GEOTECHNICAL CONSIDERATIONS FOR STORM WATER MANAGEMENT

Presented by Shawn Foy Weedon
Infiltration is likely infeasible in a large portion of Region 9:

- Southern Orange County
- Southwestern Riverside County
- Western San Diego County
NEW MS4 PERMIT

Yellow Indicates Alluvium – Infiltration Likely Feasible

Green Indicates Soft Rock – Infiltration Likely Infeasible

Red Indicates Strong Rock – Infiltration Infeasible
Technical Infeasibility

Geotechnical conditions that could be affected from required infiltration are:

• Slope stability
• Expansive soil
• Compressible soil
• Seepage
• Loss of pavement and foundation subgrade support
Groundwater Definition:

- Subsurface water that occurs beneath the water table in soils and geologic formations that are not fully saturated.
- Not just “water in the ground”.
- Discharges from the foundations/footing drains are not considered illicit discharges and are still allowed (Page 74 and 75).
- The infiltration BMP needs to be at least 10 feet above GWT. The 10 feet can be reduced if the groundwater does not support beneficial uses and water quality can be maintained (Page 91).
The Offsite mitigation will be an important factor regarding geotechnical conditions.
  • Can provide infiltration areas off-site

Prefer to have maps of each watershed.
  • Map showing the Hydrologic Soil Group
  • Map showing the infiltration categories (Feasible, Likely (In)Feasible, Infeasible)
## HYDROLOGIC SOIL GROUPS

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Soil Group Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.</td>
</tr>
<tr>
<td>B</td>
<td>Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.</td>
</tr>
<tr>
<td>C</td>
<td>Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.</td>
</tr>
<tr>
<td>D</td>
<td>Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.</td>
</tr>
</tbody>
</table>
# Hydrologic Soil Groups

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Soil Group Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>😊</td>
</tr>
<tr>
<td>B</td>
<td>😒</td>
</tr>
<tr>
<td>C</td>
<td>😞</td>
</tr>
<tr>
<td>D</td>
<td>😞</td>
</tr>
</tbody>
</table>
HYDROLOGIC SOIL GROUPS

Legend
- Major Roads
- Incorporated City Bdy
HYDROLOGIC SOIL GROUP
- Hydrologic Group Undefined
- Hydrologic Group A
- Hydrologic Group B
- Hydrologic Group C
- Hydrologic Group D
- No Soil Data
Sample Project
Sample Project

Qudf – Undocumented Fill
Qal – Alluvium
Qc – Colluvium
Kgr – Granitic Rock
Sample Project

Qudf – Undocumented Fill
Qal – Alluvium
Qc – Colluvium
Kgr – Granitic Rock
Sample Project
Geotechnical Study

Desktop Study
  • Report that provides preliminary geologic information and Hydrologic Soil Groups for existing site conditions.

Field Investigation
  • Provides field permeability/percolation testing
    • Double-Ring infiltrometer.
    • Percolation test.
    • In-Situ permeameter.
Double-Ring Infiltrometer

ASTM D 3385
- Only works on sandy soil
- Heavy and cumbersome
- About 1 test per day
- Need a lot of water (50 gallons)
- Results in a value but is an index test
- Only a vertical infiltration
Percolation Tests

County of San Diego Standard
• 24 hour pre-saturation required
• At least 4 hours to run test
• Need a lot of water
Permeability Tests

Borehole Permeameter

• Aardvark
• 30 to 45 minutes per test
• Do not need a lot of water
• Results in hydraulic conductivity value
• Can perform test up to 50 feet deep
Today’s Discussion

• Permit Requirements & Applicability of Harvest & Re-Use to Municipal Projects
• Design Process
• Case Study
• Wrap Up, Q&A
Applicability of “Priority Development” to Municipal Public Works

- Order R9-2013-001, Section E.3.b.(1) Definition of Priority Development
  - New development projects that create 10,000 square feet or more of impervious surfaces. Includes public development projects on public or private land.
  - Redevelopment projects that create and/or replace 5,000 square feet or more of impervious surface. This includes public development projects on public or private land.
  - New and redevelopment projects that create 5,000 square feet or more of impervious surface and support the following:
    - Streets, roads, highways, freeways, and driveways.
  - New or redevelopment projects that create or replace 2,500 square feet or more of impervious surface (collectively over the entire project site), and discharging directly to an Environmentally Sensitive Area (ESA).
  - New or redevelopment projects that result in the disturbance of one or more acres of land and are expected to generate pollutants post construction.
Exemption of PDP Standards to Municipal Public Works

• New or retrofit paved sidewalks, bicycle lanes, or trails that meet the following criteria:
  – Designed and constructed to direct storm water runoff to adjacent vegetated areas, or other non-erodible permeable areas; OR
  – Designed and constructed to be hydraulically disconnected from paved streets or roads; OR
  – Designed and constructed with permeable pavements or surfaces in accordance with USEPA Green Streets guidance

• Retrofitting or redevelopment of existing paved alleys, streets or roads that are designed and constructed in accordance with the USEPA Green Streets guidance
• Order R9-2013-001, Section E.3.c.(1) Stormwater Pollution Control BMP Requirements

  Each Priority Development Project must be required to implement LID BMPs that are designed to retain (i.e. intercept, store, infiltrate, evaporate, and evapotranspire) onsite the pollutants contained in the volume of storm water runoff produced from a 24-hour 85th percentile storm event (design capture volume)
Design Process: Harvest & Re-Use
Design Process

• Precipitation for the 85th Percentile Storm
  – Refer to Appendix “E” of San Diego County Hydrology Manual
  – General Range Coastal San Diego
    0.60” – 0.65”
  – General Range Inland San Diego
    0.75” - 0.85”
  – General Range Mountain Areas in San Diego
    1.0” – 1.5”
Design Process (Continued)

• DMA Determination
  – For New Construction, It Will Be Dictated By Development Footprint
  – For Redevelopment Refer to “50% Rule” Section E.3.b.(2)
    • Less Than 50% Creation or Replacement of Impervious Structural BMP Requirements Apply Only to New Impervious
    • 50% or Greater, Structural BMP Requirements Apply to Entirety of Development (New & Existing)
Design Process (Continued)

• Precipitation Loss During 85\textsuperscript{th} Percentile Event
  – Rational Method (Easiest, Most Common, Most Conservative). Refer to SDCHM Table 3-1
  – Other Potential Approaches
    • SCS “Curve Number”. Refer to SDHM Tables 4-2 & 4-6
    • Green & Ampt (Continuous Simulation)
    • Calibrated Studies/Gaged Analysis
  – Consider Other BMP Losses (If Applicable), Even Seemingly Nominal Ones!
Design Process (Continued)

• Establish Design Duration
  – For Irrigation Supplement Consider Local Average “Inter Event” Duration (Typically 3-7 Days During Rainy Season)
  – For Non Potable Indoor Use Consider 1-2 Day Minimum

• Quantifying Supply
  – Effective Precipitation (Precipitation Minus All Precipitation Losses) Over DMA
Design Process (Continued)

• Quantify Demand
  – For Irrigation Supplement:
    • Traditional Turf Areas, 1 Inch Per Week
    • “Xeriscaping” & Drought Tolerant Species, 0.25 Inch Per Week
    • Refer Also to WUCOLS Water Use Classification of Landscape Species (UC Berkeley Extension, 1994)
  – For Indoor Non Potable Use Consider 1- 2 Day Minimum (Refer to CPC Chapter 6 Section 601.1)
    • Laundry Estimate at 55 Gallons Per Load (Rule of Thumb)
    • Toilet Estimate at 20 Gallon Per Person Per Day (Rule of Thumb)
Design Process (Continued)

• Quantify Storage
  – Practical Consideration, Should Be At Least Supply Minus Demand Over Design Duration (Use Dependent)
  – Regulatory Requirement, Must Equal Or Exceed Effective Precipitation for 85th Event
Minimum Standards for Harvested Rainwater

<table>
<thead>
<tr>
<th>Application</th>
<th>Min. Treatment</th>
<th>Min. Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car washing</td>
<td>• Debris excluder (1702.9.10)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>• Filtration &lt;100 microns (1702.9.11)</td>
<td></td>
</tr>
<tr>
<td>Non-Spray irrigation:</td>
<td>• Debris excluder (1702.9.10)</td>
<td>N/A</td>
</tr>
<tr>
<td>Surface, subsurface, and drip</td>
<td>• Filtration &lt;100 microns (1702.9.11)</td>
<td></td>
</tr>
<tr>
<td>irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray irrigation:</td>
<td>• Debris excluder (1702.9.10)</td>
<td>N/A</td>
</tr>
<tr>
<td>storage volume &lt; 360 gallons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray irrigation:</td>
<td>• Debris excluder (1702.9.10)</td>
<td>• E-Coli: &lt; 100 CFU / 100 mL</td>
</tr>
<tr>
<td>storage volume ≥ 360 gallons</td>
<td></td>
<td>• Turbidity: &lt; 10 NTU</td>
</tr>
<tr>
<td>Dual-Plumbing:</td>
<td>• Debris excluder (1702.9.10)</td>
<td>• E-Coli: &lt; 100 CFU / 100 mL</td>
</tr>
<tr>
<td>Urinal and Water Closet Flushing,</td>
<td>• Filtration &lt;100 microns (1702.9.11)</td>
<td>• Turbidity: &lt; 10 NTU</td>
</tr>
<tr>
<td>Clothes Washing, and Trap Priming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water features:</td>
<td>• Debris excluder (1702.9.10)</td>
<td>• E-Coli: &lt; 100 CFU / 100 mL</td>
</tr>
<tr>
<td>Ornamental / Decorative fountains</td>
<td>• Filtration &lt;100 microns (1702.9.11)</td>
<td>• Turbidity: &lt; 10 NTU</td>
</tr>
<tr>
<td>Cooling tower make-up water</td>
<td>• Debris excluder (1702.9.10)</td>
<td>• E-Coli: &lt; 100 CFU / 100 mL</td>
</tr>
<tr>
<td></td>
<td>• Filtration &lt;100 microns (1702.9.11)</td>
<td>• Turbidity: &lt; 10 NTU</td>
</tr>
</tbody>
</table>

• Source 2013 California Plumbing Code (1702.9.45)
Design Process (Continued)

• Helpful Unit Conversions & Equations

Convert GPM to CFS - Multiply GPM*0.002228
Convert Gallons to Cubic Feet - Multiply Gallons* 0.13368

Supply \( \text{(inches)} \) = Effective Precipitation_{85th}

Irrigation Demand \( \text{(inches)} \) = Demand Rate\( \frac{\text{inches}}{\text{time}} \) \* Inter Event Time \* \( \frac{\text{Irrigation Demand Area}}{\text{Capture Area}} \)

Storage \( \text{(inches)} \) = Supply(inches) – Irrigation Demand \( \text{(inches)} \)

Storage \( \text{(gallons)} \) = Capture Area \( \text{(square feet)} \) \* \( \frac{\text{Storage (inches)}}{12} \) \* 7.4808
Design Process (Continued)

• Storage Options
  – Concrete and Fiberglass Tanks (Above or Below Ground
  – Modular Systems
  – Above Ground Barrels and Cisterns ( Likely Limited Applicability for CIP Projects)
Design Process (Continued)

• Other Design Details & Considerations
  – Avoidance of Cross Connection with Public Water Supply (Backflow Prevention)
  – Buoyancy Prevention & Anchoring
  – Seismic Design (Above Ground Tanks)
  – Pump Systems & Electric
  – Disinfection
  – Clog Prevention
  – Maintenance
  – Water Rights (Rainwater Capture Act of 2012, AB 1750)
  – Cost (General Rules of Thumb)
    • Traditional Tank Costs $1.50 to $2.00 Gallon
    • Pumps & Appurtenances Additional 10%
Design Process (Continued)

Pre Filtration

Above Ground

Post Filtration

Solar Powered

Replacement Cartridge

Submersible
Design Process (Continued)

Example Purification Package

- Housing
- Filter Bag
- UV Sterilizer
Design Process (Continued)

• Irrigation Demand
  http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf

• General Information
  http://www.rainharvest.com/atlantis-d-raintank-modular-rainwater-storage-system.asp
## Suggested Minimum Maintenance

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspect and clean filter and screens, and replace (if necessary)</td>
<td>Every 3 months</td>
</tr>
<tr>
<td>Inspect and verify that disinfection filters and water quality treatment</td>
<td>In accordance with manufacture's specifications but no less than every 3 months</td>
</tr>
<tr>
<td>devices and systems are operational and maintaining minimum water quality</td>
<td></td>
</tr>
<tr>
<td>requirements as determined by Environmental Health.</td>
<td></td>
</tr>
<tr>
<td>Inspect and clear debris from gutters, downspouts and roof washers</td>
<td>Every 6 months</td>
</tr>
<tr>
<td>Inspect and clear debris from roof or other above-ground collection surface</td>
<td>Every 6 months</td>
</tr>
<tr>
<td>Remove tree branches and vegetation overhanging roof or other above-ground</td>
<td>As needed</td>
</tr>
<tr>
<td>collection surfaces</td>
<td></td>
</tr>
<tr>
<td>Inspect pumps, valves and pressure tanks and verify operation</td>
<td>After initial installation and every 12 months thereafter</td>
</tr>
<tr>
<td>Clear debris for and inspect cistern tanks, locking devises and verify</td>
<td>After initial installation and every 12 months thereafter</td>
</tr>
<tr>
<td>operation</td>
<td></td>
</tr>
<tr>
<td>Inspect caution labels, signage and pipe marking</td>
<td>After initial installation and every 12 months thereafter</td>
</tr>
<tr>
<td>Cross connection test (Dual Plumbing)</td>
<td>After initial installation and every 12 months thereafter</td>
</tr>
</tbody>
</table>
Case Study Cucamonga Valley Water District Frontier Project

Rancho Cucamonga – 70 kilometers east of Los Angeles
Case Study (Continued)

• 0.7 acre development site
  – 14,400 S.F. building
    • Office Space
    • Meeting Facilities
    • Public Demonstration Space
  – Courtyards
  – Walkways & Sidewalks
  – Landscaped Areas
Case Study (Continued)

• Water District Project Goals
  – Sustainable Approach
  – Water Conservation
  – Public Demonstration Space
  – LEED Platinum

• Hydrologic Condition of Concern
  – Does not discharge directly to the MS4
  – Post–development volume must equal pre-development volume for 1-year, 2-year and 5 year frequency storms
Case Study (Continued)
Project Water Quality Objectives

• **Rainwater Harvesting**
  – Meet Water District Goals of:
    • Water Conservation
    • Groundwater Recharge
  – Meet Irrigation Needs
  – Runoff Reductions
  – Pollutant Removal
  – LEED Credits 6.1 & 6.2

• **Low Impact Development**
  – Runoff Reductions
  – Pollutant Removal
  – LEED Credits 6.1 & 6.2
Case Study (Continued)
LID & Water Harvesting Measures

• Green Roof
• Porous Pavement
• Decomposed Granite
• Bioretention/Rain Garden
• Cistern/Rain Tank
• Underground Infiltration Device
Case Study (Continued)

Cistern/ Rain Tank Data

- Xeres
- Capacity 1,600 gallons (6,056 ltrs)
- Irrigation needs
- Cost: $40,000
Wrap Up

• Questions?

• Contact Information

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760.476.9193
rlucera@rbf.com
Prioritizing Development Project
Structural BMP Performance Requirements and Design Examples

Discussing California Regional Water Quality Control Board, San Diego Region Order No. R9-2013-0001 Regional Municipal Separate Storm Sewer System (MS4) Permit for Municipal Copermittees in San Diego County, Orange County & Riverside County

Rick Engineering Company

- Founded in 1955
- Water Resources Division Since 1978
- Storm Water Management for New Development, Redevelopment, and Public Works Projects
  - Requirements of Municipal Storm Water Permits (MS4 Permits) driving storm water management design
Presentation Goal

• Compare development planning structural BMP performance standards of 2013 MS4 Permit to 2007 MS4 Permit

• Use examples to show size of facilities
  o 2007 vs. 2013 standards
  o Treatment only vs. treatment plus flow control
  o New development vs. redevelopment
Example Projects to be Highlighted

• The example projects were previously prepared for a March 2011 APWA BMP Sizing Calculator Training

• The example projects are priority development projects (PDPs)

• New Development (Residential) construction project
  o New construction example will demonstrate the difference between 2007 and 2013 standards for treatment by bioretention (biofiltration)

• Redevelopment (Apartment) project
  o Apartment redevelopment example will demonstrate a difference between 2007 and 2013 standards for hydromodification management that will primarily affect redevelopment projects
Changes to Storm Water Treatment Standards: 2007 to 2013

- 2007:
  - Infiltration or bioretention preferred
  - Filtration and/or extended detention also accepted
  - Can treat and release runoff

- 2013:
  - Implement LID BMP designed to retain onsite 85th percentile runoff (infiltrate, evaporate, evapotranspire, harvest and use)
  - If not feasible to retain runoff on-site, use biofiltration sized with new sizing criteria given in R9-2013-0001
  - If not feasible to retain or use biofiltration, use flow-through treatment control BMPs AND mitigate (off-site) for the design capture volume that was not retained on-site
2013 Storm Water Treatment Standards: MS4 Language

c. PRIORITY DEVELOPMENT PROJECT STRUCTURAL BMP PERFORMANCE REQUIREMENTS

In addition to the BMP requirements listed for all development projects under Provision E.3.a, Priority Development Projects must also implement structural BMPs that conform to performance requirements described below.

(1) Storm Water Pollutant Control BMP Requirements

Each Coperative must require each Priority Development Project to implement onsite structural BMPs to control pollutants in storm water that may be discharged from a project as follows:

(a) Each Priority Development Project must be required to implement LID BMPs that are designed to retain (i.e. intercept, store, infiltrate, evaporate, and evapotranspire) onsite the pollutants contained in the volume of storm water runoff produced from a 24-hour 85th percentile storm event (design capture volume);
2013 Biofiltration Sizing Standards

(i) If a Copermittee determines that implementing BMPs to retain the full design capture volume onsite for a Priority Development Project is not technically feasible, then the Copermittee may allow the Priority Development Project to utilize biofiltration BMPs. Biofiltration BMPs must be designed to have an appropriate hydraulic loading rate to maximize storm water retention and pollutant removal, as well as to prevent erosion, scour, and channeling within the BMP, and must be sized to:

[a] Treat 1.5 times the design capture volume not reliably retained onsite, OR

[b] Treat the design capture volume not reliably retained onsite with a flow-thru design that has a total volume, including pore spaces and pre-filter detention volume, sized to hold at least 0.75 times the portion of the design capture volume not reliably retained onsite.
Changes per 2013 Hydromodification Management Standards

- HMP applicability (or exemption) criteria changed
- No more credit for pre-project impervious areas on-site – calculate HMP facility size based on pre-development condition (not pre-project condition)
  - The apartment redevelopment example will demonstrate this difference
- Avoid critical sediment yield areas (to be defined by Copermittees)
2013 HMP Standards: MS4 Language

(2) Hydromodification Management BMP Requirements

Each Copermittee must require each Priority Development Project to implement onsite BMPs to manage hydromodification that may be caused by storm water runoff discharged from a project as follows:

(a) Post-project runoff conditions (flow rates and durations) must not exceed pre-development runoff conditions by more than 10 percent (for the range of flows that result in increased potential for erosion, or degraded instream habitat downstream of Priority Development Projects).
The following references were used for the example problem calculations:

- APWA BMP Sizing Calculator Training, March 8, 2011, Example 2 & Example 4
- Countywide Model SUSMP, March 25, 2011
- Final Hydromodification Management Plan, March 2011
- San Diego BMP Sizing Calculator Methodology, January 2012
- San Diego County Hydrology Manual, June 2003
- Order No. R9-2013-0001
• Hierarchy of BMP Selection
  o Infiltrate
  o Harvest and Use
  o Biofiltration

• Biofiltration has been selected for this study
  o Flow-based biofiltration will be based on “Bioretention” facility presented in the Countywide Model SUSMP and San Diego BMP Sizing Calculator Methodology
  o Volume-based biofiltration will be based on “Cistern with Bioretention” facility presented in the Countywide Model SUSMP / “Bioretention Plus Cistern” facility presented in San Diego BMP Sizing Calculator Methodology
Countywide Model SUSMP “Bioretention” Facility
(treatment-only)

San Diego BMP Sizing Calculator Methodology
“Bioretention” Facility
(treatment plus flow control)

“Cistern with Bioretention” or “Bioretention Plus Cistern”
(treatment-only or treatment plus flow control)
Example 1 Data

- Pre-project cover: pervious
- Post-project cover: varies as shown on exhibit
- Drainage soil (hydrologic soil type): Type D
- Pre-project slope: 7%
- Rainfall basin (for treatment plus flow control calculations): Oceanside
- 85th percentile precipitation: 0.7 inches
New Development (Residential) Example

• Step 1: Determine effective impervious area
  ○ Runoff factors were determined from the Countywide Model SUSMP

• Step 2: Prepare BMP sizing calculations
  ○ 85th percentile precipitation (volume-based) was determined from the San Diego County Hydrology Manual
  ○ 85th percentile intensity (flow-based) is 0.2 in/hr throughout the San Diego Region
## New Development (Residential) Example

### STEP 1 - Calculation of Effective Impervious Area for New Residential Construction Example

<table>
<thead>
<tr>
<th>Surface</th>
<th>Area (ft²)</th>
<th>Runoff Factor</th>
<th>Effective Impervious Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driveways, Sidewalks, and Roadway: Concrete or Asphalt</td>
<td>8,194</td>
<td>1.0</td>
<td>8,194</td>
</tr>
<tr>
<td>Roofs</td>
<td>19,785</td>
<td>1.0</td>
<td>19,785</td>
</tr>
<tr>
<td>Maintenance Access: Crushed Aggregate</td>
<td>1,546</td>
<td>0.1</td>
<td>155</td>
</tr>
<tr>
<td>Lawns, Park: Landscaping</td>
<td>20,361</td>
<td>0.1</td>
<td>2,036</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49,886</strong></td>
<td></td>
<td><strong>30,170</strong></td>
</tr>
</tbody>
</table>
New Development (Residential) Example

STEP 2 - Size BMP

2007 Treatment-Only Flow-Based Bioretention Sizing Calculation for New Residential Construction Example

Based on March 25, 2011 Countywide Model SUSMP Bioretention Facility

A. Determine required surface area to treat $Q_T$

Treatment-Only Bioretention Sizing Factor = 0.04 (using intensity of 0.2 in/hr and soil mix with 5 in/hr percolation rate)
Multiply the effective impervious area by 0.04 to find the required bioretention surface area:
Treatment-Only Bioretention Required Surface Area = 0.04 * 30,170 ft² = \textbf{1,207 ft}²

B. While not required, let's see what storage volume this yields using a typical treatment-only bioretention cross section*, the volume associated with 1,207 ft² of bioretention surface area is:

\[(1,207 \text{ ft}² * 4'' * (1 \text{ ft} / 12'')) + (1,207 \text{ ft}² * 18'' * (1 \text{ ft} / 12'') * 0.412) = \textbf{1,148 ft}³\]

*Assumes 4 inch ponding depth and 18 inch depth of bioretention soil mix with porosity = 0.412.
Incidental volume within gravel surrounding the underdrain has not been included in this calculation.
2013 Treatment-Only Flow-Based Biofiltration Sizing Calculation for New Residential Construction Example
Based on March 25, 2011 Countywide Model SUSMP Bioretention Facility

A. Size per 2007 flow-based parameters:
As shown in the calculation above for 2007 Treatment-Only Flow-Based Bioretention Sizing,
Treatment-Only Bioretention Required Surface Area = 0.04 * 30,170 ft² = 1,207 ft²
The associated volume is 1,148 ft³ for the cross section discussed above.

B. Check that the volume is greater than or equal to 75% of the Design Capture Volume:

B1 - Determine 85th Percentile Volume Calculation for New Residential Construction Example
The 85th Percentile Volume is the "Design Capture Volume" or "DCV"
85th Percentile Precipitation = 0.7 inches
85th Percentile Volume = (0.7 inches / 12 inches per foot) * 30,170 ft² = 1,760 ft³

B2 - Calculate 75% of Design Capture Volume = 1,320 ft³
1,148 ft³ storage volume (per above calculation) < 1320 ft³; therefore, the size must be increased to meet the volume requirement.

B3 - Determine the surface area (A) needed to provide 1,320 ft³ of bioretention volume for the same cross section used above:
(A ft² * 4" * (1 ft / 12")) + (A ft² * 18" * (1 ft / 12") * 0.412) = 1,320 ft³
A * 0.333 + A * 0.618 = 1,320
A = 1,388 ft² (as compared to 1,207 ft² from a 4% sizing criteria)

Note: the purpose of this example is to compare the surface area for the same cross section to show the increased size.
There are other ways to increase the volume without increasing the surface area, such as thickening the bioretention soil layer, adding a gravel layer below the bioretention soil layer, or increasing depth of surface ponding (as feasible considering public safety and surface drawdown time).
# New Development (Residential) Example


Based on Bioretention Facility described in January 2012 San Diego BMP Sizing Calculator Methodology

For Low Flow Threshold = 0.1Q2, Rain Gage = Oceanside, Slope = Moderate, and Soil Type = D

<table>
<thead>
<tr>
<th>Description</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention Surface Area Sizing Factor</td>
<td>0.13</td>
</tr>
<tr>
<td>Volume V1 Sizing Factor</td>
<td>0.1083</td>
</tr>
<tr>
<td>Volume V2 Sizing Factor</td>
<td>0.0780</td>
</tr>
</tbody>
</table>

Effective Impervious Area = 30,170 ft²

Required Bioretention Surface Area = 0.13 * 30,170 ft² = **3,922 ft²**

HMP Volume Required/Provided

<table>
<thead>
<tr>
<th>Volume V1</th>
<th>Volume V2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1083 * 30,170 ft² = 3,267 ft³</td>
<td>0.0780 * 30,170 ft² = 2,353 ft³</td>
</tr>
</tbody>
</table>

Volume V1 corresponds to 10" surface ponding: (10" / (12" / 1 ft)) * 3,922 ft² = 3,268 ft³

Volume V2 corresponds to 18" gravel layer at 0.400 porosity: (18" / (12" / 1 ft)) * 0.400 * 3,922 ft² = 2,353 ft³

Storage Volume = V1 plus V2 = 3,267 ft³ + 2,353 ft³ = **5,620 ft³**
### New Development (Residential) Example

#### Summary of Flow-Based Sizing Results for New Residential Construction Example

<table>
<thead>
<tr>
<th>Design Method</th>
<th>Bioretention Surface Area (ft²)</th>
<th>Bioretention Storage Volume (ft³)</th>
<th>Total BMP Volume* (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 Treatment-Only Flow-Based Design (Based on Bioretention Facility)</td>
<td>1,207</td>
<td>1,148</td>
<td>2,213</td>
</tr>
<tr>
<td>2013 Treatment-Only Flow-Based Design (Based on Bioretention Facility)</td>
<td>1,388</td>
<td>1,320</td>
<td>2,545</td>
</tr>
<tr>
<td>2007 Treatment Plus Flow Control HMP Design (Based on Bioretention Facility)</td>
<td>3,922</td>
<td>5,620</td>
<td>18,956</td>
</tr>
<tr>
<td>2013 Treatment Plus Flow Control HMP Design (Based on Bioretention Facility)</td>
<td>3,922</td>
<td>5,620</td>
<td>18,956</td>
</tr>
</tbody>
</table>

*Total BMP volume represents the actual volume of the pit to be excavated for the BMP (i.e., the surface area multiplied by the total depth of the cross section, except conveyance for larger storm events and freeboard was not included). In all cases, vertical sides were assumed for simplicity.
New Development (Residential) Example - Bioretention

- Bioretention w/ Flow Control
- Bioretention in Island
- Bioretention w/ Infiltration
- Bioretention in Hardscape
New Development (Residential) Example

2007 Treatment-Only Volume-Based Bioretention Sizing Calculation for New Residential Construction Example
Based on March 25, 2011 Countywide Model SUSMP Cistern with Bioretention Facility

Design Capture Volume = 85th Percentile Volume = 1,760 ft³

The volume to be treated must be processed by the bioretention system in 24 hours.
Assume that the bioretention soil is the limiting factor in processing the treatable volume.

1760 ft³ / (24 hours * 3,600 seconds per hour) = 0.02 cfs average outflow
For this example, assume the maximum outflow rate = 2 x average outflow rate = 0.04 cfs
The actual maximum outflow rate should be determined based on the maximum expected depth in the cistern.

For bioretention soil with 5”/hour percolation rate, find the surface area necessary to process 0.04 cfs

(5” / hour) * (1’ / 12”) * (1 hr / 3,600 s) * (A ft²) = 0.04 cfs
Required surface area = 346 ft²

Cistern storage volume = 1,760 ft³
2013 Treatment-Only Volume-Based Biofiltration Sizing Calculation for New Residential Construction Example

Based on March 25, 2011 Countywide Model SUSMP Cistern with Bioretention Facility

Increasing sizing to capture 150% of the Design Capture Volume

Design Capture Volume = 85th Percentile Volume = 1,760 ft³
150% of Design Capture Volume = 2,640 ft³

The volume to be treated should be processed by the bioretention system in 24 hours.

2,640 ft³ / (24 hours * 3,600 seconds per hour) = 0.03 cfs average outflow rate
Assume maximum outflow rate = 2 * average outflow rate = 0.06 cfs
The actual maximum outflow rate should be determined based on the maximum expected depth in the cistern.

For bioretention soil with 5"/hour percolation rate, find the surface area necessary to process 0.06 cfs

(5" / hour) * (1' / 12") * (1 hr / 3,600 s) * (A ft²) = 0.06 cfs
Required surface area = 518 ft²

Cistern storage volume = 2,640 ft³
New Development (Residential) Example

2007 & 2013 Treatment Plus Flow Control Cistern with Bioretention Sizing Calculation for New Residential Construction Example

Based on Bioretention Plus Cistern Facility described in January 2012 San Diego BMP Sizing Calculator Methodology

For Low Flow Threshold = 0.1Q2, Rain Gage = Oceanside, Slope = Moderate, and Soil Type = D
Volume V1 Sizing Factor = 0.200
Bioretention Surface Area Sizing Factor = 0.02

Effective Impervious Area = 30,170 ft²

Volume V1 = 0.200 * 30,170 ft² = 6,034 ft³
Volume V1 = Cistern Volume

Required Bioretention Surface Area = 0.02 * 30,170 ft² = 603 ft²
# New Development (Residential) Example

## Summary of Volume-Based Sizing Results for New Residential Construction Example

<table>
<thead>
<tr>
<th>Design</th>
<th>Cistern Volume (ft³)</th>
<th>Bioretention Surface Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 Treatment-Only Volume-Based Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Based on Cistern with Bioretention Facility)</td>
<td>1,760</td>
<td>346</td>
</tr>
<tr>
<td>2013 Treatment-Only Volume-Based Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Based on Cistern with Bioretention Facility)</td>
<td>2,640</td>
<td>518</td>
</tr>
<tr>
<td>2007 Treatment Plus Flow Control HMP Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Based on Bioretention Plus Cistern Facility)</td>
<td>6,034</td>
<td>603*</td>
</tr>
<tr>
<td>2013 Treatment Plus Flow Control HMP Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Based on Bioretention Plus Cistern Facility)</td>
<td>6,034</td>
<td>603*</td>
</tr>
</tbody>
</table>

*For the HMP facility, the outflow rate is controlled by the HMP requirements and the cistern may take longer than 24 hours to drain.*
New Development (Residential) Example - Cistern to Bioretention

- Underground Cistern
- Park Above Cistern
- Bioretention Area
Redevelopment (Apartment) Example

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SAN DIEGO, CA 92110
619.291.0707
(FAX)619.291.4165

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Example 2 Data

- Pre-project cover: pervious and impervious as shown on exhibit
- Post-project cover: varies as shown on exhibit
- Drainage soil (hydrologic soil type): Type D
- Pre-project slope: 1%
- Rainfall basin (for treatment plus flow control calculations): Lindbergh Field
- 85th percentile precipitation: 0.6 inches
## Redevelopment (Apartment) Example

### Calculation of Effective Impervious Area for Apartment Redevelopment Example

<table>
<thead>
<tr>
<th>Surface</th>
<th>Area (ft²)</th>
<th>Runoff Factor</th>
<th>Effective Impervious Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofs</td>
<td>11,163</td>
<td>1.0</td>
<td>11,163</td>
</tr>
<tr>
<td>Total*</td>
<td>11,163</td>
<td></td>
<td>11,163</td>
</tr>
</tbody>
</table>

*Only the roof area will be processed for treatment and flow control. The lawn can be designed as self-treating.
## Summary of Flow-Based Sizing Results for Apartment Redevelopment Example

<table>
<thead>
<tr>
<th>Design Method</th>
<th>Bioretention Surface Area (ft²)</th>
<th>Bioretention Storage Volume (ft³)</th>
<th>Total BMP Volume* (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 Treatment-Only Flow-Based Design (Based on Bioretention Facility)</td>
<td>447</td>
<td>425</td>
<td>820</td>
</tr>
<tr>
<td>2013 Treatment-Only Flow-Based Design (Based on Bioretention Facility)</td>
<td>447</td>
<td>425 &gt; 0.75*DCV (DCV = 558)</td>
<td>820</td>
</tr>
<tr>
<td>2007 Treatment Plus Flow Control HMP Design (Based on Bioretention Facility)</td>
<td>627</td>
<td>899</td>
<td>3,031</td>
</tr>
<tr>
<td>2013 Treatment Plus Flow Control HMP Design (Based on Bioretention Facility)</td>
<td>1,786</td>
<td>2,560</td>
<td>8,632</td>
</tr>
</tbody>
</table>

*Total BMP volume represents the actual volume of the pit to be excavated for the BMP (i.e., the surface area multiplied by the total depth of the cross section, except freeboard was not included). In all cases, vertical sides were assumed for simplicity.

**NOTE:** The treatment-only bioretention facility size did not increase from 2007 to 2013 due to the relatively low 85th percentile rainfall (0.6 inches) resulting in a low design capture volume (DCV). For this case, the 2007 treatment-only bioretention facility contained more than 75% of the DCV (425 ft³ > 0.75*558 ft³) and did not require additional volume.
### Summary of Volume-Based Sizing Results for Apartment Redevelopment Example

<table>
<thead>
<tr>
<th>Design</th>
<th>Cistern Volume (ft³)</th>
<th>Bioretention Surface Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 Treatment-Only Volume-Based Design</td>
<td>558 ( = DCV)</td>
<td>112</td>
</tr>
<tr>
<td>(Based on Cistern with Bioretention Facility)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 Treatment-Only Volume-Based Design</td>
<td>837 ( = 1.5 * DCV)</td>
<td>173</td>
</tr>
<tr>
<td>(Based on Cistern with Bioretention Facility)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007 Treatment Plus Flow Control HMP Design</td>
<td>1,019</td>
<td>78*</td>
</tr>
<tr>
<td>(Based on Bioretention Plus Cistern Facility)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 Treatment Plus Flow Control HMP Design</td>
<td>2,945</td>
<td>227*</td>
</tr>
<tr>
<td>(Based on Bioretention Plus Cistern Facility)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For the HMP facility, the outflow rate is controlled by the HMP requirements and the cistern may take longer than 24 hours to drain.*
Summary of Results: Treatment-Only Sizing

• Treatment-only flow-based sizing changes:
  o Generally the 2013 biofiltration volume will be slightly increased from the 2007 volume in order to meet the 75% design capture volume (DCV) storage requirement, except in cases where the 85th percentile precipitation is low and results in a low DCV. The area (square footage) footprint may or may not increase depending on selected cross section depth.

• Treatment-only volume-based sizing changes:
  o The 2013 cistern volume is increased by 150% compared to the 2007 cistern, and the 2013 biofilter size is increased due to increased outflow from the larger cistern, assuming the cistern needs to drain in 24 hours in either case.

• The differences in treatment-only sizing apply to both new development and redevelopment projects
Conclusion

Example Treatment-Only Bioretention Detail

PLANTS APPROPRIATE TO CLIMATE AND WELL DRAINED SOIL

FREEBOARD

PONDING MINIMUM

STONE INLET APRON 1 FOOT SQUARE OR LARGER

TOP/RIM OF BASIN

EMERGENCY SPILLWAY

OPTIONAL LANDSCAPE MULCH LAYER 0”-3” TYPICAL

OUTLET PIPE

PERFORATED PIPE (UNDERDRAIN) 4” MINIMUM

NO FILTER FABRIC OR IMPERMEABLE LINER ON BOTTOM OR SOIL/GRAVEL INTERFACE

ENGINEERED SOIL MIX/ GROWING MEDIA 18” MINIMUM

MINIMUM 6” DIAMETER OBSERVATION/CLEANOUT STANDPIPE

GRAVEL DRAINAGE LAYER MINIMUM 3” AROUND ENTIRE UNDERDRAIN

SECTION B
NOT TO SCALE
Summary of Results: Treatment Plus Flow Control Sizing

• Treatment plus flow control facilities:
  o Treatment plus flow control facilities are much larger than treatment-only facilities and easily meet the 2013 treatment requirements on either a flow or volume basis with no change compared to 2007.
  o There are no changes to hydromodification flow control design for new development projects, therefore the 2013 treatment plus flow control facility is the same size as the 2007 treatment plus flow control facility for the new development example.
  o For the redevelopment project, the 2013 treatment plus flow control facility is larger than the 2007 treatment plus flow control facility due to the new requirement to consider pre-development conditions instead of pre-project conditions.

• The difference in treatment plus flow control sizing applies to redevelopment projects only (i.e. – no change to HMP sizing criteria for New Development, only potential elimination of exemptions as described in prior presentations).
Conclusion

Example Treatment Plus Flow Control Bioretention Detail

CASE STUDY

TOP/RIM OF BASIN
PLANTS APPROPRIATE TO CLIMATE AND WELL DRAINED SOIL
STONE INLET APRON 1 FOOT SQUARE OR LARGER
FREEBOARD
TOP/RIM OF BASIN
INLET PIPE
EMERGENCY SPILLWAY
NATIVE SOIL: C OR D
OPTIONAL LANDSCAPE MULCH LAYER 0”-3” TYPICAL
4” TO 6” REVEAL (DROP) BETWEEN THE INLET AND ENGINEERED SOIL MIX ELEVATIONS
ENGINEERED SOIL MIX/GROWING MEDIA 18” MINIMUM
MINIMUM 6” DIAMETER OBSERVATION/CLEANOUT STANDPIPE
GRAVEL STORAGE/DRAINAGE LAYER
16” ACTIVE STORAGE
12” DEAD STORAGE
30” TOTAL
OUTLET PIPE
UNDERDRAIN END CAP WITH LOW FLOW ORIFICE FLOWLINE OF ORIFICE AT 18” BELOW INTERFACE OF ENGINEERED SOIL MIX AND GRAVEL STORAGE/DRAINAGE LAYER
NO FILTER FABRIC OR IMPERMEABLE LINER ON BOTTOM OR SOIL/GRAVEL INTERFACE
D-1
PERFORATED PIPE (UNDERDRAIN) 4” MINIMUM
SECTION D
NOT TO SCALE

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Questions?