Appendix

A

Infiltration Guidelines

As a stormwater management method, infiltration means ***retaining or detaining water within soils*** to reduce runoff. Infiltration can be a cost-effective method to manage stormwater – if the conditions on your site allow. This appendix includes the following information:

- Groundwater quality concerns related to stormwater infiltration;
- Stormwater controls that promote infiltration;
- General guidelines for selecting and designing infiltration devices;
- Infiltration devices and Class V injection well requirements;
- Specific Santa Clara Valley Water District guidelines:
- Fact sheet with EPA guidelines on Class V injection wells; and
- Map showing depths to groundwater in the Santa Clara Valley.

A.1 Groundwater Quality Concerns

Infiltration facilities allow rain and runoff to infiltrate into the soil, helping to reduce the amount of runoff from a development site, and, in some areas, provide groundwater recharge. Infiltration facilities that allow runoff to be filtered through surface soils, such as those incorporated into landscaping, are encouraged where feasible. These include: bioretention and bioinfiltration areas, microdetention in landscaping, and pervious paving on surface soils.

Nonetheless, in some situations infiltration facilities can pose a risk of contaminating groundwater. Before approving their use, municipalities need to work with applicants to determine if the appropriate conditions exist for employing infiltration methods. Protecting groundwater quality is a major concern in the Santa Clara basin, where groundwater provides approximately half of the drinking water supply for 1.7 million residents. The Santa Clara Valley

Water District (SCVWD) strictly regulates the siting and construction of deep infiltration devices such as stormwater drainage wells.[1]

Figure A-1, at the end of this appendix, shows groundwater depths throughout Santa Clara Valley. In general, the risks associated with infiltration can be managed by:

- Selecting stormwater treatment measures that are appropriate for the land use and location of the development site;
- Designing landscape drainage features so that they promote infiltration of runoff, but do not inject runoff or provide a direct conduit such that runoff bypasses the natural processes of filtering and transformation that occur in surface or near surface soils; and
- Taking steps to prevent the illegal discharge of wastes to drainage systems, including pollution prevention and source control measures.

A.2. Stormwater Controls that Promote Infiltration

A wide-range of site-design measures and stormwater treatment measures allow stormwater infiltration and can be categorized as described below.

A. ***Site design measures*** – methods such as clustering development or otherwise laying out the site to reduce impervious area, routing drainage from building roofs to landscaped areas, and using pervious pavement.

B. ***Indirect infiltration methods*** (also known as ***infiltration measures***) allow stormwater runoff to percolate into surface soils. The infiltrated water may either percolate down into subsurface soils, or it may be drained into subsurface pipes. Examples of indirect infiltration methods include bioretention areas, self-treating and self-retaining areas, and unlined detention basins used for infiltration purposes.

C. ***Direct infiltration methods*** (also known as ***infiltration devices***[2]) are designed to bypass surface soils and transmit runoff directly to subsurface soils and eventually groundwater. These types of devices must be located and designed to limit the potential for groundwater contamination. Examples of direct infiltration methods include dry wells, injection wells, and infiltration trenches (includes French drains).

A.3 Guidelines for Selecting and Designing Infiltration Devices

Special guidelines must be met if your project proposes to use infiltration devices, including:

- Dry wells;
- Infiltration basins;

[1] SCVWD, 1993. Stormwater Infiltration Devices, Supplement to Standards for the Construction and Destruction of Wells and Other Deep Excavations in Santa Clara County.,Attachment 4, Santa Clara Valley Water District Final Draft Well Standard.

[2] The reissued MRP defines “infiltration device” as any structure that is designed to infiltrate stormwater into the subsurface and, as designed, bypass the natural groundwater protection afforded by surface soil.

- Infiltration and exfiltration trenches (includes french drains);
- Unlined retention basins (i.e., basins with no outlets); and
- Unlined or open-bottomed vaults or boxes installed below grade (includes bubble ups, permeable pavement with underground storage, and subsurface infiltration systems).

In general, do not select infiltration devices for areas where any of the following conditions exist.

- Area is in proximity to or accepting runoff from locations used for chemical use or storage, washing, or waste disposal activities or is located where this may occur in the future;
- Surface and or subsurface soil of the area is contaminated (groundwater remediation site);
- Area has been recently disturbed and not stabilized or landscaped and therefore may have a high sediment load in the runoff; or,
- Soil does not permit infiltration measures to drain standing water within seventy-two (72) hours.

If the site is free of these general site conditions, municipalities must also confirm that the necessary design considerations have been met before approving the proposed infiltration device. General design considerations for stormwater infiltration devices include:

- Infiltrate through surface or near surface soils;
- Incorporate underdrains to convey excess infiltrated stormwater to the storm drain if needed;
- Provide stormwater pretreatment (i.e. sediment removal) if needed; and
- Prevent illegal discharge into infiltration areas through education, signage (such as "No Dumping" stencils), and source controls.

A.4. Infiltration Devices and Class V Injection Well Requirements

In order to protect underground sources of drinking water, the USEPA regulates some infiltration devices as Class V wells under its Underground Injection Control (UIC) Program. A ***Class V injection well*** is defined as "… any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system."[3] Infiltration trenches are typically not considered Class V injection wells because they are longer than they are wide. The USEPA's regulations state that stormwater drainage wells are "authorized by rule" (40 CFR 144), which means they do not require a permit if they do not endanger ***underground sources of drinking water***, and they comply with federal UIC requirements. For more information, the USEPA's fact sheet, "When Are Storm Water Discharges Regulated as Class V Wells?" is included at the end of this Appendix.

If your project includes one or more infiltration devices that are regulated as Class V injection wells, you will need to submit basic inventory information about the device(s) to the regional

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[3] USEPA Office of Ground Water and Drinking Water, "When Are Storm Water Discharges Regulated as Class V Wells?," June 2003.

office of the USEPA. Instructions for submitting this information are available on the USEPA Region 9 website at https://www.epa.gov/uic/underground-injection-control-regulations-and-safe-drinking-water-act-provisions . Project sponsors are responsible for constructing, operating and closing the infiltration device in a manner that does not risk contaminating underground sources of drinking water. The USEPA may place additional requirements on the infiltration device. Project sponsors should contact the appropriate USEPA staff, identified on the Internet link provided above, to learn what inventory information should be submitted and when.

A. 5. SCVWD Infiltration Device Guidelines

The Santa Clara Valley Water District (SCVWD) manages drinking water resources and provides stewardship for Santa Clara County's watersheds, reservoirs, streams and groundwater basins. As such, the SCVWD is responsible for groundwater quality protection. Concerns regarding the contamination of groundwater may limit the types and locations of stormwater treatment measures that may be used on a project site. The treatment measures of most concern are “infiltration devices”, defined as structures that are designed to bypass the natural filtration of surface soils and to transmit runoff directly to subsurface soils and groundwater aquifers. Other treatment measures that treat stormwater prior to subsurface infiltration, including landscape measures that utilize infiltration through surface or imported soils (indirect infiltration), and treatment measures that discharge directly to storm drains without infiltration pose minimal risk to groundwater quality.

The Santa Clara Valley Water District’s guidelines for infiltration devices are provided in Table A-1. The guidelines include required horizontal setbacks from drinking water wells, septic systems, underground storage tanks and known contamination sites; required vertical separation from seasonally high groundwater; and whether pretreatment prior to infiltration is required. Pretreatment can be provided by infiltration through surface soils, such as the use of an indirect infiltration measure. ***If the guidelines are not met, i.e., if there are any variances from the required setbacks or separations, SCVWD review and approval of the stormwater treatment plan is required.***

Table A-1 – SCVWD Guidelines for Stormwater Infiltration Devices

Site Use/Condition		Required Horizontal Setbacks (feet): Drinking Water Wells	Septic Systems	Underground Storage Tanks	Known Contamination Site[d]	Required Vertical Separation from Seasonally High Groundwater (feet)	Pretreatment Required[i]
Residential	Single Residential Lot (<10,000 sq. feet)	Exempt from setback and separation requirements; however, should still comply with construction and maintenance BMPs					
Residential	Single Residential Lot (10,000 sq. feet to 1 acre)	600[e]	100[g]	Dependent upon depth to water[h]	Regulatory Agency Approval Required if within 1,500 feet	10	No
Residential	Residential Subdivision (>1 acre)	600[e]	100[g]	Dependent upon depth to water[h]	Regulatory Agency Approval Required if within 1,500 feet	10	Individual Residences - No Runoff from Subdivision Roads - Yes
Commercial, Industrial, and Transportation	Transportation Corridor - Main Roads[a]	1,500[f]	100[g]	Dependent upon depth to water[h]	Regulatory Agency Approval Required if within 1,500 feet	30	Yes
Commercial, Industrial, and Transportation	Transportation Corridor - Minor Roads[a]	1,500[f]	100[g]	Dependent upon depth to water[h]	Regulatory Agency Approval Required if within 1,500 feet	10	Yes
Commercial, Industrial, and Transportation	Transportation Corridor - Other[a]	Not Allowed					
Commercial, Industrial, and Transportation	High Risk Commercial/Industrial[b]	Not Allowed					
Commercial, Industrial, and Transportation	Other Commercial/Industrial[c]	1,500[f]	100[g]	Dependent upon depth to water[h]	Regulatory Agency Approval Required if within 1,500 feet	30	Yes
Other	Known Contamination Sites[d]	Not allowed					

General Notes:

1. A stormwater infiltration device is any structure that is designed to bypass surface soils and to transmit runoff directly to subsurface soils and eventually groundwater.
2. District review is required for any variances from the required setbacks or separations.
3. Wells used to inject non-hazardous fluids underground are Class V injection wells as defined by the USEPA. A Box Below Grade (BBG) or any infiltration basin or trench that includes a subsurface distribution system is also classified as a Class V injection well. All stormwater infiltration devices meeting the EPA definition of a Class V injection well must comply with the requirements of the EPA Underground Injection Control (UIC) Program. New and existing dry wells are also required to obtain a District well permit.
4. Additional design guidelines will include guidance on setbacks to other stormwater infiltration devices, horizontal conduits, structures, and property lines. Slope restrictions may also apply.

Specific Notes:

a. Definitions for transportation corridors are as follows:
   Main Road: A major road for any form of motor transport. Average Daily Traffic flow (ADT) <25,000
   Minor Road: Smaller roads leading off major roads. ADT <15,000
   Other: Railroad and light rail corridors

b. Site use under this category includes automobile-related activities, gas stations, and petroleum processing and storage, chemical processing and storage, dry cleaners, metal plating, finishing, and fabricating, and plastics and synthetics production.

c. Other Commercial/Industrial includes all other commercial and industrial sites not included in the High Risk Commercial/Industrial category (see Note b).

d. Known contamination sites include all open or closed sites with known environmental releases, including the area overlying the associated soil and/or groundwater plumes. Regulatory agencies overseeing contaminated sites in Santa Clara County include the Regional Water Quality Control Boards, Department of Toxic Substance Control, Environmental Protection Agency, and County of Santa Clara.

e. Based on California Department of Public Health Drinking Water Source Assessment Program fixed radius for Zone A, which is meant to protect wells from viral, microbial and direct chemical contamination (based on a 2 year travel time).

f. Based on California Department of Public Health Drinking Water Source Assessment Program fixed radius for Zone B10, which is meant to protect wells from long term contamination from chemicals (based on 5 to 10 year travel time).

g. Consistent with Santa Clara County Sewage Disposal System Requirements.

h. Setback from active Underground Storage Tanks (USTs) is dependent upon the depth to groundwater. Setback is designed to minimize the potential for the groundwater table to come into contact with the UST system. Setbacks are presented in table below:

Depth to Groundwater	Setback from UST
0-15	250
> 15	100

i. Landscape or structural systems designed to treat or remove pollutants in stormwater. Treatment controls include detention basins, water quality wetlands, vegetated swales, bioretention, filters, and solid separators.

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WHEN ARE STORM WATER DISCHARGES REGULATED AS CLASS V WELLS?

Audience: This fact sheet is for storm water managers that implement the National Pollutant Discharge Elimination System (NPDES) program.

Purpose: To increase awareness that storm water drainage wells are regulated as Class V injection wells and to ensure that NPDES regulators understand the minimum federal requirements under the Safe Drinking Water Act (SDWA) for the Underground Injection Control (UIC) program.

ARE STORM WATER DRAINAGE WELLS REGULATED BY THE UIC PROGRAM?

Yes. These wells are regulated by EPA and primacy states through the UIC program as Class V injection wells with requirements to protect underground sources of drinking water (USDWs). A USDW is defined as an aquifer that contains less than 10,000 mg/L total dissolved solids and is capable of supplying water to a public drinking water system.

Class V storm water drainage wells are typically shallow disposal wells designed to place rain water or melted snow below the land surface. By definition, a Class V injection well is any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system.

Storm water management strategies that include subsurface drainage must comply with UIC program regulations.

WHY ARE STORM WATER DRAINAGE WELLS A CONCERN?

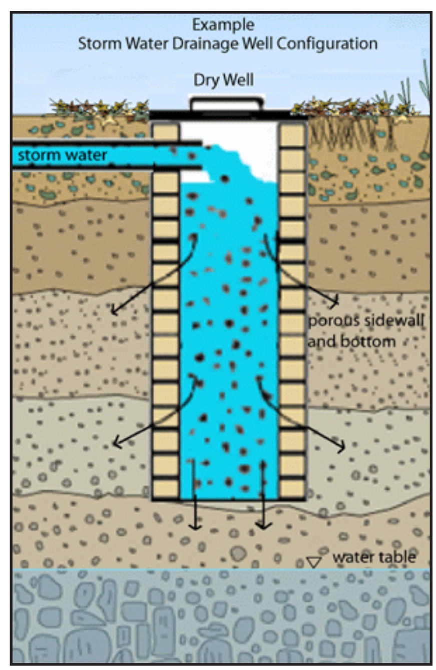
State and federal UIC program representatives are concerned that there may be a dramatic increase in the use of Class V wells as an NPDES Best Management Practice (BMP) to dispose of storm water. Infiltration through storm water drainage wells has the potential to adversely impact USDWs. The runoff that enters storm water drainage wells may be contaminated with sediments, nutrients, metals, salts, fertilizers, pesticides, and microorganisms.

WHAT ARE SOME EXAMPLES OF STORM WATER DRAINAGE WELLS?

The broad definition of Class V wells covers a variety of storm water injection well configurations, including:

- Dry wells
- Bored wells
- Infiltration galleries

The underground injection well definition applies to any subsurface drainfields that release fluids underground. These can include French drains, tile drains, infiltration sumps, and percolation areas with vertical drainage. Improved sinkholes designed for storm water management are also considered Class V storm water drainage wells. These wells are natural karst depressions or open fractures that have been intentionally altered to accept and drain storm water runoff. The pictures on the back page illustrate an example of a Class V injection well that is subject to UIC requirements.



WHAT INFILTRATION SYSTEMS ARE NOT STORM WATER DRAINAGE WELLS?

Two types of infiltration systems are not considered storm water drainage wells:

- **Infiltration trenches** are excavated trenches filled with stone (no piping or drain tile) to create an underground reservoir. They are usually wider than they are deep.

- **Surface impoundments or ditches** are excavated ponds, lagoons, and ditches (lined or unlined, without piping or drain tile) with an opened surface. They are used to hold storm water. These devices **would be** considered Class V injection wells, however, if they include subsurface fluid distribution systems.

Picture and schematic drawing of parking lot infiltration (Source: Louisiana Department of Transportation)

Storm water drainage well designs can be as varied as the engineers who design them. A fluid distribution system that discharges underground through piping is typically the defining characteristic. If you are unsure about the classification of your infiltration system, contact your UIC program representative for clarification.

HOW ARE STORM WATER DRAINAGE WELLS REGULATED?

Under the minimum federal requirements, storm water drainage wells are "authorized by rule" (40 CFR 144). This means that storm water drainage wells do not require a permit if **they do not** endanger USDWs **and they comply with** federal UIC program requirements. The prohibition on endangerment means the introduction of any storm water contaminant must not result in a violation of drinking water standards or otherwise endanger human health. Primacy states may have more stringent requirements.

Federal program requirements include:

- Submitting basic inventory information about the storm water drainage wells to the state or EPA. (Contact your UIC program to learn what inventory information must be submitted and when.) In some cases, the information may be required prior to constructing the well.

- Constructing, operating, and closing the drainage well in a manner that does not endanger USDWs.

- Meeting any additional prohibitions or requirements (including permitting or closure requirements) specified by a primacy state or EPA region.

HOW CAN I HELP PREVENT NEGATIVE IMPACTS FROM STORM WATER DRAINAGE WELLS?

As an NPDES storm water manager, you can help to ensure that current and future storm water systems using Class V wells meet regulatory requirements under the UIC program. You can also help identify storm water drainage systems that may affect USDWs, and recommend BMPs to protect USDWs. BMPs for storm water drainage wells may address well siting, design, and operation, as well as education and outreach to prevent misuse.

FOR MORE INFORMATION...

EPA's Office of Ground Water and Drinking Water Web Site:
http://www.epa.gov/safewater

UIC Program Contacts:
http://www.epa.gov/safewater/uic/primacy.html

EPA's NPDES Web Site:
http://www.epa.gov/NPDES/Stormwater

Safe Drinking Water Hotline:
1-800-426-4791

Office of Ground Water and Drinking Water (4606M)

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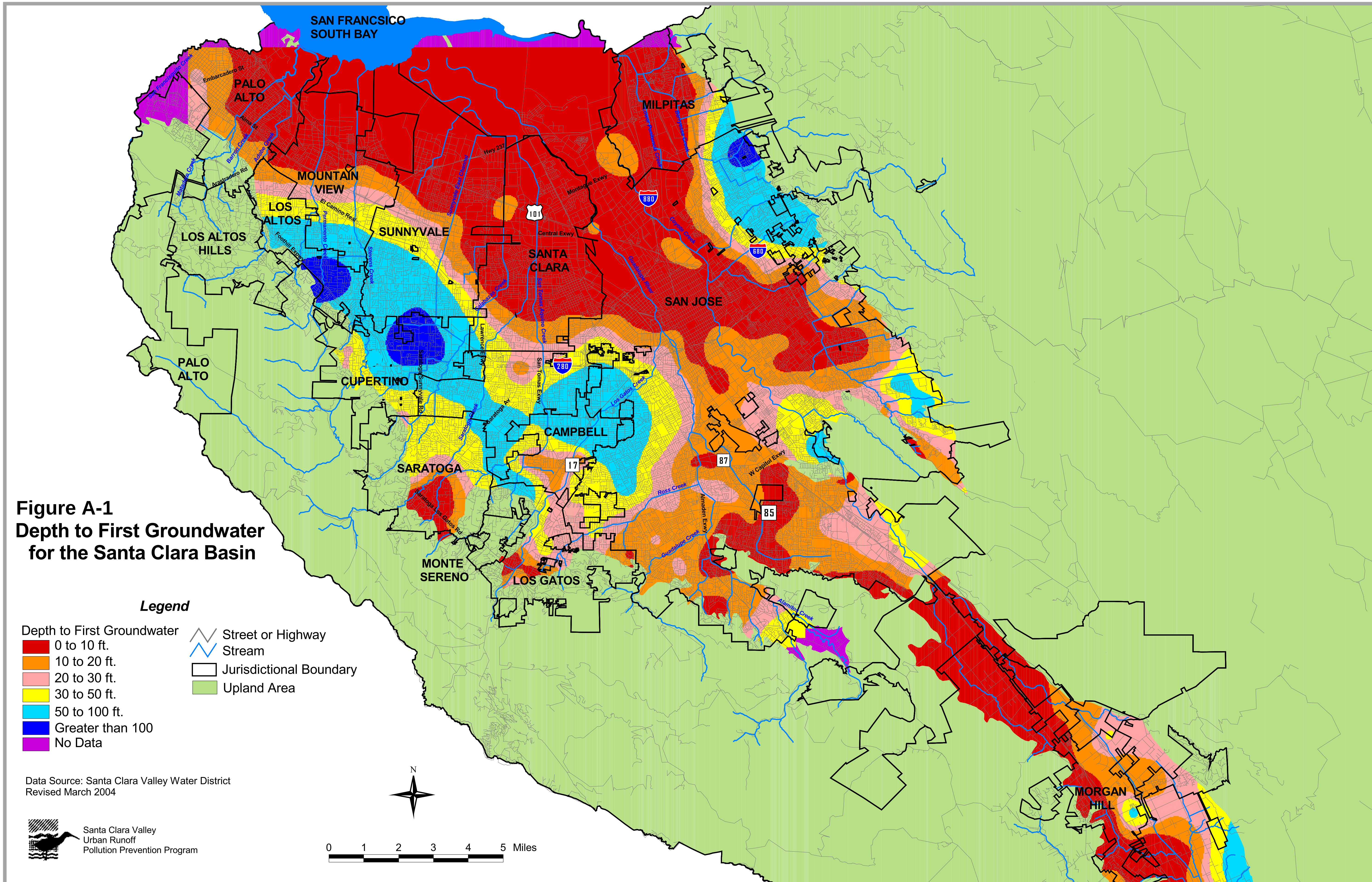

Figure A-1
Depth to First Groundwater for the Santa Clara Basin

Appendix

B

Sizing Criteria Worksheets and Examples

This Appendix provides sizing criteria worksheets and examples to illustrate the correct procedures for determining the water quality design flow and volume for sizing stormwater treatment measures, and for sizing based on a combination of flow and volume. Additional resources provided to assist with sizing treatment measures include: local rainfall data; stormwater treatment measure volume-based sizing curves; runoff coefficients; and a map showing mean annual precipitation and soil types for Santa Clara Valley.

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TABLES IN WORKSHEETS

B.2 Treatment Measure Sizing Examples:

- Example 1: Single Family Home Subdivision
  - Volume-based sizing for an infiltration trench
- Example 2: High Density Residential Development
  - Flow-based sizing method for a media filter
  - Volume-based sizing method and combination flow and volume method for a flow-through planter
- Example 3: Parking Lot
  - Simplified sizing method (4 percent method) for a bioretention facility

FIGURES

B.1 SCVURPPP Sizing Criteria Worksheets

These worksheets are designed to assist municipal staff and development project proponents in sizing stormwater treatment measures. Figures referenced in the computations can be found at the end of this Appendix B.

Section I. Selecting Sizing Approach Based on Type of Treatment Measure

1. Does the treatment measure operate by detaining a volume of runoff for a certain amount of time for pollutant removal (i.e., is it a volume-based treatment measure)? See Table B-1 for examples.

___ Yes ____ No

If Yes, continue to Section II. Sizing for Volume-Based Treatment Measures.
If No, continue to next question.

2. Does the treatment measure operate based on the flow of runoff through the device (i.e, is it a flow-based treatment measure)? See Table B-1 for examples.

___ Yes ____ No

If Yes, continue to Section III. Sizing for Flow-Based Treatment Measures.

Table B-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[1]	Flow-based
Infiltration trench	Yes	Volume-based
Subsurface infiltration system	Yes	Volume-based
Rainwater harvesting and reuse	Yes	Volume-based
Media filter	No	Flow-based
Extended detention basin	No	Volume-based

[1] A tree well filter is considered LID treatment if biotreatment soil is used as the filter media and the unit is sized based on a 5 in/hr surface loading rate.

Section II. Sizing for Volume-Based Treatment Measures

The MRP Provision C.3.d allows two methods for sizing volume-based controls: 1) the WEF Urban Runoff Quality Management Method (URQM Method); or 2) the CASQA Stormwater Best Management Practice[2] (BMP) Handbook Volume Method adapted for Santa Clara Valley. The adapted CASQA Stormwater BMP Handbook Method is recommended because it is based on local rainfall data. Steps for applying these methods are presented in Sections II.A and II.B below.

Section II.A — Sizing Volume-Based Treatment Measures based on the Urban Runoff Quality Management Approach (URQM Approach)

The equations used in this method are:

$$P_0 = (a \times C_w) \times P_6$$

$$C_w = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

Where:

- P_0 = maximized detention storage volume (inches over the drainage area to the BMP)
- a = regression constant (unitless)
- C_w = watershed runoff coefficient (unitless)[3]
- P_6 = mean storm event precipitation depth (inches);
- i = watershed impervious ratio (range: 0-1)

Step 1. Determine the drainage area for the BMP, A = __________ acres

Step 2. Determine the watershed impervious ratio, "*i*", which is the amount of impervious area in the drainage area to the BMP divided by the drainage area, or the percent of impervious area in the drainage area divided by 100.

a. Estimate the amount of impervious surface (rooftops, hardscape, streets, and sidewalks, etc.) in the area draining to the BMP = ____________ acres

b. Calculate the watershed impervious ratio, *i*:

i = amount of impervious area /drainage area for the BMP

i = (**Step 2.a**)/(**Step 1**) = ____________ (range: 0-1)

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[2] For the purpose of this worksheet, a stormwater best management practice, or BMP, is the same as a stormwater treatment measure.

[3] For the purpose of this worksheet, the watershed runoff coefficient is notated as "C_w" to avoid confusion with the runoff coefficient "C" used in the Rational Method.

Section II. Sizing for Volume-Based Treatment Measures (continued)

Section II.A — URQM Approach (continued)

Step 3. Determine the watershed runoff coefficient, "C_w", using the following equation:

$C_w = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$, using "*i*" from **Step 2.b.**

C_w =

Step 4. Find the mean annual precipitation at the site (MAP_{site}). To do so, estimate where the site is on Figure B-1 and estimate the mean annual precipitation in inches from the rain line (isopleth) nearest to the project site.[4]

Mean annual precipitation at the site, MAP_{site} =

(Each line on the figure, called a rainfall isopleth, indicates locations where the same amount of rainfall falls on average each year; e.g., the isopleth marked 14 indicates that areas crossed by this line average 14 inches of rainfall per year. If the project location is between two lines, estimate the mean annual rainfall by interpolation, based on the location of the site.)

Step 5. Identify the reference rain gage closest to the project site from Table B-2a.

Table B-2a: Precipitation Data for Three Reference Gages

Gages	Mean Annual Precipitation (MAP_{gage}) (in)	Mean Storm Event Precipitation $(P_6)_{gage}$ (in)
San Jose Airport	13.9	0.512
Palo Alto	13.7	0.522
Morgan Hill	19.5	0.760

Select the MAP_{gage} and the mean storm precipitation $(P_6)_{gage}$ for the reference gage, and use them to determine $(P_6)_{site}$ for the project site in Step 6.

MAP_{gage} =

$(P_6)_{gage}$ =

[4] Check with the local municipality to determine if more detailed maps are available for locating the site and estimating MAP.

Section II. Sizing for Volume-Based Treatment Measures, continued

Section II.A — URQM Approach (continued)

Step 6. Calculate the mean storm event precipitation depth at the project site, called $(P_6)_{site}$. Multiply the mean storm event precipitation depth for the rain gage chosen by a correction factor, which is the ratio of the mean annual precipitation at the site (MAP_{site}) to the mean annual precipitation at the rain gage (MAP_{gage}).

$$(P_6)_{site} = (P_6)_{gage} \times (MAP_{site}) / (MAP_{gage}).$$

$$(P_6)_{site} = \text{Mean Event Precipitation } (P_6)_{gage} \text{ (Step5)} \times (MAP_{site}) \text{ (Step4)} / (MAP_{gage}) \text{ (Step5).}$$

$P_{6\,site}$ = ________ inches

Step 7 Find "*a*", the regression constant (unitless)[5]:

a = 1.963 for a 48-hour drain time
a = 1.582 for a 24-hour drain time
a = 1.312 for a 12-hour drain time

a = ________

Recommendation: Use a 48-hour drain time.

Step 8 Determine the maximized detention storage volume P_0:

$$P_0 = (a \times C_W) \times P_6$$

P_0 = (**Step 7)** × (**Step 3**) × (**Step 6**)

P_0 = ________ inches

Step 9 Determine the volume of the runoff to be treated from the drainage area to the BMP (i.e., the BMP design volume):

Design volume = Po × A = (**Step 8**) × (**Step 1**) × 1 foot/12 inches

Design Volume = ________ acre-feet × 43,560 square feet/acre = ________ cubic feet

[5] *WEF Manual of Practice No. 23 and the ASCE Manual of Practice No. 87 (1998), pages 175-178.*

Section II. Sizing for Volume-Based Treatment Measures, continued

Section II.B — Sizing Volume-Based Treatment Measures based on the Adapted CASQA Stormwater BMP Handbook Approach

The equation that will be used to size the BMP is:

Design Volume = (Rain Gage Correction Factor) × (Unit Basin Storage Volume) × (Drainage Area)

Step 1. Determine the drainage area for the BMP, A = ____________acres

Step 2. Determine percent imperviousness of the drainage area:

a. Estimate the amount of impervious surface (rooftops, hardscape, streets, and sidewalks, etc.) in the area draining to the BMP: ____________acres

b. % impervious area = (amount of impervious area/drainage area for the BMP) × 100
% impervious area = **(Step 2.a/Step 1)** × 100
% impervious area = _________%

Step 3. Find the mean annual precipitation at the site (MAP_{site}). To do so, estimate where the site is on Figure B-1 and estimate the mean annual precipitation in inches from the rain line (isopleth) nearest to the project site.[6] Interpolate between isopleths if necessary.

MAP_{site} = _____inches

Step 4. Identify the reference rain gage closest to the project site from Table B-2b and record the MAP_{gage}:

MAP_{gage} = _____inches

Table B-2b: Precipitation Data for Three Reference Gages

Reference Rain Gages	Mean Annual Precipitation (MAP_{gage}) (in)
San Jose Airport	13.9
Palo Alto	13.7
Morgan Hill	19.5

[6] Check with the local municipality to determine if more detailed maps are available for locating the site and estimating MAP.

Section II. Sizing for Volume-Based Treatment Measures, continued

Section II.B —Adapted CASQA Stormwater BMP Handbook Approach (continued)

Step 5 Determine the rain gage correction factor for the precipitation at the site using the information from **Step 3** and **Step 4**.

Correction Factor = MAP_{site} (**Step 3**)/MAP_{gage} (**Step 4**)

Correction Factor = ______

Step 6. Identify the representative soil type for the BMP drainage area.

a) Identify from Figure B-1 or from site soils data, the soil type that is representative of the pervious portion of the project shown here in order of increasing infiltration capability:

____ Clay (D) ____ Sandy Clay (D) ____ Clay Loam (D)

____ Silt Loam/Loam (B) ____ Not Applicable (100% Impervious)

b) Does the site planning allow for protection of natural areas and associated vegetation and soils so that the soils outside the building footprint are not graded/compacted? ____ (Y/N)

If your answer is no, and the soil will be compacted during site preparation and grading, the soil's infiltration ability will be decreased. Modify your answer to a soil with a lower infiltration rate (e.g., Silt Loam to Clay Loam or Clay).

Modified soil type: ______

Step 7. Determine the average slope for the drainage area for the BMP: ______%

Step 8. Determine the unit basin storage volume from sizing curves.

a) Slope ≤ 1%

Use the figure at the end of this Appendix entitled "Unit Basin Volume for 80% Capture, 1% Slope" corresponding to the nearest rain gage: Figure B-2, B-3, or B-4 for San Jose, Palo Alto, or Morgan Hill, respectively. Find the percent imperviousness of the drainage area (from **Step 2**) on the x-axis. From there, find the line corresponding to the soil type (from **Step 6**), and obtain the unit basin storage volume on the y-axis.

Unit Basin Storage for 1% slope ($UBS_{1\%}$) = ______(inches)

b) Slope ≥ 15%

Use the figure at the end of this Appendix entitled "Unit Basin Volume for 80% Capture, 15% Slope" corresponding to the nearest rain gage: Figure B-5, B-6, or B-7 for San Jose, Palo Alto, or Morgan Hill, respectively. Find the percent imperviousness of the drainage area (from **Step 2**) on the x-axis. From there, find the line corresponding to the soil type (from **Step 6**), and obtain the unit basin storage volume on the y-axis.

Unit Basin Storage for 15% slope ($UBS_{15\%}$) = ______(inches)

Section II. Sizing for Volume-Based Treatment Measures, continued

Section II.B. —Adapted CASQA Stormwater BMP Handbook Approach (continued)

c) Slope > 1% and < 15%

Find the unit basin volumes for 1% and 15% using the techniques in **Steps 8.a** and **8.b** and interpolate by applying a slope correction factor per the following formula:

UBS_x = $UBS_{1\%}$ + ($UBS_{15\%}$ - $UBS_{1\%}$) × (X%-1%) / (15% -1%)
= (**Step 8a**) + (**Step 8b**- **Step 8a**) × (X%-1%)/(15%-1%)

Where UBS_x = Unit Basin Storage volume for drainage area of intermediate slope, X %

Unit Basin Storage volume (UBS_x) = ____________(inches)
(corrected for slope of site)

Step 9. Determine the Adjusted Unit Basin Storage Volume for the site, using the following equation:

Adjusted UBS = Rain Gage Correction Factor × Unit Basin Storage Volume

Adjusted UBS = (**Step 5**) × (**Step 8**)

Adjusted UBS = _______inches

Step 10. Determine the BMP Design Volume, using the following equation:

Design Volume = Adjusted Unit Basin Storage Volume × Drainage Area

Design Volume = (**Step 9**) × (**Step 1**) × 1 foot/12 inch

Design Volume = _______ acre-feet × 43,560 square feet/acre = _______ cubic feet

III. Sizing for Flow-based Treatment Measures

The MRP Provision C.3.d allows three methods for sizing flow-based treatment measures: 1) the Factored Flood Flow Method (10% of the 50-year peak flow rate); 2) the CASQA Stormwater BMP Handbook Method (the flow produced by a rain event equal to at least 2 times the 85th percentile hourly rainfall intensity); or 3) the Uniform Intensity Method (the flow produced by a rain event equal to at least 0.2 inches/hour intensity). Use of Method 2 or 3 is recommended. Steps for applying these methods are presented in Sections III.A, III.B, and III.C below.

Each of the three methods will require estimating a runoff coefficient for the area draining to the BMP. Recommended coefficients are provided in Table B-3.

Table B-3 – Estimated Runoff Coefficients for Various Surfaces During Small Storms

Type of Surface	Runoff Coefficients "C" factor
Roofs	0.90
Concrete	0.90
Stone, brick, or concrete pavers with mortared joints and bedding	0.90
Asphalt	0.90
Stone, brick, or concrete pavers with sand joints and bedding	0.90
Pervious concrete	0.10
Porous asphalt	0.10
Permeable interlocking concrete pavement	0.10
Grid pavements with grass or aggregate surface	0.10
Crushed aggregate	0.10
Grass	0.10

Notes: These C-factors are only appropriate for small storm treatment BMP design, and should not be used for flood control sizing. Where available, locally developed small storm C-factors for various surfaces should be used. Sources: BASMAA, 2003; Lindeburg, 2003; Hade and Smith, 1988; Smith, 2012.

III. Sizing for Flow-based Treatment Measures, continued

Section III.A - Sizing Flow-Based Treatment Measures based on the Factored Flood Flow Approach

This method uses the Rational Method equation to determine the design flow, using a design intensity that is 10 % of the intensity for the 50-year return period found on the local intensity-duration-frequency (IDF) curve:

$$Q=CIA$$

Where:

Q = the design flow in cubic feet per second (cfs),
C = the drainage area runoff coefficient,
I = the design intensity (in/hr), and
A = the drainage area for the BMP (acres)

Step 1. Determine the drainage area for the BMP, A = ________ acres

Step 2. Determine the runoff coefficient, C = _____ from Table B-3.

Step 3. Find the time of concentration (t_c) for the site (i.e. the travel time from the most remote portion of the BMP drainage area to the BMP). (Check with local agency's Engineering Department for standard or accepted methods of computing t_c).

t_c = Time of overland flow + time in drainage pipe: _______hrs

Step 4. Using the time of concentration as the duration, use Figure B-8 to determine the intensity for the 50-year storm (IDF curve) (in/hr). _____

Intensity for the 50-year storm = ________in/hr

Step 5. The design intensity (I) will be 10% of the intensity obtained from the IDF curve (intensity for the 50-year storm).

I = (**Step 4** × 0.10) = ________in/hr

Step 6. Determine the design flow (Q) using the Rational Method equation:

Q = C × I × A
Q = (**Step 2**) × (**Step 5**) × (**Step 1**)
Q = ______ acres-in/hr

Design Flow, Q = ________________ cfs[7]

[7] No conversion factor for correct units is needed for the rational formula because (1 acre-in/hr) X (43,560 sq. ft./acre) X (1ft/12 in) X (1hr/3600 sec) ≈ 1 ft^3/sec or cfs.

III. Sizing for Flow-based Treatment Measures, continued

Section III.B —Sizing Flow-Based Treatment Measures based on the CASQA Stormwater BMP Handbook Flow Approach

This method uses the Rational Method equation to determine the design flow:

$$Q=CIA$$

Where:
Q = the design flow in cubic feet per second (cfs),
C = the drainage area runoff coefficient,
I = the design intensity (in/hr), and
A = the drainage area for the BMP (acres)

Step 1. Determine the drainage area for the BMP, A = ______ acres

Step 2. Determine the runoff coefficient, C = _____ from Table B-3.

Step 3. Find the mean annual precipitation at the site (MAP_{site}). To do so, estimate where the site is on Figure B-1 and estimate the mean annual precipitation in inches from the rain line (isopleth) nearest to the project site.[8] Interpolate between isopleths if necessary.

MAP_{site} = ______inches

Step 4. Identify the reference rain gage closest to the project site from Table B-2b and record the MAP_{gage}:

MAP_{gage} = ______inches

Table B-2b: Precipitation Data for Three Reference Gages

Reference Rain Gages	Mean Annual Precipitation (MAP_{gage}) (in)
San Jose Airport	13.9
Palo Alto	13.7
Morgan Hill	19.5

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[8] Check with the local municipality to determine if more detailed maps are available for locating the site and estimating MAP.

Section III. Sizing for Flow-Based Treatment Measures, continued

Section III.B.— CASQA Stormwater BMP Handbook Flow Approach (continued)

Step 5. Determine the rain gage correction factor for the precipitation at the site using the information from **Step 3** and **Step 4**.

Correction Factor = MAP_{site} / MAP_{gage} = (**Step 3**)/(**Step 4**)

Correction Factor = ____________

Step 6. Select the design rainfall intensity, I, for the rain gage closest to the site from Table B-2c:

Table B-2c: Precipitation Data for Three Reference Gages

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

*The design intensity is two times the 85^{th} Percentile Hourly Rainfall Intensity.

Design Rainfall Intensity: I = ____________ in/hr

Step 7. Determine the corrected design rainfall intensity (I) for the site:

Design intensity (site) = Correction factor × Design rainfall intensity for closest rain gage

Design intensity (site) = (**Step 5**) × (**Step 6**) = ____________ in/hr

Step 8. Determine the design flow (Q) using the Rational Method equation:

$$Q = C \times I \times A$$

Q = (**Step 2**) × (**Step 7**) × (**Step 1**)

Q = ______ acres-in/hr

Design Flow, Q = ____________ cfs[9]

[9] No conversion factor for correct units is needed for the rational formula because (1 acre-in/hr) X (43,560 sq. ft./acre) X (1ft/12 in) X (1hr/3600 sec) ≈ 1 ft^3/sec or cfs.

Section III. Sizing for Flow-Based Treatment Measures, continued

Section III.C —Sizing Flow-Based Treatment Measures based on the Uniform Intensity Approach

This method uses the Rational Method equation:

$$Q=CIA$$

Where:

Q = the design flow in cubic feet per second (cfs),
C = the drainage area runoff coefficient,
I = the design intensity (in/hr), and
A = the drainage area for the BMP (acres)

Step 1. Determine the drainage area for the BMP, A = ______ acres

Step 2. Determine the runoff coefficient, C = ______ from Table B-3.

Step 3. Use a design intensity of **0.2 in/hr** for "I" in the Q=CIA equation.

I = 0.2 in/hr

Step 4. Determine the design flow (Q) using Q = CIA

$$Q = C \times I \times A$$

Q = (**Step 2**) × (0.2 in/hr) × (**Step 1**)

Q = ______ acres-in/hr

Design Flow, Q = ____________ cfs[10]

[10] No conversion factor for correct units is needed for the rational formula because (1 acre-in/hr) X (43,560 sq. ft./acre) X (1ft/12 in) X (1hr/3600 sec) ≈ 1 ft^3/sec or cfs.

Section IV. Sizing for Flow- and Volume- Based Treatment Measures (Combination Flow and Volume Approach)

For bioretention areas and flow-through planters, the following approach may be used to take into consideration both the flow of stormwater through the planting media and the volume of stormwater in the surface ponding area. Note that the approach assumes that all of the design rainfall becomes runoff, and thus it is appropriate for use where the drainage area to the treatment measure is mostly impervious. Contributing pervious surfaces can be converted to equivalent impervious surface using the procedure outlined in Step 1.

Step 1. **Contributing drainage area to the treatment measure:** **_______ sq. ft.**

Is the contributing drainage area 100% impervious? ____ Yes ____ No
If yes, skip to Step 2c and fill in the drainage area as the effective impervious area.

Step 2. Determine the effective impervious surface area draining to the treatment measure:

a. Impervious surface area draining to the treatment measure: _______ sq. ft.

b. Pervious surface area draining to the treatment measure: _______ sq. ft.

For small grass or landscaped areas, multiply the pervious surface area by a runoff coefficient of 0.10 to compute the equivalent impervious surface area.

c. Effective impervious area = (pervious area × 0.10) + impervious area
Effective impervious area = (Step 2.b x 0.10) + Step 2.a
Effective impervious area = _______ sq. ft.

Step 3. Determine the required treatment volume using Adapted CASQA Stormwater BMP Handbook Approach (Worksheet Section II.B, Steps 9 and 10). Copy the results here:

Adjusted Unit Basin Storage (UBS) Volume: **_______ in.**

Water Quality Design (WQD) Volume: **_______ cu. ft.**

Step 4. Determine the design rainfall intensity (Uniform Intensity Approach, Section III.C, Step 3):

Design Rainfall Intensity: **__0.2__ in/hr**

Step 5. Assume that the rain event that generates the Unit Basin Storage Volume of runoff occurs at the design rainfall intensity for the entire length of the storm. Calculate the duration of the storm by dividing the adjusted Unit Basin Storage Volume by the design rainfall intensity. In other words, determine the amount of time required for the Unit Basin Storage Volume to be achieved at the design intensity rate.

Duration = UBS Volume (inches) ÷ Rainfall Intensity (inches/hour)

Duration = (**Step 3**) ÷ 0.2 in/hr = _________ **hrs.**

IV. Sizing for Flow- and Volume-Based Treatment Measures, continued

Step 6. Make a preliminary estimate of the surface area of the bioretention facility by multiplying the area of impervious surface to be treated by a sizing factor of **0.03.**

Estimated Surface Area = Total Effective Impervious Area × 0.03

Estimated Surface Area = __________ sq. ft. × 0.03 = __________ **sq. ft.**
(**Step 2.c**)

Step 7. Calculate the volume of runoff that filters through the biotreatment soil at a rate of 5 inches per hour (the design surface loading rate for bioretention facilities), for the duration of the storm calculated in Step 5.

Volume of Treated Runoff = Estimated Surface Area × 5 in/hr × (1 ft/12 in) × Duration

Volume of Treated Runoff = ________ sq. ft. × 5/12 × _____ hrs. = ________ **cu. ft.**
(**Step 6**) (**Step 5**)

Step 8. Calculate the portion of the water quality design (WQD) volume remaining after treatment is accomplished by filtering through the biotreatment soil. The result is the amount that must be stored in the ponding area above the bioretention surface area estimated in Step 6.

Volume in ponding area = WQD Volume – Volume of Treated Runoff

Volume in ponding area = ________ cu. ft. – ________ cu. ft. = _________ **cu. ft.**
(**Step 3**) (**Step 7**)

Step 9. Calculate the depth of the volume in the ponding area by dividing this volume by the estimated surface area in Step 6.

Depth of ponding = Volume in Ponding Area ÷ Estimated Surface Area

Depth of ponding = __________ cu. ft. ÷ __________ sq. ft. = _________ **ft.**
(**Step 8**) (**Step 6**)

Step 10. Check to see if the average ponding depth is between 0.5 and 1.0 feet (6 and 12 inches), which is the range of allowable ponding depths in a bioretention facility or flow-through planter (**0.5 feet is recommended**). If the ponding depth is less than 0.5 feet, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps 6 through 9 with a smaller surface area). If the ponding depth is greater than 1 foot, a larger surface area will be required (i.e., repeat Steps 6 through 9 with a larger surface area).

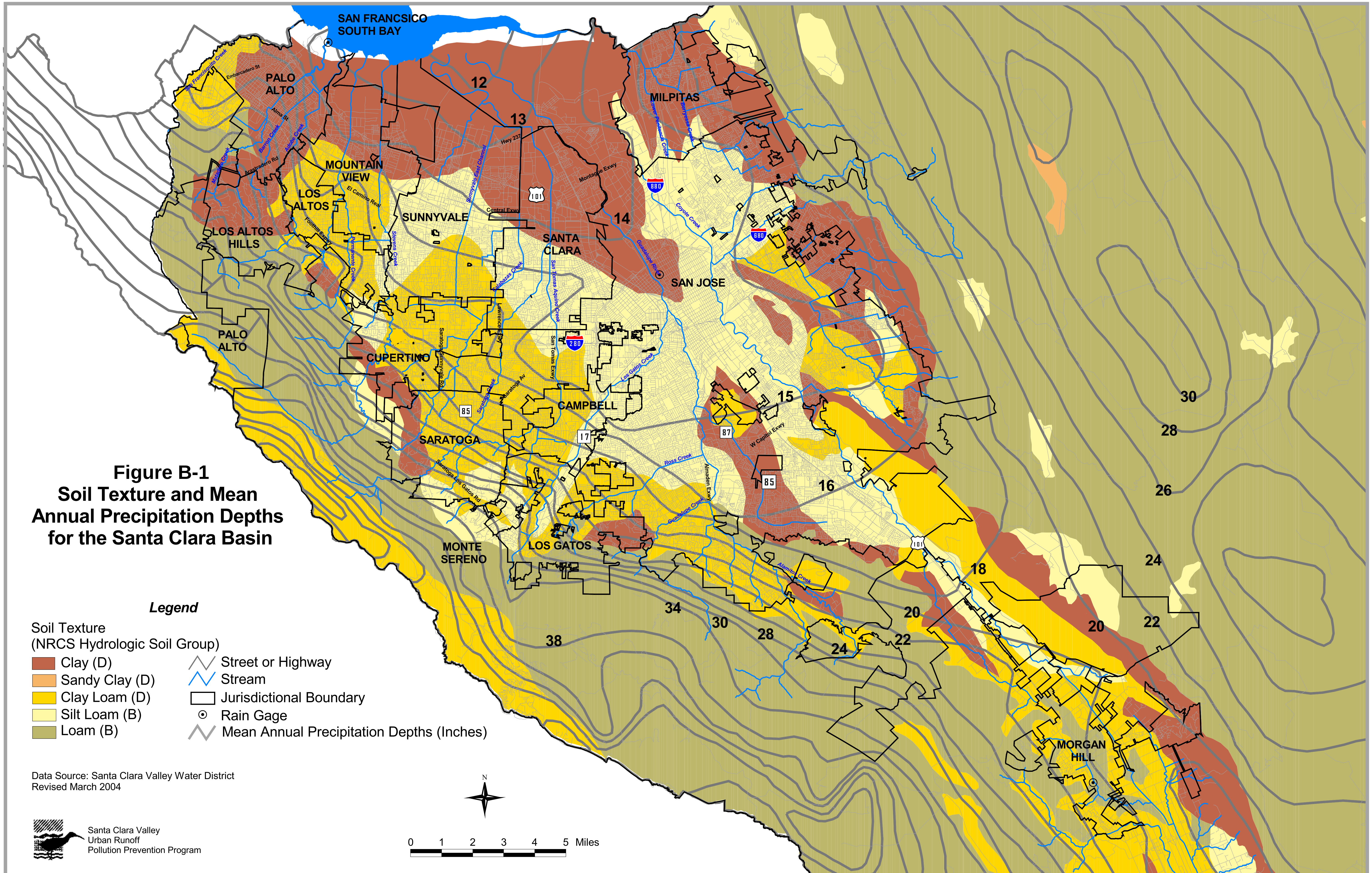

Figure B-1
Soil Texture and Mean Annual Precipitation Depths for the Santa Clara Basin

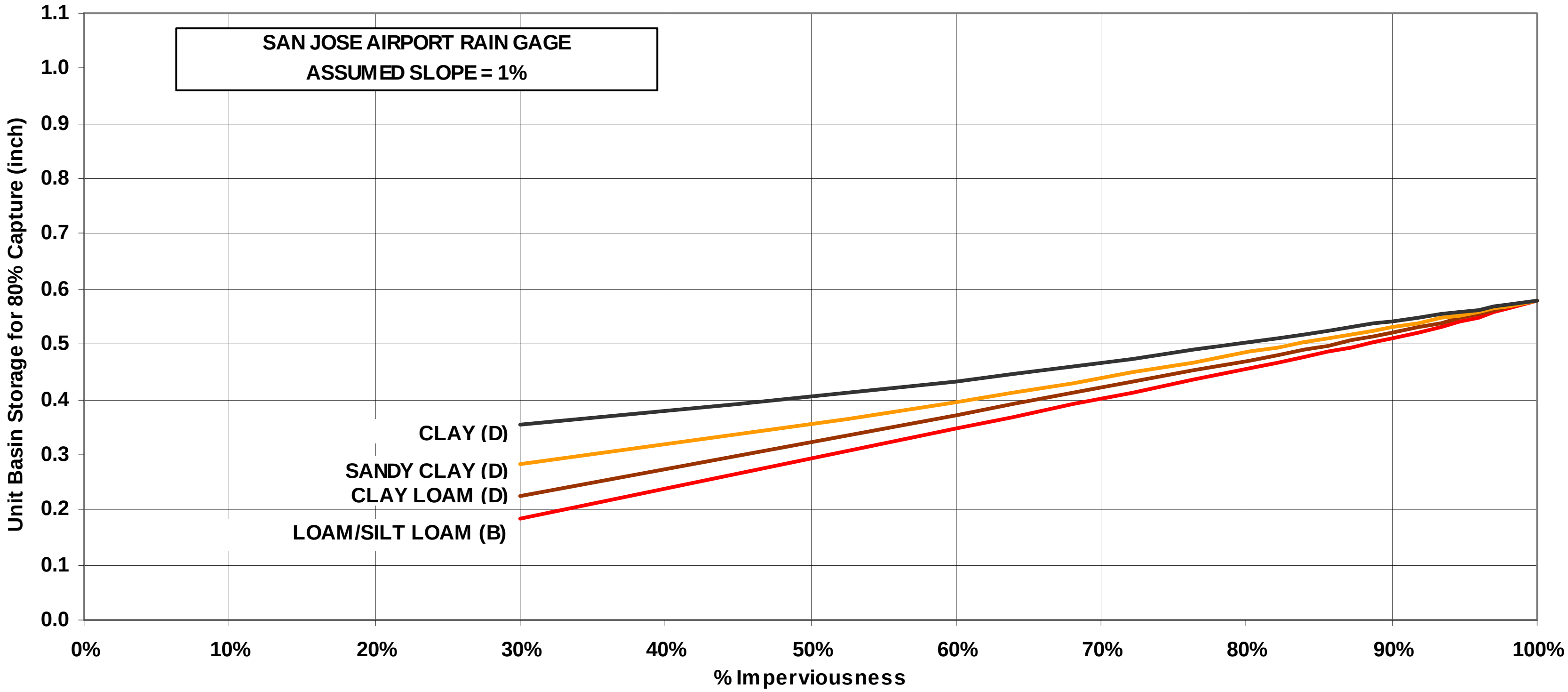

Figure B-2 Unit Basin Volume for 80% Capture - <u>San Jose Airport Rain Gage</u>

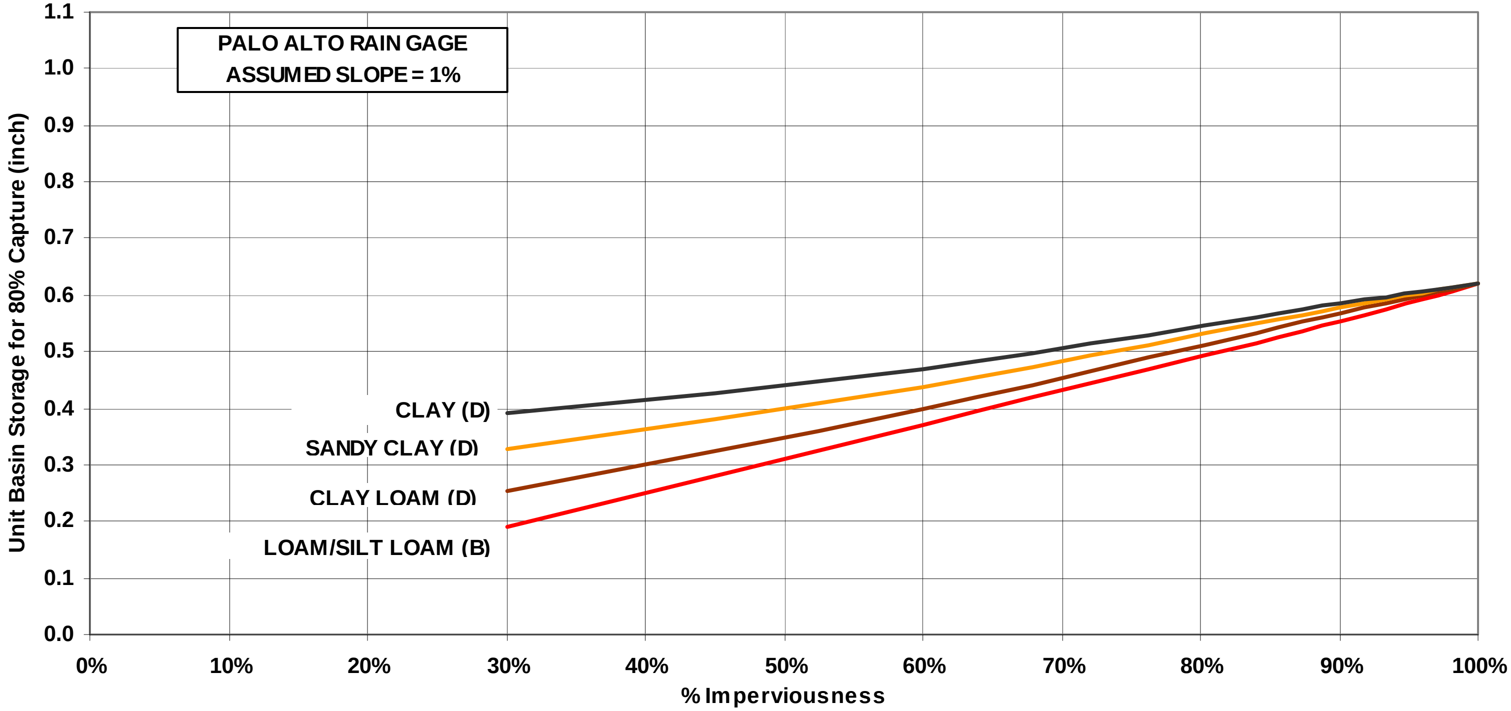

Figure B-3 Unit Basin Volume for 80% Capture - <u>Palo Alto Rain Gage</u>

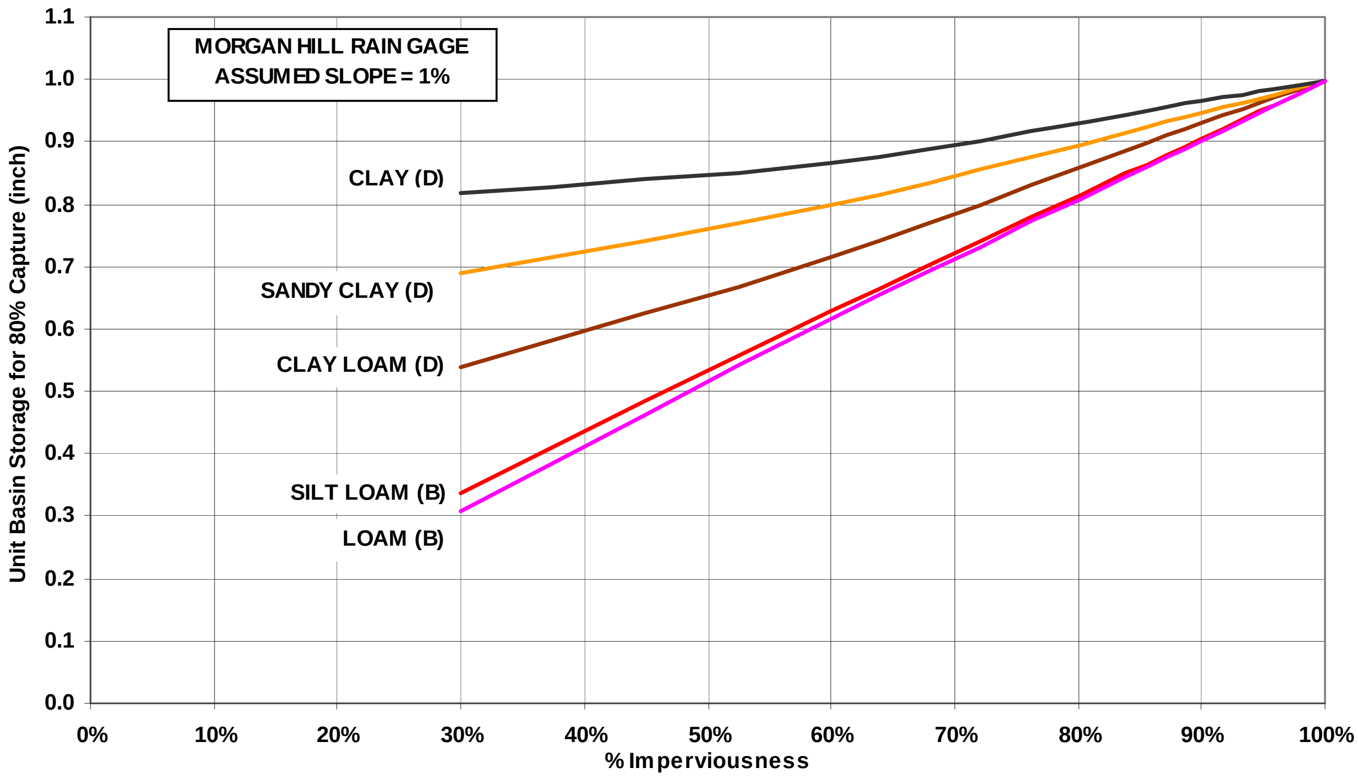

Figure B-4 Unit Basin Volume for 80% Capture - Morgan Hill Rain Gage

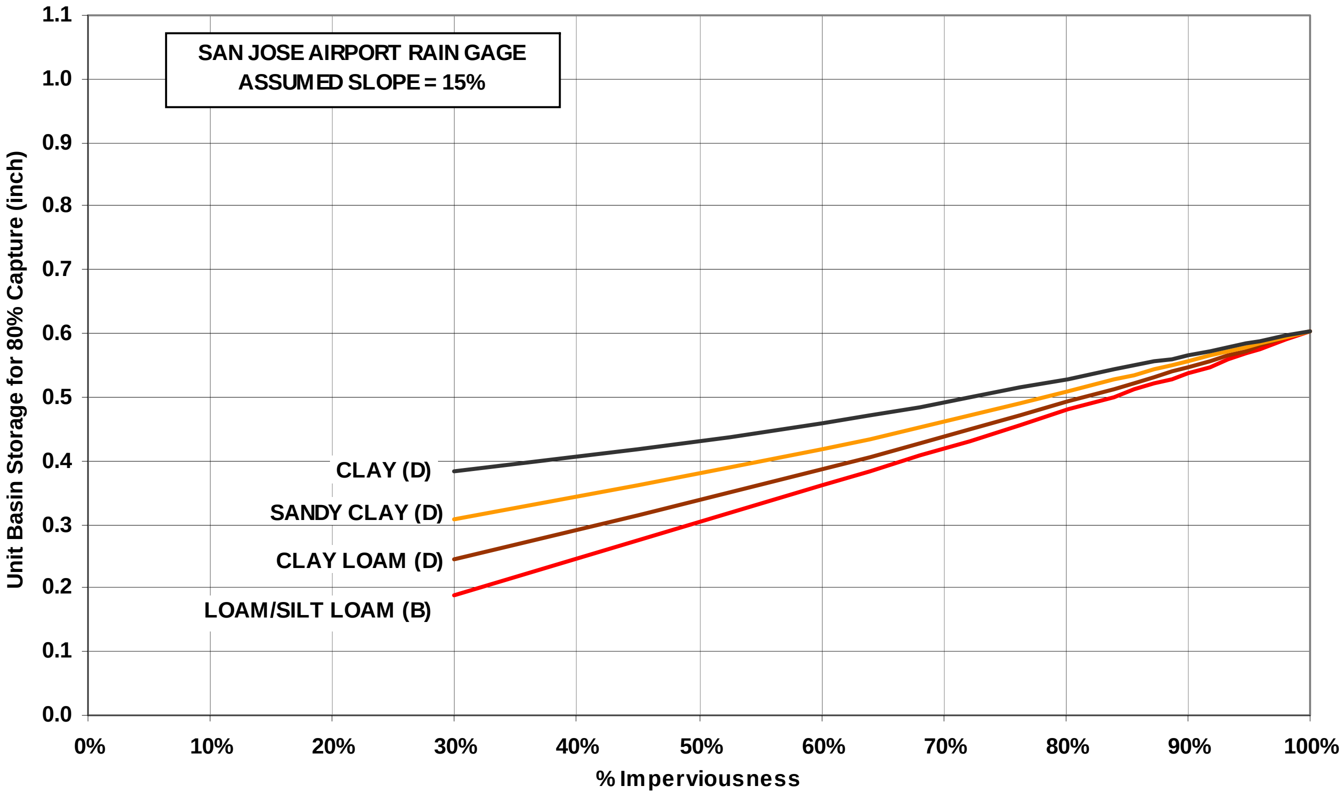

Figure B-5 Unit Basin Volume for 80% Capture - <u>San Jose Airport Rain Gage</u>

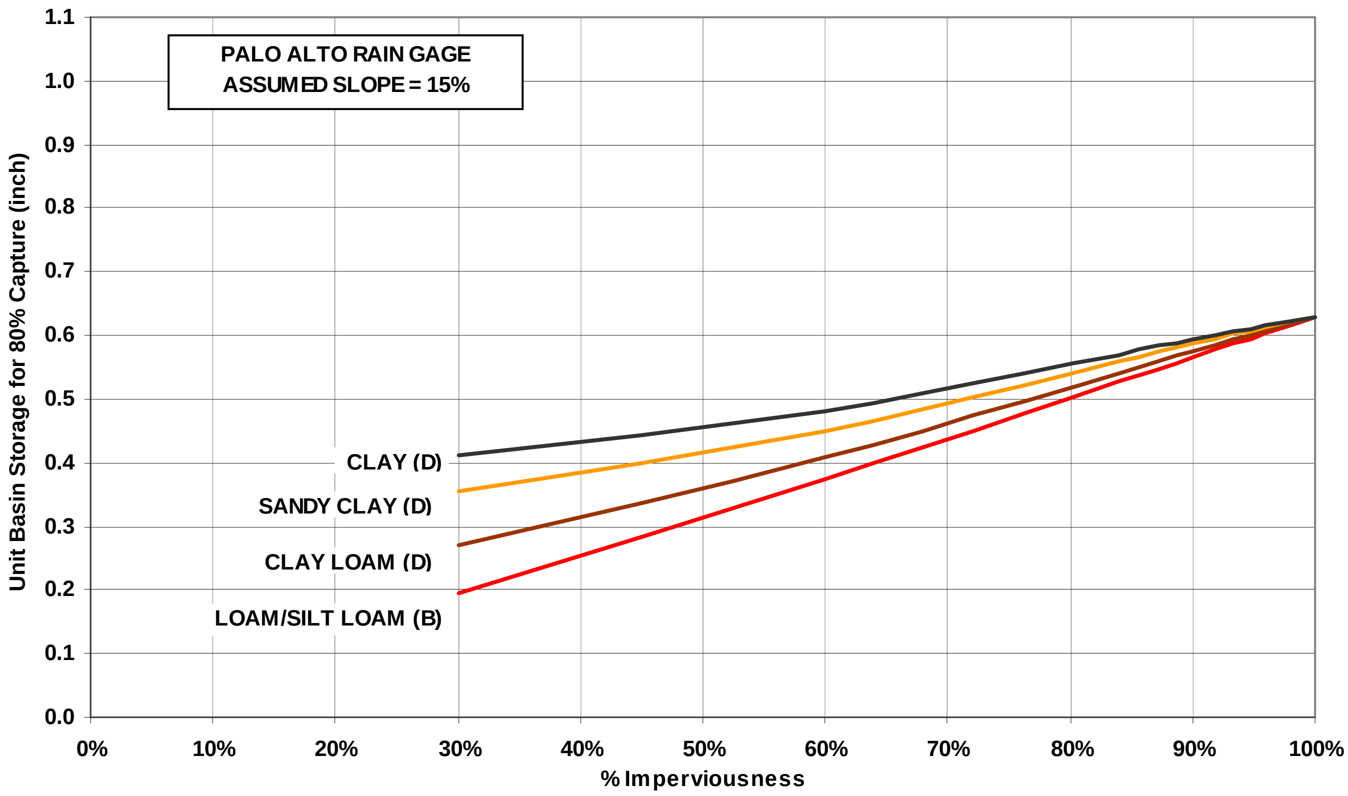

Figure B-6 Unit Basin Volume for 80% Capture - **Palo Alto Rain Gage**

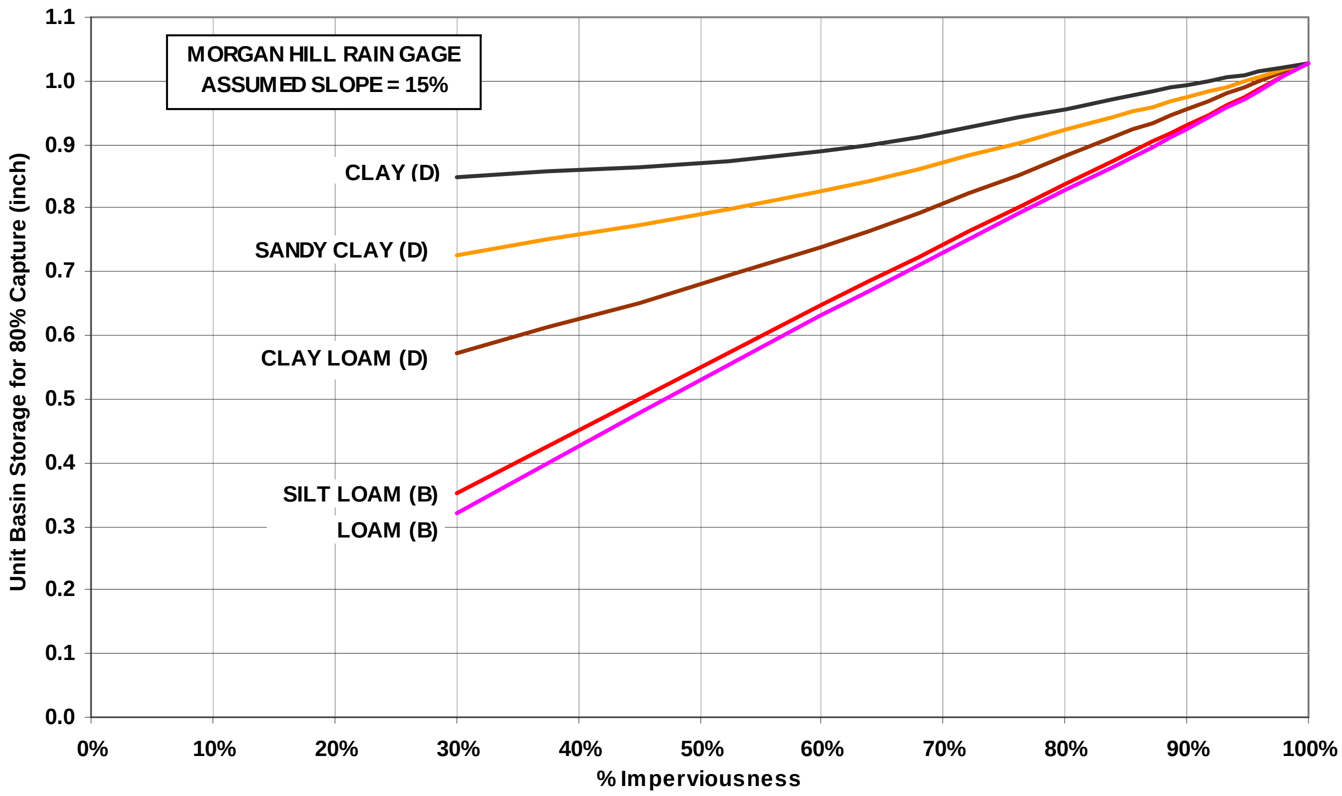

Figure B-7 Unit Basin Volume for 80% Capture - <u>Morgan Hill Rain Gage</u>

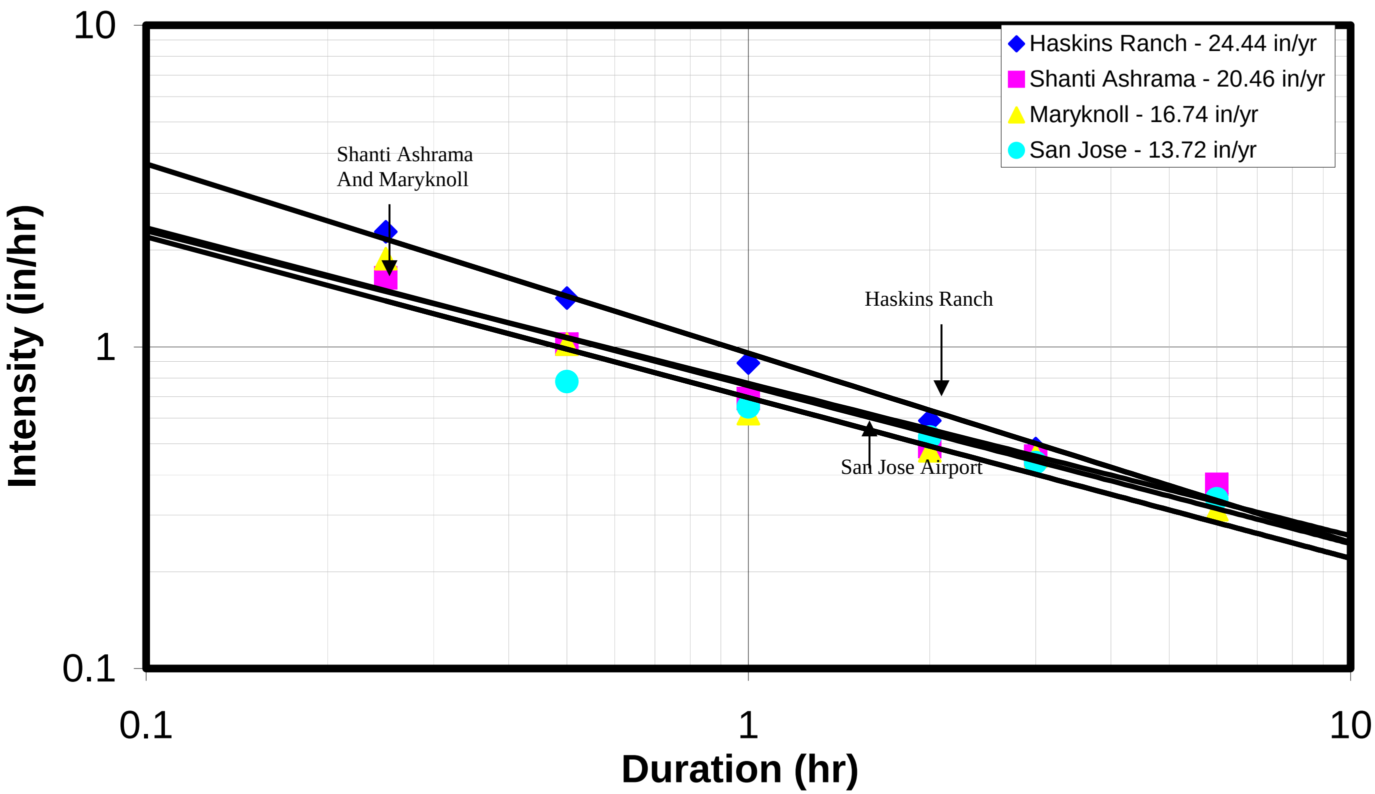

Figure B-8 Intensity-Frequency-Duration Curves for a 50-Year Return Period for Haskins Ranch, Shanti Ashrama, Maryknoll, and San Jose Airport Rain Gages

B.2 Treatment Measure Sizing Examples

This section presents examples showing how to use the worksheets to determine the water quality design flow and volume for several treatment measures, as well as an example of the combined flow and volume based sizing method. Refer to Chapter 5 for more background on and description of the various sizing methods.

Example 1 – Single Family Home Subdivision

Description:

- Single-family home subdivision consisting of 23 lots and a new private street serving the lots, on a 1.9-acre site.
- Site analysis indicates that an infiltration trench is feasible (i.e., infiltration rate of site soils is > 8 inches/hour and depth to groundwater is > 30 feet).
- The proposed treatment measures consist of:
    - An infiltration trench along one side of the private street, consisting of permeable pavers underlain by bedding gravel and drain rock; and
    - Landscape dispersion of roof runoff and pervious paving driveways on some of the individual lots.

Data:

- The infiltration trench will be sized to accept runoff from an area of 38,900 square feet (0.89 acres), which contains 24,400 square feet (0.56 acres) of impervious surface.
- The mean annual precipitation at the site is 24 inches.
- The closest rain gage is San Jose Airport gage.
- Soils consist of clayey sand and clayey sand with gravel (assume Type B soils).
- Average site slope is approximately 1%.

Approach:

- Use the Adapted CASQA BMP Handbook Method to determine the water quality design volume for sizing the infiltration trench.
- Per the worksheet on the following pages, the design volume is 2,012 cubic feet.
- Assuming that the porosity of the drain rock in the infiltration trench is 35%, the required storage volume in the trench is 2,012 / 0.35 = 5,749 cubic feet.
- The trench dimensions can now be determined to achieve this volume of drain rock. Note that if an underdrain is used, its outlet invert elevation must be above this volume of drain rock.

Example 1 – Volume-Based Sizing for Infiltration Trench

Section II.B. — Sizing Volume-Based Treatment Measures based on the Adapted CASQA Stormwater BMP Handbook Approach

The equation that will be used to size the BMP is:

Design Volume = (Rain Gage Correction Factor) × (Unit Basin Storage Volume) × (Drainage Area)

Step 1. Determine the drainage area for the BMP, A = _0.89_ acres

Step 2. Determine percent imperviousness of the drainage area:

a. Estimate the amount of impervious surface (rooftops, hardscape, streets, and sidewalks, etc.) in the area draining to the BMP: _0.56_ acres

b. % impervious area = (amount of impervious area/drainage area for the BMP) × 100
% impervious area = **(Step 2a. /Step 1)** × 100 = 0.56 / 0.89 × 100
% impervious area = ___63___%

Step 3. Find the mean annual precipitation at the site (MAP_{site}). To do so, estimate where the site is on Figure B-1 and estimate the mean annual precipitation in inches from the rain line (isopleth) nearest to the project site. Interpolate between isopleths if necessary.

MAP_{site} = _24_inches

Step 4. Identify the reference rain gage closest to the project site from Table B-2b and record the MAP_{gage}:

MAP_{gage} = _13.9_inches

Table B-2b: Precipitation Data for Three Reference Gages

Reference Rain Gages	Mean Annual Precipitation (MAP_{gage}) (in)
San Jose Airport	13.9
Palo Alto	13.7
Morgan Hill	19.5

Example 1 – Volume-Based Sizing for Infiltration Trench, continued

Section II.B. —Adapted CASQA Stormwater BMP Handbook Approach (continued)

Step 5 Determine the rain gage correction factor for the precipitation at the site using the information from **Step 3** and **Step 4**.

Correction Factor = MAP_{site} (**Step 3**)/MAP_{gage} (**Step 4**) = 24 / 13.9 =

Correction Factor = __1.73__

Step 6. Identify the representative soil type for the BMP drainage area.

a) Identify from Figure B-1 or from site soils data, the soil type that is representative of the pervious portion of the project shown here in order of increasing infiltration capability:

____ Clay (D) ____ Sandy Clay (D) ____ Clay Loam (D)

__X__ Silt Loam/Loam (B) ____ Not Applicable (100% Impervious)

b) Does the site planning allow for protection of natural areas and associated vegetation and soils so that the soils outside the building footprint are not graded/compacted? _Y_ (Y/N)

Step 7. Determine the average slope for the drainage area for the BMP: ____1____%

Step 8. Determine the unit basin storage volume from sizing curves.

a) Slope ≤ 1%

Use the figure entitled "Unit Basin Volume for 80% Capture, 1% Slope" corresponding to the nearest rain gage: Figure B-2, B-3, or B-4 for San Jose, Palo Alto, or Morgan Hill, respectively. Find the percent imperviousness of the drainage area (from **Step 2**) on the x-axis. From there, find the line corresponding to the soil type (from **Step 6**), and obtain the unit basin storage on the y-axis.

Unit Basin Storage for 1% slope ($UBS_{1\%}$) = __0.36_(inches)

For B soils, and 63% impervious

Step 9. Determine the Adjusted Unit Basin Storage Volume for the site, using the following equation:

Adjusted UBS = Rain Gage Correction Factor × Unit Basin Storage Volume

Adjusted UBS = (**Step 5**) × (**Step 8**) = 1.73 × 0.36 = 0.63

Adjusted UBS = __0.63_(inches)

Step 10. Determine the BMP Design Volume, using the following equation:

Design Volume = Adjusted Unit Basin Storage Volume × Drainage Area

Design Volume = (**Step 9**) × (**Step 1**) × 1 foot/12 inch = 0.63 × 0.89 × 1/12 = 0.046

Design Volume = __0.046___ acre-feet

OR 0.046 × 43,560 ft^2/acre = 2,012 cubic feet

Example 2 – High Density Residential Development

Description:

- Three-story building above underground parking structure ("podium" type construction) consisting of 35 residential units on a 0.70-acre site. Building has central courtyard/patio area.
- The project qualifies for up to 50% LID treatment reduction credit (Category B).
- 15% of the site is used for parking structure entrances, trash and recycling and utility access.
- The proposed treatment measures consist of:
    1. Biotreatment (flow-through planters) in the courtyard area to treat roof and courtyard runoff (at-grade to receive sheet flow from courtyard).
    2. Proprietary media filter to treat runoff from parking structure entrances and trash/recycling/utility access area.

Data:

- The drainage area to the flow-through planters includes 25,920 square feet (0.59 acres) of roof and courtyard area (100% impervious; assume a runoff coefficient of 0.90).
- The drainage area to the media filter is 4,570 square feet (0.11 acres) of asphalt pavement (assume a runoff coefficient of 0.90).
- The mean annual precipitation at the site is 15 inches.
- The closest rain gage is the San Jose Airport gage.

Approach:

- Use the CASQA BMP Handbook Method or the Uniform Intensity Method for determining the water quality design flow for sizing the media filter.
    - Using the CASQA BMP Handbook Method (per the worksheet on the following pages), the design flow is 0.018 cfs.
    - Using the Uniform Intensity Method (per the worksheet on the following pages), the design flow is 0.020 cfs[1].
    - The design flow is then used to select the appropriate size media filter product or determine the number of filter cartridges[2].

[1] Note that the Uniform Intensity Method usually results in a smaller design flow rate than the CASQA BMP Handbook Method, unless the project site is located relatively close to the Palo Alto or San Jose rain gages (i.e., if the site's mean annual precipitation is less than 14 or 16 inches, for the Palo Alto and San Jose gages, respectively.)

[2] Note that the selected media filter product must be certified by the Washington State Technical Assistance Protocol – Ecology (TAPE) program under the General Use Level Designation (GULD) for Basic Treatment. A list of proprietary media filters currently holding this certification can be obtained from the Department of Ecology's website at http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html. The media filter should be sized based on the water quality design flow specified in MRP Provision C.3.d and the cartridge design operating rate for which the product received TAPE GULD certification.

- Use the simplified sizing approach or combination flow and volume approach to size the flow-through planters.
  - Using the simplified sizing approach, the total surface area of the flow-through planter(s) is 4% of the contributing impervious area, or 0.04 × 25,920 square feet = 1,037 square feet
  - To use the combination flow and volume approach, you must first compute the water quality design volume for the flow-through planters. The design volume (per the worksheet) is 1,350 cubic feet.
  - Using the combination flow and volume approach (per the worksheet), the total required surface area of the flow-through planter(s) is 740 square feet (about 3% of the contributing impervious area).

Example 2 – Flow-Based Sizing for the Media Filter

Section III.B.—Sizing Flow-Based Treatment Measures based on the CASQA Stormwater BMP Handbook Flow Approach

This method uses the Rational Method equation to determine the design flow:

$$Q=CIA$$

Where:
Q = the design flow in cubic feet per second (cfs),
C = the drainage area runoff coefficient,
I = the design intensity (in/hr), and
A = the drainage area for the BMP (acres)

Step 1. Determine the drainage area for the BMP, A = __0.11_ acres

Step 2. Determine the runoff coefficient, C = __0.90__ from Table B-3.

Step 3. Find the mean annual precipitation at the site (MAP_{site}). To do so, estimate where the site is on Figure B-1 and estimate the mean annual precipitation in inches from the rain line (isopleth) nearest to the project site. Interpolate between isopleths if necessary.

MAP_{site} = __15__ inches

Step 4. Identify the reference rain gage closest to the project site from Table B-2b and record the MAP_{gage}:

MAP_{gage} = __13.9__ inches

Table B-2b: Precipitation Data for Three Reference Gages

Reference Rain Gages	Mean Annual Precipitation (MAP_{gage}) (in)
San Jose Airport	13.9
Palo Alto	13.7
Morgan Hill	19.5

Example 2 – Flow-Based Sizing for the Media Filter, continued

Section III.B.— CASQA Stormwater BMP Handbook Flow Approach (continued)

Step 5. Determine the rain gage correction factor for the precipitation at the site using the information from **Step 3** and **Step 4**.

Correction Factor = MAP_{site} / MAP_{gage} = (**Step 3**)/(**Step 4**) = 15 / 13.9

Correction Factor = 1.08

Step 6. Select the design rainfall intensity, I, for the rain gage closest to the site from Table B-2c:

Table B-2c: Precipitation Data for Three Reference Gages

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

*The design intensity is twice the 85th Percentile Hourly Rainfall Intensity.

Design Rainfall Intensity: I = 0.17 in/hr

Step 7. Determine the corrected design rainfall intensity (I) for the site:

Design intensity (site) = Correction factor × Design rainfall intensity for closest rain gage

Design intensity (site) = (**Step 5**) × (**Step 6**) = 0.18 in/hr

1.08 × 0.17

Step 8. Determine the design flow (Q) using the Rational Method equation:

$$Q = C \times I \times A$$

Q = (**Step 2**) × (**Step 7**) × (**Step 1**)

$$Q = 0.90 \times 0.18 \times 0.11$$

Q = 0.018 acres-in/hr

Design Flow, Q = 0.018 cfs[3]

[3] No conversion factor for correct units is needed for the rational formula because (1 acre-in/hr) X (43,560 sq.ft/acre) X (1ft/12 in) X (1hr/3600 sec) ≈ 1 ft^3/ sec or cfs.

Example 2 – Flow-Based Sizing for the Media Filter, continued

Section III.C.—Sizing Flow-Based Treatment Measures based on the Uniform Intensity Approach

This method uses the Rational Method equation:

Q=CIA

Where:

Q = the design flow in cubic feet per second (cfs),
C = the drainage area runoff coefficient,
I = the design intensity (in/hr), and
A = the drainage area for the BMP (acres)

Step 1. Determine the drainage area for the BMP, A = 0.11 acres

Step 2. Determine the runoff coefficient, C = 0.90 from Table B-3.

Step 3. Use a design intensity of **0.2 in/hr** for "I" in the Q=CIA equation.

I = 0.2 in/hr

Step 4. Determine the design flow (Q) using Q = CIA

$Q = C \times I \times A$

Q = (**Step 2**) × (0.2 in/hr) × (**Step 1**)

$Q = 0.90 \times 0.2 \times 0.11$

Q = 0.020 acres-in/hr

Design Flow, Q = 0.020 cfs

Example 2 – Volume-Based Sizing for Flow-Through Planter

Section II.B. — Sizing Volume-Based Treatment Measures based on the Adapted CASQA Stormwater BMP Handbook Approach

The equation that will be used to size the BMP is:

Design Volume = (Rain Gage Correction Factor) × (Unit Basin Storage Volume) × (Drainage Area)

Step 1. Determine the drainage area for the BMP, A = _0.59_ acres

Step 2. Determine percent imperviousness of the drainage area:

a. Estimate the amount of impervious surface (rooftops, hardscape, streets, and sidewalks, etc.) in the area draining to the BMP: _0.59_ acres

b. % impervious area =(amount of impervious area/drainage area for the BMP) × 100
% impervious area = **(Step 2a./Step 1)** × 100
% impervious area = ___100___%

Step 3. Find the mean annual precipitation at the site (MAP_{site}). To do so, estimate where the site is on Figure B-1 and estimate the mean annual precipitation in inches from the rain line (isopleth) nearest to the project site. Interpolate between isopleths if necessary.

MAP_{site} = __15__inches

Step 4. Identify the reference rain gage closest to the project site from Table B-2b and record the MAP_{gage}:

MAP_{gage} = __13.9__inches

Table B-2b: Precipitation Data for Three Reference Gages

Reference Rain Gages	Mean Annual Precipitation (MAP_{gage}) (in)
San Jose Airport	13.9
Palo Alto	13.7
Morgan Hill	19.5

Example 2 – Volume-Based Sizing for Flow-Through Planter, continued

Section II.B. —Adapted CASQA Stormwater BMP Handbook Approach (continued)

Step 5 Determine the rain gage correction factor for the precipitation at the site using the information from **Step 3** and **Step 4**.

Correction Factor = MAP_{site} (**Step 3**)/MAP_{gage} (**Step 4**) = 15 / 13.9 =

Correction Factor = ____1.08____

Step 6. Identify the representative soil type for the BMP drainage area.

c) Identify from Figure B-1 or from site soils data, the soil type that is representative of the pervious portion of the project shown here in order of increasing infiltration capability:

____ Clay (D) ____ Sandy Clay (D) ____ Clay Loam (D)

____ Silt Loam/Loam (B) __X__ Not Applicable (100% Impervious)

d) Does the site planning allow for protection of natural areas and associated vegetation and soils so that the soils outside the building footprint are not graded/compacted? __ (Y/N)

Step 7. Determine the average slope for the drainage area for the BMP: ____1____%

Step 8. Determine the unit basin storage volume from sizing curves.

b) Slope ≤ 1%

Use the figure entitled "Unit Basin Volume for 80% Capture, 1% Slope" corresponding to the nearest rain gage: Figure B-2, B-3, or B-4 for San Jose, Palo Alto, or Morgan Hill, respectively. Find the percent imperviousness of the drainage area (see answer to **Step 2**, above) on the x-axis. From there, find the line corresponding to the soil type (from **Step 6**), and obtain the unit basin storage on the y-axis.

Unit Basin Storage for 1% slope ($UBS_{1\%}$) =____0.58____(inches)

Step 9. Determine the Adjusted Unit Basin Storage Volume, using the following equation:

Adjusted UBS = Rain Gage Correction Factor × Unit Basin Storage Volume

Adjusted UBS = (**Step 5**) × (**Step 8**) = 1.08 × 0.58 = 0.63

Adjusted UBS = __0.63_(inches)

Step 10. Determine the BMP Design Volume, using the following equation:

Design Volume = Adjusted Unit Basin Storage Volume × Drainage Area

Design Volume = (**Step 9**) × (**Step 1**) × 1 foot/12 inch = 0.63 × 0.59 × 1/12 =

Design Volume = __0.031___ acre-feet

OR 0.031 × 43,560 ft^2/acre = 1,350 cubic feet

Example 2 – Combination Flow and Volume Sizing for Flow-Through Planters

Step 1. **Contributing drainage area to the treatment measure:_25,920_ sq. ft.**

Is the contributing drainage area 100% impervious? __X__ Yes ____ No
If yes, skip to Step 2c and fill in the drainage area as the effective impervious area.

Step 2. Determine the effective impervious surface area draining to the treatment measure:

a. Impervious surface area draining to the treatment measure: _______ sq. ft.

b. Pervious surface area draining to the treatment measure: _______ sq. ft.

For small grass or landscaped areas, multiply the pervious surface area by a runoff coefficient of 0.10 to compute the equivalent impervious surface area.

c. Effective impervious area = (pervious area × 0.10) + impervious area
Effective impervious area = (Step 2.b x 0.10) + Step 2.a
Effective impervious area = **__25,920__ sq. ft.**

Step 3. Determine the required treatment volume using Adapted CASQA Stormwater BMP Handbook Approach (Worksheet Section II.B, Steps 9 and 10). Copy the results here:

Adjusted Unit Basin Storage (UBS) Volume: __0.63__ in.

Water Quality Design (WQD) Volume: _1,350__ cu. ft.

Step 4. Determine the design rainfall intensity (Uniform Intensity Approach, Section III.C, Step 3):

Design Rainfall Intensity: __0.2__ in/hr

Step 5. Assume that the rain event that generates the Unit Basin Storage Volume of runoff occurs at the design rainfall intensity for the entire length of the storm. Calculate the duration of the storm by dividing the Adjusted Unit Basin Storage Volume by the design rainfall intensity. In other words, determine the amount of time required for the Unit Basin Storage Volume to be achieved at the design intensity rate.

Duration = UBS Volume (inches) ÷ Rainfall Intensity (inches/hour)

Duration = (**Step 3**) ÷ 0.2 in/hr = **__3.15__ hrs.**
(0.63 ÷ 0.2)

Example 2 – Combination Flow and Volume Sizing for Flow-Through Planters, continued

Step 6. Make a preliminary estimate of the surface area of the bioretention facility by multiplying the area of impervious surface to be treated by a sizing factor of **0.03.**

Estimated Surface Area = Total Effective Impervious Area × 0.03

Estimated Surface Area = 25,920 (**Step 2.c**) sq. ft. × 0.03 = **778 sq. ft.**

Step 7. Calculate the volume of runoff that filters through the biotreatment soil at a rate of 5 inches per hour (the design surface loading rate for bioretention facilities), for the duration of the storm calculated in Step 5.

Volume of Treated Runoff = Estimated Surface Area × 5 in/hr × (1 ft/12 in) × Duration

Volume of Treated Runoff = 778 (**Step 6**) sq. ft. × 5/12 × 3.15 (**Step 5**) hrs. = **1,021 cu. ft.**

Step 8. Calculate the portion of the water quality design (WQD) volume remaining after treatment is accomplished by filtering through the biotreatment soil. The result is the amount that must be stored in the ponding area above the bioretention surface area estimated in Step 6.

Volume in ponding area = WQD Volume – Volume of Treated Runoff

Volume in ponding area = 1,350 (**Step 3**) cu. ft. – 1,021 (**Step 7**) cu. ft. = **329 cu. ft.**

Step 9. Calculate the depth of the volume in the ponding area by dividing this volume by the estimated surface area in Step 6.

Depth of ponding = Volume in Ponding Area ÷ Estimated Surface Area

Depth of ponding = 329 (**Step 8**) cu. ft. ÷ 778 (**Step 6**) sq. ft. = **0.42 ft.** (5.0 inches)

Step 10. Check to see if the average ponding depth is between 0.5 and 1.0 feet (6 and 12 inches), which is the range of allowable ponding depths in a bioretention facility or flow-through planter (**0.5 feet is recommended**). If the ponding depth is less than 0.5 feet, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps 6 through 9 with a smaller surface area). If the ponding depth is greater than 1 foot, a larger surface area will be required (i.e., repeat Steps 6 through 9 with a larger surface area).

[In this example, the optimized surface area for a 6-inch ponding depth would be 740 square feet (about 3% of the contributing impervious area).]

Example 3 – Parking Lot

Description:

- The project site is 1.2 acres with 1% slope from edge of lot to street.
- The parking lot will have some landscaped islands as an amenity (not used for stormwater treatment).
- All areas will be graded to drain to bioretention facilities along the perimeter of the site.

Data:

- The site was divided into two drainage management areas. Drainage Areas A and B each drain to one bioretention facility. The self-treating areas (landscaped islands) do not need to drain to a treatment measure. The drainage area data summary is as follows:

Drainage Area	Impervious Area (sf)	Pervious Area (sf)	Total Area (sf)
A	6,788	7,868	14,656
B	24,491	0	24,491
Self-treating area	0	13,125	13,125
Totals	31,279	20,993	52,272

Approach:

- Use the simplified sizing method (4% method) to size the bioretention facilities.

Procedure for BMP Sizing:

1. List the area of impervious surface and the area of pervious surface (if any) that drains to the treatment measure.
2. Multiply the pervious area by a factor of 0.1.
3. Add the product obtained in Step 2 to the area of impervious surface to obtain the "effective impervious area."
4. Multiply the effective impervious area by a factor of 0.04. This is the required surface area of the bioretention facility.

Results of Steps 1 through 4 for the example drainage areas are shown below:

Drainage Area	Impervious Area (sf)	Pervious Area (sf)	Pervious Area x 0.1 (sf)	Effective Impervious Area (EIA) (sf)	Bioretention Area (sf) (EIA * 0.04)
A	6,788	7,868	786.8	7,575	303
B	24,491	0	0	24,491	980

Appendix

C

Biotreatment Soil Mix Specifications

Table of Contents

C.1 Introduction

The MRP requires Regulated Projects to use biotreatment soil media that meet the minimum specifications set forth in Attachment L of the previous permit (Order No. R2-2009-0074). The MRP also allows Permittees to collectively develop and adopt revisions to the soil media minimum specifications subject to the Water Board Executive Officer's approval. On February 5, 2016, Permittees submitted revisions to the soil specifications to address issues with the current soil media specifications that Permittees have identified, based on implementation of these soil media specifications for the last 5 years under the previous MRP. The Water Board Executive Officer approved the revised soil specifications on April 18, 2016. This appendix contains the revised biotreatment soil mix (BSM) specifications. All Regulated Projects are required to use these revised BSM specifications.

To assist permittees and others in complying with this requirement, the Program has produced several documents including a guidance memorandum, a BSM Supplier List, and a BSM Checklist to review the supplied soil mix. To access the documents, see: http://www.scvurppp-w2k.com/nd_wp.shtml#lid or go to www.scvurppp.org, and click on Low Impact Development (under the Quick Links tab).

Municipal agencies have different needs and may want to design their review processes accordingly. Some agencies may want go through a detailed process with the BSM checklist every time or only with their own agency projects. Others may want to do that only with first-time contractors or for a few projects until everyone is familiar with the process.

In 2014, the Program vetted several BSM suppliers and created a vendor list. The list is amended annually as other suppliers submit verification information. The Program provides this list of BSM suppliers for the use of its member agencies, contractors, designers and others in finding suppliers for their projects. Suppliers are listed based on a general review of their soil mix product including test results, adherence to the BSM specification in the MRP and knowledge of the specification. Users of the vendor list must make the final determination as to the products and adherence to the MRP. The listing of any soil supplier is not to be construed as an actual or implied endorsement, recommendation, or warranty of such soil supplier or their products, nor is criticism implied of similar soil suppliers that are not listed.

The BSM checklist is intended to supply municipal staff, contractors, designers and others with an easy-to-read summary of the detailed information needed to verify that the BSM being provided by the BSM supplier meets the BSM specification.

C.2 BASMAA Regional Biotreatment Soil Specification

Specification of Soils for Biotreatment or Bioretention Facilities

Soils for biotreatment or bioretention areas shall meet two objectives:

- Be sufficiently permeable to infiltrate runoff at a minimum rate of 5" per hour during the life of the facility, and
- Have sufficient moisture retention to support healthy vegetation.

Achieving both objectives with an engineered soil mix requires careful specification of soil gradations and a substantial component of organic material (typically compost).

Local soil products suppliers have expressed interest in developing 'brand-name' mixes that meet these specifications. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a 'brand-name' mix from a soil supplier.

Tests must be conducted within 120 days prior to the delivery date of the bioretention soil to the project site.

Batch-specific test results and certification shall be required for projects installing more than 100 cubic yards of bioretention soil.

SOIL SPECIFICATIONS

Bioretention soils shall meet the following criteria. "Applicant" refers to the entity proposing the soil mixture for approval by a Permittee.

1. General Requirements – Bioretention soil shall:
   a. Achieve a long-term, in-place infiltration rate of at least 5 inches per hour.
   b. Support vigorous plant growth.
   c. Consist of the following mixture of fine sand and compost, measured on a volume basis:
      60%-70% Sand
      30%-40% Compost
2. Submittal Requirements – The applicant shall submit to the Permittee for approval:
   a. A minimum one-gallon size sample of mixed bioretention soil.
   b. Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.

c. Grain size analysis results of the fine sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils or Caltrans Test Method (CTM) C202.
d. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in 4.
e. Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, “Loss-On-Ignition Organic Matter Method”.
f. Grain size analysis results of compost component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
g. A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
h. Provide the name of the testing laboratory(s) and the following information:

    (1) Contact person(s)

    (2) Address(s)

    (3) Phone contact(s)

    (4) E-mail address(s)

    (5) Qualifications of laboratory(s), and personnel including date of current certification by USCC, ASTM, Caltrans, or approved equal

3. <u>Sand for Bioretention Soil</u>
    a. Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be nonplastic.
    b. Sand for Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #40 or #50, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422, CTM 202 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)** ***Min***	***Max***
3/8 inch	100	100
No. 4	90	100
No. 8	70	100
No. 16	40	95
No. 30	15	70
No. 40 or No.50	5	55
No. 100	0	15
No. 200	0	5

Note: all sands complying with ASTM C33 for fine aggregate comply with the above gradation requirements.

4. Composted Material

   Compost shall be a well decomposed, stable, weed free organic matter source derived from waste materials including yard debris, wood wastes or other organic materials not including manure or biosolids meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

   a. Compost Quality Analysis by Laboratory – Before delivery of the soil, the supplier shall submit a copy of lab analysis performed by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Examination of Composting and Compost (TMECC). The lab report shall verify:
      (1) Organic Matter Content: 35% - 75% by dry wt.
      (2) Carbon and Nitrogen Ratio: C:N < 25:1 and C:N >15:1
      (3) Maturity/Stability: Any one of the following is required to indicate stability:
         (i) Oxygen Test < 1.3 O2 /unit TS /hr
         (ii) Specific oxy. Test < 1.5 O2 / unit BVS /hr
         (iii) Respiration test < 8 mg CO_2-C /g OM / day
         (iv) Dewar test < 20 Temp. rise (°C) e.
         (v) Solvita® > 5 Index value
      (4) Toxicity: Any one of the following measures is sufficient to indicate non-toxicity.
         (i) NH_4^+ : NO_3^--N < 3
         (ii) Ammonium < 500 ppm, dry basis
         (iii) Seed Germination > 80 % of control
         (iv) Plant Trials > 80% of control
         (v) Solvita® = 5 Index value
      (5) Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.
         (i) Total Nitrogen content 0.9% or above preferred.
         (ii) Boron: Total shall be <80 ppm;
      (6) Salinity: Must be reported; < 6.0 mmhos/cm
      (7) pH shall be between 6.2 and 8.2 May vary with plant species.

   b. Compost Quality Analysis by Compost Supplier – Before delivery of the compost to the soil supplier the Compost Supplier shall verify the following:
      (1) Feedstock materials shall be specified and include one or more of the following: landscaping/yard trimmings, grass clippings, food scraps, and agricultural crop residues.

(2) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell or containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable.
(3) Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.

c. <u>Compost for Bioretention Soil Texture</u> – Compost for bioretention soils shall be analyzed by an accredited lab using #200, 1/4 inch, 1/2 inch, and 1 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
1 inch	99	100
1/2 inch	90	100
1/4 inch	40	90
No. 200	1	10

d. Bulk density shall be between 500 and 1100 dry lbs/cubic yard
e. Moisture content shall be between 30% - 55% of dry solids.
f. Inerts – compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.

g. Select Pathogens – Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <10000 MPN/gram.
h. Trace Contaminants Metals (Lead, Mercury, Etc.) – Product must meet US EPA, 40 CFR 503 regulations.
i. Compost Testing – The compost supplier will test all compost products within 120 calendar days prior to application. Samples will be taken using the STA sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test.

VERIFICATION OF ALTERNATIVE BIORETENTION SOIL MIXES

Bioretention soils not meeting the above criteria shall be evaluated on a case by case basis. Alternative bioretention soil shall meet the following specification: "Soils for bioretention facilities shall be sufficiently permeable to infiltrate runoff at a minimum rate of 5 inches per hour during the life of the facility, and provide sufficient retention of moisture and nutrients to support healthy vegetation."

The following steps shall be followed by municipalities to verify that alternative soil mixes meet the specification:

1. General Requirements – Bioretention soil shall achieve a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth. The applicant refers to the entity proposing the soil mixture for approval.
   a. Submittals – The applicant must submit to the municipality for approval:
      (1) A minimum one-gallon size sample of mixed bioretention soil.
      (2) Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
      (3) Certification from an accredited geotechnical testing laboratory that the Bioretention Soil has an infiltration rate between 5 and 12 inches per hour as tested according to Section 1.b.(2)(ii).
      (4) Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
      (5) Grain size analysis results of mixed bioretention soil performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
      (6) A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
      (7) The name of the testing laboratory(s) and the following information:
         (i) Contact person(s)
         (ii) Address(s)
         (iii) Phone contact(s)
         (iv) E-mail address(s)
         (v) Qualifications of laboratory(s), and personnel including date of current certification by STA, ASTM, or approved equal.
   b. Bioretention Soil
      (1) Bioretention Soil Texture: Bioretention Soils shall be analyzed by an accredited lab using #200, and 1/2" inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	Percent Passing (by weight) *Min*	*Max*
1/2 inch	97	100
No. 200	2	5

(2) Bioretention Soil Permeability testing: Bioretention Soils shall be analyzed by an accredited geotechnical lab for the following tests:

(i) Moisture – density relationships (compaction tests) shall be conducted on bioretention soil. Bioretention soil for the permeability test shall be compacted to 85 to 90 percent of the maximum dry density (ASTM D1557).

(ii) Constant head permeability testing in accordance with ASTM D2434 shall be conducted on a minimum of two samples with a 6-inch mold and vacuum saturation.

MULCH FOR BIORETENTION FACILITIES

Three inches of mulch is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Projects subject to the State's Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least three inches of mulch. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Aged mulch can be obtained through soil suppliers or directly from commercial recycling yards. It is recommended to apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

C.3 Biotreatment Soil Mix
Specification Verification Checklist

This checklist is intended to supply municipal staff, contractors, designers and others with an easy-to-read summary of the detailed information needed to verify that the biotreatment soil mix being provided by the Soil Mix Supplier meets the BASMAA Regional Biotreatment Soil Specification[1] approved by the Regional Water Board Executive Officer on April 18, 2016[2].

The checklist should be provided to the Soil Mix Supplier by the municipality or contractor before the soil mix has been ordered to allow for sufficient time to compile the information and time to review the completed checklist before delivery of the soil mix to the job site.

Use of this checklist is not required by the MRP and is intended only for assistance in reviewing submittals. Additionally or alternatively, the one page Supplier Certification Statement, developed by the stormwater programs listed below, can be requested from the Supplier to guarantee that the product meets the specification.

The Certification Statement, a list of Soil Mix Suppliers, the BASMAA Regional Biotreatment Soil Specification (2016) and other materials are available at the following websites:

- Santa Clara Valley Urban Runoff Pollution Prevention Program:
  www.scvurppp-w2k.com/nd_wp.shtml#other
- San Mateo Countywide Water Pollution Prevention Program:
  www.flowstobay.org/newdevelopment
- Alameda Countywide Clean Water Program:
  www.cleanwaterprogram.org/business/development2.html

If a municipality chooses to use the checklist, the following five items are required to be submitted by the Soil Mix Supplier to the requesting municipality or contractor:

- **Sample of the Biotreatment Soil Mix**
  A minimum 1-gallon bag of soil mix.

- **Attachment A – Supplier Analysis of the Biotreatment Soil Mix**
  To be completed by the Soil Mix Supplier providing the soil mix.

- **Attachment B – Lab Analysis of Sand Component of the Biotreatment Soil Mix**
  To be completed by the laboratory conducting the analysis of the sand.

- **Attachment C – Lab Analysis of Compost Component of the Biotreatment Soil Mix**
  To be completed by the laboratory conducting the analysis of the compost. Compost analysis of a sample collected (in accordance with the STA sample collection protocol) shall be completed within the last 120 days. Analysis must be completed by a laboratory enrolled in the US Composting Council's Compost Analysis Proficiency program, and shall use the Test Methods for the Evaluation of Composting and Compost (TMECC).

- **Attachment D – Supplier Analysis of Compost Component of the Biotreatment Soil Mix**
  To be completed by the Compost Supplier providing the compost component of the soil mix.

1. www.basmaa.org
2. www.swrcb.ca.gov/rwqcb2/water_issues/programs/stormwater/mrp.shtml

Attachment A

Supplier Analysis of Biotreatment Soil Mix

The table below shall be completed by the Biotreatment Soil Mix Supplier.

Date: **(All lab tests must be done within the last 120 days)**	**Name of Person Filling Out This Form:**
Title:	**Signature:**
Phone:	**Email:**
Company Name:	**City:**
Street Address:	**Zip:**

I certify that the provided Biotreatment Soil Mix meets the requirements of the BASMAA Regional Biotreatment Soil Specification (2016).	☐ Yes (Pass) ☐ No (Fail)

Describe the equipment and methods used to mix the compost and sand components of the Biotreatment Soil Mix.	

Material	**Standard Percent (by volume)**	**Actual Mix %**	**Pass**	**Fail**
Sand	60% - 70%		☐	☐
Compost	30% - 40%		☐	☐

Does the soil mix have a permeability of at least 5 inches per hour?[1]	☐ Yes (Pass) ☐ No (Fail)
Will the soil mix support vigorous plant growth?	☐ Yes (Pass) ☐ No (Fail)

[1]Soil mix permeability testing is only required for alternative biotreatment soil mixes. Soil permeability tests must be conducted on a minimum of two samples using constant head permeability in accordance with ASTM D2434 with a 6-inch mold and vacuum saturation.

Attachment B

Lab Analysis of Sand Component of Biotreatment Soil Mix

The table below shall be completed by the laboratory conducting the sand analysis.

Name of Person Filling Out This Form:	**Signature:**
Title:	**Date:**
Phone:	**Email:**
Company:	**City:**
Street Address:	**Zip:**
Qualifications & relevant certifications (ASTM, CTM or approved equivalent certifications):	

Is sand free of wood, waste, coating (such as clay, stone dust, carbonate, etc.), or any other deleterious material?	☐ Yes (Pass) ☐ No (Fail)
Is all aggregate passing the No. 200 sieve non-plastic?	☐ Yes (Pass) ☐ No (Fail)

Particle size analysis shall be conducted in accordance with ASTM D 422 (Standard Test Method for Particle Size Analysis of Soils) or CTM 202. Other equivalent methods acceptable only if approved.

Sieve Size	Standard Percent Passing (% by weight)	Testing Results (%)	Pass	Fail
3/8 inch	100%		☐	☐
No. 4	90% - 100%		☐	☐
No. 8	70% - 100%		☐	☐
No. 16	40% - 95%		☐	☐
No. 30	15% - 70%		☐	☐
No. 40 or 50	5% - 55%		☐	☐
No. 100	0% - 15%		☐	☐
No. 200	0% - 5%		☐	☐

Attachment C

Lab Analysis of Compost Component of Biotreatment Soil Mix

The table below shall be completed by the laboratory conducting the compost analysis.

Name of Person Filling Out This Form:	**Signature:**
Title:	**Date:**
Phone:	**Email:**
Company:	**City:**
Street Address:	**Zip:**
Qualifications & relevant certifications: **(STA, ASTM or approved equivalent certification)**	

Specification	Standard	Testing Results		Pass	Fail
Organic Matter Content	35% - 75% (by dry weight)		%	☐	☐
Carbon-to-Nitrogen Ratio	15:1 to 25:1 (C:N)		C:N	☐	☐
Salinity	< 6.0 mm hos/cm		mm hos/cm	☐	☐
pH	6.2 - 8.2		pH	☐	☐
Bulk Density	500 – 1100 dry lbs / yd^3		dry lbs / yd^3	☐	☐
Moisture Content	30%-55% (of dry solids)		%	☐	☐
Percent inert ingredients (incl. plastic, glass, paper)	< 1% (by weight or volume)		%	☐	☐

Provide the results of <u>at least one</u> of the following analyses to indicate compost stability:

Specification	Standard	Testing Results		Pass	Fail
Oxygen Test	< 1.3 0_2 /unit TS/hr		0_2 /unit TS/hr	☐	☐
Specific Oxygen Test	< 1.5 0_2/unit BVS/hr		0_2/unit BVS/hr	☐	☐
Respiration Test	< 8mg CO_2-C/g OM/day		mgCO_2-C/g OM/day	☐	☐
Dewar test	< 20 ˚C Temp. rise e.		˚C Temp. rise e.	☐	☐
Solvita® Index value	> 5 Index value		Index value	☐	☐

Provide the results of <u>at least one</u> of the following analyses to indicate compost toxicity:					
Specification	**Standard**	**Testing Results**		**Pass**	**Fail**
Ratio $NH_4^+N: NO_3^-$-N	< 3		NH_4^+-N : NO_3^--N	☐	☐
Ammonium	< 500 ppm, dry basis		ppm, dry basis	☐	☐
Seed Germination	> 80% of control		% of control	☐	☐
Plant Trials	> 80% of control		% of control	☐	☐
Solvita® Index value	= 5 Index value		Index value	☐	☐

Provide the analysis of the nutrient content of the compost, including the following:					
Specification	**Standard**	**Testing Results**		**Pass**	**Fail**
Boron (total, in ppm)	< 80 ppm		ppm	☐	☐
Nitrogen (N)(total %)	> 0.9% preferred.		%		
Phosphorus (as P_2O_5)	*[not specified]*		%		
Potassium (as K_2O)	*[not specified]*		%		
Calcium (Ca)	*[not specified]*		%		
Sodium (Na)	*[not specified]*		%		
Magnesium (Mg)	*[not specified]*		%		
Sulfur (S)	*[not specified]*		ppm		

Provide the results of <u>at least one</u> of the following select pathogens:					
Specification	**Standard**	**Testing Results**		**Pass**	**Fail**
Salmonella	< 3 MPN/4 grams TS		MPN/4 grams TS	☐	☐
Coliform Bacteria	< 10,000 MPN/gram		MPN/gram	☐	☐

Does the product meet US EPA, 40CFR 503 regulations regarding trace contaminants metals (Lead, Mercury, etc.)?	☐ Yes (Pass)
	☐ No (Fail)

Particle size analysis shall be conducted in accordance with ASTM D 422 (Standard Test Method for Particle Size Analysis of Soils)-washing not required. Equivalent methods acceptable if approved.				
Sieve Size	**Standard Percent Passing (by weight)**	**Testing Results (%)**	**Pass**	**Fail**
1 inch	**99% - 100%**		☐	☐
½ inch	**90% - 100%**		☐	☐
¼ inch	**40% - 90%**		☐	☐
No. 200	**1% - 10%**		☐	☐

Attachment D

Supplier Analysis of Compost Component of Biotreatment Soil Mix

The table below shall be completed by the Compost Supplier providing the compost for the mix.

Name of Company:	**Date of Delivery:**
Qualifications & relevant certifications: **(STA, ASTM or approved equivalent certifications)**	**Date of the Compost Lab Analysis Report:** **(Must be dated within 120 days prior to delivery)**
Name of Person Filling Out This Form:	**Date:**
Signature:	**Street Address:**
Email address:	**City:**
Phone:	**Zip:**

Feedstock materials have been specified and include only the following: Landscape/yard trimmings, grass clippings, food scraps, or agricultural crop residues?	☐ Yes (Pass) ☐ No (Fail)
Compost has a dark brown color and a soil-like odor, does not exhibit a sour or putrid smell, does not contain recognizable grass or leaves, and is not hot (120˚F) upon delivery or rewetting?	☐ Yes (Pass) ☐ No (Fail)
The compost has gone through the process to further reduce pathogens (PFRP)? For example, turned windrows must reach a minimum temperature of 55˚C for 15 days with at least 5 turnings during that period.	☐ Yes (Pass) ☐ No (Fail)

Appendix

D

Plant List and Planting Guidance for Landscape-Based Stormwater Measures

Table of Contents:

D.1 Introduction

The purpose of the Plant List for Stormwater Measures is to provide guidance on the planting techniques and selection of appropriate plant materials for implementing stormwater measures. In selecting plant materials, it is important to consider factors that influence plant establishment and success, such as microclimate, type of soil, water availability, proximity to saltwater, and exposure to sun. The list has integrated specifications for each plant to improve the use and function of the list. The list has also been cross-referenced with the Santa Clara Valley Water District's *Approved Plant List* which identifies low water use plants that qualify for their Landscape Rebate Program[1]. The list also identifies water needs for plants using the

[1] For more information, see: www.valleywater.org/Programs/LandscapeRebateProgram.aspx

Water Use Classifications of Landscape Species (WUCOLS) in Region # 1 for the North Central Coast of California.

In addition, the function of the individual stormwater measure should be carefully considered when selecting plant materials. Factors to be considered include inundation period, expected flow of water, and access and maintenance requirements.

Numerous resources are available to assist in selecting appropriate plant species in Santa Clara County, including Sunset's *Western Garden Book*, the Santa Clara Valley Water District's *Approved Plant List*, and East Bay M.U.D.'s *Landscapes for Summer-Dry Climates of the San Francisco Bay Region*. There is also a list near the end of this document from the California Native Plant Society of local nurseries that offer native plants.

D.2 General Recommendations

Avoid the use of invasive species. In selecting plants for stormwater measures, the use of invasive species should be avoided. A complete list of invasive plants can be found at http://www.cal-ipc.org/paf/, the California Invasive Plant Council's Invasive Plant Inventory.

Minimize or eliminate the use of irrigated turf. Effort should be made to minimize the use of irrigated turf, which has higher maintenance requirements and greater potential for polluted runoff.

Select California natives and/or drought tolerant plants. Planting appropriate, drought tolerant California natives or Mediterranean-climate plants reduces water consumption for irrigation, and reduces mowing, fertilizing, and spraying. For the purposes of the plant list on the following pages, "drought tolerant" refers to plants that meet the following criteria:

- Are identified as drought tolerant as follows: *California Native Plants for the Garden* (Borstein, et al.).
- Are identified as requiring occasional or infrequent irrigation in Borstein, et al., *or Plants and Landscapes for Summer Dry Climates* (EBMUD).
- Are identified as requiring no summer water in EBMUD.
- Are identified as requiring little or no water in the Sunset *Western Garden Book*.
- Are identified as requiring low or very low irrigation in the *Guide to Estimating Irrigation Water Needs of Landscape Plantings in California* (University of California Cooperative Extension).

Plants not listed in any of the above references will require that the design professional base selection upon successful experience with species on previous projects under similar horticultural conditions.

SITE-SPECIFIC FACTORS

Given Santa Clara County spans several Sunset climate zones, with variable humidity, heat, frost, and wind factors, as well as varying soil characteristics, plants need to be selected with an understanding of specific climate and microclimate conditions, and grouped in appropriate hydrozones.

SUPPLEMENTAL WATERING NEEDS

Many plants listed as drought tolerant per the above references may require more supplemental watering in fast-draining, engineered soils.

D.3 Plants for Stormwater Measures

Plants play an important role in the function of landscape-based stormwater treatment measures:

- Infiltration and evapotranspiration. Plants aid in the reduction of stormwater runoff by both increasing infiltration, and by returning water to the atmosphere through evapotranspiration.
- Pollutant trapping. Vegetation helps to prevent the resuspension of pollutants associated with sediment particles. It is essential that pollutants removed during small storms are not remobilized during large storms.
- Phytoremediation. Plants for stormwater treatment measures are important for their role in phytoremediation, the uptake of nutrients and the ability to neutralize pollutants.
- Soil stabilization. As in any landscaped area, established plantings help control soil erosion. This is important both to keep sediment out of stormwater and to retain the surface soils, which help to remove pollutants from infiltrated runoff.
- Aesthetic benefits. Plants within or adjacent to stormwater facilities provide an aesthetic benefit.

Plants suitable for use in stormwater treatment measures are organized according to the following categories:

- Grasses refer to those species that are monocotyledonous plants with slender-leaved herbage found in the in the Family Poaceae.
- Perennials and groundcovers are typically herbaceous plants with soft upper growth rather than woody growth. Some species will die back to the roots at the end of the growing season and grow again at the start of the next season.
- Shrub is a horticultural distinction that refers to those species of woody plants which are distinguished from trees by their multiple stems and lower height. A large number of plants can be either shrubs or trees, depending on the growing conditions they experience.
- Tree refers to those species of woody plants with one main trunk and a rather distinct and elevated head.

Plants suitable for use in stormwater treatment measures in the Santa Clara Valley are listed in Table D-1, below, which lists the plants in alphabetical order by Latin name, in the categories described above. The columns in the table indicate stormwater treatment measures for which each plant species may be suitable.

INVASIVE SPECIES

Under no circumstances shall any plants listed as invasive by the California Invasive Plant Council's Invasive Plant Inventory be specified (http://www.cal-ipc.org/paf/).

Table D-1. Plants for Stormwater Measures

TREES		DESCRIPTION					PLANTING & MAINTENANCE					LANDSCAPE INTEREST/USES	TREATMENT TYPES			COMMENTS
Scientific Name	**Common Name**	**Evergreen (E) or Deciduous (D)**	**Height (Feet)**	**Spread (Feet)**	**Shape: Round (R), Pyramidal (P), Broad (B), Oval (O), Upright (U)**	**Growth Rate: Fast (F), Moderate (M), Slow (S)**	**Water Needs: Very Low (VL), Low (L), Moderate (M)**	**Solar Needs: Full-Sun (FS), Part-Shade (PS), Shade (S)**	**Maintenance Needs: Low (L), Moderate (M)**	**CA Native**	**SCVWD Plant List**		**Bioretention Planter**	**Flow-Through Planter**	**Tree Well Filter**	
Acer circinatum	Vine Maple	D	15	15-20	R	f	M	PS	M	●		Understory small tree from Pacific NW, avoid direct hot sun, orange-red fall color; adaptable to clay, rocky soils; tolerates moisture, drought tolerant when established.	●	●	●	Best in Sunset Zone 17 in part sunny areas.
Acer macrophyllum	Big Leaf Maple	D	40 to 80	30 to 50	B	F	M	PS	M	●		Striking fast growing native maple with bright yellow fall color.	●			Best in Sunset Zone 17 in part sunny areas.
Arbutus 'Marina'	Strawberry Tree	E	20	15	R	M	L	FS to PS	M	●	●	Red-brown trunks and large branches of mature trees become twisted and gnarled in appearance; can be messy. Clay-tolerant; acid to neutral soil.	●	●	●	*Arbutus unedo in District List*
Carpinus betulus	Fastigiate European Hornbeam	D	30 - 40	20 - 30	U	S-M	M	FS to PS	L			Upright, dense form; long lived. Tolerates moisture in well-drained soils.	●			Best in Sunset Zone 17 in part sunny areas.
Celtis reticulata	Western Hackberry	D	30-60	30-60	R	M	L	FS to PS	L	●		Spreading tree canopy. Tolerates poor soils.	●			
Cercis canadensis	Eastern Redbud	D	25-35	25-35	R	F	L-M	FS to PS	L			Deep pink early spring bloom; glossy, heat resistant leaves; short lived	●	●	●	Part sun in hotter microclimates
Cercis occidentalis	Western Redbud	D	10-18	10-18	R	S	L	FS	M	●	●	Deep pink early spring bloom; Use multi-trunk where possible; short lived. Clay-tolerant.	●	●	●	
Geijera parviflora	Australian Willow	E	40	30	O	S	M	FS to PS	L			Low, early pruning; train prune longer due to slow growth; long lived. Clay-tolerant.	●			
Ginkgo biloba 'Autumn Gold'	Autumn Gold Maidenhair Tree	D	40	30	O	S	M	FS to PS	L			Low, early pruning; train prune longer due to slow growth; long lived. Clay-tolerant. Prefers moist, well-drained soils. Golden fall color.	●			Best in Sunset Zone 17 in part sunny areas.
Ginkgo biloba 'Fairmount'	Fairmount Maidenhair Tree	D	50	20	P	F	M	FS to PS	L			Faster growing than other Ginkgos; erect pyramidal form; long lived. Clay-tolerant. Prefers moist, well-drained soils. Golden fall color.	●			Best in Sunset Zone 17 in part sunny areas.
Ginkgo biloba 'Fastigiata'	Columnar Ginkgo	D	30-50	10-15	U	S	M	FS to PS	L			Columnar. Clay-tolerant. Prefers moist, well-drained soils. Golden fall color.	●			Best in Sunset Zone 17 in part sunny areas.
Ginkgo biloba 'Magyar'	Magyar Gingko	D	50	15	U	M	M	FS to PS	L			Clay-tolerant. Prefers moist, well-drained soils. Golden fall color. Tol. urban conditions.	●			Best in Sunset Zone 17 in part sunny areas.
Ginkgo biloba 'Princeton Sentry'	Princeton Sentry Maidenhair Tree	D	40	15	P	S	M	FS to PS	L			Erect, pyramidal form; long lived. Clay tolerant. Prefers moist, well-drained soils. Heat tolerant. Golden yellow fall color.	●			Best in Sunset Zone 17 in part sunny areas.
Koelreuteria bipinnata	Chinese Flame Tree	D	30	30	R	M	M	FS	L			Summer orange, red, or salmon bloom. Clay-tolerant.	●			Best in Sunset Zone 17 in part sunny areas.
Koelreuteria paniculata 'Fastigiata'	Goldenrain Tree	D	20-25	20-25	R	S	M	FS	L			Yellow bloom; upright habit. Adaptable.	●			Best in Sunset Zone 17 in part sunny areas.
Lagerstroemia indica (cultivars)	Crape Myrtle	D	15-25	8 to 15	R	S	L	FS	M		●	Attractive peeling cinnamon bark, excellent winter feature; spec cultivars: 'Muskogee', 'Natchez', 'Osage', 'Tuscarora'. Tolerates most soils; well-drained.	●		●	

Table D-1. Plants for Stormwater Measures

TREES		DESCRIPTION					PLANTING & MAINTENANCE					LANDSCAPE INTEREST/USES	TREATMENT TYPES			COMMENTS
Scientific Name	Common Name	Evergreen (E) or Deciduous (D)	Height (Feet)	Spread (Feet)	Shape: Round (R), Pyramidal (P), Broad (B), Oval (O), Upright (U)	Growth Rate: Fast (F), Moderate (M), Slow (S)	Water Needs: Very Low (VL), Low (L), Moderate (M)	Solar Needs: Full-Sun (FS), Part-Shade (PS), Shade (S)	Maintenance Needs: Low (L), Moderate (M)	CA Native	SCVWD Plant List		Bioretention Planter	Flow-Through Planter	Tree Well Filter	
Laurus nobilis 'Saratoga'	Saratoga Bay Laurel	E	12-40	12-40	O	S	L	FS to PS	L			Tolerates many soils and climate conditions. Prefers moist, fast-draining soils.	●	●	●	
Platanus x acerfolia 'Bloodgood'	Bloodgood London Plane Tree	D	70-100	60	B	M/F	L/M	FS	M			Withstands high pH, and pollution and grime of cities. Prefers deep, rich, moist, well-drained soils.	●			
Platanus x acerfolia 'Liberty'	Liberty London Plane Tree	D	70-100	70	B	M/F	L-M	FS	M			Allergy concern; long lived; mildew resistant. Tolerates most soils.	●			
Platanus x acerifolia 'Yarwood'	Yarwood London Plane Tree	D	40-80	30-40	B	M/F	L-M	FS	M			Allergy concern; long lived; mildew resistent; 'Yarwood' foliage holds up better than most plane trees in late summer; yellow fall color. Tolerates most soils.	●			
Platanus x acerifolia 'Columbia'	Columbia London Plane Tree	D	45	40		M-F	L-M	FS	M			Allergy concern; long lived. Tolerates most soils.	●			
Prunus ilicifolia	Holley leaf Cherry	E	15	15	O	M	L	FS	L	●	●	Skinny branches with large leaves and cherry looking fruit; can be trained into a small tree. Adaptable to most soils.	●	●	●	
Prunus ilicifolia spp. Lyonii	Catalina Cherry Laurel	E	10	15	O	M	L	FS	L	●	●	Shiny green leaves with small white flowers. Adaptable to most soils.	●	●	●	
Quercus agrifolia	Coast Live Oak	E	20-70	70	O	M	VL	FS	L	●		Long-lived; atractive bark; attracts birds and butterflies; deer resistant; drought resiliant. Prefers a deep loam. Use only where sufficient room for roots.	●			Provide sufficient room for deep and wide root structure
Quercus coccinea	Scarlet Oak	D	70-80	40-50	R	M	L/M	FS	L			Foliage is a glossy green in summer turning to scarlet in fall.	●			
Quercus ilex	Holly Oak	E	30-60	30-60	R	S	L	FS	L			Tolerates water. Adaptable.	●			
Quercus suber	Cork Oak	E	40-70	35-40	R	M	L	FS	L			High VOC absorption and CO2 sequestration; long lived; ornamental cork bark. Acidic, dry to medium, well-drained loams.	●			
Quercus wislizenii	Interior Live Oak	E	25-40	25-40	O	F	VL	FS	L	●		Attractive bark; attractive birds and butterflies; deer resistant; very tough, adaptable tree. Dry, well-drained, loams, clay and gravelly loams.	●			
Robina x ambigua 'Purple Robe'	Purple Robe Locust	D	30-35	20-25	O	F	L	FS	M			Purplish bronze new foliage, showy violet purple flowers. Tolerate poor soils, heat, low water when established.	●			Brittle in high winds
Tristania laurina 'Elegant'	Elegant Water Gum	E	45	35	O	M	M	FS to PS	M			Profuse fragrant yellow flowers April-June. Tolerates damp well-drained soils, drought tolerant, cold tolerant to 28 degrees.	●		●	

Notes:
Plant selection shall be based upon site-specific conditions.
Consider subsurface infrastructure and provide sufficent growth for root area for larger trees.
Plants requiring moderate water should be planted in part sun and avoid late afternoon sun exposure on the root crowns.

Table D-1. Plants for Stormwater Measures

SHRUBS		DESCRIPTION					PLANTING & MAINTENANCE					LANDSCAPE INTEREST/USES	PLANTING ZONES			TREATMENT TYPES			COMMENTS
Scientific Name	Common Name	Flower Color	Height (Feet)	Spread (Feet)	Shape: Mounding (M), Spreading (S), Upright (U), Round (R)	Growth Rate: Fast (F), Moderate (M), Slow (S)	Water Needs: Very Low (VL), Low (L), Moderate (M)	Solar Needs: Full-Sun (FS), Part-Shade (PS), Shade (S)	Maintenance Needs	CA Native	SCVWD Plant List		Basin	Banks	Upland	Bioretention	Flow-Through Planter	Tree Well Filter	
Arctostaphylos densiflora 'McMinn'	Mazanita 'McMinn'	white	5-6	7	M	M	L	FS to PS	L	●	●	Fine textured bright green foliage and red bark. Well-drained soils.		●	●	●	●		Will not tolerate wet roots Listed as Arctostaphylos spp.
Arctostaphylos hookeri	Hooker's Manzanita	white	2-8	3-12	M	M	L	FS to PS	L	●		Fine textured bright green foliage and red bark. Well-drained soils.		●	●	●	●		Will not tolerate wet roots
Callistemon viminalis 'Little John'	Dwarf Bottlebrush	blood red	3-4	4-8	R	M	L/M	FS	L		●	Can be pruned up to small trees; heat tolerant. Clay tolerant.		●	●	●	●		
Cistus spp.	Rockrose	varies	varies 3-5 x 3-5		R	L	L	FS	M		●	neat, compact shrub with showy white, pink or rose-purple blooms. Adaptable.		●	●	●	●		Sensitive to excess water
Cotinus coggygria	Smoke Tree	purple	12-15	up to 25	U	M	L	FS	L		●	Deciduous small tree/large shrub; flowers form smoke-like look around the plant; slow growing. Well-drained soils. Cold and heat tolerant.		●	●	●	●		
Garrya elliptica	Silk Tassel	white	10-20	10-20	R	M	L	FS to PS	L	●	●	Interesting flowers hang in tassels; large shrub/small tree. Well-drained soil.		●	●	●	●		
Grevillea spp.	Grevillea	varies				M	L	FS to PS	L		●	Very heat tolerant; attracts hummingbirds. Tolerant of poor soils.		●	●	●	●		Does not tolerate wet roots
Heteromeles arbutifolia	Toyon	white	6-15	15-20	R	F	VL	FS to PS	M	●	●	Large shrub/small tree; red berries; green leaves with white flowers; takes pruning well, but flowers only on second year growth. Adaptable.		●	●	●	●		
Mahonia aquifolium 'Compacta'	Oregon Grape	yellow	1.5-2	3-4	S	S	L	PS	L	●		Yellow flowers in spring. Berries attract birds. Well-drained soil.		●	●	●	●		
Mahonia aquifolium var. repens	Creeping Barberry	yellow	2-3	3-4	S	S	L	PS	L	●		Yellow flowers in spring. Berries attract birds. Well-drained soil.		●	●	●	●		
Mahonia nevinii	Nevin Mahonia	yellow	6-10	6-12	U	M	L	PS	L	●	●	Rigid branches covered with gray-blue foliage. Adaptable; tolerates clay and alkaline		●	●	●	●		
Mahonia pinnata	California Holly Grape	yellow	4-5	4-5	U	M	L	PS	L	●	●	Reddish orange new growth.		●	●	●	●		
Nerium oleander	Oleander	red/ pink/ white	varies		R	M	L	FS	L		●	Very heat tolerant. Poisonous: eating flowers or chewing leaves or stems.			●			●	Size varies with varieties; Standard form for tree well filters. Can develop mildew in Zone 17 - prefers moisture only at root zone.
Photinia x fraseri	Fraser Photinia	white	8-12	8-10	R	F	M	FS	L										Standard form for tree well filters; bright red-bronze spring foliage
Pittosporum tenuifolium	Tawhiwhi	purple	15-25	10-15	U	F	M	FS - PS	L										Standard form for tree well filters; bright red-bronze spring foliage
Rhamnus californica 'Little Sur'	Little Sur Coffeeberry	incon-spicuous	3-4	3-4	R	M	L/M	FS-PS	M	●	●	Grey-green leaves, red bark, and showy berries in fall. Adaptable.			●	●	●		Partial shade inland
Ribes sanguineum (incl cultivars)	Red-Flowering Currant	pink	6	6	U	F	L	PS	M	●	●	Red-pink showy flower clusters. Adaptable.		●	●	●	●		
Symphoricarpos albus	Snowberry	white	6	8	S	M	L/M	PS	M	●	●	Large white berries in the fall; berries are not edible. Adaptable.		●	●	●	●		Best with regular moisture

Notes:
Plant selection shall be based upon site-specific conditions.
Taller shrubs and perennials with more substantial roots systems can be grown on green roofs with 18" growing medium.
Plants requiring moderate water should be planted in part sun and avoid late afternoon sun exposure on the root crowns.
Trees/Tall shrubs planted in tree well filters shall provide sufficient vertical clearance for the location.

Table D-1. Plants for Stormwater Measures

GRASSES		DESCRIPTION					PLANTING & MAINTENANCE					LANDSCAPE INTEREST/USES	PLANTING ZONES			TREATMENT TYPES				COMMENTS
Scientific Name	Common Name	Flower Color	Height (Feet)	Spread (Feet)	Shape: Mounding (M), Spreading (S), Upright (U), Round (R)	Growth Rate: Fast (F), Moderate (M), Slow (S)	Water Needs: Very Low (VL), Low (L), Moderate (M)	Solar Needs: Full-Sun (FS), Part-Shade (PS), Shade (S)	Maintenance Needs	CA Native	SCVWD Plant List		Basin	Banks	Upland	Bioretention	Flow-Through Planter	Tree Well Filter	Green Roof*	
Aristida purpurea	Purple Three-Awn	white	2-3	2	U	F	VL	FS	L	●	●	Purple seed heads that wave gracefully in the wind; recommended for erosion control on slopes, hillsides, and in canyons. Well-drained soil.		●	●	●	●			
Bouteloua gracilis 'Blonde Ambition'	Blonde Ambition Blue Grama	chartreuse turning to blonde	1.5-2	1	M	M	L	FS	L	●	●	Can be grown from seed; no irrigation needed once established. Adaptable to many soils, prefers well-draining. Showy flowers last summer through winter.		●	●	●	●			
Calamagrostis x acutiflora 'Karl Foerster'	Feather Reed Grass	light tan	2-3	2-3	U	F	L	PS	L	●	●	Background plant. Well-draining.			●	●	●			
Carex barbarae	Santa Barbara Sedge		1-3	1	M	M	L/M	FS	L			Rich green leaves; good for erosion control; little or no summer water. Tolerates damp soil.	●	●	●	●	●			Cannot tolerate standing water
Carex divulsa (C. tumulicola)	Berkeley Sedge		2	2	U	F	L	FS to PS	L	●	●	Greenish flowers age to brown in winter and spring. Clay-tolerant; tolerates damp, well-drained soil.	●	●	●	●	●			Cannot tolerate standing water
Carex pansa	Dune Sedge		1	1	M	F	L/M	FS to PS	L	●	●	Creeping meadow sedge, good on slopes. Tolerates variety of soil and climate conditions.	●	●	●	●	●			Sensitive to overwatering
Chondropetalum elephantinum	Large Cape Rush	brown	3-5	4-6	U	M	L/ M	FS to PS	L		●	Tolerates wet well-draining soils and drought. Large striking upright form.	●	●	●	●	●			
Chondropetalum tectorum	Small Cape Rush	brown	2-3	3-4	U	M	L	FS	L		●	Small, unique plant forms broad clumps of thin erect jointed stems; evergreen; good for erosion control. Accepts both dry and wet conditions	●	●	●	●	●			
Deschampsia caespitosa	Tufted Hairgrass	creamy white	1-2	2 (flr stalk to 3')	U	M	L	FS to PS	L	●		green to greenish gold, turning straw color in the winter; they generally maintain good color through the summer, but won't grow much when it is hot. tolerates most soils		●	●	●	●			
Deschampsia caespitosa ssp. Holciformis	Pacific Hairgrass		1-2	2	U	M	L	FS to PS	L	●		dense dark green foliage; good choice for erosion control near constant moisture such as marsh, vernal pool or seeps. tolerates most soils		●	●	●	●			
Festuca californica	California Fescue		2	2	U	M	L	FS to PS	L	●	●	Cool season bunchgrass with flower stalks that reach 5 ft. tall and create fountain-like clumps. Beneficial insect plant.		●	●	●	●			
Festuca glauca 'Elijah Blue'	Blue Fescue		>1	>1	R	F	L	PS	L		●	Forms clumps of silver-blue leaves; long lived; use as edging. well-drained		●	●	●	●			
Festuca idahoensis	Blue Bunchgrass		1	1	R	F	L	FS to PS	L		●	Well-drained		●	●	●	●	●		Blue Bunchgrass listed as Idaho Fescue
Helictotrichon sempervirens	Blue Oat Grass	light blue	1-2	1-2	U	M	L	PS	L		●	Attractive symmetrical form and bue color with straw-colored flower. well-drained		●	●	●	●			
Juncus patens	Californis Grey Rush	brown	2	1	U	M	L	FS to PS	L	●	●	Accepts both dry and wet conditions	●	●	●	●	●			
Muhlenbergia rigens	Deer Grass	yellow	4	4-6	R	M	L	FS	L	●	●	Clean, dependable form; very rugged. Adaptable.		●	●	●	●			
Muhlenbergia capillaris	Pink Muhly Grass	pink	4	3-4	R	M	L	PS	L		●	Showy pink panicles in late summer. well-drained		●	●	●	●			Pink Muhly Grass listed as Hairy awn Muhly
Sisyrinchium bellum	Blue-Eyed Grass	blue, yellow	1-1.5	0.5	U	F	VL/L	FS to PS	L	●	●	Dies back in summer; use as a small accent plant; long green leaves with blue and purple flowers with yellow center; goes dormant in summer. Adaptable		●	●	●	●		●	Check notes
Stipa arundinacea	New Zealand Wind Grass	NA	3	3	M	F	M*	S to FS	L			Arching olive, amber & gold foliage; cut to 12" in winter. *Some sources state low water req'mt. adaptable.	●	●	●	●	●			Check notes
Stipa pulchra	Purple Needlegrass		4-6	4-6	U	F	L	FS	L		●	Long-lived native bunch grass. Adaptable.	●	●	●	●	●			Check notes

Notes:
Plant selection shall be based upon site-specific conditions.
*Greenroof plants require a minimum of 4" growing medium and automatic irrigation with inline drip unless otherwise noted.
Plants requiring moderate water should be planted in part sun and avoid late afternoon sun exposure on the root crowns.

Table D-1. Plants for Stormwater Measures

GROUNDCOVERS & TURF ALTERNATIVES		DESCRIPTION					PLANTING & MAINTENANCE					LANDSCAPE INTEREST/USES	PLANTING ZONES			TREATMENT TYPES					COMMENTS
Scientific Name	Common Name	Flower Color	Height (Feet)	Spread (Feet)	Shape: Mounding (M), Spreading (S), Upright (U), Round (R)	Growth Rate: Fast (F), Moderate (M), Slow (S)	Water Needs: Very Low (VL), Low (L), Moderate (M)	Solar Needs: Full-Sun (FS), Part-Shade (PS), Shade (S)	Maintenance Needs	CA Native	SCVWD Plant List		Basin	Banks	Upland	Bioretention	Flow-Through Planter	Tree Well Filter	Green Roof*	Turf Block Pavers	
GROUNDCOVERS																					
Arctostaphylos 'Emerald Carpet'	Emerald Carpet Manzanita	white	1-1.5	3-6	S	M	L	FS	L	●		Neat, green, spreader. Adaptable, prefers well-drained		●	●	●	●				Spreads best with even moisture
Arctostaphylos uva-ursi	Bearberry, Kinnikinnick	blood red	3-12	4-9	S	M	Low	FS	L	●		Set out plants 2' apart for solid cover. Clay-tolerant.		●	●	●	●				
Baccharis pilularis 'Twin Peaks'	Dwarf Coyote Brush	white	1-2	6-10	S	F	L/M	FS	M	●		Small dark green leaves; excellent for erosion control; very important shrub for wildlife. Tolerates most soils.		●	●	●	●				
Fragaria chiloensis	Beach Strawberry	white	6-12"	1-2'	S	F	M	FS to PS	L	●		Spreading groundcover, prefers light, well-drained soils and moisture, partial shade in hotter climates. Flowers in spring folowed by edible fruit.		●	●	●	●		●		Prefers 6" growing medium and additional moisture on greenroofs
Fragaria vesca	Mountain Strawberry; Woodland Strawberry	white	6-12"	1-2'	S	F	M	FS to PS	L	●		Similar to F. chiloensis with smaller leaves and tiny edible and tasty fruit.		●	●	●	●		●		Prefers 6" growing medium and additional moisture on greenroofs
Grindelia stricta platyphylla	Coastal Gum Plant	yellow	6"	3'	S	M	L	FS	L	●		2" blooms from May thru Fall. Clay, sand & salt tolerant.		●	●	●	●				Prefers 6" growing medium and additional moisture on greenroofs
Mahonia repens	Creeping Oregon Grape	yellow	2.5'	3-5'	S	M	L/M	PS	M	●	●	Fall color; Well-draining soil.		●	●	●	●				
Salvia sonomensis	Creeping Sage	purple	2	6-8	S	M	L	FS	M	●		Nice mounding and spreading groundcover with pruple/blue flowers; fragrant leaves, especially in summer. Adaptable.		●	●	●	●		●		Prefers 6" growing medium
Verbena peruviana	Peruvian Verbena	scarlet, white	>1	2-3	S	M	L	FS	M		●	Set out plants 2' apart for solid cover; offers super vibrant red flowers with small white centers. Well-drained; adaptable.		●	●	●	●				
TURF ALTERNATIVES																					
Bouteloua gracilis	Blue Gramma Grass		1.5-2	1	S	F	L	FS	L	●		irrigate to 1ft to establish; after established needs no irrigation; nice as border planting; okay to mow down to 1.5in		●	●	●	●		●	●	
Buchloe dactyloides	Buffalograss		<1	<1	S	F	VL	FS	L			requires little or no mowing; grows to 4" tall; start from sod or plugs. Adaptable to soil types.		●	●	●	●			●	
Festuca rubra 'molate'	Molate Fescue		1	-	S	F	M/L	FS/ PS	M			Prefers part shade, regular water in hot areas, lawn alternative.				●	●		●	●	
Dymondia margaretae	Dymondia, Silver Carpet	yellow	1-3"	1-2'	S	M	M/L	FS	L		●	Tight ground-hugging groundcover good as turf substitute in small areas. Tolerates heat, sun and cold to 28 degrees.		●	●	●	●			●	
Lippia nodiflora	Kurapia	white	1"-3"	-	S	M	L	FS/ PS	L			Spreading grouncover from Japan. Tolerates periodic innundation. Flowers can atract bees.	●	●	●	●	●		●		Prefers 6" growing medium
NA	Biofiltration Sod		<1	<1	S	F	M	FS	L			Tolerates periodic innundation.	●			●	●				
NA	Native, No-Mow Sod		<1	<1	S	S	M/L	FS/PS	L	●	●	Slow growing, narrow leafed grass with blades that are very lax and flexuous.Provides soil stabilization for sloped areas. Can be mowed as turf lawn, or left unmowed.		●	●	●	●		●	●	

Notes:
Plant selection shall be based upon site-specific conditions.
*Greenroof plants require a minimum of 4" growing medium and automatic irrigation with inline drip unless otherwise noted.
Plants requiring moderate water should be planted in part sun and avoid late afternoon sun exposure on the root crowns.

Table D-1. Plants for Stormwater Measures

PERENNIALS		DESCRIPTION					PLANTING & MAINTENANCE					LANDSCAPE INTEREST/USES	PLANTING ZONES			TREATMENT TYPES			COMMENTS
Scientific Name	Common Name	Flower Color	Height (Feet)	Spread (Feet)	Shape: Mounding (M), Spreading (S), Upright (U), Round (R)	Growth Rate: Fast (F), Moderate (M), Slow (S)	Water Needs: Very Low (VL), Low (L), Moderate (M)	Solar Needs: Full-Sun (FS), Part-Shade (PS), Shade (S)	Maintenance Needs	CA Native	SCVWD Plant List		Basin	Banks	Upland	Bioretention	Flow-Through Planter	Green Roof*	
Achillea millefolium	Common Yarrow	white	3	2	S	F	L	FS	L	●	●	Erect plant with narrow green stems and wide white flowers - easy, full sun near bay, part shade inland; attracts beneficial insects. tolerates most soils		●	●	●	●	●	Maintenance challenges; longevity issues
Achillea filipendulina	Fern-Leaf Yarrow	golden	3-4	2-3	U	M	L	FS	M		●	Deeply-dissected, fern-like, aromatic, grayish-green to green foliage and its tiny, long-lasting, bright golden flowers. Tolerates most soils.		●	●	●	●	●	
Armeria maritima	Sea Pink	pink	1	1	M	S	L-M	FS	L		●	Only in zones 16-17; not for hot interior landscapes		●	●	●	●	●	Maintenance challenges; longevity issues
Anigozanthus spp.	Kangaroo Paw	red, purple, green, yellow	to 6	to 3	U	F	L	FS	L			Attracts hummingbirds. Well-draineded soils.		●	●	●	●		Unattractive if subject to freezing or standing water
Coreopsis grandiflora	Coreopsis	purple-blue	1.5-2.5	2-3	S	M	L	FS	L		●	Daisy-like single flowers feature deep yellow rays (notched at the tips) surrounding a darker golden yellow center disk. Tolerates most soils.		●	●	●	●	●	
Dietes iridioides	Fortnight Lily	pale yellow; light blue; white	up to 3	1-1.5	U	M	L	FS	L		●	Use as accent or massing, orchid-like flowers. Clay-tolerant.		●	●	●	●		Disruptive to planting/soil when pulled up and divided evey 5 years
Echeveria spp.	Hens and Chicks	pink	varies			M	L/VL	FS	L			Succulent; use in small areas; colorful foliage - variety of species and textures. Prefer light well-drained soil w/some moisture spring/summer.		●	●	●	●	●	
Epilobium bowman	Bowman California Fuchsia	orange	varies	1.5-3	S	F	L	FS	L	●		Gray foliage; showy summer flowers; height varies by cultivar		●	●	●	●		
Epilobium canum	California Fuchsia	orange-red	varies	1.5-3	S	F	L	FS	L	●		Gray foliage; showy summer flowers; height varies by cultivar		●	●	●	●		
Erigeron glaucus 'Wayne Roderick'	Wayne Roderick Daisy	lavender	1	3	M	M	M	FS to PS	L	●		Blooms spring thru fall. Well-drained soil.		●	●	●	●		
Erigeron karvinskianus	Santa Barbara Daisy	white with pink tinge	10-18"	2-3'	M	F	L-M	FS to PS	L	●		Small daisy-like flowers, feathery texure. Well-drained soil.		●	●	●	●		Reseeds
Eriogonum grande var. rubescens	Red-Flowered Buckwheat	rosy red	1-2'	1-2'	S	F	L	FS to PS	L	●		Flowers spring-summer atop slender stems, attracts beneficial insects. Tolerates most soils.		●	●	●	●	●	Reseeds
Eriogonum latifolium	Coast Buckwheat	pink, white	6	6	S	F	Low	FS	Low	●		Creamy white pom-poms rise above dark green, spoon-shaped leaves in the summer; good in containers. Tolerates most soils.		●	●	●	●	●	
Eschscholzia californica	California Poppy	orange	1.5	1.5-2	S	F	VL	FS	L	●	●	Reseeds easily; summer dormant. Well-drained soils.		●	●	●	●	●	Maintenance challenges; longevity issues
Gaillardia grandiflora	Blanket Flower	varies	2-3	1-2	U	M	L	FS	L		●	Daisy-like flowers, usually yellow to orange to red rays with maroon to orange banding at the petal bases and dark burgundy center disks. Well-drained soils.		●	●	●	●	●	Prefers 6" planting medium
Gaura lindheimeri	Gaura	white	2.5-4	2-3	U	M	L/M	FS	M					●	●	●	●		More drought tolerant in Zone 17; Can self-sow
Heuchera maxima	Island Alum Root	white, pink	1-2	3-4	S	M	L	PS	L	●		Needs shade; good edging plant. Clay-tolerant.		●	●	●	●		
Iris douglasiana	Douglas Iris	varies	1.5	1.5	S	M	L	PS	L	●		Well-drained soil.		●	●	●	●		Maintenance challenges; longevity issues
Mimulus aurantiacus	Sticky Monkey Flower	varies	3-4	3-4	M	M	L	FS to PS	L	●		Well adapted to heat, sun, summer drought. Well-drained soils.		●	●	●	●		Can be short-lived, 3 years; Maintenance challenges; longevity issues
Mimulus aurantiacus var. puniceus	Red Monkey Flower	red	3-4	3-4	M	M	L	FS to PS	L	●		Well-drained soil.		●	●	●	●		Can be short-lived, 3 years; Maintenance challenges; longevity issues
Monardella villosa	Coyote Mint	light purple	2	2	M	F	VL	FS to PS	L	●	●	Attracts butterflies, including Monarchs, Tiger Swallowtails Well-drained soil.		●	●	●	●	●	Prefers 6" growing medium; Maintenance challenges; longevity issues
Penstemon heterophyllus 'Blue Springs'	Foothill Penstemon	Iridescent blue-purple	1-2	2	M	F	L	FS	M	●		Very tough plant. Tolerates full sun, heat, most soils. Flowers attract butterflies, beees, hummingbirds.		●	●	●	●	●	Prefers 6" planting medium
Sedum sp. (many)	Stone Crop	varies	varies		S	M	L	FS	L		●	Varied succulent species. Prefer well-drained soils. Many heat adapted and thrive in dry gardens, green roofs.		●	●	●	●	●	
Tulbaghia violacea	Society Garlic	pink	2	1	M	F	L	FS	L		●	Very dependable grass-like plant with pink flower atop 2' stalks. Distinctive garlic odor. Tolerates most soils.		●	●	●	●		
Verbena lilacina	De La Mina Lilac	purple	3	3	S	M	L	S to PS	L			Low, mounding perennial, attracts bees and butterflies.		●	●	●	●		

Notes:
Plant selection shall be based upon site-specific conditions.
*Greenroof plants require a minimum of 4" growing medium and automatic irrigation with inline drip unless otherwise noted.
Taller shrubs and perennials with more substantial roots systems can be grown on green roofs with 18" growing medium.

D.4 Stormwater Measures

For each of the stormwater measures offered in the Plant List for Stormwater Measures there is a brief description of each, including the key factors that should influence planting techniques and plant selection.

BIORETENTION AREA

Bioretention areas are intended to act as filters with plants. Plants in bioretention areas help with phytoremediation and infiltration. Therefore, nutrient uptake and the ability to neutralize pollutants are priorities for species selection. Plants for these areas should be able to withstand periods of inundation as well as extended periods of drought. Emergent, grass and herbaceous species can be planted in the bioretention area, while shrub and tree species should be concentrated on the outer edges. Grasses can also be planted along the exterior to slow the velocity of flow and allow the sedimentation of coarse solids, which helps minimize clogging of the bioretention area. Supplemental irrigation will be necessary to maintain emergent species during extremely dry conditions.

FLOW-THROUGH PLANTER

Plant species for flow-through planters will depend on the size of the planter. Shrubs and trees should be placed in planters only when there is sufficient space. Recommended minimum soil depth for shrubs is 18”, and for small trees is 36”. Plant species should be adapted to well-drained soils. Irrigation is typically required, but selecting plants adapted to extended dry periods can reduce irrigation requirements.

TREE WELL FILTER

Trees and shrubs planted in tree well filters should be an appropriate size for the space provided. Plant roots are confined to the container, and therefore it is recommended that small trees and shrubs with shallow, fibrous roots be planted in the tree well filter. Provided that site conditions allow, it may be possible to work with the manufacturer to design a container that would allow for the planting of larger trees or shrubs. Plants for tree well filters should be tolerant of frequent, but temporary periods of inundation as well as adapted to extremely well-drained soils. Species with the ability to neutralize contaminants are preferred.

GREEN ROOF

A green roof is intended to capture precipitation and roof runoff. Green roofs utilize a lightweight, porous planting substrate as a medium for plant growth. The depth and composition of this substrate is extremely important in determining types of plants that will be successful as part of a green roof system. Intensive green roofs, which can have up to 48” of substrate, can support a wider variety of plant types. Look for plants with check marks in the Green Roof sections of the list. *Extensive* green roofs, which have a depth of 3” to 7” of planting medium, are suitable for a limited number of grass and herbaceous species. These roofs generally require little maintenance and should be designed to succeed with minimal irrigation. In addition to the species listed, pre-vegetated mats can be utilized on extensive green roofs.

TURF BLOCK PAVERS

Some pervious paving systems can be planted with grass or herbaceous species in order to assist with erosion prevention as well as promote infiltration and pollutant uptake. Plant species should be tolerant of compaction, have the ability to neutralize contaminants, and should not interfere with maintenance and use of the paved surface. Most plant species cannot tolerate frequent vehicular compaction. Therefore, turf block pavers are best suited for areas requiring infrequent access, such as emergency vehicle access routes. Paver manufacturer should be consulted regarding recommended and acceptable plant species.

D.5 Planting Specifications

Planting plans and specifications must be prepared by a qualified professional and coordinated with other site development details and specifications including earthwork, soil preparation and irrigation (if used). Plans indicating a planting layout, with species composition and density, should be prepared on a site-specific basis. Reference the Bay-Friendly Landscaping Guidelines (available at www.rescapeca.org), which outline principles and practices to minimize waste, protect air and water quality, conserve energy and water, and protect natural ecosystems, including:

- Evaluate site and assess the soil;
- Consider potential for fire;
- Select plants for appropriate size upon maturity, do not over-plant;
- Irrigation, if required, should be designed as a high efficiency, water conserving system; and
- Utilize compost (see the specification in the Bay-Friendly Landscaping Guidelines) and mulch to build healthy soils and increase the water holding capacity of the soil.

PROPAGATION AND PLANTING METHODS

The propagation methods for different species will vary, depending upon type of plant and stormwater adaptation. In general, container stock will be utilized most commonly for green roofs, flow-through planters, tree well filters, vegetated swales and buffer strips and infiltration trenches. Bioretention areas and extended detention basins will generally utilize native plants available as transplants (plugs), pole cuttings and seed mixes.

CONTAINER STOCK. Planting holes for container stock should be twice as wide and only as deep as the container size. Plant spacing should be determined on a site-specific basis. When planting, the root collar and base of the stem should be 1" above the adjacent soil surface. Soils should be backfilled and tamped down to assure contact with the roots. The planting should be watered-in promptly to promote the settling of soil. If appropriate, container plantings may receive a balanced time-released fertilizer tablet, quantity and placement per manufacturer's recommendation, placed in the planting hole prior to installation of the plant. Planting berms for water retention and mulch shall be used to enhance plant establishment. Trees shall be staked or guyed to provide interim support until established.

TRANSPLANTS (PLUGS). Transplanted plant divisions, referred to here as "plugs", should be planted during the fall dormant period, preferably between October 1 and November 15 after first soaking rain. Plugs should be collected from a suitable collection site in the vicinity of the constructed basins. Plugs are clumps of plant roots, rhizomes or tubers combined with associated soil that can be manually removed, or salvaged with an excavator or backhoe. The maximum recommended size is 1 foot x 1 foot. Whole plants or plant divisions can be utilized. The plugs should be from healthy specimens free of insects, weeds and disease. The plugs should be spaced from 1 foot to 6 feet apart, depending on the size of the plug. Smaller plugs can be planted at the minimum distance to promote faster spreading and cover. Larger plugs from cattail and bulrush species should be planted at 3-foot to 6-foot intervals. To plant a plug, a hole slightly wider than the diameter of the plug should be prepared and the roots system of the plug placed in the hole. Do not over-excavate the hole depth or the plant will settle below grade. A shovel could be used to create the planting hole. Manual planting with a spade is recommended for wet soils. Power augers can be used for creating holes in dry soils. Alternatively, a trench could be created along the narrow axis of the extended detention basin, and planting material manually placed at specified elevations in relation to the proximity of permanently saturated soils. To plant a plug with an established root system, the base of the stem and top of the root collar should be level with the ground surface. Tubers should be secured to prevent floating. Rhizomes should be placed in the soil with a slight upward angle. The hole or trench containing the plug(s) should be backfilled with soil and the soil tamped down to assure good soil contact and secure the plug. The vegetative portion of the plant should be cut back to prevent water loss and wilting, and encourage the growth of roots and new shoots. Plugs of wetland plants should be grown in saturated soil. The soil should not be allowed to dry out after planting. Plugs should be planted immediately, when possible. When necessary, plugs can be stored in a cool, moist, shaded location for a maximum of one day. Plants must be thoroughly watered.

POLE CUTTINGS. Pole cuttings should be collected from the 1-year old wood of dormant trees and have a minimum of 5 viable nodes. The parent material should be healthy and free of diseases. The basal area of the pole cutting should be a minimum of one to two inches in diameter; however, the diameter at the base should not exceed 2 inches. The optimum diameter width of the base is 1 inch. The length of the cutting should be a minimum of 2 feet and should not exceed a maximum of 4 feet in length. Generally, 75 percent of the length of the cutting should be planted beneath the soil surface.

Pole cuttings should be collected no more than 2 days prior to planting. Cuttings should be placed in cool water to promote swelling of the nodes. Water should be kept fresh by aeration and/or by daily replacement. The pole cuttings should be placed in a hole approximately 3 feet deep (as determined by the length of the cutting) and backfilled with native soil, or a rich organic medium mixed with native soil. Soil should be tamped down to remove air pockets and assure soil contact with the cutting.

SEEDING. Seeding should be conducted after plugs, container stock and pole cuttings are installed. Hydroseeding or broadcast method shall be utilized as appropriate for the size and accessibility of the area. The soil surface should be scarified prior to seeding. Do not damage previously planted vegetation. The seeds should be planted in fall, ideally in October. Seeds should be broadcast or hydroseeded over the specified planting area. With broadcast seeding, the seed should be applied with hand-held spreaders to scarified soil. The soil surface should then be raked to cover the seeds with about one-eighth to one-quarter inch of soil to discourage predation, and tamped or rolled to firm soil surface. Seeds should be planted at the ratios and rates specified by the supplier. The seed should be free of weeds and diseases. The certified germination percentage should be provided by the supplier.

WATER LEVEL MANAGEMENT AND IRRIGATION FOR PLANT ESTABLISHMENT

All newly planted material will need careful attention to watering requirements to ensure proper establishment. As mentioned in the introduction, it is important to select plants based on specific site conditions, which will affect the availability of water for plant use. In addition, grouping plants with similar water requirements can help reduce irrigation needs. The specific approach will vary for irrigated and non-irrigated conditions, and for each stormwater application. In most cases, stormwater applications will require a permanent irrigation system which shall be designed to maximize water conservation. Irrigation specifications and design plans shall be provided.

Plants such as shrubs and trees grown in naturalized areas that are not saturated to the surface or inundated shall be irrigated with drip irrigation. The irrigation system shall remain in place for a minimum of three years, and should continue until it is demonstrated that the plantings can survive on annual rainfall and/or groundwater. Seeded areas do not need irrigation in years of normal rainfall. If a period of drought occurs after seeding, supplemental watering may be needed for germination in the first year.

The plants on the bottom and edge of the constructed basins should be allowed to become established for one growing season prior to the onset of significant flooding that will inundate the plantings for extended periods. The types of plants recommended for these locations are rushes, sedges, grasses and herbaceous species. Initially, saturated soils are required for the bioretention areas and extended detention basins during the establishment period of the plantings. After the plants have become established, inundation with a surface depth of 1 cm to 2 cm alternating with short dry periods is recommended for the basins during the first year. Periodic shallow flooding of these basins can slow the growth of non-native weedy terrestrial species in the wetland system; however, the water depth should not be greater than the height of the plants. This initial irrigation regime will prevent plant mortality from dry periods or excessive flooding in the first year, and reduce the growth of non-native weedy species. Emergent species should be planted in saturated soil so the plants will become established. For emergent species, the water level in the first year should be maintained to allow for soil saturation or shallow inundation around the base of the plants. Significant flooding and inundation of stems and leaves of the plants should be avoided the first year. Tall plugs and plantings can tolerate greater depths of inundation if a significant portion of the stems and leaves of the plantings remain above the water surface.

D.6 Monitoring and Maintenance

GENERAL REQUIREMENTS

All planted areas shall be monitored and maintained as required to ensure proper establishment by a Contractor with a valid California C-27 contractor's license. Frequency of site visits and required maintenance practices will vary depending upon the stormwater measure and plant selection. Maintenance shall include watering, cultivation, weeding and pruning as necessary to maintain optimum growth conditions and, as appropriate to the specific stormwater measure, to keep the planted areas neat and attractive in appearance. In all instances, controlling weeds and unwanted growth with chemical applications is prohibited.

The contractor shall be familiar with the design and function of the specific stormwater measure(s) to ensure that the plantings are maintained appropriately and do not interfere with the efficient runoff drainage and filtration.

Ongoing management of invasive weed species will be required in all applications. Monthly hand weeding will allow the naturalized vegetation to take hold, and will ultimately be less costly than less frequent, and more intensive clearing. Regular application of arbor chip mulch, or other mulch material that will knit together and resist floating with surface runoff, will also help control weed growth.

EROSION CONTROL

Particularly with landscapes that are not fully established, contractors will need to monitor and evaluate potential for erosion and sediment accumulation in the runoff, which will influence irrigation scheduling and as well as determine the need for additional erosion control measures. Soil can be protected from erosion by a number of methods including:

- Keep the soil covered with vegetation to the extent possible;
- Slow water runoff by using compost berms, blanket, socks or tubes along slopes;
- Cover bare soil with a minimum of 3" of mulch;
- Minimize the use of blowers in planting beds and on turf;
- On slopes use shredded arbor mulch that is not prone to washing into storms drains; and
- Store leaf litter as additional much in planting beds as appropriate.

IRRIGATION SYSTEMS

Where irrigation systems have been installed for temporary or permanent irrigation, the contractor shall maintain the irrigation system for optimum performance, as per manufacturer's specifications. Contractor shall inspect the entire system on an ongoing basis, including cleaning and adjusting all sprinkler and bubbler heads, drip emitters and valves for proper coverage. Contractor shall monitor the irrigation system while operating to identify and correct problems with water runoff or standing water.

Monitor soil moisture within plant root zones using a soil probe or shovel and adjust irrigation schedules accordingly if a soil moisture sensor is not being utilized to signal the irrigation controller. If a Weather-Based Irrigation Controller (WBIC), otherwise known as a "Smart" Controller is not utilized on the project, irrigation shall be scheduled using a water budget approach, basing irrigation frequency on evapotranspiration data (ET) to avoid over-irrigation of plant material. Adjust irrigation frequency within each hydrozone area a minimum of every four weeks to respond to expected adjustments in ET data.

If a standard turf mix is used in lieu of a no-mow variety, implement grasscycling, where appropriate to the stormwater treatment measure. Grass clippings shall not be carried into the drainage structures. Refer to *A Landscaper's Guide to Grasscycling* available at StopWaste.org.

BIORETENTION

In bioretention areas non-native invasive plant species should be carefully monitored and controlled to reduce competition with the native plantings and to assure the success of the revegetation activities. The establishment of weeds and invasive species can be partially controlled during the establishment period by implementing the watering schedule of initial saturation followed by alternating periods of shallow inundation and dry soil. Manual methods of weed removal should be conducted on the bottom, edge and side of the areas during dry soil periods.

Weeding should be conducted regularly the first two years to prevent the growth, flowering, and seed set of non-native weeds and invasive species. After the first two years, weeding frequency will be determined on a site-specific basis as determined by the type of weeds and seasonal growth cycle of the weed species. In general, weeding once a month will be necessary to avoid more extensive and costly eradication in the future.

Long-term maintenance tasks include continued control of nonnative weeds and invasive plants, and control of erosion. Erosion could include gullies, rills and sheet erosion. Actions to control erosion should include redirecting or dissipating the water source. Recontouring and subsequent mulching and/or replanting may be required in bare areas. In the event of extensive die-off of the desired plant species, the bare areas should be replanted. Where the event that caused plant mortality was not a natural catastrophic occurrence, the site condition that resulted in the die-off should be investigated and remedial action to correct the problem should be undertaken prior to replanting.

D.7 Bay-Friendly Landscaping and Integrated Pest Management (IPM)

This section provides a summary of Bay-Friendly Landscaping and integrated pest management techniques, based on landscaping guidelines at www.rescapeca.org.

BAY-FRIENDLY LANDSCAPING

Bay-Friendly Landscaping is a whole systems approach to the design, construction and maintenance of the landscape in order to support the integrity of the San Francisco Bay watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly Landscaping practices from the initial plant selection through the long-term maintenance of the site. This section summarizes Bay-

Friendly Landscaping practices that may be implemented information that project sponsors need about how these practices canto benefit water quality of the Bay and its tributaries.

Bay-Friendly Landscaping is based on 7 principles of sustainable landscaping and features the following practices

- Landscape Locally
- Less to the Landfill
- Nurture the Soil
- Conserve Water
- Conserve Energy
- Protect Water and Air Quality
- Create and Protect Wildlife Habitat

INTEGRATED PEST MANAGEMENT

All creeks in the San Francisco Bay Area exceed water quality toxicity limits, primarily due to the pesticide Diazinon entering urban runoff. Although the residential use of Diazinon is currently being phased out, the use of a group of highly toxic chemicals, called pyrethroids, is increasing. Because all pesticides are toxins, an integrated pest management (IPM) places a priority on avoiding their use. IPM is a holistic approach to mitigating insects, plant diseases, weeds, and other pests. Each agency has a Source Control Measures List that includes provisions for using IPM in the landscaping plans of development projects. Contact the local agency to learn about the IPM requirements that may apply to your projects. Remember that avoiding pesticides and quick release synthetic fertilizers are particularly important in your project's stormwater treatment measures, to protect water quality.

IPM encourages the use of many strategies for first preventing, and then controlling, but not eliminating, pests. It places a priority on fostering a healthy environment in which plants have the strength to resist diseases and insect infestations, and out-compete weeds. Using IPM requires an understanding of the life cycles of pests and beneficial organisms, as well as regular monitoring of their populations. When pest problems are identified, IPM considers all viable solutions and uses a combination of strategies to control pests, rather than relying on pesticides alone. The least toxic pesticides are used only as a last resort. IPM features the following practices:

- Prevent Pest Problems
- Watch for and Monitor Problems
- Education is Key
- Use Physical and Mechanical Controls
- Use Biological Controls
- Least Toxic Pesticides are a Last Resort

For more information about sustainable landscaping and integrated pest management practices or to download a copy of the *Bay-Friendly Landscaping Guidelines: Sustainable Practices for the Landscape Professional*, visit www.rescapeca.org.

D.8 Nursery Sources for Native Plants

It is recommended that the native plants used in treatment controls be grown by a qualified nursery. Seed collection should be conducted by a qualified botanist and/or nursery staff. Seed should be collected locally from selected sites to maintain the genetic integrity of the native plant species. The seeds shall be propagated by the nursery for planting during the fall dormant season. The appropriate container size for each species shall be used by the nursery.

The Santa Clara Valley Chapter of the California Native Plant Society maintains a native plant nursery on the grounds of Hidden Villa Ranch in Los Altos Hills. Volunteers propagate native plants throughout the year for the chapter's native plant sales. Proceeds from plant sales are the major source of funding for all chapter activities. Inventory is updated once a month before the plant sale. Go to the following chapter webpage for more details:

www.cnps-scv.org/index.php/gardening/cnps-nursery

The following website lists local nurseries that the California Native Plant Society acknowledges as locations to buy native plants:

www.cnps-scv.org/index.php/component/content/article?id=67:where-to-buy-native-plant

SCVURPPP maintains the Bay Area Eco Gardens website with useful information on resources for garden design, plant selection, construction and maintenance:

www.bayareaecogardens.org

Phytophthora Plant Pathogens in California Native Plant Nurseries[2]

Over the past several years, numerous Phytophthora (pronounced Fie-TOF-ther-uh) plant pathogens have been detected in California native plant nurseries and habitat restoration sites. Phytophthora, which means "plant destroyer", is a genus of microscopic water molds, fungal-like organisms that are most closely related to diatoms and brown algae and can cause moderate to severe root and crown rot, and death in highly infected plants. The genus Phytophthora is large, with over 100 described species, including the sudden oak death pathogen and other destructive pathogens of agricultural, ornamental, and forest plants. Preliminary investigations have identified more than 15 Phytophthora species in native plant nurseries,. Inadvertent planting of Phytophthora-infected nursery stock into or adjacent to native habitats has the potential to introduce these pathogens into wildlands. Furthermore, many of these Phytophthora species appear to have wide host ranges, capable of causing disease on plants across many families.

Obtaining nursery stock from local plant nurseries for implementation of green infrastructure and low impact development projects has the potential to spread Phytophthora plant pathogens into wildlands (e.g. adjacent or nearby creeks) or to cause mortality of new plantings. The Santa Clara Valley Water District has developed nursery contract specifications for plant pathogen prevention, and is working with specific native plant nurseries to implement techniques or practices that prevent nursery stock from being infected with plant pathogens. For more information, contact the SCVWD Environmental Mitigation and Monitoring Unit at 408-265-2600 or Phytosphere Research at phytosphere@phytosphere.com or 707-452-8735.

D.9 References

A Field Guide to Compost Use, The Composting Council, Alexandria, VA. http://www.compostingcouncil.org/index.cfm.

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Bornstein, Carol, David Fross and Bart O'Brien, California Native Plants for the Garden.

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[2] *Adapted in part from "In Brief... Phytophthora plant pathogens in California native plant nurseries and habitats. Why the Concern?" from the Working Group on Phytophthoras in Native Plant Habitats, May 2015.

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Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide, 2nd ed., UC Publication 3359, http://www.ipm.ucdavis.edu.

Santa Clara Valley Water District Approved Plant List for Landscape Rebate Program, http://www.valleywater.org/Programs/Landscaping.aspx.

StopWaste.org

Bay-Friendly Landscape Guidelines, www.rescapeca.org

A Landscaper's Guide to Grasscycling

A Landscaper's Guide to Mulch

Sunset Magazine, www.sunset.com/garden/climate-zones

The Weed Worker's Handbook, A Guide to Techniques for Removing Bay Area Invasive Plants, The Watershed Council (510) 231-5655 and the California Invasive Plant Council (510) 843-3902.

University of California Cooperative Extension, Guide to Estimating Irrigation Water Needs of Landscape Plantings in CA.

D.10 Credits

This guidance is based on planting guidance prepared by Design, Community and Environment for the Alameda Countywide Clean Water Program's C.3 Technical Guidance. The plant list included in Section D.3 was prepared by Placeworks specifically for the Santa Clara Valley Urban Runoff Pollution Prevention Program to identify species appropriate for local climate conditions in Santa Clara Valley.

Appendix

E

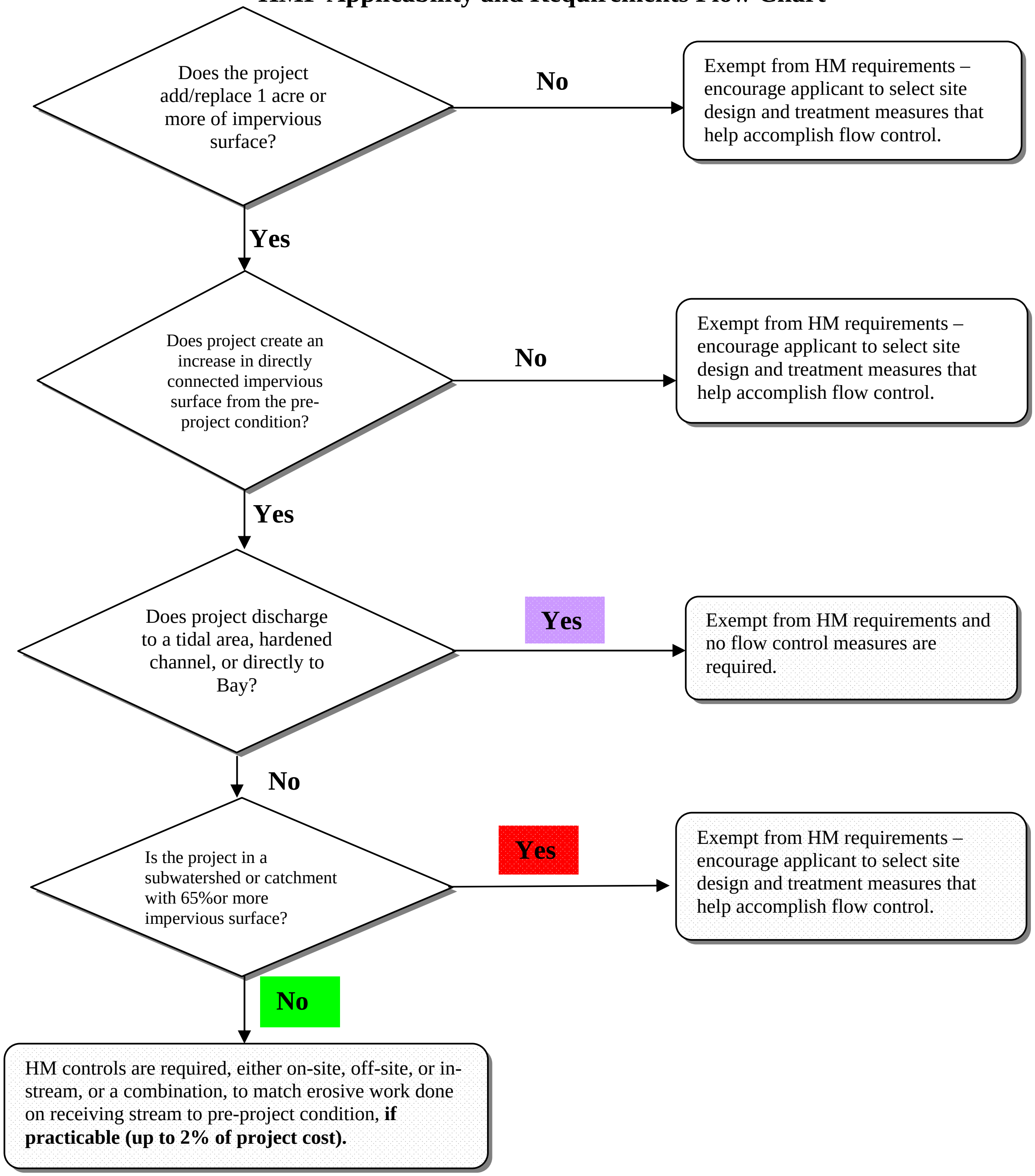
Hydromodification Management Requirements

Table of Contents

Appendix E-1

HMP Applicability and Requirements Flow Chart

Appendix E-1
HMP Applicability and Requirements Flow Chart

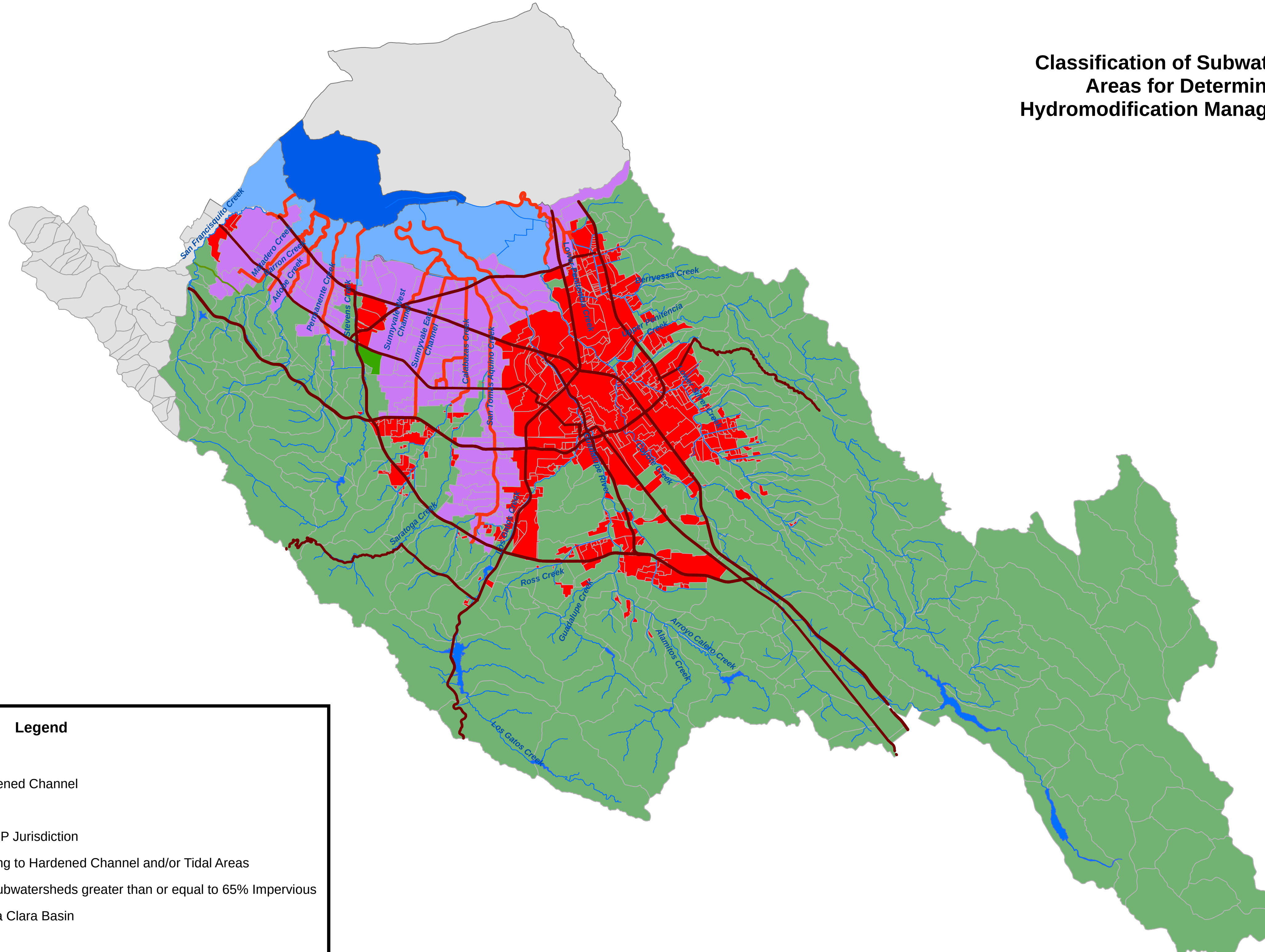


Notes:
Colors correspond to the HM Applicability Map in Appendix E-2.

Appendix E-2

HMP Applicability Map

Classification of Subwatersheds and Catchment Areas for Determining Applicability of Hydromodification Management (HM) Requirements



Legend

- Major Roads
- Continuously Hardened Channel
- Major Creeks
- Outside SCVURPPP Jurisdiction
- Catchments Draining to Hardened Channel and/or Tidal Areas
- Catchments and Subwatersheds greater than or equal to 65% Impervious
- Reservoirs in Santa Clara Basin
- Baylands
- Subwatersheds less than 65% Impervious

Revision Date: November 2010

N

0 0.5 1 2 3 4 5 Miles

This map contains revisions to the March 2009 version to reflect updated impervious surface data and/or catchment boundaries in the Cities of San Jose, Sunnyvale, Mountain View, and Milpitas, as described in the report to the Water Board dated October 14, 2010, consistent with the HM applicability criteria set forth in Attachment F, Section 4 of the MRP.

Appendix E-3

Introduction to Flow Duration Basin Design

Flow Duration Basin Design Guidance Technical Memorandum

Appendix E-3
Introduction to Flow Duration Basin Design

This introduction to flow duration basin design is excerpted from a technical memorandum entitled "Flow Duration Basin Design Guidance" (GeoSyntec Consultants and EOA, Inc., March 2005). The technical memorandum is included in its entirety following this introductory section, on page 5, and is also presented in Appendix F of the Hydromodification Management Plan (HMP) – Final Report (April 2005) available at www.scvurppp.org. The following is a brief overview of the flow duration basin design approach for meeting hydromodification management (HM) requirements[1].

On-site controls designed to provide flow duration control to the pre-project condition are considered to comply with the HM requirements. The flow duration control approach involves: 1) simulating the runoff from the project site, pre- and post-project, using a continuous rainfall record; 2) generating flow-duration curves from the results; and 3) designing a flow control facility such that when the post-project time series of runoff is routed through the facility, the discharge pattern matches the pre-project flow-duration curve. See the following section on hydrologic models for a discussion on generating flow-duration curves.

The flow control facility described here is a detention basin that diverts and retains a certain portion of the runoff. The portion to be retained is essentially the increase in surface runoff volume created between the pre-project and post-project condition. This captured increase in volume must be discharged to the ground via infiltration (and/or evapotranspiration if vegetation present) from the basin, released at a very low rate to the receiving stream (at the critical flow for basin design, Qcp, or 10% of the pre-project 2-year peak flow), and/or diverted to a safe discharge location or other infiltration site, if feasible.

As shown in Figure 1, the flow duration basin can be conceptualized as having two pools, a low flow pool (Zone A) and a high flow pool (Zone B). The low flow pool is designed to capture the difference in volume of runoff between the pre- and post-project conditions. It will also capture small to moderate size storms, the initial portions of larger storms, and dry weather flows. The high flow pool is designed to store and release higher flows to maintain, to the extent possible, the pre-project runoff conditions.

The flow duration basin is sized using an iterative process of adjusting basin storage as well as selecting and adjusting orifice sizes in the outlet structure. The low flow pool within the basin is initially sized to capture the increase in runoff volume that is generated from the development project. This capture volume is dependent on the development characteristics, the soil types, and the magnitude of increase in impervious surfaces. The post-project runoff calculations should take into account planned stormwater treatment or LID treatment measures that may detain or infiltrate runoff. Project proponents should see local municipality guidance for standard design criteria and policies (e.g. municipality may encourage basins with at least a 4:1 side slope integrated into the landscape rather than a deeper basin).

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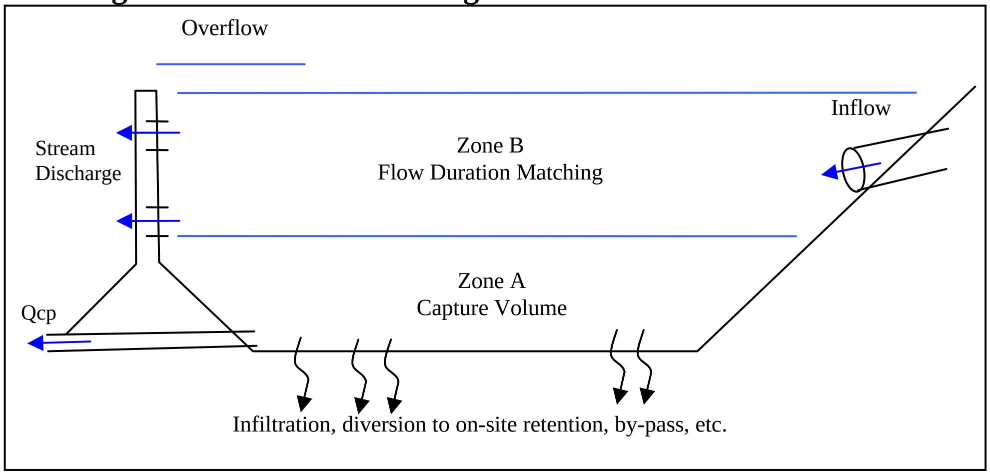
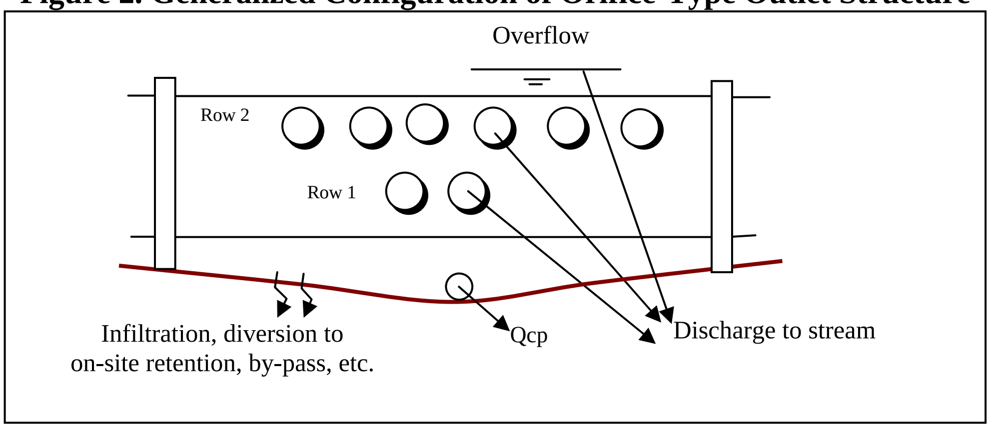
[1] Project proponents and municipal staff may choose to use the the Bay Area Hydrology Model (BAHM) to design and/or review flow duration control facilities. The basic design approach described here is utilized in the BAHM. The BAHM and User Manual are available at www.bayareahydrologymodel.org.

Figure 1. Generalized Configuration of Flow Duration Basin



Once the lower pool is sized to capture the correct volume of runoff, the upper pool of the basin is sized to detain and discharge larger flows through an outlet structure in such a way as to reproduce the flow duration curve (hydrograph). Figure 2 illustrates an outlet structure consisting of a series of orifices at set elevations above the basin bottom. The number, size and placement will vary from basin to basin depending on project conditions. The combination of sizing the lower portion of the basin to contain the increased volume and the upper portion to detain and discharge high flows has the effect of capturing the correct volume of runoff and matching the pre-project distribution of hourly flows. A weir and orifice combination could also be designed to accomplish the same level of control. A detailed description of the process for sizing a flow duration basin is provided in the technical memorandum.

Figure 2. Generalized Configuration of Orifice-Type Outlet Structure



The hydromodification control standards were applied to several case studies in the HMP. From these examples several conclusions were drawn.

- The flow duration basin sizing approach can be applied to development sites of different sizes and land use types. The area required for flow duration basins seems to be between 2 to 7 percent of the contributing catchment area, depending on the infiltration capacity of the soil and the basin depth. Where projects have good soil infiltration rates and utilize low-impact development strategies, less land area may be required (1.5 to 2 percent).

- Basin size can be reduced by applying volume reduction or low impact design strategies. For example, disconnecting impervious area such as roof drains and discharging runoff to landscaping, bioretention areas and/or infiltration trenches reduces the difference in volume between pre- and post-project runoff that need to be controlled in the basin.
- Qcp should be incorporated in every basin design but its relative impact on basin sizing is dependent on project size and soil infiltration rates. The Qcp rates for small basins may require small orifice diameters as small as 2 inches.

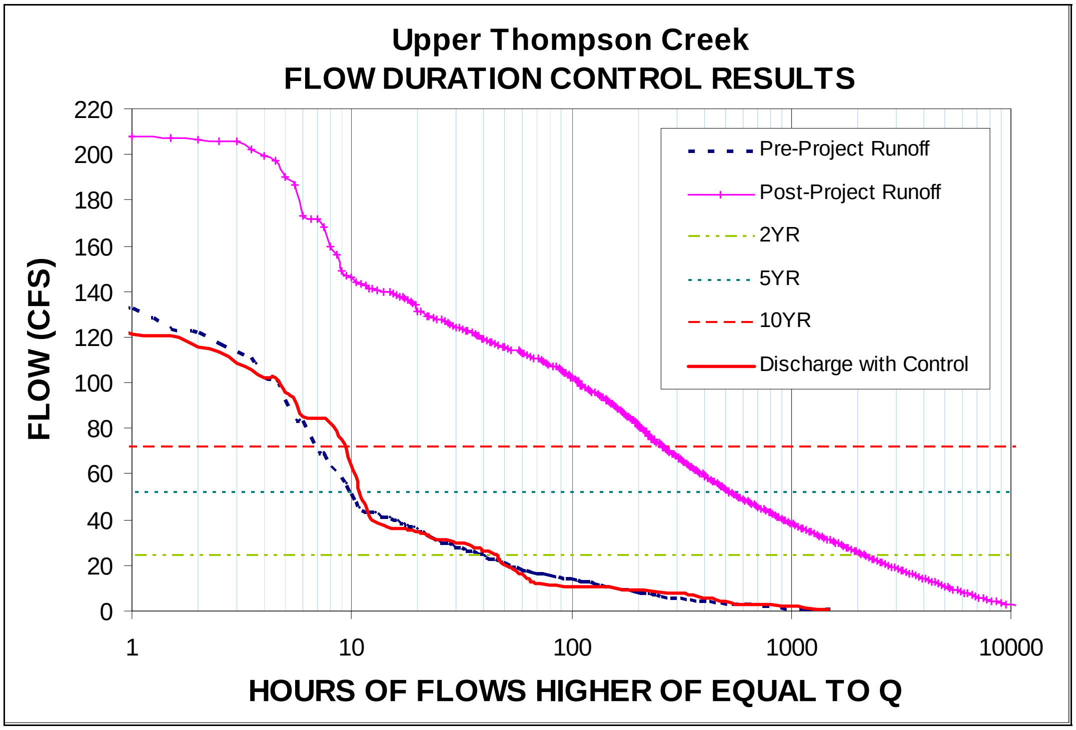
Hydrologic Models

The first two steps in designing a flow control facility are simulating the runoff from the project site, pre- and post-project, using a continuous rainfall record and generating flow-duration curves (see Figure 3 for example flow duration curves from continuous simulation modeling). Both of these steps are done using a hydrologic model. The HMP studies concluded that hydromodification controls designed for a discrete or design storm event do not provide adequate protection of the erosion potential of streams. The recommended method for hydromodification control is to maintain the pre-project flow duration curve via a flow duration control structure.

There are several hydrologic models available as public domain software that can be used[2]. The Program, in cooperation with the Alameda and San Mateo County stormwater programs, funded the adaptation of the Western Washington Hydrology Model, an automated modeling and flow control facility sizing tool, for use in the Bay Area. The completed Bay Area Hydrology Model (BAHM) is helping developers design, and municipal staff review, flow duration control facilities for HM compliance. To obtain more information and to download the BAHM and User Manual, go to www.bayareahydrologymodel.org .

[2]: Army Corps of Engineers' Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), Environmental Protection Agency's (EPA's) Hydrologic Simulation Program-Fortran (HSPF), and EPA's Stormwater Management Model (SWMM).

Figure 3. Example Flow Duration Curves from Continuous Simulation Modeling



Flow Duration Basin Design Guidance

Prepared by GeoSyntec Consultants and EOA, Inc.[3]

LIST OF FIGURES AND TABLES

INTRODUCTION

The flow duration (FD) basin design process is essentially an iterative process where the designer selects basin storage volumes and outlet configurations and compares the resulting discharge flow duration curve to the pre-project results. Guidelines on selecting the initial estimates are provided, as well as guidance for adjusting storage and outlet configurations. The affects of increasing or decreasing orifice diameter, invert elevation (weir elevation), and number (length); and basin storage are summarized.

DESCRIPTION OF THE FLOW DURATION BASIN

The flow duration control approach involves: 1) simulating the runoff from the project site, pre- and post-project, using a continuous rainfall record (50 years of record in this case); 2) generating flow-duration curves from the results; and 3) designing a flow control facility such that when the post-project time series of runoff is routed through the facility, the discharge pattern matches the pre-project flow-duration curve. The flow control facility is a detention basin that diverts and retains a certain portion of the runoff. The portion to be retained is essentially the increase in surface runoff volume created between the pre-project and post-project condition. This captured increase in volume is typically discharged to the ground via infiltration (and/or evapotranspiration if vegetation is present) in the basin, released at a very low rate to the

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[3] From SCVURPPP Hydromodification Management Plan – Final Report, Appendix F, April 2005. Available at www.scvurppp.org.

receiving stream (at the critical flow for basin design, Qcp, or 10% of the “pre-project” 2-year storm), and/or diverted to a safe discharge location or other infiltration site, if feasible. For the examples presented here, the captured runoff is assumed to be infiltrated in the basin and discharged at Qcp (see next section for computation of Qcp).

The flow duration basin is designed to have two pools (Figure F-1), a low flow pool (Zone A) and a high flow pool (Zone B). The low flow pool is designed to capture small to moderate size storms, the initial portions of larger storms, and dry weather flows. The high flow pool is designed to store and release higher flows to maintain, to the extent possible, the pre-project runoff conditions. The flow duration basin can also serve as a water quality treatment facility and can be designed to treat dry and wet weather flows using a combination of extended detention and natural treatment processes. Most dry weather “nuisance flows” will also infiltrate in the basin.

The flow duration basin is sized using an iterative process of adjusting basin storage as well as selecting and adjusting orifice sizes in the outlet structure. The low flow pool within the basin is initially sized to capture the increase in runoff volume that is generated from the impervious surfaces. This capture volume is dependent on the development characteristics, the soil types, and the magnitude of change in runoff created by the proposed development. Previous analyses have shown that area requirements have less to do with the range of storms selected for management and more to do with site and development characteristics.

Once the lower pool is sized to capture the correct volume of runoff, the upper pool of the basin is sized to detain and discharge larger flows through a specific set of orifices in such a way as to reproduce the flow duration curve. The number, diameter, and elevation of these orifices are determined by a trial and error approach (King County, 1998). The combination of sizing the lower portion of the basin and the upper portion to detain and discharge high flows has the affect of capturing the correct volume of runoff and matching the pre-project distribution of hourly flows.

The outlet structure is designed to reproduce the pre-developed flow duration (runoff histogram) using orifice diameter and elevation above the bottom of the basin. Figure F-2 illustrates the outlet structure. The number, size and placement will vary from basin to basin depending on project conditions. The headwall could be constructed using steel plates in a manner that allows owner/operators to easily change the outlet configuration to improve basin performance if necessary.

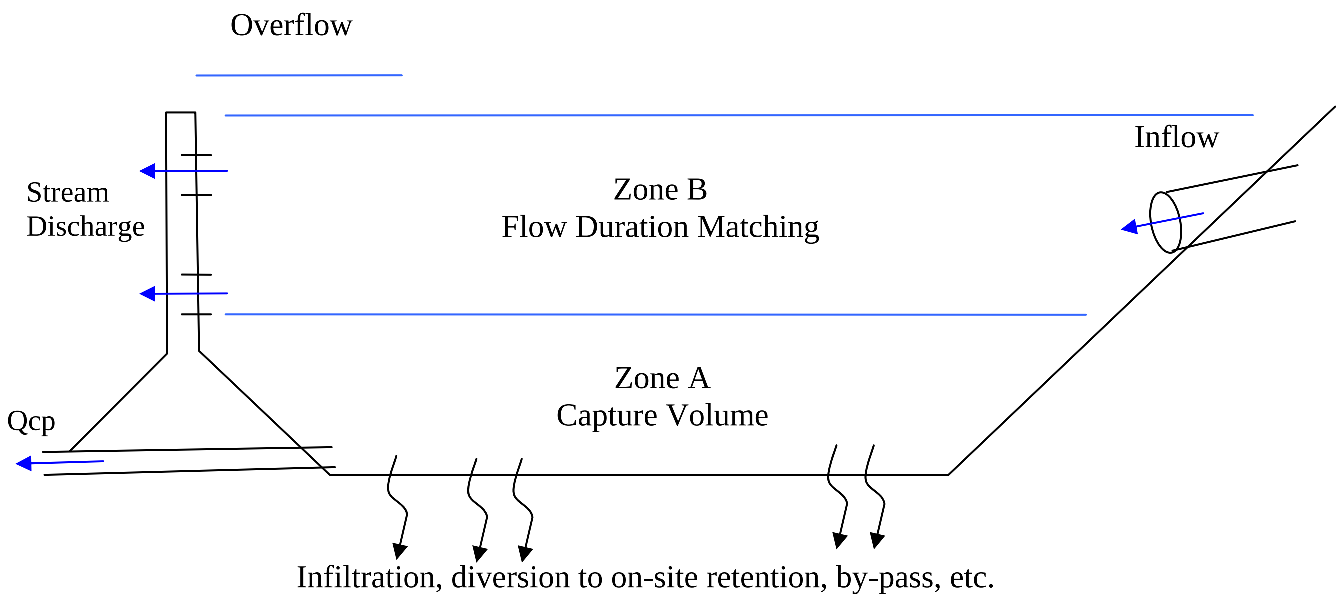

Figure F-1. Generalized Configuration of Flow Duration Basin

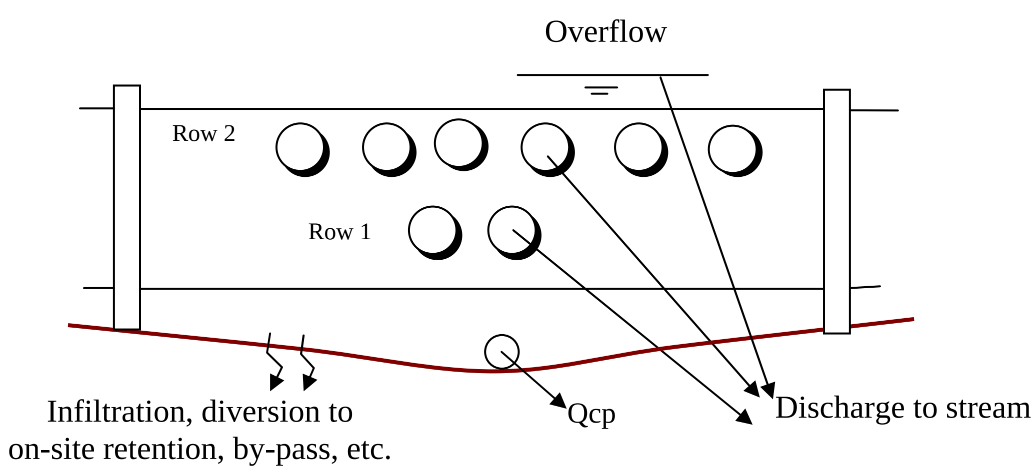

Figure F-2. Generalized Configuration of Orifice-Type Outlet Structure

DETERMINATION OF ALLOWABLE LOW FLOW DISCHARGE, QCP

The critical flow of a stream (Qc) is defined as the flow that produces the critical shear stress that initiates bed movement or erodes the toe of stream banks. A goal of hydromodification management is to control the discharge of the increased flow and volume created by development to below Qc, to minimize the potential for increased erosion. In order for the critical flow to be useful to dischargers in design of on-site hydromodification control structures, the critical flow in the stream must be partitioned or related to an on-site project-based variable. For this purpose, the in-stream critical flow was related to the pre-urban 2-year peak flow in the stream. Based on the hydrologic studies of Thompson and Ross Creeks (Chapter 3 of the HMP Report), the critical flow was generalized as being approximately 10% of the 2-year peak flow under undeveloped land use conditions.

Using this relationship, the allowable low flow discharge from a flow control structure on a project site, Qcp, can be calculated as 10% of the pre-project 2-year peak flow from the site. In computing Qcp, the original condition of the site before development must be considered. This does not imply that the developer is being required to provide flow controls to match pre-development conditions; rather, it is a means of apportioning the critical flow in a stream to individual projects that discharge to that stream, such that cumulative discharges do not exceed the critical flow in the stream.

Qcp can be computed using any standard engineering method for calculating the peak flow for a 2-year return period storm event. These include the Rational Method, synthetic design storm hydrograph approaches, and continuous simulation model records. In the Rational Method, the equation Q = CiA is used, where discharge (Q) is a function of the drainage area (A), rainfall intensity (i), and a runoff coefficient (C). The rainfall intensity can be obtained from local agency intensity-duration-frequency curves, using an estimated time of concentration for the undeveloped site. The runoff coefficient should also be selected to represent the undeveloped site and can be found in a number of standard engineering references.

As an example, the allowable low flow discharge for the San Jose Small Site Example (see Chapter 6 of the HMP Report and Technical Memorandum #8) was calculated using the Rational Method. The project drainage area (A) for the small site example is equal to 3.6 acres. The runoff coefficient (C) selected for this analysis is equal to 0.36, and is based on the undeveloped, pre-urban condition of the project site. Using a time of concentration of roughly 6 minutes for the undeveloped project site, the rainfall intensity (i) for the 2-year event was determined from Figure 6 of the County of Santa Clara Drainage Manual (March 1966) to equal 1.5 inches/hour. Therefore, the 2-year design discharge for the undeveloped project site is equal to:

$Q_{2\text{-yr}} = CiA = (0.36 * 1.5 * 3.6) = 1.94$ cfs

and

10% of $Q_{2\text{-yr}} = 0.19$ cfs

Therefore, the design Qcp for the flow-duration-basin sizing analysis of the small site example is equal to 0.19 cfs.

PROCEDURES FOR SIZING A FLOW DURATION BASIN

1. Data file preparation
   a. Need long-term (~25-50 years) stormwater runoff records for pre- and post-development conditions. These are generated using hydrologic programs, such as HEC-HMS, SWMM, and HSPF. Input to these programs is a long-term precipitation record (generally in hours although 15 minute data could be used), project area and development information, and soils information, to produce a long-term continuous runoff record.

2. Compute Pre- and Post- Flow Duration Curves
   a. For each of the runoff records, develop a histogram[4] and cumulative frequency distribution of the hourly runoff values. Use the post-project record to select histogram flow range and bin (interval) increments. Use consistent increments for the pre-project flow histogram and the post-project with control measures in place histogram.
   b. When generating the cumulative frequency distribution it is preferable to begin the count with the largest flow bin proceeding downwards to the smallest value. The cumulative frequency distribution is the flow duration curve.

3. Select Initial Estimates for Basin
   a. Area: set the starting area at ~2% to 7% of the catchment area. FD basins in catchments with clay soils are about 2%, while basin collecting runoff from sandy soils can be up to 7%. This seems to be a reasonable starting point.
   b. Depth: range from 2 to 10 feet. The storage of the basin will be determined from the iterative analysis; however, local jurisdictions may have limitations on depth of a basin. Shallow depths may be preferred for multi-purpose facilities.

4. Select Initial Estimate for Outlet Structure
   a. Start with ONLY a bottom orifice, which is sized to discharge at a maximum rate equal to the critical flow rate (Qcp = 10% of pre-project 2-year peak flow) when the basin is full. The volume of the initial FD basin can be approximated by routing post-project flows through this basin with the bottom orifice and weir overflow, and then comparing the total number of hours of the resulting FD curve at Qcp to the pre-project curve at this flow magnitude. Adjust the volume of the initial FD basin so that these curves match in total number of flow hours at Qcp. Increasing the basin storage volume moves the FD curve to the left. Decreasing storage volume moves the curve to the right.
   b. After adjusting the basin storage volume, then add one orifice at ¾ of the effective depth of the basin. Set the orifice diameter at 6 inches. The lowest orifice corresponds to the lowest arc of the flow duration curve.
   c. After adjusting the basin storage volume and adding the first orifice, then add a second orifice at ⅞ of the effective depth of the basin. The combined first and second orifice corresponds to the second arc of the flow duration curve, and represents the combined flows.

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[4] A histogram is a graphical representation of the frequency distribution of a series of data. The histogram provides a visual impression of the shape of the distribution as well as the amount of scatter. A histogram is developed by dividing the range of values in the data set into equal intervals. The procedure is to count the number of data points that fall into each interval, thereby determining the frequency of occurrence of flows with similar magnitudes for each interval.

   d. Increasing the lower orifice diameter will adjust the slope and curvature of the lowest arc of the flow duration curve. Increasing orifice diameter increases the range of flow magnitude that can be discharged through this orifice, which shifts the arc upwards. Decreasing orifice diameter reduces the lowest arc.
   e. Increasing or decreasing orifice elevation shifts the transition point between arcs along the FD curve. Increasing the elevation moves the transition point left and upwards, while decreasing the elevation moves the point right and downwards.
   f. Increasing storage volume also helps match the curve in the upper high flow range. In most cases, the facility can be sized so that a small amount of overflow occurs during infrequent large flows.
   g. Refinements should be made in small increments and performing one change at a time. It is best to begin with sizing the storage volume and then adjusting the number/size of the lowest orifice to match the lowest part of the FD curve first. Then proceed upwards by adding and adjusting the next highest orifice discharges to match the remaining portion of the FD curve.

5. The range of discharge capacity should approximately match the range of pre-project discharge.
   a. Orifice diameters should be selected such that the range of flows, given the range of hydraulic head on the orifice, approximates the range of flows discharging from the site under pre-project conditions.

6. Stage-Discharge Relationship
   a. The stage-discharge relationship is defined by the sum of all the outflows from the basin: 1) discharge by infiltration through the wetted bottom of the basin; 2) discharge through a small orifice discharging at the critical flow rate (Qcp); and 3) discharge through the outlet structure designed to match the pre-project flow duration curve.

TEST FOR GOODNESS-OF-FIT

Matching flow duration curves is the preferred method of hydromodification management to protect the beneficial uses of streams. The question addressed in this section is, how close do these curves need to match?

Figure F-3 shows the flow duration curves for the small 12-lot subdivision in San Jose described in Section 5.3 of the HMP Report. This figure includes the pre-project, post-project, and post-project with BMP flow duration curves. Based on this figure, the post-project with BMP curve closely matches the pre-project curve for small frequent flows up to 1.5 cfs, than deviates for less frequent high flows. Visually this looks like a pretty good match. However, the HMP needs a consistent and accurate means to measure the difference and limit deviations above the pre-project conditions.

According to the Western Washington flow duration basin sizing guidelines (Washington Department of Ecology, 2000), the post-project curve cannot exceed the pre-project curve by more than 10%, over no more than 10% of the length of the curve. Deviations less than the pre-project condition are allowed and unlimited[5]. Basins designed with large over control will require larger land areas.

Figure F-4 plots the difference between the pre- and post- cumulative volume, which is simply the magnitude of flow for each bin in the histogram times the frequency of that bin, and then summed. Flows less than Qcp are not included. The difference is plotted as a percent of the cumulative pre-project volume. The figure shows, or expresses, the definition of the goodness-of-fit in terms of runoff volume. The cumulative post-project runoff volume cannot exceed the cumulative pre-project volume by more than 10%, over no more than 10% of the length of the curve. Also, the total cumulative runoff volume over the full histogram cannot exceed the pre-project condition.

Figure F-3

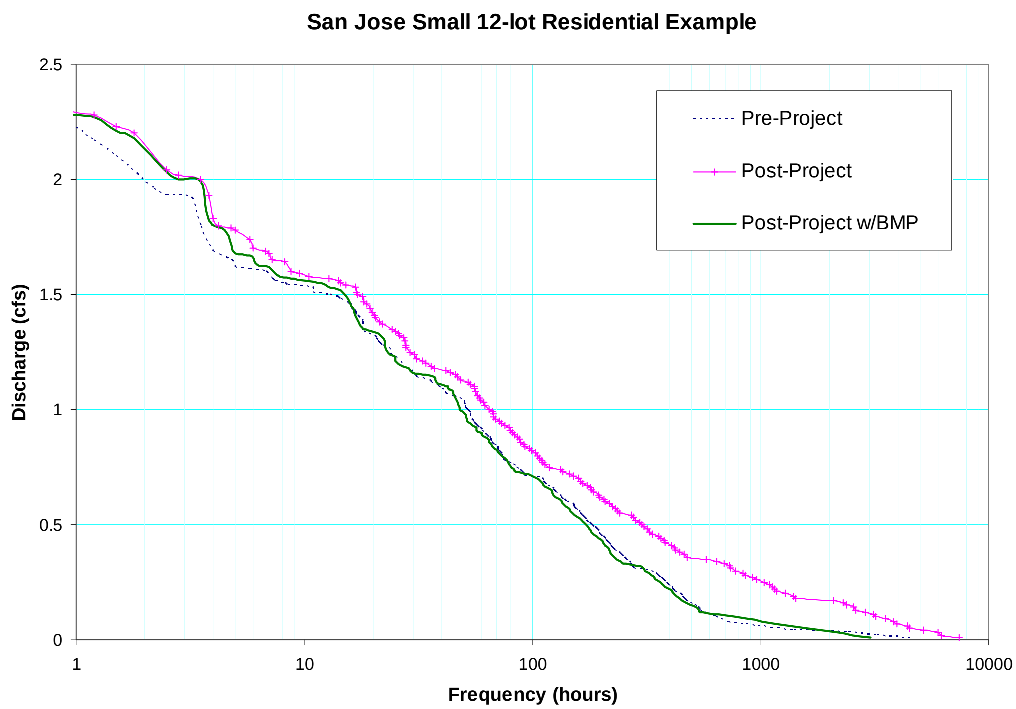
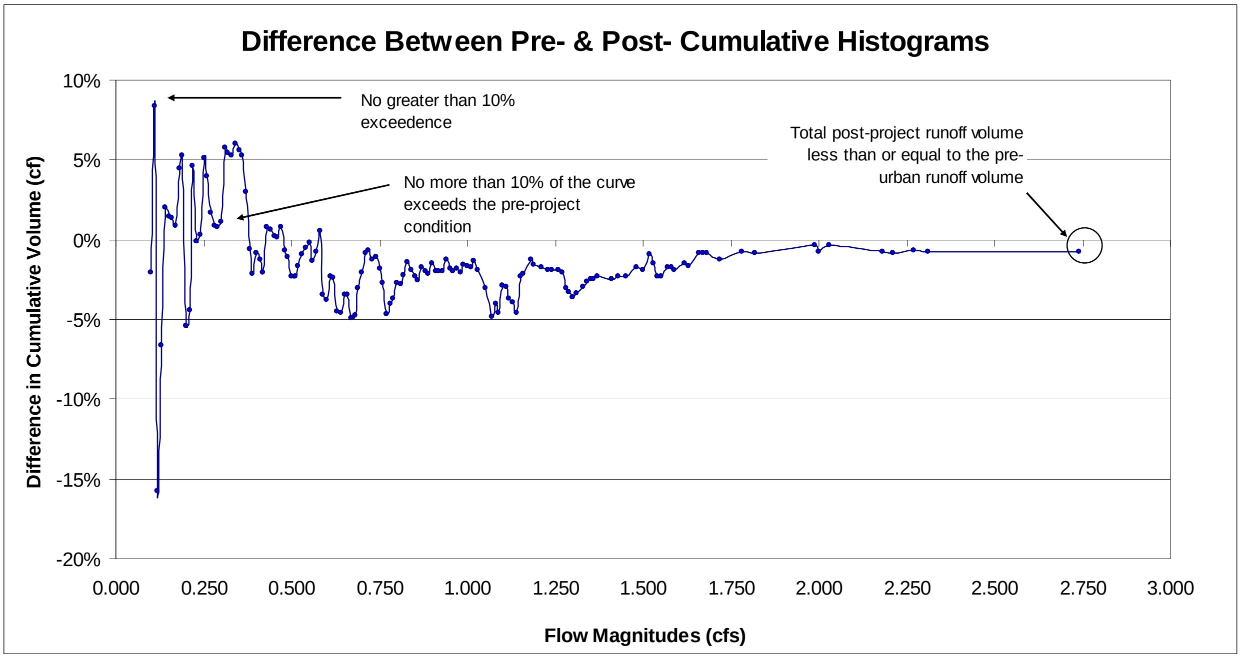


Figure F-4

[5] Deviations are unlimited with respect to erosion but habitat issues could require limits on too little runoff.



REPORTING AND GRAPHICS

This section describes the recommended reporting information and presentation graphics useful for conveying the adequacy of flow duration basin sizing to agencies plan review staff. This information includes a table of resulting basin characteristics, histograms of resulting flow characteristics, and flow duration curves of resulting flow characteristics.

TABLE OF BASIN CHARACTERISTICS

Table 1 below lists the basin characteristic information to be included and presents example information for three scenarios. The characteristics presented should include basin volume, area, depth, drain time, and discharge modes.

Table F-1
Resulting Flow Duration Basin Characteristics

Basin Characteristics	DESIGN SCENARIOS		
	Discharge at infiltration rate only	Discharge at infiltration rate plus <Qc	Basin size with roofs disconnected
Basin Volume (acre-feet)	0.11	0.10	0.08
Basin Size (% catchment)	2.1%	1.7%	1.3%
Basin Size (%DCIA)	4.6%	3.7%	2.8%
Basin Depth (feet)	1.75 ft	2.25 ft	2.5 ft
Drain time (days)	3.7 days	<1 day	3.6 days
Qc (cfs)	0	0.1 cfs	0

Infiltration Rate (loss through wetted bottom, cfs)	0.2 in/hr	0.2 in/hr (0.01 cfs)	0.2 in/hr
Outlet type and dimensions (inches)	Orifice: 3 to 6-inches	Orifice: 3 to 6-inches	Orifice: 3 to 6-inches

HISTOGRAM SHOWING PRE-PROJECT, POST-PROJECT, AND POST-PROJECT WITH BMP RESULTS

Figure F-5 presents the resulting histograms using the 716 acre Thompson Creek example. The histograms for pre-project, post-project and post-project with BMPs are shown. The frequency scale is shown as logarithmic to highlight the differences throughout the flow bin scale, otherwise the differences at the high flow end would be hard to observe.

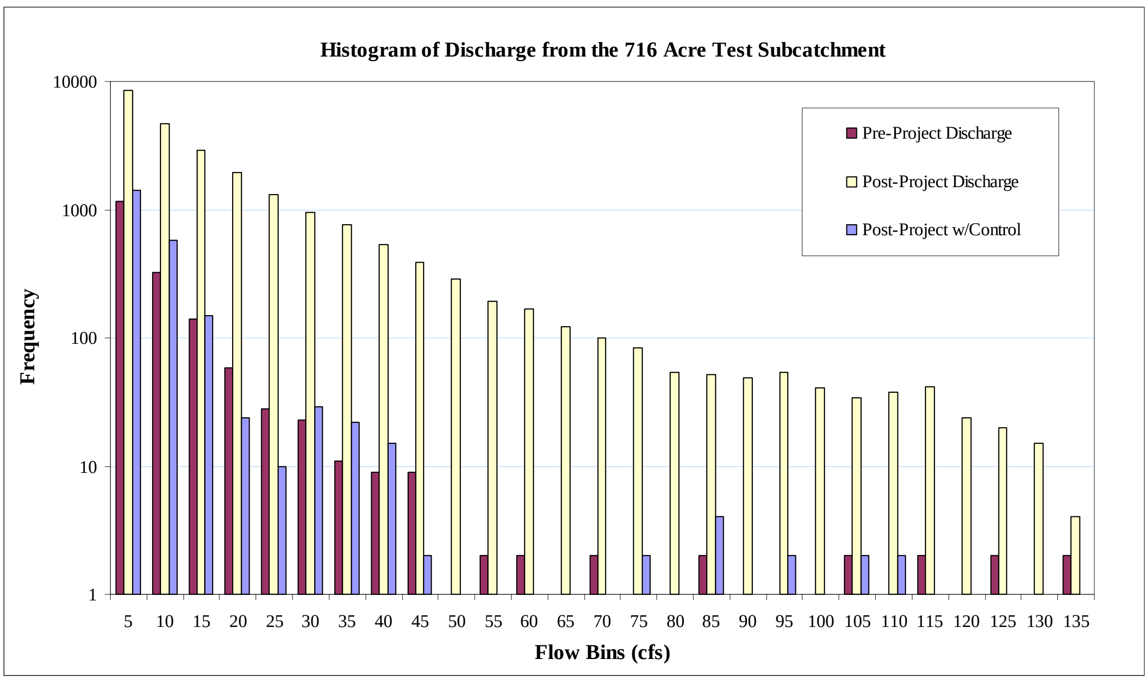


Figure F-5. Histogram of Discharge from the 716 Acre Test Subcatchment

FLOW DURATION CURVES SHOWING PRE-PROJECT, POST-PROJECT AND POST-PROJECT WITH BMP

Figure F-6 presents the resulting flow duration curves for the same Thompson Creek example. The flow duration curves for pre-project, post-project and post-project with BMPs are shown. The frequency scale is shown as logarithmic to highlight the differences throughout the flow bin scale; otherwise the differences at the high flow end would be hard to observe.

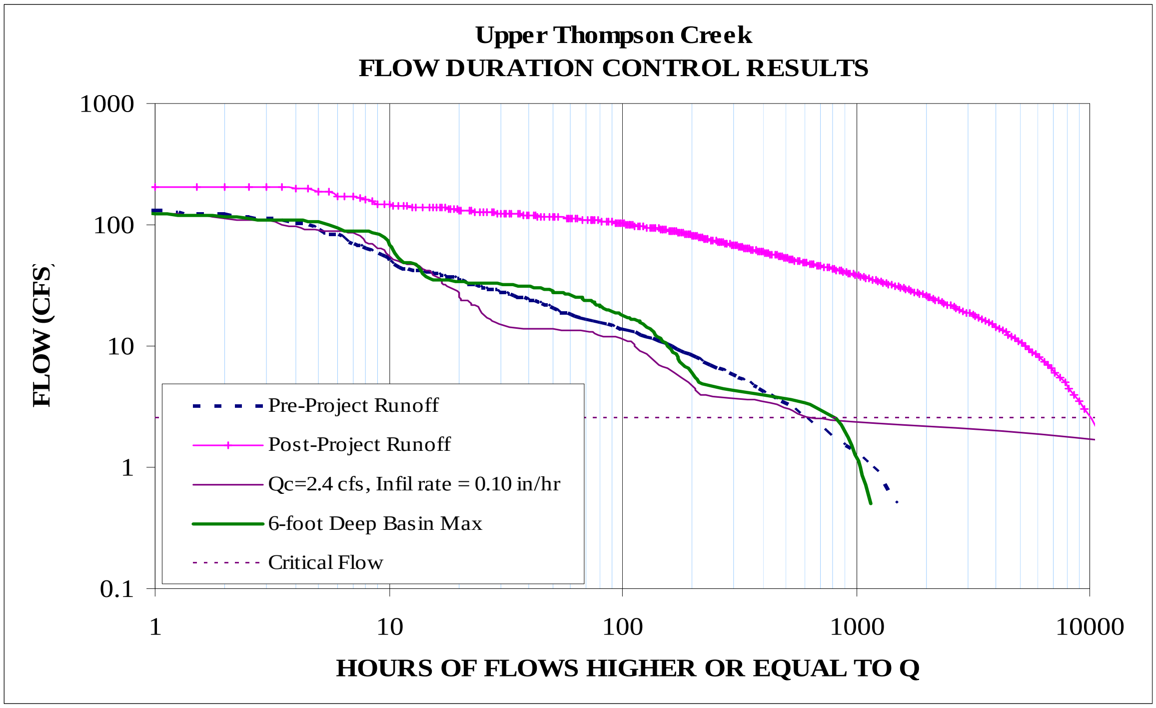


Figure F-6. Example Flow Duration Curves

Outlet Design for the Purpose of Matching Flow-Duration

The following addresses a number of detention basin outlet design considerations as they pertain to the goal of matching pre- and post-project flow-duration distributions.

Comparison of Multi-tier Rectangular Weir and Circular Orifice Outlet Designs

In an effort to identify significant outlet design criteria for matching pre- and post-project flow-duration, the relative performance of two outlet configurations was considered: a 3-tier rectangular, sharp-crested weir, and an outlet consisting of three tiers of circular orifices. Each outlet was assumed to discharge flows from a detention basin 1200 feet long by 1000 feet wide, with a maximum depth of 4 feet and 3:1 side slopes. Infiltration rates through the bottom of the wetted surface of the basin were assumed to be 0.2 in/hr. Downstream discharges for each outlet were calculated from a 50-year continuous rainfall time-series, input to a runoff-storage-discharge model.

Figure F-7 shows the general design of the multi-tiered rectangular weir and circular orifice outlets analyzed.

a) rectangular weir

b) circular orifice

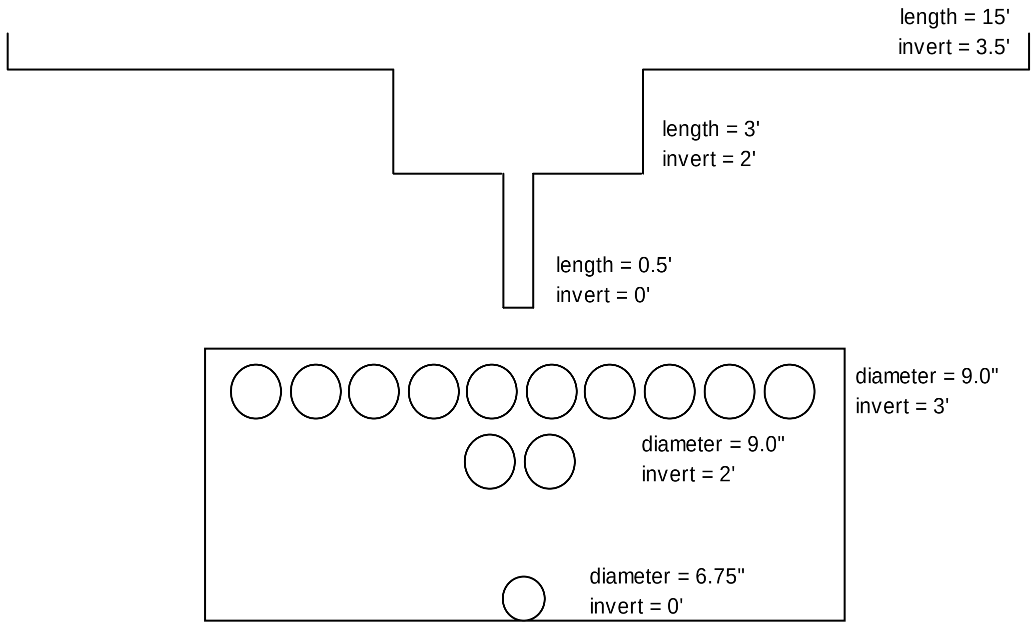


Figure F-7: 3-Tier Sharp-Crested Rectangular Weir (A) and Circular Orifice (B) Outlet Designs

The cumulative flow-duration distribution calculated for a 50-year continuous runoff-storage-discharge simulation of each outlet design is plotted in Figure F-8 alongside the flow-duration curves for the modeled pre-project catchment, post-project without flow control, and the critical discharge threshold (Qcp) (2.4 cfs in this simulation).

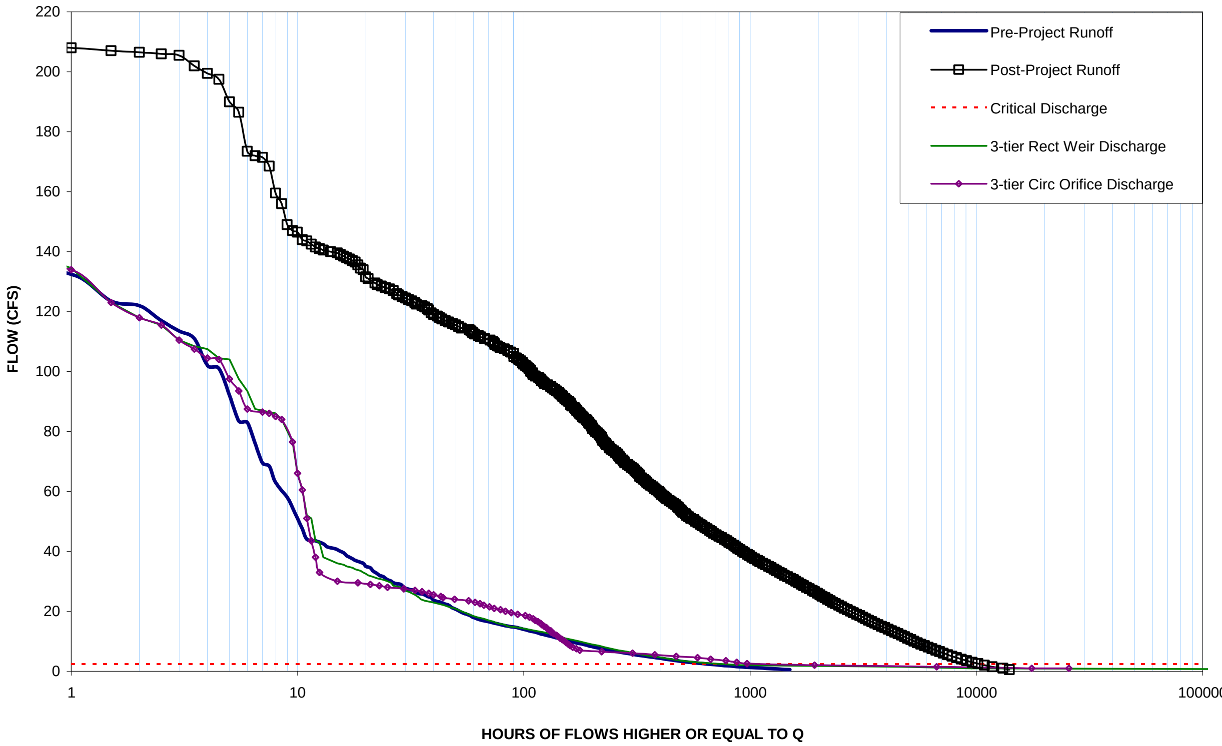


Figure F-8. Flow Duration Control Results

The 3-tier rectangular weir appears to provide a closer match to the pre-project flow-duration curve than the 3-tier circular orifice design, particularly for discharges of approximately 30 cfs or less, which constitute 96% of the pre-project flow duration. While both the rectangular and circular orifice simulations fail to match the pre-project curve above 43 cfs, flows of this magnitude represent roughly 1% of the modeled flow duration. If more time were invested, the the orifice design could be improved to achieve a closer match.

The relative performance of the rectangular weir as compared to the circular orifice design is more evident when Figure F-8 is re-plotted on a log-log scale, as provided in Figure F-9.

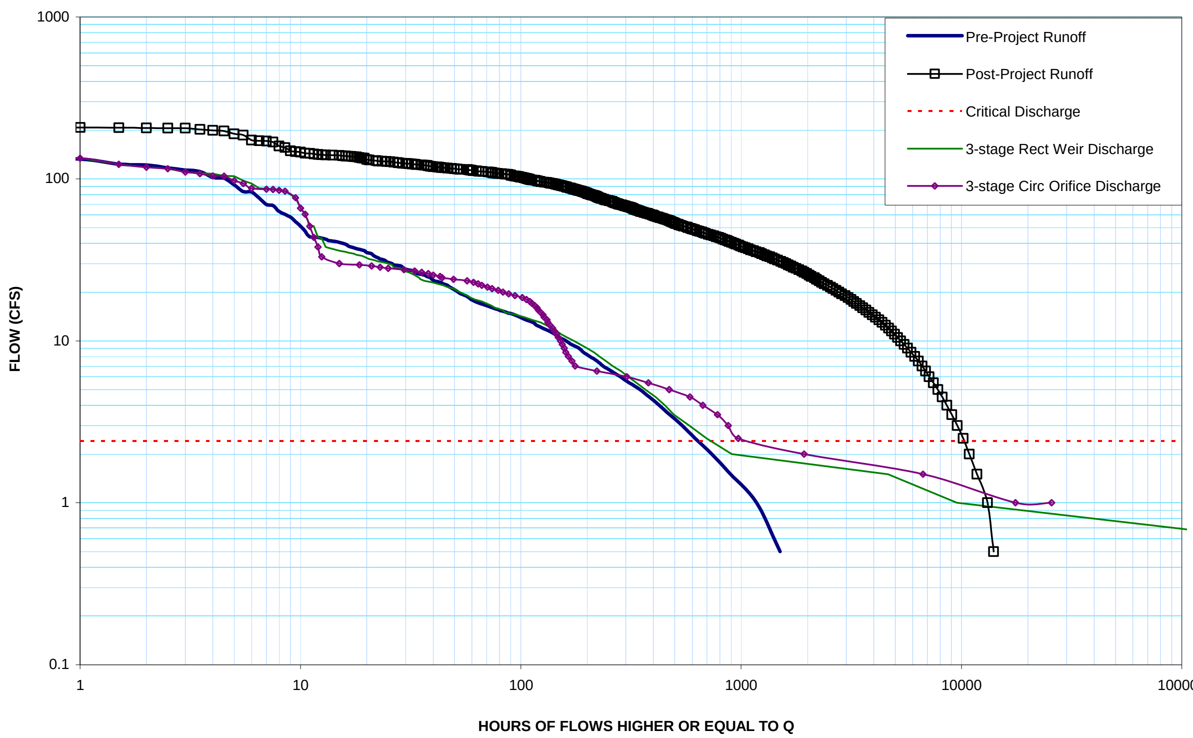


Figure F-9. Flow Duration Curve Results – Log-Log Scale

The expanded scale highlights the difference in curve shape between the rectangular and the circular orifice outlet designs. The multi-stage rectangular outlet closely follows the smooth, convex shape of the pre-project curve, with the exception of large, low-duration flows (Q > 43 cfs) and flows less than the designated "Critical Discharge". In contrast, the circular orifice outlet curve meanders about the pre-project curve, resulting in a significant proportion of duration where post-project flows are greater than those modeled for the pre-project conditions.

Comparison of the respective stage-discharge curves for each of the two designs, as shown in Figure F-10, illustrates the critical difference. For each tier of the circular orifice outlet, the stage-discharge relationship is convex, whereas the rectangular outlet yields a smoother, approximately concave curve, as is desired to match the pre-project flow-duration.

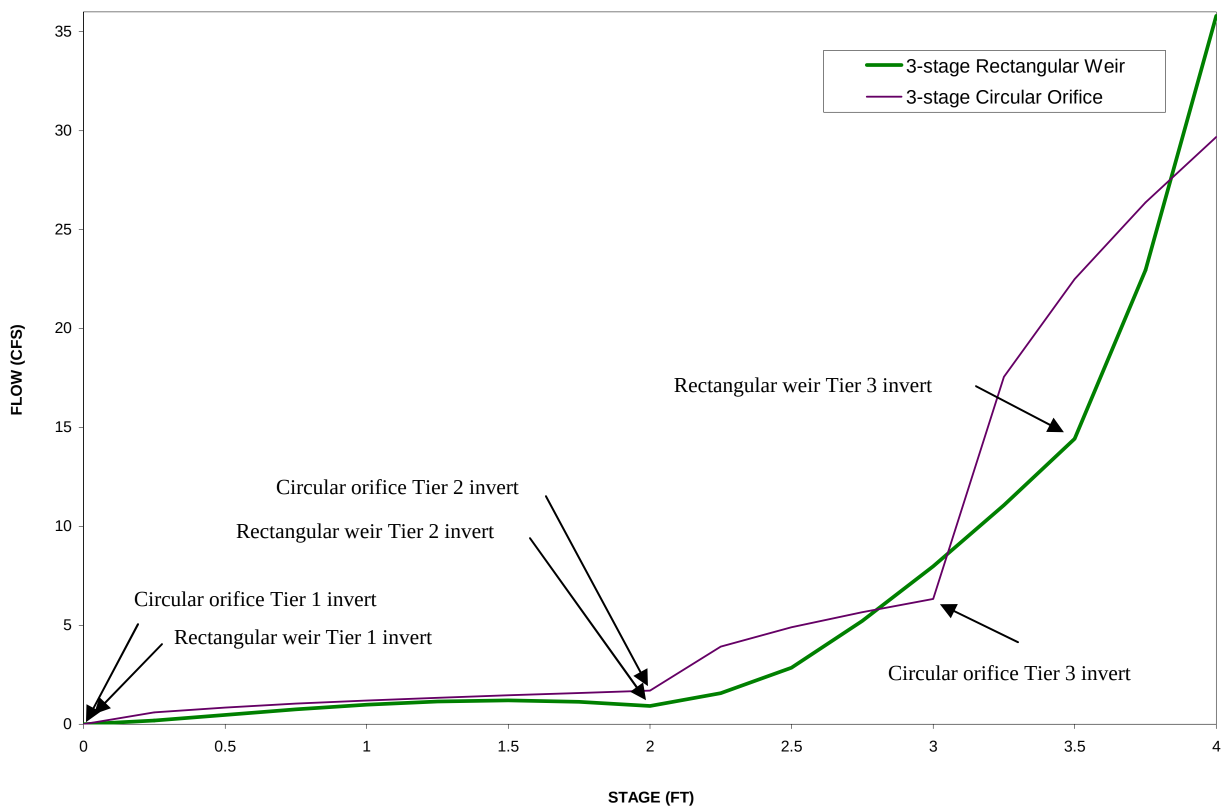


Figure F-10. Stage-Discharge Curves

In summary, these results suggest that an "ideal" outlet design in terms of matching flow-duration is similar to the multi-tier rectangular weir analyzed here, but with smooth, curved sides as shown in Figure F-11, rather than a stepped design. It is assumed that a power equation could be derived for such an outlet, thereby facilitating design and sizing calculations.

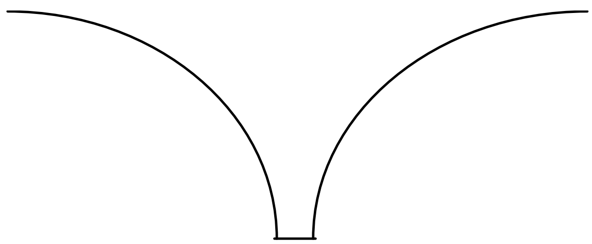
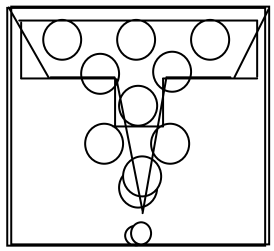


Figure F-11.Continuous curve outlet design



Alternative Outlet Designs

The outlet designs compared in this analysis represent only two possible configurations. Figure F-12 displays several additional conceptual designs. The actual performance of these configurations was not analyzed here. However, the performance of these designs can be easily evaluated by looking at stage-discharge curves for any proposed design.

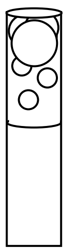


Figure F-12. Alternative outlet designs

Possible outlet configurations vary in terms of complexity of design and construction, and in suitability for matching flow-duration. Of the three above, the perforated outlets (6a) offer the greatest flexibility, as essentially any number of orifices of varying diameter may be used to achieve the desired stage-discharge relationship; however this design is difficult to construct properly. The other two designs combine different outlet shapes to develop this relationship. Based on results from the 3-tier rectangular weir analysis, it is presumed that the performance of these alternative methods is associated with how well they approximate the shape of the design in Figure F-11 and a smooth concave stage-discharge relationship.

Limitations on Three Stage Outlet Design

In order to achieve acceptable matching of the pre- and post-project flow duration curves at low, high-duration flows (e.g. < 4 cfs) in this analysis, it was necessary to significantly constrict the size of the lowermost tier (6” at most for L1 of the rectangular weir, 6.75” diameter for the circular orifice outlet)[i]. Such a small low-flow outlet size exposes the structure to a heightened risk of clogging. It is presumed that such an issue arises with any relevant outlet design – namely, that to match the very low, high duration pre-project flows, a blockage-prone low-flow outlet is required, and will be part of any design configuration.

A possible solution is to employ an outlet design that is not prone to clogging by incorporating a filtration component for low flow in order to screen out small debris. For example, flows could pass through a high flow rate (large diameter) perforated vertical riser embedded in crushed stone and filter fabric before discharging through the outlet control (e.g. multi-stage weir or series of orifices).

DATA AND RESOURCE REQUIREMENTS

The primary data requirements for flow duration basin sizing are long term flow records from the project site, representing pre-project and post-project conditions. The post-project flow record is then routed through hydraulic modeling software (e.g. SWMM, HEC-RAS), which approximates the effect of a flow duration basin, represented as a stage-storage-discharge curve, in order to match the pre-project condition.

The long term precipitation records and watershed hydrologic characteristics, used to create the necessary flow records through the application of hydrology modeling software (e.g. HEC-HMS, SWMM, HSPF), are also required.

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[i] A secondary issue which arises is that the standard sharp-crested rectangular weir discharge equations break down when applied to very narrow crest lengths under high hydraulic head. To account for minor energy losses at the contraction of the weir crest, the "effective" length of each stage crest (L) is calculated as follows:

$$L_e = L - 0.1nH$$

where:
- L_e = effective length of weir crest (ft)
- L = measured length of weir crest (ft)
- n = number of contractions (2)
- H = head above crest (ft)

From this equation, the effective length of L1 goes to zero when the head above the crest is 5 times the measured crest length, resulting in zero discharge when calculated from the standard equation for a sharp-crested rectangular weir.

$$Q = C\, L_e\, H^{3/2}$$

where:
- Q = discharge (cfs)
- C = discharge coefficient, C = 3.27 + 0.4 (H/P)

This yields an unsatisfactory result for this stage of the weir.

Appendix E-4

The Bay Area Hydrology Model – A Tool for Analyzing Hydromodification Effects of Development Projects and Sizing Solutions

The Bay Area Hydrology Model – A Tool for Analyzing Hydromodification Effects of Development Projects and Sizing Solutions

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Abstract

The California Regional Water Quality Control Board, San Francisco Bay Region, is requiring stormwater programs to address the increases in stormwater runoff rate, volume, and duration created by new and redevelopment projects, known as hydromodification, where those increases could cause erosion of receiving streams. Municipal stormwater discharge permits in the San Francisco Bay area contain a requirement for stormwater programs to develop Hydro-modification Management Plans (HMPs) that describe how each program's agencies will meet this requirement.

The hydromodification control standard established in municipal permits is that post-project runoff shall not exceed pre-project rates and/or durations, over a defined range of storm event sizes. Research has shown that, to develop effective measures for control of changes in flow duration, the changes in a project site's hydrology cannot be evaluated for a single storm event with traditional design storm approaches. The change in hydrology must be evaluated over a longer time frame using a continuous simulation hydrologic model, and the results used to size control measures to match pre-project flow duration patterns. These analysis methods require specialized expertise and are difficult for many developers' engineers to perform and for municipal staff to review.

During development of their HMPs, three stormwater programs in the southern San Francisco Bay area, the Santa Clara Valley Urban Runoff Pollution Prevention Program, the Alameda Countywide Clean Water Program, and the San Mateo Countywide Storm Water Pollution Prevention Program, recognized this problem and decided to jointly fund development of a tool to simplify the analysis of hydromodification effects and to help design flow control measures. The tool, known as the Bay Area Hydrology Model (BAHM), is a Bay area version of the Western Washington Hydrology Model developed by Clear Creek Solutions for the Washington State Department of Ecology. It consists of a user-friendly graphical interface through which the user inputs information about the project and desired control measure (e.g., detention basin or underground vault); an engine that automatically loads appropriate parameters and meteorological data and runs the continuous simulation model HSPF to generate flow duration curves; a module that sizes the control measure to achieve the hydromodification control standard; and a reporting module. The tool uses parameters that have been calibrated for two watersheds in Alameda County, and is in the process of being calibrated for two watersheds in Santa Clara County.

This paper describes the background and need for the BAHM, development of the BAHM and appropriate parameters for the southern Bay Area, and examples of the application of the tool to size hydromodification control facilities for two development projects.

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Introduction

Urbanization of a watershed modifies natural watershed and stream processes by altering the terrain, modifying the vegetation and soil characteristics, introducing pavement and buildings, installing drainage and flood control infrastructure, and altering the condition of stream channels through straightening, deepening, and armoring. These changes affect hydrologic characteristics in the watershed (rainfall interception, infiltration, runoff and stream flows), and affect the supply and transport of sediment in the stream system. The change in runoff characteristics from a watershed caused by changes in land use conditions is called hydrograph modification, or simply hydromodification.

As the total area of impervious surfaces increases in previously undeveloped areas, infiltration of rainfall decreases, causing more water to run off the surface as overland flow at a faster rate. Storms that previously didn't produce runoff under rural conditions can produce erosive flows. The increase in the volume of runoff and the length of time that erosive flows occur ultimately intensify sediment transport, causing changes in sediment transport characteristics and the hydraulic geometry (width, depth, slope) of channels. The larger runoff durations and volumes and the intensified erosion of streams can impair the beneficial uses of the stream channels.

The California Regional Water Quality Control Board (Water Board), San Francisco Bay Region, is requiring stormwater programs to address the increases in runoff rate and volume from new and redevelopment projects where those increases could cause increased erosion of receiving streams. The Phase 1 municipal stormwater permits in the Bay Area contain requirements to develop and implement hydromodification management plans (HMPs) and to implement associated management measures.

The first Bay Area permit to include the new requirements was that of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)[4]. SCVURPPP conducted an assessment of hydromodification impacts on streams tributary to South San Francisco Bay and developed an HMP Report[5] that describes how SCVURPPP agencies will meet this requirement. On July 20, 2005, the Water Board adopted key provisions of the HMP Report and required implementation of the provisions within three months.

Other Bay Area stormwater permits that contain the requirement to develop and implement HMPs include those of the Alameda County, San Mateo County, Contra Costa County, and Fairfield-Suisun area stormwater programs[6]. The Contra Costa HMP was adopted by the Water Board on July 12, 2006. The other stormwater programs have submitted final HMPs to the Water Board and are awaiting review and approval.

Permit Requirements

Provision C.3.f. of the NPDES permit, *Limitation on Increase of Peak Stormwater Runoff Discharge Rates*, describes the HMP requirements. Under Provision C.3.f., municipalities are required to develop an HMP to describe how they plan to manage increases in the magnitude, volume, and duration of runoff from new development and significant redevelopment projects in order to protect streams from increased potential for erosion or other adverse impacts. The

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[4] SCVURPPP consists of the thirteen cities of Santa Clara Valley, Santa Clara County, and the Santa Clara Valley Water District (SCVWD), all of which are Co-permittees on a joint NPDES permit to discharge stormwater to South San Francisco Bay.

[5] SCVURPPP, *Hydromodification Management Plan, Final Report*, April 2005 (www.scvurppp.org)

[6] These programs together comprise about 60 additional municipal or county co-permittees.

requirements apply to development projects that create and/or replace 1 acre or more of impervious surface area.

In implementing the HMP, runoff controls[7] must be designed so that "post-project runoff shall not exceed estimated pre-project rates, durations, and volumes from the development site" (Provision C.3.f.i). Runoff controls are not required for projects that discharge stormwater runoff where the potential for erosion, or other impacts to beneficial uses, is minimal. Such situations may include: discharges into creeks that are concrete-lined or significantly hardened (e.g., with rip-rap, sack concrete, etc.) downstream to their outfall in San Francisco Bay; underground storm drains discharging to the Bay; and construction of infill projects in highly developed watersheds, where the potential for single-project and/or cumulative impacts is minimal (Provision C.3.f.ii).

The permit also requires: completion of a literature review; development of a protocol to evaluate hydromodification impacts to downstream watercourses; identification of an appropriate limiting rainfall event or range of events; a description of how municipal agencies will incorporate the HMP requirements into local approval processes; and guidance on management practices.

Technical Analysis of Hydromodification Controls

SCVURPPP and its consultant team completed a number of technical analyses to address key issues for the HMP, such as the effectiveness of various flow control techniques, the range of storm events to be considered for HMP criteria, and examples of flow duration basin sizing for local projects[8]. The key findings of these analyses, which served as the basis for developing performance criteria for the HMP, are described below.

Effective Design Approaches

It has been previously demonstrated that control of peak flows alone is not adequate for erosion control (MacCrae, 1996). SCVURPPP's studies (GeoSyntec, 2004, TMs #5 and 7) showed that hydromodification controls designed for discrete event volume control or design storm hydrograph matching do not provide adequate protection of receiving streams. The recommended effective method for hydromodification control is *flow duration control*. This approach involves maintaining the magnitude and duration of post-project flows at the same level as the pre-project flows (i.e., matching the long term pattern of flow rates and the number of hours they occur) via a flow duration control structure, for the full distribution of flows within a significant range. The flow duration approach considers the entire multi-year discharge record, as opposed to a single event. Flow controls should be supplemented by site design measures that reduce the amount of post-project runoff generated at the site.

Range of Storms to Manage

An evaluation was performed of the range of flows that are the most important for stream channel erosion and hydromodification impacts in Santa Clara Valley (GeoSyntec, 2004, TM#4). The evaluation was based on watershed assessments conducted for three subwatersheds in the Valley. The lower limit of the range is based on the critical flow (Qc) in each stream reach that initiates erosion of the stream bed or bank. For all three subwatersheds, Qc could be approximated as 10% of the 2-year pre-development peak flow. To partition this allowable flow

[7] This document uses the term runoff controls or flow controls to refer to Best Management Practices (BMPs) that reduce impacts of runoff volume, rate, and duration. Runoff controls that remove pollutants from stormwater will be referred to as treatment controls.

[8] Technical memoranda describing these analyses are available in Appendix C of the HMP Report (www.scvurppp.org).

among contributing land areas, an on-site project design criteria of 10% of the pre-project 2-year peak flow was proposed as the allowable low flow from a flow control facility.

The upper limit on the range of storms was determined by evaluating the contribution of different flow magnitudes to the total amount of erosive "work"[9] done on the stream bed and banks over a period of time. The low flows contribute the most work over time, whereas high flows contribute less work because they occur less frequently. Approximately 90-95% of the total work on the channel boundary is done by flows between Qc and the pre-development 10-year peak flow magnitude. Flows greater than the 10-year peak flow contribute less than 10% of the total work. Thus, the 10-year pre-project peak flow was selected as the practical upper limit for controlling erosive flows.

Hydromodification Management Performance Criteria and Design Approach

As stated earlier, Permit Provision C.3.f. requires that post-project runoff shall not exceed pre-project rates and/or durations, where the increased rates and durations will result in increased potential for erosion in the receiving stream. All of the Bay Area stormwater program HMPs include performance and applicability criteria to meet this requirement. These criteria will be used by local agencies as part of the development plan review process to manage hydromodification impacts of development projects.

A common theme among the various HMPs is that applicable projects with on-site flow control facilities that are designed to provide flow duration control to the pre-project condition are considered to comply with the HMP. Currently, most of the HMPs contain the following performance criterion: *Flow duration controls shall be designed such that post-project stormwater discharge rates and durations match pre-project discharge rates and durations from 10% of the pre-project 2-year peak flow up to the pre-project 10-year peak flow.*[10]

On-site flow controls include site design techniques, treatment controls that have the added effect of reducing flow (normally via infiltration), and flow control structures. Examples of site design features (also known as low impact development (LID) techniques) include minimizing impervious surface areas, preserving natural areas, limiting development especially where native soils have good infiltration characteristics, directing roof runoff to bioretention areas, and using vegetated swales in lieu of traditional underground storm drains. Flow control structures are generally detention/retention basins or underground vaults or tanks fitted with outlet structures such as weirs and/or orifices to control outflow rate and duration. Flood control and water quality treatment facilities can be combined with flow control structures; for example, water quality detention basins and wet ponds can be modified to provide hydromodification control.

The basic approach for design of flow control structures to meet hydromodification requirements involves: 1) simulating the runoff from the project site, pre- and post-project, using a continuous rainfall record; 2) generating flow-duration curves from the results; and 3) designing a flow control facility such that when the post-project time series of runoff is routed through the facility, the discharge pattern matches the pre-project flow-duration curve[11]. The flow control structure is a detention facility that diverts and retains a certain portion of the runoff. The portion to be retained is essentially the increase in surface runoff volume created between the pre-project and

[9] "Work" is a measure of the erosive hydraulic forces on the stream segment in excess of what the stream bed and bank materials can withstand (critical shear stress) before sediment movement occurs.
[10] The matching criterion is as follows: the post-project flow duration curve may not deviate above the pre-project flow duration curve by more than 10% over more than 10% of the length of the curve.
[11] See SCVURPPP, *Hydromodification Management Plan, Final Report*, April 2005, Appendix F (www.scvurppp.org) for more detailed guidance on how to design facilities for flow duration control.

post-project condition. This captured increase in volume must be discharged in one of several ways: 1) to the ground via infiltration (and/or evapotranspiration if vegetation is present) in the basin; 2) released at a very low rate to the receiving stream (at the critical flow for basin design, or 10% of the pre-project 2-year storm); and/or 3) diverted to a safe discharge location or other infiltration site, if feasible. Figure 1 shows a schematic pond facility in which the outlet structure is a standpipe riser with various openings.

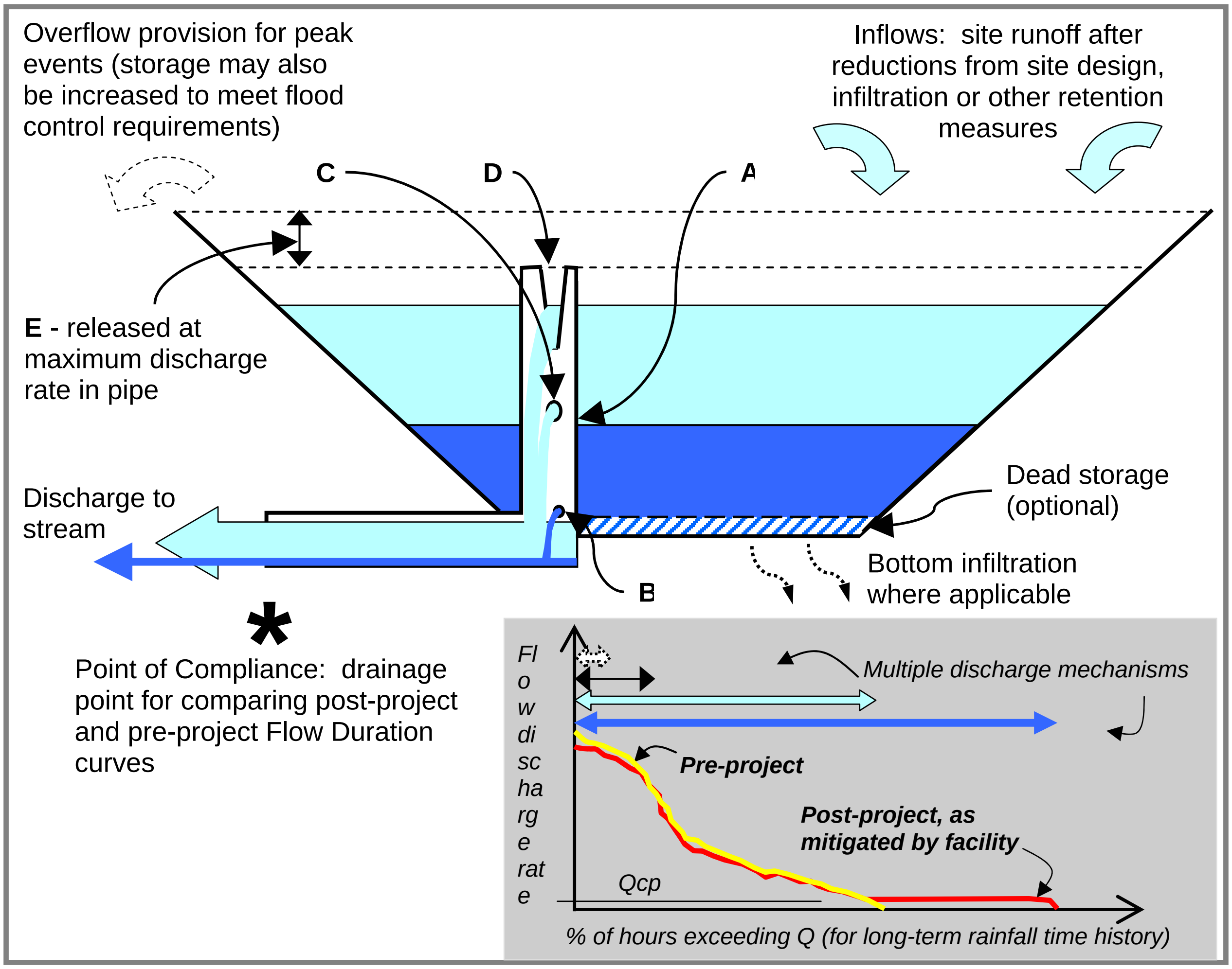

Figure 1. Schematic of flow duration pond and flow duration curves matched by varying discharge rates according to detained volume. Legend: A) outlet pipe riser; B) low flow orifice; C) intermediate orifice (1 shown); D) weir notch (V-type shown); E) freeboard above riser (typically 1 foot).

There are several public domain hydrologic models that can be used for simulating runoff for a continuous rainfall record and sizing flow control facilities. Examples are: 1) the Army Corps of Engineers' Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) which was used for the SCVURPPP analyses; 2) the U.S. Geological Survey and Environmental Protection Agency (EPA) software package called Hydrologic Simulation Program Fortran (HSPF); and 3) the EPA's Stormwater Management Model (SWMM).

Design Challenges

The concept of designing a flow duration control facility is relatively new and, as described above, requires the use of a continuous simulation hydrologic model. Development, calibration and use of such models can be data intensive and time consuming, and there is a general lack of knowledge and experience with these models among the development community and municipal staff. An additional challenge is integrating flow controls with site design and treatment controls, i.e., estimating the flow reduction benefits of site design and treatment controls and accounting for this reduction in determining the size of the flow control facility, as well as evaluating the treatment capability of the flow control facility.

To address these design challenges, SCVURPPP investigated a user-friendly, automated modeling and flow duration control facility sizing tool called the Western Washington Hydrology Model (WWHM) and decided to jointly fund the adaptation of this tool, in collaboration with the Alameda County and San Mateo County stormwater programs, for use in the Bay Area. The WWHM was developed in 2001 for the Washington State Department of Ecology to support Ecology's *Stormwater Management Manual for Western Washington* (Washington State Department of Ecology, 2001) and assist project proponents in complying with the Western Washington hydromodification control requirements. The adapted tool, known as the Bay Area Hydrology Model (BAHM), is being calibrated to southern Bay Area watersheds and enhanced to be able to size other types of control measures and LID techniques for flow reduction as well.

BAHM Overview

The BAHM software architecture and methodology is the same as that developed for the WWHM and uses HSPF as its computational engine[12]. Like WWHM, BAHM is a tool that generates flow duration curves for the pre- and post-project condition and then sizes a flow duration control basin or vault and outlet structure to match the pre-project curve. The software package consists of a user-friendly graphical interface with screens for input of pre-project and post project conditions; an engine that automatically loads appropriate parameters and meteorological data and runs continuous simulations of site runoff to generate flow duration curves; a module for sizing or checking the control measure to achieve the hydromodification control standard; and a reporting module.

The HSPF hydrology parameter values used in BAHM are based on calibrated watersheds located in the San Francisco Bay Area. The initial phase of calibration for two Alameda County watersheds (AQUA TERRA Consultants, 2005) is described later in this paper. Currently work is ongoing to calibrate two watersheds in Santa Clara County.

BAHM uses one or more long-term[13] local precipitation gages for each of the three South Bay counties and then scales the precipitation to the user's site using mean annual precipitation maps developed by local flood control districts or published as NOAA rainfall maps.

BAHM computes stormwater runoff for a site selected by the user. BAHM runs HSPF in the background to generate an hourly runoff time series from the available rain gauge data over a number of years. Stormwater runoff is computed for both pre-project and post-project land use conditions. Then, another part of the BAHM routes the post-project stormwater runoff through a stormwater control facility of the user's choice.

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[12] The Department of Ecology developed the present Version 2 of the WWHM to incorporate user comments. The BAHM is based on WWHM Version 3 which is currently in development.

[13] At least 30 years of record; 40 years or more are preferred.

BAHM uses the pre-project peak flood value for each water year to compute the pre-project 2- through 100-year flood frequency values[14]. The post-project runoff 2- through 100-year flood frequency values are computed at the outlet of the proposed stormwater facility. The model routes the post-project runoff through the stormwater facility. As with the pre-project peak flow values, the maximum post-project flow value for each water year is selected by the model to compute the developed 2- through 100-year flood frequency.

The pre-project two-year peak flow is multiplied by 10% to set the lower limit of the erosive flows, in accordance with the current HMP performance criteria[15]. The pre-project 10-year peak flow is the upper limit. A comparison of the pre-project and post-project flow duration curves is conducted for 100 flow levels between the lower erosive zone limit and the upper limit. The model counts the number of hours that pre-project flows exceed each of the flow levels during the entire simulation period. The model does the same analysis for the post-project mitigated flows.

Using the BAHM

BAHM input is relatively simple. The user must locate the project site on the appropriate county map (Figure 2). The user can zoom in or out on the map to find the exact location. BAHM uses this information to select the appropriate precipitation record and multiplier for this location.

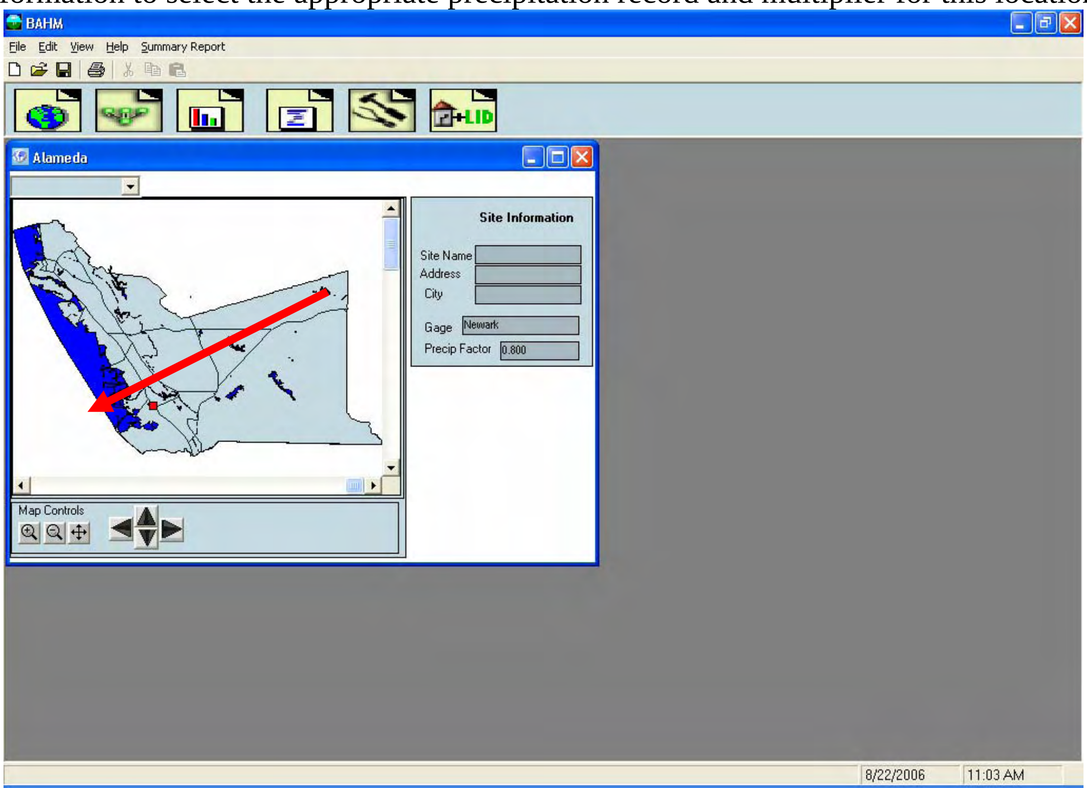

Figure 2. Example project site location.

[14] The actual flood frequency calculations are made using the federal standard Log Pearson Type III distribution described in Bulletin 17B (United States Water Resources Council, 1981). This standard flood frequency distribution is provided in U.S. Geological Survey program J407, version 3.9A-P, revised 8/9/89. The Bulletin 17B algorithms in program J407 are included in the BAHM calculations.
[15] In the BAHM, this low flow limit is a user-defined variable, to allow flexibility pending potential changes in regulatory requirements.

The user then goes to the Scenario Generator screen (Figures 3a and 3b) where the land use, vegetation, and soils information are specified. For the Bay Area counties, the vegetation categories are forest, shrub, grass, and urban landscape. Pre-project vegetation can be any of the first three categories. There are three major soil categories: SCS A, B, and C/D soils[16]. Post-project land use can include roofs, streets/sidewalks/parking, and pond in addition to the four vegetation categories.

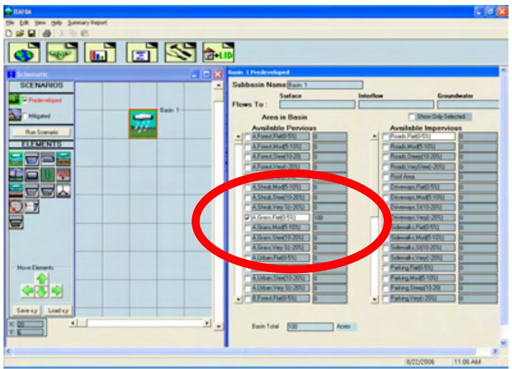

Figure 3a. Pre-project land use.

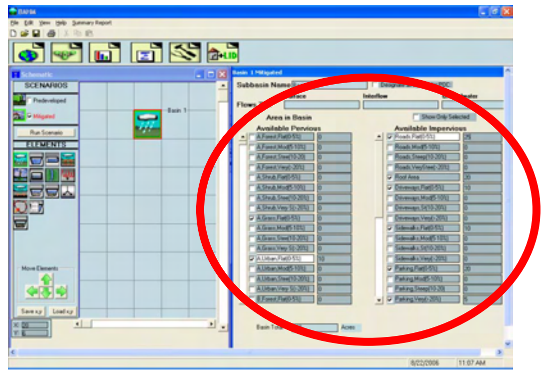

Figure 3b. Post-project land use.

The user inputs the number of acres of pre-project land use in each of the different land categories and does the same for the proposed development. For residential development there is the option to include low impact development (LID) practices such as roof runoff infiltration or dispersal and porous pavement. These LID practices reduce runoff and stormwater facility size. The user selects the type of stormwater control facility to include in the analysis. The available types are standard trapezoidal pond, tank (cylindrical, arched), vault, and irregular-shaped pond. The user can select one, two, or three orifices and a riser with a flat or notched weir (notch types include rectangular, V-shaped, and Sutro types). The facility can include infiltration, if appropriate for the site. The facility can be either manually sized to meet flow duration standards or the user can use the pond optimization feature (AutoPond) in BAHM to size the facility. An example of the BAHM pond information input form is shown in Figure 4.

[16] Soil groupings based on calibration work completed to date.

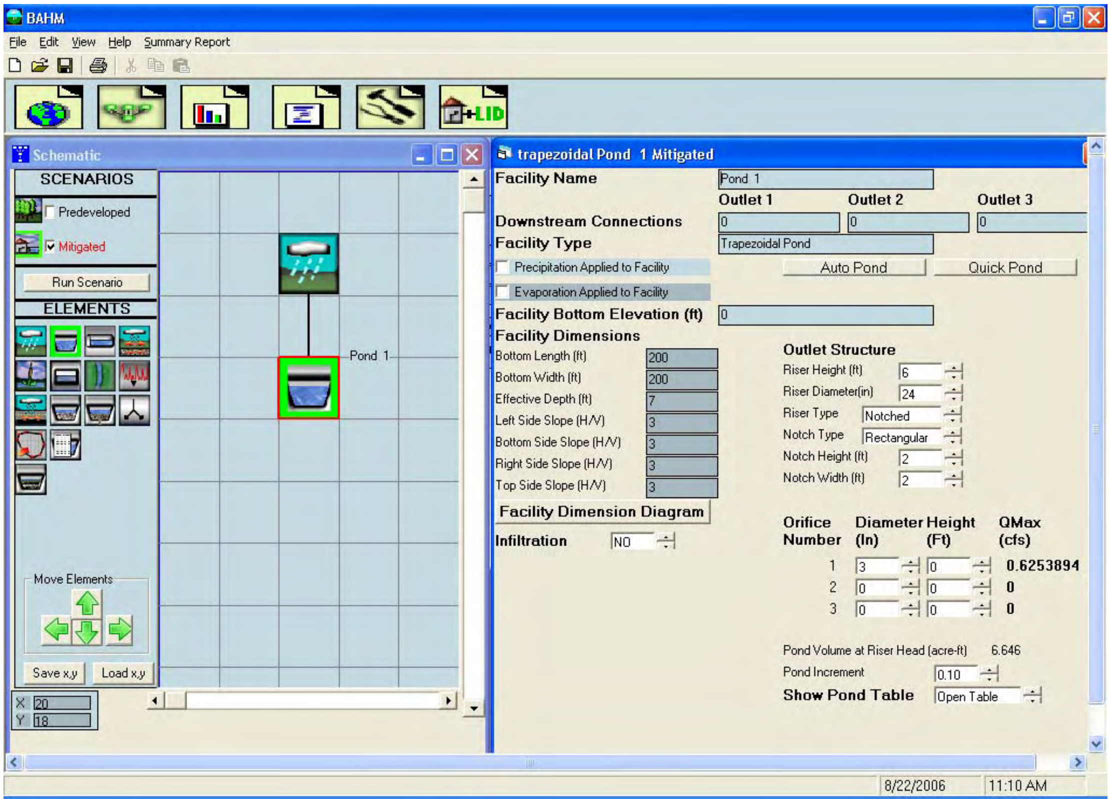

Figure 4. Pond information.

AutoPond uses a complex set of rules to select pond dimensions and outlet orifice diameters and heights. Once AutoPond has made an initial selection of pond and orifice sizes, BAHM runs HSPF to generate the long-term hourly runoff time series. The runoff is routed through the stormwater control facility and a flow duration comparison is made with the pre-project flows. If the post-project flow duration results do not pass the flow duration standard criteria then AutoPond changes dimensions and tries again. If the post-project flow duration results pass the standard then AutoPond tries to make the pond smaller. This produces the smallest (and most efficient) pond possible to meet the flow duration standard. Any time in this process the user has the option to stop AutoPond and make manual changes, if desired.

The user has the option of adding a water quality facility either upstream or downstream of the stormwater control facility. By placing the water quality facility upstream the user can take advantage of the flow moderation it provides to the control facility. This will result in a smaller stormwater control facility. Conversely, the water quality facility will have to be made larger to handle the greater variations in flows than if it is downstream of the control facility (which then moderates the flows to the water quality facility)[17].

BAHM produces model output in both graphical and tabular form. The major graphical output of interest is the flow duration plot of pre-project flow and mitigated post-project flow (Figure

[17] If the user wishes to design a flow control basin that will also accomplish stormwater treatment, the BAHM can be used to check the detention time in the basin to see if it meets design standards (typically 48 hours for settling fine-grained particulates).

5). All of the mitigated post-project flow values must be the same as or to the left of the pre-project values.

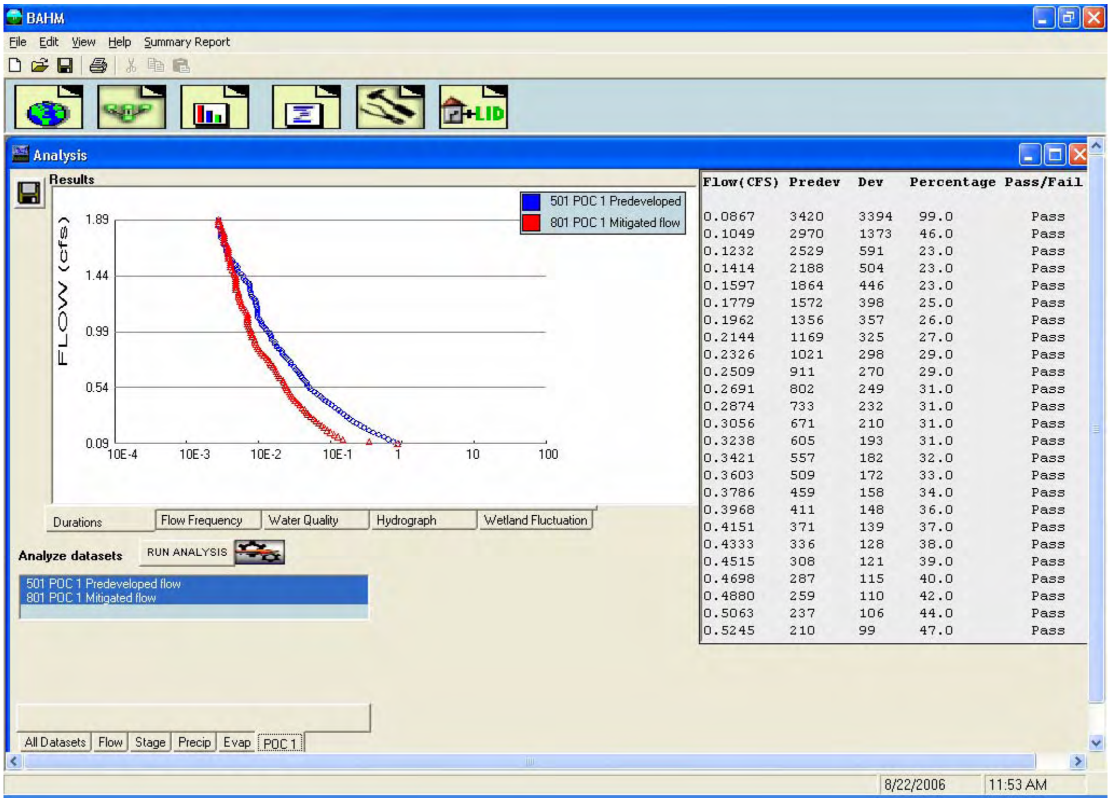

Figure 5. Flow duration comparison.

Numeric output is provided in tabular form. BAHM produces a project report that lists all of the input information. This includes the precipitation station and multiplier used, both pre- and post-project land use types and acreages, and dimensions and specifications of the flow control facility. This can be used by municipal staff to check the facility design. The user also has the option of saving the project file to disk. This project file can be later read into BAHM by the user or a reviewer to check or further modify the project.

The project report also lists the number of hours the pre- and post-project flows exceed each of the 100 flow duration levels and whether or not the flow control facility passes or fails the flow control standard for that level (Figure 5). Failure at any one of the 100 levels means the facility fails to meet the flow duration standard.

Low impact development (LID) practices have been recognized as opportunities to reduce and/or eliminate stormwater runoff at the source before it becomes a problem. They include compost-amended soils, bioretention, permeable pavement, green roofs, rain gardens, and spray irrigation. All of these approaches reduce stormwater runoff. BAHM can be used to determine the magnitude of the reduction and the amount of stormwater detention storage still required to meet HMP requirements.

BAHM explicitly includes the following LID practices:

- Roof runoff dispersion on adjacent pervious land
- Bioretention
- Green roofs

Other LID practices (such as pervious pavement and amended soils), can be implicitly modeled by adjusting parameters to represent these surfaces.

BAHM Parameter Development

BAHM uses HSPF calibrated parameter values to accurately compute stormwater runoff for the range of land use, soil, topographic, and climatic conditions found in the southern Bay area counties. Since it is not appropriate to use parameter values from other parts of the country, the participating stormwater programs are sponsoring calibration activities to support BAHM development.

For the ACCWP-sponsored phase, a review of Alameda County watersheds with appropriate streamflow and meteorological records was conducted, and Castro Valley Creek and upper Alameda Creek were selected as calibration watersheds (see Figure 5)[18]. These two watersheds encompass an appropriate range of land use, soils, vegetation, and climatic conditions that represent a significant fraction of Alameda County. The Castro Valley Creek watershed is a highly developed urban and suburban area of about 5.5 square miles with moderate precipitation averaging 20-22 inches per year. Significant and continuous base flow reflects impacts of lawn and landscape irrigation, especially during summer months. In contrast, the modeled portion of the Alameda Creek watershed is a highly rugged and almost completely undeveloped area approximately 33.5 square miles in size. Most of the drainage originates in Santa Clara County and annual precipitation averages approximately 20-24 inches though rain gauge data is sparse. The objective for deriving calibrated HSPF parameter values from these watersheds is for the model to be usable for both urban and undeveloped areas throughout the county.

To provide local calibrated parameter values, HSPF model simulations were performed for a period of 10 years for Castro Valley Creek and 7.5 years for upper Alameda Creek. The Castro Valley simulation period was divided into a 5-year calibration period and a 5-year validation period.

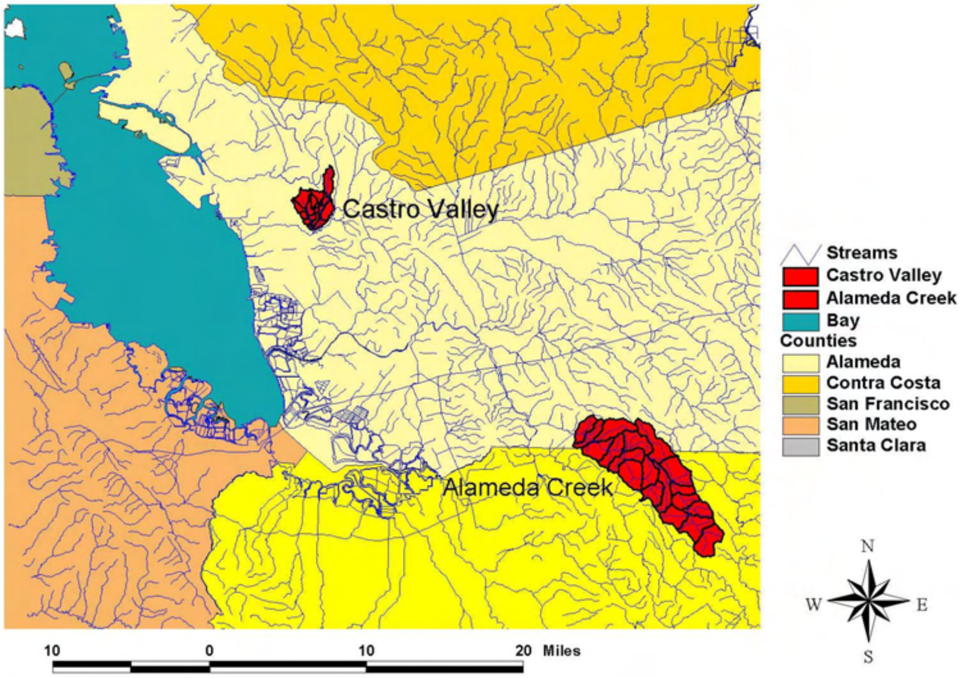

Figure 6. Castro Valley and Alameda Watersheds

[18] The ACCWP-sponsored calibration report and data memorandum can be found at www.cleanwaterprogram.org.

Calibration of a watershed with HSPF is a cyclical process of making parameter changes, running the model and producing comparisons of simulated and observed values, and interpreting the results. The procedures have been well established over the past 20 years as described in the HSPF Application Guide (Donigian et al., 1984) and recently summarized by Donigian (2002).

Hydrologic simulation combines physical characteristics of a watershed and observed meteorological data to produce a simulated hydrologic response. HSPF simulates flow to the stream network from four components: surface runoff from hydraulically connected impervious areas, surface runoff from pervious areas, interflow from pervious areas, and shallow groundwater flow from pervious areas. Because historic streamflow is not divided into these four units, the relative relationship among these components must be inferred from the examination of many events over several years of continuous simulation.

Figure 7 illustrates the mean daily flow over the simulation periods in log format for Castro Valley Creek and Alameda Creek, respectively. The daily patterns shown by the model clearly reflect the observations.

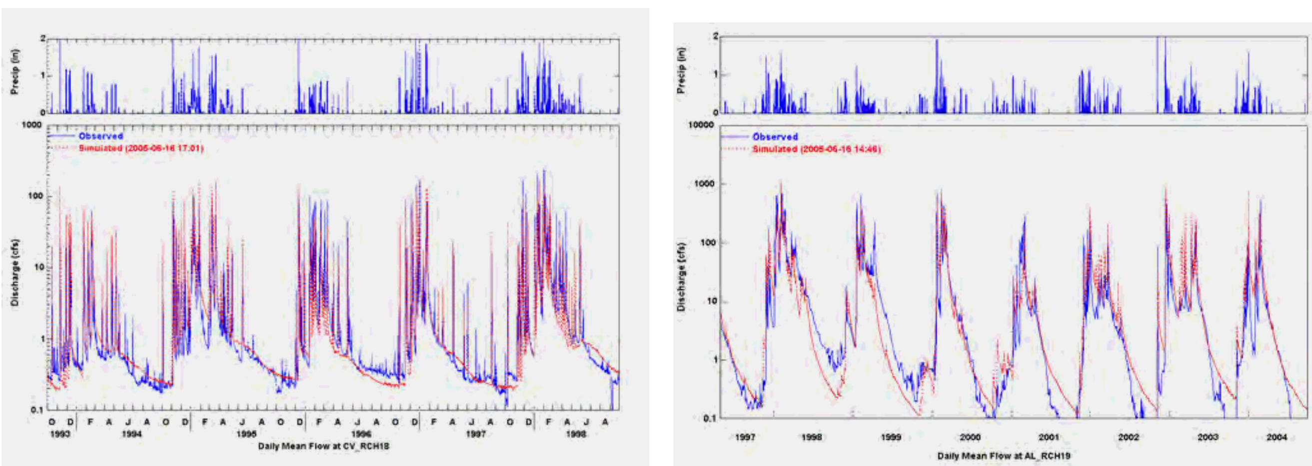

Figure 7. Calibration Daily Flow (simulated vs. observed) for Castro Valley Creek and upper Alameda Creek, with observed precipitation inputs.

Another way to look at the calibration results is to look at the statistics for different components of the streamflow record. For Castro Valley Creek, the percent differences between observed and simulated values are primarily less than 5%, with errors for some statistics in the 5-10% range but still indicating a very good calibration. Alameda Creek statistics show similar results and indicate a very good calibration for this watershed also.

Considering the quality of available data, the hydrographs and statistics indicate a very good calibration of HSPF parameter values for the Castro Valley Creek and upper Alameda Creek watersheds. The resulting model parameters were recommended for use in the Alameda County version of the BAHM. SCVURPPP has begun additional calibration modeling for two watersheds in Santa Clara County

Application of the Tool

There have not been opportunities to demonstrate BAHM applications due to its recent adoption and introduction to the local engineering community. However, in Western Washington there is now considerable experience with using BAHM's cousin, WWHM.

In the Seattle metro area WWHM was used to size the stormwater control facilities for a new Costco store. Runoff from the site drains directly to adjacent Little Bear Creek, a salmon-spawning tributary of the Sammamish River. WWHM was used to design underground stormwater storage facilities.

The Costco store site is located on 14.38 acres between SR 522 and Highway 9. An additional 2.35 acres of Highway 9 improvements were built along the store's frontage. WWHM was used to size two stormwater systems for Costco. On-site stormwater runoff (from the store and parking lot) is routed to an underground storage facility consisting of 5,240 linear feet of 96-inch diameter pipe (6.04 ac-ft of storage). The runoff from off-site Highway 9 improvements is directed to a separate underground storage system with 1,140 linear feet of 96-inch pipe (1.31 ac-ft of storage). Both systems include 6 inches of dead storage for initial water quality treatment. Additional water quality treatment was provided by Stormwater Management, Inc.'s Stormfilter units. Costco was able to meet the Washington State Department of Ecology HMP requirements on a commercial site with limited space adjacent to critical salmon habitat.

Another example is Snoqualmie Ridge, a 1,343 acre planned community in Upper Snoqualmie Valley, 30 miles east of Seattle. Over 40 percent of the community has been set aside as open space, including parks, trails, preserved wetlands and a golf course. The community includes 2,200 homes plus a business park and retail space.

Ten stormwater detention ponds were designed using WWHM to control stormwater impacts. The ponds range in size from 2 acre-feet of storage to 20 acre-feet and have been incorporated into the adjacent residential neighborhoods and golf course. The community views these ponds as visual amenities.

Conclusions

The WWHM methodology and software have been used extensively in major metropolitan areas and have been shown to be an effective tool for assisting project proponents meet regulatory requirements regarding hydromodification control. Its successor, the BAHM, will facilitate design of flow control facilities in the San Francisco Bay area, by providing a easier and more standardized way of using continuous simulation modeling and allowing computation of the benefits of site design/LID and treatment measures in reducing flows.

Furthermore, the BAHM will assist municipal agencies in their review of flow control facilities as part of development project approval.

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Appendix E-5

Guidance on Estimating Treatment and HMP Control Measure Costs for Application of the 2% "Cost Cap" Criterion

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Memorandum

Date: 9 April 2009 (Approved by Hydromodification Management Program (HMP) Implementation Phase Ad Hoc Task Group 13 November 2009)

To: Ms. Jill Bicknell, Santa Clara Valley Urban Runoff Pollution Prevention Program

From: Peter Mangarella, Geosyntec Consultants

Subject: Cost Estimating Guidance

Background

A provision related to hydromodification management[1] in the Santa Clara Valley Urban Runoff Pollution Prevention Program (Program) permit states that construction cost of the controls needed to meet the requirements is the primary measure for determining whether flow controls are practicable for a development project. Full implementation of the required flow controls as specified in the Program's Hydromodification Management Plan (HMP) will be considered impracticable "if the combined construction cost of both required stormwater treatment and flow control measures[2] exceeds 2% of the project construction costs (excluding land costs). If a developer demonstrates that the cost to fully comply with the HMP and other C.3 treatment requirements will exceed this cost threshold, a determination will be made by the reviewing agency that the project shall comply with this criterion by implementing HMP controls on-site to the maximum extent practicable and contributing to an in-stream or off-site solution, if available, up to the maximum cost for all controls of 2% of project cost."

Currently there is no guidance for the developer or co-permittees to estimate these costs. In response to this, the Program contracted with Geosyntec Consultants to develop cost estimating worksheets for estimating project and stormwater control costs thatcan be used by the developer to prepare a request for alternative compliance (i.e., the options described above), and by the reviewing agency to evaluate the request. The work was performed in coordination with the Program's HMP Implementation Phase Work Group. The scope of work included: identification of appropriate cost categories, preparation of cost estimating worksheets for proposed

[1] Order No. R2-2005-0035, Attachment A, Performance Criteria (3.), adopted July 20, 2005.

[2] Costs of control measures shall not include land costs, soil disposal costs, hauling, contaminated soils testing, mitigation, disposal, or other normal site enhancement costs such as landscaping or grading that are required for other development purposes.

development projects and associated BMPs for water quality and hydromodification control, presentation of progress at the 14 June 2007 Program C.3. Workshop, and development of guidance to assist municipalities and developers in completing the worksheets.

Cost Estimating Methods

For BMPs, there are generally two types of cost estimating methods: (1) methods based on a correlation with one or two major factors (e.g. drainage area or BMP size), or (2) methods based on summing individual costs based on the item, quantities, and unit costs (referred to as an "engineer's estimate"). The former method is quicker and is generally adequate for watershed scale planning level estimates whereas the latter method is more site specific and more appropriate at the bidding phase of a project when detailed information on quantities is available. Both methods are described herein and can be applied at the discretion of the applicant.

For projects, cost estimating based on a correlation method alone is inadequate because costs incurred in a project are very specific to the project design and local conditions. The most feasible approach at the planning level is a hybrid wherein structural costs are estimated based on the building type and size (e.g., square footage); costs for other items, such as paving and infrastructure, are estimated individually, similar to an engineers' estimate. In this method, the quantity estimates are rough approximations based on planning level information.

Sources of Cost Estimating Guidance

There is extensive information on methods to estimate costs for both BMPs and development projects. The following provides some examples of source material that could potentially assist municipalities and project proponents in better understanding cost estimation methods.

Cost estimating methods for BMP costs have been described by US EPA (Muthukrishnan et. al. 2004), which segregates costs into capital, design and permitting, operation and maintenance, and land costs. They also address the issues of accounting for inflation and lifecycle considerations. Recent guidance also is available from the Water Environment Research Federation (WERF) report "Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems," which includes spreadsheets for estimating the cost of selected BMPs (extended detention, permeable pavement, retention basins, and swales) using either the correlation or engineer's approach (Lampe et. al. 2005). Recently Colorado State University and the Denver Urban Drainage Flood Control District prepared the "BMP Effectiveness and Whole Life-Cycle Cost Analysis Model" that uses the correlation cost estimating method (Olson et. al. 2008). As indicated by the title of the report, this model is designed to assist the engineer in evaluating not only the cost of the BMP, but the benefit in terms of water quality performance. Cost curves are provided for a number of BMPs including wetland basins, extended dry detention, constructed wetland channels, hydrodynamic separators, inlet inserts, media filter vaults, porous landscape detention, retention (wet) pond, sand filter vault, and a vault with a capture volume. This user manual also provides detailed cost guidance for maintenance over the life of the BMP. As of January 2009, this model was undergoing beta testing and is available as described in Reference section.

A number of sources are available to assist in estimating project development costs. R.S. Means (www.rsmeans.com) provides heavy construction cost data that includes material and labor unit cost estimates for earthwork, concrete, and utilities (including water supply, sanitary, and drainage). R.S. Means also provides estimated building costs (primarily commercial) on a per square foot basis. Corrections for differences among cities are also provided, including costs for San Jose, California. Various services allow one to access web-based software designed to estimate building construction costs including the D4Cost software provided by Design Cost Data (http://www.d4cost.net/d4cweb/) that is based on actual costs incurred for buildings of similar type. Other commercial publishers include the Engineering News Record (ENR) which provides an On-Line Estimator (a web-accessed database) and hard copy Construction Costs Reference Guide (www.enr.com). The ENR Reference Guide provides unit costs for buildings on a square foot basis, with multipliers to reflect differences in regional costs. Access to all these sources is by subscription only.

Lifecycle costs require accounting for anticipated inflation based on historical cost trends. A useful source of trends in the cost of material and labor is the Engineering News Record (ENR) Construction Cost Index History to account for cost trends (http://env.construction.com/economics/default.asp).

Cost Categories and Cost Estimating Worksheets

Cost categories for typical development projects were arranged by project phase as shown in Table 1. In compliance with the permit language, only those costs in Table 1 listed under construction are considered in the cost estimating methodology. Based on these cost categories, a cost estimating worksheet was developed for estimating project costs. The worksheet follows the typical practice for engineering cost estimates that, in addition to the cost category, include a column for estimated unit costs, a column for estimating quantities or units, and a final column for estimating the total cost for each cost category. A similar worksheet was developed for estimating the costs of stormwater controls.

Sources of Unit Costs

The next step in the process is to have a set of agreed-upon unit costs. There are various sources of unit costs, including commercial publishers (discussed above), local agencies, or developer specific values. Unit costs for some cost categories are also available from some local agencies. For example, San Jose maintains a unit cost database to support engineer's estimates that is updated each fiscal year. The cost categories address public works type projects and provide a good source of information for infrastructure costs, such as material costs for installing storm drains or public streets. The project proponent should check with the local agency for unit rate information that may be available at the agency, and/or to determine other sources that would be acceptable to the agency. Attachment A provides an example of the unit costs information maintained by the City of San Jose for private and public street construction and associated infrastructure.

Quantities or Units

The last column in the worksheets calls for estimated units or quantities. Quantities will be estimated by the project proponent based on the proposed project and actual site conditions. Since the request for alternative compliance will likely be made in the early planning phases of the project, quantities will need to be estimated based on the preliminary site plan, grading plan, drainage plan, landscaping plan, and water quality and hydromodification control plan. There may be additional plans depending on the type of development and complexity, or, there may be fewer plans for smaller projects. Costs of similar projects can vary considerably depending on site conditions such as slope, soils, geotechnical issues and bearing requirements, and grading requirements, so it may be reasonable to consider a contingency when such conditions are anticipated.

For single family developments, in the absence of actual site plans for estimating units, one may wish to review a recent report developed by researchers at Michigan State University that included data on utility requirements (e.g., length of storm drain required) as a function of housing density (Najafi et. al. 2006).

Example: Hitachi Global Storage Technologies, Inc., Santa Teresa Transit Village

Hitachi Global Storage Technologies, Inc. and Signature Properties proposed a Master Planned Development on approximately 332 acres at the existing Hitachi Campus bounded by Monterey Road, Manassas Road, State Route 85, and Cottle Road in San Jose (RBF, 2005). Within the campus, the proposed project called for a 148-acre residential development referred to as the Santa Teresa Transit Village (Exhibit 1). The village was sufficient in size and percent imperviousness area (81%) such that, pursuant to the SCVURPPP NPDES Permit, water quality and hydromodification controls were required. The plan called for a variety of controls, including two detention basins: one 6.4 acre-ft basin (Cottle Road detention basin) to receive runoff from a 115 acre portion of the Transit Village that drained towards Cottle Road, and one 8.0 acre-ft basin (Highway 85 detention basin) to receive runoff from the 33 acre portion of the Transit Village that drained towards Highway 85.

The sub-areas within the Santa Teresa Transit Village consisted of:

- Sub-Area 01: mixed-use residential with density of 40-60 dwelling units per acre (du/ac) (North Village),
- Sub-Area 0-2: retail and mixed-use with density of 40-60 du/ac (Cottle Transit Village) and Recreational Park/Historic Preservation,
- Sub-Area 03: retail mixed-use with 40-60 du/ac, and

- Sub-Areas 04 and 05: mixed-use residential (South Village) with density varying from 40-60 du/ac in the western portion to 25-40 du/ac to 16-25 du/ac to 12-25 du/ac in the eastern portion of Sub-Areas 04 and 05.

The estimated construction costs for the proposed development are about $140,000,000 and are provided in Table 2. Only major cost items are included and quantities were very approximately estimated based on information provided in the RBF report. Notations provided to the right of the table indicate the sources of the unit cost information. A city correction is applied at the bottom of the spreadsheet. (Strictly speaking, the correction applies only to those unit costs derived from R.S. Means, but as most unit costs identified were from R.S. Means, the correction has been applied uniformly to all cost items.) Where quantities and costs were not available (e.g., communications and power), Geosyntec inserted a lump sum figure for the purposes of the example only.

The estimated construction cost for the two detention basins was determined using the engineer's estimate method and is about $600,000 (Table 3). By comparison, the estimate based on the cost versus extended detention basin volume provided by Olsen et al is approximately $1,000,000, but this includes generic land costs. Using either cost estimate, the estimated cost of the BMPs is less than 1% of the cost of the development project.

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TABLE 1
COST CATEGORIES FOR A TYPICAL DEVELOPMENT PROJECT

Project Phase	Cost Category
Land Purchase	Land price
Carry Costs	Escrow fees, legal fees; local, state, and federal taxes
	Interest on loans
	Marketing and advertising
Entitlement and Permitting	Land planning, preparation of Environmental Impact Report, hazardous material testing
	Geotechnical soil exploration and testing
	Plan checking, and grading and building permit fees
	Offsite mitigation including roads and utilities
Construction	Grading, Excavation, Demolition, Staking
	Utilities (water, power, communication)
	Structures including foundation
	Landscaping
	Engineering and Architecture

TABLE 2
HITACHI DEVELOPMENT PROJECT COST ESTIMATE WORKSHEET

Development Project Construction Cost Calculation Sheet				Construction Cost		
Item No.	**Description**	**Units**	**Unit Cost (c)**	**Qty (Q)**	**Cost (C = c x Q)**	**Notes**
1.0 GRADING						
1.1	Clearing and Grubbing	AC	$1,500	100	$150,000	RS Means Heavy Construction 2006: category 02230 (grubbing) 100-0150
1.2	Rough and Finish Grading	SY	$1.23	200,000	$246,000	RS Means Heavy Construction 2006: category 02310 (grading) 100-1100
1.3	Excavation and Backfill	CY	$16.55	1,000	$16,550	RS Means Heavy Construction 2006: category 02316 (excavation) 110-0300
1.4	Construction Staking (Surveying)	AC	$85.00	100	$8,500	RS Means Heavy Construction 2006: category 01107 (prof consult) 700-1850
2.0 UTILITIES						
2.1a	Storm Drains	LF	$170.00	15,000	$2,550,000	San Jose Unit Costs Storm Sewers 24 inch RCP
2.1b	Storm Drain Manholes	EA	$3,575.00	30	$107,250	San Jose Unit Costs
2.1c	Standard Hood Inlets	EA	$2,035.00	100	$203,500	San Jose Unit Costs
2.2a	Sanitary Sewers	LF	$231.00	15,000	$3,465,000	San Jose Unit Costs Sanitary Sewers 18 inch VCP
2.2b	Sanitary Sewer Manholes	LF	$3,575.00	150	$536,250	San Jose Unit Costs
2.3	Water	LF	$100.00	2000	$200,000	Geosyntec estimate
2.4	Phone/Gas/Electricity/Cable	LF	$150.00	15,000	$2,250,000	Geosyntec estimate
2.5	Trenching	LF	$24.60	45,000	$1,107,000	RS Means Heavy Construction 2006: category G1030 805 (trenching) 1460
3.0 PAVEMENT						
3.1	Public Roads	SF	$2.92	750,000	$2,190,000	San Jose Attachment A Surface Improvements Item 5
3.2	Standard Sidewalks	SF	$6.30	15,000	$94,500	San Jose Attachment A Surface Improvements item 21
3.3	Parking Lots	SF	$2.27	130,000	$295,100	San Jose Attachment A Surface Improvements item 4
3.4	Curbs	LF	$16.80	15,000	$252,000	San Jose Attachement A Surface Improvements item 17

Development Project Construction Cost Calculation Sheet				Construction Cost		
Item No.	Description	Units	Unit Cost (c)	Qty (Q)	Cost (C = c x Q)	Notes
4.0 BUILDING UNITS						
4.1	Single Family Residential	SF				
4.2	Multi Family Residential	SF	$110.00	700,000	$77,000,000	RS Means Heavy Construction 2006: category 50 17 (sq foot costs) 02-0010
4.3	Schools	SF				
4.4	Office Buildings	SF				
4.5	Resorts / Hotels	SF				
4.6	Golf Courses	AC				
4.7	Parks	AC	$15,000.00	30	$450,000	
4.8	Commercial / Retail Space	SF	$92.50	200,000	$18,500,000	RS Means Heavy Construction 2006: category 50 17 (sq foot costs) 72-0010
4.0 LANDSCAPING						
4.1	Landscaping	EA	$18.60	2000	$37,200	RS Means Site Work & Landscape Cost Data 2006: Category 02930 Exterior Plants, cost per 5 gallon plant
UNITS **AC -** Acres, **CY -** Cubic Yards, **LS** - Lump Sum, **SY** - Square Yards, **SF** – Square Feet, **LF** – Linear Feet, **EA** - Each				**Sub-Total (ST) :**	**$109,658,850**	
				San Jose Cost Index:	116.30	RS Means 2006 City Cost Index San Jose Weighted Average
				Adjusted Sub-total **:**	**$127,533,243**	
				Technical Services (10%)	**$12,753,324**	
				PROJECT TOTAL	**$140,286,567**	

TABLE 3
HITACHI BMP CONSTRUCTION COST ESTIMATE WORKSHEET

Water Quality Treatment Facility Construction Cost Calculation Sheet				**Construction Cost**		
Item No.	**Description**	**Units**	**Unit Cost (c)**	**Qty (Q)**	**Cost (C = c x Q)**	**Notes**
1.0 GRADING						
1.1	Clearing and Grubbing	AC	$1,500	3	$4,500	RS Means Heavy Construction 2006: category 02230 (grubbing) 100-0150
1.2	Rough and Finish Grading	SY	$1.23	2,000	$2,460.00	RS Means Heavy Construction 2006: category 02310 (grading) 100-1100
1.3	Excavation and Backfill	CY	$16.55	22,000	$364,100	RS Means Heavy Construction 2006: category 02316 (excavation) 110-0300
1.4	Construction Staking (Surveying)	AC	$2,000.00	3	$6,000	R.S. Means Heavy Construction 2006: Category 01107 (prof cons) 700-0400
2.0 STRUCTURAL ELEMENTS						
2.1	Inlet	EA	$2,387.00	2	$4,774	San Jose Attachment A Public Street Construction Storm Sewers item 17
2.2	Outlet	EA	$4,807.00	2	$9,614	San Jose Attachment A Public Street Construction Storm Sewers item 19
2.3	Inlet/Outlet Piping	EA	$170.00	200	$34,000	San Jose Unit Costs Storm Sewers 24 inch RCP
2.4	Overflow Spillway	EA	$9,625.00	2	$19,250	San Jose Attachment A Public Street Construction Storm Sewers item 20
2.5	Access Road	SF	$1.62	1,000	$1,620	San Jose Attachment A Public Street Construction Surface Improvements item 9
3.0 MISCELLANEOUS						
3.1	Geosynthetic Fabric/Impervious Liner	SY				
3.2	Landscaping	EA	$20	300	$6,000	RS Means Site Work & Landscape Cost Data 2006: Category 02930 Exterior Plants

Water Quality Treatment Facility Construction Cost Calculation Sheet				Construction Cost		
Item No.	**Description**	**Units**	**Unit Cost (c)**	**Qty (Q)**	**Cost (C = c x Q)**	**Notes**
UNITS **AC -** Acres, **CY -** Cubic Yards, **SF** - Square Foot, **SY** - Square Yards, **EA** - Each						
				Sub-Total (ST) :	**$452,318**	
				San Jose Cost Index:	116.30	RS Means 2006 City Cost Index San Jose Weighted Average
				Adjusted Sub-total **:**	**$526,046**	
				Technical Services (10%)	**$52,605**	
				PROJECT TOTAL	**$578,650**	

ATTACHMENT A
City of San Jose

Unit Cost Table

(FY 2006-2007)

EXHIBIT A
ENGINEER'S ESTIMATE (FY 2006-2007 UNIT COSTS)
TRACT NO. 9999 OR MAJOR 3-99999

PUBLIC STREET CONSTRUCTION COST ESTIMATE							
Sanitary Sewers						**Construction Credit**	
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	**Unit Cost ($)**	**Extension ($)**
1	4" VCP	LF		48.00	0.00		
2	6" VCP	LF		79.00	0.00		
3	8" VCP	LF		84.00	0.00		
4	10" VCP	LF		182.00	0.00	7.85	0.00
5	12" VCP	LF		187.00	0.00	9.85	0.00
6	15" VCP	LF		198.00	0.00	12.65	0.00
7	18" VCP	LF		231.00	0.00	17.25	0.00
8	21" VCP	LF		264.00	0.00	22.15	0.00
9	24" VCP	LF		303.00	0.00	22.55	0.00
10	27" VCP	LF		380.00	0.00	25.00	0.00
11	30" VCP	LF		407.00	0.00	28.70	0.00
12	33" VCP	LF		451.00	0.00	34.05	0.00
13	36" VCP	LF		528.00	0.00	39.35	0.00
14	42" VCP	LF		660.00	0.00	49.70	0.00
15	MANHOLES	EA		3,575.00	0.00	663.05	0.00
16	FLUSHING INLET	EA		605.00	0.00	172.20	0.00
17	LATERALS & CLEANOUTS	EA		275.00	0.00		
18					0.00		
19					0.00		
20					0.00		
21					0.00		0.00 CREDIT
					0.00		

PUBLIC STREET CONSTRUCTION COST ESTIMATE							
Storm Sewers						**Construction Credit**	
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	**Unit Cost ($)**	**Extension ($)**
1	12" RCP:	LF		104.00	0.00		
2	15" RCP:	LF		120.00	0.00		
3	18" RCP:	LF		143.00	0.00		
4	21" RCP:	LF		157.00	0.00		
5	24" RCP:	LF		170.00	0.00		
6	27" RCP:	LF		187.00	0.00		
7	30" RCP:	LF		206.00	0.00	16.00	0.00
8	33" RCP:	LF		216.00	0.00	19.00	0.00
9	36" RCP:	LF		227.00	0.00	22.50	0.00
10	42" RCP:	LF		239.00	0.00	27.75	0.00
12	48" RCP:	LF		286.00	0.00	32.50	0.00
13	54" RCP:	LF		337.00	0.00	38.50	0.00
14	60" RCP:	LF		385.00	0.00	44.25	0.00
15	MANHOLES	EA		3,575.00	0.00	405.00	0.00
16	STD. HOOD INLET	EA		2,035.00	0.00		
17	LARGE HOOD INLET	EA		2,387.00	0.00		
18	G.O.L. HOOD INLET	EA		2,266.00	0.00		
19	FLAT GRATE	EA		1,430.00	0.00		
19	OUTFALL SAC CONC.	EA		4,807.00	0.00		
20	OUTFALL 1/4 TON ROCK	EA		9,625.00	0.00		
21	RIP-RAP INLET	EA		1,194.00	0.00		0.00 CREDIT
22	21" RCP/REMOVE-REPLACE	LF		70.00	0.00		

PUBLIC STREET CONSTRUCTION COST ESTIMATE							
Storm Sewers						**Construction Credit**	
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	**Unit Cost ($)**	**Extension ($)**
23	PCC DITCH/SWALE	LF		30.00	0.00		
24					0.00		
25					0.00		
26					0.00		
					0.00		

PUBLIC STREET CONSTRUCTION COST ESTIMATE						
Surface Improvements						
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	
1	MONUMENTS (STREET)	EA		594.00	0.00	
2	MONUMENTS (WITNESS)	EA		297.00	0.00	
3	ELECTROLIERS	EA		3,575.00	0.00	
4	4.2 INCHES A.C.	SF		2.27	0.00	
5	5.4 INCHES A.C.	SF		2.92	0.00	
6	7.8 INCHES A.C.	SF		4.21	0.00	
7	12 INCHES A.C.	SF		6.48	0.00	
8	AC OVERLAY (2")	SF		1.08	0.00	
9	AC OVERLAY (3")	SF		1.62	0.00	
	TOTAL PAVEMENT AREA:		0	**SF**		
10	GRADING	SF		0.38	0.00	

PUBLIC STREET CONSTRUCTION COST ESTIMATE						
Surface Improvements						
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	
11	A2 CURB & GUTTER	LF		25.00	0.00	
12	REMOVE C. & G.	LF		9.60	0.00	
13	REMOVE SIDEWALK	SF		3.60	0.00	
14	REMOVE DRIVEWAY	SF		5.50	0.00	
15	SAWCUT	LF		7.20	0.00	
16	VALLEY GUTTER	LF		18.20	0.00	
17	A1 CURB	LF		16.80	0.00	
18	B1 CURB	LF		29.70	0.00	
19	B3 CURB, 6"	LF		17.90	0.00	
20	B3 CURB, 8"	LF		21.50	0.00	
21	STD. SIDEWALK	SF		6.30	0.00	
22	PCC DRIVEWAY	SF		12.00	0.00	
23	WHEELCHAIR RAMP	EA		957.00	0.00	
24	PCC PAVEMENT (6"/6")	SF		2.70	0.00	
25	BUS STRESS PAD	EA		9,350.00	0.00	
26	4.2 INCHES AB	SF		1.80	0.00	
27	8.4 INCHES AB	SF		3.60	0.00	
28	12.6 INCHES AB	SF		5.39	0.00	
29	BARRICADE	LF		20.60	0.00	
30	RETAINING WALL	LF		59.70	0.00	
31	RETAINING WALL/1' HIGH	LF		23.90	0.00	
32	CONDUITS &	LF		15.60	0.00	

PUBLIC STREET CONSTRUCTION COST ESTIMATE						
Surface Improvements						
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	
	CABLES					
33	JUNCTION BOXES	EA		258.50	0.00	
34	E-8 BOXES	EA		451.00	0.00	
35	PCC DITCH	LF		12.00	0.00	
36	CONCRETE PARKING BAYS	SF		12.00	0.00	
37	CONTROLLER CAB.	EA		228.80	0.00	
38	STREET TREES	EA		352.00	0.00	
39					0.00	
40					0.00	
41					0.00	
					0.00	

SIGNAL COST (Manual Input, Obtain number from Signal Team)	$0.00
CONSTRUCTION COST (Use this number for E&I fee calculations)	$0.00
Non-Reimb Public Landscaping (Manual Input, Obtain number from Landscape Architect)	0.00
Reimb Public Landscaping	0.00
TOTAL LANDSCAPING	$0
MUNI-WATER IMPR (Manual Input, Obtain number from Muni Water)	$0.00

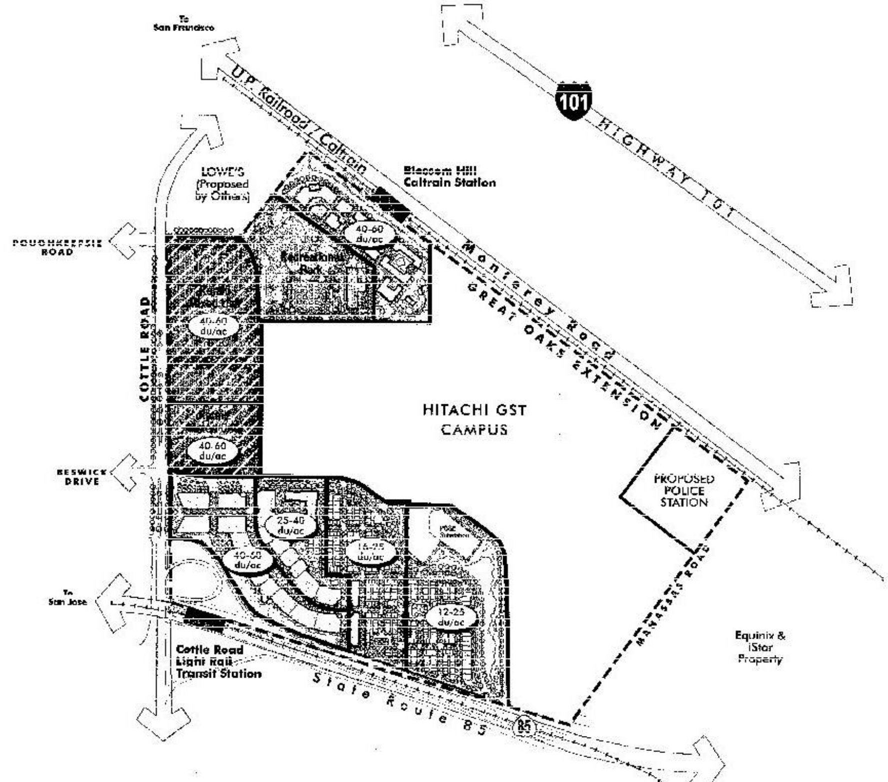
PUBLIC STREET CONSTRUCTION COST ESTIMATE						
Surface Improvements						
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	
			TOTAL CONSTRUCTION		**$0.00**	
(Use this number for bonding amounts, rounded up to nearest $100)						
			WARRANTY BOND		**$0.00**	
			(Tracts and Majors require a 25% Warranty Bond)			
			COMPLETION DEPOSIT (CD)		**$0.00**	
			(This is only required for Major 3- Agreements)			
			MONUMENT BOND		**$0.00**	
			(Use a CD for 3 dash permits)			

PRIVATE STREET CONSTRUCTION COST ESTIMATE						
#	**Description**	**Units**	**Qty**	**Unit Cost ($)**	**Extension ($)**	
1	MONUMENTS (STREET)	EA		594.00	0.00	
2	MONUMENTS (WITNESS)	EA		297.00	0.00	
3	5.0 INCHES A.C.	SF		2.70	0.00	
4	10 INCHES AGGREGATE BASE	SF		4.28	0.00	
5	4.0 INCHES A.C.	SF		2.16	0.00	

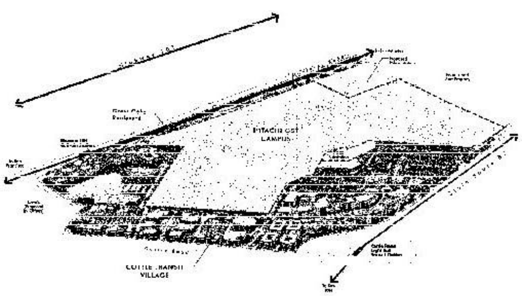
PRIVATE STREET CONSTRUCTION COST ESTIMATE						
#	Description	Units	Qty	Unit Cost ($)	Extension ($)	
6	8 INCHES AGGREGATE BASE	SF		3.42	0.00	
7	BOMANITE (6" PCC/6" AB)	SF		12.60	0.00	
8	PAVERS (ON 6" AB)	SF		9.60	0.00	
9	PCC DRIVEWAY (STANDARD)	SF		12.00	0.00	
10	PCC S/WALK (STANDARD)	SF		6.30	0.00	
11	VALLEY GUTTER (STANDARD)	LF		18.30	0.00	
12	A1 CURB	LF		16.80	0.00	
13	A2 CURB & GUTTER	LF		23.90	0.00	
14	B1 CURB	LF		29.90	0.00	
15	B3 CURB	LF		17.90	0.00	
16	ROLLED CURB & GUTTER	LF		23.90	0.00	
17	WHEELCHAIR RAMPS	EA		957.00	0.00	
18	STRESS PADS	EA		2,700.00	0.00	
19	BOLLARDS	EA		201.00	0.00	
20	RCP: 12"DIA.	LF		104.00	0.00	
21	15"DIA.	LF		120.00	0.00	
22	18"DIA.	LF		143.00	0.00	
23	21"DIA.	LF		157.00	0.00	
24	VCP: 4"DIA.	LF		48.00	0.00	
25	6"DIA.	LF		79.00	0.00	

PRIVATE STREET CONSTRUCTION COST ESTIMATE						
#	Description	Units	Qty	Unit Cost ($)	Extension ($)	
26	8"DIA.	LF		84.00	0.00	
27	PVC: 4"DIA.	LF		48.00	0.00	
28	6"DIA.	LF		60.00	0.00	
29	8"DIA.	LF		72.00	0.00	
30	10"DIA.	LF		84.00	0.00	
31	12"DIA	LF		96.00	0.00	
32	STORM MANHOLES	EA		3,575.00	0.00	
33	HOODED INLETS	EA		2,035.00	0.00	
34	FLAT GRATE INLETS	EA		1,430.00	0.00	
35	AREA DRAINS	EA		264.00	0.00	
36	AREA DRAIN/JUNCTIO N BOX	EA		957.00	0.00	
37	SANITARY MANHOLES	EA		3,575.00	0.00	
38	FLUSHING INLETS	EA		605.00	0.00	
39	SANITARY CLEANOUTS	EA		776.00	0.00	
40	OUTFALL SLOPE PROTECT.	SY		4,807.00	0.00	
41	PCC DITCH/SWALE	LF		30.00	0.00	
					0.00	
					0.00	
					0.00	
				TOTAL=	0.00	

EXHIBIT 1
Proposed Hitachi GST Development



DENSITY DIAGRAM OPTION



CONCEPTUAL AERIAL PERSPECTIVE RENDERING - COTTLE TRANSIT VILLAGE

REVISED
GENERAL DEVELOPMENT PLAN
DATE LAST REVISED
A (PD) PLANNED DEVELOPMENT
ORDINANCE NO.
CITY COUNCIL APPROVAL DATE
EFFECTIVE DATE

KENKAY ASSOCIATES
URBAN PLANNING
LANDSCAPE ARCHITECTURE

HITACHI
GLOBAL STORAGE TECHNOLOGIES INC.
SAN JOSE, CA
PLANNED DEVELOPMENT ZONING

SUBMITTAL / REVISION

DATE
SCALE

SHEET TITLE
GENERAL DEVELOPMENT PLAN - EXHIBIT C

Cottle Transit Village
Density Option

SHEET NO.
L-7

PDC04-031

Appendix

F

Mosquito Control Guidelines

The Santa Clara Vector Control District (SCC VCD) has the responsibility for providing enforcement of mosquito control measures when public health is threatened. It is concerned with the spread of insects and other nuisance pests that could result from poorly designed and/or maintained structures, especially those containing standing water. Detention basins, water quality wetlands and infiltration basins are examples of stormwater treatment control structures that may offer prime breeding habitats for mosquitoes and other nuisance pests if not properly designed and maintained. Stagnant water associated with storm water treatment can provide habitat for the aquatic stages of mosquitoes. Santa Clara and other California vector control districts are particularly concerned that the expanding number of treatment controls may result in increased mosquito habitat at the same time as the potential arrival of West Nile Virus.

This appendix presents guidance for designing and maintaining stormwater treatment measures to control mosquitoes . Project sponsors are responsible for incorporating this guidance as appropriate in their treatment measure designs and maintenance plans.

F.1 Design Guidance for Mosquito Control

The following design considerations were adapted from guidance prepared by the California Department of Public Health,[1] and are provided for project sponsors to use when selecting, designing, and constructing stormwater treatment measures.

General Design Principles

- Preserve natural drainage. Better site design measures reduce the amount of stormwater runoff and provide for natural on-site runoff control. This will reduce the number of stormwater treatment measures required.

[1]California Department of Public Health, 2010. Best Management Practices for Mosquito Control on California State Properties.

- In flat areas, where standing water may occur for more than five days under existing conditions, consider grading to make minor increases in slope to improve surface drainage and prevent standing water.
- Select stormwater treatment measures based on site-specific conditions. Designs that take into account site conditions tend to improve drainage and limit the occurrence of stagnant water.
- Careful consideration should be made before intermittently flooded stormwater treatment measures are selected for handling stormwater. Facilities that pond water temporarily (e.g., extended detention basins) should be ***designed to drain water completely within five***[2] ***days of a storm event***. Avoid placement of extended detention basins and underground structures in areas where they are likely to remain wet (i.e., high water tables). The principal outlet should have positive drainage.
- When a new stormwater treatment measure is being installed, consider selecting a type that does not require a wet pond or other permanent pool of water.
- Properly design storm drains. The sheltered environment inside storm drains can promote mosquito breeding. Pipes should be designed and constructed for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe. Storm drains should be constructed so that the invert out is at the same elevation as the interior bottom to prevent standing water.
- Use grouted rock energy dissipaters instead of loose rock.
- If a stormwater treatment measure holds water for over five days, due to an outdated design or improper construction and maintenance, do one of the following:
  - Perform proper maintenance and reinspect to see if conditions improve;
  - Select or design an alternative (or modified) device that provides adequate pollutant removal and complete drainage in five days;
  - Contact the Santa Clara County Vector Control District to determine whether conditions may allow a longer drain time.

General Access Requirements for Mosquito Control

The following requirements are necessary to provide mosquito abatement personnel access to treatment measures for inspection and abatement activities.

- Design stormwater treatment measures to be easily and safely accessible without the need for special requirements (e.g., OSHA requirements for "confined space").
- If utilizing covers, include in the design spring-loaded or light-weight access hatches that can be opened easily for inspection.

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[2] The Department of Public Health's 2010 guidance recommends that treatment measures drain within four days. However, the Santa Clara County Vector Control District recommends limiting the duration of standing water to 5 days in Santa Clara County based on local climate conditions and mosquito species.

- Provide all-weather road access (with provisions for turning a full-size work vehicle) along at least one side of large above-ground structures that are less than 25 feet wide. For structures that are greater than 25 feet wide, a perimeter road is required for access to all sides.
- Control vegetation (by removal, thinning, or mowing) periodically to prevent barriers to access.

Dry System Design Principles for Mosquito Control

- Structures should be designed so they do not hold standing water for more than five days.
- Incorporate features that prevent or reduce the possibility of clogged discharge orifices (e.g., debris screens). The use of weep holes is not recommended due to rapid clogging.
- Use the hydraulic grade line of the site to select a stormwater treatment measure that allows water to flow by gravity through the structure. Pumps are not recommended because they are subject to failure and often require sumps that hold water.
- Design distribution piping and containment basins with adequate slopes to drain fully and prevent standing water. The design slope should take into consideration buildup of sediment between maintenance periods. Compaction during grading may also be needed to avoid slumping and settling.
- Avoid the use of loose riprap or concrete depressions that may hold standing water.
- Avoid barriers, diversions, or flow spreaders that may retain standing water.
- Use mosquito netting to cover sand media filter sump pumps.
- Use aluminum "smoke proof" covers for any vault sedimentation basins.
- Properly design storm drain measures. The sheltered environment inside storm drains can promote mosquito breeding. Pipes should be designed and constructed for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe.

Sumps, Wet Vaults, and Catch Basin Design Principles for Mosquito Control

- Completely seal structures that retain water permanently or longer than five days to prevent entry of adult mosquitoes. Adult female mosquitoes may penetrate openings as small as 1/16 inch (2 mm) to gain access to water for egg laying. Screening (24 mesh screens) can exclude mosquitoes, but it is subject to damage and is not a method of choice.
- If covers are used, they should be tight fitting with maximum allowable gaps or holes of 1/16 inch (2 mm) to exclude entry of adult mosquitoes. Gaskets are a more effective barrier when used properly.
- Any covers or openings to enclosed areas where stagnant water may pool must be large enough (2 feet by 3 feet) to permit access by vector control personnel for surveillance and, if necessary, abatement activities.

- If the sump, vault, or basin is sealed against mosquitoes, with the exception of the inlet and outlet, use a design that will submerge the inlet and outlet completely to reduce the available surface area of water for mosquito egg-laying (female mosquitoes can fly through pipes).
- Creative use of flapper or pinch valves, collapsible tubes and "brush curtains" may be effective for mosquito exclusion in certain designs.
- Design structures with the appropriate pumping, piping, valves, or other necessary equipment to allow for easy dewatering of the unit, if necessary.

Wet Ponds and Wetlands Design Principles for Mosquito Control

- If a wet pond or constructed, modified, or restored wetland must be built, appropriate and adequate funds must be allocated to support long-term site maintenance as well as routine monitoring and management of mosquitoes by a qualified agency.
- Long-term management of mosquitoes in wet ponds and wetlands should integrate biological control, vegetation management and other physical practices, and chemical control as appropriate.
- Provide for regular inspection of sites for detection of developing mosquito populations. Local factors may influence the overall effectiveness of certain approaches for mosquito reduction.
- Wet ponds and wetlands should maintain water quality sufficient to support surface-feeding fish such as mosquito fish (*Gambusia affinis*), which feed on immature mosquitoes and can aid significantly in mosquito control.
- If large predatory fish are present (e.g., perch and bass), mosquito fish populations may be negatively impacted or eradicated. In this case, careful vegetation management remains the only nonchemical mosquito control system.
- Where mosquito fish are not allowed, careful vegetation management remains the only nonchemical mosquito control system. Other predators such as dragonflies, diving beetles, birds, and bats feed on mosquitoes when available, but their effects are generally insufficient to preclude chemical treatment.
- Perform routine maintenance to reduce emergent plant densities. Emergent vegetation provides mosquito larvae with refuge from predators, protection from surface disturbances, and increased nutrient availability while interfering with monitoring and control efforts.
- Whenever possible, maintain wet ponds and wetlands at depths in excess of 4 feet to limit the spread of invasive emergent vegetation such as cattails (*Typha* spp.). Deep, open areas of exposed water are typically unsuitable for mosquito immatures due to surface disturbances and predation. Deep zones also provide refuge areas for fish and beneficial macroinvertebrates should the densely vegetated emergent zones be drained.
- If possible, compartmentalize managed treatment wetlands so the maximum width of ponds does not exceed two times the effective distance (40 feet) of land-based application technologies for mosquito control agents.

- Build shoreline perimeters as steep and uniform as practicable to discourage dense plant growth.
- Use concrete or liners in shallow areas to discourage unwanted plant growth where vegetation is unnecessary.
- Eliminate floating vegetation conducive to mosquito production, such as water hyacinth (*Eichhornia* spp.), duckweed (*Lemna* and *Spirodela* spp.), water primrose, parrot's feather, duckweed, and filamentous algal mats.
- Make shorelines accessible to maintenance and vector control crews for periodic maintenance, control, and removal of emergent vegetation, as well as for routine mosquito monitoring and abatement procedures, if necessary.
- Improve designs of permanent pools. Minimize shallow depths and increase circulation in ponds. Permanently flooded measures should be stocked with native *Gambusia* minnows to foster biological predation on mosquito larvae.
- Do not use stormwater structures to meet endangered species mitigation requirements. Aquatic habitat for endangered species should not be created near areas populated by humans.

F.2 Maintenance Guidance for Mosquito Control

Routine and timely maintenance is critical for suppressing mosquito breeding as well as for meeting local water quality goals. If maintenance is neglected or inappropriate for a given site, even structures designed to be the least "mosquito friendly" may become significant breeding sites. Although general principles of vector control are described here, maintenance guidelines for individual treatment measures are often site-specific.

The maintenance principles given below are intended to reduce the mosquito population. These principles should be incorporated, as appropriate, in maintenance plans developed for stormwater treatment control measures and in the ongoing maintenance and inspection of treatment measures.

General Maintenance Principles

- With the exception of certain treatment control measures designed to hold permanent water, treatment measures should drain completely within five days to effectively suppress vector production.
- Any circumstances that restrict the flow of water from a system as designed should be corrected. Debris or silt build-up obstructing an outfall structure should be removed. Under drains and filtration media should be inspected periodically and cleaned out or replaced as needed.
- Conduct maintenance activities regularly, in accordance with a municipality-approved maintenance plan.

Vegetation Management Maintenance Principles

- Conduct annual vegetative management, such as removing weeds and restricting growth of aquatic vegetation to the periphery of wet ponds.
- Remove grass cuttings, trash and other debris, especially at outlet structures.
- Avoid producing ruts when mowing (water may pool in ruts).

Dry System Maintenance Principles for Mosquito Control

- Extended detention basins are usually designed to detain water for 40 or 48 hours. If they detain water for longer than five days, they are poorly maintained.
- If a detention basin has been installed at an inappropriate location (e.g., on a site where the water table is too close to the surface), and if elimination or modification of the system is not possible then mosquitoes must be controlled with larvicides. The larvicide operation, in order to be effective, must be supported by a quality inspection program. Larvacides should only be applied by licensed pesticide applicators.

Underground Structure Maintenance Principles for Mosquito Control

- Prevent mosquito access to underground treatment control measures that may have standing water (i.e., seal openings that are 1/16-inch in diameter or greater).
- Provide vector control agencies access to underground measures that may have standing water.

Infiltration and Filtration Device Maintenance Principles for Mosquito Control

- Infiltration trenches and sand filter structures should not hold water for longer than 48 hours. If they retain water for longer than 48 hours, they are poorly designed or maintained.

Appendix

G

Operation & Maintenance Document Templates

The following templates are provided to assist project applicants in preparing stormwater treatment measure maintenance plans, which municipalities may require as exhibits to a stormwater treatment measure maintenance agreement:

- Standard Treatment Measure O&M Report Form
- Maintenance Plan for Bioretention Area
- Maintenance Plan for Flow-through Planter
- Maintenance Plan for Tree Well Filter
- Maintenance Plan for Infiltration Trench
- Maintenance Plan for Subsurface Infiltration System
- Maintenance Plan for Extended Detention Basin
- Maintenance Plan for Pervious Paving
- Maintenance Plan for Rainwater Harvesting Systems
- Maintenance Plan for Media Filters

Templates are available on the Urban Runoff Program website (www.scvurppp.org ; click on "Low Impact Development" under Quick Links; go to C.3 Handbook Appendix G).

Requirements vary from one municipality to the next. Contact the local jurisdiction to obtain information on municipality-specific requirements.

For proprietary tree well filters and media filters, contact the manufacturer for recommended maintenance activities and frequencies.

Stormwater Treatment Measure Operation and Maintenance Inspection Report to the [[== Insert Name of Municipality==]], California

This report and attached Inspection and Maintenance Checklists document the inspection and maintenance conducted for the identified stormwater treatment measure(s) subject to the Maintenance Agreement between the [**Municipality**] and the property owner during the annual reporting period indicated below.

I. Property Information:

Property Address or APN: ____

Property Owner: ____

II. Contact Information:

Name of person to contact regarding this report:_____________________________

Phone number of contact person:______________ Email:______________________

Address to which correspondence regarding this report should be directed:

____

____

III. Reporting Period:

This report, with the attached completed inspection checklists, documents the inspections and maintenance of the identified treatment measures during the time period from ______ ______ to __________.

IV. Stormwater Treatment Measure Information:

The following stormwater treatment measures (identified treatment measures) are located on the property identified above and are subject to the Maintenance Agreement:

Identifying Number of Treatment Measure	Type of Treatment Measure	Location of Treatment Measure on the Property

V. Summary of Inspections and Maintenance:

Summarize the following information using the attached Inspection and Maintenance Checklists:

Identifying Number of Treatment Measure	Date of Inspection	Operation and Maintenance Activities Performed and Date(s) Conducted	Additional Comments

VI. Sediment Removal:

Total amount of accumulated sediment removed from the stormwater treatment measure(s) during the reporting period: __________ cubic yards.

How was sediment disposed?

- ☐ landfill
- ☐ other location on-site as described in and allowed by the maintenance plan
- ☐ other, explain ____________________

VII. Inspector Information:

The inspections documented in the attached Inspection and Maintenance Checklists were conducted by the following inspector(s):

Inspector Name and Title	Inspector's Employer and Address

VIII. Certification:

I hereby certify, under penalty of perjury, that the information presented in this report and attachments is true and complete:

____ ____________________

Signature of Property Owner or Other Responsible Party Date

____

Type or Print Name

____

Company Name

____

Address

Phone number:____________________ Email:_________________________________

Bioretention Area Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets_______________________________________

Assessor's Parcel No.: _______________________________

Property Owner: _________________________ Phone No.:__________________

Designated Contact: ______________________ Phone No.:__________________

Mailing Address:____

The property contains [[== insert number ==]] bioretention area(s), located as described below and as shown in the attached site plan[1].

Bioretention Area No. 1 is located at [[== describe location ==]].

[[== Add descriptions of other bioretention areas, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to bioretention area failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Bioretention Areas

No.	Maintenance Task	Frequency of Task
1	Remove obstructions, weeds, debris and trash from bioretention area and its inlets and outlets; and dispose of properly.	Quarterly, or as needed after storm events
2	Inspect bioretention area for standing water. If standing water does not drain within 2-3 days, till and replace the surface biotreatment soil with the approved soil mix and replant.	Quarterly, or as needed after storm events
3	Check underdrains for clogging. Use the cleanout riser to clean any clogged underdrains.	Quarterly, or as needed after storm events
4	Maintain the irrigation system and ensure that plants are receiving the correct amount of water (if applicable).	Quarterly
5	Ensure that the vegetation is healthy and dense enough to provide filtering and protect soils from erosion. Prune and weed the bioretention area. Remove and/or replace any dead plants.	Annually, before the wet season begins
6	Use compost and other natural soil amendments and fertilizers instead of synthetic fertilizers, especially if the system uses an underdrain.	Annually, before the wet season begins
7	Check that mulch is at appropriate depth (2 - 3 inches per soil specifications) and replenish as necessary before wet season begins. It is recommended that 2" – 3" of arbor mulch be reapplied every year.	Annually, before the wet season begins
8	Inspect the energy dissipation at the inlet to ensure it is functioning adequately, and that there is no scour of the surface mulch. Remove accumulated sediment.	Annually, before the wet season begins

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

9	Inspect overflow pipe to ensure that it can safely convey excess flows to a storm drain. Repair or replace damaged piping.	Annually, before the wet season begins
10	Replace biotreatment soil and mulch, if needed. Check for standing water, structural failure and clogged overflows. Remove trash and debris. Replace dead plants.	Annually at the end of the rainy season, and/or after large storm events
11	Inspect bioretention area using the attached inspection checklist.	Annually, before the wet season

II. Use of Pesticides

Do not use pesticides or other chemical applications to treat diseased plants, control weeds or removed unwanted growth. Employ non-chemical controls (biological, physical and cultural controls) to treat a pest problem. Prune plants properly and at the appropriate time of year. Provide adequate irrigation for landscape plants. Do not over water.

III. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

IV. Inspections

The attached Bioretention Area Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Bioretention Area
Inspection and Maintenance Checklist

Property Address: ______________________________ Property Owner: ______________________

Treatment Measure No.: __________ Date of Inspection: __________ Type of Inspection: ☐ Quarterly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:__________

Inspector(s): ______________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	**Results Expected When Maintenance Is Performed**
1. Standing Water	Water stands in the bioretention area between storms and does not drain within 2-3 days after rainfall.			There should be no areas of standing water once storm event has ceased. Any of the following may apply: sediment or trash blockages removed, improved grade from head to foot of bioretention area, or added underdrains.
2. Trash and Debris Accumulation	Trash and debris accumulated in the bioretention area, inlet, or outlet.			Trash and debris removed from bioretention area and disposed of properly.
3. Sediment	Evidence of sedimentation in bioretention area.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, and/or other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased and/or overgrown.			Vegetation is healthy and attractive in appearance.
6. Mulch	Mulch is missing or patchy in appearance. Areas of bare earth are exposed, or mulch layer is less than 2 inches in depth.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even in appearance, at a depth of 2 – 3 inches.
7. Miscellaneous	Any condition not covered above that needs attention in order for the bioretention area to function as designed.			Meets the design specifications.

Flow-Through Planter Maintenance Plan for [[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets_______________________________________

Assessor's Parcel No.: _______________________________

Property Owner: _________________________ Phone No.:__________________

Designated Contact: ______________________ Phone No.:__________________

Mailing Address:____

The property contains [[== insert number ==]] Flow-Through Planter(s), located as described below and as shown in the attached site plan[1].

Flow-Through Planter No. 1 is located at [[== describe location ==]].

[[== Add descriptions of other Flow-Through Planters, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objectives are to ensure that water flows unimpeded into the flow-through planter and landscaping remains attractive in appearance. Table 1 shows the routine maintenance activities, and the frequency at which they will be conducted.

Table 1
Routine Maintenance Activities for Flow-Through Planters

No.	Maintenance Task	Frequency of Task
1	Inspect the planter surface area, inlets and outlets for obstructions and trash; clear any obstructions and remove trash.	Quarterly
2	Inspect planter for standing water. If standing water does not drain within 2-3 days, the surface biotreatment soil should be tilled or replaced with the approved soil mix and replanted. Use the cleanout riser to clear any underdrains of obstructions or clogging material.	Quarterly
3	Check for eroded or settled biotreatment soil media. Level soil with rake and remove/replant vegetation as necessary.	Quarterly
4	Maintain the vegetation and irrigation system. Prune and weed to keep flow-through planter neat and orderly in appearance.	Quarterly
5	Evaluate health and density of vegetation. Remove and replace all dead and diseased vegetation. Remove excessive growth of plants that are too close together.	Annually, before the rainy season begins
6	Use compost and other natural soil amendments and fertilizers instead of synthetic fertilizers, especially if the system uses an underdrain.	Annually, before the rainy season begins
7	Inspect the overflow pipe to make sure that it can safely convey excess flows to a storm drain. Repair or replace any damaged or disconnected piping. Use the cleanout riser to clear underdrains of obstructions or clogging material.	Annually, before the rainy season begins
8	Inspect the energy dissipator at the inlet to ensure it is functioning adequately, and that there is no scour of the surface mulch. Remove any accumulation of sediment.	Annually, before the rainy season begins
9	Inspect and, if needed, replace wood mulch. It is recommended that 2" to 3" of composted arbor mulch be applied once a year.	Annually, before the rainy season begins
10	Inspect system for erosion of biotreatment soil media, loss of mulch, standing water, clogged overflows, weeds, trash and dead plants. If using rock mulch, check for 3" of coverage.	Annually at the end of the rainy season and/or after large storm events,

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

11	Inspect system for structural integrity of walls, flow spreaders, energy dissipators, curb cuts, outlets and flow splitters.	Annually at the end of the rainy season and/or after large storm events,

II. Use of Pesticides

Do not use pesticides or other chemical applications to treat diseased plants, control weeds or removed unwanted growth. Employ non-chemical controls (biological, physical and cultural controls) to treat a pest problem. Prune plants properly and at the appropriate time of year. Provide adequate irrigation for landscape plants. Do not over water.

III. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

IV. Inspections

The attached Flow-Through Planter Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Flow-Through Planter
Inspection and Maintenance Checklist

Property Address: ____ Property Owner: _____________________________

Treatment Measure No.: ___________ Date of Inspection: __________ Type of Inspection: ☐ Quarterly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:________________

Inspector(s): ________________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	**Results Expected When Maintenance Is Performed**
1. Vegetation	Vegetation is dead, diseased and/or overgrown.			Vegetation is healthy and attractive in appearance.
2. Soil	Soil too deep or too shallow.			Soil is at proper depth (per soil specifications) for optimum filtration and flow.
3. Mulch	Mulch is missing or patchy in appearance.			Mulch is even in appearance and 2-3" deep.
4. Sediment, Trash and Debris Accumulation	Sediment, trash and debris accumulated in the flow-through planter. Planter does not drain within 3-4 hours.			Sediment, trash and debris removed from flow-through planter and disposed of properly. Planter drains within 3-4 hours.
5. Clogs/Drainage	Planter does not drain within 3-4 hours after rainfall.			Planter drains per design specifications.
6. Downspouts and Sheet Flow	Flow to planter is impeded. Downspouts are clogged or pipes are damaged. Splash blocks and rocks in need of repair, replacement or replenishment.			Downspouts and sheet flow is conveyed efficiently to the planter.
7. Overflow Pipe	Does not safely convey excess flows to storm drain. Piping damaged or disconnected.			Overflow pipe conveys excess flow to storm drain efficiently.
8. Structural Soundness	Planter is cracked, leaking or falling apart.			Cracks and leaks are repaired and planter is structurally sound.
9. Miscellaneous	Any condition not covered above that needs attention in order for the flow-through planter to function as designed.			Meet the design specifications.

Tree Well Filter Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets_______________________________________

Assessor's Parcel No.: ______________________________

Property Owner: ________________________ Phone No.:_________________

Designated Contact: _____________________ Phone No.:_________________

Mailing Address:____

The property contains [[== insert number ==]] tree well filter(s), located as described below and as shown in the attached site plan[1].

- **Tree Well Filter No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other tree well filters, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to tree well filter failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Tree Well Filters

No.	Maintenance Task	Frequency of Task
1	Evaluate health of trees and groundcover. Remove and replace all dead and diseased vegetation.	Twice a year
2	Maintain the vegetation and irrigation system. Prune and weed to keep tree well filter neat and orderly in appearance.	As needed
3	Use compost and other natural soil amendments and fertilizers instead of synthetic fertilizers, especially if the system uses an underdrain.	As needed
4	Check that planting mix is at appropriate depth and replenish as necessary. Replenish mulch as needed.	Before wet season and as necessary
5	Remove sediment, litter and debris from tree well filter. Confirm that no clogging will occur and that the filter will drain per the design specifications. Dispose of sediment, litter and debris properly.	Before wet season and as necessary
6	Inspect tree well filter to ensure that it drains between storms per design specifications	Periodically or as needed after storm events
7	Inspect overflow pipe to ensure that it will safely convey excess flows to storm drain. Repair or replace any damaged or disconnected piping.	As necessary
8	Inspect tree well filter using the attached inspection checklist.	Monthly, or after large storm events, and after removal of accumulated debris or material

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

II. Use of Pesticides

Do not use pesticides or other chemical applications to treat diseased plants, control weeds or removed unwanted growth. Employ non-chemical controls (biological, physical and cultural controls) to treat a pest problem. Prune plants properly and at the appropriate time of year. Provide adequate irrigation for landscape plants. Do not over water.

III. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

IV. Inspections

The attached Tree Well Filter Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Tree Well Filter
Inspection and Maintenance Checklist

Property Address: ______________________________ Property Owner: ______________________

Treatment Measure No.: __________ Date of Inspection: _________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:______________

Inspector(s): ____________________________

Defect	Conditions When Maintenance Is Needed	Maintenance Needed? (Y/N)	Comments (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	Results Expected When Maintenance Is Performed
1. Vegetation	Vegetation is dead, diseased and/or overgrown.			Vegetation is healthy and attractive in appearance.
2. Planting Mix	Planting mix too deep or too shallow.			Planting mix is at proper depth for optimum filtration and flow.
3. Mulch	Mulch is missing or patchy in appearance.			Mulch is even in appearance and 2-3" deep.
4. Trash and Debris Accumulation	Trash and debris accumulated in the tree well filter.			Trash and debris removed from tree well filter and disposed of properly.
5. Clogs/Drainage	Tree well filter does not drain as specified.			Filter drains per design specifications.
6. Sediment	Evidence of sedimentation in tree well filter.			Material removed so that there is no clogging or blockage. Sediment is disposed of properly.
7. Standing Water/Vector Control	Water stands in the tree well filter between storms and does not drain per design specifications.			Filter drains per design specifications. Any of the following may apply: sediment or trash blockages removed, overflow pipe repaired.
8. Overflow Pipe	Does not safely convey excess flows to storm drain. Piping damaged or disconnected.			Overflow pipe conveys excess flow to storm drain efficiently.
9. Miscellaneous	Any condition not covered above that needs attention in order for the tree well filter to function as designed.			Meets the design specifications.

Infiltration Trench Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets____

Assessor's Parcel No.: ________________________________

Property Owner: _________________________ Phone No.:__________________

Designated Contact: ______________________ Phone No.:__________________

Mailing Address:____

The property contains [[== insert number ==]] infiltration trench(es), located as described below and as shown in the attached site plan.

- **Infiltration Trench No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other infiltration trenches, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to trench failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Infiltration Trenches

No.	Maintenance Task	Frequency of Task
1	Monitor observation well to confirm that trench has drained during dry season. If inspection indicates that the trench is partially or completely clogged, restore to design conditions.	Annually, during dry season
2	Remove obstructions, debris and trash from infiltration trench and dispose of properly.	Monthly, or as needed after storm events
3	Check observation well 2 to 3 days after storms to confirm drainage. Trench should completely dewater within 5 days.	Monthly during wet season, or as needed after storm events
4	Mow and trim vegetation around the trench to maintain a neat and orderly appearance.	As needed
5	Remove any trash, grass clippings and other debris from the trench perimeter and dispose of properly.	As needed
6	Check for erosion at inflow or overflow structures. Repair as necessary.	Monthly, or as needed after storm events
7	Inspect infiltration trench using the attached inspection checklist.	Monthly, or after large storm events, and after removal of accumulated debris or material

II. Prohibitions

Trees and other large vegetation shall be prevented from growing adjacent to the trench to prevent damage.

III. Use of Pesticides

Do not use pesticides or other chemical applications to control weeds or unwanted growth near the trench.

IV. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

V. Inspections

The attached Infiltration Trench Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Infiltration Trench
Inspection and Maintenance Checklist

Property Address: ____ Property Owner: _____________________________

Treatment Measure No.: ___________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:________________

Inspector(s): ________________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	**Results Expected When Maintenance Is Performed**
1. Standing Water/Vector Control	Water stands in the infiltration trench between storms and does not drain within 2-3 days.			There should be no areas of standing water once storm event has ceased. Any of the following may apply: sediment or trash blockages removed, improved grade from head to foot of infiltration trench, removed clogging at check dams, or added underdrains.
2. Trash and Debris Accumulation	Trash and debris accumulated in the infiltration trench.			Trash and debris removed from infiltration trench and disposed of properly.
3. Sediment	Evidence of sedimentation in trench.			Material removed and disposed of properly so that there is no clogging or blockage.
4. Inlet/Outlet	Inlet/outlet areas clogged with sediment or debris, and/or eroded.			Material removed and disposed of properly so that there is no clogging or blockage in the inlet and outlet areas.
5. Overflow Drain	Clogged with sediment or debris, and/or eroded.			Material removed and disposed of properly so that there is no clogging or blockage, and trench is restored to design condition.
6. Observation Well	Routine monitoring of observation well indicates that trench is not draining within specified time or observation well cap is missing.			Restore trench to design conditions. Observation well cap is sealed.
7. Miscellaneous	Any condition not covered above that needs attention in order for the infiltration trench to function as designed.			Meets the design specifications.

Subsurface Infiltration System Maintenance Plan for
[[== Insert Project Name ==]]
[[== Insert Date =]]

Project Address and Cross Streets____

Assessor’s Parcel No.: ________________________________

Property Owner: __________________________ Phone No.:__________________

Designated Contact: _______________________ Phone No.:__________________

Mailing Address:____

The property contains [[== insert number ==]] Subsurface Infiltration System(s) located as described below and as shown in the attached site plan.

- **Subsurface Infiltration System No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other subsurface infiltration systems, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to system failure. A pretreatment measure is typically required to keep sediment and other pollutants out of the infiltration system. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1. Routine maintenance of the pretreatment measure should also be conducted; refer to the maintenance plan for the appropriate type of measure.

Table 1
Routine Maintenance Activities for Subsurface Infiltration Systems

No.	Maintenance Task	Frequency of Task
1	Monitor observation well to confirm that the subsurface infiltration system has drained during dry season. If inspection indicates that the system is partially or completely clogged, restore to design conditions.	Annually, during dry season
2	Remove obstructions, debris and trash near inlet and dispose of properly.	Monthly during wet season, or as needed after storm events
3	Check observation well 2 to 3 days after storms to confirm drainage. The subsurface infiltration system should completely dewater within 3 days (preferred) or within 5 days to avoid mosquito production.	Monthly during wet season, or as needed after storm events
4	Check for erosion at inflow or overflow structures. Repair as necessary.	Monthly, or as needed after storm events
5	Inspect subsurface infiltration system using the attached inspection checklist.	Monthly, or after large storm events, and after removal of accumulated debris or material

II. Prohibitions

Trees and other large vegetation shall be prevented from growing adjacent to the subsurface infiltration system to prevent damage.

III. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

IV. Inspections

The attached Subsurface Infiltration System Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Subsurface Infiltration System
Inspection and Maintenance Checklist

Property Address: ____ Property Owner: __________________________________

Treatment Measure No.: ____________ Date of Inspection: ___________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:__________________

Inspector(s): ____________________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	**Results Expected When Maintenance Is Performed**
1. Standing Water	Water stands in the infiltration system or pretreatment measure between storms and does not drain within 3 days.			There should be no areas of standing water 3 days after a storm event. Sediment or trash blockages have been removed and infiltration system is restored to design condition.
2. Trash and Debris Accumulation	Trash and debris accumulated in the infiltration system or pretreatment measure.			Trash and debris removed from infiltration system and/or pretreatment measure and disposed of properly.
3. Sediment	Evidence of sedimentation in infiltration system.			Material removed and disposed of properly so that there is no clogging or blockage.
4. Inlet/Outlet, or Overflow Drain	Inlet/outlet areas or overflow drain clogged with sediment or debris, and/or eroded.			Material removed and disposed of properly so that there is no clogging or blockage in the inlet and outlet areas or overflow drain.
5. Observation Well	Routine monitoring of observation well indicates that infiltration system is not draining within specified time or observation well cap is missing.			Restore infiltration system to design conditions. Observation well cap is sealed.
6. Miscellaneous	Any condition not covered above that needs attention in order for the infiltration system to function as designed.			Meets the design specifications.

Extended Detention Basin Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets_______________________________________

Assessor's Parcel No.: _______________________________

Property Owner: _________________________ Phone No.:_________________

Designated Contact: ______________________ Phone No.:_________________

Mailing Address:____

The property contains [[== insert number ==]] extended detention basins, located as described below and as shown in the attached site plan.

- **Extended Detention Basin No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other extended detention basins, if applicable. ==]]
- [[==Identify Extended Detention Basin(s) designed for Hydromodification Management (HM).]]

I. Routine Maintenance Activities

Primary maintenance activities include vegetation management and sediment removal, although mosquito abatement is a concern if the extended detention basin is designed to include permanent pools of standing water. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Extended Detention Basins

No.	Maintenance Task	Frequency of Task
1	Evaluate the health of vegetation and remove and replace any dead or dying plants.	Twice a year
2	Trim vegetation at beginning and end of wet season.	Twice a year
3	Inspect vegetation to prevent establishment of woody vegetation and for aesthetics and mosquito control.	Monthly
4	Harvest vegetation annually, during the summer	Annually
5	Examine the outlet, embankments, dikes, berms, and side slopes for structural integrity and signs of erosion or rodent burrows. Fill in any holes detected in the side slopes.	Twice a year
6	Inspect inlets, outlets and overflow structures to ensure that piping is intact and not plugged. Remove any accumulated sediment and debris. Ensure that energy dissipation is functioning adequately.	Twice a year
7	Inspect for standing water and correct any problems that prevent the basin from draining as designed.	Twice a year
8	Confirm that any fences around the facility are secure	Twice a year
9	Remove sediment from forebay when the sediment level reaches the level shown on the fixed vertical sediment marker and dispose of sediment properly.	As needed
10	Remove accumulated sediment from the detention basin and regrade when the accumulated sediment volume exceeds 10% of basin volume and dispose of sediment properly.	Every 10 years, or as needed
11	Remove accumulated trash and debris from the extended detention basin and dispose of properly.	Twice a year
12	Inspect extended detention basin using the attached inspection checklist.	Quarterly, or as needed

II. Use of Pesticides

Do not use pesticides or other chemical applications to treat diseased plants, control weeds or removed unwanted growth. Employ non-chemical controls (biological, physical and cultural controls) to treat a pest problem. Prune plants properly and at the appropriate time of year. Provide adequate irrigation for landscape plants. Do not over water.

III. Vector Control Contact

Standing water shall not remain in the treatment and/or hydromodification management measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

IV. Inspections

The attached Extended Detention Basin Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Extended Detention Basin
Inspection and Maintenance Checklist

Property Address: ______________________________ Property Owner: ______________________________

Treatment Measure No.: __________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:______________

Inspector(s): ______________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.)	**Results Expected When Maintenance Is Performed**
Trash & Debris	Trash and debris accumulated in basin. Visual evidence of dumping.			Trash and debris cleared from site and disposed of properly.
Tree/Brush Growth, Woody Vegetation	Growth does not allow maintenance access or interferes with maintenance activity. Dead, diseased, or dying trees.			Trees do not hinder maintenance activities. Vegetation harvested annually, during the summer.
Erosion	Erosion on a compacted berm embankment. Rodent burrows on slope.			Cause of erosion is managed appropriately. Side slopes or berm restored to design specifications, as needed. Rodent burrows filled up.
Drainage time/Vector control	Standing water remains in basin more than five days.			Any circumstances that restrict the flow of water from the system corrected. Drainage restored to design condition. If the problem cannot be corrected and problems with standing water recur, then mosquitoes should be controlled with larvicides, applied by a licensed pesticide applicator. Contact the Santa Clara County Vector Control District.
Inlet and outlet	Piping broken. Inlet or outlet blocked.			Piping intact. Debris/sediment removed and disposed properly.
Fences	Fences broken or missing			Fences around facility are secure
Sediment	Accumulated sediment >10% of designed basin depth			Sediment cleaned out to designed basin shape and depth; basin reseeded if necessary to control erosion. Sediment disposed of properly.
Miscellaneous	Any condition not covered above that needs attention to restore extended detention basin to design conditions.			Meets the design specifications.

Pervious Paving Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets_______________________________________

Assessor's Parcel No.: ______________________________

Property Owner: ________________________ Phone No.:_________________

Designated Contact: _____________________ Phone No.:_________________

Mailing Address:____

The property contains [[== insert number ==]] pervious paving area(s), located as described below and as shown in the attached site plan[1].

- **Pervious Paving Area No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other pervious paving areas, if applicable. ==]]

I. Routine Maintenance Activities

Types of pervious pavement include pervious concrete, porous asphalt, and permeable interlocking concrete pavement (PICP), concrete grid pavers, and plastic reinforcement grid pavers. The principal maintenance objective is to prevent sediment buildup and clogging, which reduces infiltration capacity and pollutant removal efficiency. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Pervious Paving Areas

No.	Maintenance Task	Frequency of Task
1	Check for sediment and debris accumulation. Prevent soil from washing or blowing onto the pavement. Do not store sand, soil, mulch or other landscaping materials on pervious pavement surfaces.	Two to four times annually
2	Conduct preventative surface cleaning, using commercially available regenerative air or vacuum sweepers, to remove sediment and debris.	Two to four times annually
3	Inspect for any signs of pavement failure. Repair any surface deformations or broken pavers. Replace missing joint filler in PICP.	Two to four times annually
4	Check for standing water on the pavement surface within 30 minutes after a storm event.	Two to four times annually
5	Inspect underdrain outlets and cleanouts, preferably before the wet season. Remove trash/debris.	Two to four times annually
6	Remove sediment and debris accumulation on pervious pavement.	Two to four times annually
7	Remove weeds. Mow vegetation in grid pavements (such as turf block) as needed.	As needed
8	Perform restorative surface cleaning with a vacuum sweeper, and/or reconstruction of part of the pervious surface to restore surface permeability as needed. Replenish aggregate in PICP joints or grids as needed after restorative surface cleaning.	As needed
9	Power washing with simultaneous vacuuming also can be used to restore surface infiltration to highly clogged areas of pervious concrete, porous asphalt or PICP, but is not recommended for grid pavements.	As needed
10	Inspect pervious paving area using the attached inspection checklist.	Quarterly or as needed

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

II. Use of Pesticides

Do not use pesticides or other chemical applications to control weeds or unwanted growth near pavement or between pavers.

III. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

IV. Inspections

The attached Pervious Pavement Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Pervious Pavement
Inspection and Maintenance Checklist

Property Address: ______________________________ Property Owner: ______________________

Treatment Measure No.: __________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:__________

Inspector(s): ______________________

Defect	Conditions When Maintenance Is Needed	Maintenance Needed? (Y/N)	Comments (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	Results Expected When Maintenance Is Performed
1. Standing Water	Water stands in the pervious pavement and does not drain within 30 minutes after storm event			There should be no areas of standing water once storm event has ceased. Restorative surface cleaning with a vacuum sweeper and/or reconstruction of part of the pervious surface may be required.
2. Trash, or Sediment and Debris Accumulation	Trash, sediment or debris accumulated on pervious pavement			Trash and debris removed from pervious pavement and disposed of properly. Adjacent areas do not contribute to sediment and debris.
3. Damage	Surface deformation or broken pavers			Surface restored; no deformation or broken pavers.
4. Vegetation	Weeds growing on pervious pavement			No weeds on pervious pavement.
5. Underdrain Outlets	Water accumulates due to trash/sediment accumulation in outlets.			No standing water observed. Clean underdrain outlets and cleanouts.
6. Miscellaneous	Any condition not covered above that needs attention in order for the pervious pavement to function as designed.			Meets the design specifications.

Rainwater Harvesting Systems Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets____

Assessor's Parcel No.: ________________________________

Property Owner: __________________________ Phone No.:__________________

Designated Contact: _______________________ Phone No.:__________________

Mailing Address:____

The property contains [[== insert number ==]] pervious paving area(s), located as described below and as shown in the attached site plan[1].

- **Rainwater Harvesting System No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other rainwater harvesting systems, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduce rainwater harvesting capacity. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Rainwater Harvesting Systems

No.	Maintenance Task	Frequency of Task
1	Inspect and clean filters and screens, and replace as needed.	Every 3-6 months
2	Inspect and clean debris from gutters, downspouts, first-flush devices and roof washers.	Every 3-6 months
3	Inspect and verify that disinfection, filters, and other water quality treatment devices are operational, in accordance with manufacture's recommendations or local jurisdictional requirements	Every 3-6 months
4	Inspect and clean debris from rainwater gutters, roof surfaces, downspouts, roof washers, and first-flush devices, Remove tree branches and vegetation overhanging roof surfaces.	Every 6 months, or as needed to prevent clogging
5	If rainwater is provided for indoor use, conduct annual water quality testing per the requirements of the local jurisdiction.	Annually
6	Inspect all components, including pumps, valves, tanks, backflow prevention systems, and verify operation.	Annually
7	Flush or vacuum cisterns to remove sediment. Drain flushed water to landscaping or sanitary sewer.	Annually
8	Inspect rainwater harvesting systems using the attached inspection checklist.	Quarterly or as needed

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

II. Vector Control

Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

III. Inspections

The attached Rainwater Harvesting Systems Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Rainwater Harvesting Systems
Inspection and Maintenance Checklist

Property Address: ____ Property Owner: ______________________________

Treatment Measure No.: ___________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season
☐ After heavy runoff ☐ End of Wet Season
Inspector(s): _________________________________ ☐ Other:________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	**Results Expected When Maintenance Is Performed**
1. Sediment and Debris Accumulation	Sediment or debris accumulated in filters, screens, gutters, downspouts, first-flush devices, or roof washers, or on roof or other collection surfaces. Sediment accumulated in collection system.			Sediment and debris removed and disposed of properly. Collection surfaces do not contribute sediment and debris.
2. Leaks and holes	Water leaking from system. Mosquitoes entering the system.			No leakage. No evidence of mosquitoes or larvae.
3. Water Quality	Treatment system is not working properly.			Treatment system is operational and maintaining minimum water quality requirements.
4. Miscellaneous	Any condition not covered above that needs attention in order for the rainwater harvesting system to function as designed.			Meets the design specifications.

Media Filter Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets____

Assessor's Parcel No.: _________________________________

Property Owner: __________________________ Phone No.:___________________

Designated Contact: _______________________ Phone No.:___________________

Mailing Address:____

The property contains [[== insert number ==]] media filter (s), located as described below and as shown in the attached site plan[1].

- **Media Filter No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other media filters, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to failure of the media filter. Follow manufacturer's requirements for maintenance. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Media Filters

No.	Maintenance Task	Frequency of Task
1	Inspect for standing water, sediment, trash and debris.	Monthly during rainy season
2	Remove accumulated trash and debris in the unit during routine inspections.	Monthly during rainy season, or as needed after storm events
3	Inspect to ensure that the facility is draining completely within five days and per manufacturer's specifications.	Once during the wet season after major storm event.
4	Replace the media per manufacturer's instructions or as indicated by the condition of the unit.	Per manufacturer's specifications.
5	Inspect media filters using the attached inspection checklist.	Quarterly or as needed

II. Vector Control

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the Santa Clara Valley Vector Control District (District). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the District, and then only by a licensed professional or contractor. Contact information for the District is provided below.

Santa Clara Valley Vector Control District
1580 Berger Dr.
San José, California 95112
Phone: (408) 918-4770 / (800) 675-1155 - Fax: (408) 298-6356
www.sccgov.org/portal/site/vector

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

IV. Inspections

The attached Treatment Measure Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Media Filters
Inspection and Maintenance Checklist

Property Address: ____ Property Owner: ____________________________

Treatment Measure No.: ___________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:________________

Inspector(s): ________________________________

Defect	Conditions When Maintenance Is Needed	Maintenance Needed? (Y/N)	Comments (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	Results Expected When Maintenance Is Performed
1. Sediment, trash and debris accumulation on filter	Sediment, trash and debris accumulated in the media filter unit, vault or piping.			Sediment, trash and debris removed and disposed of properly.
2. Standing water	Treatment unit or vault does not drain within five days after rainfall.			Source of clogging removed. Filter drains per design specifications.
3. Mosquitoes	Evidence of mosquito larvae in treatment unit.			No evidence of mosquito larvae.
4. Miscellaneous	Any condition not covered above that needs attention in order for the manufactured treatment measure to function as designed.			Meet the design specifications.

Appendix

H

Model Conditions Of Approval For Stormwater Quality

Introduction

The SCVURPPP Model Conditions of Approval contain site design and source control measures to reduce runoff and control sources of storm water pollutants associated with the post-construction phase of new development and redevelopment projects. Each identified source of pollutants may have one or more appropriate control measures. The model list is intended to be a menu of measures from which Co-permittees may select appropriate measures to apply to specific projects. Co-permittees do not have to use the exact wording of a site design or source control measure as long as the intent of the measure (i.e., to keep pollutants out of storm water, groundwater, creeks and the Bay) is preserved. Phrases in brackets represent alternative or optional wording.

Site Design Measures

General

1. The project will incorporate site design measures for reducing water quality impacts of the project, in compliance with the Municipal Regional Stormwater Permit Provision C.3. requirements. Guidance on approved site design measures is available from the [Public Works/Planning Department]. Final approval for site design measures must be obtained from the [Planning/Community Development/Public Works Department].
2. Projects that discharge directly to CWA section 303(d) listed waterbodies will implement appropriate source control, site design and treatment measures for the listed pollutants of concern.

Minimize Land Disturbance

1. Significant natural features and resources on site such as undisturbed forest area, setbacks, easements, trees and other vegetation, steep slopes, erosive soils, channels, wetlands or riparian areas shall be identified within the area to be developed and protected as project amenities during construction and during future use of the site.
2. Site layout shall conform to natural landforms on-site. Buildings shall be located to utilize natural drainage systems as much as possible and avoid unnecessary disturbance of vegetation and soils. Development on unstable or easily erodible soils shall be avoided due to their greater erosion potential.
3. Compaction of highly permeable soils shall be minimized.
4. Disturbance of natural water bodies and drainage systems shall be minimized.
5. Impacts from stormwater and urban runoff on the biological integrity of natural drainage systems and water bodies shall be minimized.

Minimize Impervious Surfaces

1. Directly connected impervious surfaces shall be minimized. Runoff from impervious areas --including rooftops, driveways and/or uncovered parking lots -- shall be directed into cisterns or rain barrels for use, or channeled to vegetated areas (e.g., park strips, vegetated planters) where possible prior to discharge to the storm drain.
2. Site permeability shall be maximized by clustering structures and pavement, reducing building footprints, minimizing impervious surfaces (especially parking lots), and paving with permeable materials where feasible.
3. The project shall cluster structures and incorporate smaller lot sizes where feasible to reduce overall impervious surface coverage and provide more undisturbed open space, for protection of water resources.

Preserve Open Space

1. The amount of open space on the site shall be maximized, as appropriate for the density of proposed development, and the open space area maintained in a natural manner.

2. Undisturbed natural areas such as forested conservation areas and stream buffers shall be utilized to treat and control stormwater runoff from other areas of the site with proper design.

Reduce Effects of Hydromodification

1. The project shall utilize harvesting and reuse, infiltration, evapotranspiration or biotreatment measures to reduce stormwater discharge to the greatest extent feasible.
2. The project shall minimize increases in stormwater flow and volume to protect creeks and waterways from flooding and erosion impacts.

Street Design

1. Where density, topography, soils, slope and safety issues permit, vegetated open channels or other landscape measures shall be used in the street right of way to convey and treat stormwater runoff from roadways.
2. Sidewalks shall be sloped to drain to adjacent vegetated park strips.

Parking Lots

1. Where feasible, parking lots and other impervious areas shall be designed to drain stormwater runoff to vegetated drainage swales, filter strips, and/or other treatment devices that can be integrated into required landscaping areas and traffic islands prior to discharge into storm drain systems.
2. The amount of impervious area associated with parking lots shall be minimized by providing compact car spaces, reducing stall dimensions, incorporating efficient parking lanes, and using permeable pavement in overflow parking areas where feasible.
3. Curb cuts (one every 10 feet), tire stops, or other means shall be provided to protect landscaped areas and allow maximum flow of stormwater into landscaped areas.
4. The use of permeable paving for parking and driveway surfaces is encouraged, to reduce runoff from the site. Such paving should meet fire department requirements and be structurally appropriate for the location.

Landscaping as a Stormwater Drainage/Treatment Feature

1. Projects shall be designed to direct stormwater runoff into landscaping or natural vegetation where feasible.
2. Large landscaped areas shall be designed to collect and infiltrate stormwater where feasible. Overflow drains shall be placed so that landscaped areas can store runoff and drain at capacity. Such collection areas shall be designed and maintained to meet vector control requirements.
3. Where possible, runoff from impervious areas such as rooftops, roadways and parking lots shall be directed to cisterns or rain barrels, pervious areas, open channels or vegetated areas prior to discharge to the storm drain system.

Riparian Areas

1. Naturally vegetated buffers shall be delineated, preserved and/or restored along perennial streams, rivers, lakes and wetlands.

Source Control Measures

Structural Control Measures

A. Illegal Dumping to Storm Drain Inlets and Waterways

1. On-site storm drain inlets shall be clearly marked with the words "No Dumping! Flows to Bay," or equivalent, using methods approved by the [Co-permittee].
2. It is unlawful to discharge any wastewater into storm drains, gutters, creeks, or the San Francisco Bay. Unlawful discharges to storm drains include, but are not limited to, discharges from toilets; sinks; industrial processes; cooling systems; boilers; fabric cleaning; equipment cleaning; or vehicle cleaning.
3. It is unlawful to cause hazardous domestic waste materials to be deposited in such a manner or location as to constitute a threatened discharge into storm drains, gutters, creeks or San Francisco Bay.

B. Interior Floor Drains

1. Interior floor drains shall be plumbed to the sanitary sewer system and shall not be connected to storm drains.

C. Parking Lots

1. Interior level parking garage floor drains shall be connected to [a water treatment device approved by the (Co-permittee) prior to discharging to] the sanitary sewer system. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

D. Pesticide/Fertilizer Application

1. Landscaping shall be designed to minimize irrigation and runoff, promote surface infiltration wherepossible, minimize the use of quick-release and/or syntheticfertilizers and pesticides that can contribute to stormwater pollution, and incorporate appropriate sustainable landscaping practices such as Bay Friendly Landscaping (see www.bayfriendly.org).
2. Structures shall be designed to discourage the occurrence and entry of pests into buildings, thus minimizing the need for pesticides. For example, dumpster areas should be located away from occupied buildings, and building foundation vents shall be covered with screens.
3. Additional requirements are covered in the "Model Conditions of Approval for Pest Resistant Landscaping" (August 19, 2002).

E. Pool, Spa, and Fountain Discharges

1. New or rebuilt swimming pools, hot tubs, spas and fountains shall have a connection to the sanitary sewer system, subject the local sanitary sewer agency's authority and standards, to facilitate draining events. This connection could be a drain in the pool to the sanitary sewer, or a sanitary sewer cleanout located close enough to the pool so that a hose can readily direct the pool discharge into the sanitary sewer cleanout.

2. Discharges from swimming pools, hot tubs, spas and fountains shall be directed to the sanitary sewer, subject to the local sanitary sewer agency's authority and standards, or to a landscaped area that can accommodate the volume.
3. When draining is necessary, a hose or other temporary system shall direct the pool discharge into a sanitary sewer clean out, subject the local sanitary sewer agency's authority and standards.
4. Discharges from swimming pools, hot tubs, spas and fountains are not allowed into storm drain collection systems.

F. Food Service Equipment Cleaning

1. Food service facilities (including restaurants and grocery stores) shall have a sink or other area for cleaning floor mats, containers, hood filters, and equipment, that is connected to a grease interceptor prior to discharging to the sanitary sewer system. The cleaning area shall be large enough to clean the largest mat or piece of equipment to be cleaned. The cleaning area shall be indoors or in a covered area outdoors; both areas must be plumbed to the sanitary sewer.

G. Refuse Areas

1. New buildings [such as food service facilities and/or multi-family residential complexes or subdivisions] shall provide a covered or enclosed area for dumpsters and food waste and recycling containers. The area shall be designed to prevent water run-on to the area and runoff from the area.
2. Areas around trash enclosures, food waste storage and recycling areas, and/or food compactor enclosures shall not discharge to the storm drain system. Any drains installed in or beneath dumpsters, compactors, and tallow bin areas serving food service facilities shall be connected [to a grease removal device prior to discharging] to the sanitary sewer. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

H. Outdoor Process Activities/Equipment[1]

1. Process activities shall be performed either indoors or outdoors under cover. If performed outdoors, the area shall be designed to prevent run-on to and runoff from the site.
2. Process equipment areas shall drain to the sanitary sewer system. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

I. Outdoor Equipment/Materials Storage

1. All outdoor equipment and materials storage areas shall be covered [and bermed], or shall be designed to limit the potential for runoff to contact pollutants [or a storm drain inlet valves shall be provided on exterior drains in the area].

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[1] Examples of businesses that may have outdoor process activities and equipment include machine shops and auto repair shops, and industries that have pretreatment facilities.

2. Storage areas containing non-hazardous liquids shall be covered by a roof and/or drain to the sanitary sewer system, and be contained by berms, dikes, liners or vaults. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.
3. All hazardous materials and wastes, as defined [or regulated] by [cite ordinance or regulation], on the site must be used and stored in compliance with the [Co-permittee's] Hazardous Materials Ordinance and Hazardous Materials Management Plan for the site approved by the [Co-permittee department].

J. Vehicle/Equipment Cleaning

1. Wastewater from washing of vehicles, equipment, and accessories shall not be discharged to the storm drain system.
2. Commercial/industrial facilities having vehicle/equipment cleaning needs [and new residential complexes of 25 units or greater] shall either provide a covered, bermed area for washing activities or discourage vehicle/equipment washing by removing hose bibs and installing signs prohibiting such uses. Vehicle/equipment/accessories washing areas shall be paved, designed to prevent run-on to or runoff from the area, and plumbed to drain to the sanitary sewer. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.
3. Commercial car wash facilities shall be designed and operated such that no runoff from the facility is discharged to the storm drain system. Wastewater from the facility shall discharge to the sanitary sewer [or a wastewater reclamation system shall be installed]. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

K. Vehicle/Equipment Repair and Maintenance

1. Vehicle/equipment repair and maintenance shall be performed in a designated area indoors, or if such services must be performed outdoors, in an area designed to prevent the run-on and runoff of stormwater.
2. Secondary containment shall be provided for exterior work areas where motor oil, brake fluid, gasoline, diesel fuel, radiator fluid, acid-containing batteries or other hazardous materials or hazardous wastes are used or stored. Drains shall not be installed within the secondary containment areas.
3. Vehicle service facilities shall not contain floor drains unless the floor drains are connected to wastewater pretreatment systems prior to discharge to the sanitary sewer, for which an industrial waste discharge permit has been obtained. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.
4. Tanks, containers or sinks used for parts cleaning or rinsing shall not be connected to the storm drain system. Tanks, containers or sinks used for such purposes may only be connected to the sanitary sewer system if allowed by an industrial waste discharge permit. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

L. Fuel Dispensing Areas

1. Fueling areas[2] shall have impermeable floors (i.e., portland cement concrete or equivalent smooth impervious surface) that are: a) graded at the minimum slope necessary to prevent ponding; and b) separated from the rest of the site by a grade break that prevents run-on of stormwater to the maximum extent practicable.
2. Fueling areas shall be covered by a canopy that extends a minimum of ten feet in each direction from each pump. [Alternative: The fueling area must be covered and the cover's minimum dimensions must be equal to or greater than the area within the grade break or fuel dispensing area, as defined below1.] The canopy [or cover] shall not drain onto the fueling area.

M. Loading Docks

1. Loading docks shall be covered and/or graded to minimize run-on to and runoff from the loading area. Roof downspouts shall be positioned to direct stormwater away from the loading area. Water from loading dock areas shall be drained to the sanitary sewer, or diverted and collected for ultimate discharge to the sanitary sewer. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.
2. Loading dock areas draining directly to the sanitary sewer shall be equipped with a spill control valve or equivalent device, which shall be kept closed during periods of operation.
3. Door skirts between the trailers and the building shall be installed to prevent exposure of loading activities to rain.

N. Fire Sprinkler Test Water

1. Fire sprinkler test water shall discharge to onsite vegetated areas, or to the sanitary sewer, subject to local sanitary sewer agency's authority and standards, if discharge to onsite vegetated areas is not feasible.

O. Miscellaneous Drain or Wash Water

1. Boiler drain lines shall be directly or indirectly connected to the sanitary sewer system and may not discharge to the storm drain system.
2. [Air compressor or air conditioner] condensate drain lines may not discharge to the storm drain system. Condensate from air conditioning units shall be directed to landscaped areas or the ground.
3. Roof drains shall discharge and drain away from the building foundation to an unpaved area wherever possible.

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[2] The fueling area shall be defined as the area extending a minimum of 6.5 feet from the corner of each fuel dispenser or the length at which the hose and nozzle assembly may be operated plus a minimum of one foot, whichever is greater.

4. Roof top equipment shall drain to onsite vegetated areas, if feasible. If this is not feasible, roof top equipment may drain to the sanitary sewer. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

P. Copper Architectural Features

1. Waste water generated from the installation, cleaning, treating, and washing of the surface of copper architectural features, including coppers roofs, shall not be discharged to storm drains.

Operational Control Measures

A. Paved Sidewalks and Parking Lots

1. Sidewalks and parking lots shall be swept regularly to prevent the accumulation of litter and debris. Debris resulting from pressure washing shall be trapped and collected to prevent entry into the storm drain system. Washwater containing any cleaning agent or degreaser shall be collected and discharged to the sanitary sewer and shall not be discharged to a storm drain. The applicant shall contact the local permitting authority and/or sanitary district with jurisdiction for specific connection and discharge requirements.

B. Private Streets

1. Owner of private streets and storm drains shall prepare and implement a plan for street sweeping of paved private roads and cleaning of all storm drain inlets.

C. Vehicle/Equipment Repair and Maintenance

1. No person shall dispose of, nor permit the disposal, directly or indirectly, of vehicle fluids, hazardous materials, or rinsewater from parts cleaning operations into storm drains.
2. No vehicle fluid removal shall be performed outside a building, nor on asphalt or ground surfaces, whether inside or outside a building, except in such a manner as to ensure that any spilled fluid will be in an area of secondary containment. Leaking vehicle fluids shall be contained or drained from the vehicle immediately.
3. No person shall leave unattended drip parts or other open containers containing vehicle fluid, unless such containers are in use or in an area of secondary containment.

D. Fueling Areas

1. The property owner shall dry sweep the fueling area routinely.

Pesticide Reduction Measures

If a landscaping plan is required as part of a development project application, the plan shall meet the following conditions related to reduction of pesticide use on the project site:

1. Landscaping shall be designed with efficient irrigation to reduce runoff, promote surface infiltration, and minimize the use of fertilizers and pesticides that can contribute to water pollution.
2. Where feasible, landscaping shall be designed and operated to treat stormwater runoff by incorporating elements that collect, detain, and infiltrate runoff. In areas that provide detention of water, plants that are tolerant of saturated soil conditions and prolonged exposure to water shall be specified.
3. Plant materials selected shall be appropriate to site specific characteristics such as soil type, topography, climate, amount and timing of sunlight, prevailing winds, rainfall, air movement, patterns of land use, ecological consistency and plant interactions to ensure successful establishment.
4. Existing native trees, shrubs, and ground cover shall be retained and incorporated into the landscape plan to the maximum extent possible.
5. Proper maintenance of landscaping, with minimal pesticide use, shall be the responsibility of the property owner. ("Fact Sheet on Landscape Maintenance Techniques for Pest Reduction" may be used as an example education piece for property owners.)
6. Landscaping shall incorporate appropriate sustainable landscaping practices and programs such as Bay-Friendly Landscaping.

References

Site Design Measures

Atlanta Regional Commission, *Georgia Stormwater Management Manual Volume 2 (Technical Handbook)*, August 2001

City of Palo Alto, Municipal Code Title 18.12.050 Site Development Regulations.

City of Portland Environmental Services, *Stormwater Management Manual,* September 2002.

City of San Bruno Community and Economic Development Department, *San Bruno Redevelopment Project Area Plan Draft Environmental Impact Report*, prepared by ESA, March 1999.

City of Sunnyvale, *Industrial Pretreatment/Urban Runoff Program,* August 1998.

San Mateo Countywide Stormwater Pollution Prevention Program New Development Subcommittee, *Model Development Policies,* May 2001.

Washington State Department of Ecology, *Stormwater Management Manual for Western Washington*, August 2001.

Source Control Measures

BASMAA "Start at the Source Tools Handbook" (June 2000);

Alameda Countywide Clean Water Program (ACCWP) Model Conditions of Approval (1999);

City of Palo Alto Municipal Code Chapter 16.09, and revisions to Chapter 16.09 approved July 22, 2002;

City of Cupertino, Guidance for Selecting BMPs for Development Projects;

Example source control measures provided by Regional Board staff in Provision C.3.k. of the SCVURPPP NPDES Permit (October 2001);

San Francisco Bay Regional Water Quality Control Board, Municipal Regional Stormwater Permit, October 2009.

Pesticide Control Measures

Alameda Countywide Clean Water Program, Model Conditions of Approval, 1999.

City of Concord, North Carolina, *Unified Development Ordinance*, "Article 7, Landscaping and Buffering Standards" https://www.concordnc.gov/Portals/0/Documents/Planning/HistoricHandbook/appendix_h.pdf ,

IPM Access, IPM Information Service, http://www.ipmaccess.com/D-Mhome.html, *IPM Based Landscape Design.*

IPM Access, Integrated Pest Management Information Service, http://www.ipmaccess.com/des-cnsd.html, *Fundamentals of a Low Maintenance, Integrated Pest Management Approach to Landscape Design.*

King County Local Hazardous Waste Management Program, *Tri-County Integrated Pest and Vegetation Management: Guidelines.*

Appendix

I

Guidance on Determining Feasibility and Sizing of Rainwater Harvesting Systems

Table of Contents

I.1 Introduction

The MRP allows development projects to use infiltration, evapotranspiration, harvesting and use, or biotreatment to treat the full water quality design flow or volume of stormwater runoff, as specified in MRP Provision C.3.d. Project applicants are no longer required to evaluate the feasibility of infiltration of rainwater harvesting and use before proceeding to biotreatment.

If a project applicant desires to use rainwater harvesting systems to meet LID treatment requirements, there must be sufficient demand on the project site to use the water quality design volume, i.e., 80 percent of the average annual rainfall runoff, from the collection area. Appendix I provides guidance on how to the estimate the required landscaping or toilet flushing demand to meet C.3.d requirements. If the project appears to have sufficient demand for captured rainwater, Appendix I provides guidance on sizing the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume.

The information presented in this guidance is based on the "Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report" (referred to as the "Feasibility Report") prepared by the Bay Area Stormwater Management Agencies Association (BASMAA) and submitted to the Regional Water Board in 2011[1].

I.2 Rainwater Harvesting/Use Feasibility Guidance

Rooftop runoff is the source of stormwater most often collected in a harvesting/use system, because it often contains lower pollutant loads than at-grade surface runoff, and it provides accessible locations for collection in storage facilities via gravity flow.

The 2013 California Plumbing Code effective January 1, 2014 includes rainwater harvesting and graywater requirements, codes, and treatment standards. Chapter 17 of the Plumbing Code, which contains the rainwater harvesting requirements, allows rainwater to be harvested from rooftops for use in outdoor irrigation and some non-potable indoor uses. Rainwater collected from parking lots or other impervious surfaces at or below grade is considered graywater and subject to the water quality requirements for graywater in Chapter 16 of the Code. Some small catchment systems (5,000 gallons or less) being used for non-spray irrigation do not require permits – see Chapter 17 for more details[2].

The Plumbing Code defines rainwater as "precipitation on any public or private parcel that has not entered an offsite storm drain system or channel, a flood control channel, or any other stream channel, and has not previously been put to beneficial use."3 The Rainwater Capture Act of 2013, which took effect January 1, 2013, specifically states that the use of rainwater collected from rooftops does not require a water right permit from the State Water Resources Control Board.

I.3 Determining Feasibility of Rainwater Harvesting and Sizing of Cisterns

A key parameter needed to evaluate the feasibility of using harvested rainwater for irrigation or indoor toilet flushing use is the **Potential Rainwater Capture Area**. This is the impervious area from which rainwater may potentially be captured, if rainwater harvesting and use were implemented for a project. This is typically the roof area of the building(s) draining to the capture facilities.

The text below describes how to determine if you can use rainwater harvesting to treat the C.3.d amount of runoff on your project site.

Feasibility of Using Harvested Rainwater for Irrigation. Harvested rainwater can be used for irrigation in projects that include a considerable amount of landscaping. Follow the steps below to determine if adequate landscaping is available on the project site:

- Calculate the landscaping available on the project site. Note that the landscape area(s) would have to be contiguous and within the same Drainage Management Area to use harvested rainwater for irrigation via gravity flow.

[1] This report is available on the Urban Runoff Program's website. Go to www.scvurppp.org and click on "Low Impact Development" under Quick Links.

[2] www.iapmo.org/Pages/2013CaliforniaPlumbingCode.aspx Click on Chapter 17.

[3] www.iapmo.org/Pages/2013CaliforniaPlumbingCode.aspx Click on Chapter 2.

- Refer to Table 11 in Attachment 2 of this guidance, which present ratios of "Effective Irrigated Area to Impervious Area" (EIATIA) for rain gauge areas.
- Determine if your project has sufficient demand for rainwater for use in landscaping, and size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to your project. You can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of your project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Feasibility of Using Harvested Rainwater for Residential Toilet Flushing. If your project consists entirely of residential use, or you are considering rainwater harvesting for the residential portion of mixed use projects that include some residential use, follow the following steps:

- Calculate the dwelling units per impervious acre by dividing the number of dwelling units by the acres of the Potential Rainwater Capture Area.
- Refer to applicable Countywide table in Attachment *2.*
- Identify the number of dwelling units per impervious acre needed in your Rain Gauge Area to provide the toilet flushing demand required for rainwater harvesting.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to your project. The applicant can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of your project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Commercial/Institutional/Industrial Toilet Flushing. For projects that consist entirely of commercial, institutional, and/or industrial use, and for the commercial portion of mixed use projects, follow the following steps:

- Calculate the proposed interior floor area (sq.ft.) per acre of impervious surface by diving the interior floor area (sq.ft.) by the acres of the Potential Rainwater Capture Area.
- Refer to Table 10 in Attachment 2. This table identifies the required toilet flushing demand based on employees per impervious acre. Identify the square feet of non-residential interior floor area per impervious acre needed in your Rain Gauge Area to provide the toilet flushing demand required for rainwater harvest feasibility.

- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to your project. You can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of your project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

School Toilet Flushing. For school projects, follow the following steps:

- Calculate the proposed interior floor area (sq.ft.) per acre of impervious surface by diving the interior floor area (sq.ft.) by the acres of the Potential Rainwater Capture Area.
- Refer to Table 10 in the Feasibility Report (see Attachment 2), which identifies the required toilet flushing demand based on employees per impervious acre.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 3. Find the page that shows curves corresponding to the closest rain gauge to your project. You can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of your project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Mixed Commercial and Residential Use Projects. Follow the following steps for mixed use projects:

- Evaluate the residential toilet flushing demand based on the dwelling units per impervious acre for the residential portion of the project, following the instructions above, except you will use a prorated acreage of impervious surface, based on the percentage of the project dedicated to residential use.
- Evaluate the commercial toilet flushing demand per impervious acre for the commercial portion of the project, following the instructions above, except you will use a prorated acreage of impervious surface, based on the percentage of the project dedicated to commercial use.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to your project. You can select any

combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of your project's rainwater capture area.

- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Industrial Projects. Follow the steps below for industrial projects:

- If the project will include an industrial processing use for non-potable water, identify the demand for this use.
- Refer to Table 9 in Attachment 2. This Table identifies demand based on the required cistern volume and demand, for the maximum allowable drawdown time, to capture the C.3.d amount of runoff.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 3. Find the page that shows curves corresponding to the closest rain gauge to your project. You can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of your project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

I.4 Attachments

The following pages include the attachments listed below.

- Attachment 1: Toilet-Flushing Demand for Harvested Rainwater
- Attachment 2: Excerpts from the Feasibility Report (Map of Soil Hydraulic Conductivity and Rain Gauge Areas, Tables 8 through 11 and curves from the report's Appendix F)

Appendix I

Attachment 1: Toilet-Flushing Demand Required for Rainwater Harvesting Feasibility per Impervious Acre (IA) [1,2]

Table 1 - Alameda County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Berkeley	5,900	690	255	860	172,000	170	51,000
Dublin	4,100	480	177	590	118,000	120	36,000
Hayward	4,800	560	207	700	140,000	140	42,000
Palo Alto	2,900	340	125	420	84,000	90	27,000
San Jose	2,400	280	103	350	70,000	70	21,000

Table 2 - Santa Clara County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Morgan Hill	6,500	760	260	940	188,000	190	57,000
Palo Alto	2,900	340	116	420	84,000	90	27,000
San Jose	2,400	280	96	350	70,000	70	21,000

Table 3 – San Mateo County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Palo Alto	2,900	340	124	420	84,000	90	27,000
San Francisco	4,600	530	193	670	134,000	140	42,000
SF Oceanside	4,300	500	182	620	124,000	130	39,000

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Table 4 – Contra Costa County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Berkeley	5,900	690	254	860	172,000	170	51,000
Brentwood	4,200	490	180	610	122,000	120	36,000
Dublin	4,100	480	176	590	118,000	120	36,000
Martinez	5,900	690	254	860	172,000	170	51,000

Table 5 – Solano County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Lake Solano	9,000	1,050	362	1,300	260,000	270	81,000
Martinez	5,900	690	238	860	172,000	170	51,000

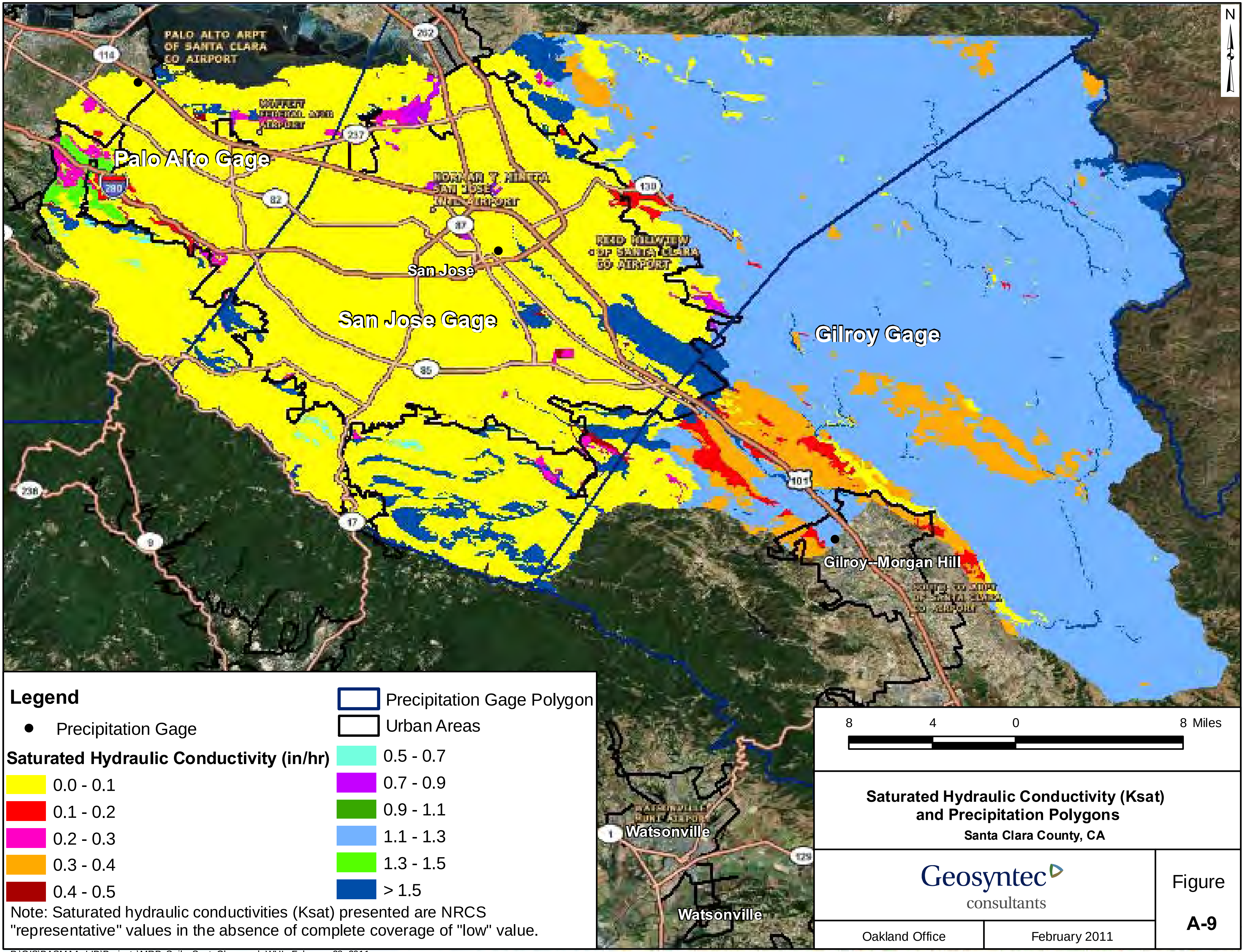
Notes:

1. Demand thresholds obtained from the “Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report” (LID Feasibility Report) submitted to the Regional Water Board on May 1, 2011.
2. Toilet flushing demands assume use of low flow toilets per the California Green Building Code.
3. See Attachment 3 to identify the rain gauge that corresponds to the project site.
4. Required demand per acre of impervious area to achieve 80% capture of the C.3.d runoff volume with the maximum allowable drawdown time for cistern of 50,000 gallons or less, from Table 9 of the LID Feasibility Report.
5. “Office/Retail” includes the following land uses: office or public buildings, hospitals, health care facilities, retail or wholesale stores, and congregate residences.
6. “Schools” includes day care, elementary and secondary schools, colleges, universities, and adult centers.
7. Residential toilet flushing demand identified in Table 10 of the LID Feasibility Report.
8. Residential toilet flushing demand divided by the countywide average number of persons per household (US Census data reported on www.abag.org), as follows: Alameda County: 2.71 persons per household; Santa Clara County: 2.92; San Mateo County: 2.74; Contra Costa County: 2.72; Solano County: 2.90.
9. Office/retail employee toilet flushing demand identified in Table 10 of the LID Feasibility Report.
10. Interior floor area required for rainwater harvest and use feasibility per acre of impervious area is based on the number of employees in Column 5 multiplied by an occupant load factor of 200 square feet per employee (reference: 2010 California Plumbing Code, Chapter 4, Plumbing Fixtures and Fitting Fixtures, Table A, page 62.)
11. School employee toilet flushing demand identified in Table 10 of the LID Feasibility Report. Each school employee represents 1 employee and 5 “visitors” (students and others).
12. Interior floor area required for rainwater harvest and use feasibility per acre of impervious area is based on the number of employees in Column 7 multiplied by 6 to account for visitors, then multiplied by an occupant load factor of 50 square feet per employee (reference: 2010 California Plumbing Code).

Appendix I

Attachment 2:
Excerpts from BASMAA's
Feasibility/Infeasibility Report

- Figure A-9: Saturated Hydraulic Conductivity (Ksat) and Precipitation Polygons, Santa Clara County, CA
- Table 8: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with a 48-hour Drawdown Time
- Table 9: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with the Longer Drawdown Time Allowable (Minimum Demand) for Cistern of 50,000 Gallons or Less
- Table 10: TUTIA Ratios for Typical Land Uses for Rain Gauges Analyzed
- Table 11: EIATIA Ratios for Rain Gauges Analyzed
- Figure F-7: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area: Morgan Hill
- Figure F-8: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area: Palo Alto
- Figure F-11: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area: San Jose



Note: Saturated hydraulic conductivities (Ksat) presented are NRCS "representative" values in the absence of complete coverage of "low" value.

Saturated Hydraulic Conductivity (Ksat) and Precipitation Polygons

Santa Clara County, CA

Geosyntec consultants

Oakland Office | February 2011

Figure A-9

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Table 8: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with a 48-hour Drawdown Time

Rain Gauge	Drawdown Time (hr.)	Required Cistern Size (gallons)	Required Demand (gal/day)
Berkeley	48	23,000	11,500
Brentwood	48	19,000	9,500
Dublin	48	21,000	10,500
Hayward	48	23,500	11,750
Lake Solano	48	29,000	14,500
Martinez	48	23,000	11,500
Morgan Hill	48	25,500	12,750
Palo Alto	48	16,500	8,250
San Francisco	48	20,000	10,000
San Francisco Oceanside	48	19,000	9,500
San Jose	48	15,000	7,500

If a longer drawdown time (and lower minimum demand) is desired, Table 9 includes the maximum drawdown time allowable to achieve 80 percent capture for a cistern sized at 50,000 gallons or less per acre of impervious area, along with the required cistern sizes and daily demands.

Table 9: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with the Longer Drawdown Time Allowable (Minimum Demand) for Cistern of 50,000 Gallons or Less

Rain Gauge	Drawdown Time (hr.)	Required Cistern Size (gallons)	Required Demand (gal/day)
Berkeley	180	44,000	5,900
Brentwood	240	42,000	4,200
Dublin	240	41,000	4,100
Hayward	240	47,500	4,800
Lake Solano	120	45,000	9,000
Martinez	180	44,000	5,900
Morgan Hill	180	49,000	6,500
Palo Alto	360	44,000	2,900
San Francisco	240	45,500	4,600
San Francisco Oceanside	240	43,000	4,300
San Jose	480	48,000	2,400

Table 10: TUTIA Ratios for Typical Land Uses for Rain Gauges Analyzed

Rain Gauge	Required Demand[1] (gal/day)	Toilet Users per Impervious Acre (TUTIA)[2]							
		Residential		Office/Retail		Schools		Industrial	
		Current	CGBC[3]	Current	CGBC	Current	CGBC	Current	CGBC
Assumed Per Capita Use per Day (gal/day)[4]		18	8.6	14	6.9	66	34	11	5.4
Berkeley	5,900	320	690	420	860	90	170	540	1,090
Brentwood	4,200	230	490	300	610	60	120	380	780
Dublin	4,100	220	480	290	590	60	120	370	760
Hayward	4,800	260	560	340	700	70	140	440	890
Lake Solano	9,000	490	1050	640	1,300	140	270	820	1,670
Martinez	5,900	320	690	420	860	90	170	540	1090
Morgan Hill	6,500	350	760	460	940	100	190	590	1,200
Palo Alto	2,900	160	340	210	420	40	90	260	540
San Francisco	4,600	250	530	330	670	70	140	420	850
San Francisco Oceanside	4,300	230	500	310	620	70	130	390	800
San Jose	2,400	130	280	170	350	40	70	220	440

Footnotes:
1 For a 50,000 or less gallon tank to achieve 80 percent capture within maximum allowable drawdown time (Table 9).
2 The TUTIA ratios are based on employee toilet users per impervious acre. These ratios were calculated using the daily toilet and urinal water usage from Table 5, which are per employee and encompass usage by visitors and students within the daily demand (assumes about 5 students per school employee).
3 CGBC = California Green Building Code Requirements water usage accounting for water conservation.
4 From Table 5, Toilet and Urinal Water Usage per Resident or Employee.

EIATA Ratios

Comparing the required daily demands for rainwater harvesting systems for both 48-hour drawdown times and maximum drawdown times to daily demands per irrigated acre, it becomes evident that the required demands are many times larger than irrigation demands. This can be translated into an ‘Effective Irrigated Area to Impervious Area’ (EIATIA) ratio by dividing the required rainwater harvesting system demand by the daily irrigation demand (shown in Table 7). Since both demands are calculated on a per acre basis, the EIATIA ratio represents the number of acres of irrigated area needed per acre of impervious surface to meet the demand needed for 80 percent capture. EIATIA ratios were analyzed for the rain gauges used for analysis and the evapotranspiration data listed in Table F-1. These ratios, as well as the required total imperviousness (assuming a project includes the impervious tributary area and the irrigated area only) are included in Table 11.

Table 11: EIATIA Ratios for Rain Gauges Analyzed

Rain Gauge	Required Daily Demand[1] (gal/day)	ET Data Location[2]	Conservation Landscaping			Turf Areas		
			Demand per Irrigated Acre[3]	EIATIA	Resultant Imper-viousness (%)	Demand per Irrigated Acre[3]	EIATIA	Resultant Imper-viousness (%)
Berkeley	5,900	Oakland	420	14.0	7%	850	6.9	13%
Brentwood	4,200	Brentwood	420	10.0	9%	850	4.9	17%
Dublin	4,100	Pleasanton	430	9.5	9%	850	4.8	17%
Hayward	4,800	Fremont	520	9.2	10%	1,040	4.6	18%
Lake Solano	9,000	Fairfield	420	21.4	4%	840	10.7	9%
Martinez	5,900	Martinez	380	15.5	6%	760	7.8	11%
Morgan Hill	6,500	Morgan Hill	500	13.0	7%	1,000	6.5	13%
Palo Alto	2,900	Redwood City	450	6.4	13%	900	3.2	24%
San Francisco	4,600	San Francisco	360	12.8	7%	720	6.4	14%
San Francisco Oceanside	4,300	San Francisco	360	11.9	8%	720	6.0	14%
San Jose	2,400	San Jose	470	5.1	16%	940	2.6	28%

Footnotes:
1 To achieve 80 percent capture within maximum allowable drawdown time (Table 9).
2 Closest location selected, from Table F-1.
3 From Table 7.

3.3.3 Summary

In summary, TUTIA ratios indicate that dense land uses would be required to provide the needed demand to make rainwater harvesting feasible in the MRP area. A project must have sufficiently high toilet flushing uses to achieve 80 percent capture within the maximum allowable drawdown time (see Table 9 for maximum allowable drawdown time for a 50,000 gallon tank or less). For instance, approximately 280 to 1,050 residential toilet users (roughly 90 – 130 dwelling units per acre[5]) are required, depending on location, per impervious acre to meet the demand needed for 80 percent capture with the maximum allowable drawdown time and CA Green Building Code flush requirements. Meeting the demand requirements would entail a very dense housing

5 Assuming three residents per dwelling unit.

Figure F-7: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Morgan Hill

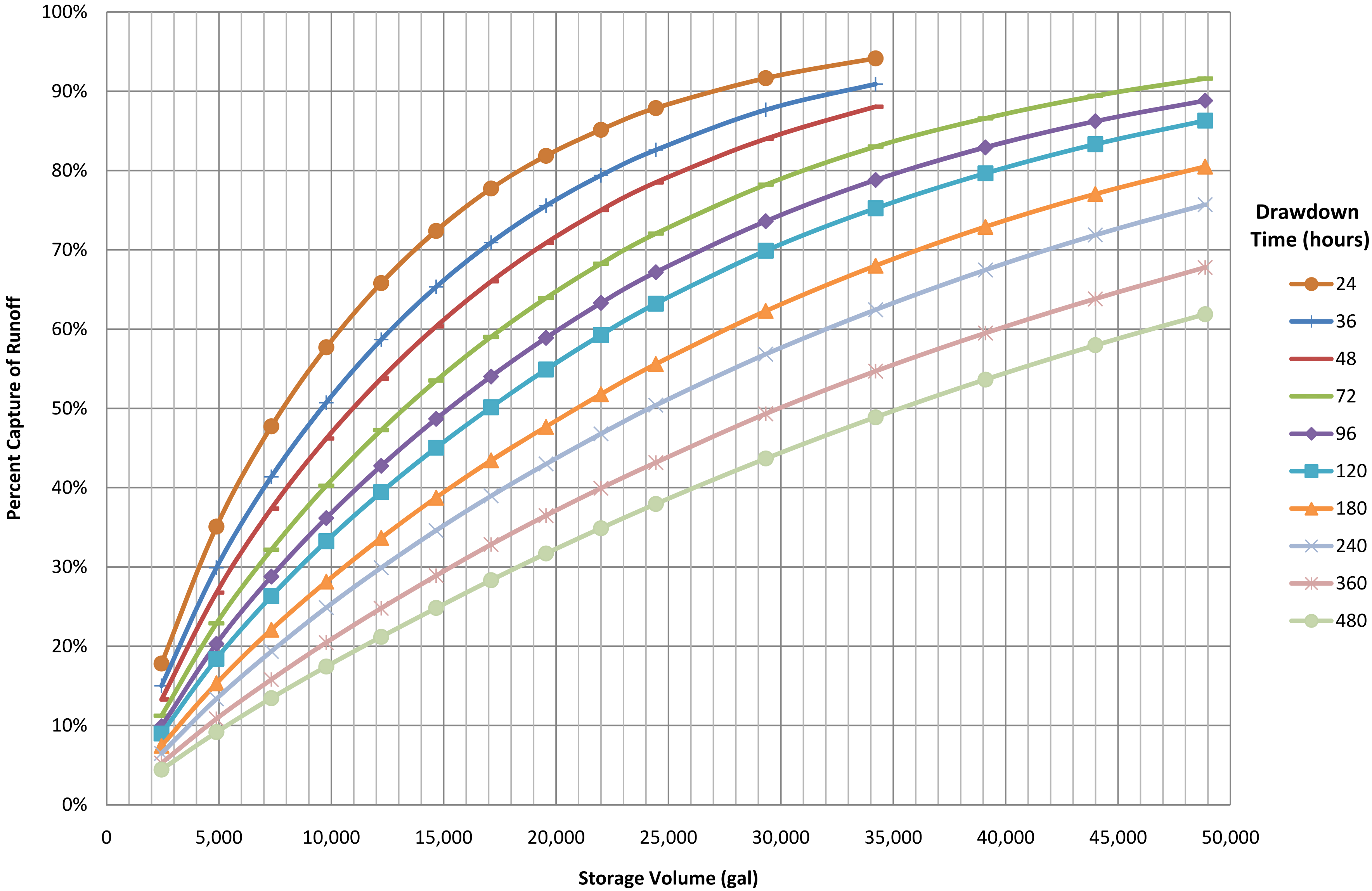
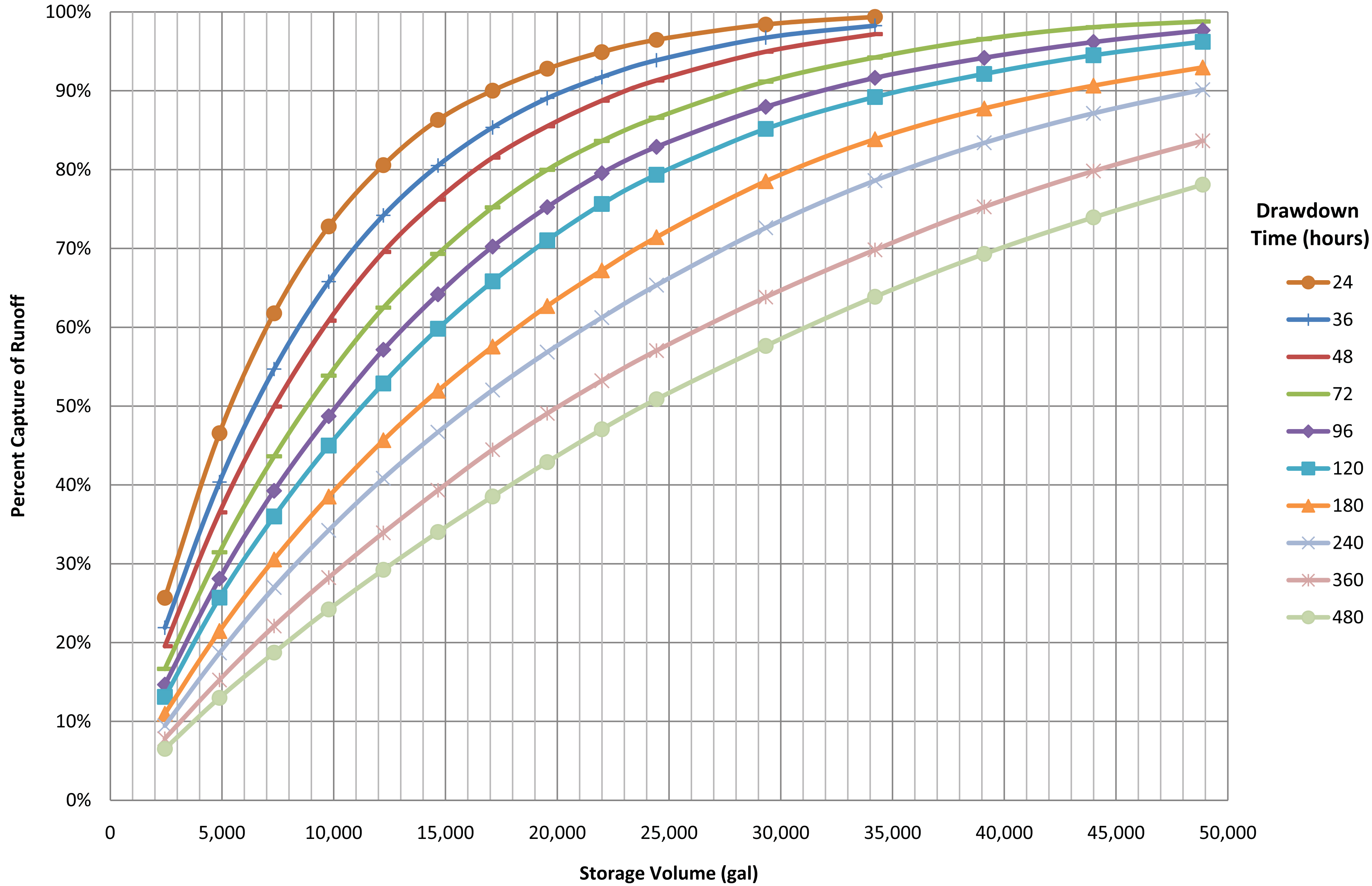


Figure F-8: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Palo Alto



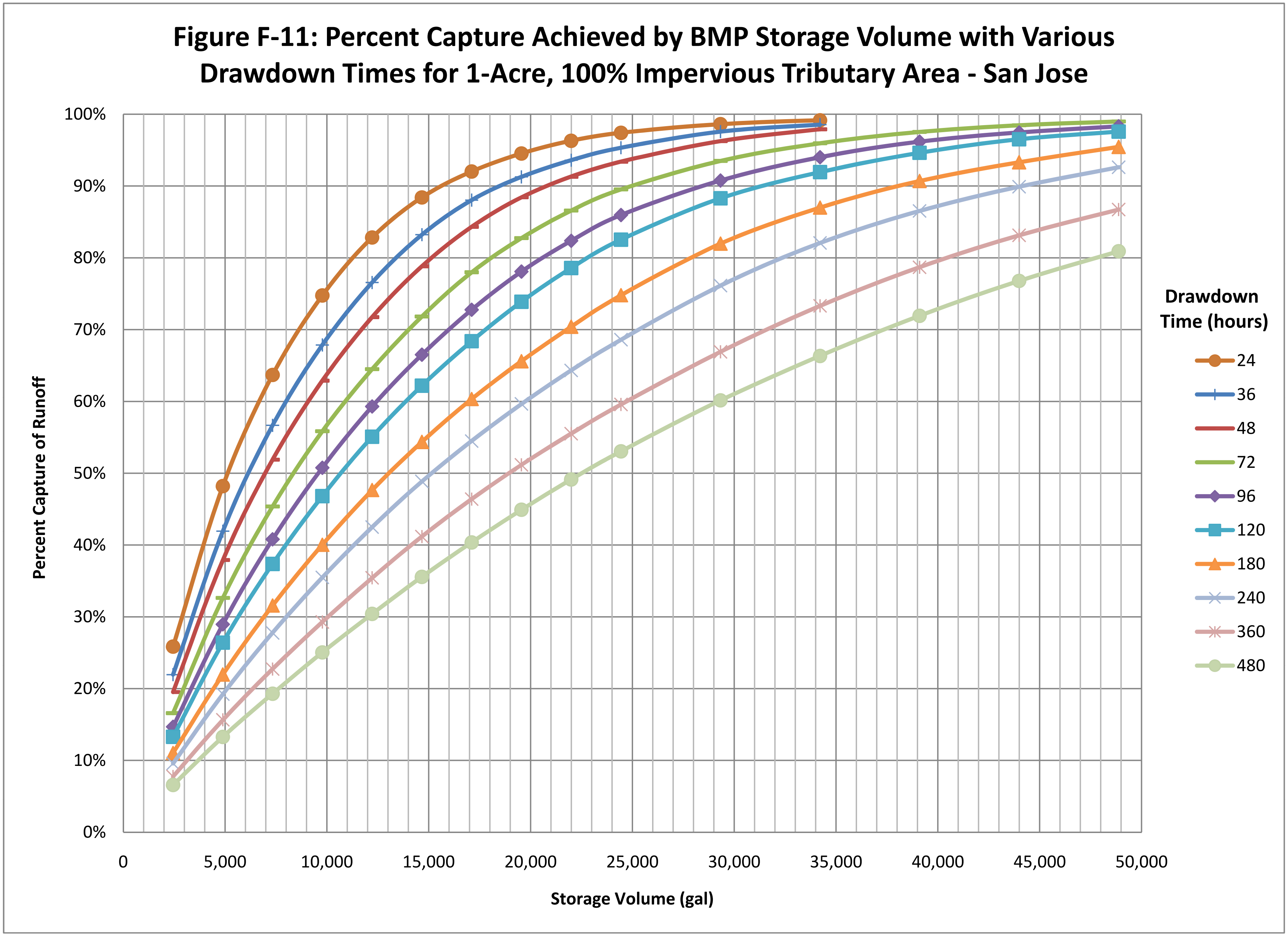


Figure F-11: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - San Jose
Percent Capture of Runoff
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Storage Volume (gal)
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480

Appendix

J

Special Projects

Table of Contents

J.1 Introduction

On November 28, 2011, the San Francisco Bay Regional Water Quality Control Board (Water Board) amended the MRP to allow LID treatment reduction credits for three categories of "Smart Growth" development, specifically urban infill, high-density, and transit oriented development projects, called "Special Projects". LID treatment credits are allowed for Special Projects because, when considered at the watershed scale, these types of development projects can either reduce existing impervious surfaces, or create less "accessory" impervious areas and automobile-related pollutant impacts, and thus these types of projects were recognized by the Water Board as having inherent water quality and other environmental benefits. When the MRP was reissued on November 19, 2015, certain aspects of Provision C.3.e.ii were revised.

Projects that receive LID treatment reduction credits are allowed to use specific types of non-LID treatment, if the use of LID treatment is first evaluated and determined to be infeasible. As described in Section J.7, documentation must be provided to show why the use of LID treatment is infeasible and LID treatment reduction credits will be used.

The types of non-LID treatment that may be used are:

- High flow-rate media filters, and
- High flow-rate tree well filters (also called high flow-rate tree box filters).

The three categories of Special Projects are:

- Category A: Small Infill Projects (≤ ½ acre of impervious surface)
- Category B: High Density Projects (≤ 2 acres of impervious surface)
- Category C: Transit-Oriented Development

Any Regulated Project that meets all the criteria for more than one Special Project Category may only use the LID treatment reduction credit allowed under one of the categories. For example, a Regulated Project that may be characterized as a Category B or C Special Project may use the LID Treatment Reduction Credit allowed under Category B or Category C, but not the sum of both.

J.2 Category A: Small Infill Projects

The defining criteria and LID treatment reduction credits for Category A projects are described below.

CRITERIA FOR CATEGORY A (SMALL INFILL) SPECIAL PROJECTS

To be considered a Category A Special Project, a Regulated Project must meet <u>all</u> of the following criteria:

1. Be built as part of the municipality's stated objective to preserve or enhance a pedestrian-oriented type of urban design, such as that of a General Plan or a specific area plan.
2. Be located in the municipality's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian oriented commercial district, or historic preservation site and/or district.
3. Create and/or replace one half acre or less of impervious surface area.
4. Include no surface parking, except for incidental surface parking. Incidental surface parking is allowed only for emergency vehicle access, Americans with Disabilities Act (ADA) accessibility, and passenger and freight loading zones.
5. Have at least 85% coverage of the entire project site by permanent structures. The remaining 15% portion of the site is to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping, and stormwater treatment.

LID TREATMENT REDUCTION CREDIT FOR CATEGORY A (SMALL INFILL) SPECIAL PROJECTS

Any Category A Special Project may qualify for 100% LID treatment reduction credit, which would allow the Category A Special Project to treat up to 100% of the amount of stormwater runoff specified by Provision C.3.d with either one or a combination of the two types of non-LID treatment systems identified in Section J.1. Prior to receiving the LID treatment reduction credits, the applicant must demonstrate to the satisfaction of municipal staff that LID treatment is infeasible, as described in Section J.6.

J.3 Category B: High Density Projects

The defining criteria and LID treatment reduction credits for Category B projects are described below.

CRITERIA FOR CATEGORY B (HIGH DENSITY) SPECIAL PROJECTS

To be considered a Category B Special Project, a Regulated Project must meet all of the following criteria:

1. Be built as part of the municipality's stated objective to preserve or enhance a pedestrian-oriented type of urban design, such as that of a General Plan or a specific area plan.
2. Be located in a Permittee's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian oriented commercial district, or historic preservation site and/or district.
3. Create and/or replace greater than one-half acre but no more than 2 acres of impervious surface area.
4. Include no surface parking, except for incidental surface parking. Incidental surface parking is allowed only for emergency vehicle access, ADA accessibility, and passenger and freight loading zones.
5. Have at least 85% coverage of the entire project site by permanent structures. The remaining 15% portion of the site is to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping, and stormwater treatment.

LID TREATMENT REDUCTION CREDIT FOR CATEGORY B (HIGH DENSITY) SPECIAL PROJECTS

For Category B Special Projects, the maximum LID treatment reduction credit allowed depends on the density achieved by the project in accordance with the criteria shown in Table J-1. Density is expressed as Floor Area Ratio (FAR)[1] for commercial projects and as Dwelling Units per Acre (DU/Ac)[2] (gross density) for residential development projects. Density of mixed-use development projects may be expressed as FAR or DU/Ac. The credits are expressed in percentages of the amount of stormwater runoff specified by Provision C.3.d for the Project's drainage area. The Special Project may treat the percentage of the C.3.d amount of runoff that corresponds to the project's density using either one or a combination of the two types of non-LID treatment systems listed in Section J.1. To be eligible to receive the LID treatment

[1] Floor Area Ratio = The ratio of the total floor area on all floors of all buildings at a project site (except structures, floors, or floor areas dedicated to parking) to the total project site area.

[2] Gross Density in Dwelling Units per Acre = The total number of residential units divided by the acreage of the entire site area, including land occupied by public rights-of-way, recreational, civic, commercial and other non-residential uses

reduction credits, the applicant must demonstrate to the satisfaction of municipal staff that LID treatment not possible, as described in Section I.7. Any remaining amount of stormwater runoff must be treated with LID treatment measures.

Table J-1
Category B LID Treatment Reduction Credits, Based on the Density of Development

% of the C.3.d Amount of Runoff that May Receive Non-LID Treatment	Land Use Type	Density Required to Obtain the LID Treatment Reduction Credit
50%	Commercial	Floor Area Ratio 2:1
50%	Residential	50 welling nits/cre
50%	Mixed Use	Floor Area Ratio 2:1, or 50 Dwelling Units/Acre
75%	Commercial or Mixed Use	Floor Area Ratio 3:1
75%	Residential	75 Dwelling Units/Acre
50%	Mixed Use	Floor Area Ratio 3:1, or 75 Dwelling Units/Acre
100%	Commercial or Mixed Use	Floor Area Ratio 4:1
100%	Residential	100 Dwelling Units/Acre
100%	Mixed Use	Floor Area Ratio 4:1, or 100 Dwelling Units/Acre

J.4 Category C: Transit-Oriented Development

The defining criteria and LID treatment reduction credits for Category C projects are described below.

CRITERIA FOR CATEGORY C (TRANSIT ORIENTED DEVELOPMENT) SPECIAL PROJECTS

To be considered a Category C Special Project, a Regulated Project must meet all of the following criteria:

1. Be characterized as a non auto-related land use project. That is, Category C specifically excludes any Regulated Project that is a stand-alone surface parking lot; car dealership; auto and truck rental facility with onsite surface storage; restaurant,

bank or pharmacy with drive-through lanes; gas station, car wash, auto repair and service facility; or other auto-related project unrelated to the concept of transit-oriented development.

2. If a commercial project, achieve an FAR of at least 2:1.
3. If a residential development project, achieve a gross density of at least 25 DU/Ac.
4. If a mixed-use development project, achieve an FAR of at least 2:1, or a gross density of 25 DU/Ac.

LID TREATMENT REDUCTION CREDIT FOR CATEGORY C (TRANSIT-ORIENTED DEVELOPMENT)

For Category C Special Projects, the maximum LID treatment reduction credit allowed is the sum of three different types of credits for which the Category C Special Project qualifies. These credits are categorized as follows:

- Location Credits,
- Density Credits, and
- Minimized Surface Parking Credits.

The Special Project may use either one or a combination of the two types of non-LID treatment systems listed in Section J.1 to treat the total percentage of the C.3.d amount of stormwater runoff that results from adding together the Location, Density and Minimized Surface Parking credits for which the project is eligible. In addition, to be eligible to receive the LID treatment reduction credits, the applicant must demonstrate to the satisfaction of municipal staff that LID treatment is infeasible, as described in Section J.7. Any remaining amount of stormwater runoff must be treated with LID treatment measures.

Location Credits (Transit-Oriented Development)

Location credits are based on the project site's proximity to a transit hub[3], or its location within a planned Priority Development Area (PDA)[4]. Only one Location Credit may be used by an individual Category C Special Project, even if the project qualifies for multiple Location Credits. In order to qualify for a Location Credit, at least 50 percent or more of a Category C Special Project's site must be located within the ¼ or ½ mile radius of an existing or planned transit hub, or 100 percent of the site must be located within a PDA. The Location Credits, presented in Table J-2, are expressed in percentages of the amount of stormwater runoff specified by Provision C.3.d for the project's drainage area.

[3] Transit hub is defined as a rail, light rail, or commuter rail station, ferry terminal, or bus transfer station served by three or more bus routes (i.e., a bus stop with no supporting services does not qualify). A planned transit hub is a station on the MTC's Regional Transit Expansion Program list, per MTC's Resolution 3434 (revised April 2006), which is a regional priority funding plan for future transit stations in the San Francisco Bay Area.

[4] A planned Priority Development Area (PDA) is an infill development area formally designated by the Association of Bay Area Government's / Metropolitan Transportation Commission's FOCUS regional planning program. FOCUS is a regional incentive-based development and conservation strategy for the San Francisco Bay area.

Table J-2 Location Credits for Category C: Transit Oriented Development (Only one Location Credit may be used)	
% of the C.3.d Amount of Runoff that May Receive Non-LID	**Project Site Location**
50%	50% or more of the site is located within a ¼ mile radius of an existing or planned transit hub
25%	50% or more of the site is located within a ½ mile radius of an existing or planned transit hub
25%	100% of the site is located within a PDA

Density Credits (Transit-Oriented Development)

To qualify for any Density Credits, a Category C Special Project must first qualify for one of the Location Credits listed above. The Density Credits are based on the density achieved by the project in accordance with the criteria shown in Table J-3. Density is expressed as Floor Area Ratio (FAR) for commercial and as Dwelling Units per Acre (DU/Ac) (gross density) for residential development projects. For mixed-use development projects, density may be expressed as DU/Ac or FAR. The credits are expressed in percentages of the amount of stormwater runoff specified in Provision C.3.d. Commercial Category C projects do not qualify for Density Credits based on DU/Ac, and residential Category C Projects do not qualify for Density Credits based on FAR. Only one Density Credit may be used by an individual Category C Special Project, even if the project qualifies for multiple Density Credits.

Table J-3 **Density Credits for Category C: Transit Oriented Development** (Only one Density Credit may be used)		
% of the C.3.d Amount of Runoff that May Receive Non-LID Treatment	**Land Use Type**	**Density Required to Obtain the Density Credit**
10%	Commercial	Floor Area Ratio 2:1
10%	Residential	30 Dwelling Units/Acre
10%	Mixed Use	Floor Area Ratio 2:1, or 30 Dwelling Units/Acre
20%	Commercial or Mixed Use	Floor Area Ratio 4:1
20%	Residential	60 Dwelling Units/Acre
20%	Mixed Use	Floor Area Ratio 3:1, or 60 Dwelling Units/Acre
30%	Commercial or Mixed Use	Floor Area Ratio 6:1
30%	Residential	100 Dwelling Units/Acre
30%	Mixed Use	Floor Area Ratio 6:1, or 100 Dwelling Units/Acre

Minimized Surface Parking Credits (Transit-Oriented Development)

To qualify for any Minimized Surface Parking Credits, a Category C Special Project must first qualify for one of the Location Credits listed above. The LID treatment reduction credit is based on the amount of post-project impervious surface area that is dedicated to at-grade surface parking, in accordance with the criteria shown in Table J-4. The credits are expressed in percentages of the amount of stormwater runoff specified in Provision C.3.d. If the Minimized Surface Parking Credit is applied, any at-grade surface parking must be treated with LID treatment measures. If a project does not qualify for Minimized Surface Parking Credit or is not claiming that credit, credits (e.g.,non-LID treatment) can be used to treat surface parking. Only one Minimized Surface Parking Credit may be used by an individual Category C Special Project, even if the project qualifies for multiple Minimized Surface Parking Credits.

Table J-4
Minimized Surface Parking Credits for Category C: Transit Oriented Development
(Only one Minimized Surface Parking Credit may be used)

% of the C.3.d Amount of Runoff that May Receive Non-LID	Percentage of the Total Post-Project Impervious Surface Dedicated to At-Grade, Surface Parking
10%	10% or less
20%	0% (except for emergency vehicle access, ADA accessibility and passenger and freight loading zones)

The MRP does not specify how to calculate the amount of surface parking. SCVURPPP recommends not including the drive aisle (i.e., only including parking stalls) if the drive aisle is used for access to the building, for calculating Special Project credits. The whole parking lot (parking stalls and drive aisles) should be used to evaluate if the site exceeds the C.3 size thresholds as discussed in Section 2.3.

J.5 Calculating the LID Treatment Reduction Credit (Special Projects Worksheet)

The Special Projects Worksheet at the end of Appendix J should be used to document that your project meets the criteria for Special Project Categories A, B, and/or C and to calculate the total allowable LID treatment reduction credit for which the project is eligible. As mentioned earlier, if the project meets all the criteria for more than one Special Project Category, it may only use the LID treatment reduction credit allowed under one of the categories. However, the worksheet may be used to compute the credit allowed under each category in order to determine which category would allow the most credit.

The municipality may require submittal of the Special Projects Worksheet, or a similar worksheet, as part of the stormwater management plan for the project. To download an electronic version of the worksheet, visit the Program's website www.scvurppp.org and click on "Low Impact Development" (under Quick Links on the home page).

J.6 Applying the LID Treatment Reduction Credits to Special Projects

The following steps should be used to develop the stormwater management plan for Special Projects and apply the LID treatment reduction credits allowed for the project.

1. Determine the total amount of impervious surface created and/or replaced on site that is subject to C.3 treatment requirements, and the associated C.3.d volume of runoff. This is the area and volume for which the LID treatment reduction credits will be applied to determine the maximum amount of runoff that can be treated using non-LID treatment measures.

2. Define drainage management areas on the site, and identify self-treating and self-retaining areas, if any (see Chapter 4).
3. Adjust drainage management areas as needed to route the amount of runoff that needs to be treated with LID treatment measures and as much of the rest of the C.3.d amount of runoff as possible to LID treatment measures.
4. For the portion of runoff that must be treated with non-LID treatment measures (up to the allowable LID treatment reduction credit), document the reasons why LID treatment measures cannot be used (see Section J.7).

J.7 LID Infeasibility Requirement for Special Projects

In order to obtain approval for the LID treatment reduction credits, the applicant must provide a narrative discussion of the feasibility or infeasibility of using 100 percent LID treatment, onsite and offsite, as part of the stormwater management plan. Both technical and economic feasibility or infeasibility should be discussed, as applicable. The narrative discussion should establish all of the following:

- The infeasibility of treating 100% of the amount of runoff identified in Provision C.3.d for the Regulated Project's drainage area with LID treatment measures onsite.
- The infeasibility of treating 100% of the amount of runoff identified in Provision C.3.d for the Regulated Project's drainage area with LID treatment measures onsite or paying in-lieu fees to treat 100% of the Provision C.3.d runoff with LID treatment measures at an offsite or Regional Project.
- The infeasibility of treating 100% of the amount of runoff identified in Provision C.3.d for the Regulated Project's drainage area with some combination of LID treatment measures onsite, offisite, and/or paying in-lieu fees toward an offsite or Regional Project.

The narrative discussion should describe how the routing of stormwater runoff has been optimized to route as much runoff as possible to LID treatment measures. A discussion should also be provided for each area of the site for which runoff must be treated with non-LID treatment measures, and should include the following:

1. Uses of impervious surfaces that preclude the use of LID treatment; and
2. Technical constraints that preclude the use of any landscaped areas for LID treatment, such as:
    a. Inadequate size to accommodate biotreatment facilities that meet the sizing requirements for the drainage area;
    b. Slopes too steep to terrace;
    c. Proximity to an unstable bank or slope;
    d. Environmental constraints (e.g., landscaped area is within riparian corridor);
    e. High groundwater or shallow bedrock;
    f. Conflict with subsurface utilities;
    g. Cap over polluted soil or groundwater;

h. Lack of head or routing path to move collected runoff to the landscaped area or from the landscaped area to the disposal point;

i. Other conflicts or required uses that preclude use for stormwater treatment.

In addition, the applicant must demonstrate to the municipality performing the project review that it is infeasible to provide LID treatment of an equivalent amount of runoff offsite either at a regional project or on other property owned by the project proponent in the same watershed (i.e., that alternative compliance, as described in Chapter 9, is infeasible). Check with the local municipality to determine if there are any regional projects available for alternative compliance purposes (at the time of completion of this Handbook, there were none in Santa Clara Valley).

Special Projects Worksheet

Project Name:

Project Address:

Applicant/Developer Name:

1. "Special Project" Determination:

Special Project Category "A"

Does the project have ALL of the following characteristics?

- ☐ Located in a municipality's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian-oriented commercial district, or historic preservation site and/or district[1];
- ☐ Creates and/or replaces 0.5 acres or less of impervious surface;
- ☐ Includes no surface parking, except for incidental parking for emergency vehicle access, ADA access, and passenger or freight loading zones;
- ☐ Has at least 85% coverage of the entire site by permanent structures. The remaining 15% portion of the site may be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping and stormwater treatment.

☐ No (continue) ☐ Yes – complete Section 2 of the Special Project Worksheet

Special Project Category "B"

Does the project have ALL of the following characteristics?

- ☐ Located in a municipality's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian-oriented commercial district, or historic preservation site and/or district[1];
- ☐ Creates and/or replaces an area of impervious surface that is greater than 0.5 acres, and no more than 2.0 acres;
- ☐ Includes no surface parking, except for incidental parking for emergency access, ADA access, and passenger or freight loading zones;
- ☐ Has at least 85% coverage of the entire site by permanent structures. The remaining 15% portion of the site may be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping and stormwater treatment;
- ☐ Minimum Gross[2] density of either 50 dwelling units per acre (for residential or mixed use projects) or a Floor Area Ratio[3] (FAR) of 2:1 (for commercial or mixed use projects)

☐ No (continue) ☐ Yes – complete Section 2 of the Special Project Worksheet

Special Project Category "C"

Does the project have ALL of the following characteristics?

- ☐ At least 50% of the project area is within 1/2 mile of an existing or planned transit hub[4] or 100% within a planned Priority Development Area[5];
- ☐ The project is characterized as a non-auto-related use[6]; and
- ☐ Minimum Gross density of either 25 dwelling units per acre (for residential or mixed use projects) or a Floor Area Ratio (FAR) of 2:1 (for commercial or mixed use projects)

☐ No ☐ Yes – complete Section 2 of the Special Project Worksheet

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[1] And built as part of a municipality's stated objective to preserve/enhance a pedestrian-oriented type of urban design.

[2] Gross density is defined as the total number of residential units divided by the acreage of the entire site area, including land occupied by public right-of-ways, recreational, civic, commercial and other non-residential uses

[3] Floor Area Ratio is defined as the ratio of the total floor area on all floors of all buildings at a project site (except structures, floors, or floor areas dedicated to parking) to the total project site area.

[4] "Transit hub" is defined as a rail, light rail, or commuter rail station, ferry terminal, or bus transfer station served by three or more bus routes. (A bus stop with no supporting services does not qualify.)

[5] A "planned Priority Development Area" is an infill development area formally designated by the Association of Bay Area Government's / Metropolitan Transportation Commission's FOCUS regional planning program.

[6] Category C specifically excludes stand-alone surface parking lots; car dealerships; auto and truck rental facilities with onsite surface storage; fast-food restaurants, banks or pharmacies with drive-through lanes; gas stations; car washes; auto repair and service facilities; or other auto-related project unrelated to the concept of transit oriented development.

2. LID Treatment Reduction Credit Calculation:

Category	Impervious Area Created/Replaced (acres)	Site Coverage (%)	Project Density or FAR	Density/Criteria	Allowable Credit (%)	Applied Credit (%)
A			N.A.	N.A.	100%	
B				Res ≥ 50 DU/ac or FAR ≥ 2:1	50%	
				Res ≥ 75 DU/ac or FAR ≥ 3:1	75%	
				Res ≥ 100 DU/ac or FAR ≥ 4:1	100%	
C				**Location credit (select one)[7]:**		
				Within ¼ mile of transit hub	50%	
				Within ½ mile of transit hub	25%	
				Within a planned PDA	25%	
				Density credit (select one):		
				Res ≥ 30 DU/ac or FAR ≥ 2:1	10%	
				Res ≥ 60 DU/ac or FAR ≥ 4:1	20%	
				Res ≥ 100 DU/ac or FAR ≥ 6:1	30%	
				Parking credit (select one):		
				≤ 10% at-grade surface parking[8]	10%	
				No surface parking	20%	
				TOTAL TOD CREDIT =		

[7] To qualify for the location credit, at least 50% of the project's site must be located within the ¼ mile or ½ mile radius of an existing or planned transit hub, as defined on page 1, footnote 2. A planned transit hub is a station on the MTC's Regional Transit Expansion Program list, per MTC's Resolution 3434 (revised April 2006), which is a regional priority funding plan for future transit stations in the San Francisco Bay Area. To qualify for the PDA location credit, 100% of the project site must be located within a PDA, as defined on page 1, footnote 3.

[8] The at-grade surface parking must be treated with LID treatment measures.

Attachment J2:
Template for Narrative Discussion of LID Feasibility or Infeasibility

For each potential Special Project, provide a narrative discussion of the feasibility or infeasibility of 100% LID treatment, onsite and offsite, using the template provided below. Insert information specific to the project where indicated with brackets and yellow shading [[== insert information here ==]]. Delete this text box before completing your narrative discussion.

[[== Insert Project Name ==]]
Narrative Discussion of Low Impact Development Feasibility/Infeasibility

This report provides a narrative discussion of the feasibility or infeasibility of providing 100 percent low impact development (LID) treatment for [[== Insert Project Name ==]], which has been identified as a potential Special Project, based on Special Project criteria provided in Provision C.3.e.ii of the Municipal Regional Stormwater Permit (MRP). This report is prepared in accordance with the requirement in MRP Provision C.3.e.vi.(2), to include in Special Projects reporting a narrative discussion of the feasibility or infeasibility of 100 percent LID treatment onsite or offsite.

1. Feasibility/Infeasibility of Onsite LID Treatment

The project site was reviewed with regard to the feasibility and infeasibility of onsite LID treatment. The results of this review showed that it was [[== feasible/infeasible ==]] to treat [[==___ percent [fill in percentage] ==]] of the C.3.d amount of runoff with LID treatment. The findings of this review are presented below.

a. **On-site Drainage Conditions.** [[== Describe the site drainage, including the site slope, direction of flow, and how the site was divided into drainage management areas that will each drain to a separate stormwater treatment measure.==]]

b. **Self-treating and Self-Retaining Areas and LID Treatment Measures.** [[== Describe any drainage management areas for which self-treating or self-retaining areas (such as pervious pavement, green roofs or landscaped areas) or LID treatment measures are provided. If there are none, delete this paragraph. ==]].

c. **Maximizing Flow to LID Features and Facilities.** [[== Explain how the routing of drainage has been optimized to route as much drainage as possible to LID features and facilities (if any). If there are no LID features or facilities, delete this paragraph. ==]]

d. **Constraints to Providing On-site LID.** The drainage management areas that are proposed to drain to tree-box type high flow rate biofilters and/or vault-based high flow rate media filters include some areas that are not covered by buildings. [[== Briefly describe all areas within these portions of the site that are not covered by buildings.==]] In these areas, conditions and technical constraints are present that preclude the use of LID features and facilities, as described below.

   i. Impervious paved areas: [[== Describe the uses of all impervious paved areas in these areas, and why the uses preclude the use of LID treatment.==]]

   ii. Landscaped areas: [[== For any of the following bullet points that are applicable, briefly describe how the conditions apply to the applicable landscaped areas. Delete any of the bullet points that are not applicable.==]]

   - Inadequate size to accommodate biotreatment facilities that meet sizing requirements for the tributary area.
   - Slopes too steep to terrace;
   - Proximity to an unstable bank or slope;
   - Environmental constraints (for example, landscaped area is within riparian corridor);
   - High groundwater or shallow bedrock;
   - Conflict with subsurface utilities;
   - Cap over polluted soil or groundwater;

- Lack of head or routing path to move collected runoff to the landscaped area or from the landscaped area to a disposal point;
- Other conflicts, including required uses that preclude use for stormwater treatment (describe in more detail).

2. **Feasibility/Infeasibility of Off-Site LID Treatment.** The possibility of providing off-site LID treatment was found to be [[== feasible/infeasible ==]] for the following reasons.

   i. [[**==** Describe whether the project proponent owns or otherwise controls land within the same watershed of the project that can accommodate in perpetuity off-site bioretention facilities adequately sized to treat the runoff volume of the primary project. ==]]

   ii. [[**==** Indicate whether there is a regional LID stormwater mitigation program available to the project for in-lieu C.3 compliance. ==]]

Appendix

K

Standard Specifications for Lot-Scale Measures for Small Projects

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K.1 Permit Requirements for Small Projects

Since December 1, 2012, specific sizes of small projects are required meet site design requirements in Provision C.3.i of the Municipal Regional Stormwater Permit (MRP). This applies to projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface, and individual single family home projects that create and/or replace 2,500 square feet or more of impervious surface. Applicable projects must implement at least one of the following site design measures:

- Direct roof runoff into cisterns or rain barrels for use.
- Direct roof runoff onto vegetated areas.
- Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas.
- Direct runoff from driveways/uncovered parking lots onto vegetated areas.
- Construct sidewalks, walkways, and/or patios with permeable surfaces.
- Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.

Do the Requirements Apply to My Project?

The new requirements apply to your project if it meets the size thresholds described above, and it received ***final discretionary approval on or after December 1, 2012***. If your project does not require discretionary approval, such as tract map approval, conditional use permit, or design review, then the requirements apply if the building permit is issued on or after December 1, 2012.

Please note that projects in the following four ***"Special Land Use Categories"*** that create and/or replace 5,000 square feet or more of impervious surface are required to implement stormwater treatment, source control measures, AND site design measures:

- Restaurants;
- Retail gasoline outlets;
- Auto service facilities; and
- Surface parking (stand-alone or part of another use).

For these "Special Land Use Category" projects, the implementation of LID site design and stormwater treatment systems will satisfy the requirements of Provision C.3.i.

Consistent with Provision C.3.c, ***interior remodels and routine maintenance or repair are excluded from the Provision C.3.i requirements***, including:

- Roof replacement. This exclusion applies to all roof replacement projects, including those that remove the entire roof.
- Exterior wall surface replacement;
- Pavement resurfacing within the existing footprint. This exclusion applies to any routine maintenance of paved surfaces within the existing footprint, including the repaving that occurs after conducting utility work under the pavement, and the routine reconstruction of pavement, which may include removal and replacement of the subbase. If a repaving project results in changes to the footprint, grade, layout or configuration of the paved surfaces, it would trigger the requirements of Provision C.3. The pavement resurfacing exclusion also applies to the reconstruction of existing roads and trails.

K.2 Regional Guidance for Site Design Measures

To help you select and design site design measures appropriate for the project site, the Santa Clara Valley Urban Runoff Pollution Prevention Program collaborated regionally through the Bay Area Stormwater Management Agencies Association (BASMAA) to develop four fact sheets that provide guidance regarding the six site design measures listed above. Table K-1 shows how the fact sheets, which are included at the end of this appendix, correspond with the six site design measures.

Table K-1:
Regional Fact Sheets and Corresponding Site Design Measures

Fact Sheet	**Corresponding Site Design Measures listed in Provision C.3.i**
Managing Stormwater in Landscapes	▪ Direct roof runoff onto vegetated areas. ▪ Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas. ▪ Direct runoff from driveways/uncovered parking lots onto vegetated areas.
Rain Gardens	▪ Corresponds to the same site design measures as "Managing Stormwater in Landscapes", above. Differences between rain gardens and other landscaped area include: o Applicants may choose to select a rain garden if they want to capture and infiltrate more stormwater in a smaller area than is possible with most native soils. o Rain gardens should have well-drained soil; soil amendments may be needed. o An underdrain may be required if native soils are slow-draining.
Pervious Paving	▪ Construct sidewalks, walkways, and/or patios with permeable surfaces. ▪ Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.
Rain Barrels and Cisterns	▪ Direct roof runoff into cisterns or rain barrels for use.

K.3 Selecting Site Design Measures

To supplement guidance provided in the regional fact sheets, refer to Table K-2 to identify key opportunities and constraints for the site design measures listed in Provision C.3.i. Choose one or more site design measures that are a good match for your project site. Only one site design measure is required, but you may choose to implement additional measures to increase the water quality benefits of your project.

Table K-2: Opportunities and Constraints for Site Design Measures

Site Design Measure	Opportunities	Constraints	Guidance to Address Constraints
Managing Stormwater in Landscapes	▪ Low areas. ▪ Flat areas or minimal slope.	▪ Steep slopes ▪ Insufficient space for landscaping	▪ Avoid in steep slopes where increased infiltration may undermine slope. ▪ Landscaped area should be at least half the size of the impervious area draining to it. ▪ Direct runoff away from building foundations.
Rain Gardens	▪ Low areas. ▪ Flat areas or minimal slope. ▪ Well-drained soil ▪ Existing storm drain to tie in underdrain (if underdrain is needed)	▪ Steep slopes ▪ Insufficient space for landscaping ▪ Poorly drained soil	▪ Avoid in steep slopes. ▪ Rain garden should be at least 4% of the size of the impervious area draining to it. ▪ If soils do not drain well, consider soil amendments. ▪ An underdrain may be needed if native soils are clayey. ▪ Recommended setbacks: 10 ft. from building foundation and 5 ft. from property line
Pervious Paving	▪ Flat areas or minimal slope. ▪ Well-drained soil. ▪ Existing storm drain to tie in underdrain (if underdrain is needed).	▪ Steep slopes ▪ Poorly drained soils ▪ Buildings close to pavement	▪ Avoid use in 5% slopes and greater, unless municipality approves use of underdrain. ▪ Underdrain may be needed if native soils are clayey. ▪ Install away from buildings, or provide impermeable barrier.
Rain Barrels and Cisterns	▪ Roof area that drains to downspouts. ▪ Flat, firm area near the building for rain barrel or cistern. ▪ Landscaping that is downslope from rain barrel or cistern, allowing gravity flow of water for irrigation and discharge of overflow.	▪ Lack of landscape that requires irrigation. ▪ Irrigation system that requires high water pressure. ▪ Absence of flat, firm area near the building. ▪ Lack of suitable areas to receive overflow	▪ Interior non-potable use may be considered, if allowed by municipality. ▪ Use with low-pressure irrigation systems. ▪ Ensure adequate space to safely install rain barrel or cistern and accommodate overflow.

K.4. Selecting Site Design Measures for Constrained Sites

Provision C.3.i does not allow for findings of infeasibility or impracticability, nor does it provide alternative compliance or in-lieu options. Therefore, one of the six site design measures must be implemented in applicable projects, even on sites with constraints such as those identified in Table K-2.

If your site has constraints such as poorly draining soils, steep slopes, or limited space for landscaping, consult with municipal staff regarding approaches to incorporating the site design measures within the constrained site.

LANDSCAPE DESIGNS FOR STORMWATER MANAGEMENT

Stormwater Control for Small Projects

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Dry creek infiltrates and conveys runoff.

Designing landscaped areas to soak up rainfall runoff from building roofs and paved areas helps protect water quality in local creeks and waterways. These landscape designs reduce polluted runoff and help prevent creek erosion.

As the runoff flows over vegetation and soil in the landscaped area, the water percolates into the ground and pollutants are filtered out or broken down by the soil and plants.

This fact sheet shows how you can design your landscape to absorb runoff from impervious surfaces, such as roofs, patios, driveways, and sidewalks, with landscape designs that can be very attractive.

If you are interested in capturing and storing water for irrigation use, see the Rain Barrel fact sheet in this series.

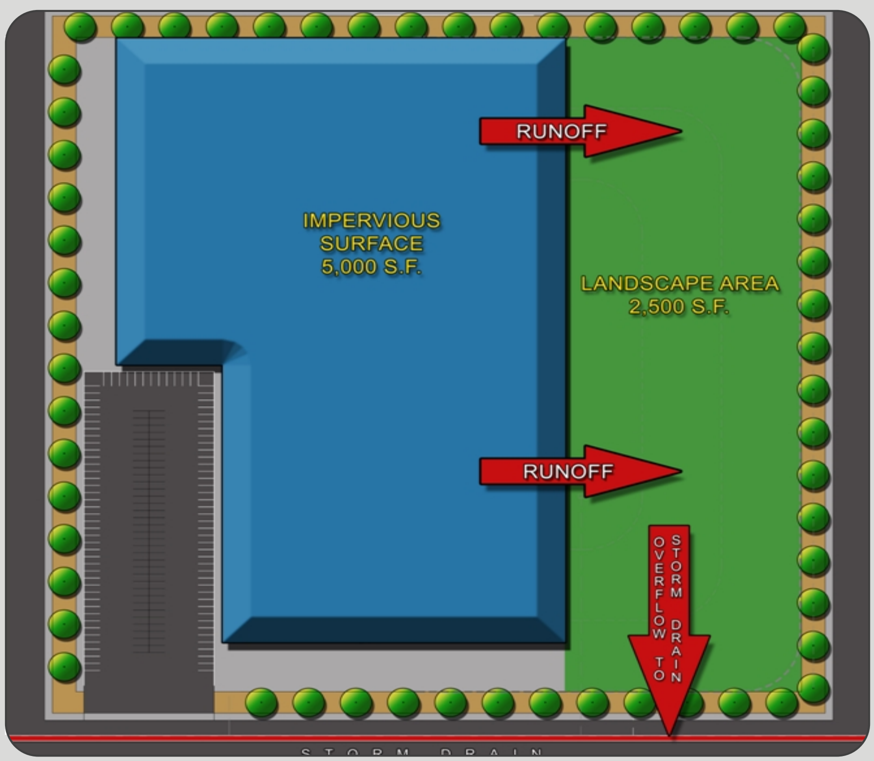
Can My Project Manage Stormwater in the Landscape?

Directing stormwater runoff to the landscape is suitable for sites with the following conditions:

- Roofs, driveways, parking areas, patios, and walkways that can drain to an existing landscape, or an area that may be converted to landscape.
- Areas of landscape with a slope of 5% or less are preferred; check with the municipality regarding requirements for steeper sites.
- Works best in well-drained soil; soil amendments may be used in areas with poor drainage.
- Landscaped areas that total at least 1/2 the size of the impervious area draining to it.
- Direct runoff away from building foundations.
- Runoff should not create ponding around trees and plants that won't tolerate wet conditions.

How Do I Size My Landscape?

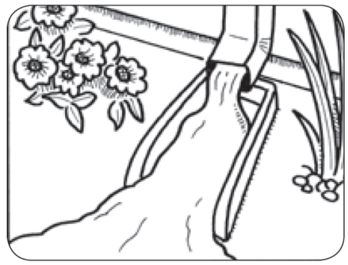
The landscaped area should be 50% of the size of the contributing impervious surface. For example (see below), to manage runoff from a 5,000 square foot roof or paved surface, you should have 2,500 square feet of landscaping.



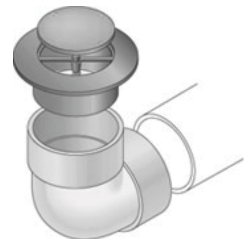
Techniques to Manage Stormwater in Landscaping

Direct Roof Runoff to Landscape

- Use additional piping to connect the downspout to the landscape if needed.
- Direct runoff away from building foundation.
- Prevent erosion by installing:
    - Splash blocks,
    - Rain chains,
    - Gravel area under a gutterless roof,
    - Pop-up drainage emitter connected to a pipe that carries runoff away from the foundation, or
    - Other energy dissipation technique.



Splash block

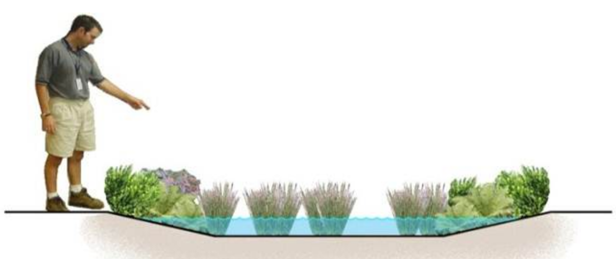


Pop-up emitter

Gravel area under a gutterless roof

Rain chain

Swales or Dry Creeks



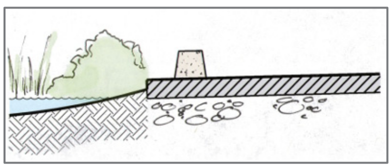
Cross section

Swales and dry creeks are narrow, linear depressions designed to capture and convey water. Swales imitate a natural creek's ability to slow, infiltrate, and filter stormwater. To install a swale follow these steps:

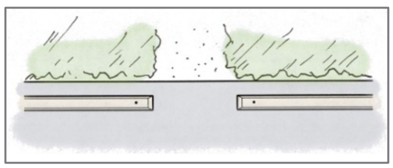
- Excavate a narrow linear depression that slopes down to provide a flow path for runoff. The path length (10 to 15 feet or more) should meander to slow water and prevent erosion.
- Use plants from creek and river ecosystems to help reduce erosion and increase evaporation of runoff.
- The end of the swale requires an outlet for high flows (another landscaped area or a yard drain). Talk to municipal staff to identify an appropriate discharge location.
- Contact municipal staff for a local list of plants suitable for swales.

Techniques to Manage Stormwater in Landscaping

Direct Parking Lot Runoff to Landscape



Cross section



View from above

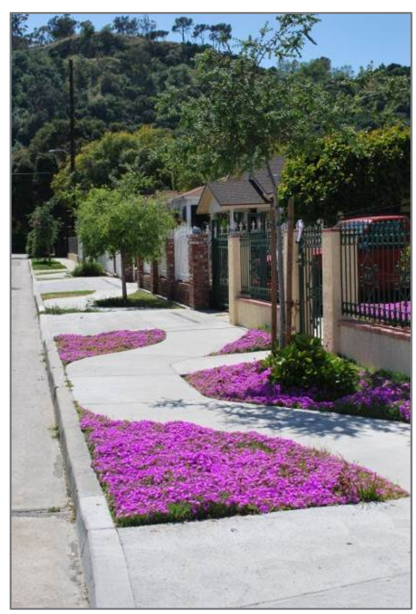
During storms, parking lots generate large amounts of runoff, which picks up oils, grease, and metals from vehicles. Landscaped areas can be designed to absorb and filter this runoff.

- Landscaped areas must be below the paved elevation. Allow an elevation change of 4 to 6 inches between the pavement and the soil, so that vegetation or mulch build-up does not block the flow.
- Grade the paved area to direct runoff towards the landscaping.
- If possible, provide a long path for runoff to infiltrate (while meeting the landscaped area sizing on page 1).
- Provide multiple access points for runoff to enter the landscape. Install curb cuts or separate wheel stops for the water to flow through. Provide cobbles or other permanent erosion control at points of concentrated flow.

Manage Runoff from Driveways/Small Paved Areas

Driveways, sidewalks, patios, walkways, and other small paved areas can offer creative opportunities to drain runoff to landscaping.

- Install landscape adjacent to the paved surface, and grade the paved area so runoff flows toward the landscaping.
- Landscaped areas must be below the paved elevation. Allow an elevation change of 4 to 6 inches between the pavement and the soil, so that vegetation or mulch build-up does not block the flow.
- Install cobbles or rocks where runoff enters the landscape to avoid erosion.
- Use sizing ratio described on page 1.
- Use drought-tolerant native or climate-adapted plants to reduce irrigation.



Design Checklist

- ❑ Maximize the use of landscaping and natural areas that already exist. Try to design new landscapes immediately adjacent to impervious surfaces.
- ❑ Water should flow evenly (without concentrating runoff into small streams) from the impervious surface to the landscape; this will maximize the filtration and settling of sediment and pollutants and prevent erosion. The design should avoid allowing straight channels and streams to form.
- ❑ Amend soils to improve drainage, when necessary.
- ❑ If the project is located next to standard asphalt or concrete pavement, and there is concern about water undermining the pavement, include a water barrier in the design.
- ❑ Use curb cuts to create places where water can flow through to the landscape.
- ❑ Disconnect roof downspouts and redirect flow to adjacent landscapes. Disconnected downspout systems should incorporate a splash block to slow the runoff flow rate; a landscape flow path length of 10 to 15 feet is recommended.
- ❑ Use drought-tolerant native or climate-adapted plant species whenever possible. Avoid invasive or pest species. A list of invasive species may be found at the California Invasive Plant Council website (www.cal-ipc.org). Contact municipal staff for a list of plants suitable for stormwater management areas.
- ❑ Design the landscape area so that overflow from large storms discharges to another landscaped area or the storm drain system to prevent flooding.

Maintain Your Landscape

The following practices will help maintain your landscape to keep it attractive and managing stormwater runoff effectively.

- ❑ During dry months, irrigate during the first year to encourage root growth and establish the plants. In subsequent years, irrigate as needed by the plant species to maintain plant health.
- ❑ Repair signs of erosion immediately and prevent further erosion by reinforcing the surrounding area with ground cover or using rocks for energy dissipation.
- ❑ If standing water remains in the landscaped area for more than 4 days, use soil amendments to improve infiltration.
- ❑ Inspect the locations where water flows into a landscaped area from adjacent pavement to ensure that there is positive flow into the landscape, and vegetation or debris does not block the entrance point.

The City of Los Angeles and Geosyntec Consultants are acknowledged for providing text, formatting and various images used in this fact sheet. The Sonoma Valley Groundwater Management Program, San Mateo Countywide Water Pollution Prevention Program, City of San Jose, Sacramento Stormwater Quality Partnership, and the Purissima Hills Water District are acknowledged for images used in the fact sheet.

RAIN GARDENS

Stormwater Control for Small Projects

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Large Residential Rain Garden

Rain gardens are landscaped areas designed to capture and treat rainwater that runs off roof and paved surfaces. Runoff is directed toward a depression in the ground, which is planted with flood and drought-resistant plants. As the water nourishes the plants, the garden stores, evaporates, and infiltrates rainwater into the soil. The soil absorbs runoff pollutants, which are broken down over time by microorganisms and plant roots.

Rain gardens are a relatively low-cost, effective, and aesthetically pleasing way to reduce the amount of stormwater that runs off your property and washes pollutants into storm drains, local streams, and the San Francisco Bay. While protecting water quality, rain gardens also provide attractive landscaping and habitat for birds, butterflies, and other animals, especially when planted with native plants.

Is a Rain Garden Feasible for My Project?

Rain gardens are appropriate where the following site characteristics are present:

- Rain gardens should be installed at least 10 feet from building foundations. The ground adjacent to the building should slope away at a 2% minimum slope. A downspout extension or ”swale” (landscaped channel) can be used to convey rain from a roof directly into a rain garden. Rain gardens can also be located downstream from a rain barrel overflow path.
- Rain gardens should be at least 3 feet from public sidewalks (or have an appropriate impermeable barrier installed), 5 feet from property lines, and in an area where potential overflow will not run onto neighboring properties.
- The site should have well-drained soil and be relatively flat. Soil amendments can improve infiltration in areas with poor drainage. Add about 3 inches of compost to any soil type and till it in to a depth of about 12 inches.
- A front or backyard can work well for a rain garden, especially in areas where the slope naturally takes the stormwater.

How Large Does My Rain Garden Need to Be?

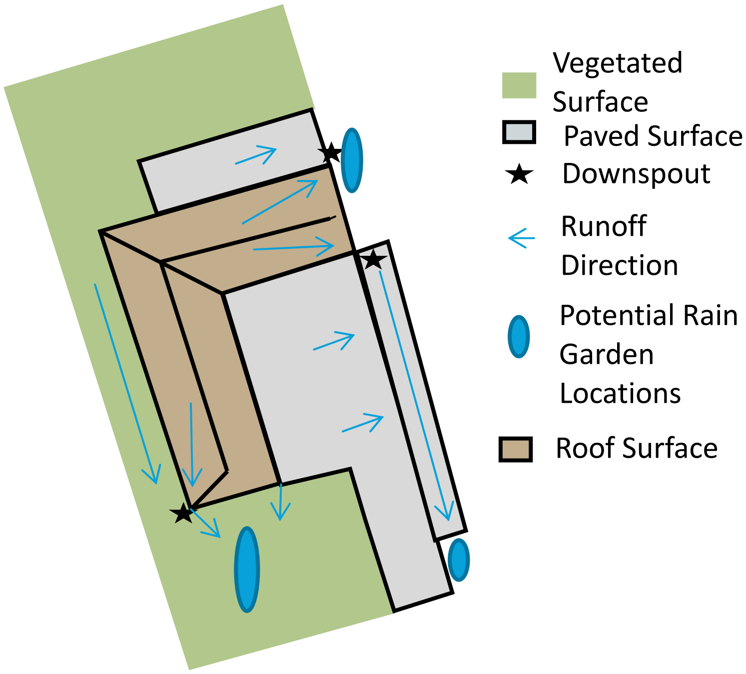
A general recommendation for a garden with a 6-inch ponding depth is to size the rain garden to approximately 4% of the contributing impervious area. Your soil type will affect how the rain garden should be sized because the water infiltration rate depends on the soil type; rain gardens should be larger in areas with slower infiltration. The following table can be used as general guidance.

Contributing Area (sq. ft.)	Rain Garden Area (sq. ft.)
500 – 700	24
701 – 900	32
901 – 1,100	40
1,101 – 1,300	48
1,301 – 1,500	56
1,501 – 2000*	70

*Projects adding roof or other impervious areas in excess of 2,000 sq. ft. should add 20 sq. ft. of rain garden surface area per every 500 sq. ft. of additional area.

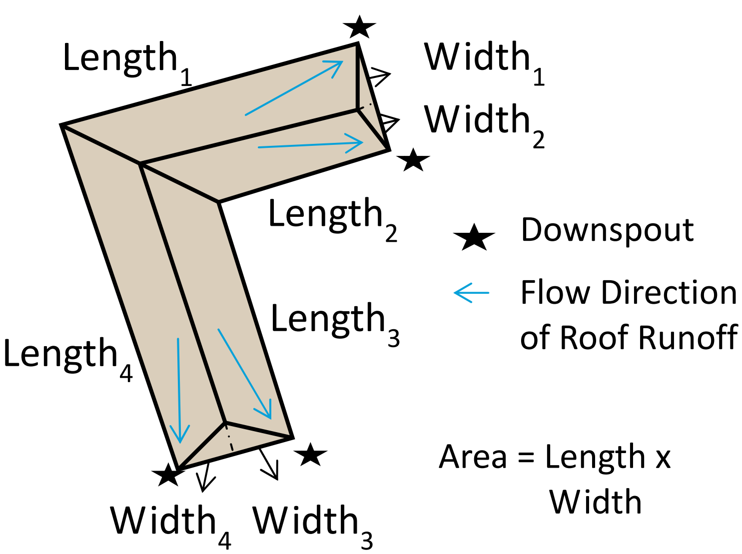
How to Plan and Install a Rain Garden

Select a Location and Plan for Overflow



- Before choosing the location of your rain garden, observe how rainwater is distributed across your home and yard. The ideal rain garden location is a flat or gently sloped area and is down slope from a runoff source.
- Site your garden at least 10 feet away from any structures (unless an impermeable barrier is used) and 5 feet from property lines.
- Avoid siting your garden over underground utilities and septic systems, near large trees, or next to a creek, stream or other water body.
- Your rain garden will overflow in large storms. Therefore, all garden designs should include an overflow system. One option is to build the perimeter of the garden so that it is perfectly level and to allow water to gently spill over the top during large storms. Another option is to build in a spillway that connects to another landscaped area, or the storm drain system.

Plan the Size of Your Rain Garden

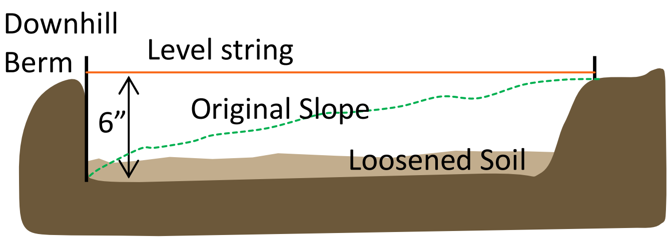


- Once you have determined where your garden will be sited, look at the surrounding area and identify which surfaces will contribute runoff to the garden. Is it all or just a part of the roof, patio, or driveway?
- Estimate the roof area by measuring the length and width of the building foundation and adding a few inches for the overhang. Multiply the length times the width to determine the contributing area. Once you have calculated the area of each contributing surface, add them up to obtain the total contributing area.
- Refer to the chart on page 1 to identify the size of the rain garden you will need to manage runoff from the contributing area.

If you do not have the space, budget, or interest in building a garden of this size, you may consider capturing some of your roof runoff in rain barrels to reduce the amount of runoff, or discharge the overflow to another landscaped area.

How to Plan and Install a Rain Garden

Install your Rain Garden



- Once you have selected a site and planned the size of your rain garden, lay out the shape using a string or tape to define the outline of where you will dig.
- If the yard is level, dig to a depth of 6-inches and slope the sides. If the site is sloped, you may need to dig out soil on the uphill side of the area and use the soil to construct a small berm (a compacted wall of soil) along the down slope side of the garden.
- Use a string level to help level the top of the garden and maintain an even 6-inch depth.
- Once the garden is excavated, loosen the soil on the bottom of the area so you have about 12 inches of soft soil for plants to root in. Mix in about 3 inches of compost to help the plants get established and improve the water-holding capacity of the soil.
- If water enters the garden quickly, include a layer of gravel or river rock at the entry points to prevent erosion.

Select Appropriate Plants


California Fuchsia


Common Rush


White Sage


Douglas Iris

You can design your rain garden to be as beautiful as any other type of garden. Select plants that are appropriate for your location and the extremes of living in a rain garden

Site Considerations:

- How much light will your garden receive?
- Is your property near the coast or located in an inland area (this affects sun and temperature)?
- Are there high winds near your home?

Recommended plant characteristics:

- Native plants adapted to local soil and climate,
- Drought tolerant,
- Flood tolerant,
- Not invasive weedy plants,
- Non-aggressive root systems to avoid damaging water pipes,
- Attracts birds and beneficial insects.

*Contact municipal staff to obtain a full list of recommended plants, provided in the countywide stormwater guidance.

Design Checklist

When installing a rain garden, the following design considerations are recommended.

- ❑ Locate the rain garden at least 10 feet from home foundation, 3 feet from public sidewalks, and 5 feet from private property lines. If rain gardens need to be located closer to buildings and infrastructure, use an impermeable barrier.
- ❑ Locate the rain garden to intercept and collect runoff from a roof downspout or adjacent impervious area.
- ❑ Size the rain garden appropriately based on the soil type and drainage area (see Page 1).
- ❑ Do not locate the rain garden over septic systems or shallow utilities. Locate utilities before digging by calling Underground Service Alert at 811 or (800) 227-2600.
- ❑ Locate the rain garden on a relatively flat area, away from steep slopes. If you plan on moving a large quantity of soil, you may need a grading permit. Contact your local municipality for further assistance.
- ❑ Consider installing an underdrain to enhance infiltration in very clayey soils. Contact municipal staff for guidance on how to properly install an underdrain.
- ❑ An overflow should been incorporated in the rain garden to move water that does not infiltrate to another pervious area and away from the home's foundation or neighboring property.
- ❑ Drought and flood resistant native plants are highly recommended and a variety of species should be planted. Avoid invasive plants. Contact municipal staff for a list of plants appropriate for rain gardens from the applicable countywide stormwater guidance. A list of invasive species may be found at the California Invasive Plant Council website (www.cal-ipc.org).

Maintenance Considerations

Once a rain garden is installed, the following steps will help the garden function effectively.

- ❑ Rain gardens should be irrigated periodically (as needed) during dry months, especially while plants are being established. Plants should be inspected for health and weeds should be removed as often as necessary.
- ❑ Apply about 2 inches of mulch and replace as needed. Mulch with a material that will not float away such as compost or a larger sized hardwood mulch (avoid microbark, for example).
- ❑ Areas of erosion should be repaired. Further erosion can be prevented by stabilizing the eroding soil with ground cover or using energy dispersion techniques (e.g., splashblock or cobbles) below downspouts.
- ❑ Avoid using synthetic fertilizers or herbicides in your rain garden because these chemicals are water pollutants.
- ❑ Standing water should not remain in a rain garden for more than 3 days. Extended periods of flooding will not only kill vegetation, but may result in the breeding of mosquitos or other vectors.

The City of Los Angeles and Geosyntec Consultants are acknowledged for providing text, formatting and various images used in this fact sheet. Contra Costa County is acknowledged for an image used in the fact sheet.

PERVIOUS PAVEMENT

Stormwater Control for Small Projects

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Permeable Interlocking Concrete Pavers

Pervious pavement, also referred to as permeable pavement, contains pores or separation joints that allow water to flow through and seep into a base material (typically gravel or drain rock). Types of pervious pavement include porous asphalt and concrete, open joint pavers, interlocking concrete or permeable pavers, and plastic or concrete grid systems with gravel-filled voids.

Pervious pavement systems allow infiltration of stormwater into soils, thereby reducing runoff and the amount of pollutants that enter creeks, San Francisco Bay, the Pacific Ocean, and other water bodies. This improves water quality, helps reduce creek erosion, and can facilitate groundwater recharge. Pervious pavement is available in many different types that offer environmentally-friendly and aesthetically pleasing options for driveways, walkways, parking areas, and patios.

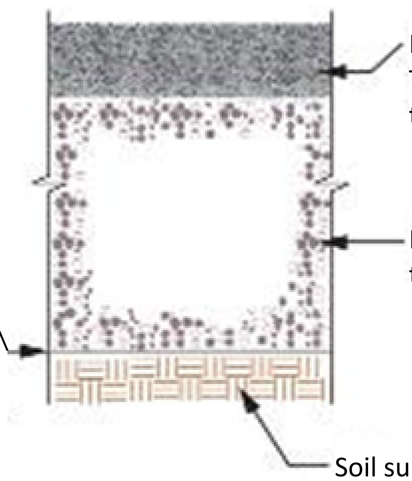
Is Pervious Pavement Feasible for My Project?

Pervious pavement is appropriate in locations with the following characteristics:

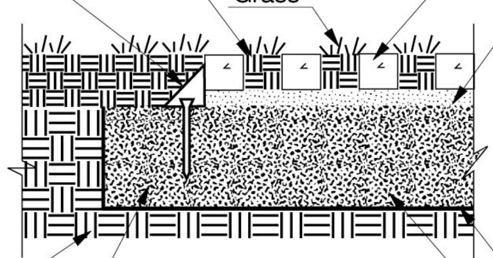
- The location is flat or nearly flat (a maximum 2% slope).
- The location is not in a seasonally wet area.
- The location is not close to a building foundation, unless measures are taken to prevent infiltration under the structure. (See Design Checklist.)

Typical Materials and Example Applications

Pervious Concrete

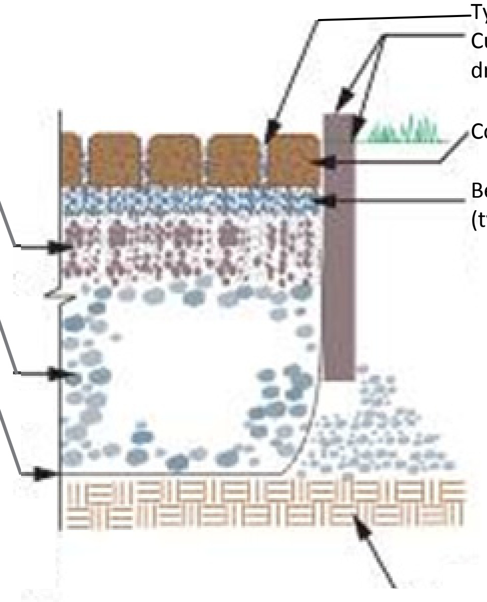


Turf Block



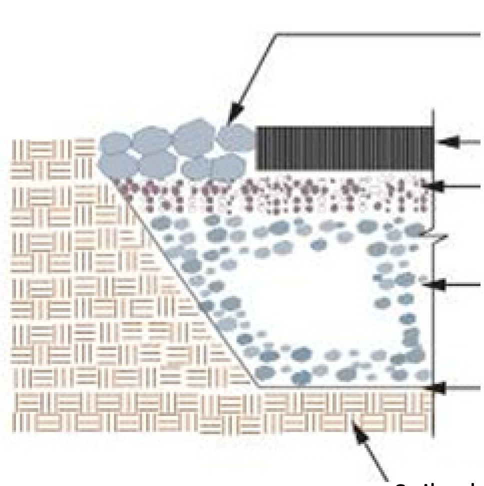
Typical Materials and Example Applications

Permeable Interlocking Concrete Pavers



Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone.
ASTM No. 89 or 9 stone may be used in the paver openings.

Porous Asphalt



Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone.
ASTM No. 89 or 9 stone may be used in the paver openings.

Design Checklist

When installing pervious pavement, the following design criteria should be considered.

- ❑ An open-graded base of crushed stone, which has 35 to 45 percent pore space, is installed below the surface pavement. The recommended base thickness is 6 inches for pedestrian use and 10 inches for driveways to provide adequate structural strength.
- ❑ Slope is flat or nearly flat (not greater than 2 percent).
- ❑ Flow directed to pervious pavement is dispersed so as not to be concentrated at a small area of pavement.
- ❑ No erodible areas drain onto the pavement.
- ❑ The subgrade is uniform and compaction is the minimum required for structural stability.
- ❑ If a subdrain is provided, its outlet elevation is a minimum of 3 inches above the bottom of the base course.
- ❑ A rigid edge is provided to retain granular pavements and unit pavers.
- ❑ If paving is close to a building, a barrier or impermeable liner may be required to keep water away from the building foundation.
- ❑ Pavers have a minimum thickness of 80 mm (3 1/8 inches) and are set in sand or gravel with minimum 3/8-inch gaps between pavers.
- ❑ Proprietary products must be installed per the manufacturer's specifications.
- ❑ The project complies with applicable sections of the current municipal code, including disabled access requirements and site drainage requirements, if applicable.

Maintenance Considerations

Once pervious pavement is installed, the following maintenance criteria should be followed:

- ❑ The use of leaf blowers on permeable pavement can force dirt and debris into pavement void spaces. Avoid blowing leaves, grass trimmings and other debris across permeable pavement.
- ❑ Remove weeds from pavement and replace missing sand or gravel between pavers as needed.
- ❑ Inspect subdrain outlets (if applicable) yearly to verify they are not blocked.
- ❑ Inspect pavement after rains for ponding or other visible problems. If there are problems with standing water, vacuum sweeping with specialized equipment may be required. Concrete grid pavers do not require sweeping.

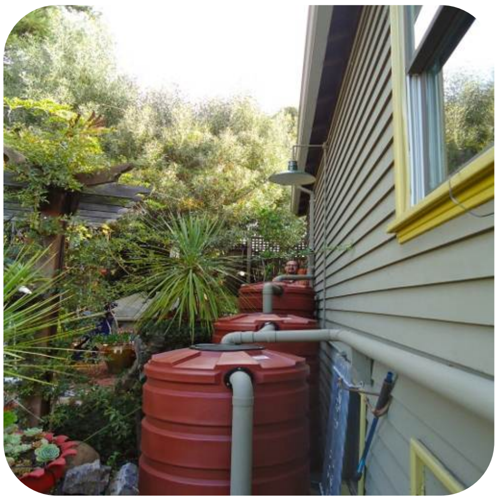
Open Joint Pavers

The City of Los Angeles and Geosyntec Consultants are acknowledged for providing text, formatting and various images used in this fact sheet. The Interlocking Concrete Pavement Institute is acknowledged for contributing pavement sections, design details and specifications. The San Mateo Countywide Water Pollution Prevention Program, Santa Clara Valley Urban Runoff Pollution Prevention Program, and City of San Jose are acknowledged for images used in the fact sheet.

RAIN BARRELS AND CISTERNS

Stormwater Control for Small Projects

Santa Clara Valley
Urban Runoff
Pollution Prevention Program



Daisy chained system of 205-gallon rain barrels
Courtesy of The City of Oakland

Rain barrels and cisterns can be installed to capture stormwater runoff from rooftops and store it for later use. They are low-cost systems that will allow you to supplement your water supply with a sustainable source and help preserve local watersheds by detaining rainfall.

Collected rainwater may be used for landscape irrigation. Subject to permitting requirements, harvested rainwater may be allowed for toilet flushing; contact municipal staff for more information. Capturing even a small amount of your roof runoff will have environmental benefits because it will reduce the quantity and speed of stormwater runoff flowing to local creeks.

Rain barrels typically store between 50 and 200 gallons. They require very little space and can be connected or "daisy chained" to increase total storage capacity.

Cisterns are larger storage containers that can store 200 to over 10,000 gallons. These come in many shapes, sizes, and materials, and can be installed underground to save space.

How Much Storage is Recommended?

The number of rain barrels recommended to capture runoff from a given roof (or other impervious area) is shown in the following table.

Are Rain Barrels or Cisterns Feasible for My Project?

Rain barrels and cisterns are appropriate for sites with the following characteristics:

- Roof areas that drain to downspouts.
- A level, firm surface is needed to support a rain barrel(s) or cistern to prevent shifting or falling over. A full 55-gallon rain barrel will weigh over 400 lbs.
- A landscaped area where the captured water can be used (and where it can be drained by gravity flow) should be located within a reasonable distance from the rain barrel(s).
- A landscaped area or safe path to the storm drain system that can handle overflow.

Roof or Impervious Area (sq. ft.)	Suggested Minimum Number of 55 Gallon Rain Barrels*
Up to 750	1-2
750 – 1,250	2-3
1,250 – 1,750	3-4
1,750 – 2,250**	4-5

* Or equivalent capture using larger rain barrels or a cistern.
** To harvest rainwater from an area greater than 2,250 sq. ft. install 1 additional rain barrel per each additional 500 sq. ft.

Components of a Rainwater Harvesting System

Roofing Materials

Wood shingle roof
Courtesy of Gutter Glove

Technically, any impervious surface can be used for harvesting rainwater; however, the surface materials will affect the quality of captured rainwater, which has implications for the recommended uses.

Although it is technically possible to harvest runoff from parking lots, patios, and walkways, it is more difficult since a subterranean cistern or a pump is usually needed to move the water into an above-ground rain barrel or cistern. Also, there are typically greater levels of debris and contaminants that must be filtered out of the runoff before it enters the storage system. Due to these complexities, it is more common to harvest rainwater from rooftops, which is the focus of this fact sheet.

When designing your system, consider the roofing material on the building.

- If you have asphalt or wooden shingles, use the harvested rainwater only for non-edible landscapes, unless the water is treated first. Petroleum or other chemicals from these roofing materials can leach into the rain water.
- Roofs with cement, clay, or metal surfaces are ideal for harvesting water for a wide variety of uses.

Gutters and Downspouts

Properly sized and maintained gutters and downspouts are essential to a rainwater harvesting system.

- Strategically locate any new downspouts in an area where the rain barrel or cistern will be most useful.
- Consider the height of the rain barrel and the first flush device. Existing downspouts may have to be shortened to make room for the rain barrel and first flush device.
- Install a fine mesh gutter guard on gutters to keep leaves and other debris from entering and clogging the gutters. This will reduce the need for cleaning gutters and the rain barrel or cistern.
- As needed, consult a professional roofer to aid in gutter and downspout installation.

This gutter is covered by a fine mesh gutter guard to keep debris out.
Courtesy of Gutter Glove

Components of a Rainwater Harvesting System

Rain Barrel and Cistern Accessories to Keep Water Clean

First flush and downspout diverter installation
Courtesy of The City of Oakland

Various accessories to rain barrels and cisterns help protect the quality of harvested water and reduce maintenance. These accessories include "first flush" diverters, filters, and screens.

Leaves, twigs, sediment, and animal waste are common in runoff, especially at the beginning of a storm ("first flush"). This debris can result in clogging and encourage bacterial growth. A first flush diverter helps remove debris and contaminants by directing the first few gallons of runoff from the roof to landscaping, away from the rain barrel or cistern.

The following tips will help you keep the water in your system clean.

- Install a first flush diverter directly under your downspout. You may have to cut the downspout to connect the first flush diverter above the rain barrel.
- Use the same diameter pipe for the first flush diverter, the downspout, and the connector to the rain barrel. Avoid changing diameters of pipes in order to keep the system from backing up.
- Design the first flush diverter to discharge the first flush to non-edible landscaping.
- Install mosquito-proof screens under the lid of the rain barrel and inside the overflow outlet.

Foundation and Overflow

Before installing a rain barrel or cistern, prepare the site so that the system will function safely.

- Find or create a level location near the downspout on which to place the rain barrel or cistern.
- A concrete or stone paver foundation may be appropriate for smaller rain barrels. A more substantial foundation will likely be required for large cisterns.
- Secure rain barrels and cisterns to your structure with metal strapping, or anchor to the foundation, to prevent tipping in an earthquake.
- Maintain clear access to the rain barrel outlets and cleaning access points.
- Design an overflow path, so that overflow from the rain barrel(s) will discharge safely to a landscaped area, or storm drain system.
- Where possible, direct overflow to a rain garden, swale, or other landscaped area to maximize retention of rainwater onsite.
- Direct the overflow away from the rain barrel, building foundation, and neighboring properties.
- Consult with the municipality to identify overflow locations.

Large unit installed at a single family residence.
Courtesy of Stephanie Morris

Design Checklist

When installing rain barrels and cisterns, consider the following criteria unless otherwise instructed by the municipality.

- ❑ Do not use flexible piping, to prevent mosquito breeding in water that may pool in flexible pipes. If irrigating edible landscapes, consider pipes that meet FDA food grade standards.
- ❑ When designing the overflow path, remember that in heavy storms rain barrels and cisterns *will* overflow. A 1,000-sq.-ft. roof will produce about 600 gallons of runoff during a storm that has produces a depth of 1 inch of rain.
- ❑ There shall be no direct connection of any rain barrel or cistern and/or rainwater collection piping to any potable water pipe system. Rainwater systems shall be completely separate from potable water piping systems.
- ❑ Place the bottom of the barrel at a higher elevation than the landscape, to use gravity flow.
- ❑ All rain barrels and cisterns should have a screen to ensure mosquitoes cannot enter.
- ❑ Allow overflow to drain to your landscape or a rain garden. Ensure that areas receiving overflow do not have standing water for more than 48-hours.
- ❑ The low water pressure from a small rain barrel will not operate in-ground sprinkler or low-volume devices. Consider using a soaker hose.
- ❑ If using a soaker hose, remove the pressure-reducing washer to increase the water flow.
- ❑ If the water is not needed for irrigation during the rainy season, consider releasing the water to a vegetated area between storms, so the barrels will be empty to catch rain from the next storm. This will help protect your watershed by reducing the quantity and speed of water entering local creeks during storms. Install a spigot and drip tape to allow the rain barrel or cistern to slowly drain between storms. You can store the water captured towards the end of the rainy season to irrigate your garden in the dry season.
- ❑ For more information, ask municipal staff to refer you to countywide stormwater guidance.

Operation and Maintenance

After installing your rain barrel or cistern, follow these tips for long-term safety and functionality.

- ❑ Regularly check the gutters and gutter guards to make sure debris is not entering the rainwater harvesting system.
- ❑ Inspect the screens on the rain barrel or cistern prior to the wet season to make sure debris is not collecting on the surface and that there are not holes allowing mosquitoes to enter the rain barrel. Inspect screens more frequently if there are trees that drop debris on the roof.
- ❑ Clean the inside of the rain barrel once a year (preferably at the end of the dry season when the rain barrel has been fully drained) to prevent buildup of debris. If debris cannot be removed by rinsing, use vinegar or another non-toxic cleaner. Use a large scrub brush on a long stick, and avoid actually entering the rain barrel. Drain washwater to landscaping.
- ❑ Clean out debris from cisterns once a year, preferably at the end of the dry season.

Daisy-chained system
Courtesy of Acterra

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