C.3 Workshop – Track 2:
Sizing Calculations and Design Considerations for LID Treatment Measures

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Presentation Overview

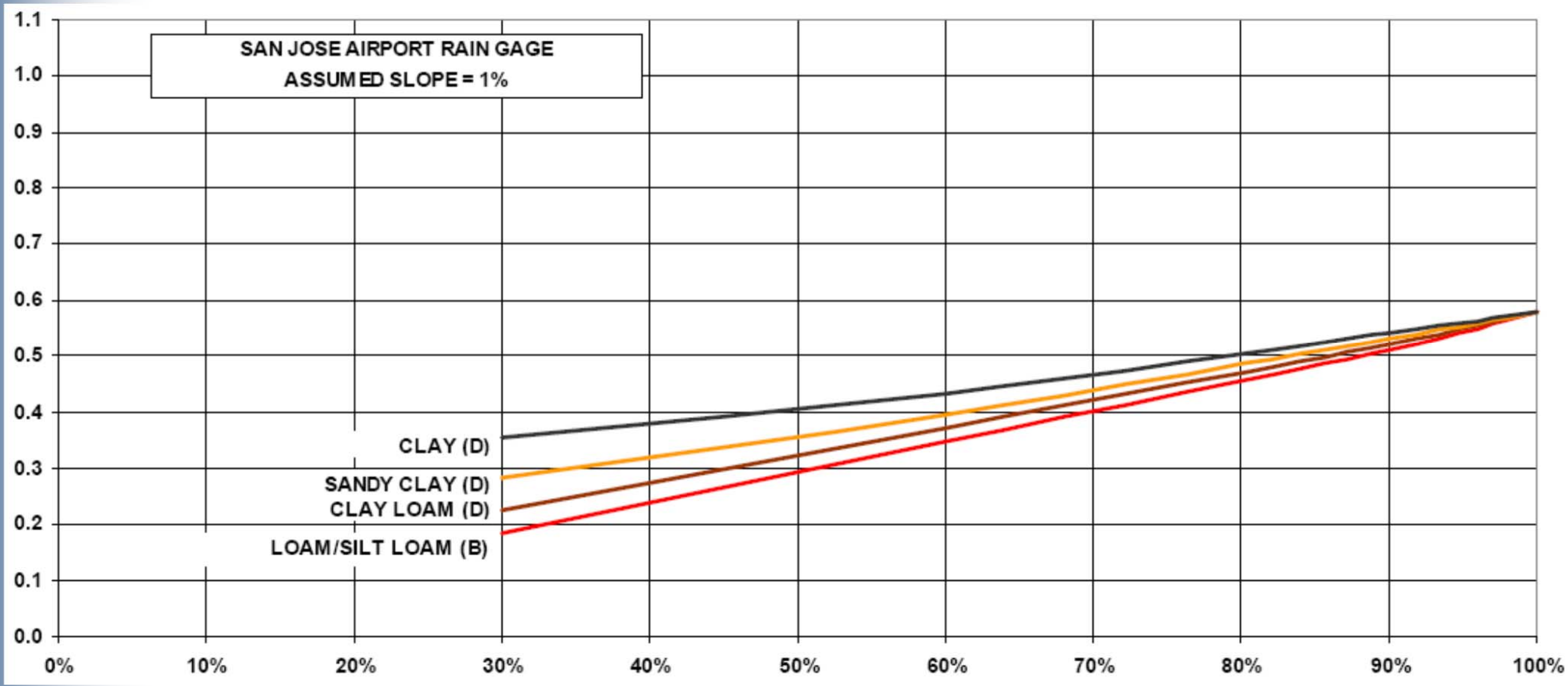
- Determining Water Quality Design Flow and Volume ("Q_{BMP}" and "V_{BMP}")
- Sizing Bioretention and Flow-Through Planters
- Sizing Pervious Paving and Infiltration Trenches
- Sizing Rainwater Harvesting Cisterns
- Sizing Non-LID Components

C.3.d Sizing Criteria

- Volume-based sizing criteria:
  - URQM Method - use formula and volume capture coefficients in "Urban Runoff Quality Management", WEF/ASCE MOP No. 23 (1998), pages 175-178
  - CASQA BMP Handbook Method - Determine volume equal to 80% of the annual runoff, using methodology in Appendix D of the CASQA BMP Handbook (2003) using local rainfall data
    - **Sizing curves specific to Santa Clara Valley provided in Appendix B of C.3 Handbook**

Unit Basin Storage Volume for 80% Capture (inches)

San Jose Rain Gage, 1% Slope



Percent Imperviousness

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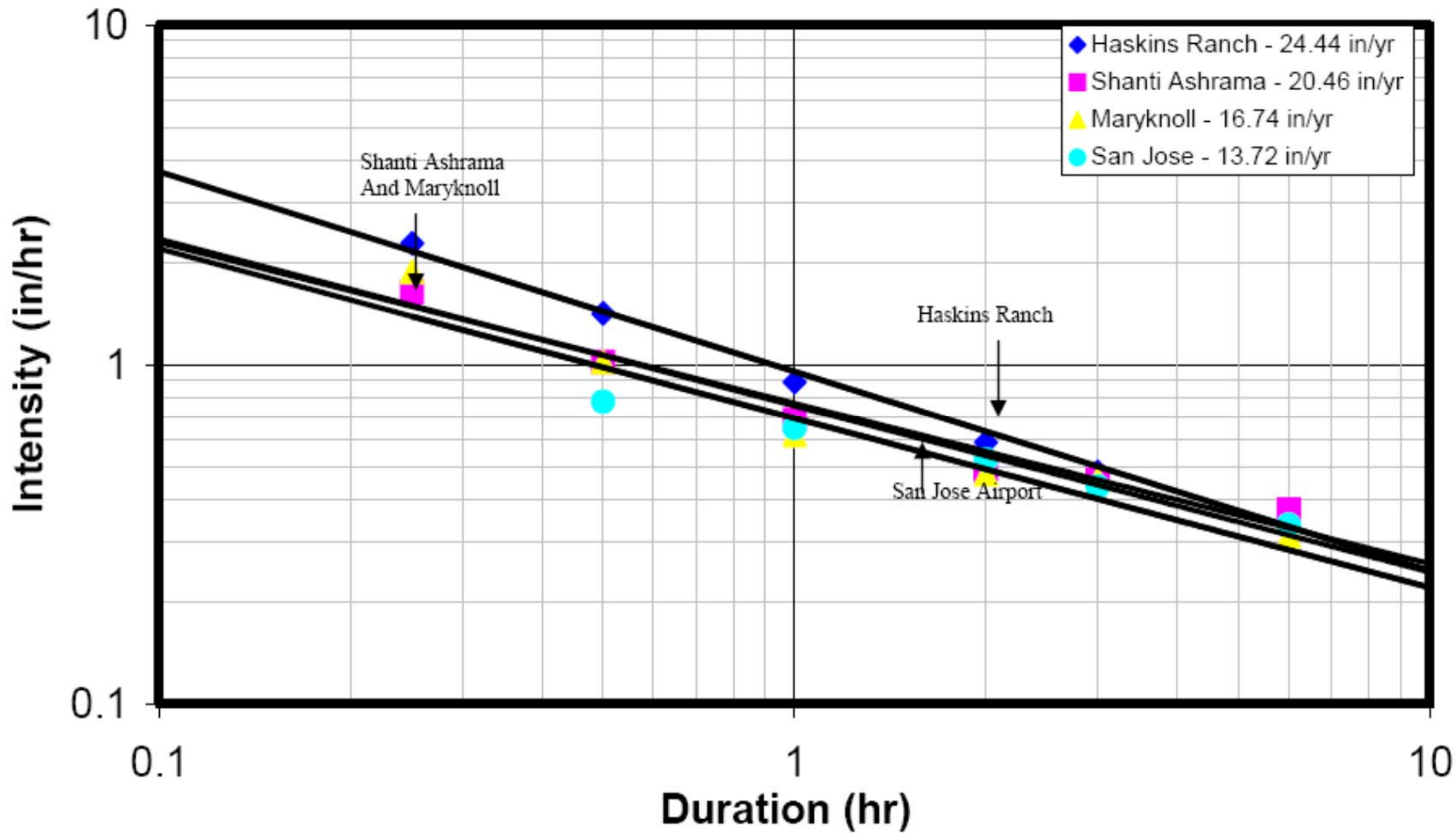
C.3.d Sizing Criteria

- Flow-based sizing criteria:
  - Factored Flood Flow - 10% of the 50-year peak flow rate, determined using Intensity-Duration-Frequency curves published by the local flood control agency
  - Percentile Rainfall Intensity - Flow of runoff produced by a rain event equal to two times the 85th percentile hourly rainfall intensity
    - **Data for Santa Clara Valley rain gages in Sizing Worksheets (Appendix B of C.3 Handbook)**
  - **Uniform Intensity - Flow of runoff resulting from a rain event equal to 0.2 inches per hour intensity**

Intensity-Duration-Frequency Curve (50-Year Return Period)



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C.3.d Sizing Criteria

- 85th Percentile Rainfall Intensity Data:

Reference Rain Gages	85th Percentile Hourly Rainfall Intensity (in/hr)	Design Rainfall Intensity (in/hr)*
San Jose Airport	0.087	0.17
Palo Alto	0.096	0.19
Morgan Hill	0.12	0.24

*Design rainfall intensity = 2 X 85th percentile hourly rainfall intensity

- By comparison, Uniform Intensity = 0.2 in/hr

C.3.d Sizing Criteria

- Flow-based sizing criteria:
  - Simplified Sizing Approach – Variation of Uniform Intensity Method (0.2 in/hr)
    - The surface area of a biotreatment measure is sized to be 4% of the contributing impervious area
    - Based on a runoff inflow of 0.2 in/hr (assume equal to the rainfall intensity), with an infiltration rate through the biotreatment soil of 5 in/hr

      $$(0.2 \text{ in/hr} \div 5 \text{ in/hr} = 0.04)$$

    - Conservative approach because does not account for surface ponding – good for planning purposes

C.3.d Sizing Criteria

- Combination Flow & Volume Design Basis:
  - Treatment systems can be sized to treat "at least 80% of total runoff over the life of the project"
  - Option 1: Use a continuous simulation hydrologic model (typically not done for treatment measures)
  - Option 2: Show how treatment measure sizing meets both flow and volume-based criteria
    - Used for bioretention and flow-through planters
    - Appropriate where drainage area is mostly impervious

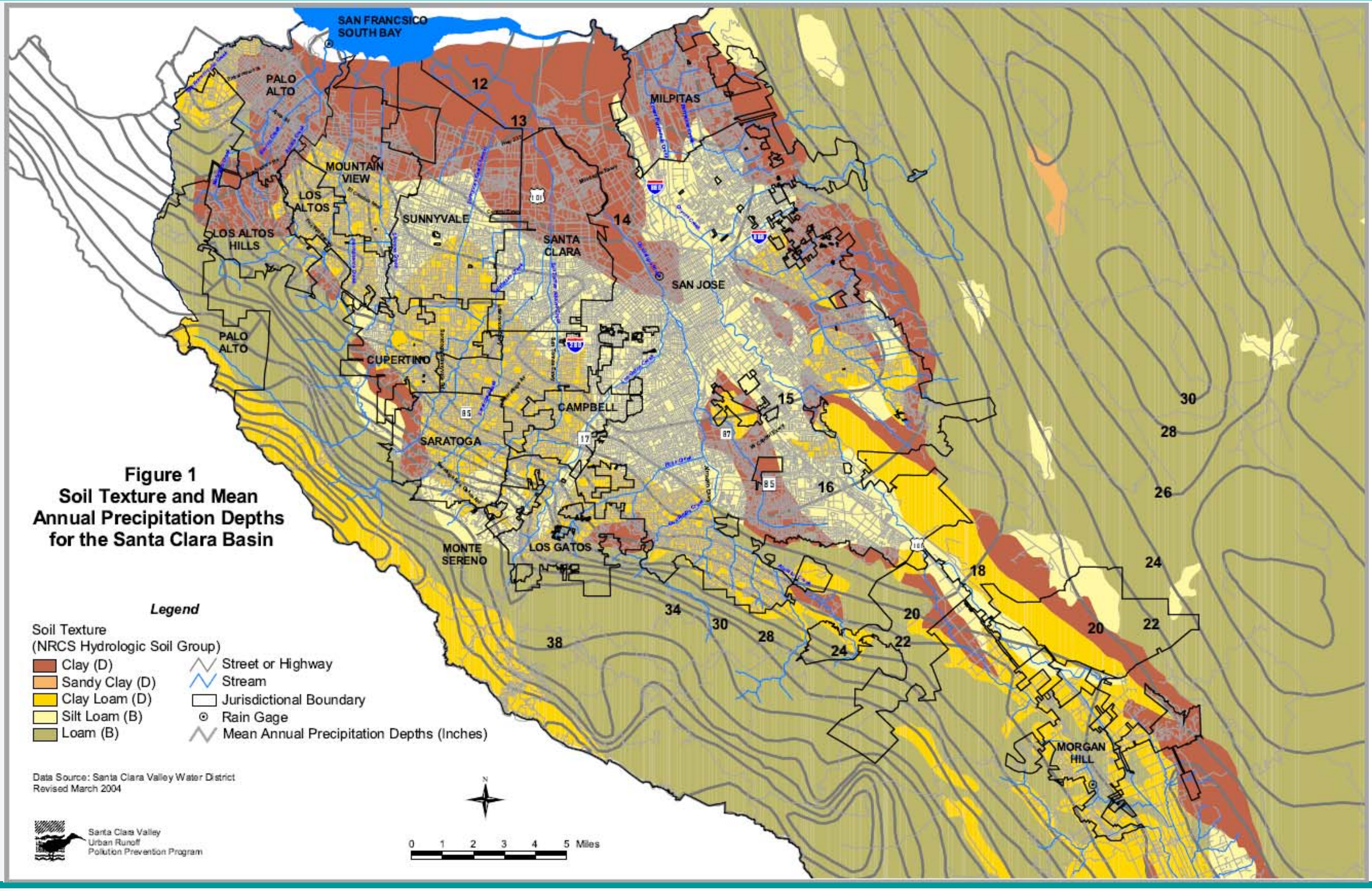
Flow- or Volume-Based Sizing for Treatment Measures?

Table 5-1 Flow and Volume Based Treatment Measure Sizing Criteria		
Type of Treatment Measure	**LID?**	**Hydraulic Sizing Criteria**
Bioretention area	Yes	Flow- or volume-based or combination
Flow-through planter box	Yes	Flow- or volume-based or combination
Tree well filter	Yes	Flow-based
Infiltration trench	Yes	Volume-based
Subsurface infiltration system	Yes	Volume-based
Rainwater harvesting and use	Yes	Volume-based
Media filter	No	Flow-based
Extended detention basin	No	Volume-based

Sizing Criteria Worksheets

- Appendix B of SCVURPPP C.3 Handbook
  - Worksheets for determining water quality design flow and volume
  - Figure B-1: Soil Texture and Mean Annual Precipitation (MAP) Depths
  - Figures B-2 – B-7: Unit Basin Storage Volume for 80% Capture (3 gages, 1% and 15% slopes)
  - Figure B-8: Intensity-Duration-Frequency Curves for 50-year Return Period (4 gages)

Figure B-1: Soil Texture and Mean Annual Precipitation (MAP) Depth



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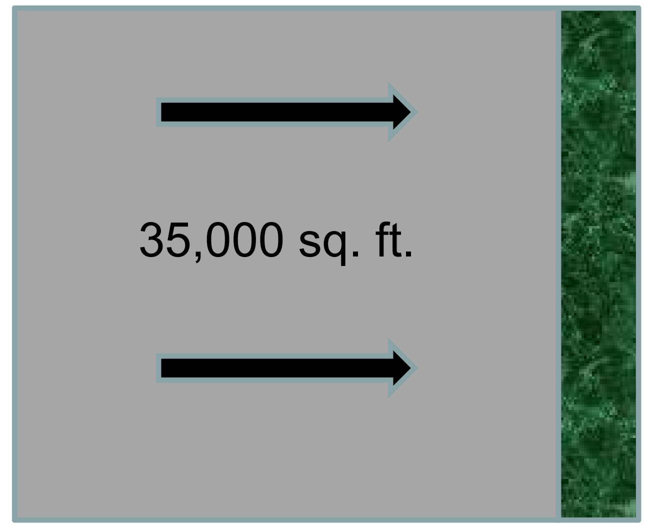
Sizing Example #1

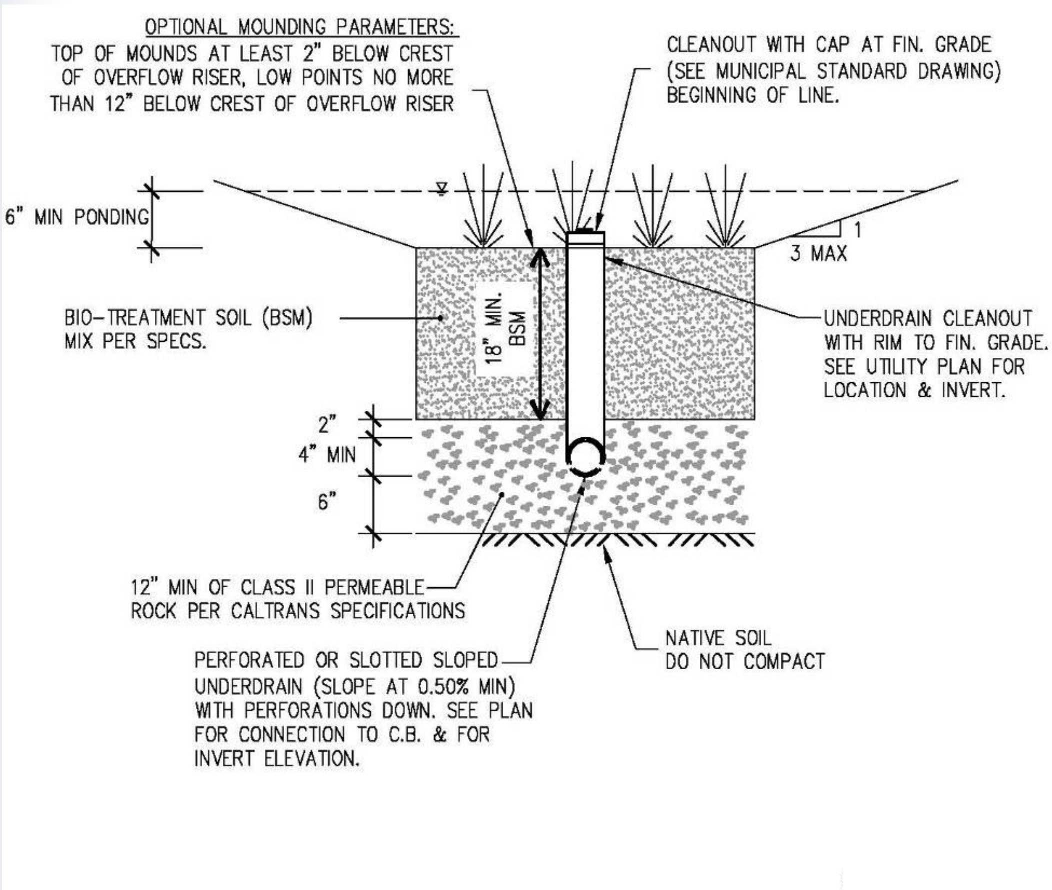
- Parking lot in Santa Clara
  - Area = 35,000 sq. ft. (0.80 acres)
  - 100% impervious
  - Slope = 1%
  - Mean annual precipitation (MAP) = 15 inches
- Use the sizing worksheets to determine $\mathbf{Q_{BMP}}$ and $\mathbf{V_{BMP}}$
- **Answer: V_{BMP} = 1,819 cu. ft.; Q_{BMP} = 0.103 cfs**

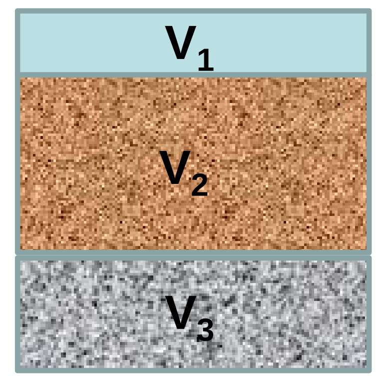


Sizing Bioretention Facilities

- Simplified Sizing Approach
  - Surface area is 4% of contributing impervious area
  - Does not consider storage in surface ponding area
- Volume Based Approach
  - Store $\mathbf{V_{BMP}}$ in just surface ponding area
  - Store $\mathbf{V_{BMP}}$ in ponding area, soil media & drain rock
- Combination Flow and Volume Approach
  - Compute both $\mathbf{Q_{BMP}}$ and $\mathbf{V_{BMP}}$
  - Route through facility, allowing ponding

Sizing Bioretention Facilities: Volume-Based Approach





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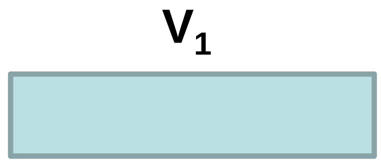
Sizing Bioretention Facilities: Volume-Based Approach

Method 1: Store entire volume in surface ponding area

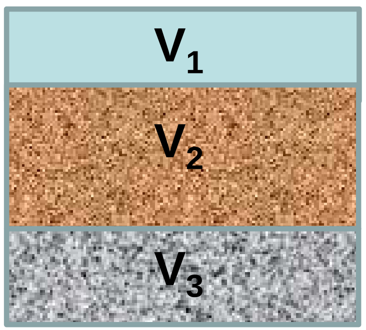


Depth (ft)	Porosity	Volume per sq. ft. (cubic feet)
0.5	1.0	0.5

Surface Area = $\mathbf{V_{BMP}}$ (cu.ft.) ÷ 0.5 cu.ft./sq.ft.

Sizing Bioretention Facilities: Volume-Based Approach

Method 2: Store volume in ponding area and media



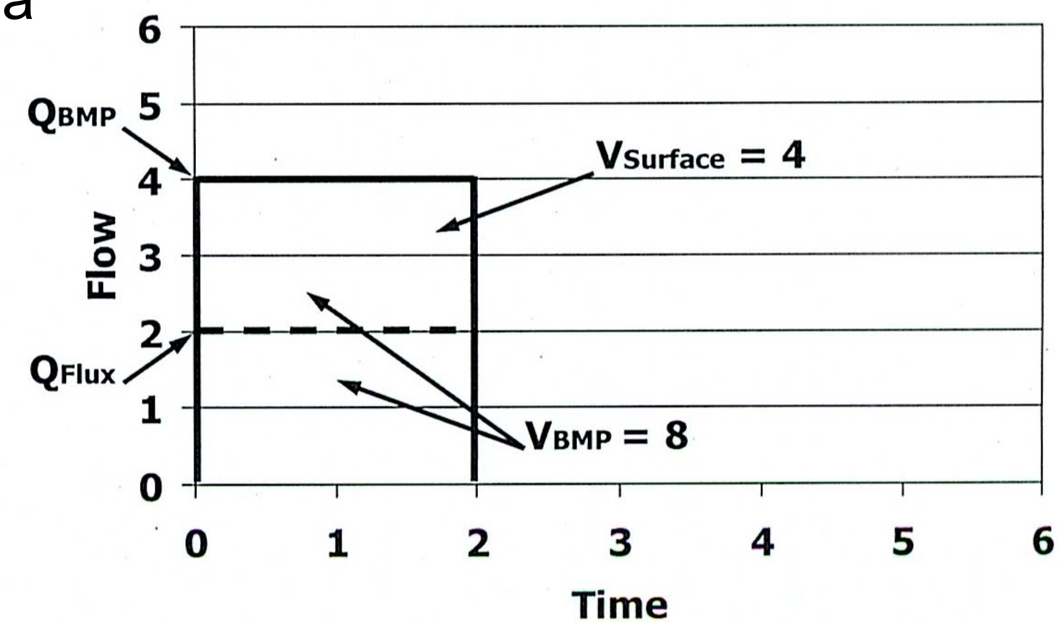
Depth (ft)	Porosity	Volume per sq. ft. (cubic feet)
0.5	1.0	0.5
1.5	0.30	0.45
0.5*	0.40	0.20
	Total	1.15

*Depth below bottom of underdrain

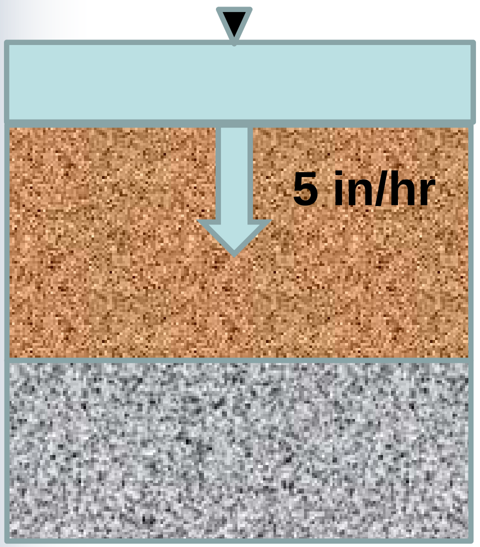
Surface Area = $\mathbf{V_{BMP}}$ (cu.ft.) ÷ 1.15 cu.ft./sq.ft.

Sizing Bioretention Facilities: Flow & Volume Approach

- "Hydrograph Approach"
  - Runoff is routed through the treatment measure
  - Assume rectangular hydrograph that meets both flow and volume criteria

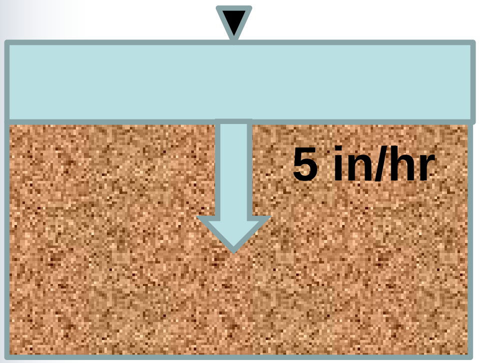


Sizing Bioretention Facilities: Flow & Volume Approach



- Determine V_{BMP}
- Assume constant rainfall intensity of 0.2 in/hr continues throughout the storm (rectangular hydrograph)
- Calculate the duration of the storm by dividing the Unit Basin Storage by the rainfall intensity
- Calculate the volume of runoff that filters through the biotreatment soil at a rate of 5 in/hr over the duration of the storm and the volume that remains on the surface

Sizing Bioretention Facilities: Flow & Volume Approach



- To start the calculation, you have to assume a surface area "A_S" -- use 3% of the contributing impervious area as a first guess
- Determine volume of treated water "V_T" during storm:

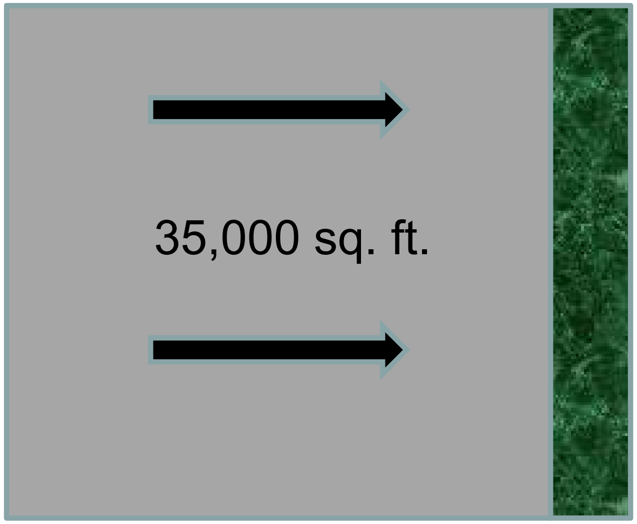
  $V_T = A_S \times 5 \text{ in/hr} \times \text{duration (hrs)} \times 1 \text{ in/12 ft}$
- Determine volume remaining on the surface "V_S":

  $V_S = V_{BMP} - V_T$
- Determine depth "D" of ponding on the surface:

  $D = V_S \div A_S$
- Repeat until depth is approximately 6 inches

Sizing Example #1, continued

- Parking lot in Santa Clara
  - Area = 35,000 sq. ft. (0.8 acres)
  - 100% impervious
  - $\mathbf{V_{BMP}}$ = 1,819 cu. ft.
  - UBS Volume = 0.63 in.



- Use the combination flow and volume sizing worksheet to determine the bioretention surface area
- **Answer: 1,000 sq. ft. (depth of 0.5 ft.)**

Sizing Bioretention Facilities: Comparison of Methods

Example: 35,000 sq. ft. parking lot in Santa Clara

MAP= 15 inches, 100% impervious

$\mathbf{V_{BMP}}$ = 1,819 cu. ft. (80% of annual runoff)

Sizing Method	Surface Area (sq. ft.)
Simplified Method (flow-based)	1,400
Volume ponded on surface	3,638
Volume stored in unit (V_1+V_2+V_3)	1,580
Combination flow & volume	1,000

Sizing Pervious Paving and Infiltration Trenches

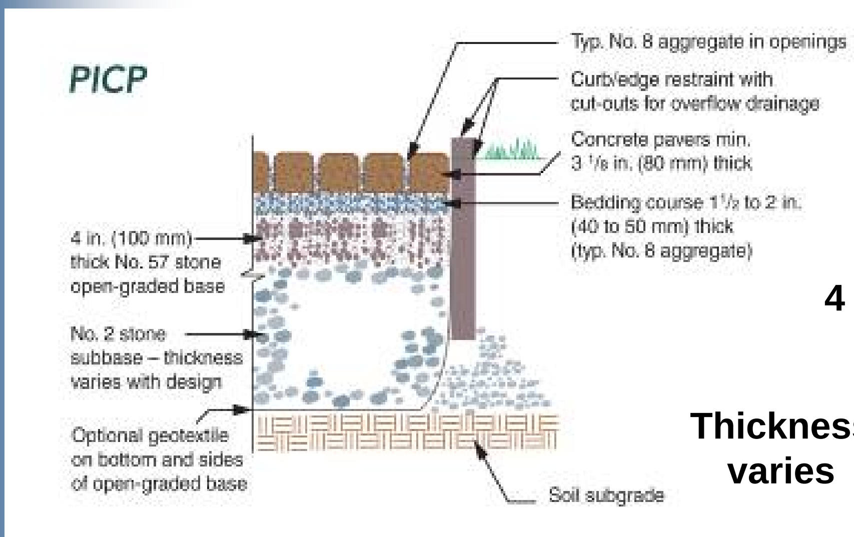
- General Principles
  - Store the WQD Volume in void space of stone base/subbase and infiltrate into subgrade
  - Surface allows water to infiltrate at a high rate
  - Any underdrains must be placed above the void space needed to store and infiltrate the WQD volume

Sizing Pervious Paving and Infiltration Trenches

- Pervious Paving
  - May be self-treating area or self-retaining area (accept runoff from other areas)
  - Can only be considered a "pervious area" if stone base/subbase sized to store the WQD volume
  - Can work where native soils have low infiltration rates (stored water depths are relatively small)
  - Surface area is usually predetermined
  - Base and subbase thickness usually determined by expected traffic load and saturated soil strength
  - Slope should be $\leq$ 1% (or use cutoff trenches)

Pervious Paving

Typical Section



- Base and subbase layers available for water storage
- Both typically have 40% void space

Pervious Paving

- Approach to Sizing Pervious Paving
  - Self-Treating
    - Check the depth of the WQD volume in base/subbase: UBS volume (in.) ÷ 0.40 = Depth (in.)

      Example: UBS volume = 1.0 in., depth = 2.5 in. (Minimum depth for vehicular traffic is 10 in.)
    - Check the time required for stored water to drain: UBS Vol. (in.) ÷ Infiltration rate (in/hr) = Drain time (hrs) (recommend < 48 hrs)

Pervious Paving

- Approach to Sizing Pervious Paving
  - Self-Retaining
    - Check the depth of the WQD volume in base/subbase:
      UBS volume (in.) ÷ 0.40 = Depth (in.)

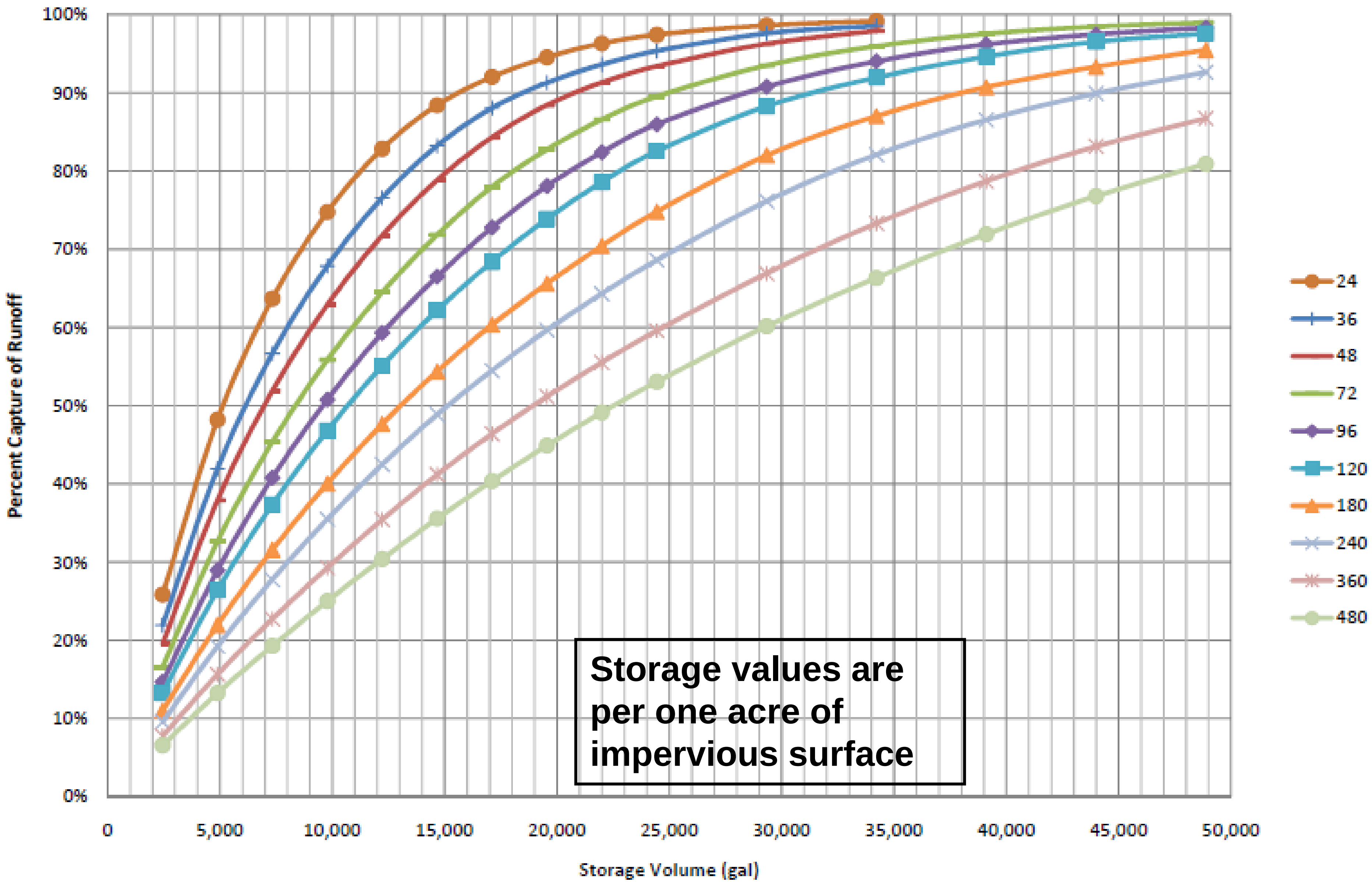
      Example: UBS volume = 1.0 in., depth = 2.5 in.
      (Minimum depth for vehicular traffic is 10 in.)
    - Check the time required for stored water to drain:
      UBS Vol. (in.) ÷ Infiltration rate (in/hr) = Drain time (hrs)
      (recommend < 48 hrs)

Sizing Rainwater Harvesting Cisterns

- **Rainwater Harvesting and Use**

- Types of Demands
  - Irrigation
  - Toilet flushing
  - Other non-potable
- Volume based sized criteria in C.3.d is 80% capture of the annual runoff
- Key concept is drawdown time
- Barriers: lack of plumbing codes, treatment, recycled water preference

Figure G-9: Percent Capture Achieved by BMP Storage Volume for Various Drawdown Times - San Jose



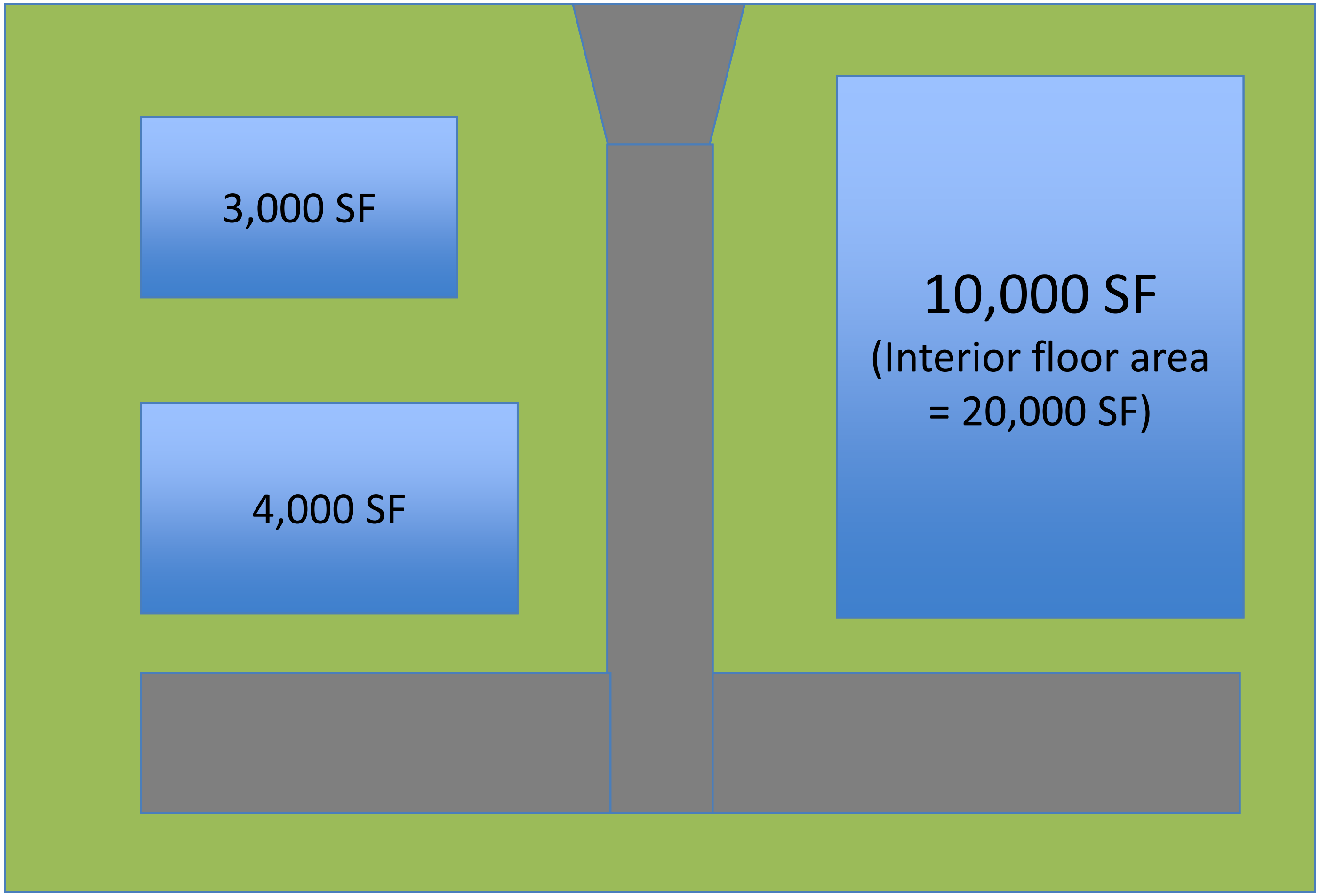
Estimate Actual Demand

Daily Use Rates for Toilets and Urinals[1]

Land Use Type	User Unit	User Unit Factor[2]	Daily Use/Unit (gal/day/unit)
Residential	Resident	2.9 residents per dwelling unit	8.6
Office or Retail	Employee (non-visitor)	200 SF per employee	6.9
Schools	Employee (not including students)	50 SF per employee	33.9

[1]References: CCCWP Stormwater C.3 Guidebook, 6th edition, 2012; BASMAA LID Feasibility Report, 2011; California Plumbing Code, 2010.
[2]Use project-specific data if available

Example:
2-story Office Building



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Screening Worksheet Results

- Potential rainwater capture area = area of one building roof = 10,000 SF
- Convert to acres:
  10,000 SF ÷ 43,560 SF/acre = 0.23 acres
- Demand for commercial building:
  Interior floor area = 20,000 SF
- Minimum floor area to meet toilet flushing demand = 70,000 SF per acre of impervious surface
- Minimum floor area for this project to meet demand = 70,000 SF/ac X 0.23 acres = 16,100 SF
- 20,000 SF > 16,100 SF ⇨ Building will have minimum toilet flushing demand

Determine Building Toilet Flushing Demand

- Building interior floor area = 20,000 SF
- Estimate no. of employees:
  - 200,000 SF ÷ 200 SF/employee = 100 employees
  - 100 employees × 6.9 gpd/employee = 690 gpd
- Convert to equivalent demand per impervious acre (to allow use of sizing curves):
  - 10,000 SF roof area ÷ 43,560 SF/ac = 0.23 ac.
  - 690 gpd ÷ 0.23 = 3,000 gpd per impervious acre

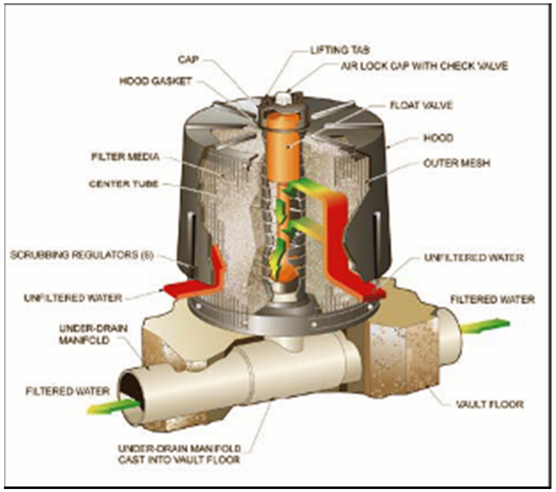
Determine Required Cistern Size

- From sizing curves, find right combination of drawdown time, tank size and required demand:
  - 480-hr (20-day) drawdown ⇨ 49,000 gallon tank ⇨ 2,450 gpd
  - 360-hr (15-day) drawdown ⇨ 40,000 gallon tank ⇨ 2,667 gpd
  - 240-hr (10-day) drawdown ⇨ 32,000 gallon tank ⇨ 3,200 gpd
  - 288-hr (12-day) drawdown ⇨ 36,000 gallon tank ⇨ 3,000 gpd √
- Adjust tank size back to actual impervious area:
  - 36,000-gallon tank per 1 acre impervious area
  - 36,000 × 0.23 acres = <u>8,300-gallon tank</u>

Sizing Non-LID Components

Media Filters (cartridge type)

- Flow-based Treatment Measure
- Determine **Q_{BMP}**
- From manufacturer's specifications, determine the design flow rate per cartridge
- Divide **Q_{BMP}** by the cartridge flow rate to calculate the number of cartridges required (round up)



Sizing Non-LID Components

High Flow Rate Tree Box Filters

- Flow-based Treatment Measure
- Determine $\mathbf{Q}_{BMP}$
- From manufacturer's specifications, determine the appropriate size of unit or combination of units
- A tree box filter that uses bio-treatment soil can be sized like a bioretention area or flow-through planter

Sizing Non-LID Components

Detention Basin

- Volume-based Treatment Measure (can only be used in treatment train)
- Determine **V_{BMP}**
- Design outlet for 48-hour detention time
- If sizing for hydromodification management, use Bay Area Hydrology Model to determine size to meet HM standards

??? Questions ???

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