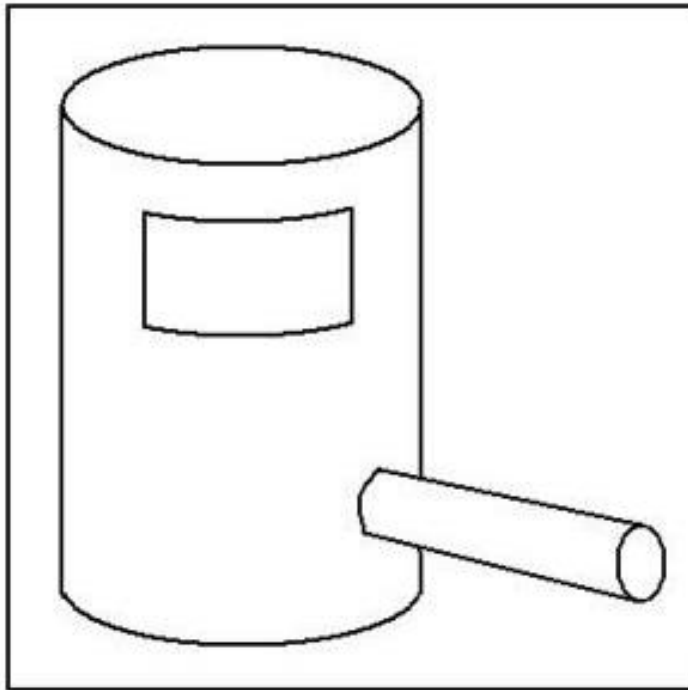


Stormwater as a Resource: Sustainable Projects at Sacramento State

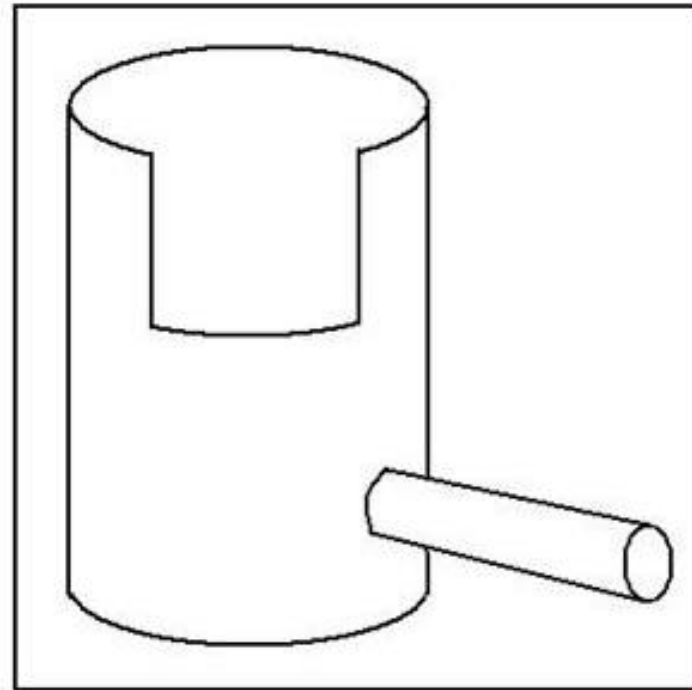
Dr. John Johnston, PhD, PE
Professor, Civil Engineering

Maureen Kerner, PE
Research Engineer, Office of Water Programs

Stormwater humor



Riser with Orifice and Pipe
Outlet Control



Riser with Weir and Pipe
Outlet Control

Flooding

Missouri Governor Warns of 'Historic and Dangerous' Floods

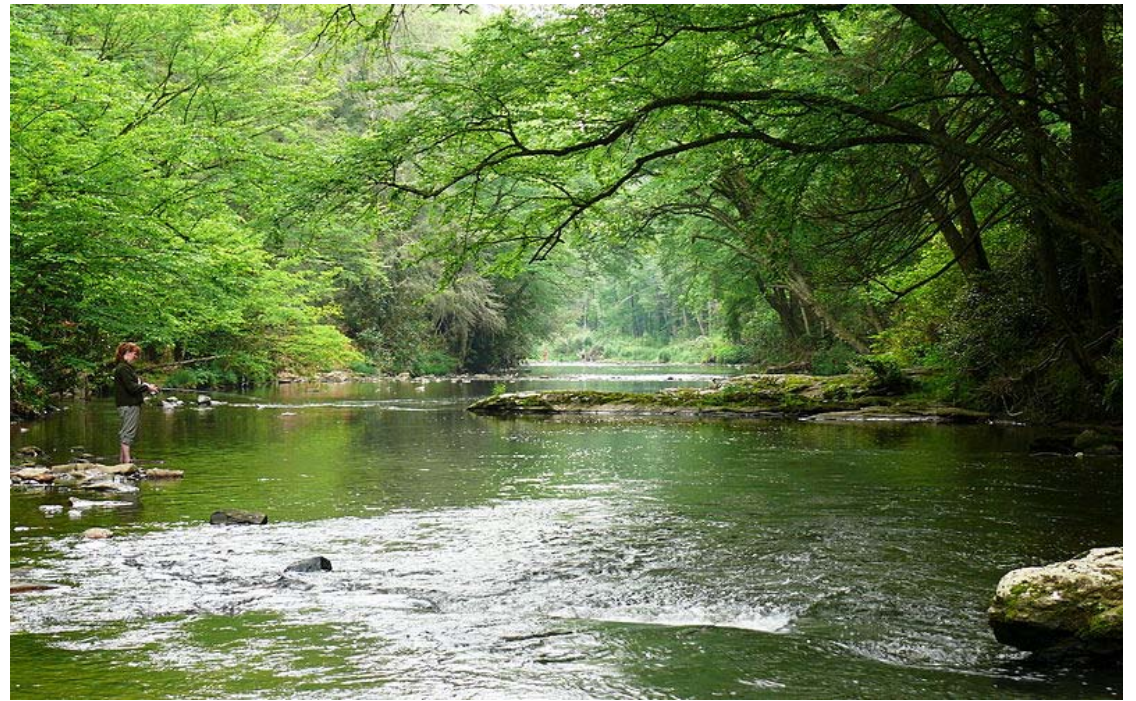


<http://www.nbcnews.com/news/us-news/missouri-governor-warns-historic-dangerous-floods-n487541>

Traditional drainage design



Traditional drainage design



Traditional drainage design



[movie](#)

http://www.hcn.org/issues/41.2/non-navigable-river-blues/image_viewer

Stormwater pollutants

Sediment



Nutrients



Pesticides



Trash



Campus Stormwater



Stormwater
discharge



American R upstream

Stormwater pollution impacts

- ✓ Fish toxicity
- ✓ Algae blooms
- ✓ Aquatic habitat destruction
- ✓ Visually unappealing
- ✓ Beach closures



Stormwater is one of the leading, remaining causes of water quality problems (EPA)

Local impact examples



Spawning
habitat



<http://littlegreentent.blogspot.com/2013/08/cordova-ak.html>

http://nature.ca/explore/di-ef/wstr_pyb_e.cfm

Local impact examples



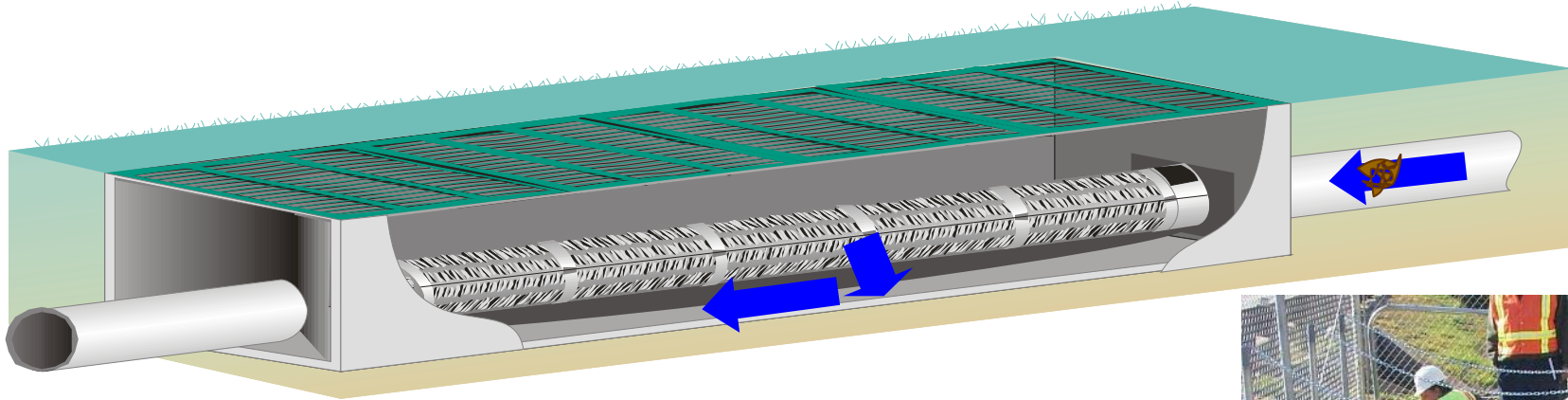
Excessive algae growth
(eutrophication)

Treatment !

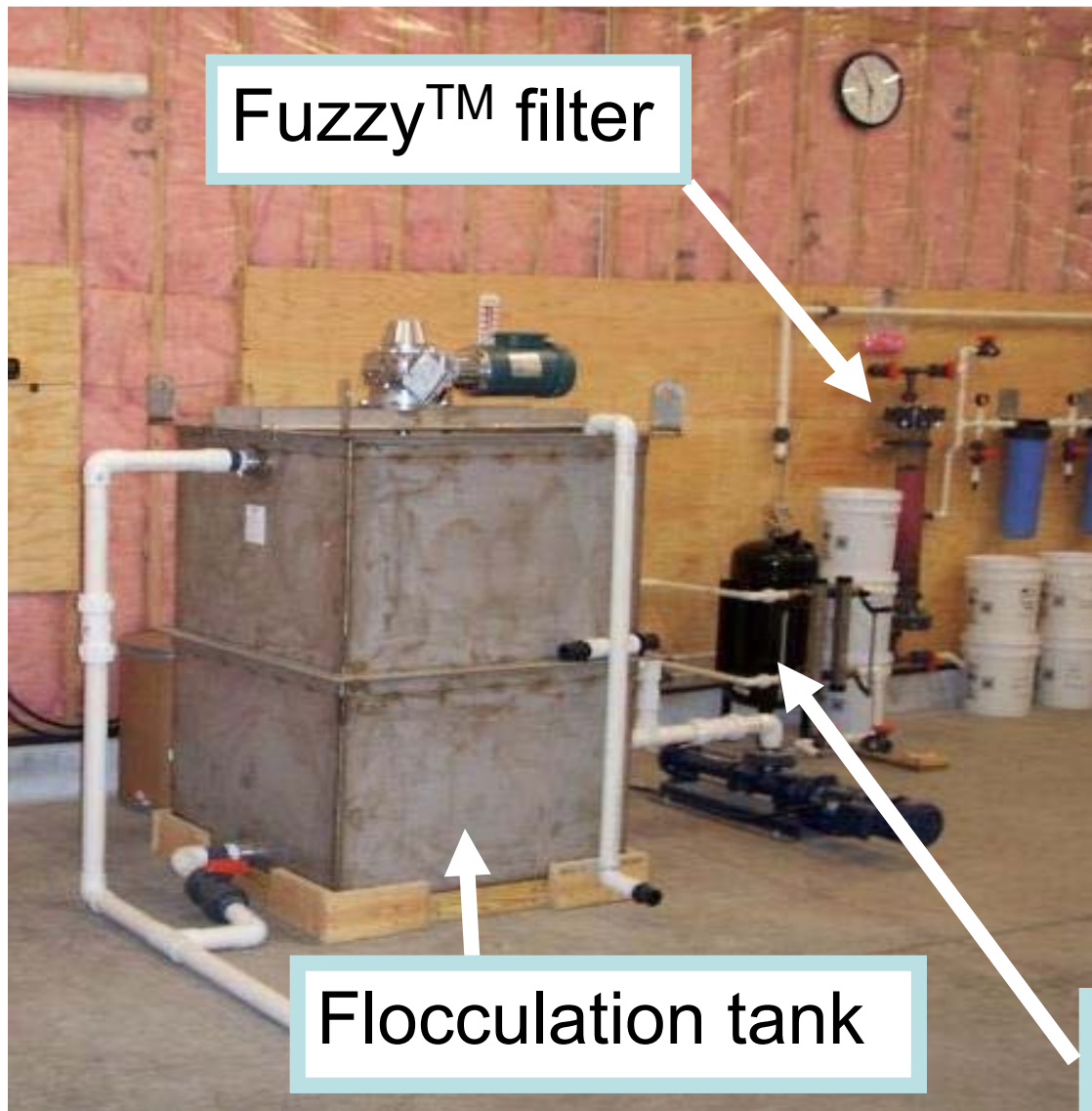


Fairbairn WTP

Trash screens (Caltrans projects)



Mechanized System Pilot in Tahoe



Pressure sand filter

Tahoe stormwater filter studies



30-inch dia, 24-inch depth



Sand

Activated Alumina

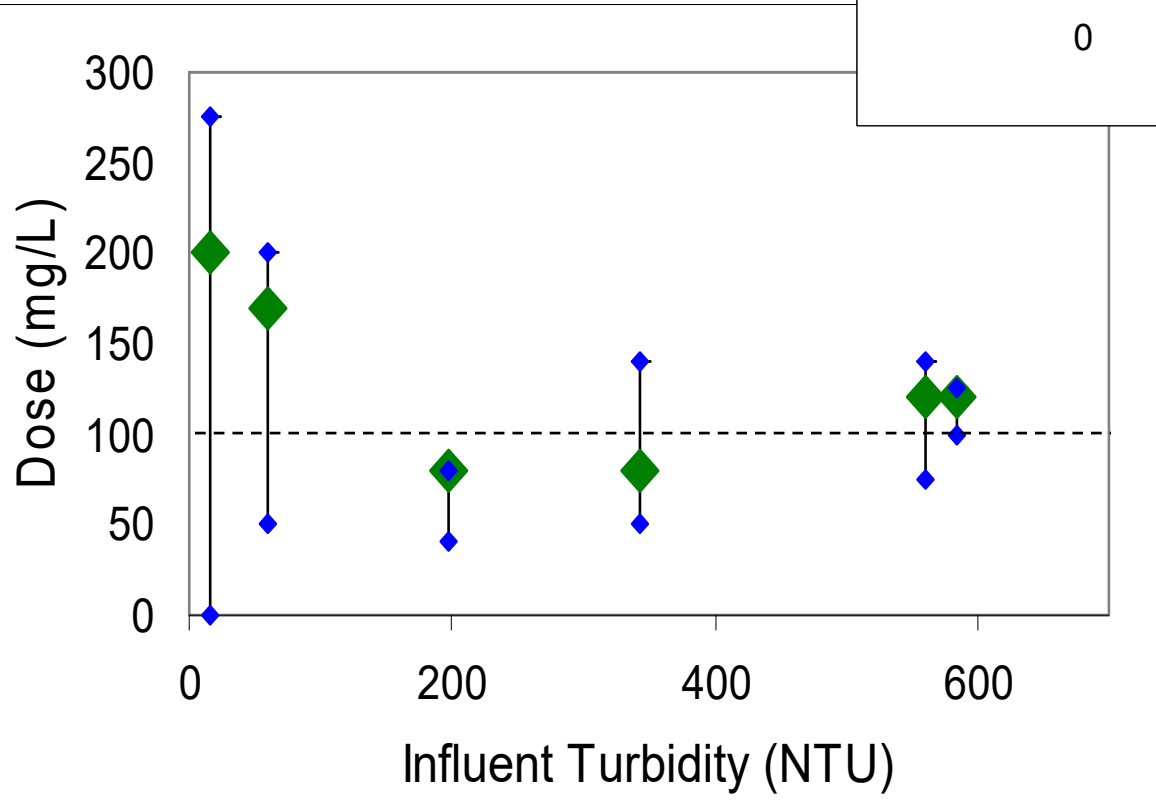
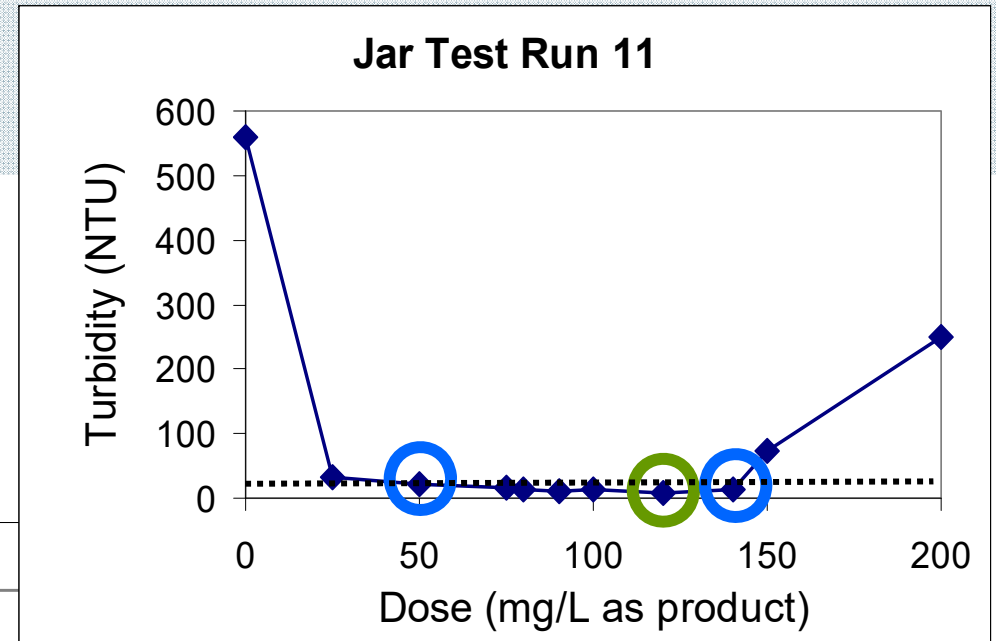
4-inch dia, 24-inch depth

Tahoe chemical treatment



- 35 chemicals; 50 different stormwater samples
- Polyaluminum chlorides, organic polymers, aluminum chlorohydrates

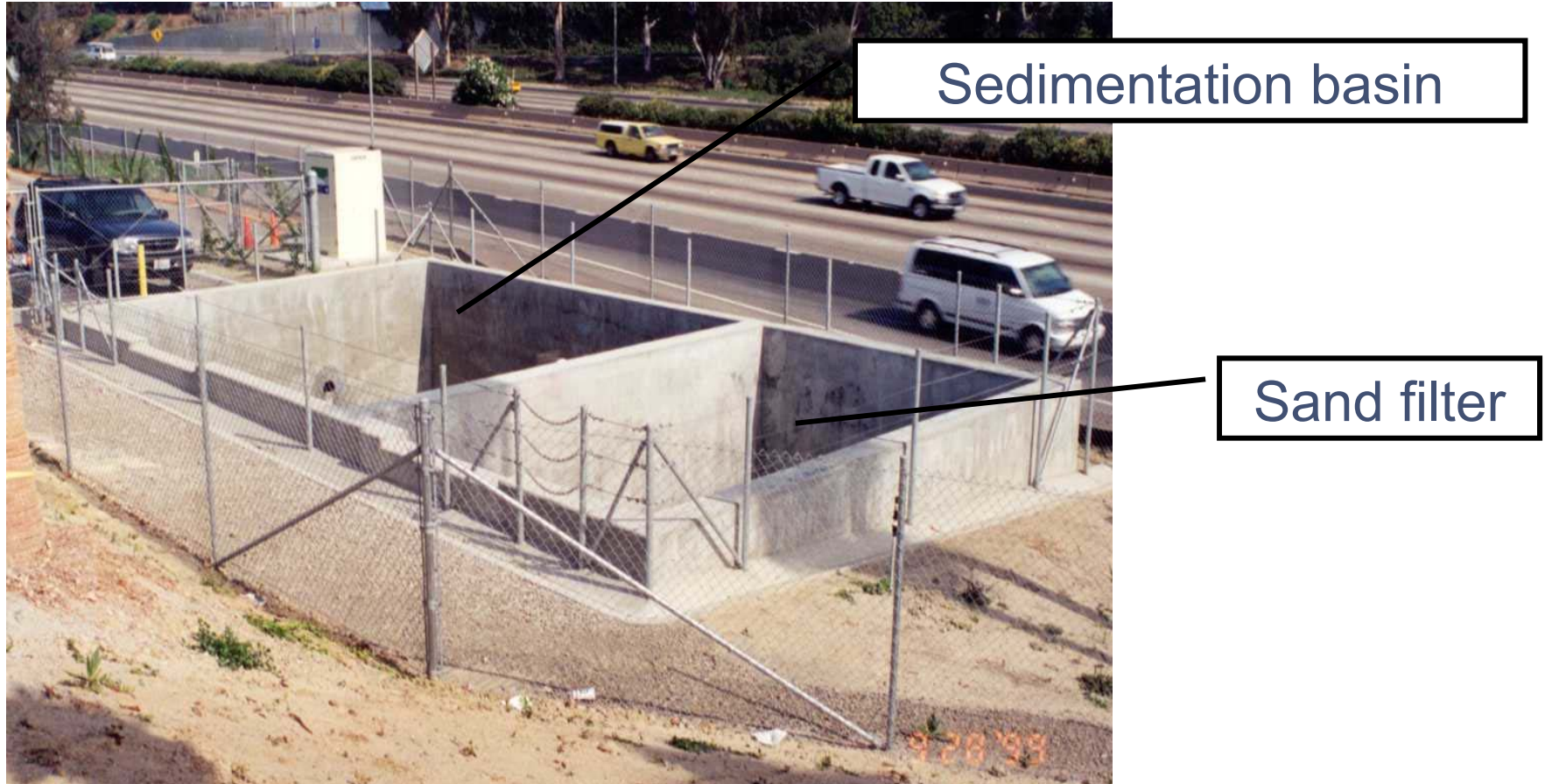
Variable Dosing



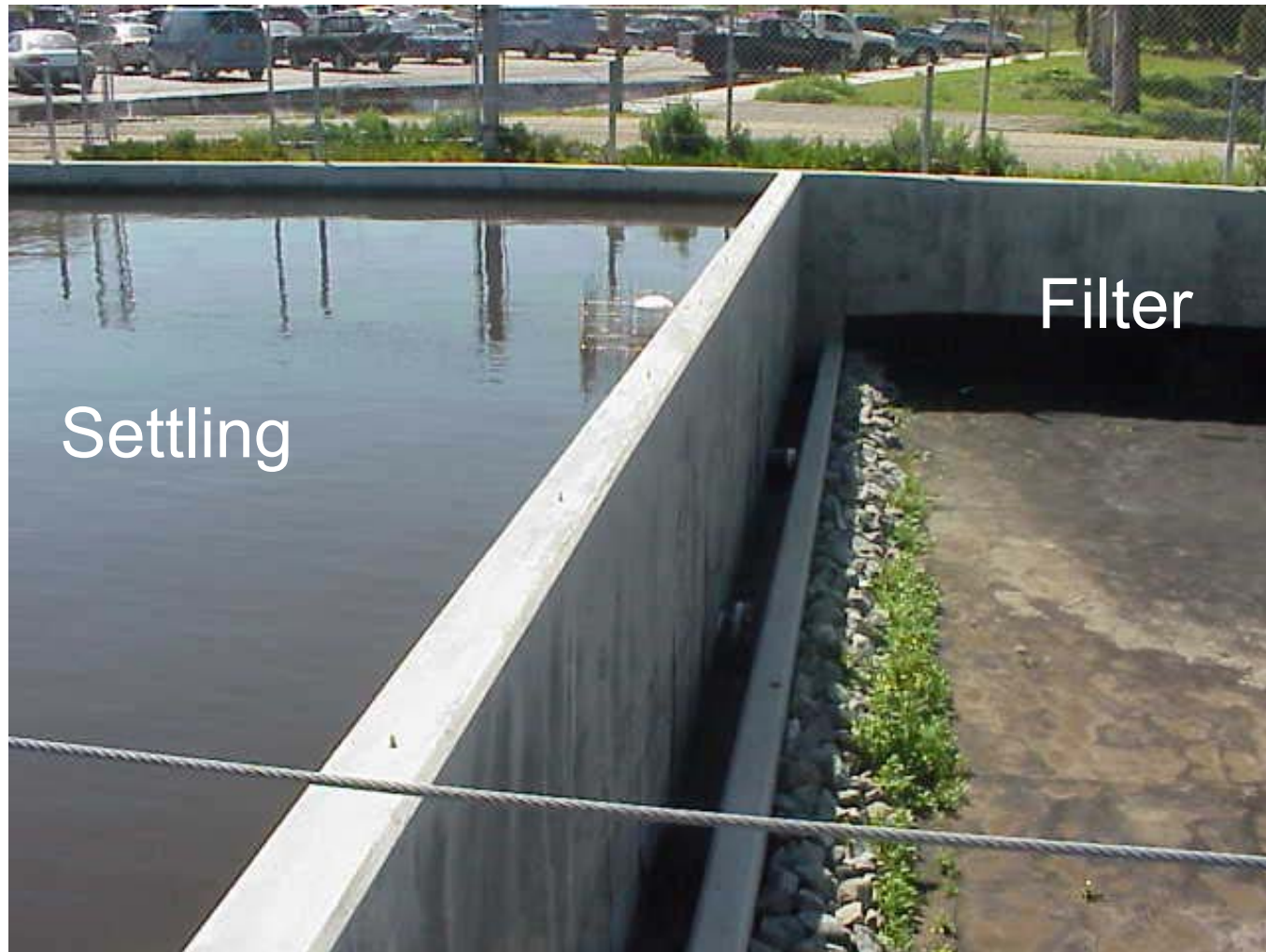
Prototype chemical feed system



Settling basins and filters

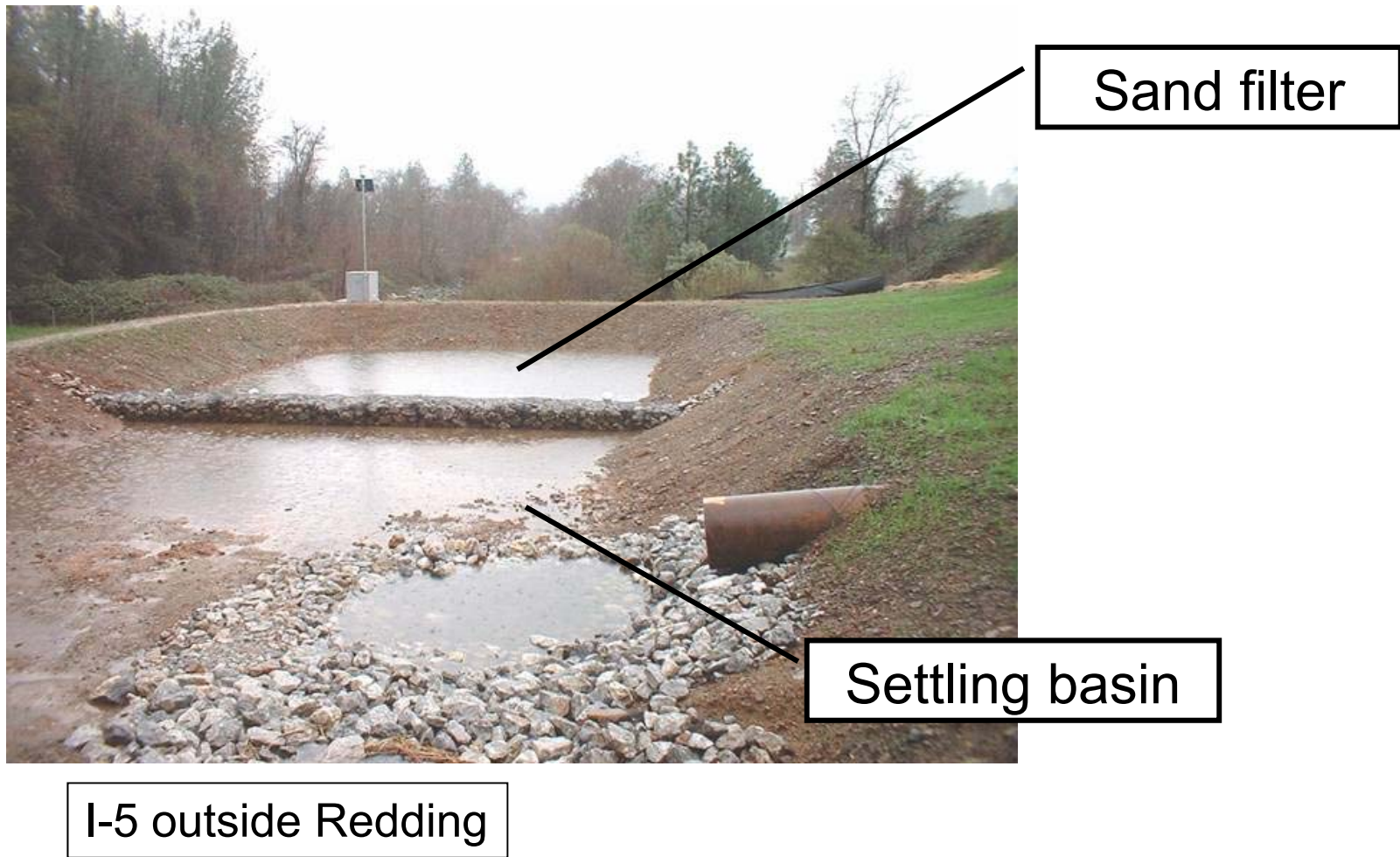


Settling basins and filters



Caltrans installation on urban SoCal freeway

Settling basins and filters

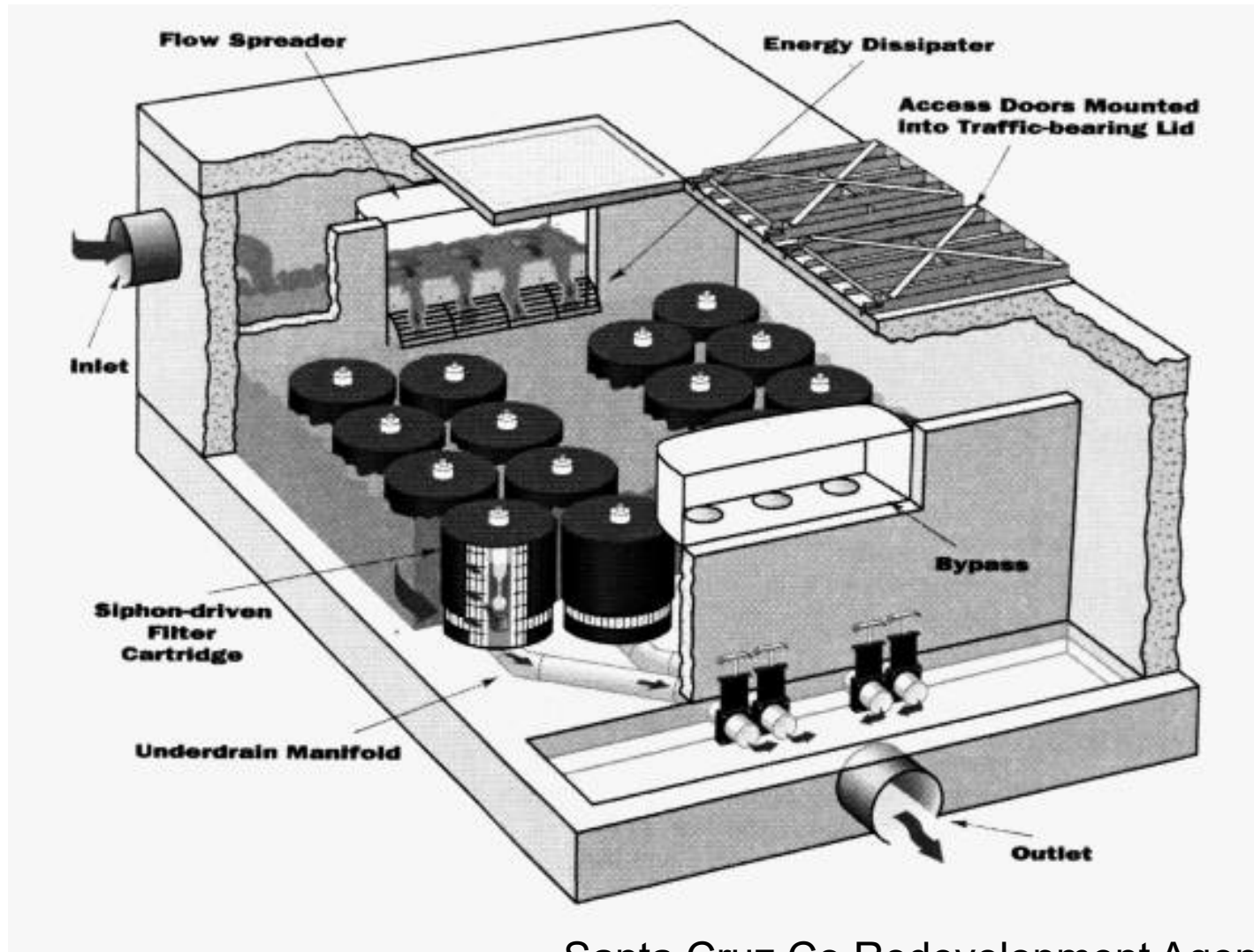


Settling basins and filters



Basin 2, SR 267

Manufactured treatment units

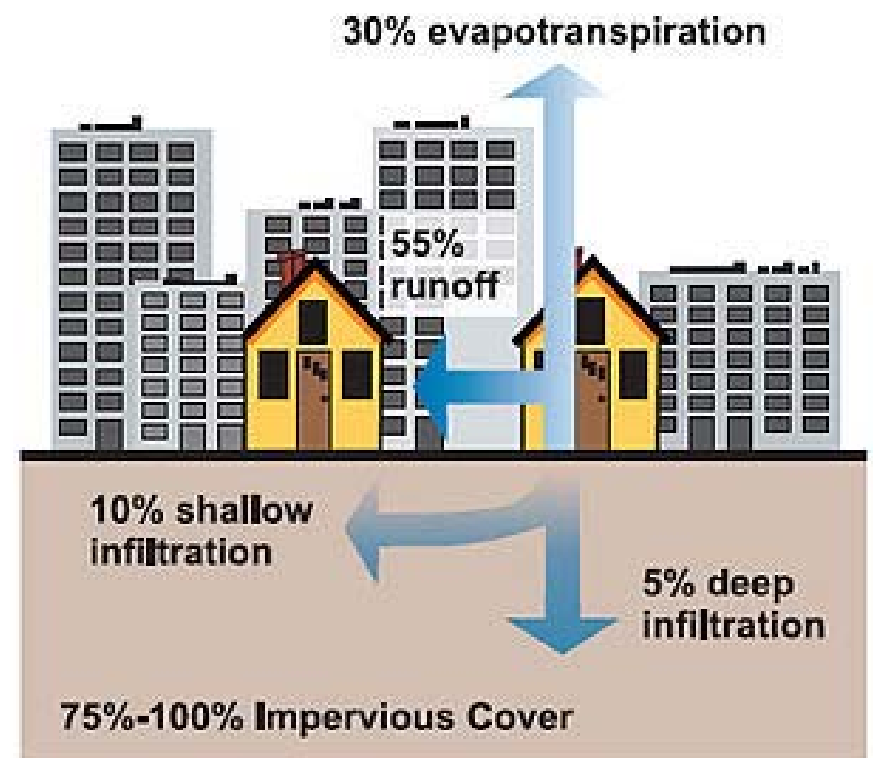
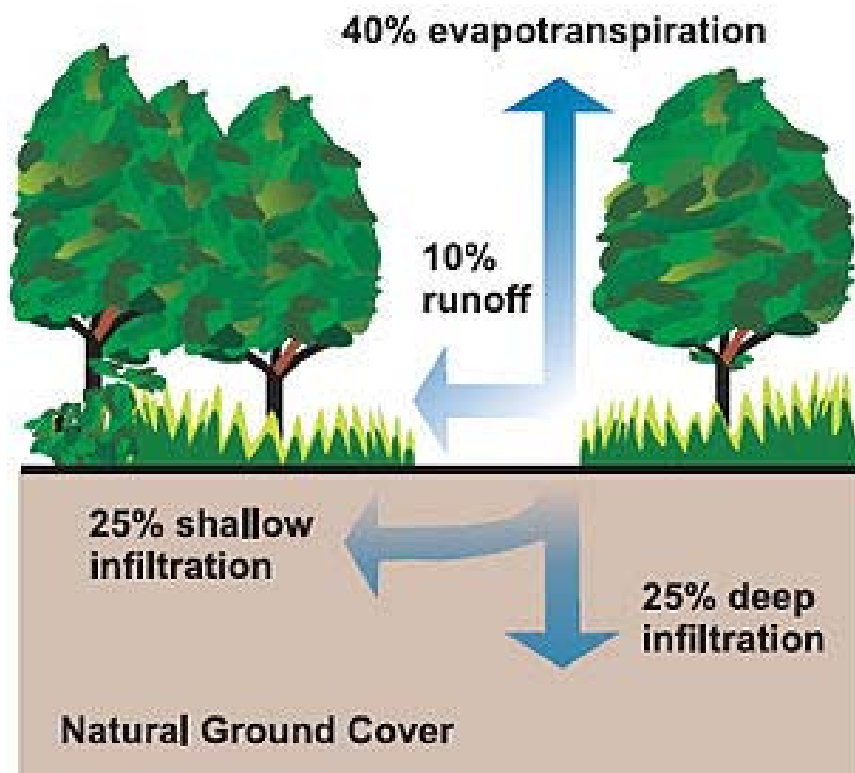


Santa Cruz Co Redevelopment Agency

Treatment problems

- ✓ Footprint
- ✓ Operational challenges (timing, manpower, distributed facilities)
- ✓ Cost
- ✓ Doesn't address hydromodification problem

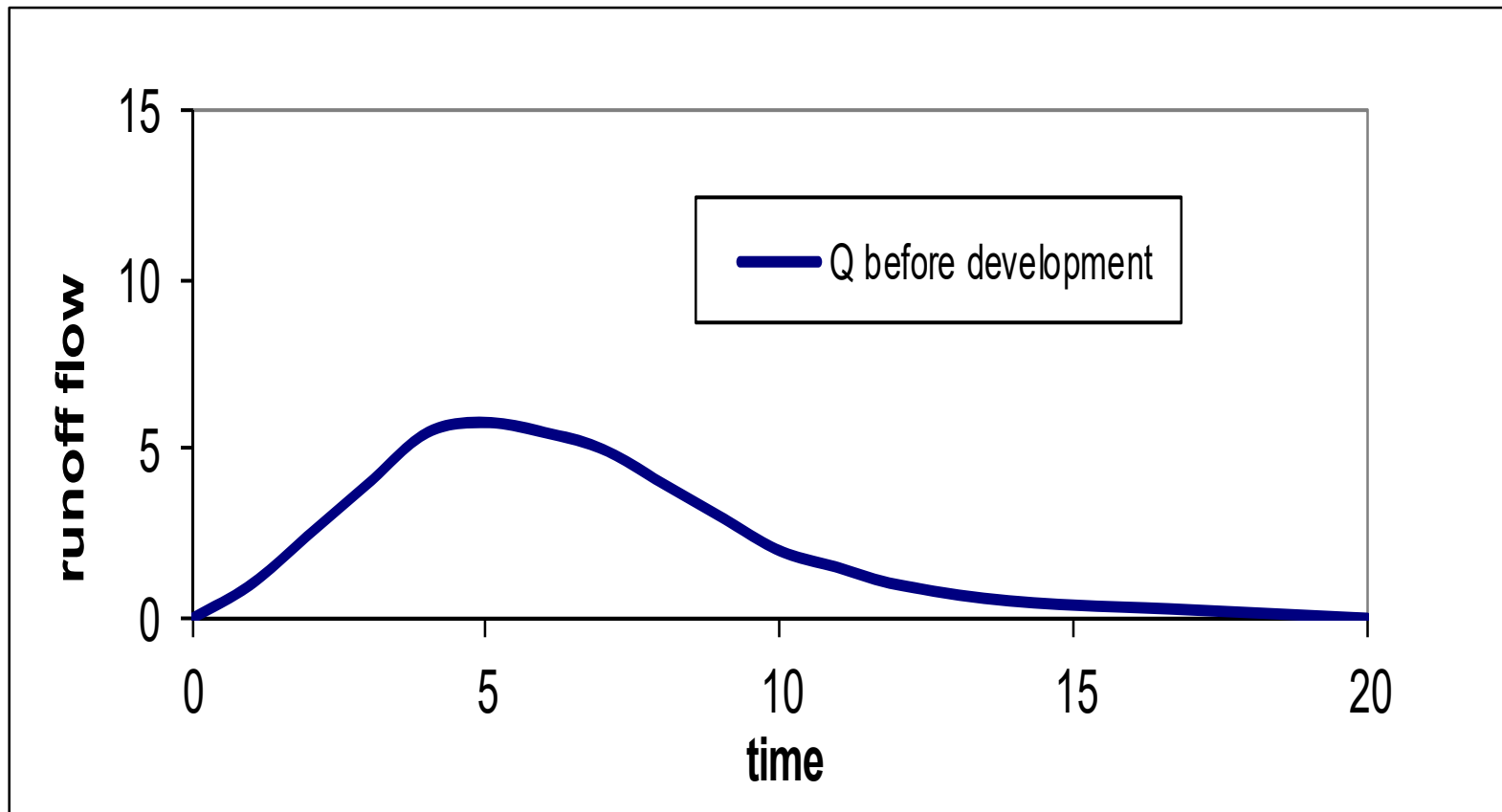
Hydromodification



Example numbers

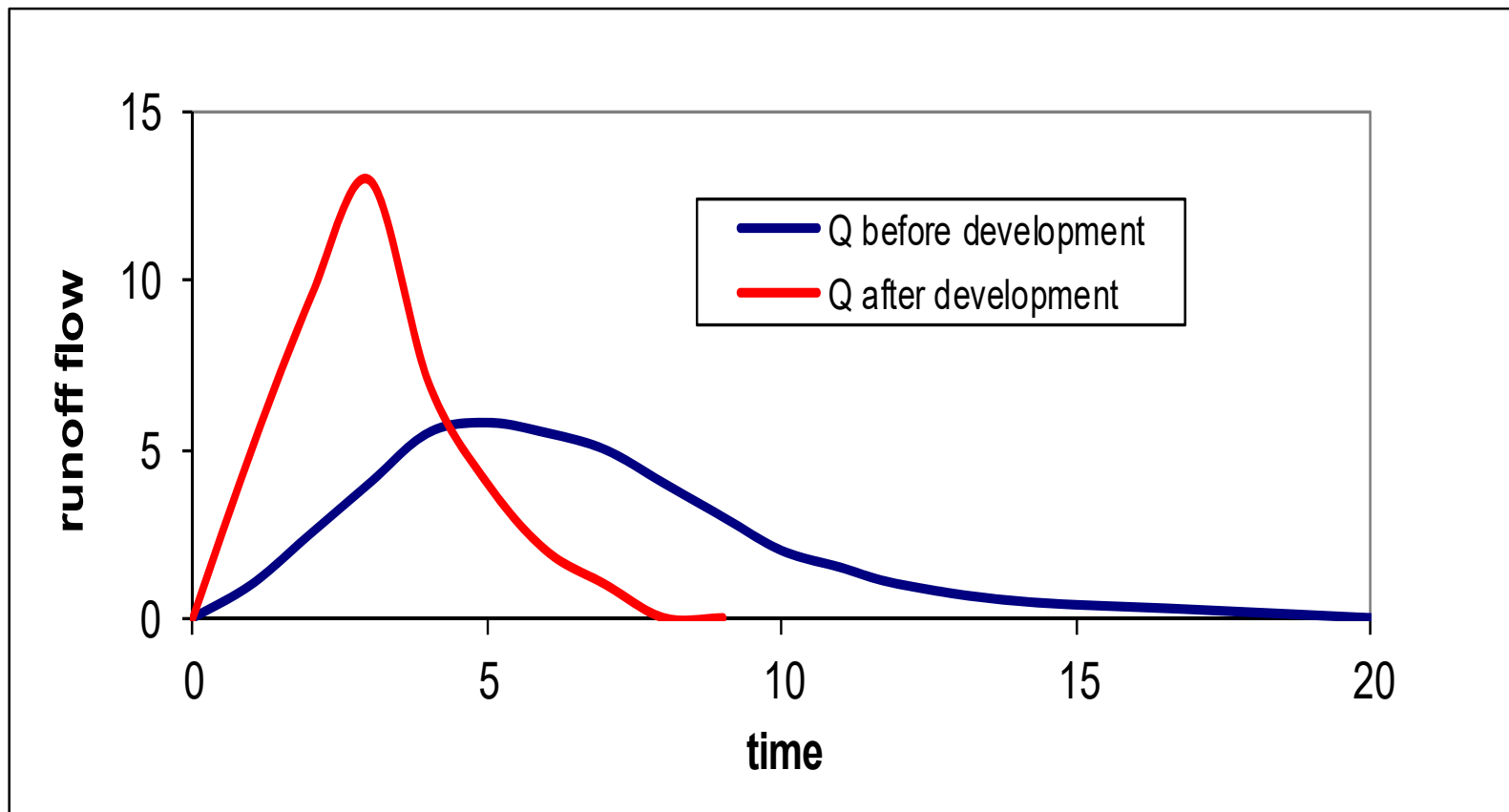
US EPA

Hydromodification

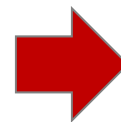


- Slow rise; slow fall

Hydromodification



- Higher flows
- Quicker peaks; faster drawdown



- More erosion
- More flooding
- Less infiltration

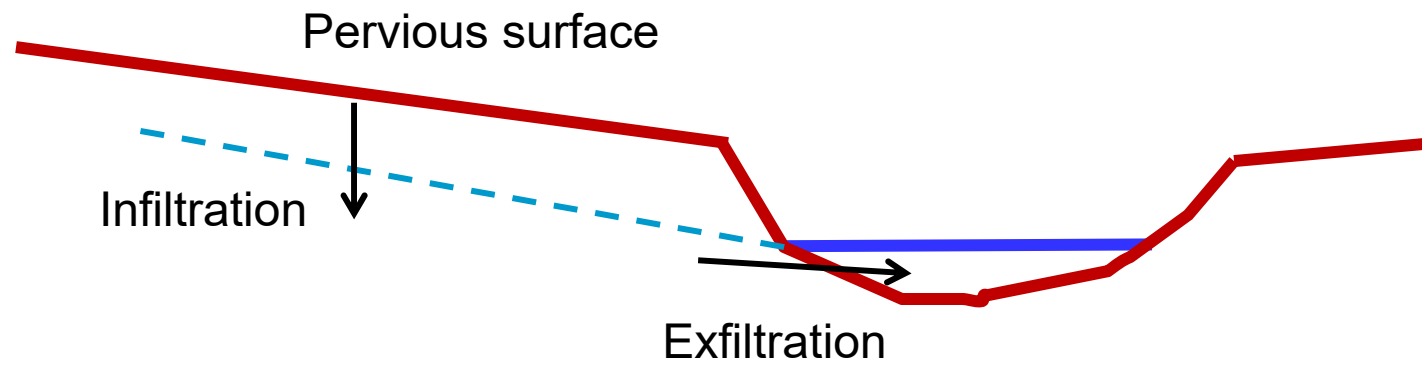
Hydromodification



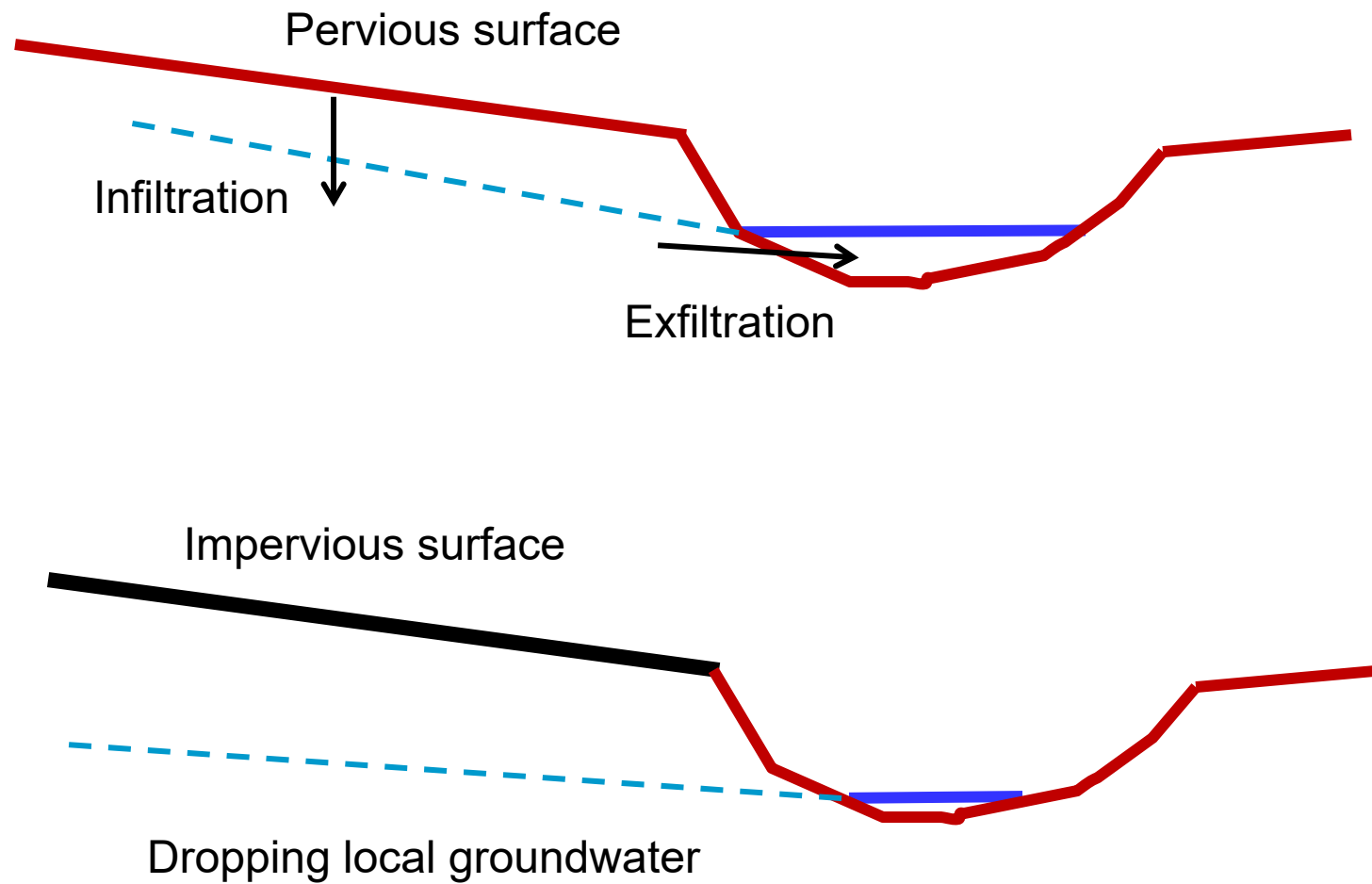
FIGURE 1-7 Urbanization has increased stormwater runoff in Paint Branch, in College Park, Maryland. The resulting hydromodification causes more erosion, deepening of urban streams, and unstable channels compared to the pre-development state.

SOURCE: <http://www.anacostiaaws.org/news/blog/tags/12>.

Hydromodification (summer flows)



Hydromodification (summer flows)

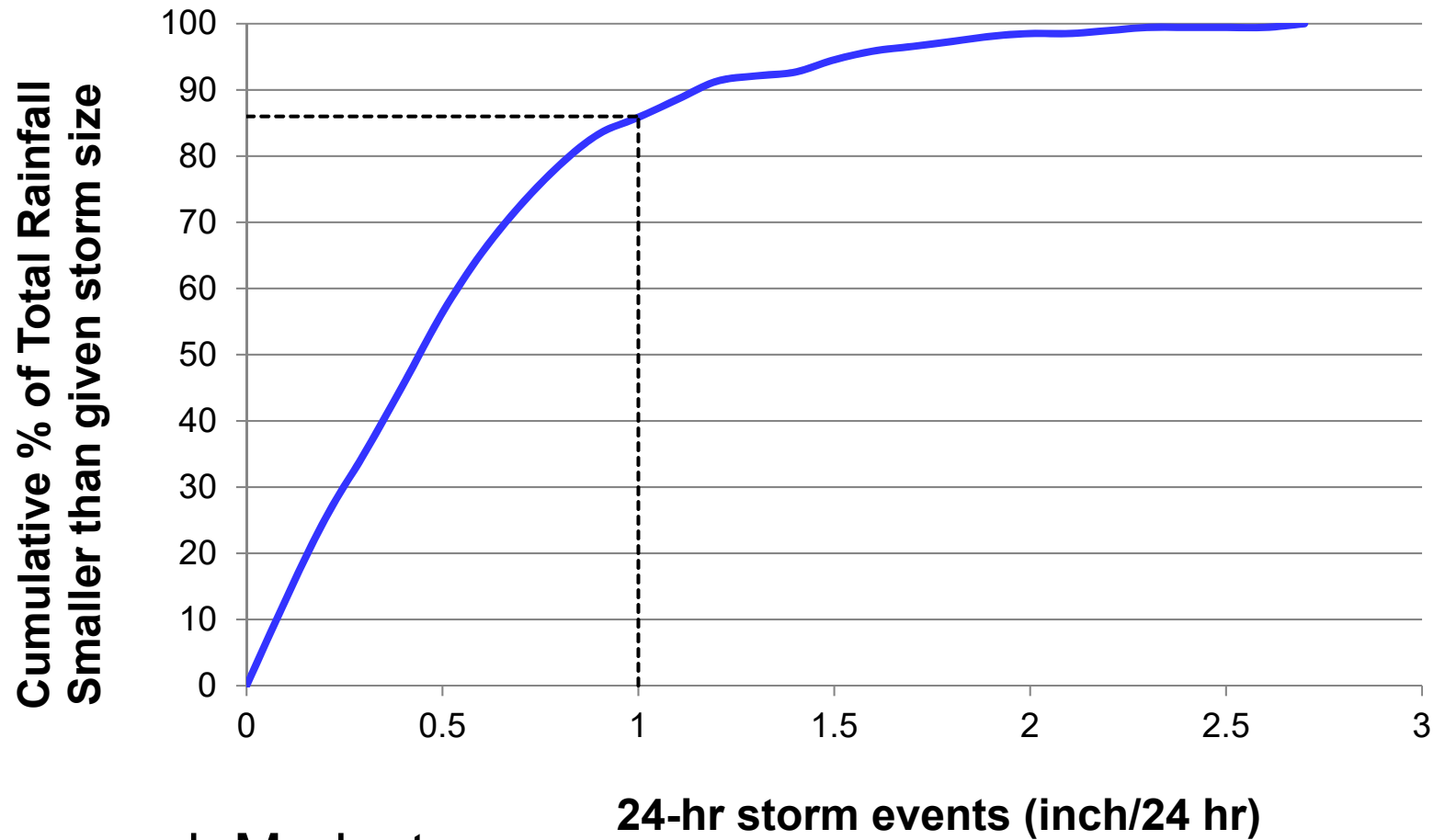


Low Impact Development (LID)

Strategies

- ✓ Mimic natural hydrology
 - Reduce impervious surfaces
 - Capture stormwater close to its source
 - Infiltrate (recharge groundwater)
- ✓ Treat where we can't infiltrate
- ✓ Accommodate flood flows

Rainfall distribution

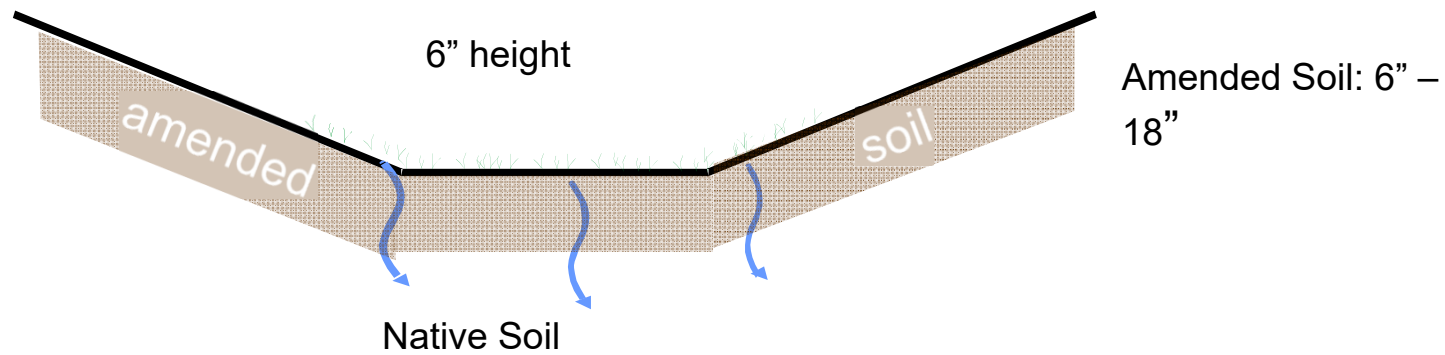


36-yr record, Modesto

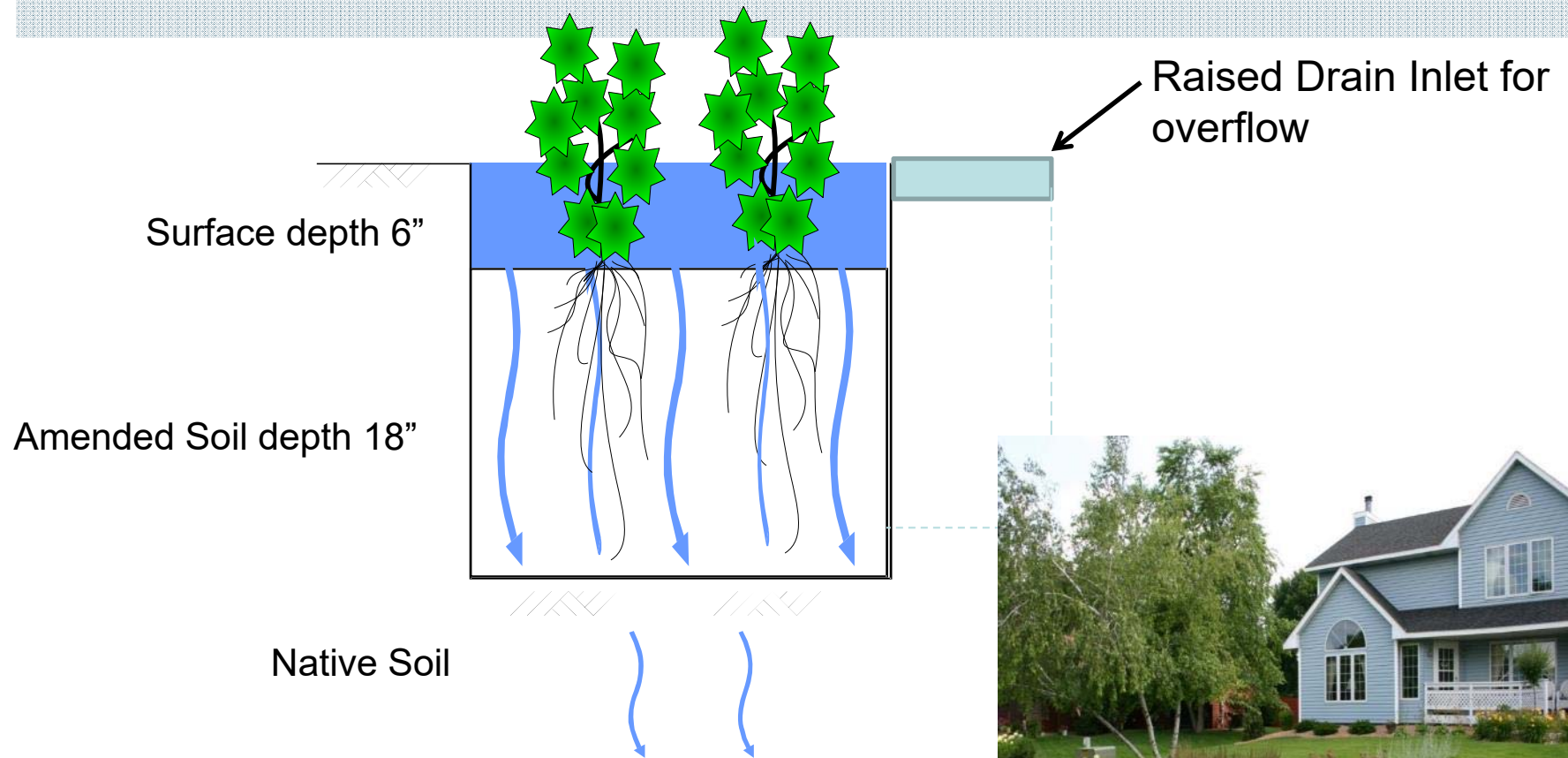
Low Impact Development practices (BMPs)

- Bioretention Planters
- Rain Gardens
- Bioswales
- Porous Pavement
- Biostrips
- Road Narrowing
- Cisterns or Rain Barrels
- Tree Box Filters
- Constructed Wetlands
- Green Roofs
- Infiltration Trenches
- Water-wise vegetation

Bioswale



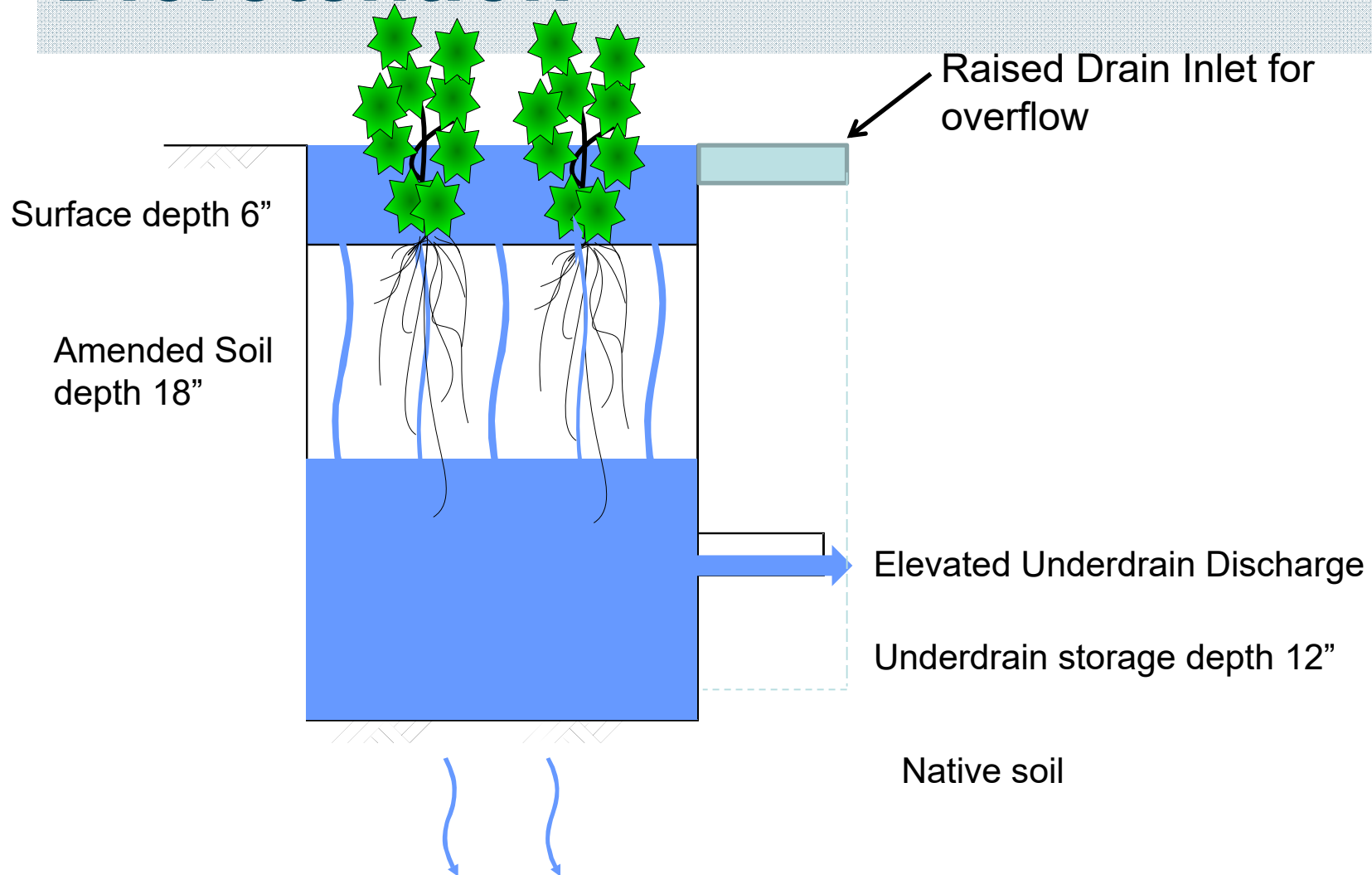
Rain Garden



US EPA



Bioretention

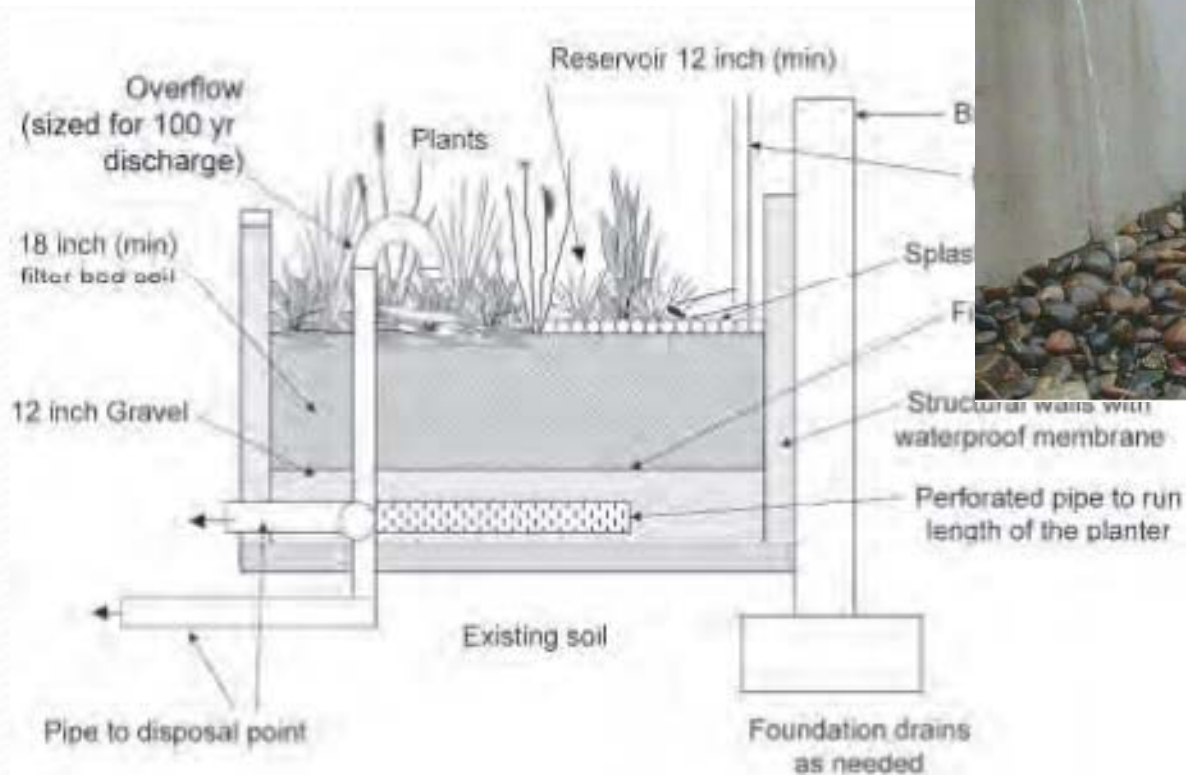


Bioretention



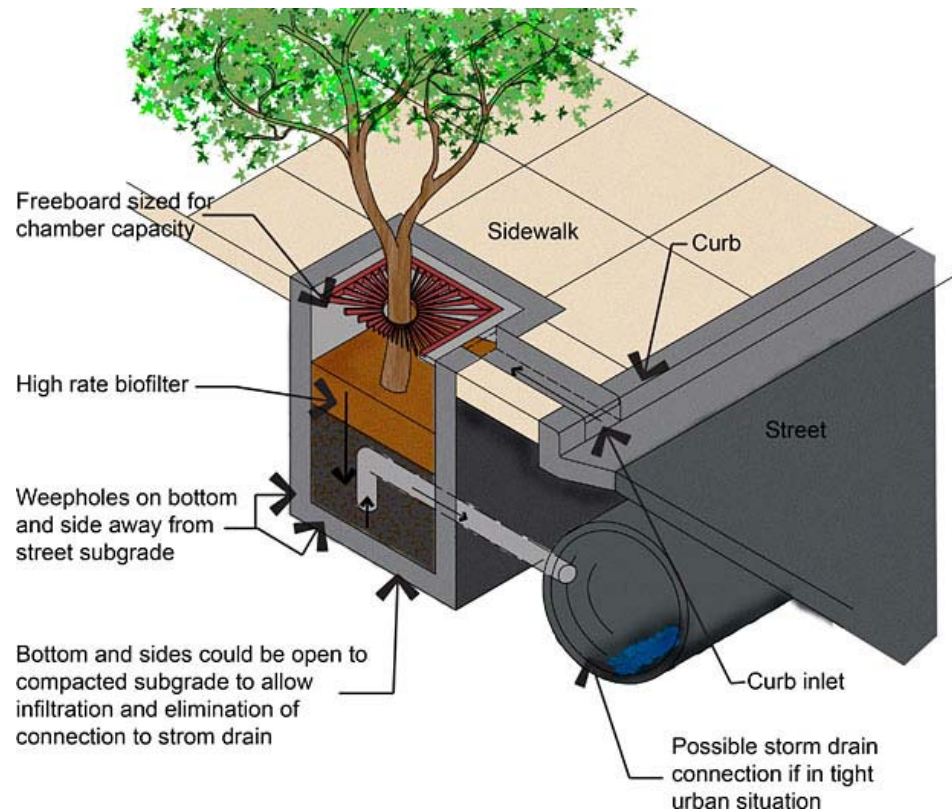
CASQA

Planters and tree boxes



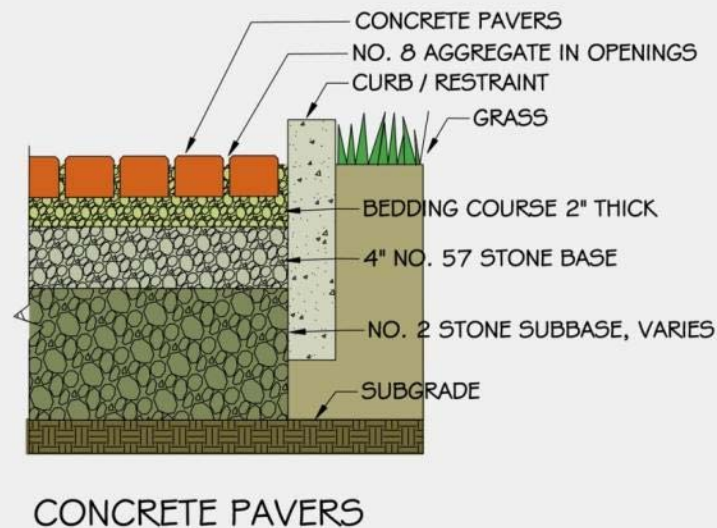
CASQA

Planters and tree boxes



http://www.lid-stormwater.net/treeboxfilter_home.htm
<http://www.crwa.org/rc/2010/rivercurrentissue120.html>

Porous pavement



Concrete solution

Pervious concrete, widely used in the South, is becoming increasingly popular in northern climates. Tests have shown that the porous concrete, if installed and maintained properly, can hold up under the freeze-thaw cycles experienced in Ohio.

▼ Conventional concrete

1. Strong, good for heavy truck traffic.
2. Smooth surface.
3. Deflects water.
4. Used on roads, parking lots, sidewalks and airport runways.



Gravel or crushed stone mixed with cement, water and sand.

◀ Pervious concrete

1. Not as strong as conventional concrete.
2. Rougher surface.
3. Water seeps through, reducing stormwater runoff.
4. Muffles noise and reduces hydroplaning.
5. Used primarily on parking lots, sidewalks and some roads.



Uses stone that is smaller than conventional concrete and cement with little or no sand in the mixture. This creates porous spaces that allow water to pass through.

SOURCE: Researchers at Cleveland State University and Iowa State University

THE PLAIN DEALER

http://www.abbey-associates.com/splash-splash/blue_standards/porous_paving.html
<http://www.cleveland.com/business/wide/index.ssf?concrete1009.html>

C Street, Seattle, WA

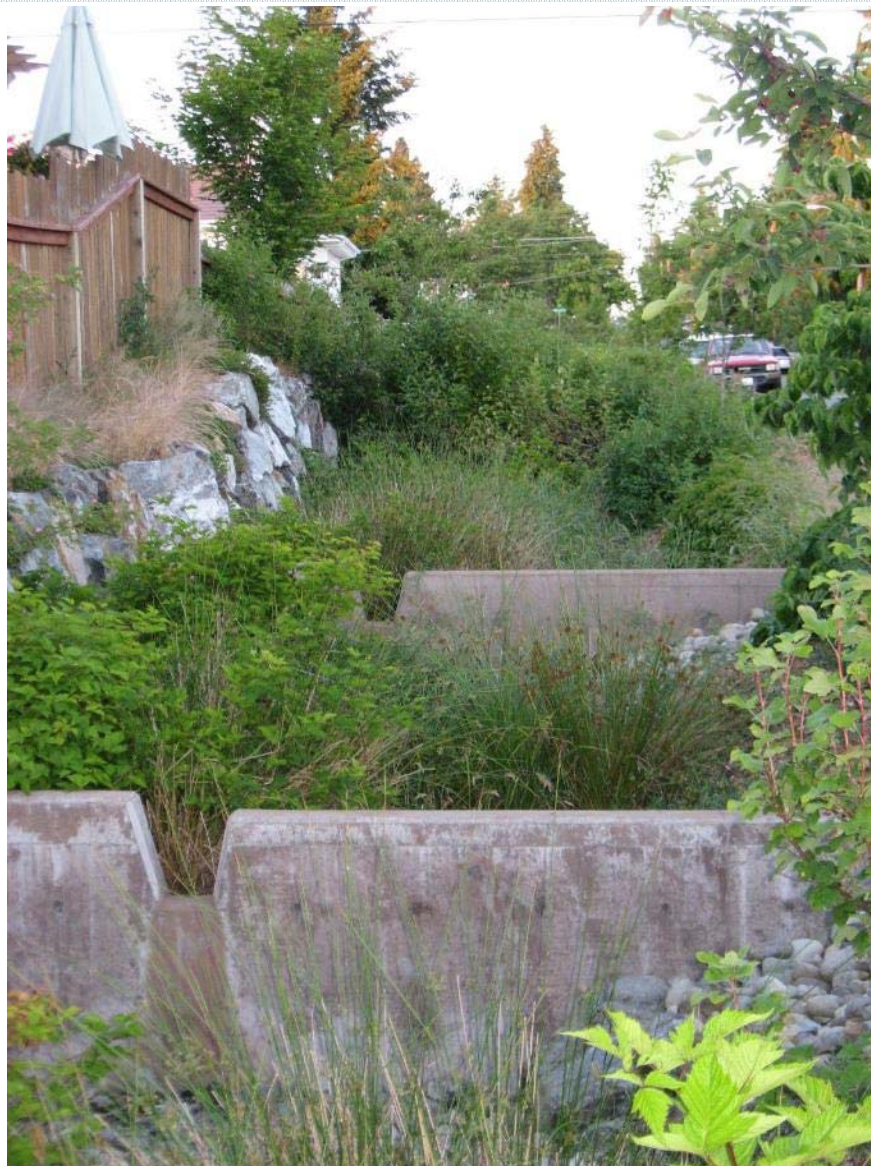


Reconstructed street

C Street, Seattle, WA



C Street, Seattle, WA



Village Homes, Davis, CA



Village Homes, Davis, CA

Bioswale



Village Homes, Davis, CA

Bioswale



Village Homes, Davis, CA



Rain garden

Village Homes, Davis, CA



Rain garden

Village Homes, Davis, CA



Rain garden

South Davis



South Davis



South Davis



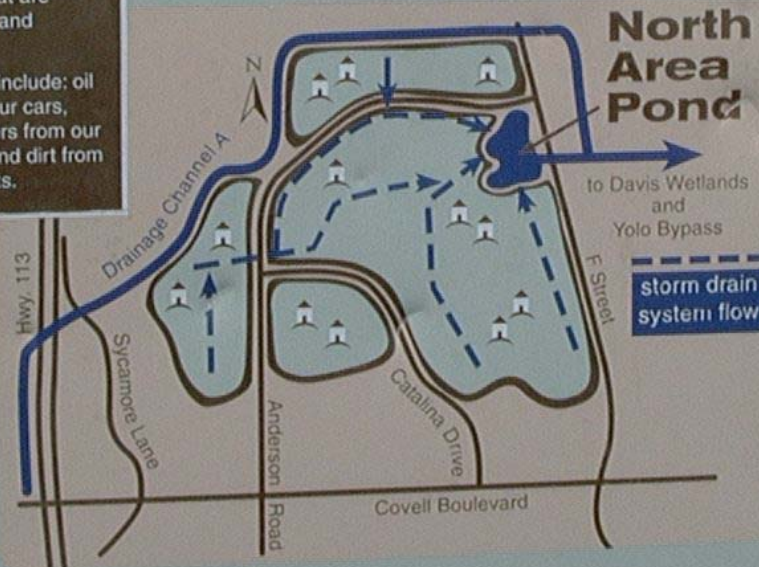
Neighborhood-scale pond, Davis

We are all connected to our waterways

The North Area Pond provides flood protection and wildlife habitat. Four hundred-thirty acres of homes, landscaping, streets, gutters, and greenbelts are directly connected to the pond by a storm drain system. To safeguard the health of this pond, its wildlife, and other area wetlands, we should make sure that only stormwater goes into storm drains.

We need to protect our pond

- Recent studies show that runoff from our neighborhoods contain toxics and nutrients that are harmful to aquatic life and encourage algae.
- Some of these toxics include: oil and anti-freeze from our cars, pesticides and fertilizers from our gardens, and debris and dirt from our properties and pets.



We can do our part by following some simple guidelines

- Autos: Keep leaks from cars off driveways and streets. Use drip pans and dry cleanup methods, make repairs and don't hose down spilled or leaked auto fluids.
- Landscape/Gardens: Consider alternatives to chemical pesticides. If you must use pesticides, follow label instructions, use the minimum amount recommended, and dispose of carefully. Don't over water. Keep water out of curbside gutters.
- Clean-up after your pets and keep litter off the streets and green belts.

Over 50 wildlife species make the pond their home.

Mammals/Amphibians/Fish

Muskrat, jackrabbit, raccoon, opossum, American Bullfrog, Mosquitofish

Resident/Nesting Waterbirds

Mallard, American Coot, Canada Goose, Egrets, Herons, Stilts, Avocets

Migratory Waterbirds

Canvasback, American Widgeon, Ruddy Duck, Snow Goose

Vegetation

Willows, Cottonwoods, Toyon, Coyote Brush, Tall Wheat-Grass, Bulrush and Cattails.



Black-necked Stilt



American Avocet

For more information on the Davis Pollution Prevention Program, please call 757-5686

Neighborhood-scale pond, Davis



Stormwater wetlands, Tahoe City



Are all the problems solved?

- ✓ Questions about treatment efficiency and BMP design details
 - Engineered Soils Project (Prop 84)
- ✓ Retrofitting BMPs into an existing infrastructure

Engineered soils project (Sac State)



State Water
Resources Control
Board funding

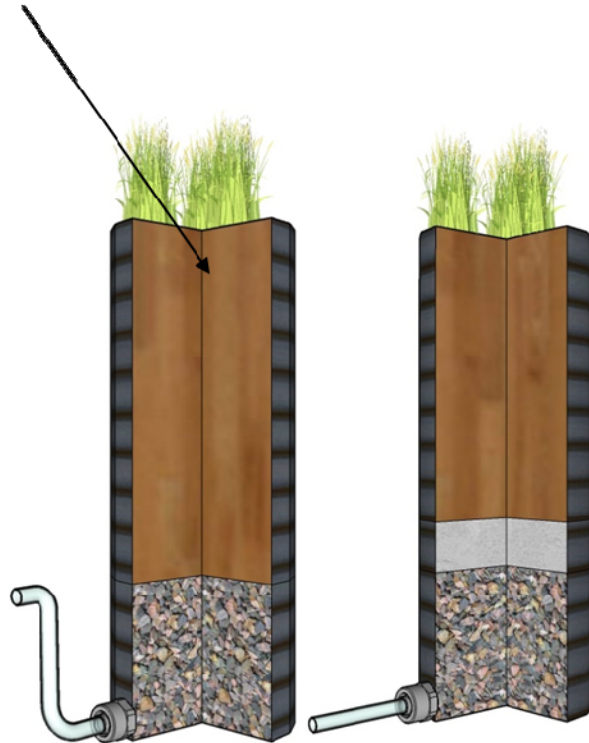


Engineered soils project



Engineered soils project

BSM, 18"



Elevated Outlet,
No AA
Elevated Outlet,
No AA, Washed

Bottom
Drain



BSM or
BSM/Soil
Mix, 18"

AA, 4"

Orifice

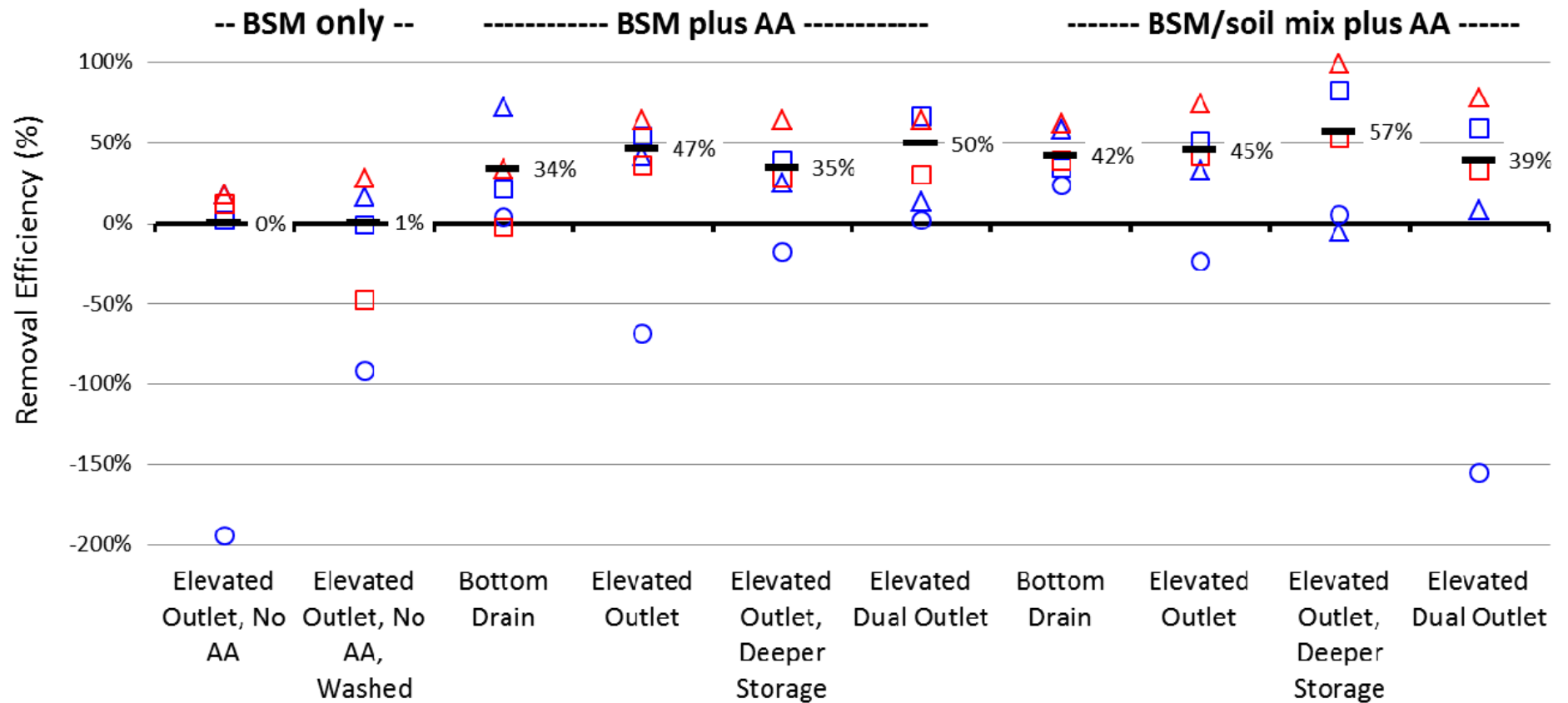
Elevated
Outlet

Elevated
Dual Outlet

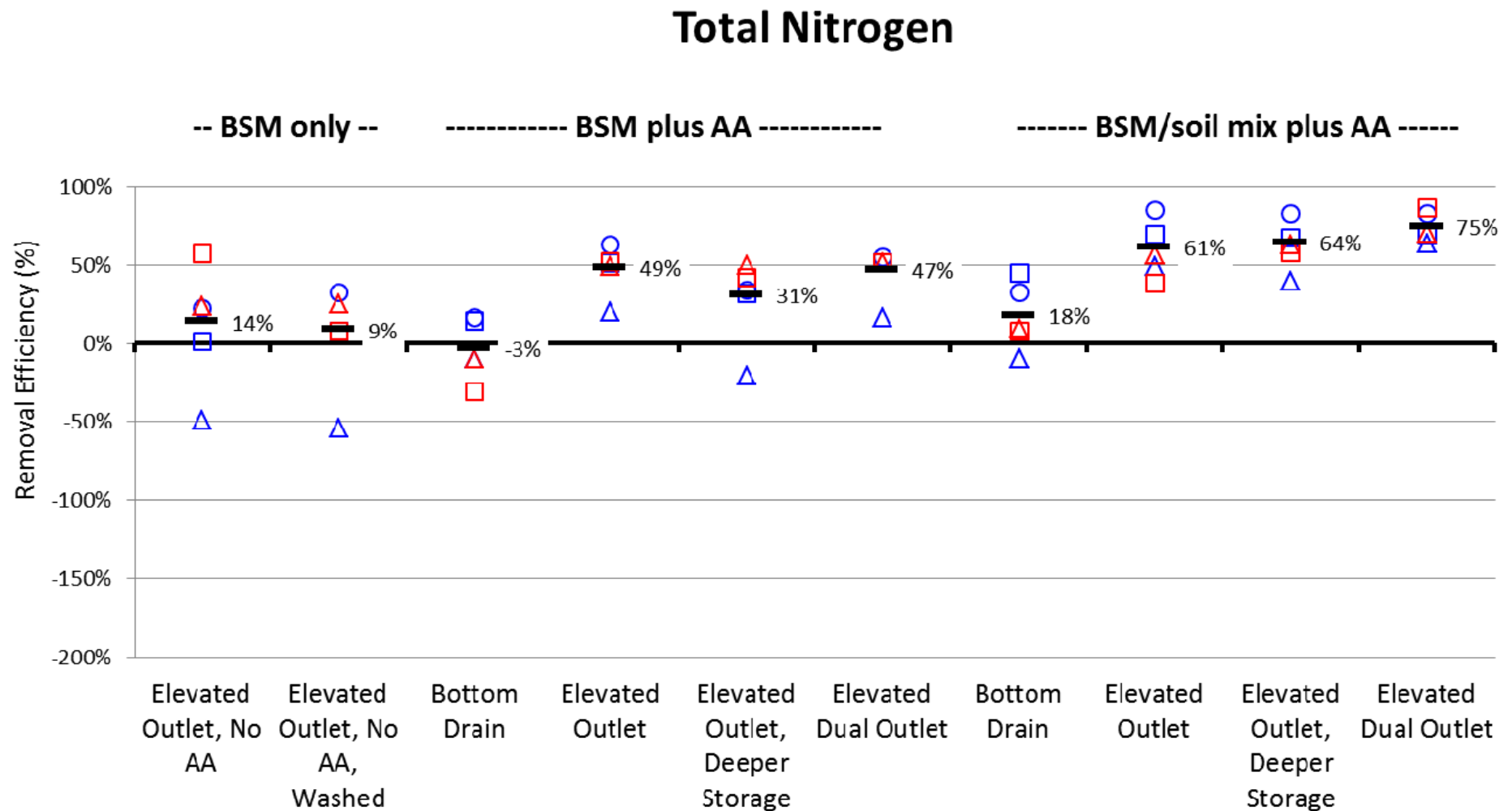
Gravel Underdrain, 12"
(24" for Deep Storage)

Configuration Comparisons (runs 2-6)

Total Phosphorus as P



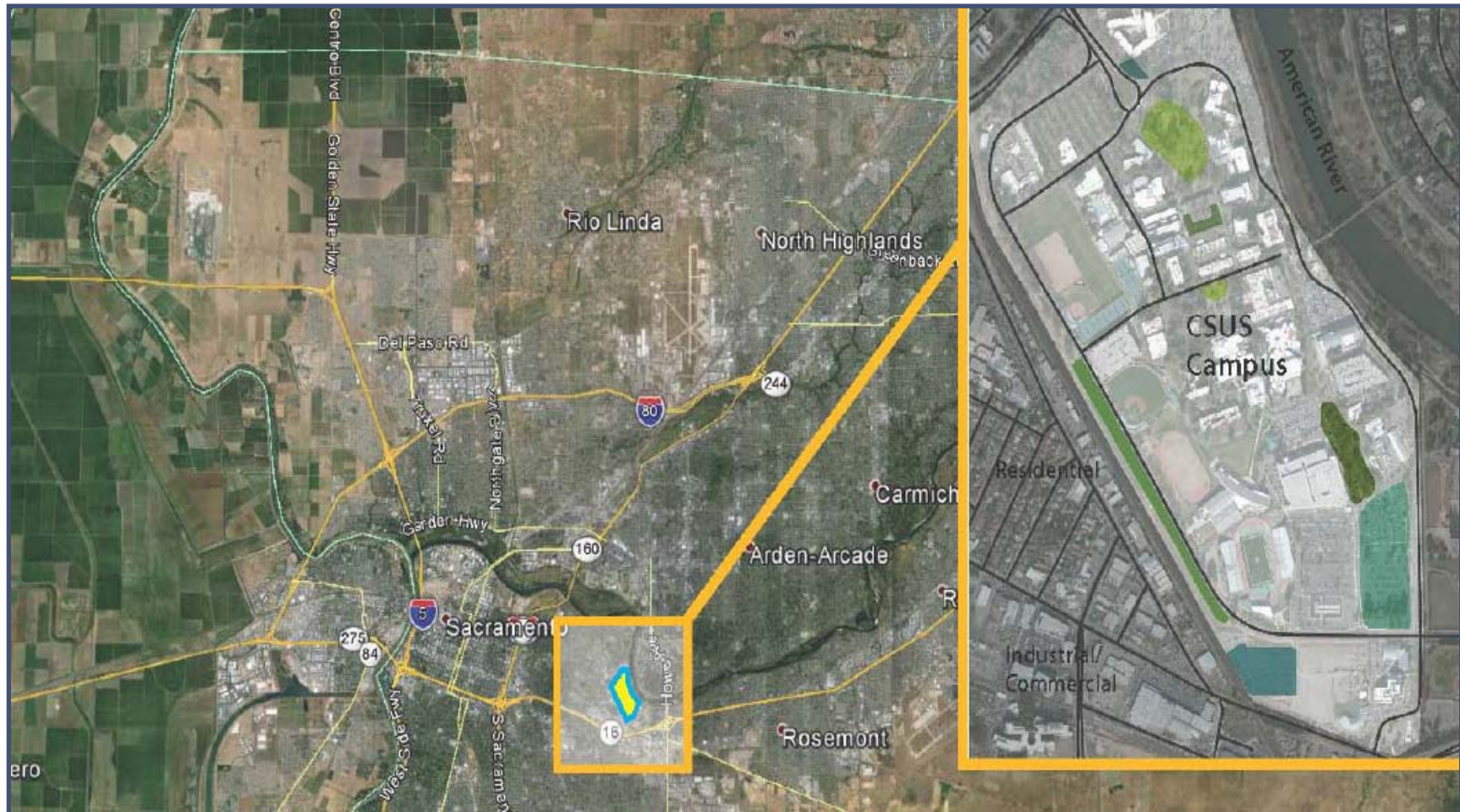
Configuration Comparisons (runs 2-6)



Are all the problems solved?

- ✓ Questions about treatment efficiency and BMP design details
 - Prop 84 Engineered Soils Project
- ✓ Retrofitting BMPs into an existing infrastructure

LID Implementation at Sacramento State



Project Background: Campus Stormwater



Drain Inlet - Campus



Storm Drain Discharges into American River

Project Background: American River



Outfall – Guy West Bridge



Upstream
Sample

Discharge
Sample

Project Collaboration



State Water Resources Control Board
(Proposition 84 Stormwater Grant)

City of Sacramento

Office of Water Programs @ Sacramento State/UEI

Sacramento State Facilities Management

Design and Construction Contractors

City of
SACRAMENTO

 **WATER PROGRAMS**
SACRAMENTO STATE

- Project Management
- Design Oversight
- Construction Oversight
- Stormwater Monitoring
- Education and Outreach



SACRAMENTO
COUNTY

Urban Rain | Design



SACRAMENTO
STATE



Project Funding

✓ State Water Board Prop. 84 Stormwater Grant

✓ Objectives:

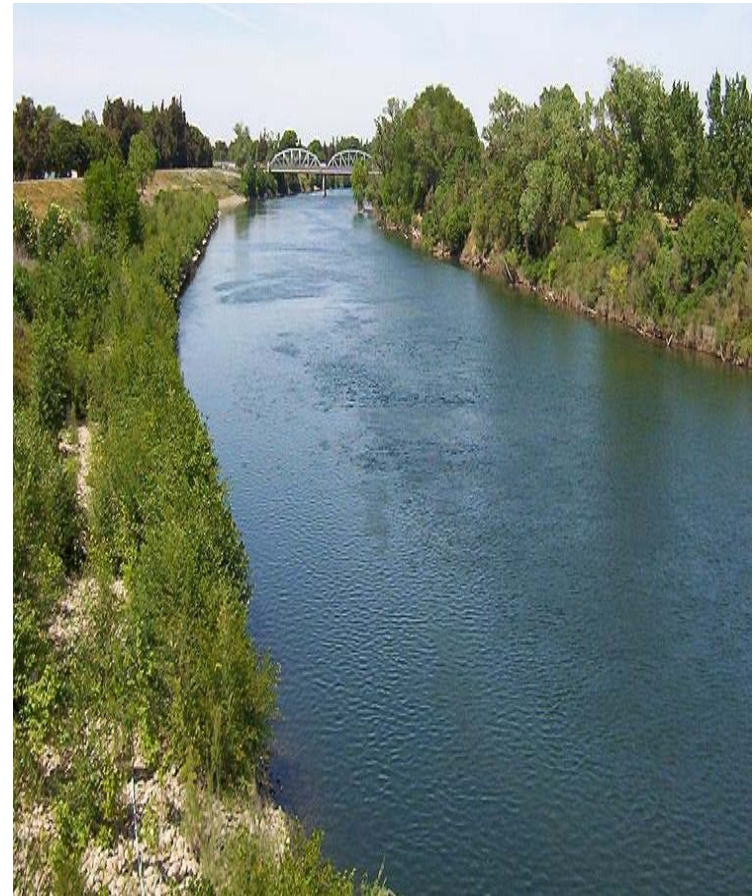
- Prevent stormwater contamination of water bodies
- Meet stormwater permit requirements
- Implement LID
- Monitor performance
- Provide education and outreach

✓ Project Total - \$3.3M

- Prop 84 - \$2.6M
- Local Match - \$0.7M

Project Benefits

- ✓ Protect American River
- ✓ Meet permit requirements
- ✓ Replenish groundwater (campus irrigation supply)
- ✓ Engage campus community
- ✓ Provide a demonstration facility for Northern CA



Site & BMP Selection: Bang-for-the-Buck

✓ Large Drainage Areas

- Parking lots, streets, rooftops, and existing landscaping

✓ Maximize Infiltration

- Replace less pervious with more pervious

✓ Existing Infrastructure

- Tie into existing grades
- Use existing storm drain system for overflow
- Minimize need for new irrigation infrastructure

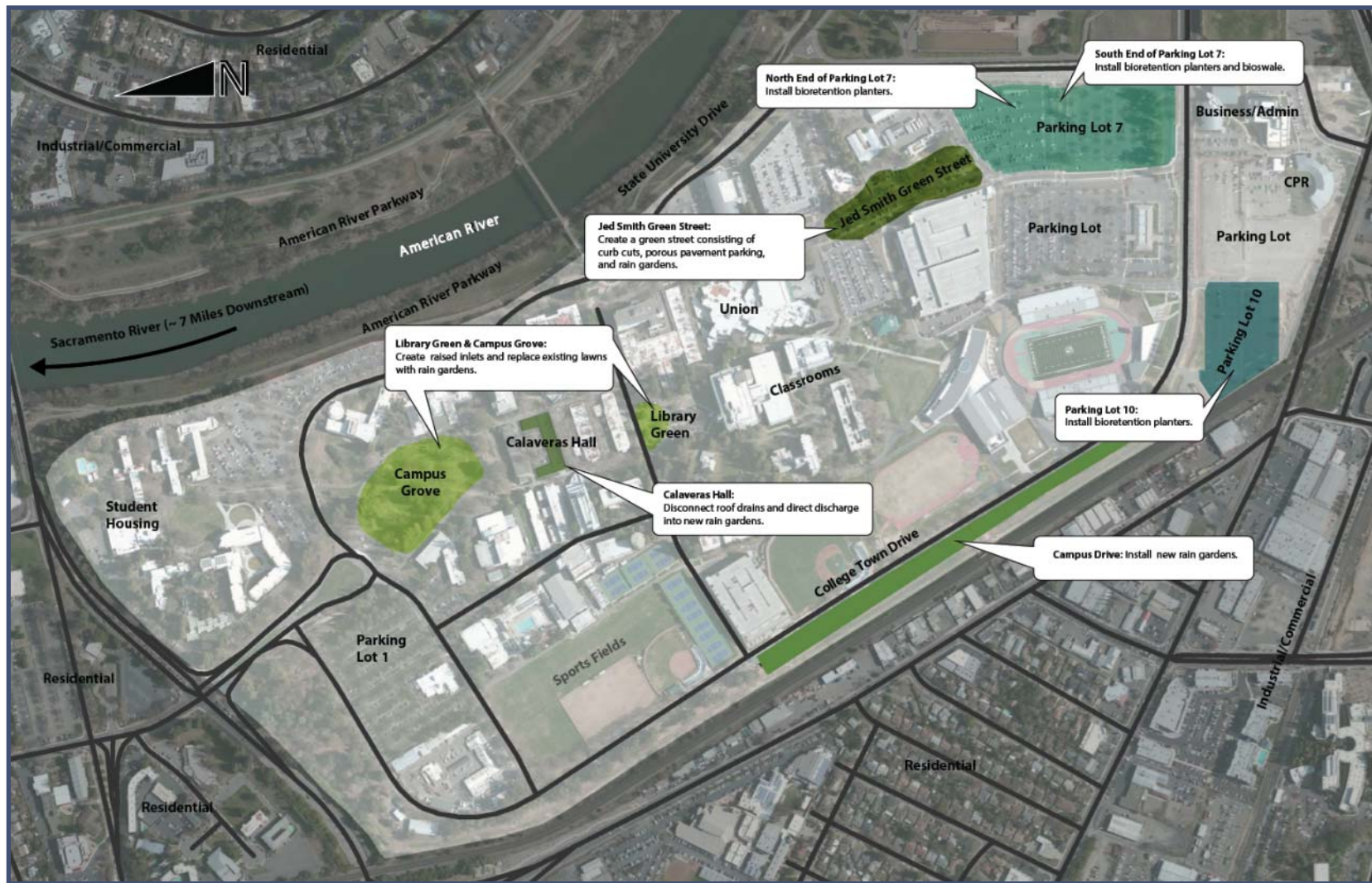
✓ “Smarter” Vegetation

- Water-wise
- Drought- and inundation-tolerant



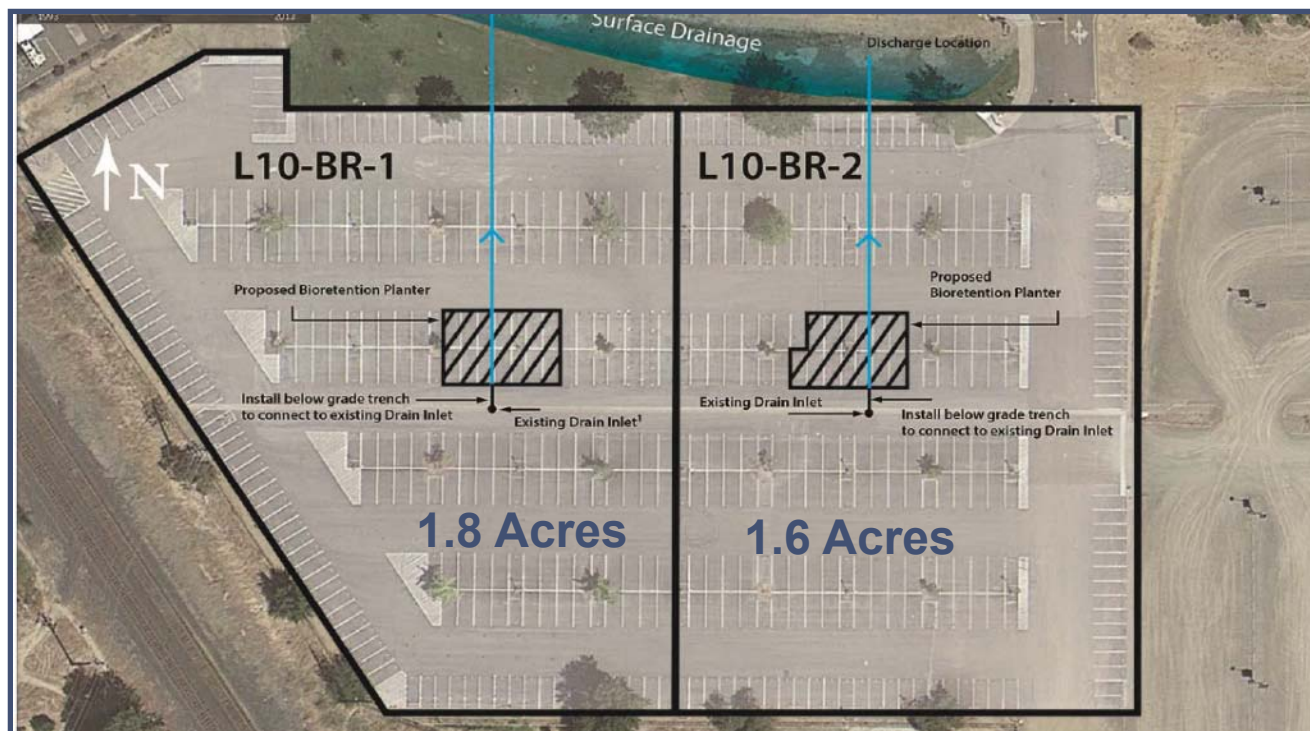
madremiraqueluna.blogspot.com

Campus Layout



Site & BMP Selection – Parking Lots

- ✓ Capture parking lot runoff
- ✓ Replace impervious parking stalls with pervious planters
- ✓ Build planters around existing DIs to address overflow
- ✓ Plant water-wise vegetation



Site & BMP Selection – Streets

- ✓ Capture curb & gutter runoff
- ✓ Cut curbs to direct runoff to pervious areas
- ✓ Replace turf with amended soils and water-wise plants



Site & BMP Selection – Rooftops

- ✓ Capture rooftop runoff
- ✓ Disconnect roof drains and redirect to rain gardens
- ✓ Use water-wise vegetation



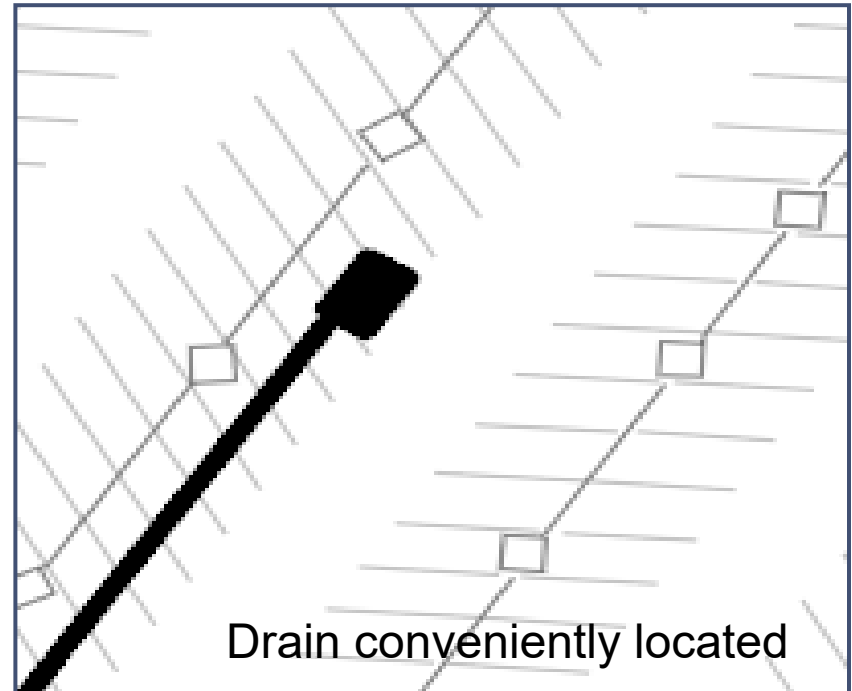
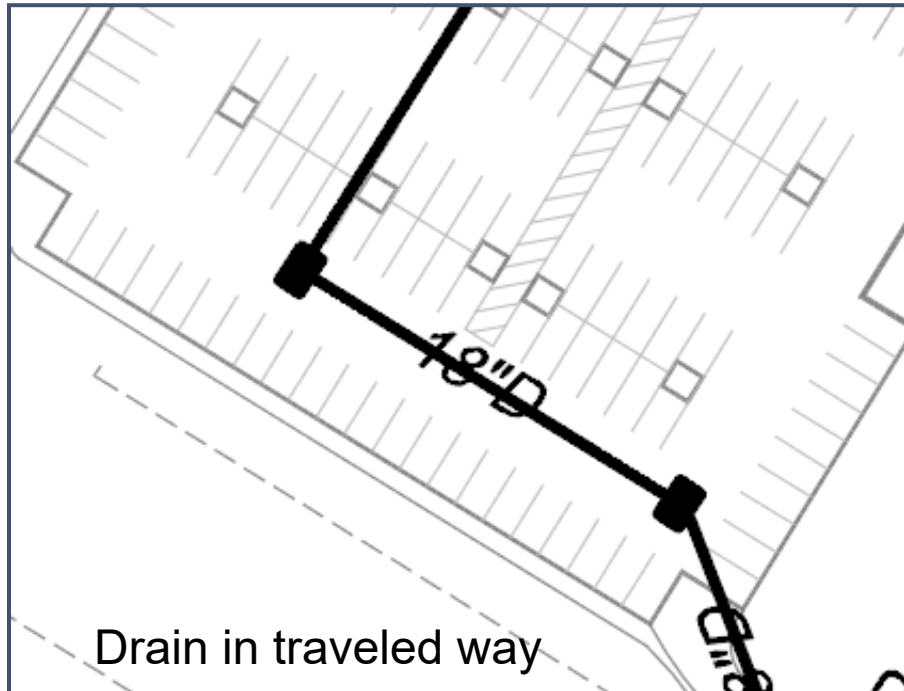
Site & BMP Selection – Existing Landscape

- ✓ Capture runoff from impervious surface and turf
- ✓ Amend soils to enhance infiltration
- ✓ Replace turf with water-wise vegetation
- ✓ Regrade to create raised inlet



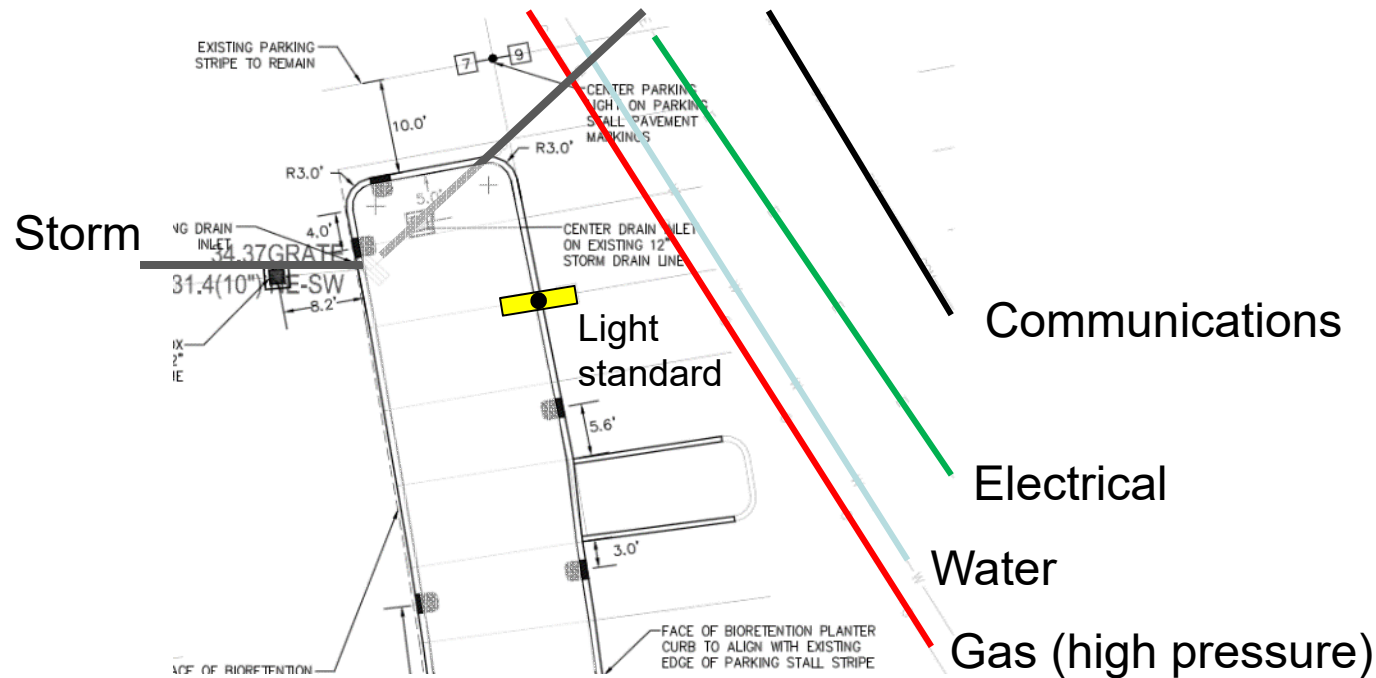
Design Challenges

- ✓ Fitting into the existing drainage system
 - Horizontal



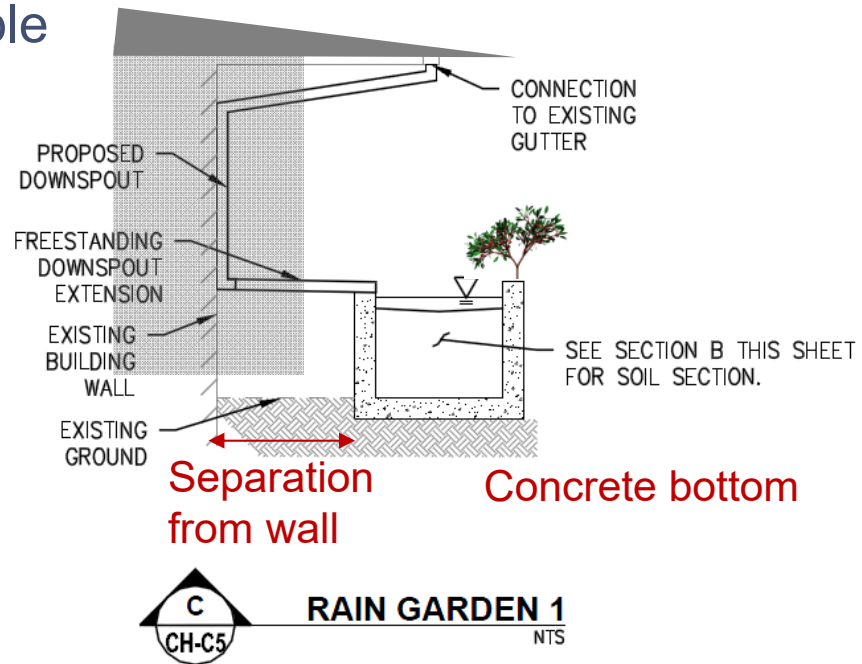
Design Challenges

- ✓ Conflicts with other infrastructure
 - Sanitary sewer, gas, electric, light standards, trees



Design Challenges

- ✓ Interactions with buildings
 - Avoid saturating soils around foundations
 - Tapping into building drainage systems
 - May require architect or mechanical engineer
 - Some may be inaccessible



Design Challenges

- ✓ Compatibility with campus master plan



Construction Challenges

✓ Unanticipated utilities and tree roots

- Reduced footprints
- Changed geometry
- Broken irrigation lines
(excavations flooded)



✓ Contractors unfamiliar with intent

- Raised inlets should be raised
- Keep heavy equipment off excavations
- Use spec'd soils
(chosen for treatment capabilities)



Construction – Parking Lots 7 & 10

✓ Bioretention Planters & Infiltrating Bioswale



Construction – Jed Smith Drive

- ✓ Porous pavement and rain gardens



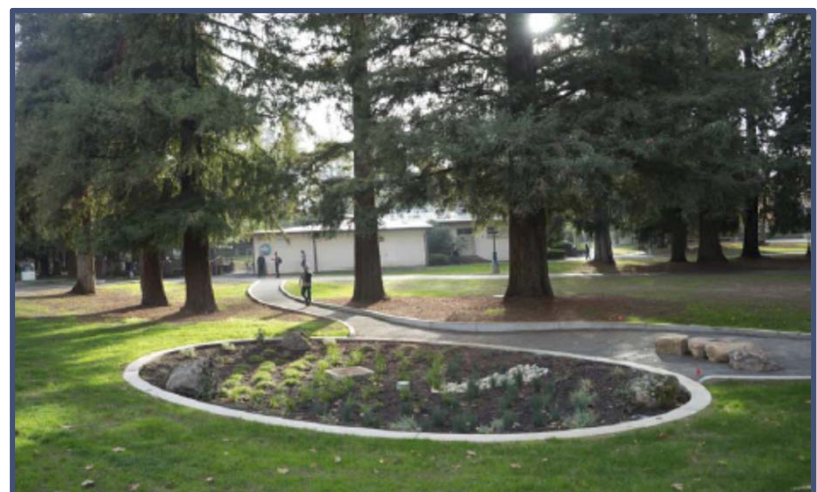
Construction – Calaveras Hall

- ✓ Roof drain disconnects, rain gardens, & porous pavement



Construction – Library Green & Campus Grove

✓ Raised inlets, rain gardens, & porous pavement

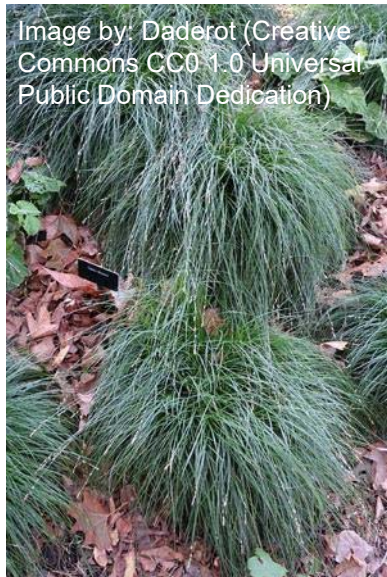


Construction – College Town Drive

✓ Curb cuts and rain gardens

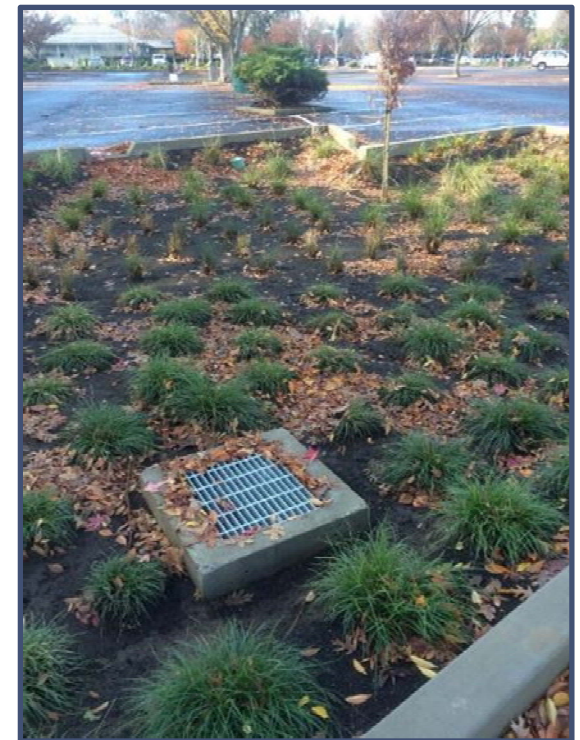


Plants



Operation and Maintenance

- ✓ Remove weeds, litter, & debris
- ✓ Use integrated pest management techniques (minimize fertilizer, pesticide, & herbicide use)
- ✓ Inspect for erosion and sediment issues
- ✓ Fix erosion/sediment problems
- ✓ Inspect for infiltration
- ✓ Replace soils (eventually)



Existing Performance

- ✓ Performing as designed
 - Runoff entering BMPs
 - Temporary ponding
 - Infiltrating within 48 hrs
 - Minimum overflow & discharge

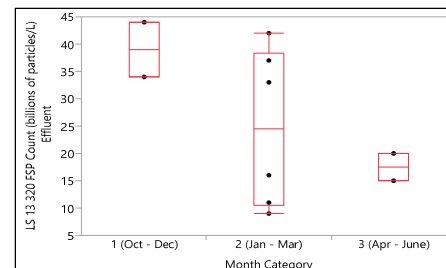
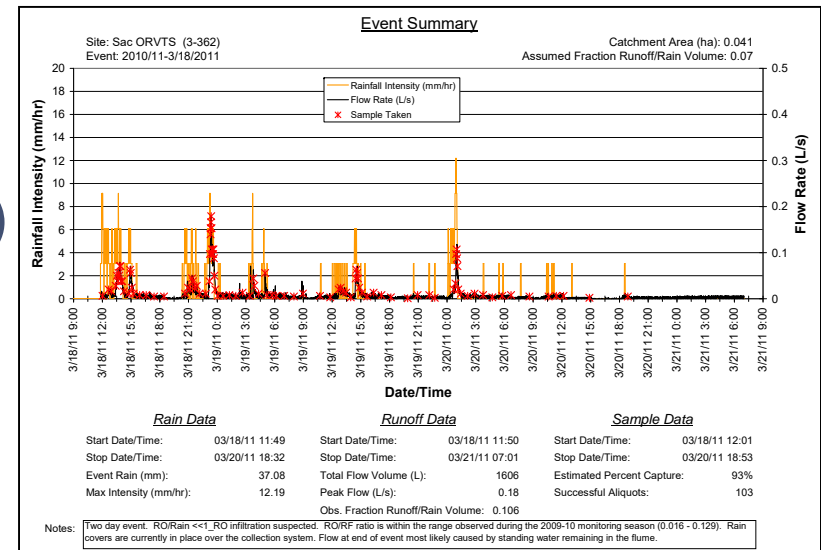


[PP](#)
[video](#)

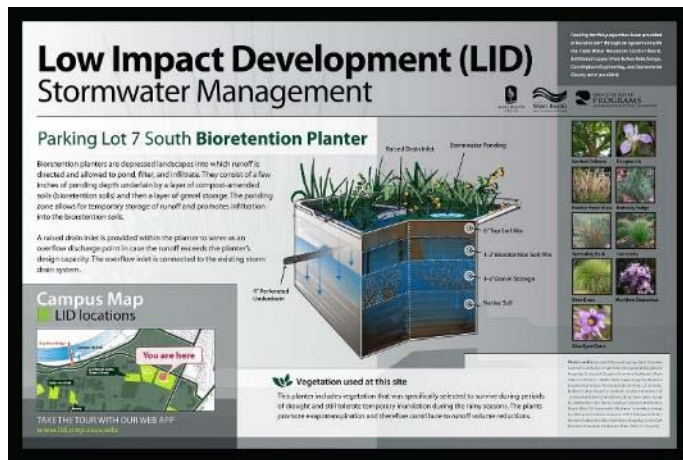


Monitoring & Reporting

- ✓ Measure Flows
- ✓ Analyze Water Quality
(sediment, pesticides, metals)
- ✓ Data Evaluation



Education and Outreach



**SCIENCE
TECHNOLOGY
ENGINEERING
MATHEMATICS
STEM
Lecture Series**

**Stormwater as a Resource:
Sustainable Projects at Sacramento State**

*John Johnston, P.E., Ph.D.
Professor, Civil Engineering
California State University, Sacramento*

*Maureen Kerner, P.E.
Office of Water Programs
California State University, Sacramento*

www.csus.edu/stem

Free Community Lecture > Free Parking
(Display Permit on Back of Card)
Thursday, February 18, 2016 > 6 p.m.
University Union, Redwood Room

SACRAMENTO STATE
Center for STEM Excellence



SACRAMENTO STATE
Office of Water Programs

Water Programs
SACRAMENTO STATE

Sign In
Create Account

Campus LID

Low Impact Development Stormwater Management at Sacramento State

Capturing Stormwater

0 Items

- Home
- Operator Training
- Research
- Stormwater Training
- Campus LID Project
 - Construction Log December 7, 2015
 - Regional LID Conference November 4, 2015
 - Construction Log September 25, 2015
 - Construction Log August 25, 2015
 - Construction Log August 11, 2015
- Upcoming Events
- About
- Contact Us
- Need Answers? Click!
- How to Report a Problem

More LID is Coming!!

- ✓ Now a permit requirement for campus projects
- ✓ Incorporated into campus Master Plan



LID & Sustainability

- ✓ Managing resources for tomorrow's generations
- ✓ Think globally. Act locally!
- ✓ LID is site scale approach
- ✓ Implement at home!



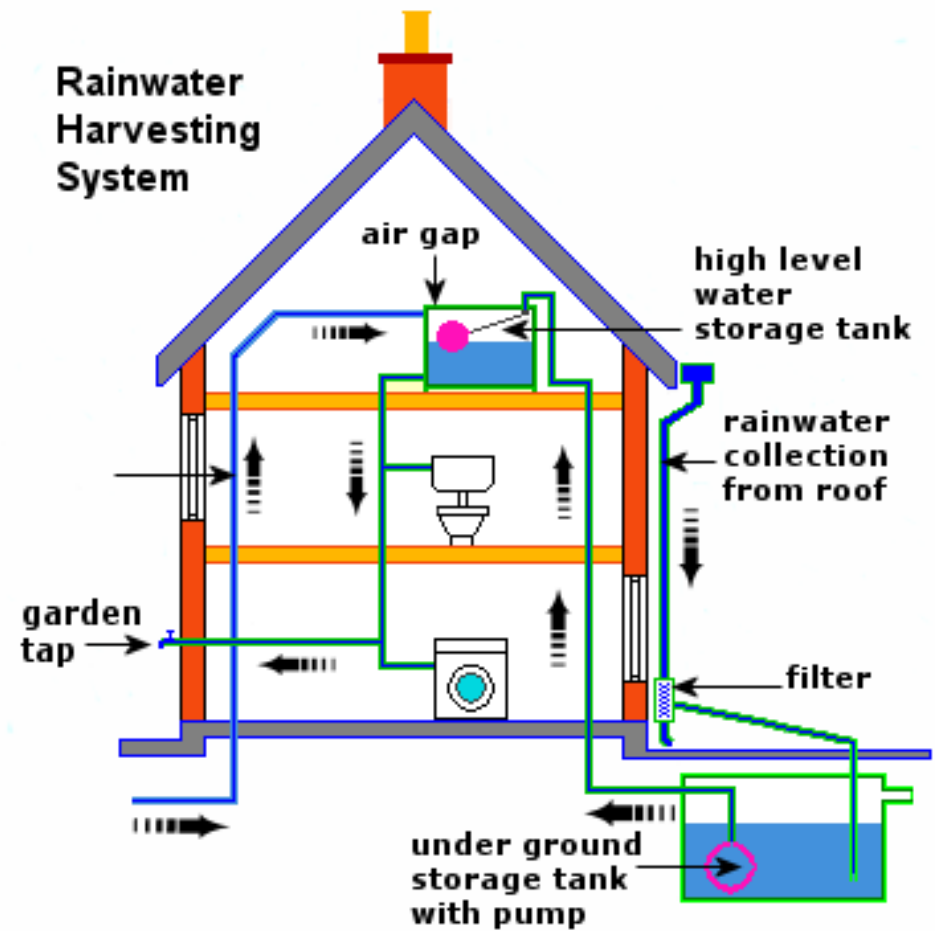
<http://www.beriverfriendly.net/>



<http://www.owp.csus.edu/csus-lid/>



Stormwater treatment and reuse



Stormwater treatment and reuse

PREPUBLICATION COPY

Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

NOT FOR PUBLIC RELEASE BEFORE

Wednesday, December 16, 2015
At 11:00 a.m. EDT

THIS PREPUBLICATION VERSION has been provided to facilitate timely access to the committee's findings. Although the substance of the report is final, editorial changes may be made throughout the text prior to publication. The final report will be available through the National Academies Press in the spring of 2016.

HighDRO®-Pure Rainwater Harvesting System

