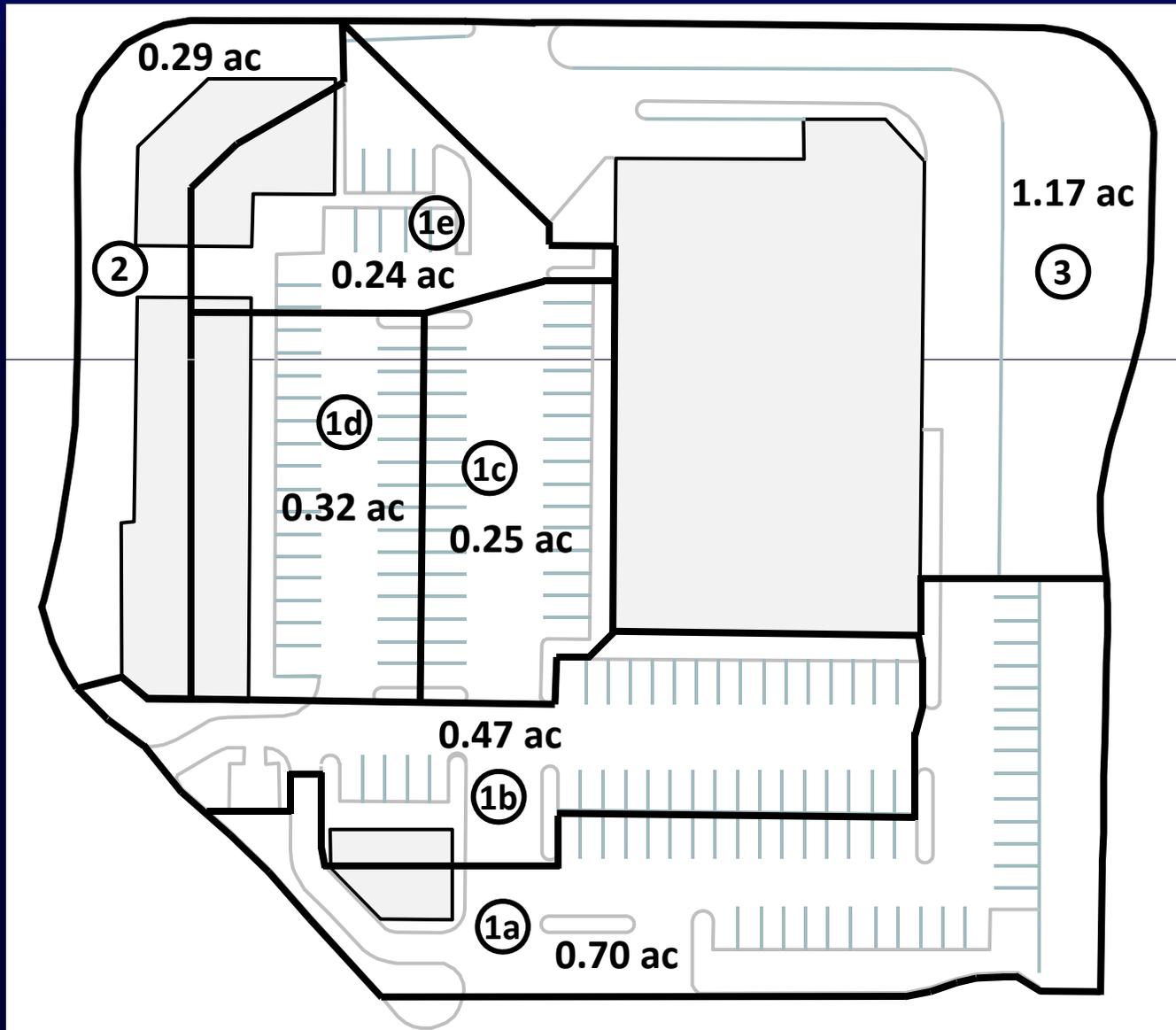
¹ Excludes land acquisition and maintenance

² Excludes Tree Box Filters which are below grade



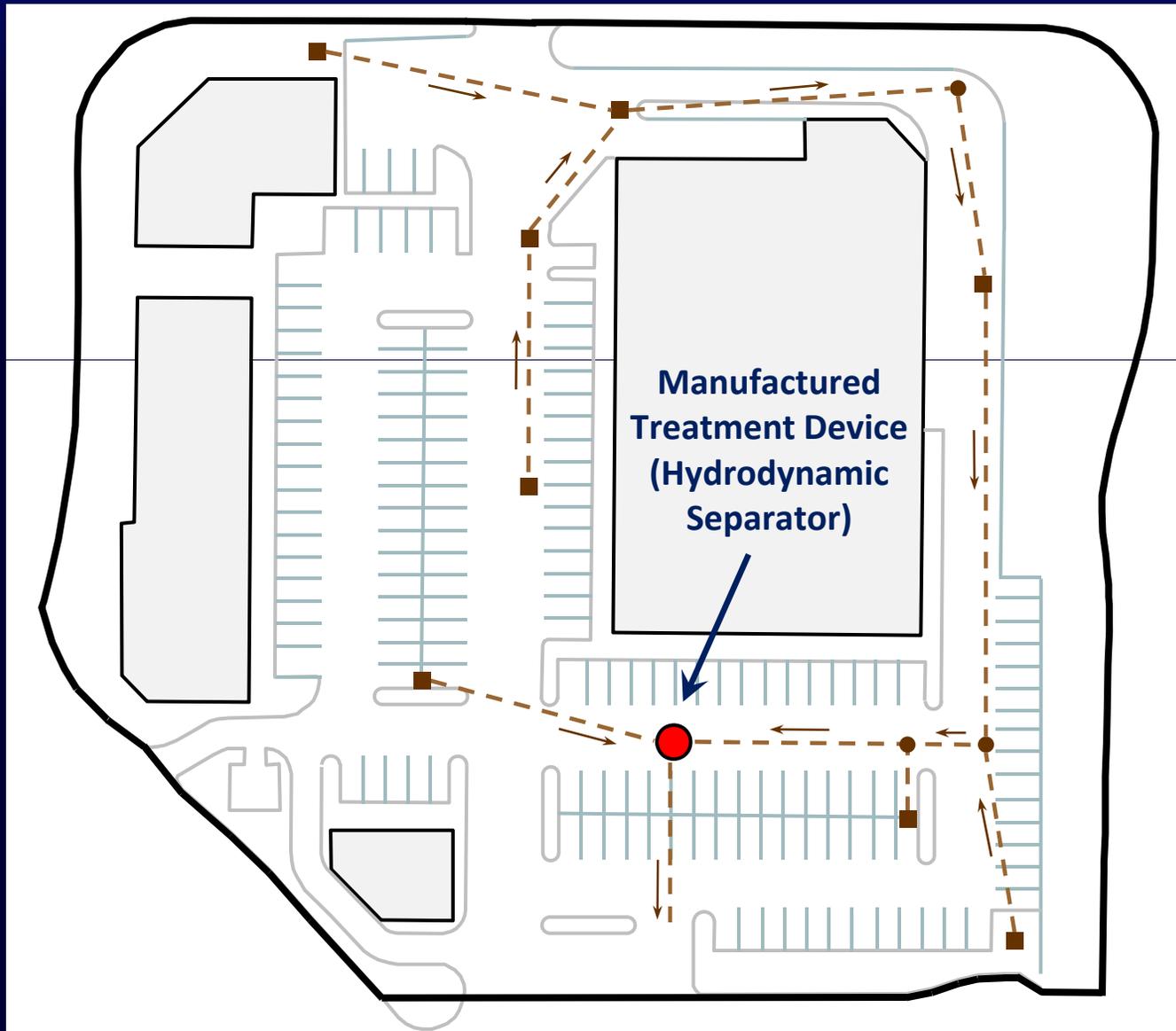
3.4 ACRE COMMERCIAL DEVELOPMENT

Site & Drainage Plan



3.4 ACRE COMMERCIAL DEVELOPMENT

WQ Management Scheme under Old Rules



3.4 ACRE COMMERCIAL DEVELOPMENT

Does this WQ Management Scheme comply with the Retention & Biofiltration requirements specified in the new Rules?

- Yes
- No
- Maybe
- I Don't Know



It depends...

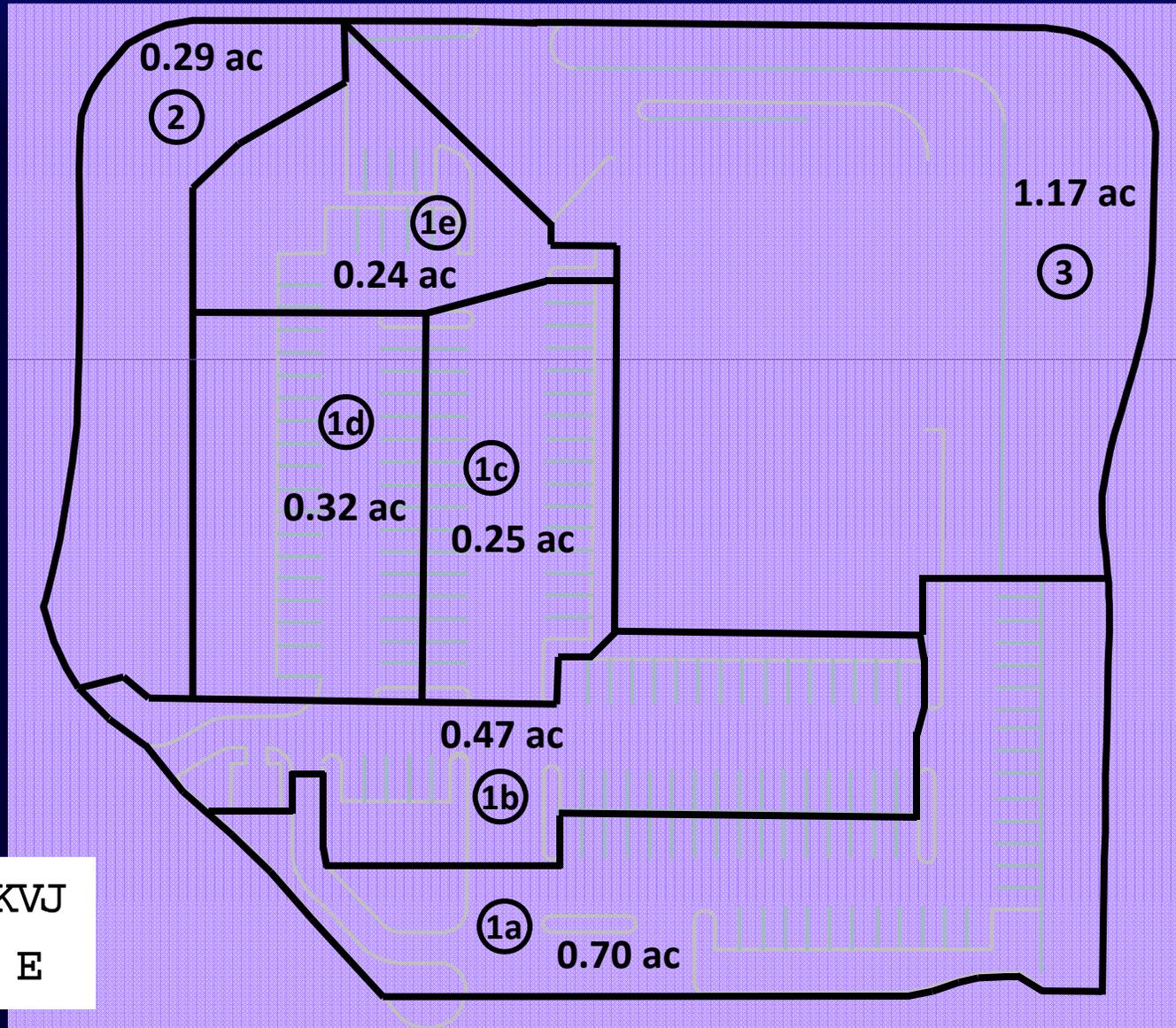
If any Retention or Biofiltration BMPs are feasible, then it doesn't comply.

If all Retention and Biofiltration BMPs are infeasible, then it complies.



3.4 ACRE COMMERCIAL DEVELOPMENT

Hydrologic Soil Groups (NRCS Web Soil Survey)



So, retention and biofiltration may be possible...

- An exemption from Retention may not be claimed solely based on infiltration rates.
- The WQV must be either retained or biofiltered, unless an exemption from every Retention BMP and every Biofiltration BMP is claimed



3.4 ACRE COMMERCIAL DEVELOPMENT

BMPs that could achieve compliance

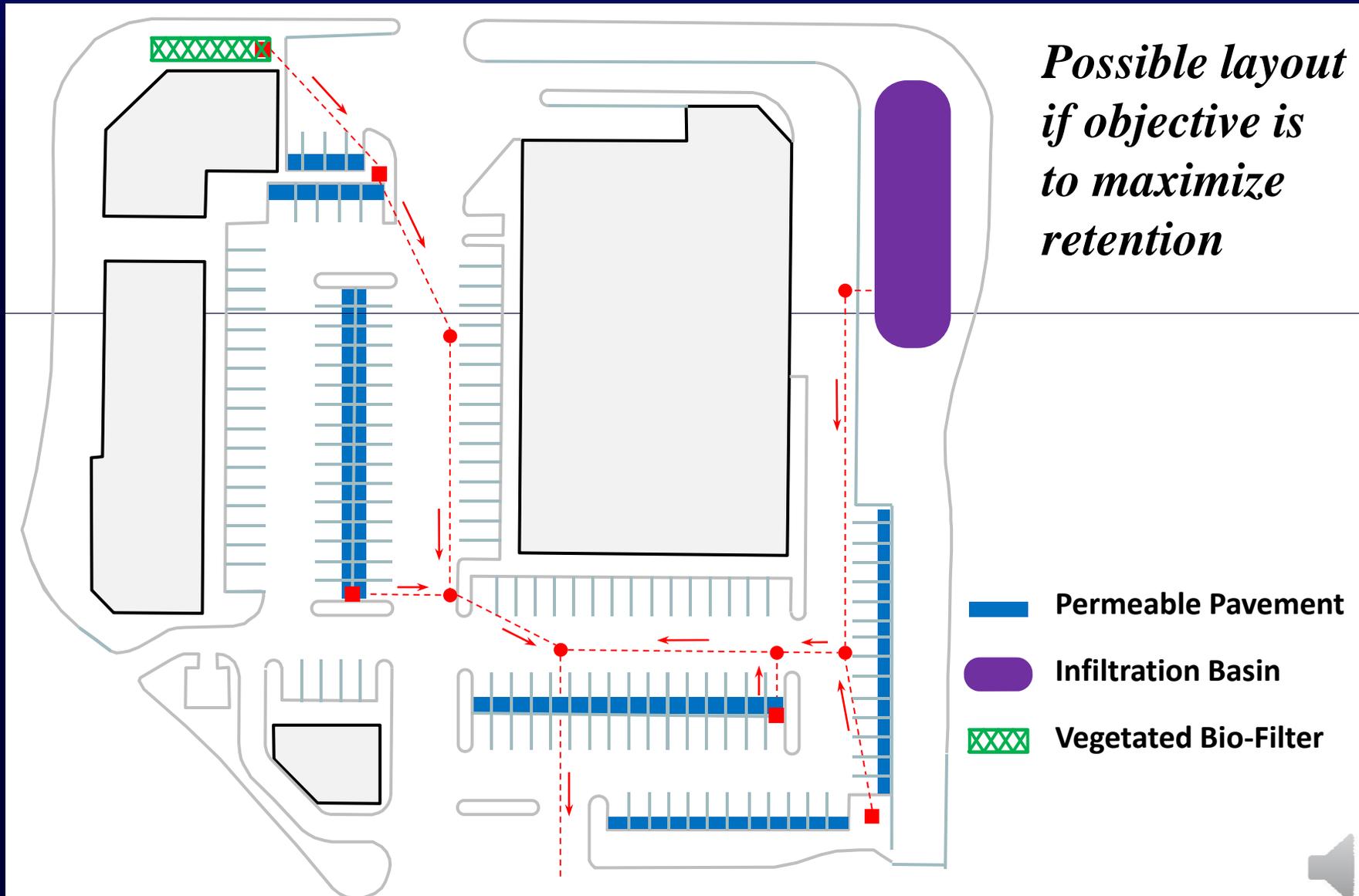
	BMP	Drainage Area						
		1a	1b	1c	1d	1e	2	3
<i>Retention</i>	Infiltration Basin							✓
	Infiltration Trench	✓	✓	✓	✓	✓		✓
	Subsurface Infiltration	✓	✓	✓	✓	✓		✓
	Dry Well							✓
	Bioretention Basin							✓
	Permeable Pavement	✓	✓	✓	✓	✓		
<i>Biofiltration</i>	Green Roof	✓	✓		✓	✓	✓	✓
	Bioretention Filter	✓	✓	✓	✓	✓	✓	✓
	Dry Swale							
	Downspout Disconnect						✓	✓
	Vegetated Swale						✓	
	Vegetated Buffer Strip							
	Tree Box Filter	✓	✓	✓	✓	✓		✓



3.4 ACRE COMMERCIAL DEVELOPMENT

One Possible WQ Management Scheme

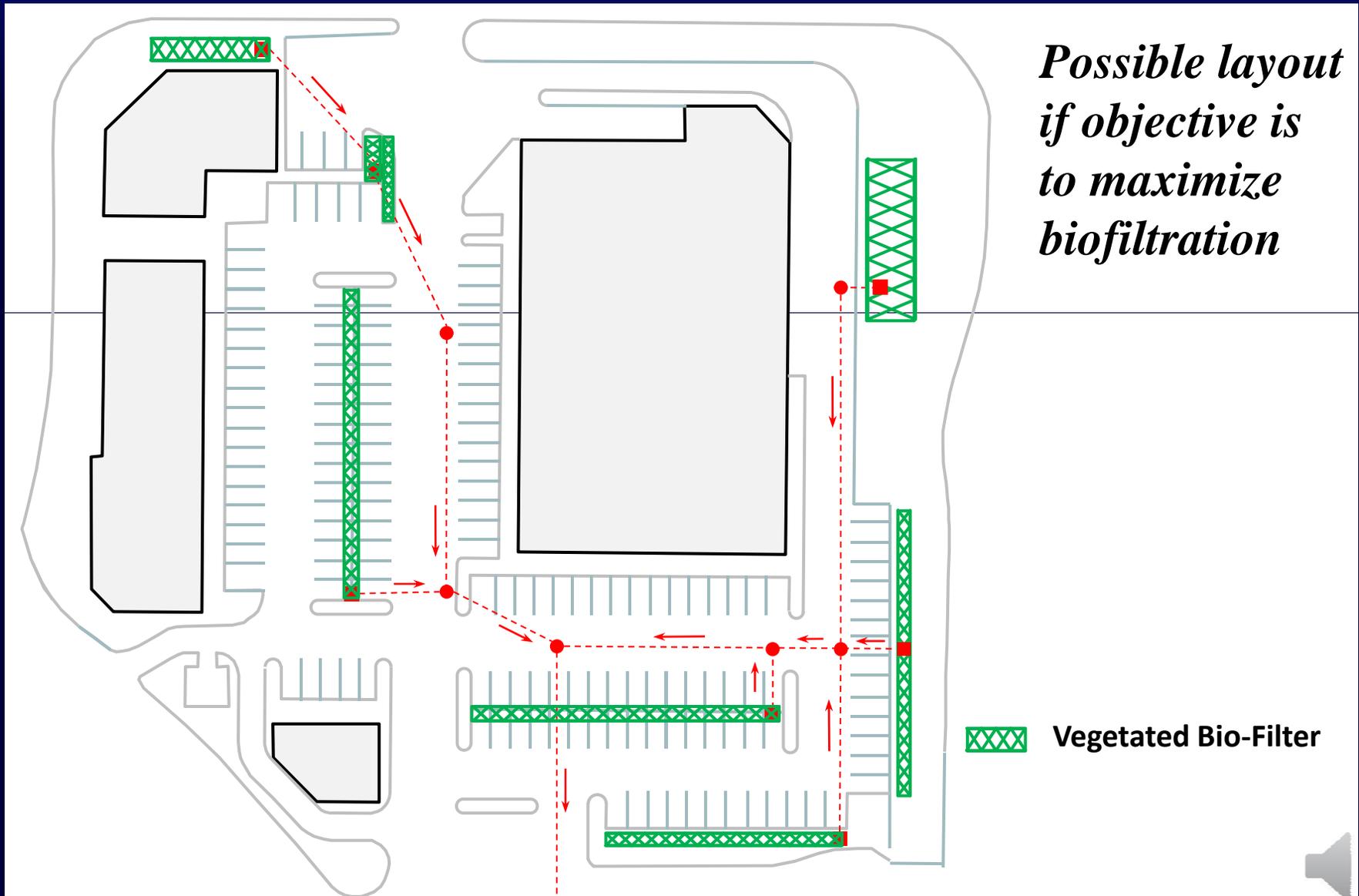
*Possible layout
if objective is
to maximize
retention*



3.4 ACRE COMMERCIAL DEVELOPMENT

Another Possible WQ Management Scheme

*Possible layout
if objective is
to maximize
biofiltration*



3.4 ACRE COMMERCIAL DEVELOPMENT

BMP Sizing Worksheet: Vegetated Bio-Filter

Project: 3.4 ac Commercial Development, DA 1a **Date:** Dec-2012

1. Water Quality Volume

- a. BMP Tributary Drainage Area, **A** 0.70 ac
- b. % Impervious Area, **I** 80 %
- c. Water Quality Design Storm Depth, **P** 1.0 in
- d. Volumetric Runoff Coefficient, **C** 0.77
- e. Water Quality Volume, **WQV** 1,957 cu-ft

2. Filter Bed Surface Area

- a. Planting Media Depth, I_m (2.0 - 5.0 ft) 2.0 ft
- b. Maximum Ponding Depth, d_p (12 in) 4.0 in
- c. Planting Media Coefficient of Permeability, **k** 1 ft/day
- d. Filter Bed Drain Time, **t** 48 hrs
- e. Filter Bed Surface Area, **A_{BMP}** 903 sq-ft

3. BMP Area

- a. Side Slopes (length per unit height), **z** 0
- b. Freeboard, **f** 0.25 ft
- c. Filter Bed Width, **w_b** 3.78 ft
- d. Filter Bed Length, **l_b** 239 ft
- e. Top Width, **w_t** 3.78 ft
- f. Top Length, **l_t** 239 ft
- g. Min. Top Surface Area excluding pretreatment, **A_{BMP}** 903 sq-ft

BMP Sizing Worksheet: Permeable Pavement

Project: 3.4 ac Commercial Development, DA 1a **Date:** Dec-2012

1. Water Quality Volume

- a. BMP Tributary Drainage Area, **A** 0.70 ac
- b. % Impervious Area, **I** 80 %
- c. Water Quality Design Storm Depth, **P** 1.0 in
- d. Volumetric Runoff Coefficient, **C** 0.77
- e. Water Quality Volume, **WQV** 1,957 cu-ft

2. Maximum Storage Depth

- a. Soil Infiltration Rate, **k** (0.5 min) 0.5 in/hr
- b. Infiltration Rate Safety Factor (2 - 5), **F_s** 4
- c. Drawdown Time, **t** 48 hrs
- d. Max. Storage Depth, **d_{max}** 0.5 ft

3. Design Storage Depths

- a. Pavement Course Thickness, **l_p** 7.0 in
- b. Reservoir Course Thickness, **l_r** 14.0 in
- c. Pavement Course Porosity, **n_p** 0.15
- d. Reservoir Course Porosity, **n_r** 0.35
- e. Total Effective Storage Depth, **d_t** 0.50 ft

4. BMP Area Requirements

- a. Fill Time, **T** 2 hrs
- b. Min. Surface Area, **A_{BMP}** 3,787 sq-ft



3.4 ACRE COMMERCIAL DEVELOPMENT

WQ Management Scheme Comparison

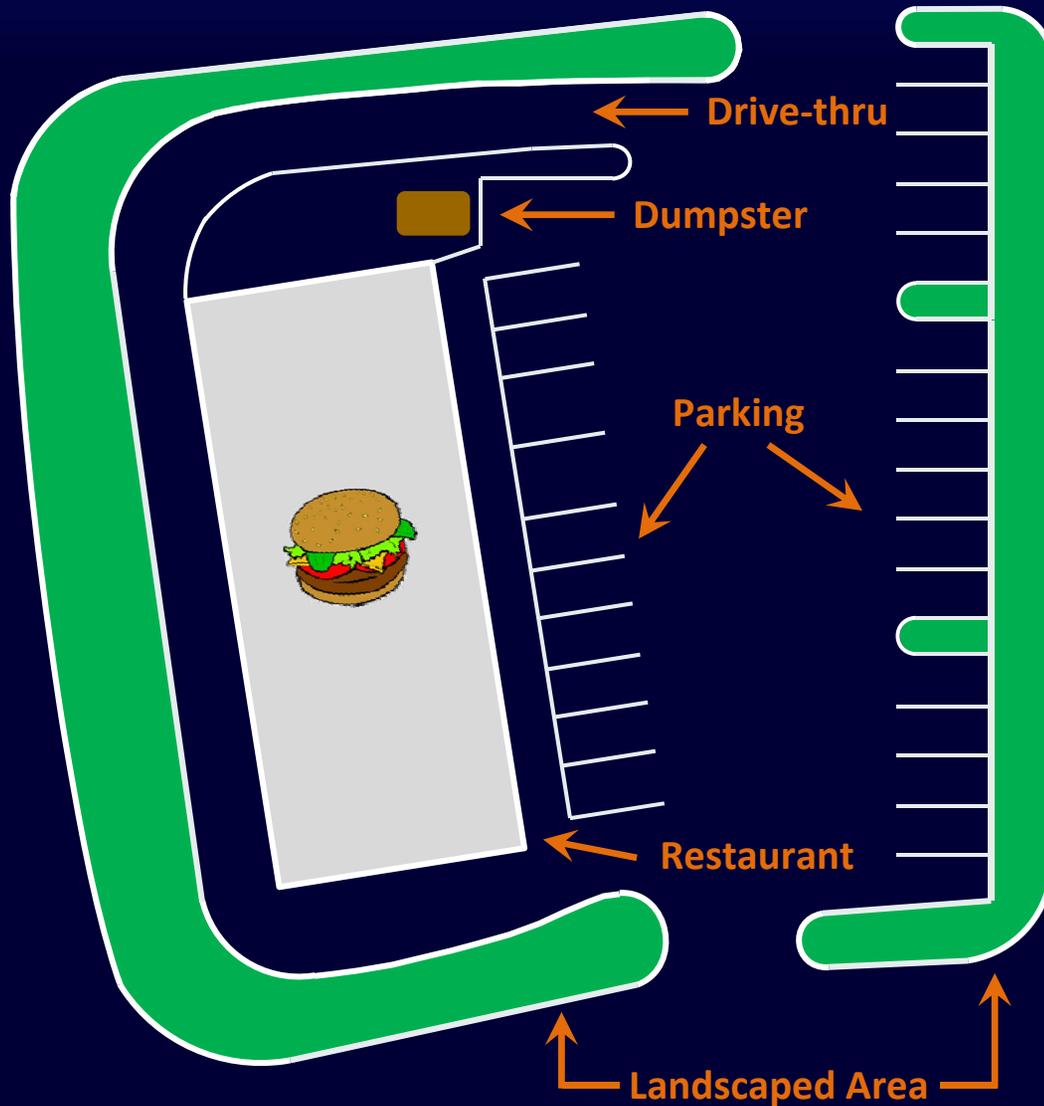
BMP	BMP Qty	Footprint (sq-ft)	Approx. Cost ¹ (\$1000)
Hydrodynamic Separator <i>(Old Rules)</i>	1	25	\$40
Permeable Pavement Infiltration Basin Vegetated Bio-Filter <i>(Maximize Retention)</i>	8	9,000 - 13,000	\$20 - \$120
Vegetated Bio-Filters <i>(Maximize Biofiltration)</i>	7	4,700 – 5,200	\$45 - \$200

¹ Excludes land acquisition and maintenance



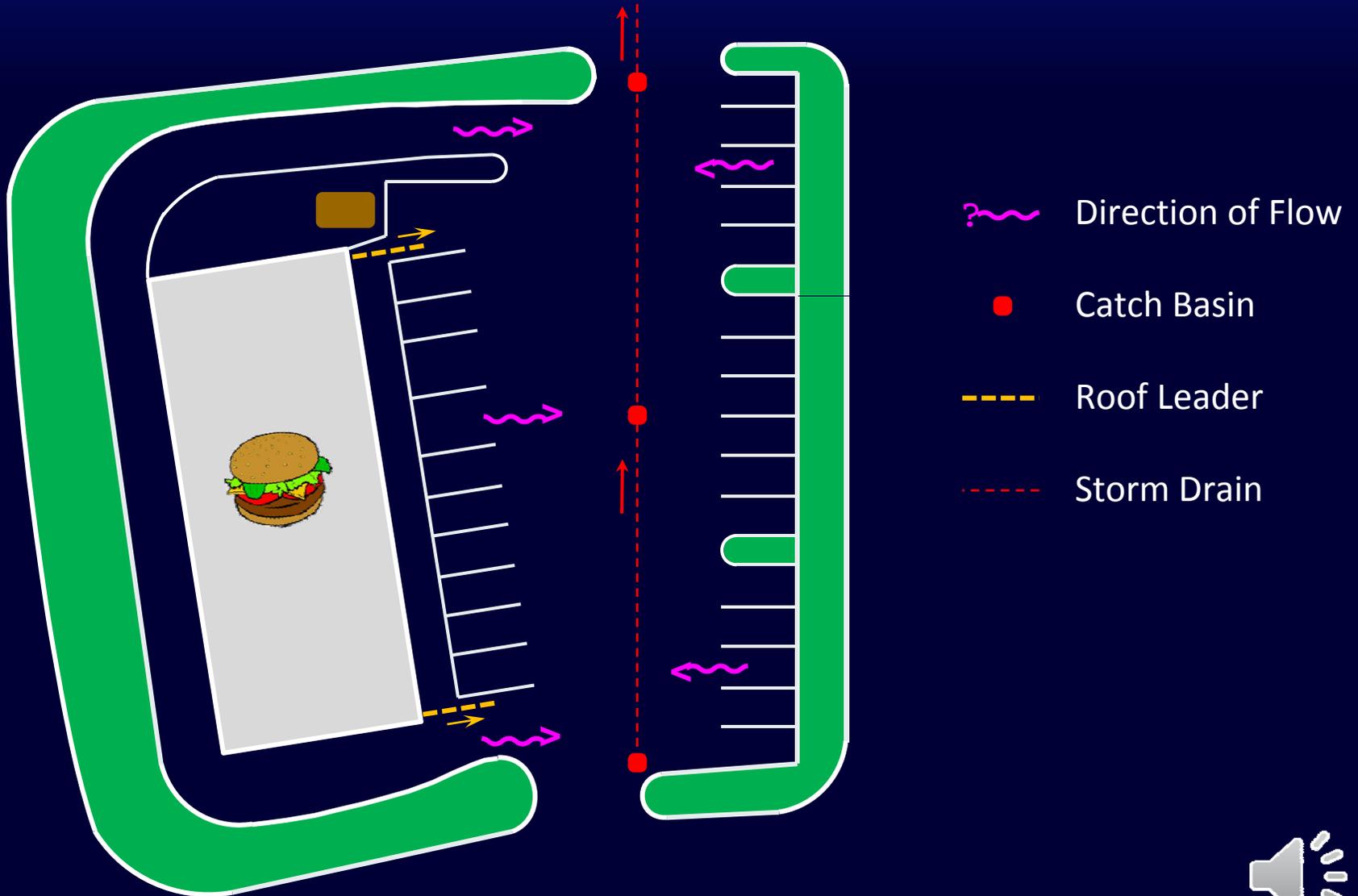
4,000 SQ-FT RESTAURANT ON 0.75 ACRE LOT

Site Plan



4,000 SQ-FT RESTAURANT ON 0.75 ACRE LOT

Site Design & Source Control Under Old Rules



Does this WQ Management Scheme
comply with the requirements for
Priority B projects under the new Rules?

- Yes
- No
- Maybe
- I Don't Know



Site Design is Optional, but Source Control is not

- Does Dumpster have a lid?
- Does Dumpster have secondary containment?
- Is there a “No Dumping” Sign by Dumpster?
- Are catch basins stencilled?



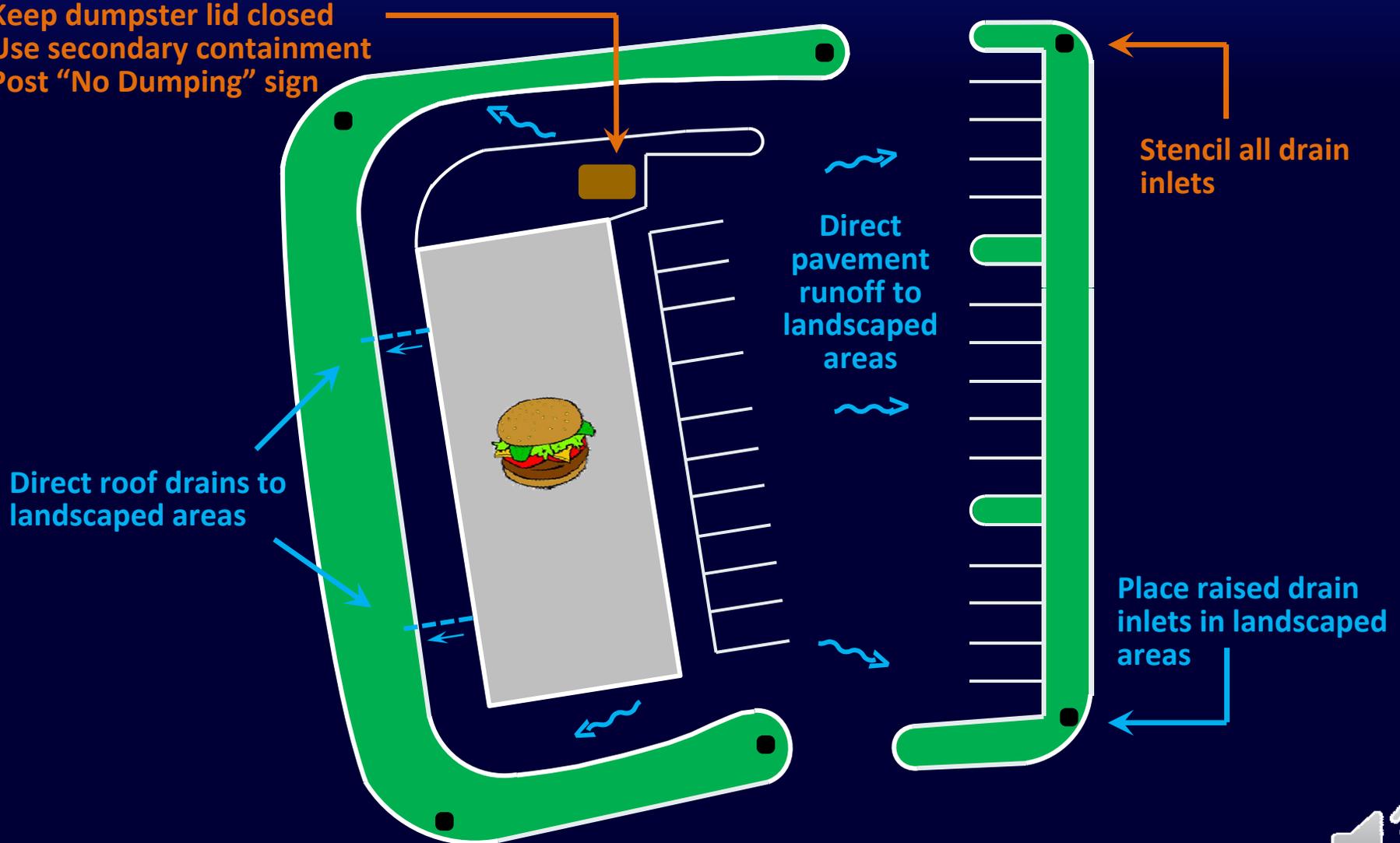
If the answer is YES, then it complies



4,000 SQ-FT RESTAURANT ON 0.75 ACRE LOT

Alternate Site Design & Source Control

Keep dumpster lid closed
Use secondary containment
Post "No Dumping" sign

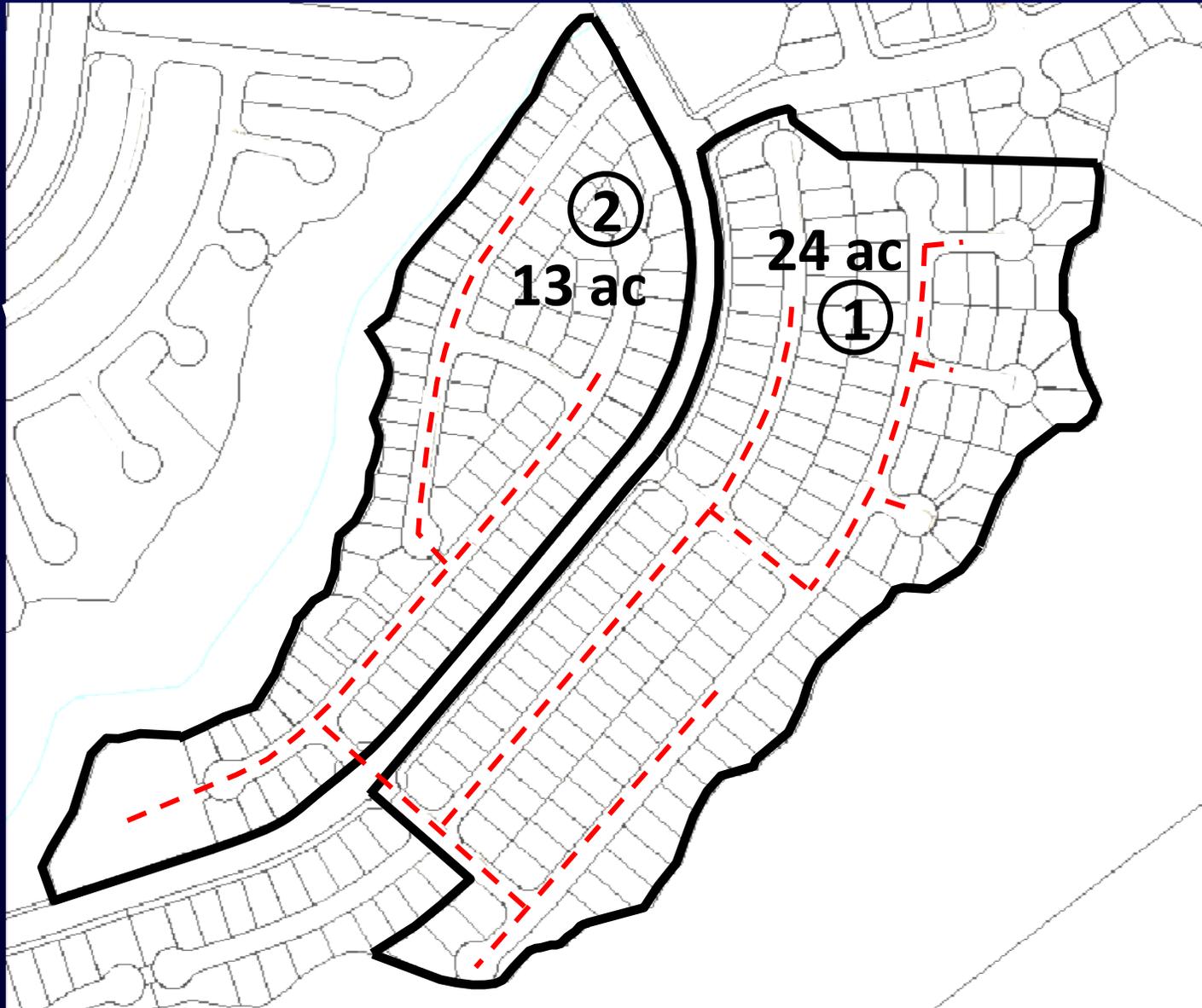


Objective: Consider Site Design & Source Control



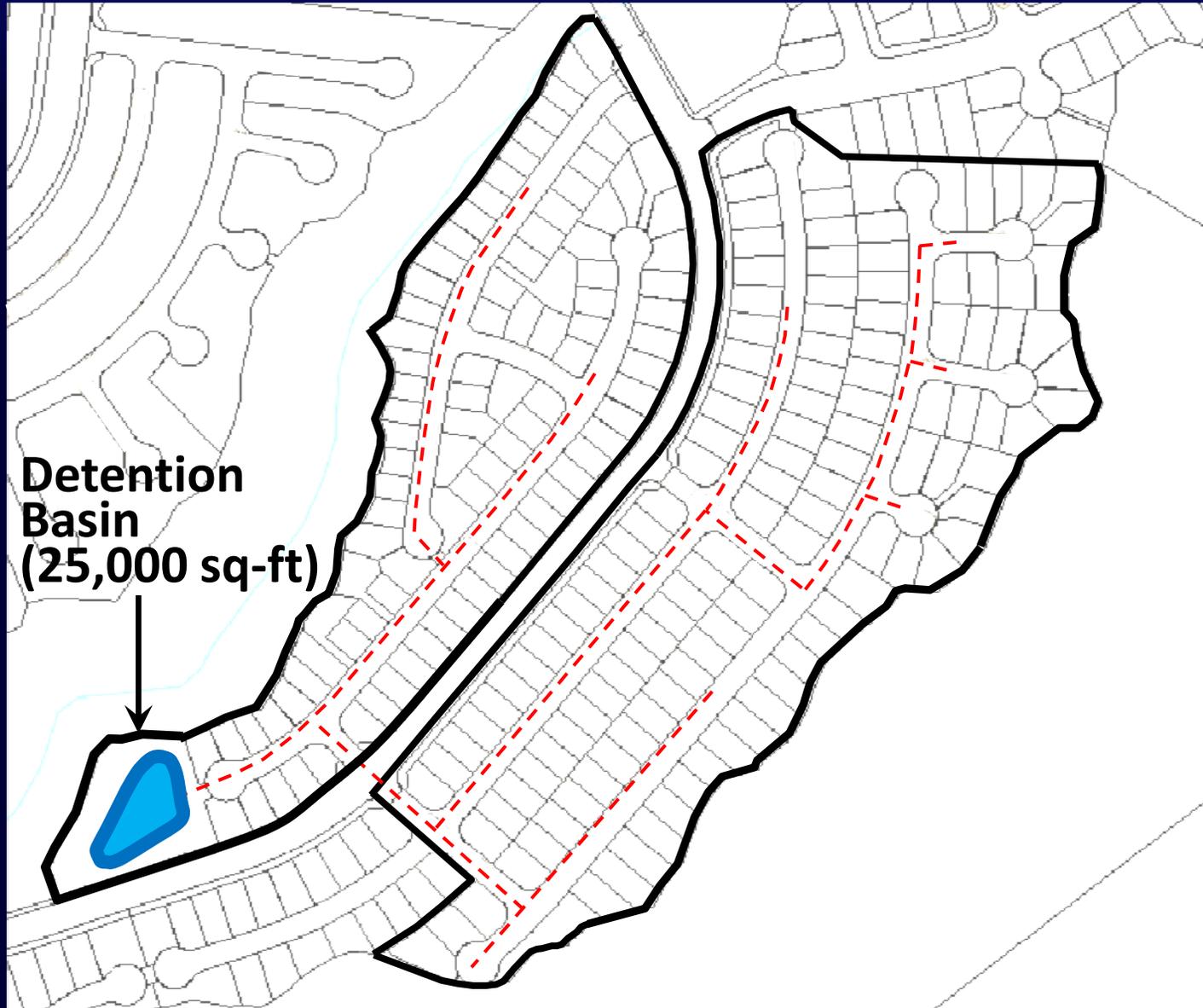
37 ACRE RESIDENTIAL DEVELOPMENT

Site Plan



37 ACRE RESIDENTIAL DEVELOPMENT

WQ Management Scheme under Old Rules



Does this WQ Management Scheme
comply with the Retention & Biofiltration
requirements specified in the new Rules?

- Yes
- No
- Maybe
- I Don't Know



It depends...

If any Retention BMPs are feasible, then it doesn't comply.

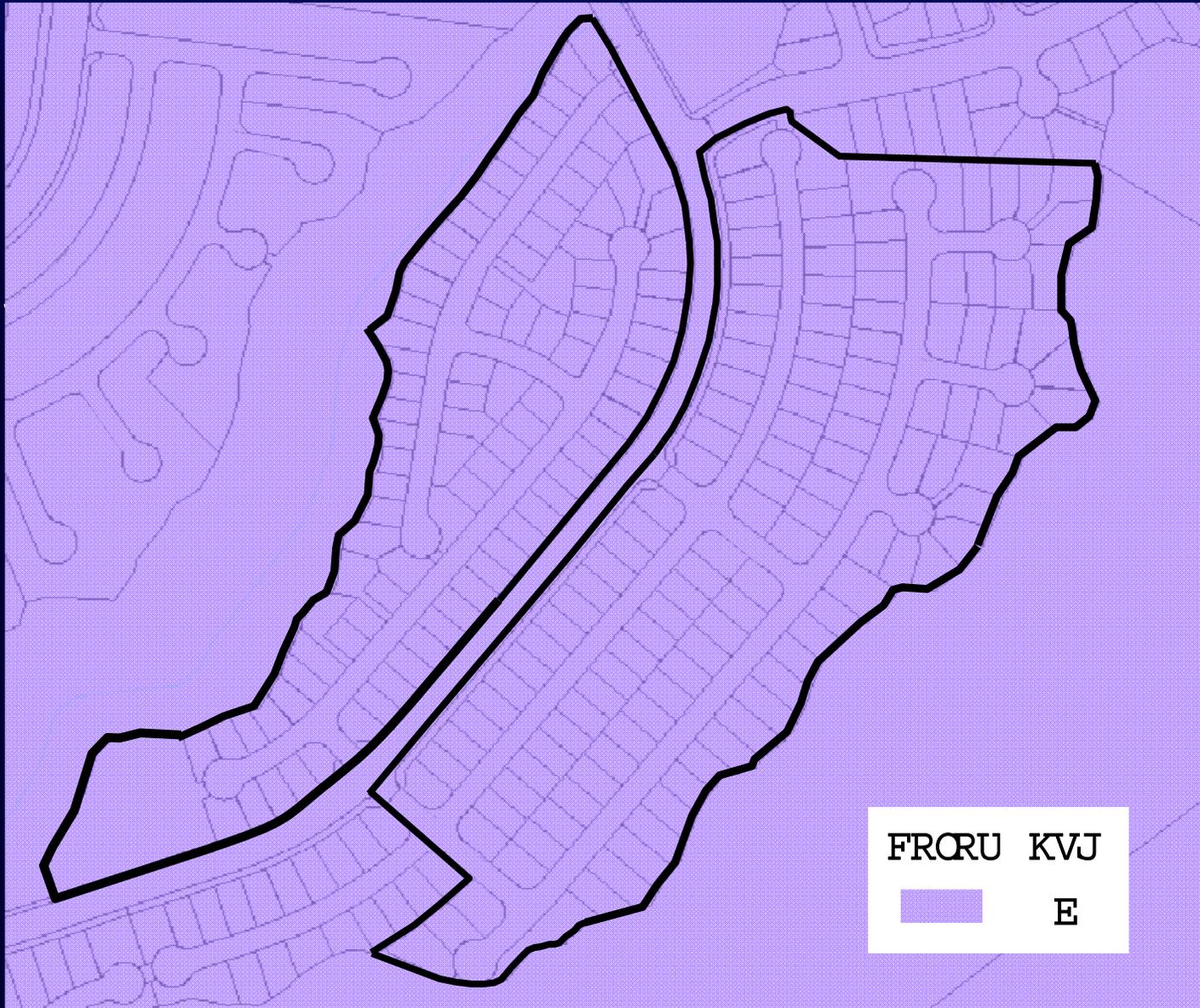
If all Retention BMPs are infeasible, and any Biofiltration BMPs are feasible, then it doesn't comply.

If all Retention and Biofiltration BMPs are infeasible, then it complies.



37 ACRE RESIDENTIAL DEVELOPMENT

Hydrologic Soil Groups (NRCS Web Soil Survey)



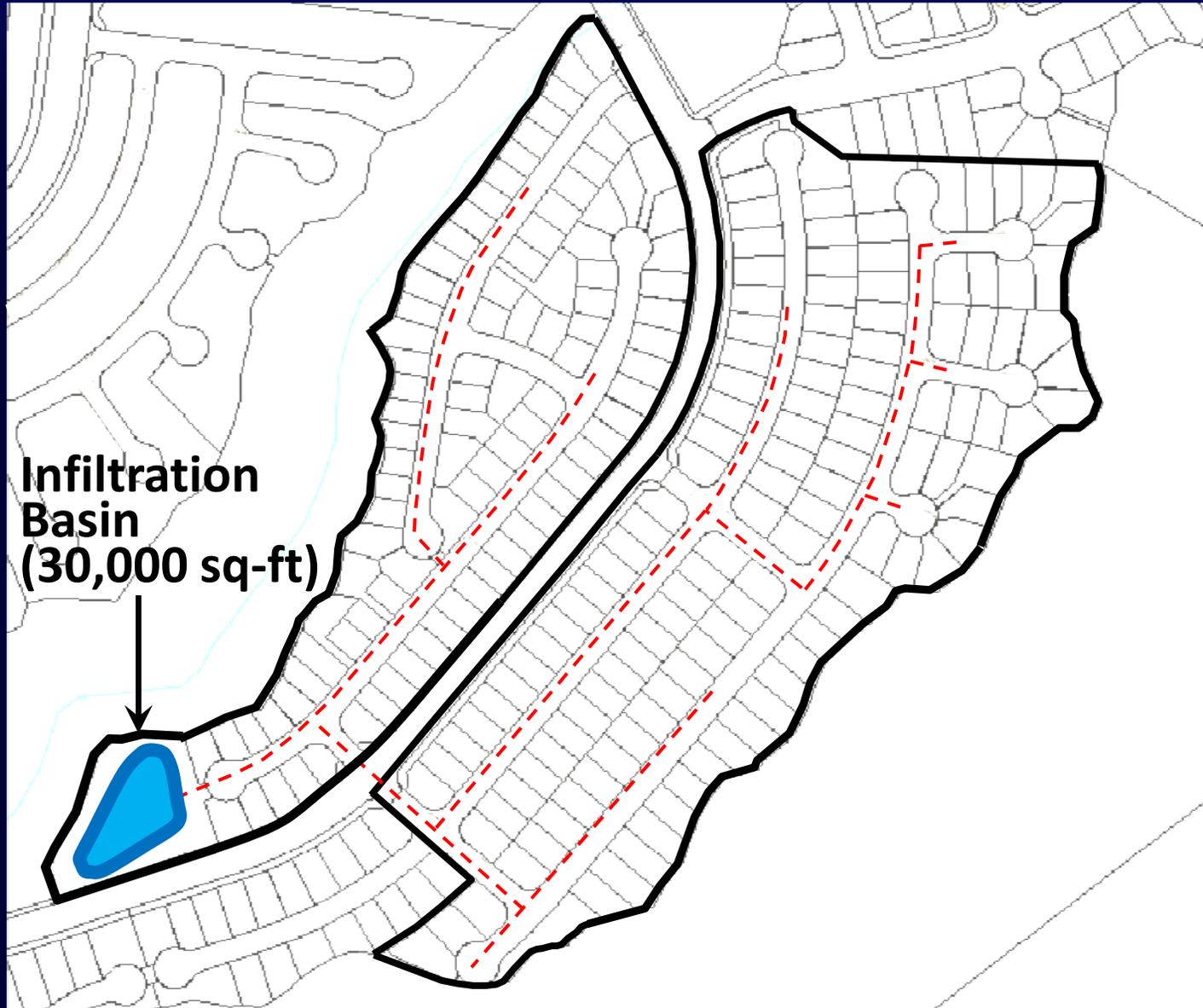
So, retention may be possible...

- An exemption from Retention may not be claimed solely based on infiltration rates. As much of the WQV as possible must be retained unless an exemption is claimed for another reason



37 ACRE RESIDENTIAL DEVELOPMENT

One Possible WQ Management Scheme



37 ACRE RESIDENTIAL DEVELOPMENT

BMP Sizing Worksheet: Infiltration Basin

Project: 37 ac Residential Development Date: Dec-2012

1. Water Quality Volume

- a. BMP Tributary Drainage Area, **A** 37.40 ac
- b. % Impervious Area, **I** 50 %
- c. Water Quality Design Storm Depth, **P** 1.0 in
- d. Volumetric Runoff Coefficient, **C** 0.5
- e. Water Quality Volume, **WQV** 67,881 cu-ft

2. Maximum Storage Depth

- a. Soil Infiltration Rate, **k** (0.5 min) 1.5 in/hr
- b. Infiltration Rate Safety Factor (2 - 5), **F_s** 2
- c. Drawdown Time, **t** 48 hrs
- d. Max. Storage Depth, **d_{max}** 3.0 ft

3. Design Storage Depth

- a. Ponding Depth, **d_p** 3.00 ft

4. Basin Invert Footprint

- b. Reservoir Fill Time, **T** 2 hrs
- c. Min. Bottom Surface Area, **A_b** 21,722 sq-ft

5. BMP Area Requirements

- a. Side Slopes (length per unit height), **z** (3.0 min) 3
- b. Freeboard, **f** (1.0 min) 1 ft
- c. Invert Width, **w_b** 200.0 ft
- d. Invert Length, **l_b** 108.6 ft
- e. Top Width, **w_t** 224.0 ft
- f. Top Length, **l_t** 132.6 ft
- g. Min. Top Surface Area excluding pretreatment, **A_{BMP}** 29,705 sq-ft

BMP Sizing Worksheet: Infiltration Trench

Project: 37 ac Residential Development Date: Dec-2012

1. Water Quality Volume

- a. BMP Tributary Drainage Area, **A** 37.40 ac
- b. % Impervious Area, **I** 50 %
- c. Water Quality Design Storm Depth, **P** 1.0 in
- d. Volumetric Runoff Coefficient, **C** 0.5
- e. Water Quality Volume, **WQV** 67,881 cu-ft

2. Maximum Storage Depth

- a. Soil Infiltration Rate, **k** (0.5 min) 1.5 in/hr
- b. Infiltration Rate Safety Factor (2 - 5), **F_s** 2
- c. Drawdown Time, **t** 48 hrs
- d. Max. Storage Depth, **d_{max}** 3.0 ft

3. Design Storage Depths

- a. Ponding Depth, **d_p** 0.00 ft
- b. Backfill Material (Trench Rock) Thickness, **l_b** 8.00 ft
- c. Sand Layer Thickness, **l_s** 0.5 ft
- d. Backfill Material Porosity, **n_b** 0.35
- e. Sand Porosity, **n_s** 0.40
- f. Total Effective Storage Depth, **d_t** 3.00 ft

4. BMP Area Requirements

- a. Reservoir Fill Time, **T** 2 hrs
- b. Min. Surface Area excluding pretreatment, **A_{BMP}** 21,722 sq-ft



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WQ Management Scheme Comparison

BMP	BMP Qty	Footprint (sq-ft)	Approx. Cost* (\$1000)
Detention Basin <i>(Old Rules)</i>	1	25,000	\$135 - \$270
Infiltration Basin	1	25,000 - 70,000	\$135 - \$270
Infiltration Trench	1	18,000 – 66,000	\$300 - \$1300
Permeable Pavement	10	34,000 – 68,000	\$65 - \$670

* Excludes land acquisition and maintenance



Module Summary



EXAMPLES

- Don't wait until Layout is done to incorporate water quality management scheme
- LID is not always more expensive than non-LID
- More than one LID Retention or LID Biofiltration scheme may work – compare options
- Using the Web Soil Survey is perfectly acceptable, but will result in larger Retention BMPs



EXAMPLES

End of Module 4

