GRAPHIC SCALE

80 0 40 80 160

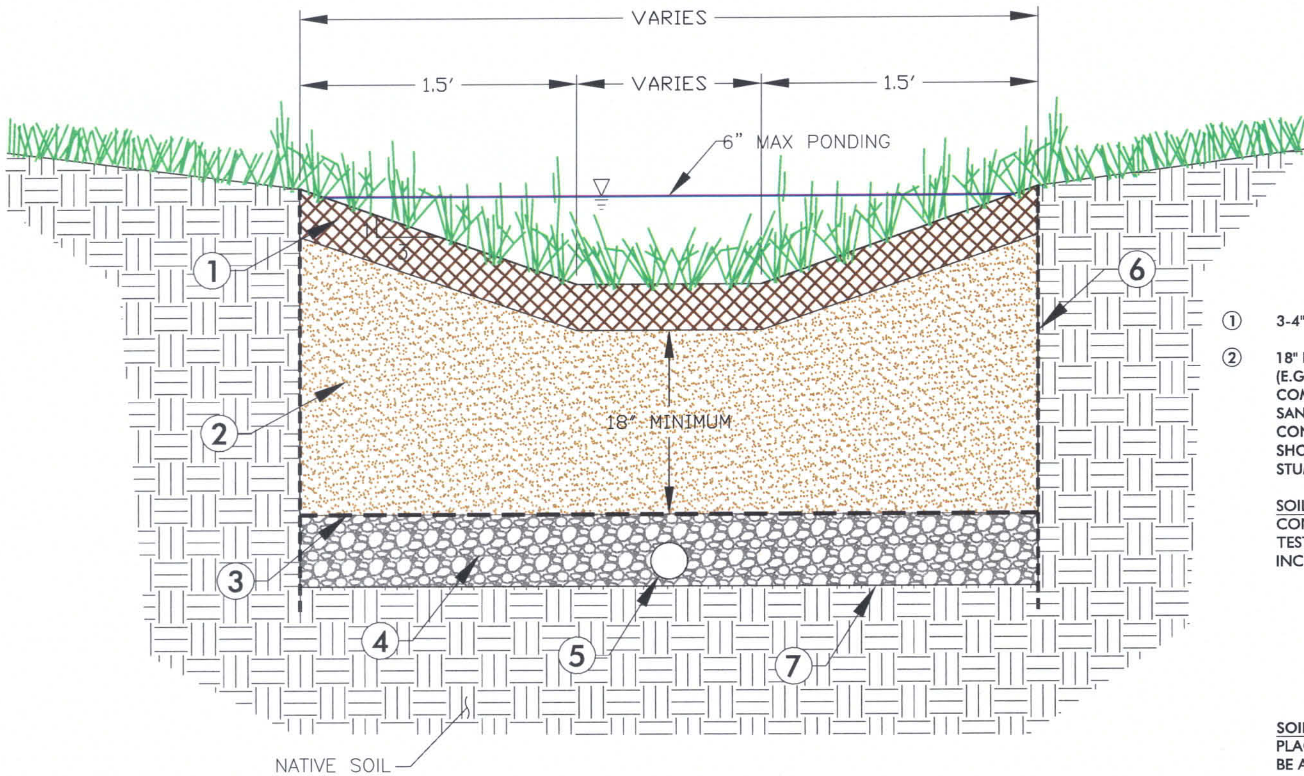
(IN FEET)
1 inch = 80 ft.

FUSCOE ENGINEERING
16795 Von Karman, Suite 100
Irvine, California 92606
tel 949.474.1960 fax 949.474.5315
www.fuscoe.com

Scale: 1" = 80'
Exhibit Date: 7/23/2012

SITE PLAN / PRELIMINARY WQMP
TOWN CENTRE TTM 17446
LAKE FOREST, CA

P:\PROJECTS\308\44\WAT\GRAPHICS\30844XH_CONCEPTWQMP_120723.DWG (07-23-12 12:16:22PM) Plotted by: April McMillion



BIORETENTION CELL TYPICAL CROSS-SECTION

NOT TO SCALE

NOTES:

① 3-4" MULCH PER LANDSCAPE PLANS & SPECIFICATIONS

② 18" PLANTING MEDIA TO BE HIGHLY PERMEABLE AND HIGH IN ORGANIC MATTER (E.G., LOAMY SAND MIXED THOROUGHLY WITH COMPOST AMENDMENTS WITH COMPOST AMENDMENTS). PLANTING MEDIA MIXTURE TO CONSIST OF 60-70% SAND, 15-25% COMPOST, AND 10-20% CLEAN TOPSOIL. THE ORGANIC CONTENT OF THE SOIL MIXTURE SHOULD BE 8% TO 12%; THE pH RANGE SHOULD BE 5.5-7.5. THE SOIL MUST BE A UNIFORM MIX, FREE OF STONES, STUMPS, ROOTS, OR OTHER SIMILAR OBJECTS LARGER THAN 2 INCHES.

SOIL TESTING:
CONTRACTOR SHALL SUBMIT SOIL TESTS RESULTS TO THE ENGINEER (ONE TEST PER BIO-RETENTION CELL) PRIOR TO INSTALLATION. TESTING SHALL INCLUDE:

- a - GRANULOMETRIC ANALYSIS (SAND, SILT & CLAY) PER WEIGHT (SAND BETWEEN 60% - 70%; CLAY LESS THAN 5%)
- b - PH (5.5 TO 7.5)
- c - PERCENTAGE OF ORGANIC MATTER IN THE SOIL (8% TO 12%)
- d - SIEVE ANALYSIS
- e - SATURATED HYDRAULIC CONDUCTIVITY TEST (HIGHER THAN 0.5 in/hr)

SOIL PLACEMENT
PLACEMENT OF THE PLANTING MEDIA IN THE BIO-RETENTION AREA SHOULD BE AFTER SCARIFYING THE INVERT AREA OF THE PROPOSED FACILITY, AND BE IN LIFTS OF 12 TO 18 INCHES AND MINIMALLY COMPACTED TO REDUCE THE POSSIBILITY OF EXCESSIVE SETTLEMENT. NO ADDITIONAL COMPACTION OF SOIL IS NECESSARY. INSTALLATION OF PLANTING MEDIA MUST BE DONE IN A MANNER THAT WILL ENSURE ADEQUATE FILTRATION.

③ FILTER FABRIC MIRAFI 160N OR EQUIVALENT.

④ UNDERDRAIN GRAVEL (AASHTO M-43), PEA GRAVEL SIZE FROM 0.5" TO 1" IN DIAMETER

⑤ OPTIONAL 6" PERFORATED PIPE SCHEDULE 40

⑥ ROOT BARRIER OR IMPERMEABLE LINER

⑦ OPTIONAL IMPERMEABLE LINER TO RESTRICT INFILTRATION

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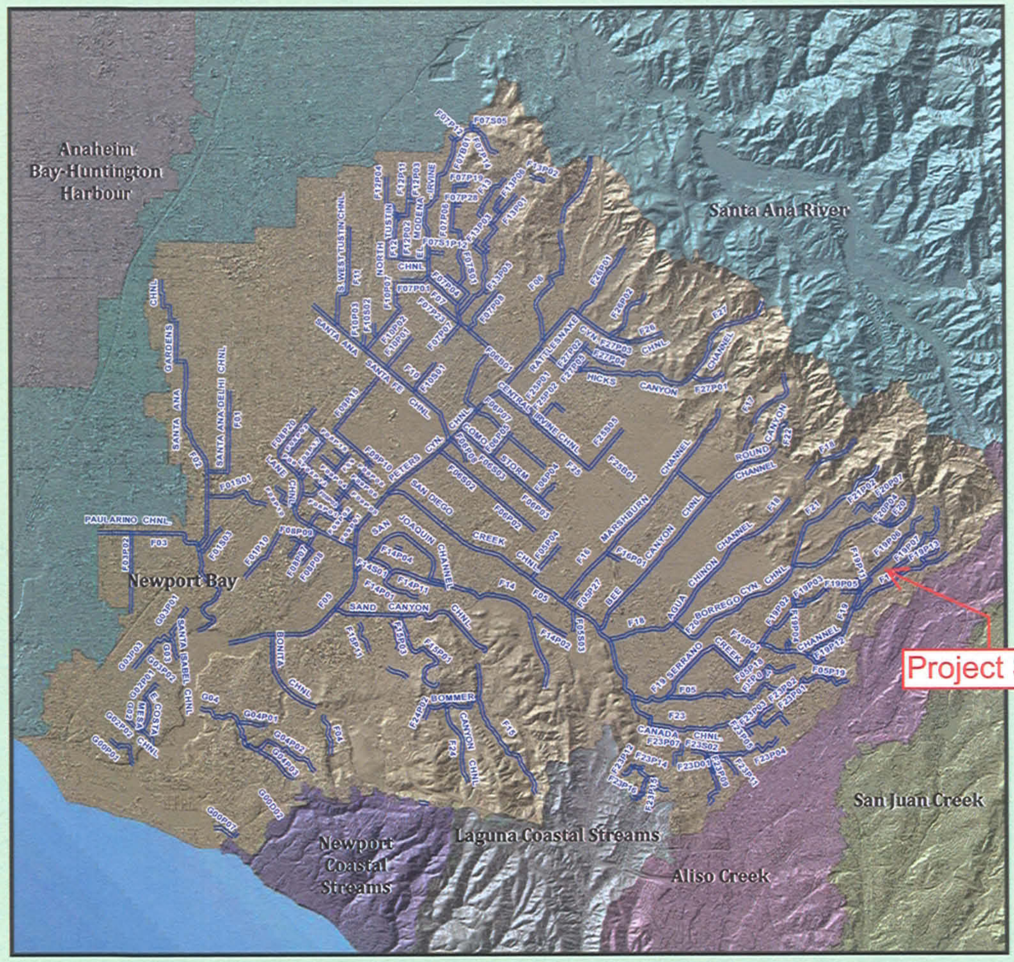
www.fuscoe.com

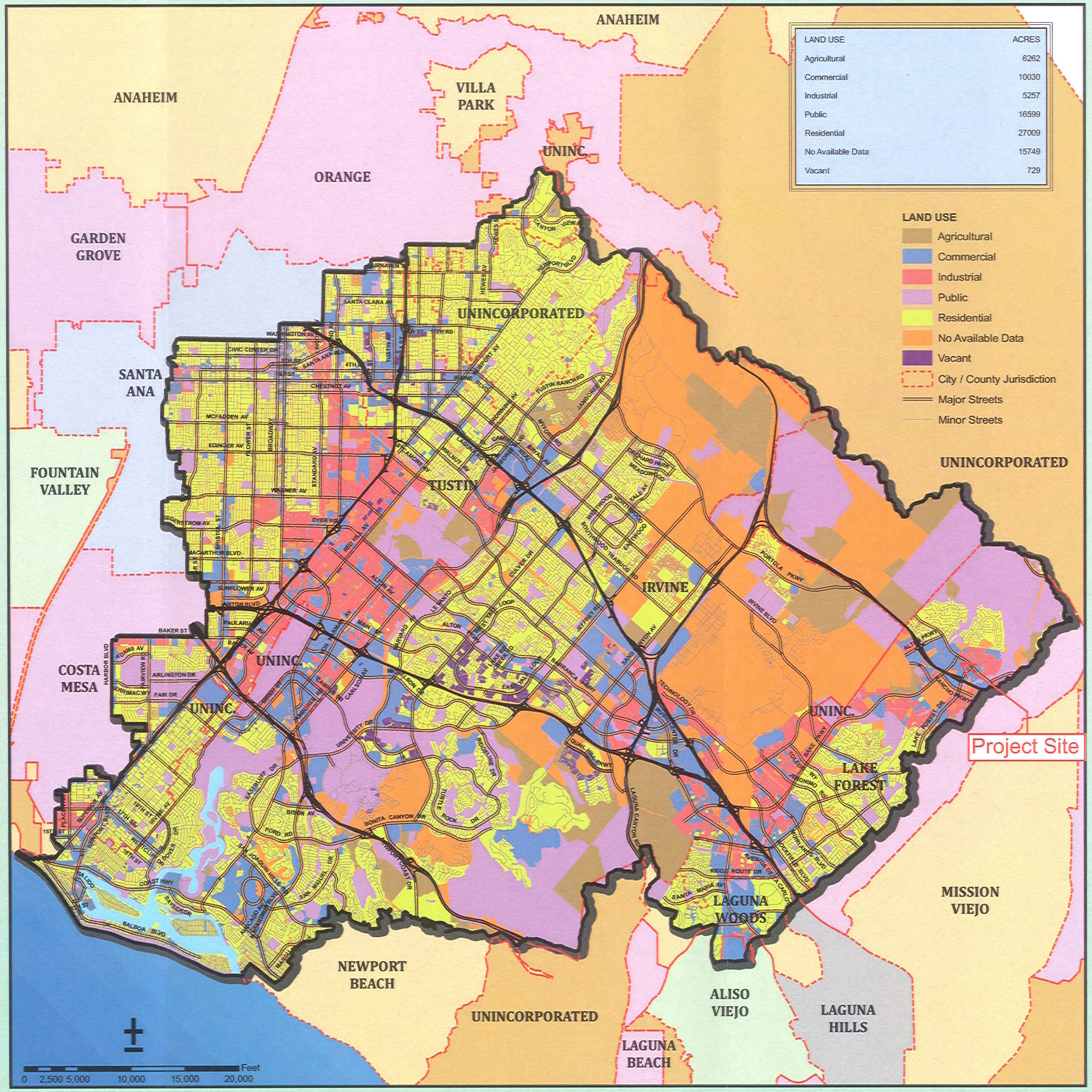
Not-to-Scale

Exhibit Date: 4/6/2012

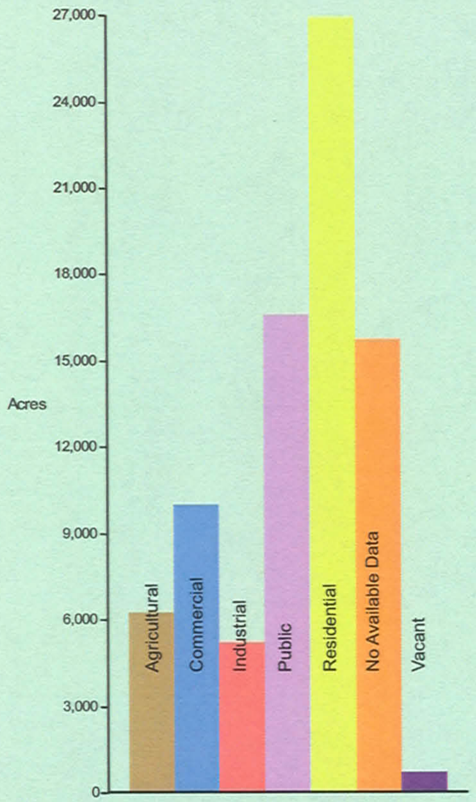
BMP DETAILS

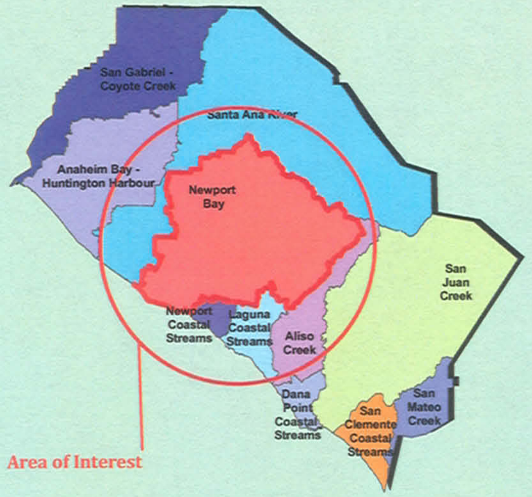
TOWN CENTRE
LAKE FOREST, CA





LAND USE	ACRES
Agricultural	6262
Commercial	10030
Industrial	5257
Public	16599
Residential	27009
No Available Data	15749
Vacant	729





97294 Acres

WATERSHED: NEWPORT BAY

COUNTY OF ORANGE, CALIFORNIA

DESIGNED AND PRODUCED BY:
OC Public Works
GIS Mapping Unit
Philip Pappas

DATA SOURCE:
- Geomatics Land Information Systems Division

DATE: November 18, 2009

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XIV.5. Biotreatment BMP Fact Sheets (BIO)

Conceptual criteria for biotreatment BMP selection, design, and maintenance are contained in **Appendix XII**. These criteria are generally applicable to the design of biotreatment BMPs in Orange County and BMP-specific guidance is provided in the following fact sheets.

Note: Biotreatment BMPs shall be designed to provide the maximum feasible infiltration and ET based on criteria contained in ***Appendix*** *XI.2.*

BIO-1: Bioretention with Underdrains

Also known as:

- *Rain gardens with underdrains*
- *Vegetated media filter*
- *Downspout planter boxes*

Bioretention
Source: Geosyntec Consultants

Bioretention stormwater treatment facilities are landscaped shallow depressions that capture and filter stormwater runoff. These facilities function as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. The facilities normally consist of a ponding area, mulch layer, planting soils, and plants. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, biodegraded, and sequestered by the soil and plants. Bioretention with an underdrain are utilized for areas with low permeability native soils or steep slopes where the underdrain system that routes the treated runoff to the storm drain system rather than depending entirely on infiltration. Bioretention must be designed without an underdrain in areas of high soil permeability.

Feasibility Screening Considerations

- If there are no hazards associated with infiltration (such as groundwater concerns, contaminant plumes or geotechnical concerns), bioinfiltration facilities, which achieve partial infiltration, should be used to maximize infiltration.
- Bioretention with underdrain facilities should be lined if contaminant plumes or geotechnical concerns exist. If high groundwater is the reason for infiltration infeasibility, bioretention facilities with underdrains do not need to be lined.

Opportunity Criteria

- Land use may include commercial, residential, mixed use, institutional, and subdivisions. Bioretention may also be applied in parking lot islands, cul-de-sacs, traffic circles, road shoulders, road medians, and next to buildings in planter boxes.
- Drainage area is ≤ 5 acres.
- Area is available for infiltration.

- Site must have adequate relief between land surface and the stormwater conveyance system to permit vertical percolation through the soil media and collection and conveyance in underdrain to stormwater conveyance system.

OC-Specific Design Criteria and Considerations

☐ Ponding depth should not exceed 18 inches; fencing may be required if ponding depth is greater than 6 inches to mitigate drowning.

☐ The minimum soil depth is 2 feet (3 feet is preferred).

☐ The maximum drawdown time of the bioretention ponding area is 48 hours. The maximum drawdown time of the planting media and gravel drainage layer is 96 hours, if applicable.

☐ Infiltration pathways may need to be restricted due to the close proximity of roads, foundations, or other infrastructure. A geomembrane liner, or other equivalent water proofing, may be placed along the vertical walls to reduce lateral flows. This liner should have a minimum thickness of 30 mils.

☐ If infiltration in bioretention location is hazardous due to groundwater or geotechnical concerns, a geomembrane liner must be installed at the base of the bioretention facility. This liner should have a minimum thickness of 30 mils.

☐ The planting media placed in the cell shall be designed per the recommendations contained in MISC-1: Planting/Storage Media

☐ Plant materials should be tolerant of summer drought, ponding fluctuations, and saturated soil conditions for 48 hours; native place species and/or hardy cultivars that are not invasive and do not require chemical inputs should be used to the maximum extent feasible

☐ The bioretention area should be covered with 2-4 inches (average 3 inches) or mulch at the start and an additional placement of 1-2 inches of mulch should be added annually.

☐ Underdrain should be sized with a 6 inch minimum diameter and have a 0.5% minimum slope. Underdrain should be slotted polyvinyl chloride (PVC) pipe; underdrain pipe should be more than 5 feet from tree locations (if space allows).

☐ A gravel blanket or bedding is required for the underdrain pipe(s). At least 0.5 feet of washed aggregate must be placed below, to the top, and to the sides of the underdrain pipe(s).

☐ An overflow device is required at the top of the bioretention area ponding depth.

☐ Dispersed flow or energy dissipation (i.e. splash rocks) for piped inlets should be provided at basin inlet to prevent erosion.

☐ Ponding area side slopes shall be no steeper than 3:1 (H:V) unless designed as a planter box BMP with appropriate consideration for trip and fall hazards.

Simple Sizing Method for Bioretention with Underdrain

If the Simple Design Capture Volume Sizing Method described in **Appendix** III.3.1 is used to size a bioretention with underdrain facility, the user selects the basin depth and then determines the appropriate surface area to capture the DCV. The sizing steps are as follows:

Step 1: Determine DCV

Calculate the DCV using the Simple Design Capture Volume Sizing Method described in **Appendix** III.3.1.

Step 2: Verify that the Ponding Depth will Draw Down within 48 Hours

The ponding area drawdown time can be calculated using the following equation:

$DD_P = (d_P / K_{MEDIA}) \times 12$ in/ft

Where:

DD_P = time to drain ponded water, hours

d_P = depth of ponding above bioretention area, ft (not to exceed 1.5 ft)

K_{MEDIA} = media design infiltration rate, in/hr (equivalent to the media hydraulic conductivity with a factor of safety of 2; K_{MEDIA} of 2.5 in/hr should be used unless other information is available)

If the drawdown time exceeds 48 hours, adjust ponding depth and/or media infiltration rate until 48 hour drawdown time is achieved.

Step 3: Determine the Depth of Water Filtered During Design Capture Storm

The depth of water filtered during the design capture storm can be estimated as the amount routed through the media during the storm, or the ponding depth, whichever is smaller.

$d_{FILTERED}$ = Minimum [(($K_{MEDIA} \times T_{ROUTING}$)/12), d_P]

Where:

$d_{FILTERED}$ = depth of water that may be considered to be filtered during the design storm event, ft

K_{MEDIA} = media design infiltration rate, in/hr (equivalent to the media hydraulic conductivity with a factor of safety of 2; K_{MEDIA} of 2.5 in/hr should be used unless other information is available)

$T_{ROUTING}$ = storm duration that may be assumed for routing calculations; this should be assumed to be no greater than 3 hours. If the designer desires to account for further routing effects, the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix** III.3.2) should be used.

d_P = depth of ponding above bioretention area, ft (not to exceed 1.5 ft)

Step 4: Determine the Facility Surface Area

$A = DCV / (d_P + d_{FILTERED})$

Where:

A = required area of bioretention facility, sq-ft

DCV = design capture volume, cu-ft

$d_{FILTERED}$ = depth of water that may be considered to be filtered during the design storm event, ft

d_P = depth of ponding above bioretention area, ft (not to exceed 1.5 ft)

Capture Efficiency Method for Bioretention with Underdrains

If the bioretention geometry has already been defined and the user wishes to account more explicitly for routing, the user can determine the required footprint area using the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix** III.3.2) to determine the fraction of the DCV that must be provided to manage 80 percent of average annual runoff volume. This method accounts for drawdown time different than 48 hours.

Step 1: Determine the drawdown time associated with the selected basin geometry

$DD = (d_p / K_{DESIGN}) \times 12$ in/ft

Where:

DD = time to completely drain infiltration basin ponding depth, hours

d_P = bioretention ponding depth, ft (should be less than or equal to 1.5 ft)

K_{DESIGN} = design media infiltration rate, in/hr (assume 2.5 inches per hour unless otherwise proposed)

If drawdown is less than 3 hours, the drawdown time should be rounded to 3 hours or the Capture Efficiency Method for Flow-based BMPs (See **Appendix III.3.3**) shall be used.

Step 2: Determine the Required Adjusted DCV for this Drawdown Time

Use the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix III.3.2**) to calculate the fraction of the DCV the basin must hold to achieve 80 percent capture of average annual stormwater runoff volume based on the basin drawdown time calculated above.

Step 3: Determine the Basin Infiltrating Area Needed

The required infiltrating area (i.e. the surface area of the top of the media layer) can be calculated using the following equation:

$A = \text{Design Volume} / d_p$

Where:

A = required infiltrating area, sq-ft (measured at the media surface)

Design Volume = fraction of DCV, adjusted for drawdown, cu-ft (see Step 2)

d_p = ponding depth of water stored in bioretention area, ft (from Step 1)

This does not include the side slopes, access roads, etc. which would increase bioretention footprint. If the area required is greater than the selected basin area, adjust surface area or adjust ponding depth and recalculate required area until the required area is achieved.

Configuration for Use in a Treatment Train

- Bioretention areas may be preceeded in a treatment train by HSCs in the drainage area, which would reduce the required design volume of the bioretention cell. For example, bioretention could be used to manage overflow from a cistern.
- Bioretention areas can be used to provide pretreatment for underground infiltration systems.

Additional References for Design Guidance

- CASQA BMP Handbook for New and Redevelopment: http://www.cabmphandbooks.com/Documents/Development/TC-32.pdf
- SMC LID Manual (pp 68): http://www.lowimpactdevelopment.org/guest75/pub/All_Projects/SoCal_LID_Manual/SoCalLID_Manual_FINAL_040910.pdf
- Los Angeles County Stormwater BMP Design and Maintenance Manual, Chapter 5: http://dpw.lacounty.gov/DES/design_manuals/StormwaterBMPDesignandMaintenance.pdf
- San Diego County LID Handbook Appendix 4 (Factsheet 7): http://www.sdcounty.ca.gov/dplu/docs/LID-Appendices.pdf

  Los Angeles Unified School District (LAUSD) Stormwater Technical Manual, Chapter 4: http://www.laschools.org/employee/design/fs-studies-and-reports/download/white_paper_report_material/Storm_Water_Technical_Manual_2009-opt-red.pdf?version_id=76975850
- County of Los Angeles Low Impact Development Standards Manual, Chapter 5: http://dpw.lacounty.gov/wmd/LA_County_LID_Manual.pdf

Bioretention TC-32

Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).

- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

References and Sources of Additional Information

Coffman, L.S., R. Goo and R. Frederick, 1999: Low impact development: an innovative alternative approach to stormwater management. Proceedings of the 26th Annual Water Resources Planning and Management Conference ASCE, June 6-9, Tempe, Arizona.

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Davis, A.P., Shokouhian, M., Sharma, H., Minami, C., and Winogradoff, D. "Water Quality Improvement through Bioretention: Lead, Copper, and Zinc," *Water Environ. Res.*, accepted for publication, August 2002.

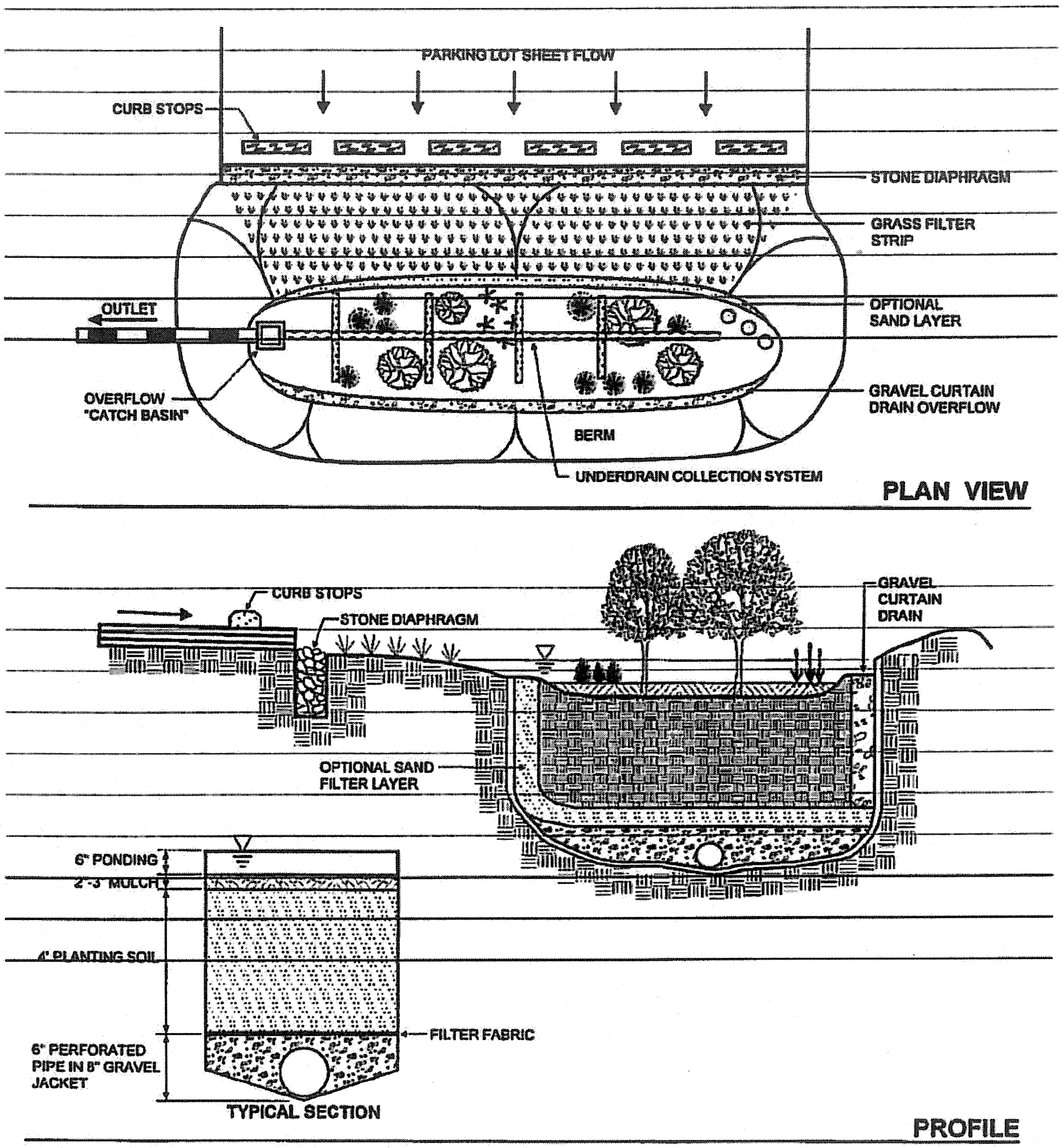
Kim, H., Seagren, E.A., and Davis, A.P., "Engineered Bioretention for Removal of Nitrate from Stormwater Runoff," *WEFTEC 2000 Conference Proceedings on CDROM Research Symposium, Nitrogen Removal*, Session 19, Anaheim CA, October 2000.

Hsieh, C.-h. and Davis, A.P. "Engineering Bioretention for Treatment of Urban Stormwater Runoff," *Watersheds 2002, Proceedings on CDROM Research Symposium*, Session 15, Ft. Lauderdale, FL, Feb. 2002.

Prince George's County Department of Environmental Resources (PGDER), 1993. Design Manual for Use of *Bioretention in Stormwater Management*. Division of Environmental Management, Watershed Protection Branch. Landover, MD.

U.S. EPA Office of Water, 1999. Stormwater Technology Fact Sheet: Bioretention. EPA 832-F-99-012.

Weinstein, N. Davis, A.P. and Veeramachaneni, R. "Low Impact Development (LID) Stormwater Management Approach for the Control of Diffuse Pollution from Urban Roadways," *5th International Conference Diffuse/Nonpoint Pollution and Watershed Management Proceedings*, C.S. Melching and Emre Alp, Eds. 2001 International Water Association



Schematic of a Bioretention Facility (MDE, 2000)

BIO-7: Proprietary Biotreatment

Proprietary biotreatment devices are devices that are manufactured to mimic natural systems such as bioretention areas by incorporating plants, soil, and microbes engineered to provide treatment at higher flow rates or volumes and with smaller footprints than their natural counterparts. Incoming flows are typically filtered through a planting media (mulch, compost, soil, plants, microbes, etc.) and either infiltrated or collected by an underdrain and delivered to the storm water conveyance system. Tree box filters are an increasingly common type of proprietary biotreatment device that are installed at curb level and filled with a bioretention type soil. For low to moderate flows they operate similarly to bioretention systems and are bypassed during high flows. Tree box filters are highly adaptable solutions that can be used in all types of development and in all types of soils but are especially applicable to dense urban parking lots, street, and roadways.

Also known as:

- *Catch basin planter box*
- *Bioretention vault*
- *Tree box filter*

Proprietary biotreatment
Source: http://www.americastusa.com /index.php/filterra/

Feasibility Screening Considerations

- Proprietary biotreatment devices that are unlined may cause incidental infiltration. Therefore, an evaluation of site conditions should be conducted to evaluate whether the BMP should include an impermeable liner to avoid infiltration into the subsurface.

Opportunity Criteria

- Drainage areas of 0.25 to 1.0 acres.
- Land use may include commercial, residential, mixed use, institutional, and subdivisions. Proprietary biotreatment facilities may also be applied in parking lot islands, traffic circles, road shoulders, and road medians.
- Must not adversely affect the level of flood protection provided by the drainage system.

OC-Specific Design Criteria and Considerations

☐ Frequent maintenance and the use of screens and grates to keep trash out may decrease the likelihood of clogging and prevent obstruction and bypass of incoming flows.

☐ Consult proprietors for specific criteria concerning the design and performance.

☐ Proprietary biotreatment may include specific media to address pollutants of concern. However, for proprietary device to be considered a biotreatment device the media must be capable of supporting rigorous growth of vegetation.

☐ Proprietary systems must be acceptable to the reviewing agency. Reviewing agencies shall have the discretion to request performance information. Reviewing agencies shall have the discretion to deny the use of a proprietary BMP on the grounds of performance, maintenance considerations, or other relevant factors.

☐ In right of way areas, plant selection should not impair traffic lines of site. Local jurisdictions may also limit plant selection in keeping with landscaping themes.

Computing Sizing Criteria for Proprietary Biotreatment Device

- Proprietary biotreatment devices can be volume based or flow-based BMPs.
- Volume-based proprietary devices should be sized using the Simple Design Capture Volume Sizing Method described in **Appendix** III.3.1 or the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs described in **Appendix** III.3.2.
- The required design flowrate for flow-based proprietary devices should be computed using the Capture Efficiency Method for Flow-based BMPs described in **Appendix** III.3.3).

Additional References for Design Guidance

- Los Angeles Unified School District (LAUSD) Stormwater Technical Manual, Chapter 4: http://www.laschools.org/employee/design/fs-studies-and-reports/download/white_paper_report_material/Storm_Water_Technical_Manual_2009-opt-red.pdf?version_id=76975850
- Los Angeles County Stormwater BMP Design and Maintenance Manual, Chapter 9: http://dpw.lacounty.gov/DES/design_manuals/StormwaterBMPDesignandMaintenance.pdf
- Santa Barbara BMP Guidance Manual, Chapter 6: http://www.santabarbaraca.gov/NR/rdonlyres/91D1FA75-C185-491E-A882-49EE17789DF8/0/Manual_071008_Final.pdf

Filterra Bioretention Systems

www.filterra.com • design@filterra.com

Corporate Headquarters
11352 Virginia Precast Rd
Ashland, VA 23005
(866) 349-3458

Low Impact Development Solutions for Stormwater Runoff

Filterra Bioretention Systems is the leading provider of stormwater biofiltration systems for the treatment of stormwater runoff generated from parking lots, roadways, commercial and residential developments. The Filterra System can be built in a variety of sizes, models and configurations. Filterra's compact size makes it ideal for both urban retrofits and space-constrained new developments. Filterra is easy to install, simple to maintain, and is approved by over 500 local, regional and state agencies.

Standard Filterra® System

The standard Filterra System is similar in concept to "raingardens" in its function and application but has been optimized for high volume/flow treatment and high pollutant removal.

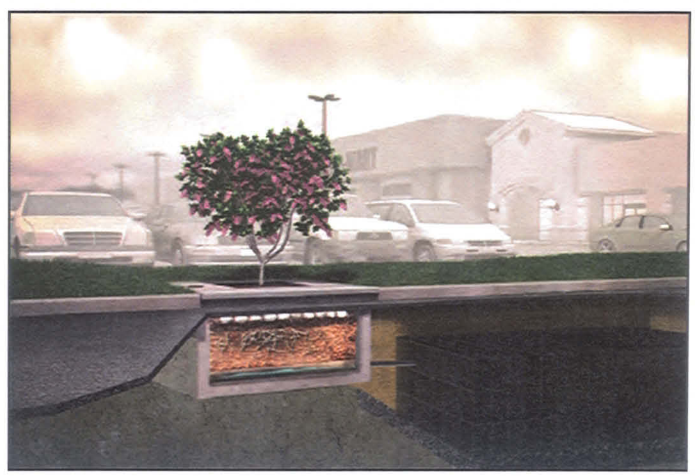
Filterra® Curb Inlet with Internal Bypass System

The Filterra Curb Inlet with Internal Bypass system incorporates biofiltration and an internal high flow bypass chamber into one single structure. This system eliminates the need and cost of installing a separate bypass structure and enables placement on grade or at low points.

Filterra® Roofdrain System

The Filterra Roofdrain System treats "Piped-In" stormwater runoff from rooftops and area drains. Using biofiltration, the system captures and immobilizes pollutants of concern such as: TSS, nutrients, oils, greases, metals nd bacteria.

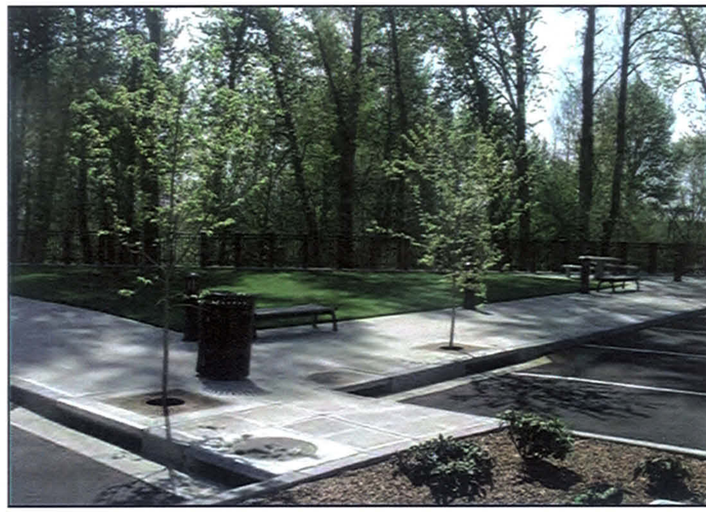
Filterra® combined with Underground Storage



Filterra combined with underground storage provides complete stormwater capture, treatment and storage in one packaged system. Surface flows can be conveyed into the Filterra and discharged to any underground storage system for detention, retention and re-use applications including landscape irrigation systems.

Corporate Headquarters
11352 Virginia Precast Rd
Ashland, VA 23005
(866) 349-

Standard Filterra System
Richmond, VA



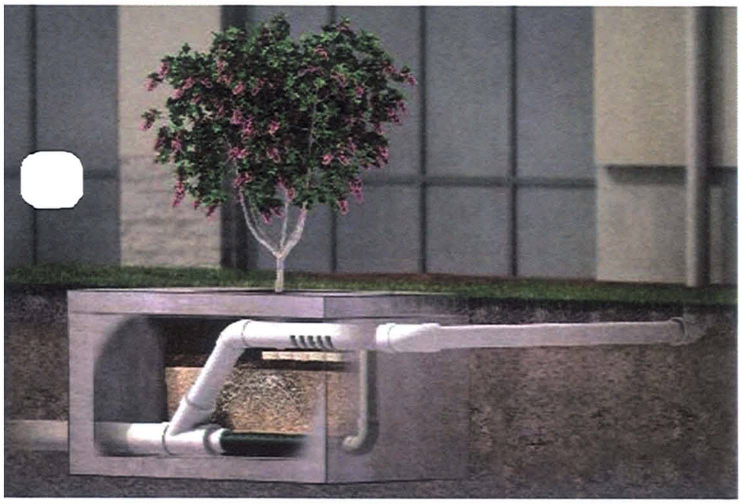
Standard Filterra System
Independence, WA

Filterra Roofdrain System
Salem, VA

Filterra Curb Inlet with Internal Bypass
Everett, WA

Standard Filterra System with Modified Recessed Top
Charlottesville, VA

Standard Filterra System Linear/ROW Application
Mill Creek, WA



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Bioretention Systems
CELEBRATING 10 YEARS
by KRISTAR

Filterra® Roofdrain Stormwater Treatment System

A Greenroof at Ground Level™

Filterra® Roofdrain System

The Filterra Roofdrain System treats piped in stormwater runoff from rooftops. Using bioretention filtration the system captures and immobilizes pollutants of concern such as: TSS, nutrients and metals.

Stormwater continues to flow through the media and into the underdrain system, where treated water is discharged. Higher flows bypass the bioretention treatment via an overflow/bypass pipe design.

Features and Benefits

Best Value for Rooftop Treatment.

- compact size
- needs no external bypass
- easy installation
- simple maintenance

Versatile.
Filterra Roofdrain can be used for:

- new construction
- retrofits
- commercial or residential applications.

Filterra Roofdrain can be placed:

- At grade
- Above grade with effluent below grade to meet elevation challenges of high water tables
- Install next to or away from your building

Maintenance. Maintenance is simple and safe (at ground level), and the first year is provided FREE with the purchase of every unit. The procedure is so easy you can perform it yourself.

Protection. The Filterra Roofdrain's hydraulic configuration was tested by the Colorado State University Hydraulics Laboratory.

Below grade treatment using Filterra Roofdrain avoids the slipping hazard liabilities of daylighted roofdrains during freezing weather.

Protect from erosion with Filterra's monolithic water tight design.

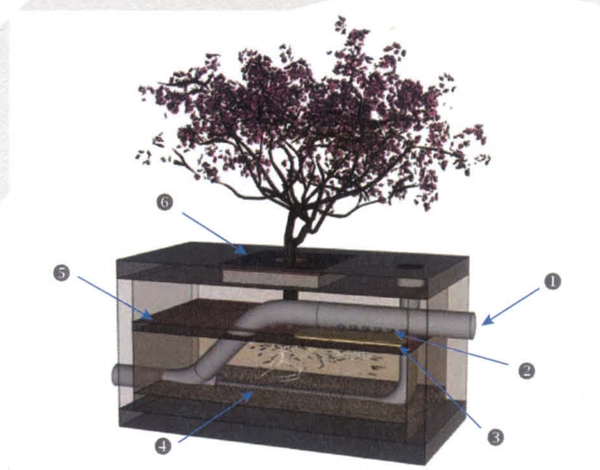
Expected Pollutant Removal

(Ranges Varying with Particle Size, Pollutant Loading and Site Conditions)

TSS Removal	85%
Phosphorus Removal	60% - 70%
Zinc Removal	> 66%
Copper Removal	>58%
Nitrogen Removal	43%
Oil & Grease	> 93%

Information on the pollutant removal efficiency of the filter soil/plant media is based on third party lab and field studies.

Filterra media has been TAPE and TARP tested and approved.



1. Influent Pipe from Roof Leader
2. Pipe slots allow treatment flow to media surface
3. Erosion Control
4. Perforated Underdrain for Treatment Flows
5. Protective Mulch Layer
6. Cast Iron Tree Grate for Maintenance Access

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Bioretention Systems
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by KRISTAR

Filterra® Roofdrain Stormwater Treatment System

A Greenroof at Ground Level™

Design Guidelines

1) Use the Filterra Roofdrain Design Guidance as a reference available from info@kristar.com.

2) Select Filterra Roofdrain model according to your Regional Sizing Table, and according to the building's roof drainage area and associated roof drain pipe sizes.

3) Determine Filterra Roofdrain placement next to a building, or away from your building.

4) Ensure piping to and from Filterra Roofdrain system is free-draining at minimum 1% slope, or per local codes.

Placement Review

Because we want your project with Filterra to be a great success, we respectfully require that each Filterra Roofdrain project be reviewed by our placement/design staff. This review is mandatory, as proper placement ensures you of the most efficient and cost effective solution, as well as optimum performance and minimal maintenance.

Proper Placement

1) Pipe flow of the Filterra Roofdrain System eliminates the cross-linear flow requirements necessary with standard Filterra.

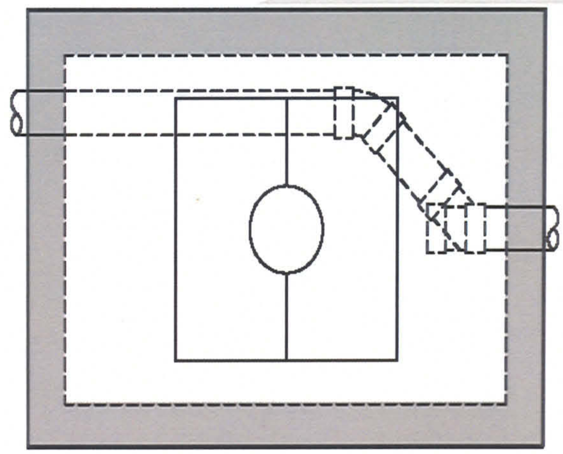
2) Filterra Roofdrain Systems should only receive piped in runoff.

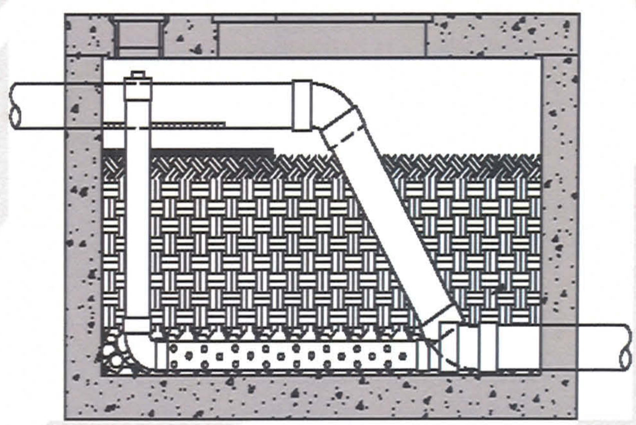
3) Rooftop drainage should still be designed with emergency bypass relief prior to the Filterra Roofdrain System (e.g.: rooftop scuppers, etc.)

Always follow local plumbing codes for roof drainage requirements.

The Filterra System is not a substitute for rooftop overflow/bypass.

4) Send completed project information form along with plans to KriStar for placement and application review.





Filterra Roofdrain System
One pipe in, one pipe out, with internal high-flow bypass.

Western Region Support
34428 Yucaipa Blvd., Suite E-312
Yucaipa, CA 92399

KriStar Enterprises, Inc.
360 Sutton Place
Santa Rosa, CA 95407

Toll Free: (800) 579-8819 • F: (707) 524-8186
E-mail: info@kristar.com • Web: www.kristar.com


Bacterra™ is ideal for urban retrofits

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Bacterra™ Media Blend

Optimized Filterra® media blend for bacteria removal

Why Bacterra™ ?

Adverse economic and public health impacts are on the rise due to increasing bacterial contamination of our swimmable and fishable waters from urban runoff. In response to this growing problem, Filterra® Bioretention Systems has developed Bacterra media blend, an effective stormwater treatment technology for removal of bacteria from urban runoff. Designed to treat bacteria at the source, Bacterra can help meet local TMDLs, and reduce public health threats and sources of bacteria to beaches and rivers.

Removal Mechanisms

The standard Filterra media blend is currently designed to remove typical stormwater pollutants such as TSS, phosphorus, nitrogen, heavy metals, and oil and grease. Bacterra media blend has been optimized to capture and destroy bacteria, and relies on multiple pollutant removal mechanisms. Once the Bacterra media has matured, it develops a complex natural microbiological ecosystem that enhances predation, and other physical, chemical and biological processes that all contribute to the removal process. The coarse sand filtration media provides both pore space and a high degree of surface area to support biofilm development. The complex organics and plants support growth of an advanced biological population. Microscopic examination of mulch and media samples from in-service Bacterra units reveals the presence of a dynamic and diverse microbial population including flagellates, ciliates and amoebae (Figure 1). These results were notable for the high concentrations of protozoa, a higher order class of organisms that are known to prey upon bacterial populations as a primary food source.

Figure 1 (Protozoan Classes Observed in Bacterra™ Media Blend)


Ciliate — Flagellate — Amoeba

1. Photos courtesy www.blm.gov/nstc/soil/protozoa/index.html and www.tvt-bio.com/micro2.html

07/2011

Pollutant Removal

Like standard Filterra media blend which removes typical stormwater pollutants, Bacterra media blend is expected to remove as much or more pollutants with higher bacteria removal. Bacterra media blend is recommended if higher bacteria removal is desired.

(Ranges Varying with Particle Size, Pollutant Loading and Site Conditions)

E. coli	99%[1], 99%[2]
Fecal Coliform	98%[1], 99%[2]
Enterococcus	95%[1], 99%[2]
TSS*	87%[1], 92%[2]
Predicted Phosphorus	60% - 70%
Predicted Nitrogen	42% - 45%
Predicted Oil & Grease	> 93%
Predicted Total Zinc	> 66%
Predicted Total Copper	> 58%

*For influent concentration >10mg/L [1]Average [2]Median percentages

Information on the pollutant removal efficiency of the filter soil/plant media is based on third party field studies and lab data.

Filterra standard media blend has been TAPE and TARP tested and approved.

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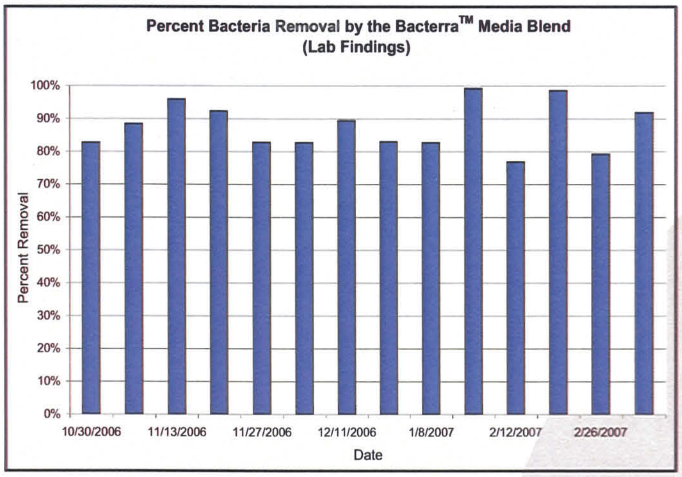
Bacterra™ Media Blend

Optimized Filterra® media blend for bacteria removal

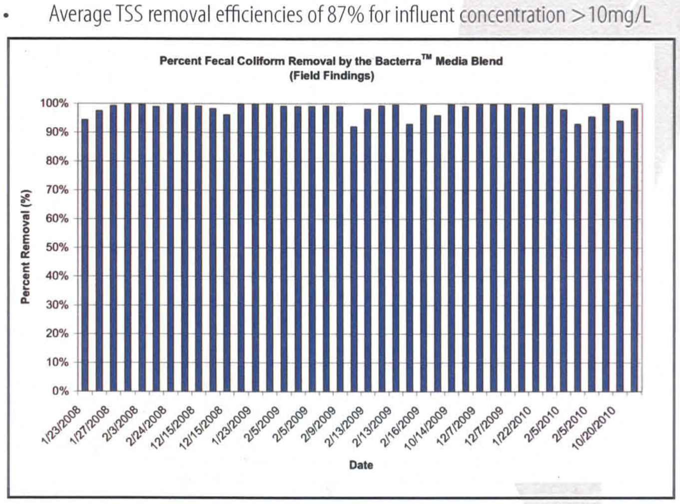
Laboratory Findings

- Removal efficiencies ranging from 77% - 99%.



Field Findings

- Average Fecal coliform , E. coli, & Enterococcus removal efficiencies of **95% - 99%**
- Average TSS removal efficiencies of 87% for influent concentration >10mg/L



E.coli & Enterococcus field findings showed similar results to Fecal coliform.

Based on lab and field data, Bacterra demonstrates that a high flow rate media can achieve high removal efficiencies. Lab data showing removal rates of 77% - 99% has been supported by field results showing removal rates of 95% - 99%.

All testing conducted using approved EPA methods. Field data obtained by third parties.

Features and Benefits

Water Quality. Achieve receiving water quality goals and reduce sources of bacteria to beaches, rivers and fisheries.

Best Value. The most cost effective stormwater treatment system available featuring low cost, easy installation and maintenance.

Aesthetics. Landscaping enhances the appearance of your site making it more attractive while removing pollutants.

Maintenance Support. Maintenance is safe and inexpensive; a one year maintenance agreement is included free with the purchase of every unit.

Versatility. Use for new construction or as an urban retrofit device.

- **Streetscapes**
- **Parking lots**
- **Highways**
- **Industrial settings**
- **Urban settings**
- **Filterra Roofdrains**
- **Combined Sewer Overflows (CSO)**

Design Support. KriStar engineers can assist you with all aspects of each Bacterra application, including flora selection and sizing. *Contact us to request a sizing table for your region.

Adaptability. May be used alone or in combination with other BMPs.

Selection. Varying configurations to meet both standard and unique site conditions.

More Information

Visit **www.filterra.com** for a list of FAQ's about the standard Filterra system and Bacterra media blend, and a product animation featuring how the Filterra system works and maintenance.

Western Region Support
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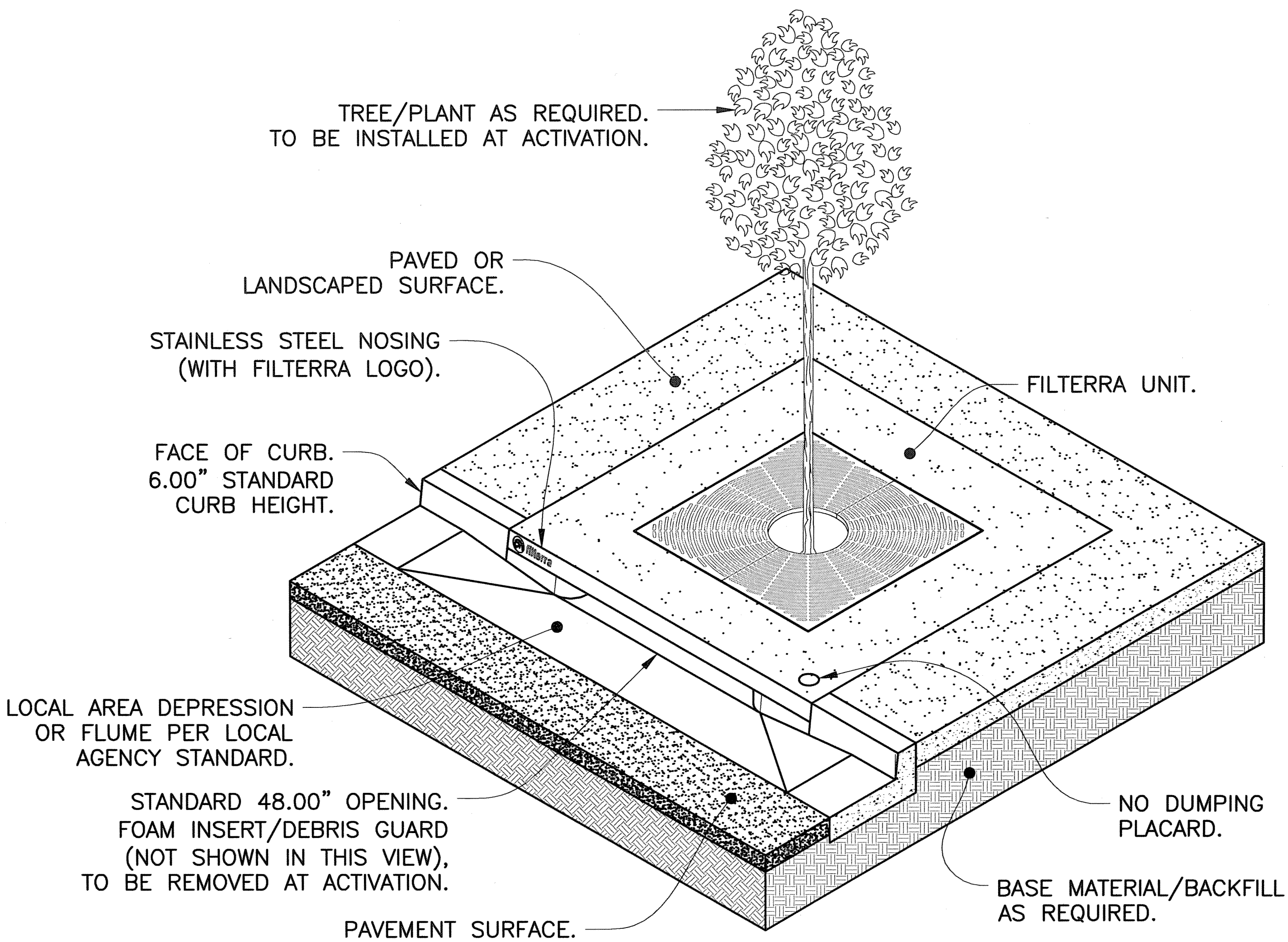
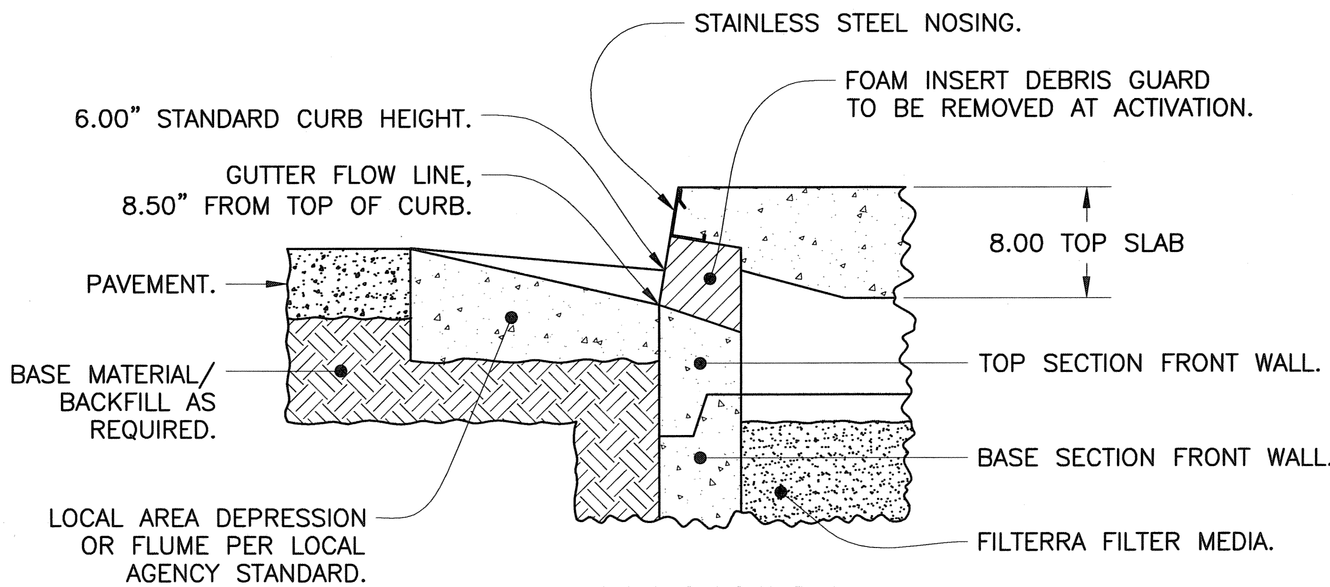




CROSS SECTION

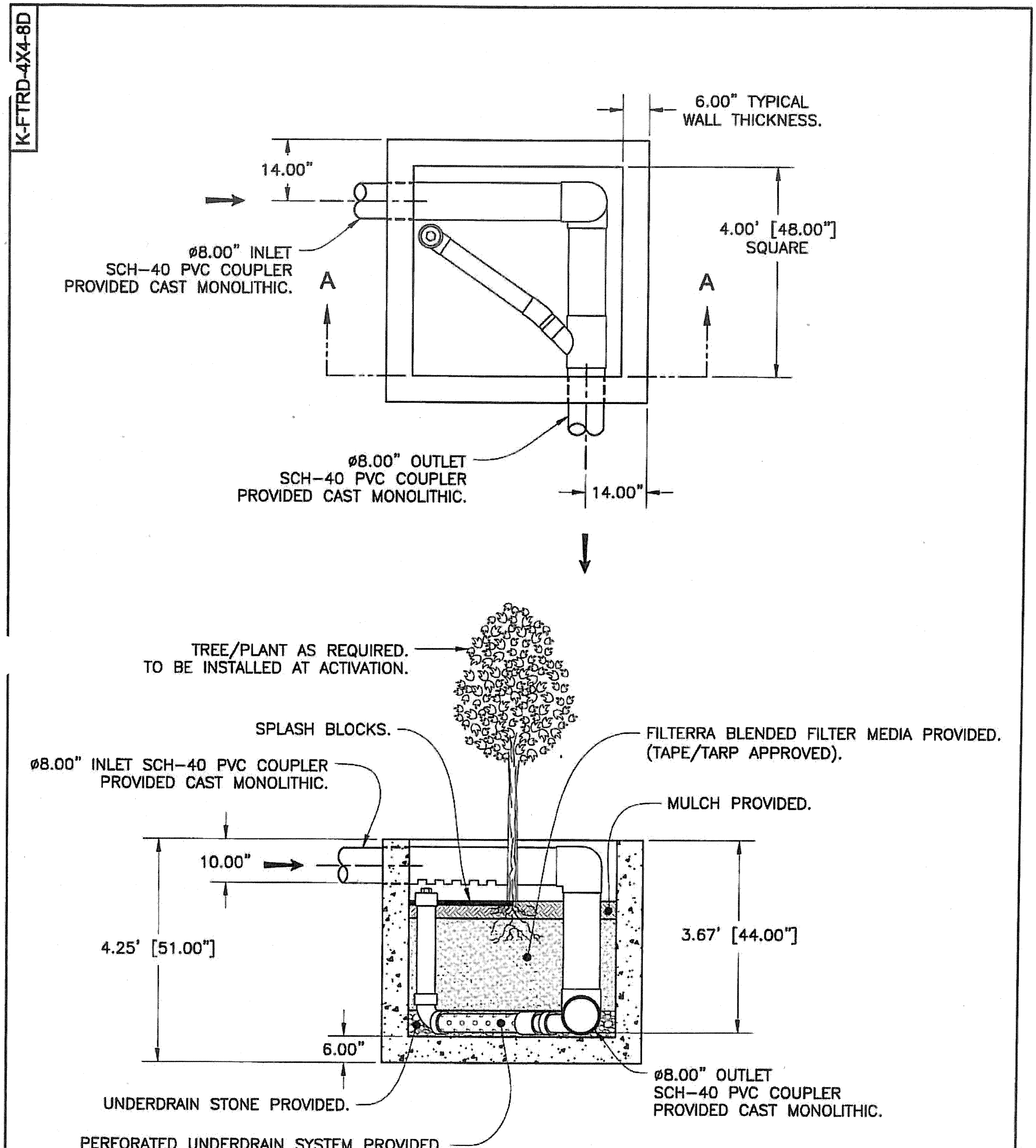
TITLE

Filterra®
Precast Curb Inlet Opening and Gutter / Flume Detail

KriStar Enterprises, Inc.
360 Sutton Place, Santa Rosa, CA 95407
Ph: 800.579.8819, Fax: 707.524.8186, www.kristar.com

US PAT 6,277,274 AND 6,569,321

DRAWING NO.	REV	F-ECO	DATE
K-CGT	03	0006 JPR 6/17/11	JPR 1/17/11



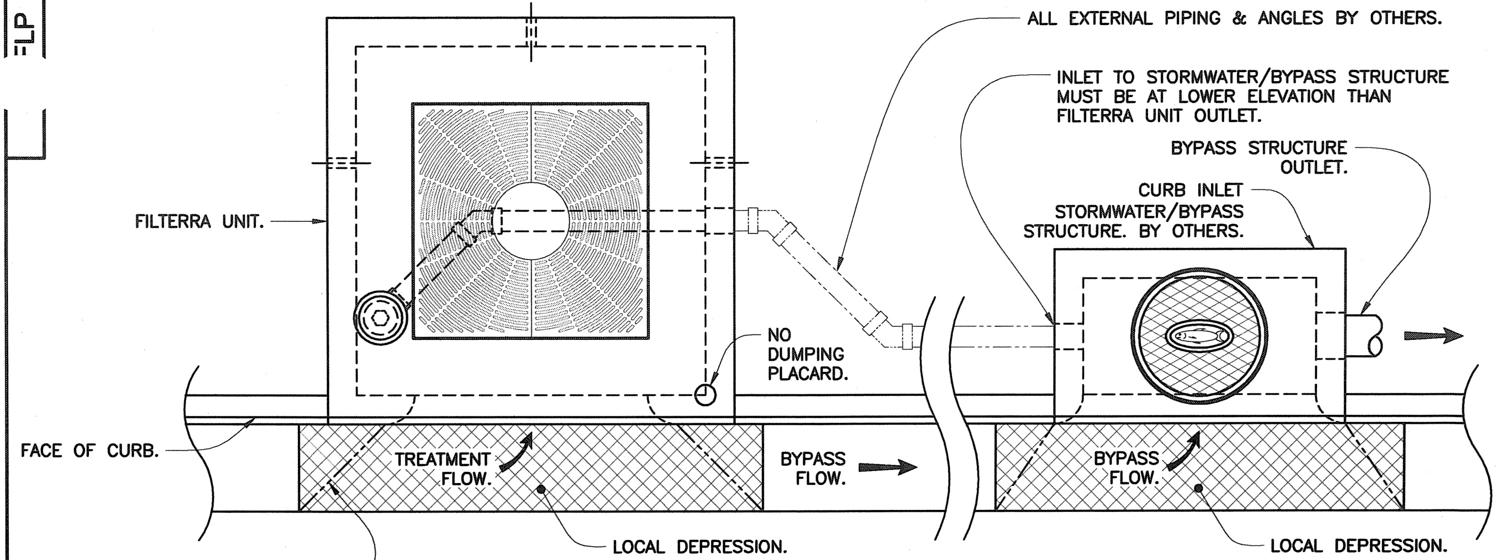
TITLE

4'X4' Precast Filterra® Unit Roof Drain Configuration with Ø8" PVC Inlet

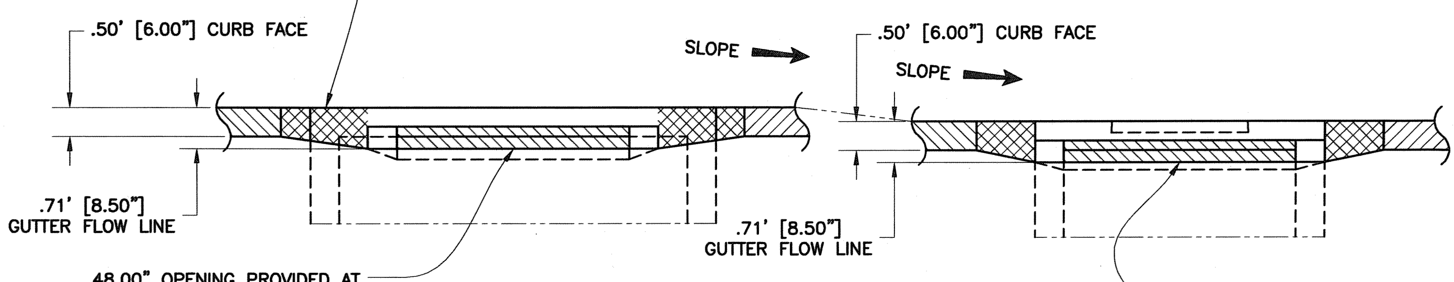
KriStar Enterprises, Inc.
360 Sutton Place, Santa Rosa, CA 95407
Ph: 800.579.8819, Fax: 707.524.8186, www.kristar.com

filterra® US PAT 6,277,274 AND 6,569,321

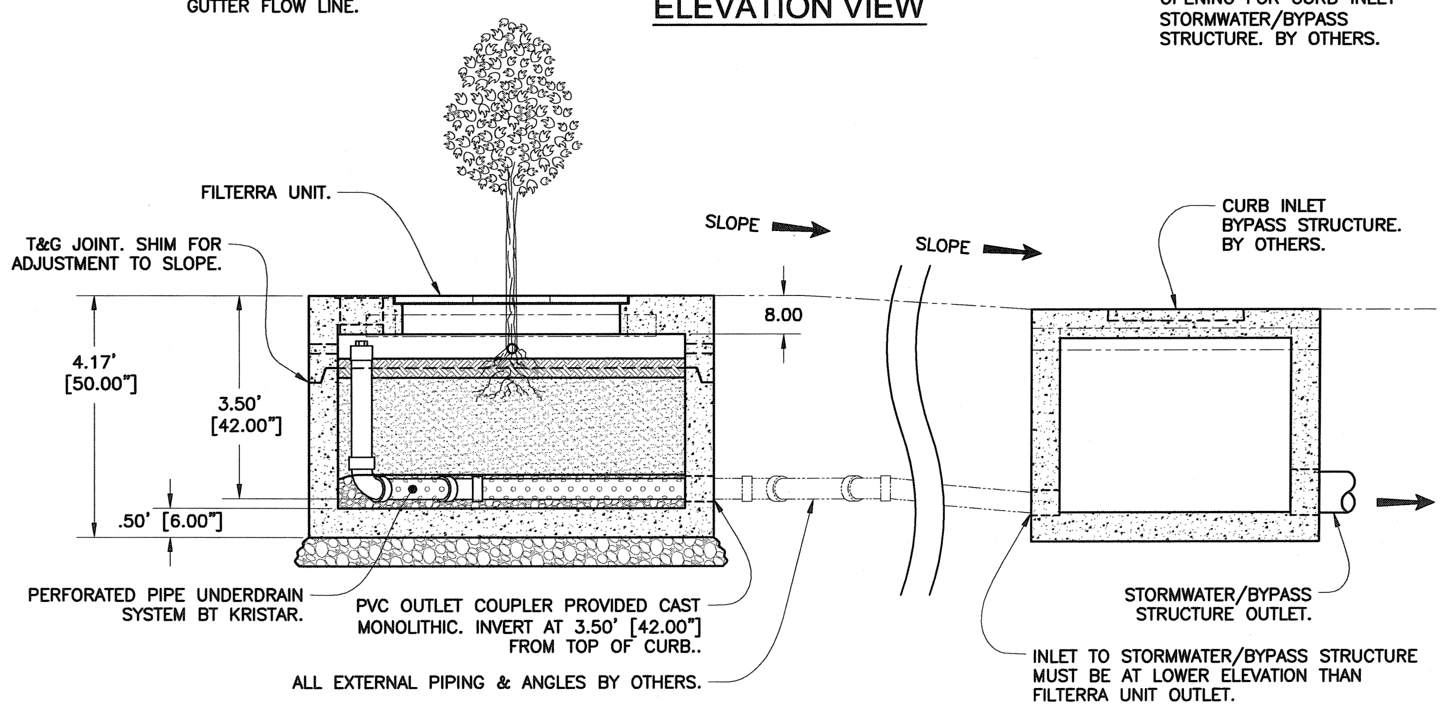
DRAWING NO.	REV	F-ECO	DATE
K-FTRD-4X4-8D	02	0006 NEW 6/17/11	JPR 1/19/11



PLAN VIEW



ELEVATION VIEW



CROSS SECTION

TITLE

Filterra®
Typical Flowline and Outlet Pipe Relationship

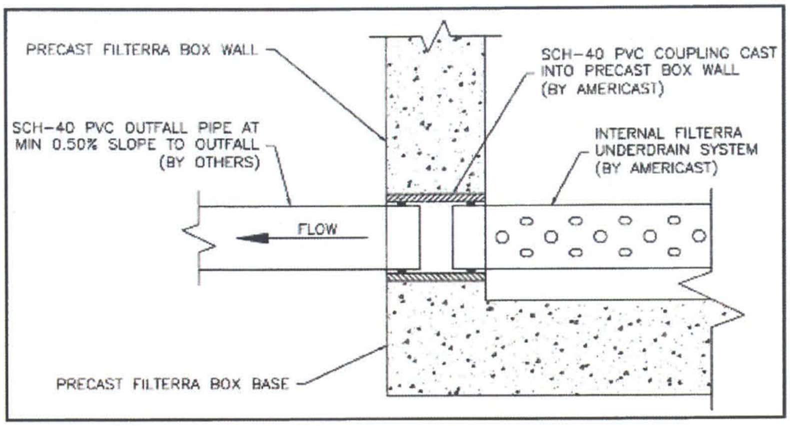
KriStar Enterprises, Inc.
360 Sutton Place, Santa Rosa, CA 95407
Ph: 800.579.8819, Fax: 707.524.8186, www.kristar.com

filterra® US PAT 6,277,274 AND 6,569,321

DRAWING NO.	REV	F-ECO	DATE
K-FLP	03	0006 JPR 6/17/11	JPR 1/5/11

Filterra® Piping Technical Details

Filterra® is supplied with an internal underdrain system that exits a wall in a perpendicular direction. Most efficient drainage is accomplished when the drain exits on the lower side of the Filterra®, i.e. nearest the overflow bypass. This is more important when using the larger sized Filterra® Systems.



Drawing DP1:
Section View through Filterra Precast Box Wall at Outfall Pipe Connection

All units are supplied with the drainage pipe coupling precast into the wall, at a depth of 3.50 feet (INV to TC). Drawing DP1 is a detail of the coupling. The coupling used is SCH-40 PVC.

Typically, a minimum slope of 0.5% is adequate to accommodate the flow of treated water from the Filterra®, but each site may present unique conditions based on routing of the outfall pipe (elbows). The pipe must not be a restricting point for the successful operation of Filterra®. All connecting pipes must accommodate freefall flow. Table 3 lists WA DOE approved treatment sizing flow rates of the various size Filterra® units. A safety factor of at least two should be used to size piping from the Filterra based on these conservative approved treatment flow rates.

Table 3: Filterra Flow Rates & Pipe Details

Important Note: Actual flow rate may be more than double rates below.

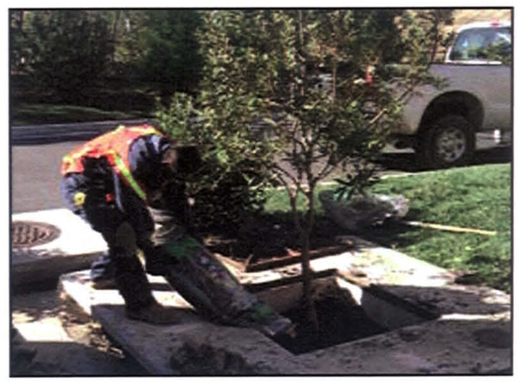
Filterra® Size (feet)	Expected Flow Rate (cubic feet/second)	Connecting Drainage Pipe
4x4	0.037	4" SCH-40 PVC
4 x 6 or 6 x 4	0.061	4" SCH-40 PVC
4x6.5 or 6.5x4	0.061	4" SCH-40 PVC
4 x 8 or 8 x 4	0.075	4" SCH-40 PVC
4x16 or 16x4	0.150	6" SCH-40 PVC
6 x 6	0.084	4" SCH-40 PVC
6 x 8 or 8 x 6	0.112	4" SCH-40 PVC
6 x 10 or 10 x 6	0.140	6" SCH-40 PVC
6 x 12 or 12 x 6	0.168	6" SCH-40 PVC
8x12 or 12x8	0.224	6" SCH-40 PVC
8x16 or 16x8	0.229	6" SCH-40 PVC
8x18 or 18x8	0.337	6" SCH-40 PVC
8x20 or 20x8	0.374	6" SCH-40 PVC

Filterra® Maintenance Steps

1. Inspection of Filterra and surrounding area

2. Removal of tree grate and erosion control stones

3. Removal of debris, trash and mulch



4. Mulch replacement

5. Clean area around Filterra

6. Complete paperwork and record plant height and width

For additional information please contact your local Filterra sales representative.
Eastern Zone: 866-349-3458, Western Zone: 877-345-1450.

SECTION VII EDUCATIONAL MATERIALS

The educational materials included in this WQMP are provided to inform people involved in future uses, activities, or ownership of the site about the potential pitfalls associated with careless storm water management. "The Ocean Begins at Your Front Door" provides users with information about storm water that is/will be generated on site, what happens when water enters a storm drain, and its ultimate fate, discharging into the ocean. Also included are activities guidelines to educate anyone who is or will be associated with activities that have a potential to impact storm water runoff quality, and provide a menu of BMPs to effectively reduce the generation of storm water runoff pollutants from a variety of activities. The educational materials that may be used for the proposed project are included in Appendix C of this WQMP and are listed below.

EDUCATION MATERIALS			
Residential Materials (http://www.ocwatersheds.com)	**Check If Applicable**	**Business Materials (http://www.ocwatersheds.com)**	**Check If Applicable**
The Ocean Begins at Your Front Door	☒	Tips for the Automotive Industry	☐
Tips for Car Wash Fund-raisers	☐	Tips for Using Concrete and Mortar	☐
Tips for the Home Mechanic	☐	Tips for the Food Service Industry	☐
Homeowners Guide for Sustainable Water Use	☐	Proper Maintenance Practices for Your Business	☐
Household Tips	☒	**Other Materials (http://www.ocwatersheds.com) (http://www.cabmphandbooks.com)**	**Check If Attached**
Proper Disposal of Household Hazardous Waste	☒		
Recycle at Your Local Used Oil Collection Center (North County)	☐	DF-1 Drainage System Operation & Maintenance	☒
Recycle at Your Local Used Oil Collection Center (Central County)	☒	R-1 Automobile Repair & Maintenance	☐
Recycle at Your Local Used Oil Collection Center (South County)	☐	R-2 Automobile Washing	☐
Tips for Maintaining Septic Tank Systems	☐	R-3 Automobile Parking	☒
Responsible Pest Control	☐	R-4 Home & Garden Care Activities	☒
Sewer Spill	☐	R-5 Disposal of Pet Waste	☒
Tips for the Home Improvement Projects	☒	R-6 Disposal of Green Waste	☒
Tips for Horse Care	☐	R-7 Household Hazardous Waste	☒
Tips for Landscaping and Gardening	☒	R-8 Water Conservation	☒
Tips for Pet Care	☒	SD-10 Site Design & Landscape Planning	☒
Tips for Pool Maintenance	☒	SD-11 Roof Runoff Controls	☒
Tips for Residential Pool, Landscape and Hardscape Drains	☒	SD-12 Efficient Irrigation	☒
Tips for Projects Using Paint	☒	SD-13 Storm Drain Signage	☒
Other:	☐	SD-31 Maintenance Bays & Docs	☐
Other:	☐	SD-32 Trash Storage Areas	☐

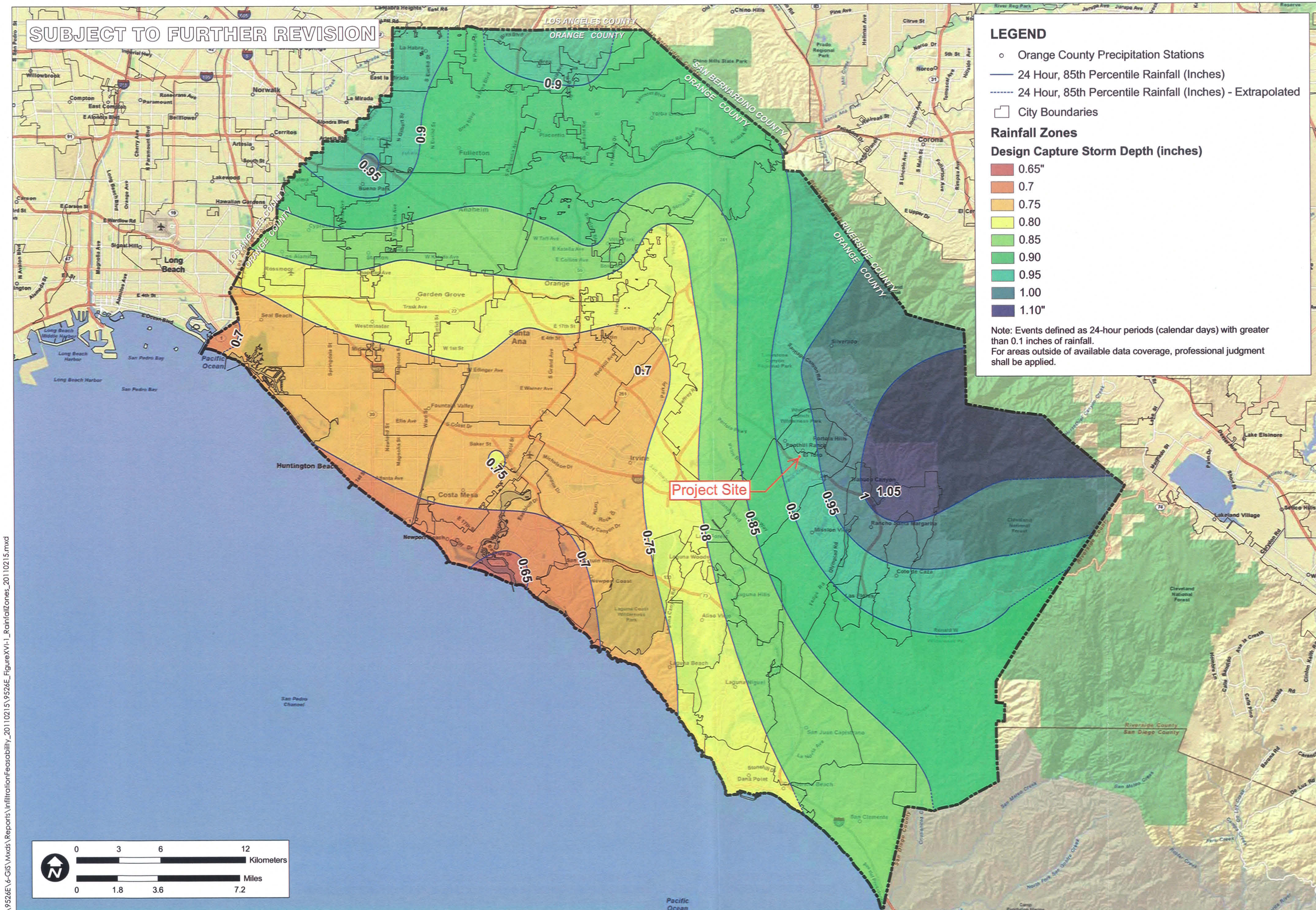
Appendices

APPENDICES

Appendix A

Appendix A

Supporting Calculations



TITLE
RAINFALL ZONES

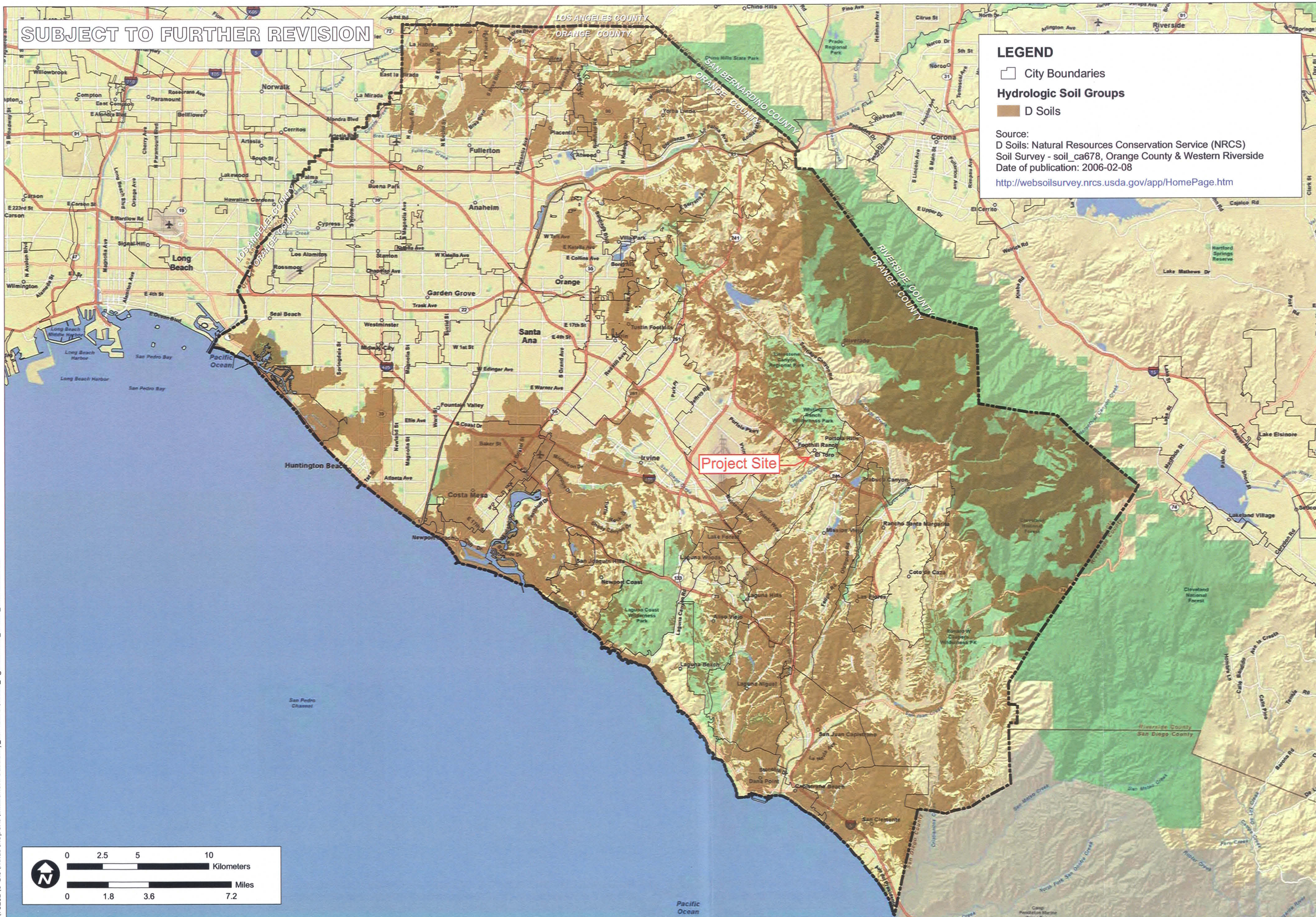
ORANGE COUNTY TECHNICAL GUIDANCE DOCUMENT

JOB
ORANGE CO. CA

SCALE	1" = 1.8 miles
DESIGNED	TH
DRAWING	TH
CHECKED	BMP
DATE	04/22/10
JOB NO.	9526-E

PACE
Advanced Water Engineering

FIGURE
XVI-1



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TITLE
HYDROLOGIC SOIL GROUP
TYPE D NRCS SOIL SURVEY

JOB
ORANGE COUNTY
INFILTRATION STUDY
ORANGE CO. CA

SCALE	1" = 1.8 miles
DESIGNED	TH
DRAWING	TH
CHECKED	BMP
DATE	02/09/11
JOB NO.	9526-E

PACE
Advanced Water Engineering

FIGURE
XVI-2b

Preliminary Storm Water Quality Design Calculations

4/3/2012

Storm Water Design Capture Volume (DCV)

Drainage Area Name	% impervious	Runoff Coefficient	Design Storm Depth (in)	Average 2-year Tc (min)	Rainfall Intensity (in/hr)	Drainage Area (ft^2)	Drainage Area (acres)	DCV (ft^3)	Q (cfs)	Biotreatment Unit Size	Cost Estimate
Assumes No HSCs											
A1+A2 (Filterra #1)	90%	0.83	0.95	9.11	0.23	69,260	1.59	**4,531.8**	**0.30**	see 80% Capture	
A3 (Filterra #2)	80%	0.75	0.95	9.21	0.23	48,787	1.12	**2,902.5**	**0.19**	2-6x8	$26,800
A4 (Filterra #3)	85%	0.79	0.95	9.7	0.225	71,874	1.65	**4,489.4**	**0.29**	2-6x12	$40,000
A6 (Filterra #4)	90%	0.83	0.95	10	0.225	56,192	1.29	**3,676.7**	**0.24**	2-6x10	$34,200
A5 North (Filterra #5)	85%	0.79	0.95	10	0.225	54,450	1.25	**3,401.1**	**0.22**	2-6x8	$26,800
A5 South (Filterra #6)	85%	0.79	0.95	9	0.23	56,628	1.30	**3,537.1**	**0.24**	2-6x10	$34,200
Total	86.07%	0.80	0.95	9.5	0.225	357,192	8.20	**22,538.7**	**1.47**		$188,800
80% Capture											
A1+A2 (Filterra #1)	90%	0.83	0.95	9.11	0.17	69,260	1.59	**4,531.8**	**0.22**	2-6x8	$26,800

assumes Filterra

Worksheets from Orange County Technical Guidance Document (5-19-2011)

See TGD for instructions and/or examples related to these worksheets:
www.ocwatersheds.com/WQMP.aspx

Table 2.7: Infiltration BMP Feasibility Worksheet

	Infeasibility Criteria	Yes	No
1	**Would Infiltration BMPs pose significant risk for groundwater related concerns?** Refer to Appendix VII (Worksheet I) for guidance on groundwater-related infiltration feasibility criteria.		X
Provide basis: *Groundwater was not encountered during the geotechnical investigations.* Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
2	Would Infiltration BMPs **pose significant risk of increasing risk of geotechnical hazards that cannot be mitigated to an acceptable level**? (Yes if the answer to any of the following questions is yes, as established by a geotechnical expert): The BMP can only be located less than 50 feet away from slopes steeper than 15 percent The BMP can only be located less than eight feet from building foundations or an alternative setback. A study prepared by a geotechnical professional or an available watershed study substantiates that storm water infiltration would potentially result in significantly increased risks of geotechnical hazards that cannot be mitigated to an acceptable level.		X
Provide basis: *The site is relatively flat. The western portions of the site consist generally of engineered fill placed during the grading activities for nearby Bake Parkway. The eastern/northeastern portion of the site generally consists as cut bedrock at the surface, with the exception of the placement of engineered fill for over-excavation of a cut to fill transition in support of the existing car dealership structure at the northeast portion of the site.* Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
3	Would infiltration of the DCV from drainage area **violate downstream water rights**?		X
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			

Table 2.7: Infiltration BMP Feasibility Worksheet (continued)

	Partial Infeasibility Criteria	*Yes*	*No*
4	Is proposed infiltration facility **located on HSG D soils** or the site geotechnical investigation identifies presence of soil characteristics which support categorization as D soils?	X	
Provide basis: *Refer to Figure XVI-db in Appendix A.* Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
5	Is **measured infiltration rate below proposed facility less than 0.3 inches per hour**? This calculation shall be based on the methods described in Appendix VII.	X	
Provide basis: *Based on 3 borings conducted on-site, the measured infiltration rate averaged 0.044 in/hr prior to applying safety factors. After applying a safety factor of 3, the design infiltration rate provided by the geotechnical engineer is 0.014 in/hr. Refer to Appendix F for infiltration test results.* Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
6	Would **reduction of over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?**		X
Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
7	Would **an increase in infiltration over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?**		X
Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			

Table 2.7: Infiltration BMP Feasibility Worksheet (continued)

Infiltration Screening Results (check box corresponding to result):		
8	Is there substantial evidence that infiltration from the project would result in a significant increase in I&I to the sanitary sewer that cannot be sufficiently mitigated? (See Appendix XVII) Provide narrative discussion and supporting evidence: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.	No
9	If any answer from row 1-3 is yes: infiltration of any volume is **not feasible** within the DMA or equivalent. Provide basis: Summarize findings of infeasibility screening	No
10	If any answer from row 4-7 is yes, infiltration is **permissible but is not presumed to be feasible for the entire DCV.** Criteria for designing biotreatment BMPs to achieve the maximum feasible infiltration and ET shall apply. Provide basis: *Infiltration rates are too low to achieve infiltration of full DCV. Biotreatment BMPs will be utilized.* Summarize findings of infeasibility screening	Not feasible.
11	If all answers to rows 1 through 11 are no, infiltration of the full DCV is potentially feasible, BMPs must be designed to infiltrate the full DCV to the maximum extent practicable.	Not feasible.

Worksheet H: Factor of Safety and Design Infiltration Rate Worksheet

Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) $p = w \times v$
A	Suitability Assessment	Soil assessment methods	0.25	1	0.25
		Predominant soil texture	0.25	3	0.75
		Site soil variability	0.25	1	0.25
		Depth to groundwater / impervious layer	0.25	1	0.25
		Suitability Assessment Safety Factor, $S_A = \Sigma p$			1.5
B	Design	Tributary area size	0.25	2	0.5
		Level of pretreatment/ expected sediment loads	0.25	1	0.25
		Redundancy	0.25	2	0.5
		Compaction during construction	0.25	3	0.75
		Design Safety Factor, $S_B = \Sigma p$			2

Combined Safety Factor, $S_{TOT} = S_A \times S_B$	3
Measured Infiltration Rate, inch/hr, K_M (corrected for test-specific bias)	0.044
Design Infiltration Rate, in/hr, $K_{DESIGN} = S_{TOT} / K_M$	0.014

Supporting Data

Briefly describe infiltration test and provide reference to test forms:

See Appendix F for infiltration test information & data.

Note: The minimum combined adjustment factor shall not be less than 2.0 and the maximum combined adjustment factor shall not exceed 9.0.

For all high concerns, assign a factor value of 3, for medium concerns, assign a factor value of 2, and for low concerns assign a factor value of 1.

Table VII.3: Suitability Assessment Related considerations for Infiltration Facility Safety Factors

Consideration	High Concern	Medium Concern	Low Concern
Assessment methods (see explanation below)	Use of soil survey maps or simple texture analysis to estimate short-term infiltration rates	Direct measurement of ≥ 20 percent of infiltration area with localized infiltration measurement methods (e.g., infiltrometer)	Direct measurement of ≥ 50 percent of infiltration area with localized infiltration measurement methods or Use of extensive test pit infiltration measurement methods
Texture Class	Silty and clayey soils with significant fines	Loamy soils	Granular to slightly loamy soils
Site soil variability	Highly variable soils indicated from site assessment or limited soil borings collected during site assessment	Soil borings/test pits indicate moderately homogeneous soils	Multiple soil borings/test pits indicate relatively homogeneous soils
Depth to groundwater/ impervious layer	<5 ft below facility bottom	5-10 ft below facility bottom	>10 below facility bottom

Localized infiltration testing refers to methods such as the double ring infiltrometer test (ASTM D3385-88) which measure infiltration rates over an area less than 10 sq-ft, may include lateral flow, and do not attempt to account for heterogeneity of soil. The amount of area each test represents should be estimated depending on the observed heterogeneity of the soil.

Extensive infiltration testing refers to methods that include excavating a significant portion of the proposed infiltration area, filling the excavation with water, and monitoring drawdown. The excavation should be to the depth of the proposed infiltration surface and ideally be at least 50 to 100 square feet.

In all cases, testing should be conducted in the area of the proposed BMP where, based on review of available geotechnical data, soils appear least likely to support infiltration.

Table VII.4: Design Related Considerations for Infiltration Facility Safety Factors

Consideration	High Concern	Medium Concern	Low Concern
Tributary area size	Greater than 10 acres	Greater than 2 acres but less than 10 acres	2 acres or less
Level of pretreatment/ expected influent sediment loads	Pretreatment from gross solids removal devices only, such as Hydrodynamic separators, racks and screens AND tributary area includes landscaped areas, steep slopes, high traffic areas, or any other areas expected to produce high sediment, trash, or debris loads.	Good pretreatment with BMPs that mitigate coarse sediments such as vegetated swales AND influent sediment loads from the tributary area are expected to be relatively low (e.g., low traffic, mild slopes, disconnected impervious areas, etc.).	Excellent pretreatment with BMPs that mitigate fine sediments such as bioretention or media filtration OR sedimentation or facility only treats runoff from relatively clean surfaces, such as rooftops.
Redundancy of treatment	No redundancy in BMP treatment train	Medium redundancy, other BMPs available in treatment train to maintain at least 50% of function of facility in event of failure.	High redundancy, multiple components capable of operating independently and in parallel, maintaining at least 90% of facility functionality in event of failure.
Compaction during construction	Construction of facility on a compacted site or elevated probability of unintended/ indirect compaction.	Medium probability of unintended/ indirect compaction.	Heavy equipment actively prohibited from infiltration areas during construction and low probability of unintended/ indirect compaction.

Worksheet J: Summary of Harvested Water Demand and Feasibility

1	What demands for harvested water exist in the tributary area (check all that apply):			
2	Toilet and urinal flushing			
3	Landscape irrigation		X	
4	Other:______________________________			
5	What is the design capture storm depth? (Figure III.1)	d	0.95	inches
6	What is the project size?	A	8.2	ac
7	What is the acreage of impervious area?	IA	7.06	ac
For projects with multiple types of demand (toilet flushing, irrigation demand, and/or other demand)				
8	What is the minimum use required for partial capture? (Table X.6)	--		gpd
9	What is the project estimated wet season total daily use (Section X.2)?	--		gpd
10	Is partial capture potentially feasible? (Line 9 > Line 8?)	--		
For projects with only toilet flushing demand				
11	What is the minimum TUTIA for partial capture? (Table X.7)	--		
12	What is the project estimated TUTIA?	--		
13	Is partial capture potentially feasible? (Line 12 > Line 11?)	--		
For projects with only irrigation demand				
14	What is the minimum irrigation area required based on conservation landscape design? (Table X.8)	3.67 (see explanation below)		ac
15	What is the proposed project irrigated area? (multiply conservation landscaping by 1; multiply active turf by 2)	1.14		ac
16	Is partial capture potentially feasible? (Line 15 > Line 14?)	No		

Provide supporting assumptions and citations for controlling demand calculation:

0.52 ac landscaping required per acre of impervious area
7.06 acres impervious on the project site, landscaping required = 0.52 x 7.06 = 3.67 ac minimum
Actual landscaping proposed on-site = 1.14 ac

Worksheet assumes conservation landscape design. Actual landscaping on-site will consist of a mix of both turf and conservation landscape design. Refer to detailed harvest & reuse calculations (EAWU Method) performed in accordance with the WQMP TGD Appendix X.

Table X.6: Harvested Water Demand Thresholds for Minimum Partial Capture

Design Capture Storm Depth[1], inches	Wet Season Demand Required for Minimum Partial Capture, gpd per impervious acre
0.60	490
0.65	530
0.70	570
0.75	610
0.80	650
0.85	690
0.90	730
0.95	770
1.00	810

1- Based on isopluvial map (See XIV.1)

Table X.8: Minimum Irrigated Area for Potential Partial Capture Feasibility

General Landscape Type	Conservation Design: K_L = 0.35			Active Turf Areas: K_L = 0.7		
Closest ET Station	*Irvine*	*Santa Ana*	*Laguna*	*Irvine*	*Santa Ana*	*Laguna*
Design Capture Storm Depth, inches	**Minimum Required Irrigated Area per Tributary Impervious Acre for Potential Partial Capture, ac/ac**					
0.60	0.66	0.68	0.72	0.33	0.34	0.36
0.65	0.72	0.73	0.78	0.36	0.37	0.39
0.70	0.77	0.79	0.84	0.39	0.39	0.42
0.75	0.83	0.84	0.90	0.41	0.42	0.45
0.80	0.88	0.90	0.96	0.44	0.45	0.48
0.85	0.93	0.95	1.02	0.47	0.48	0.51
0.90	0.99	1.01	1.08	0.49	0.51	0.54
0.95	1.04	1.07	1.14	0.52	0.53	0.57
1.00	1.10	1.12	1.20	0.55	0.56	0.60

Worksheet E: Determining Capture Efficiency of Volume Based, Constant Drawdown BMP based on Design Volume

Rain Gardens (A1 + A2)

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from Figure III.1, *d* (inches)	d=	0.95	inches
2	Enter the storage volume provided in the BMP, *V* (cu-ft)	V=	370	cu-ft
3	Enter Project area tributary to BMP (s), *A* (acres)	A=	1.59	acres
4	Enter Project Imperviousness, *imp* (unitless)	imp=	90%	
5	Calculate runoff coefficient, $C = (0.75 \times imp) + 0.15$	C=	0.83	
6	Calculate the effective design storm depth provided (inches), $d_{provided}=(V \times 12)/(C \times A \times 43560)$	$d_{provided}$=	0.077	inches
7	Calculate the design storm depth as a fraction of the design capture depth, $X_{fraction} = d_{provided}/d$	$X_{fraction}$=	0.08	
Step 2: Calculate the capture efficiency of the BMP system				
1	Determine the drawdown time of the proposed BMP based on equations provided in the applicable BMP Fact Sheet, *T* (hours)	T=	2.4	hours
2	Enter the effect of provided HSCs upstream, d_{HSC} (inches) (Worksheet A)	d_{HSC}=	--	inches
3	Enter capture efficiency corresponding to d_{HSC} from Table 6.7 (regionally based), Y_1 (Worksheet A)	Y_1=	--	%
4	Using Figure III.2, determine the fraction of "design capture storm depth" at which the drawdown time (T) achieves the upstream capture efficiency(Y_1), X_1	X_1=	--	
5	Determine the fraction of design capture storm depth corresponding to the cumulative capture efficiency, $X_2=X_1+X_{fraction}$	X_2=	0.08	
6	Using Figure III.2, determine the capture efficiency corresponding to total fraction of design storm depth (X_2) for drawdown time (T), Y_2	Y_2=	40%	
Supporting Calculations				