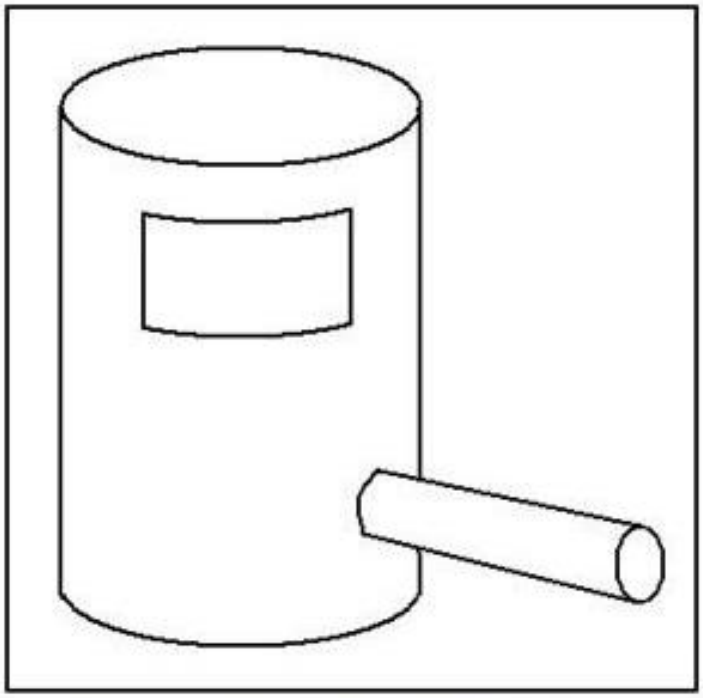
Stormwater as a Resource:
Sustainable Projects at Sacramento State

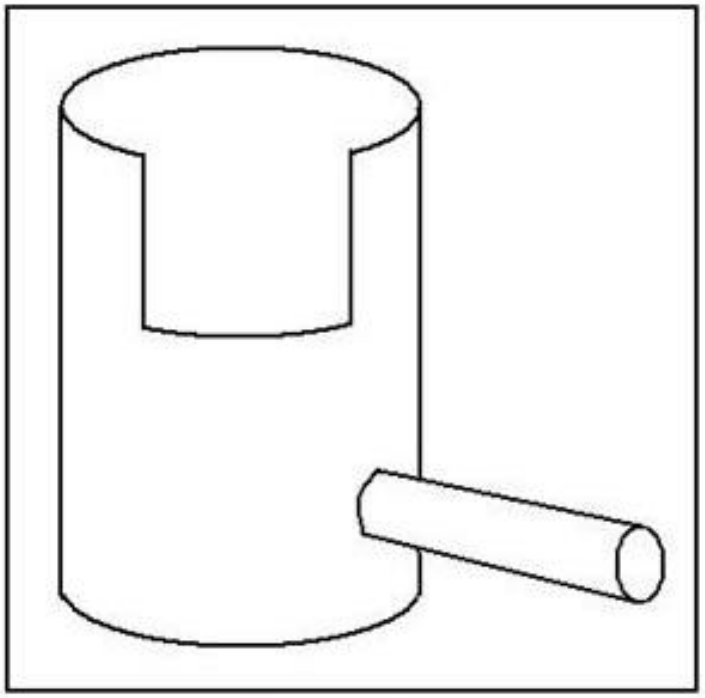
Dr. John Johnston, PhD, PE
Professor, Civil Engineering

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

http://en.wikipedia.org/wiki/File:Linville_River-27527.jpg

Traditional drainage design

movie

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

Stormwater pollutants

Sediment

Nutrients

Pesticides

Pathogens

Heavy metals and hydrocarbons

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

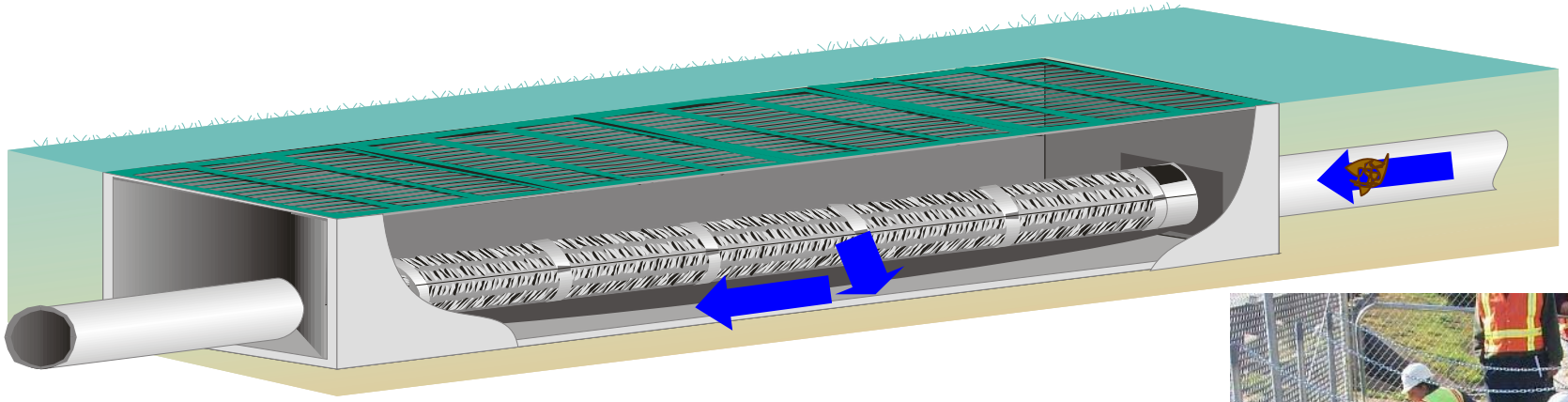
Local impact examples

Excessive algae growth (eutrophication)

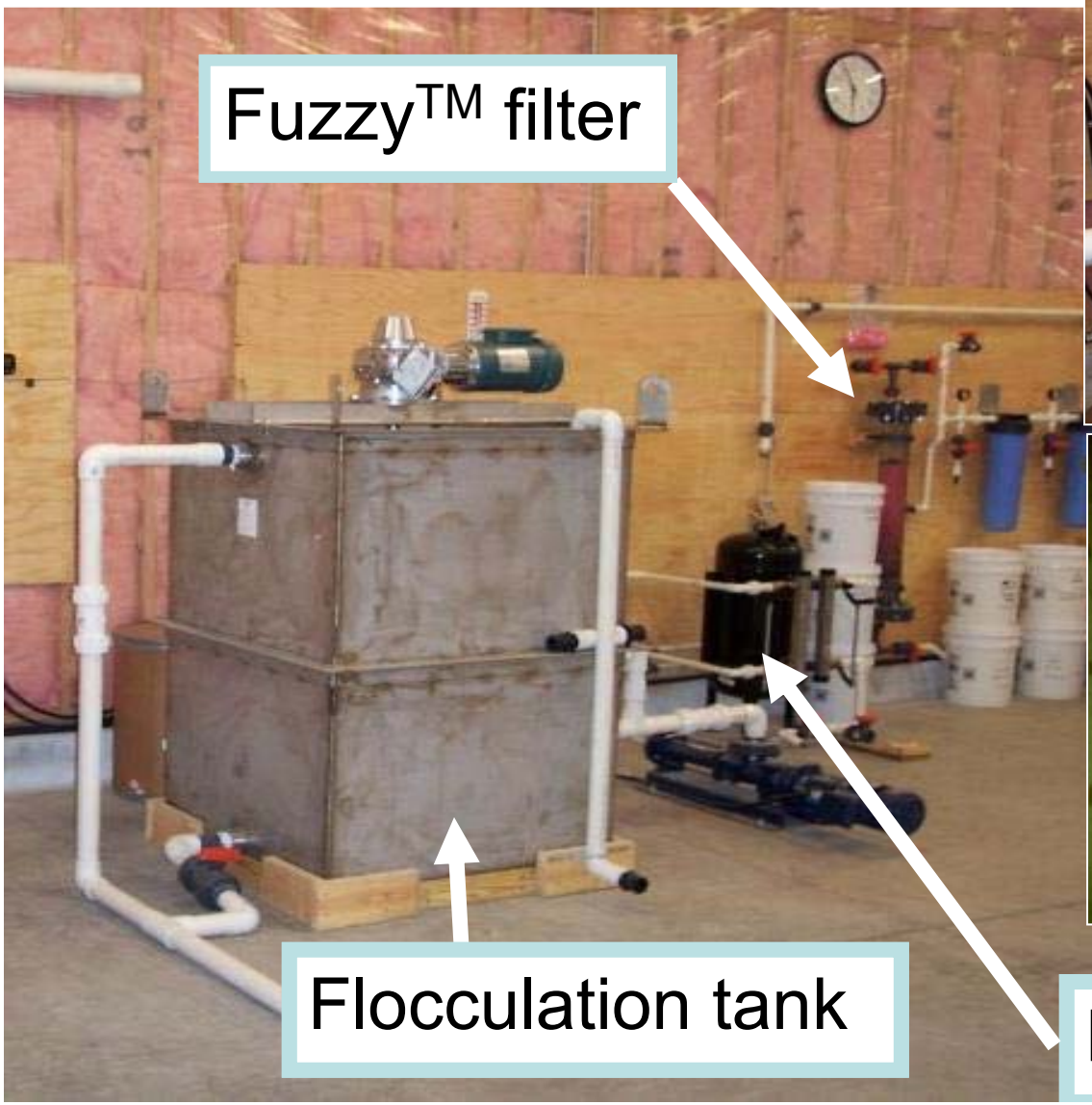
Treatment !

Fairbairn WTP

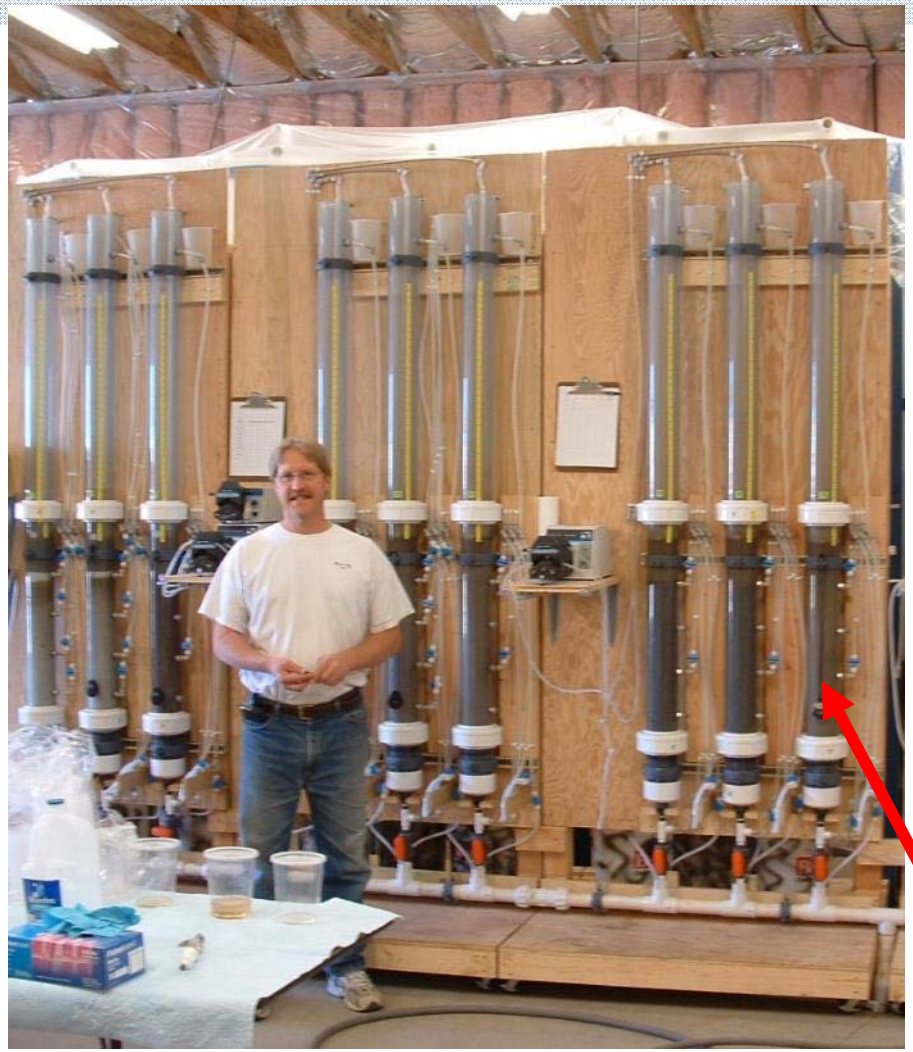
Trash screens (Caltrans projects)



Mechanized System Pilot in Tahoe



Tahoe stormwater filter studies



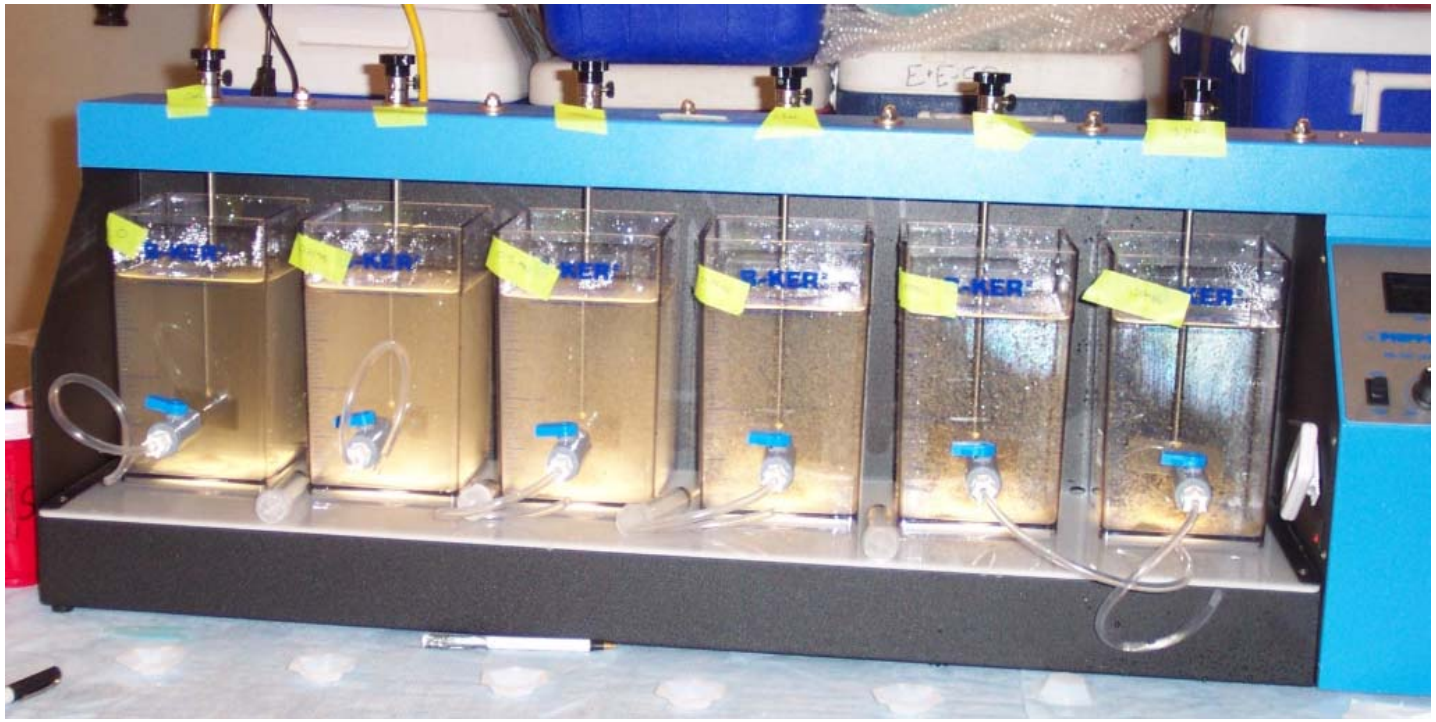
30-inch dia, 24-inch depth

Sand

Activated Alumina

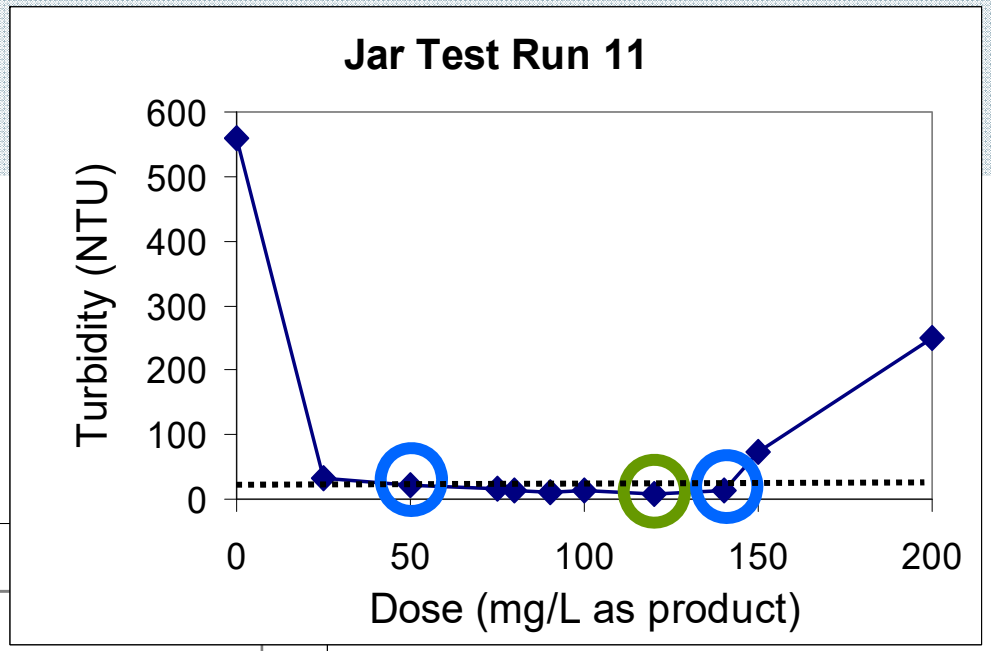
4-inch dia, 24-inch depth

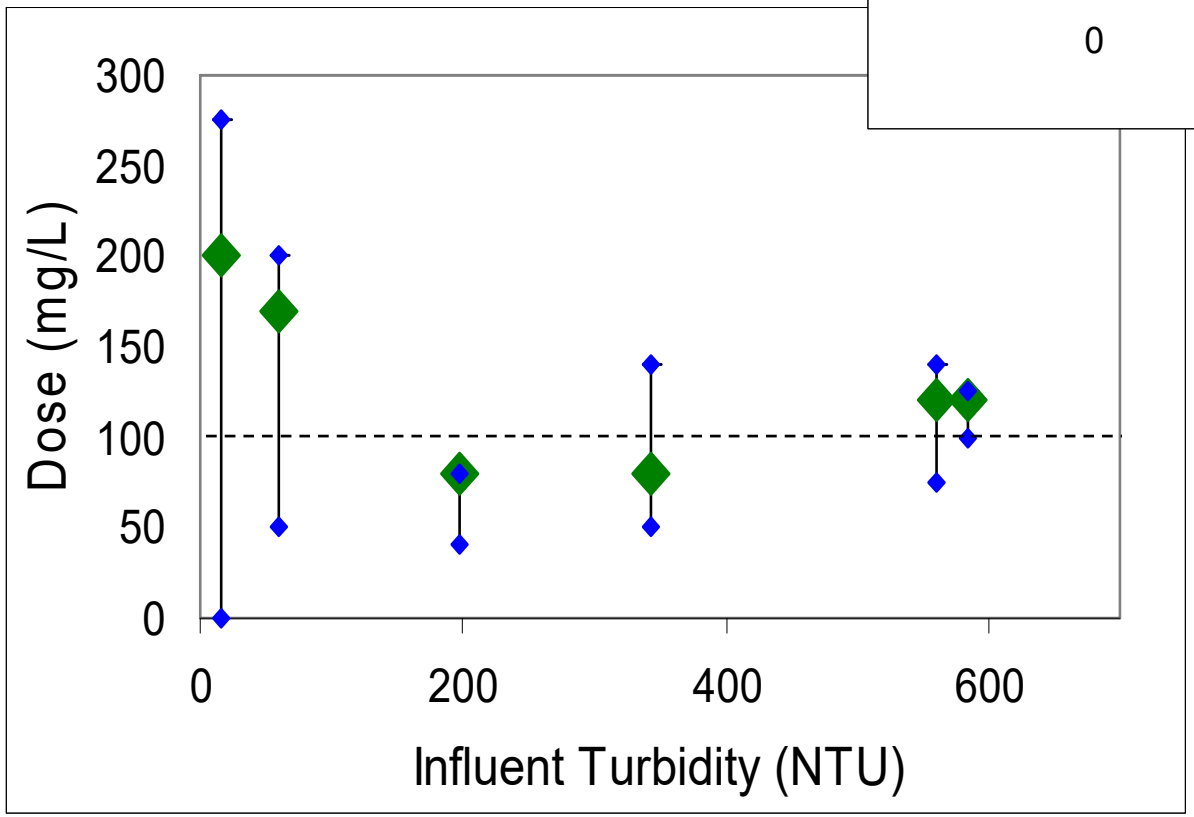
Tahoe chemical treatment



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

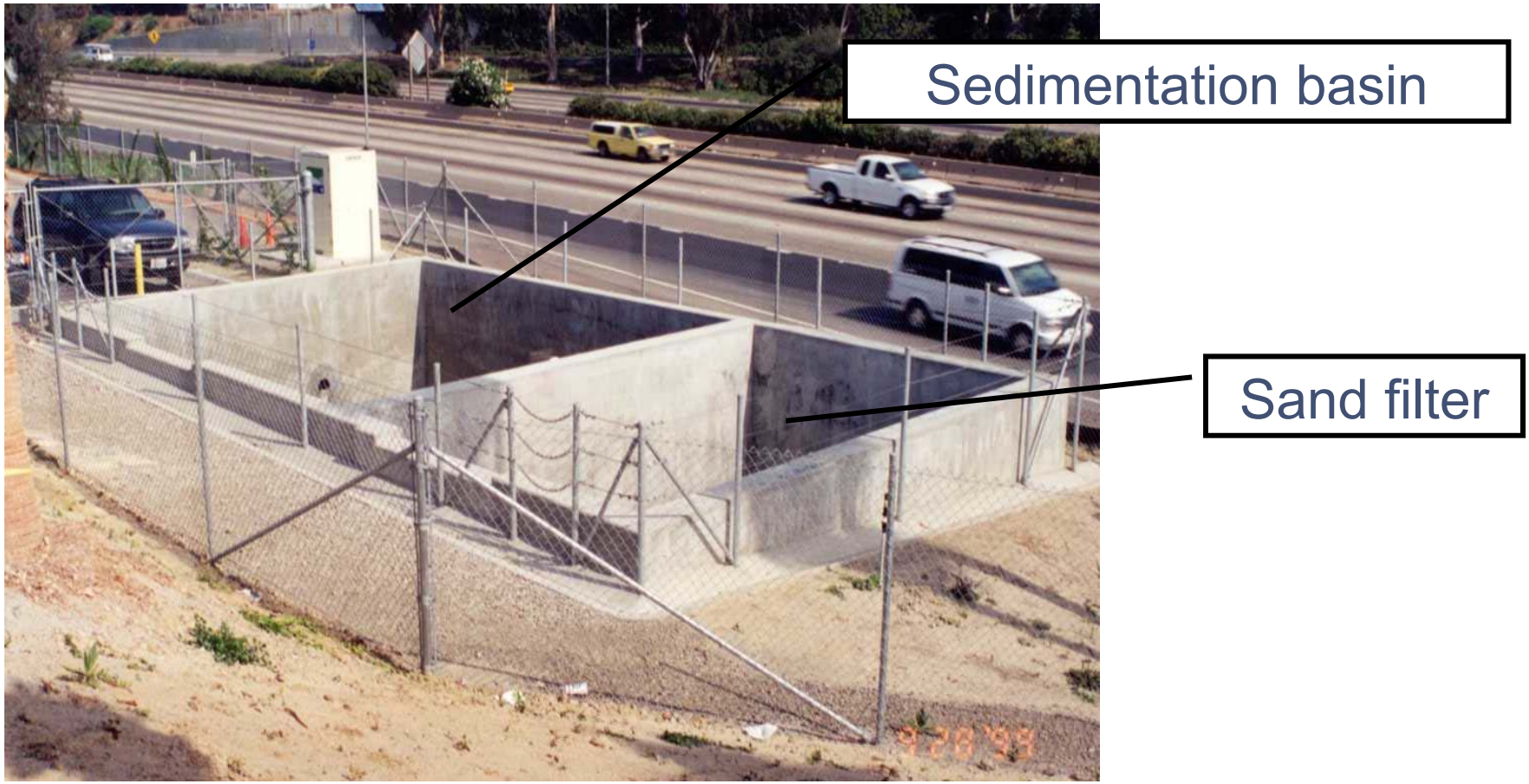
Variable Dosing





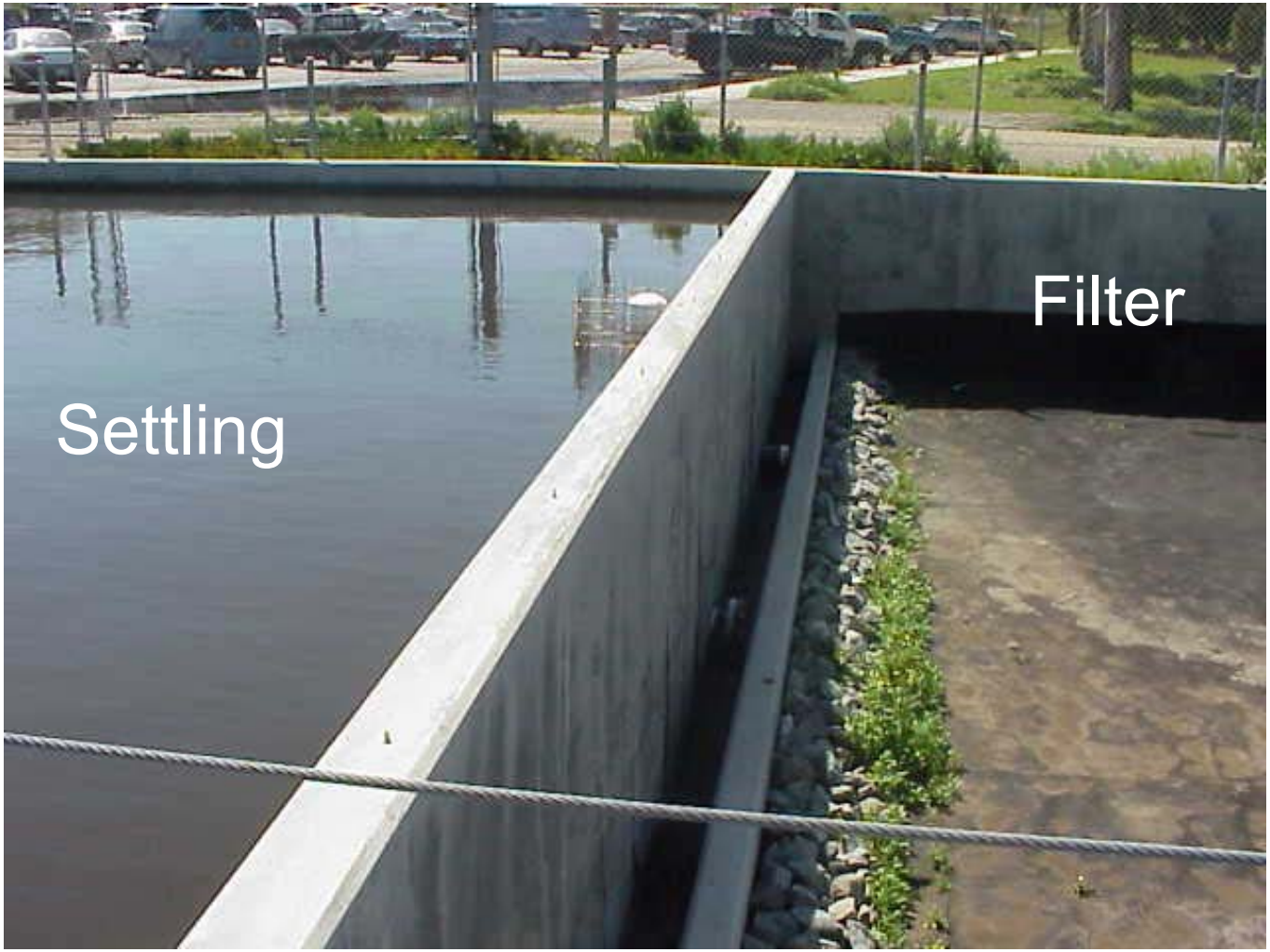
Prototype chemical feed system

Settling basins and filters



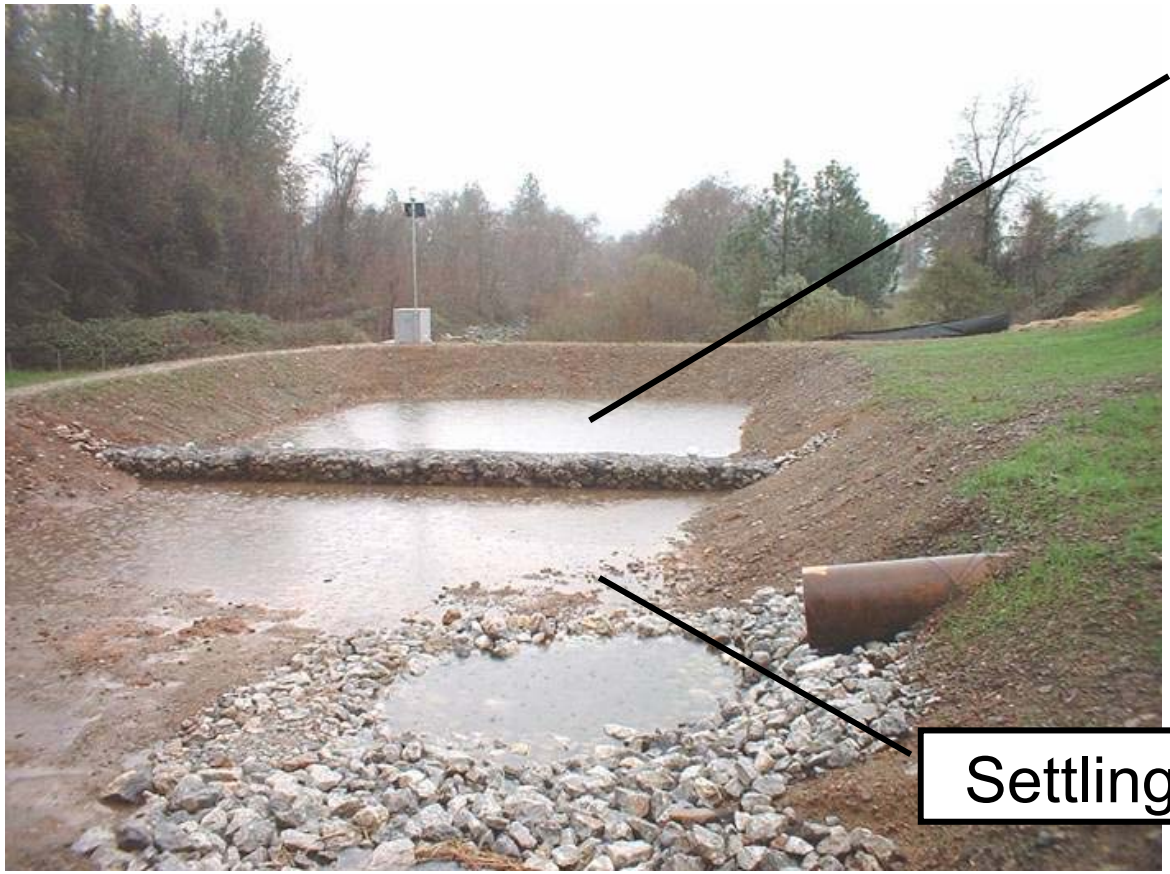
San Diego Caltrans installation

Settling basins and filters



Caltrans installation on urban SoCal freeway

Settling basins and filters

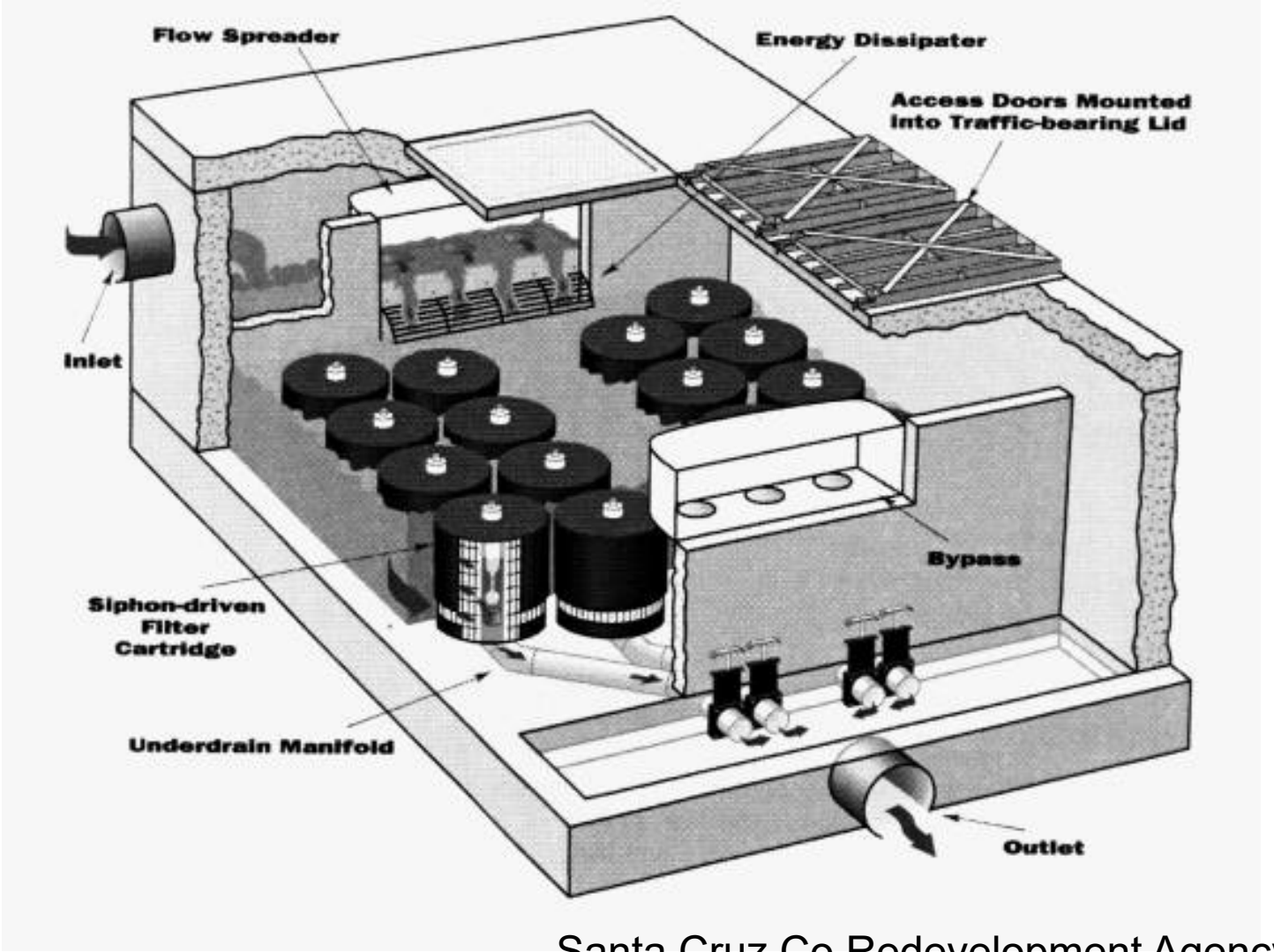


I-5 outside Redding

Settling basins and filters

Basin 2, SR 267

Manufactured treatment units

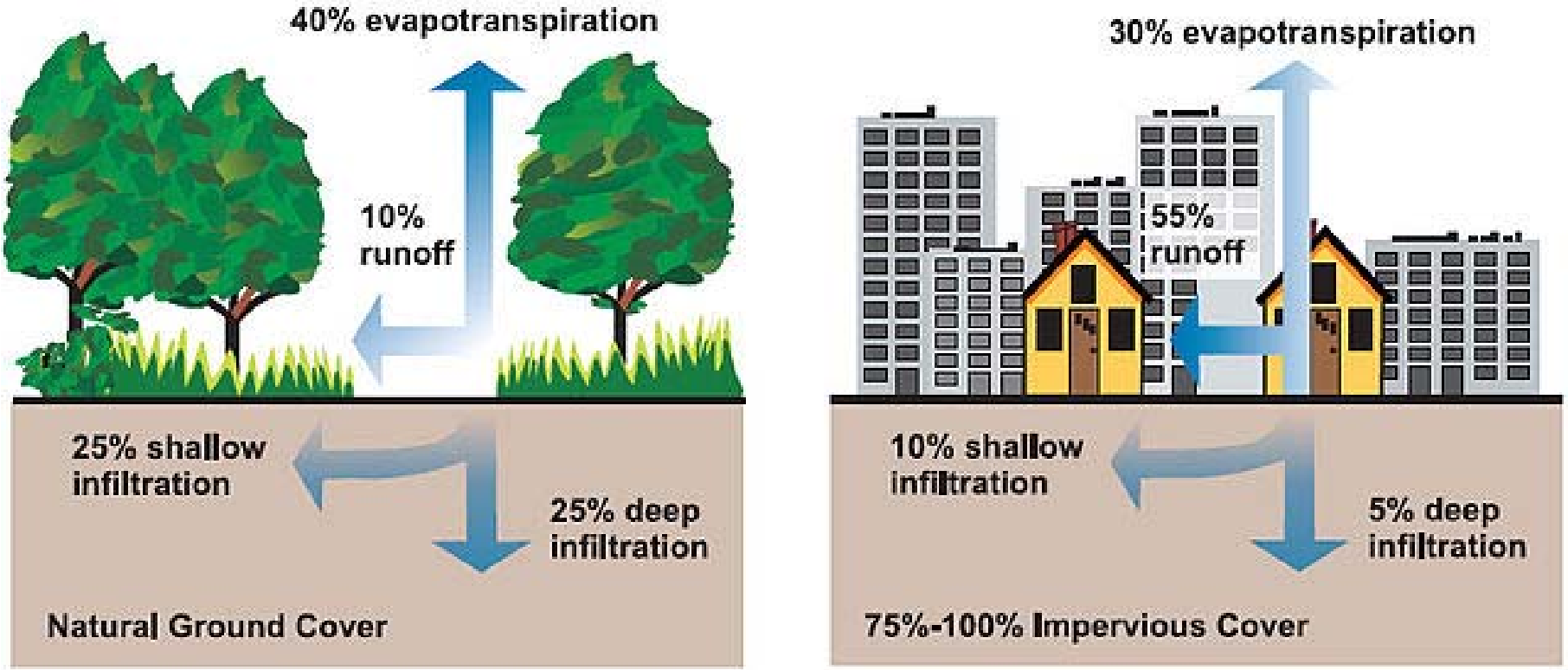


Santa Cruz Co Redevelopment Agency

Treatment problems

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

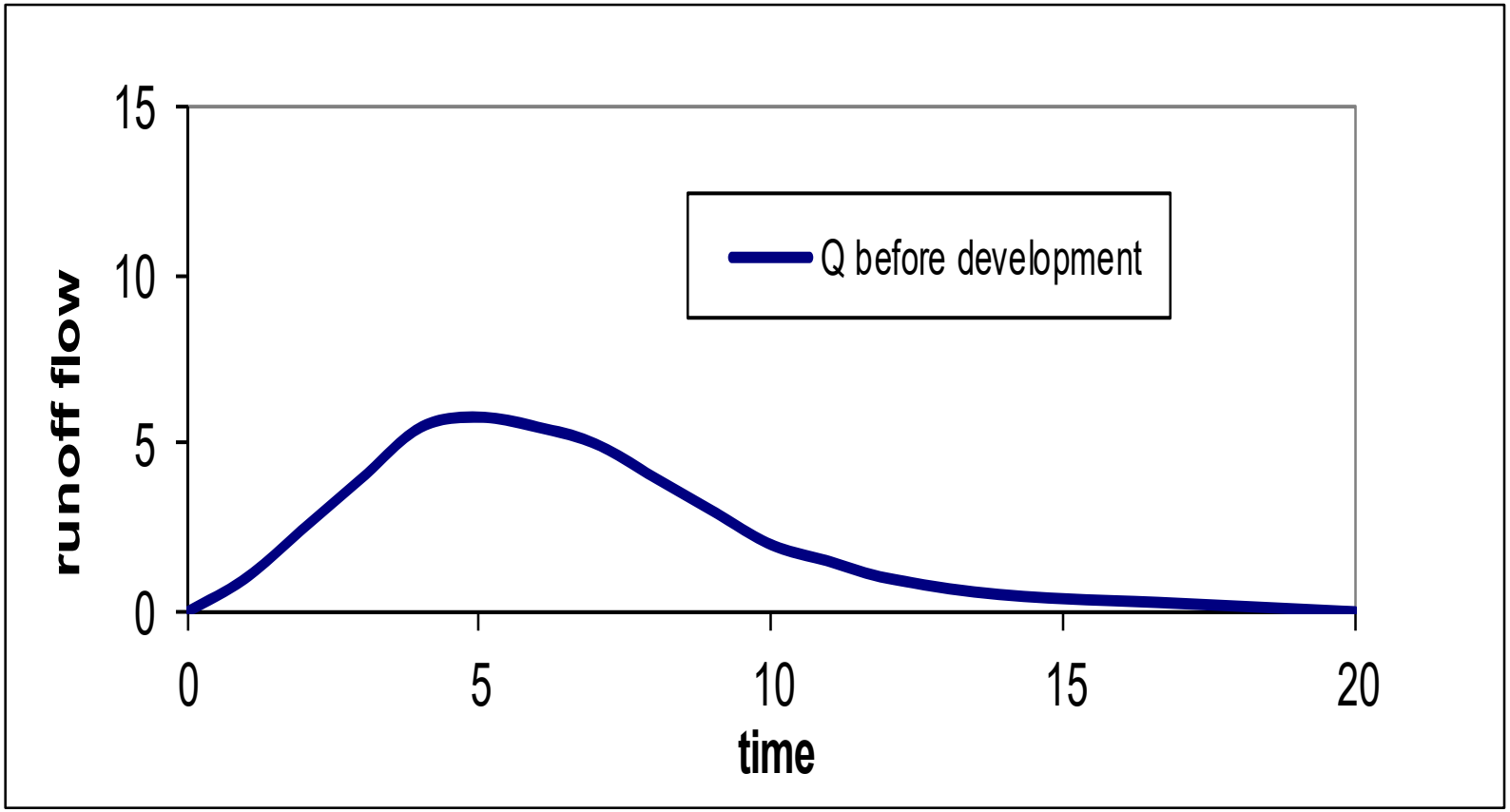
Hydromodification



Example numbers

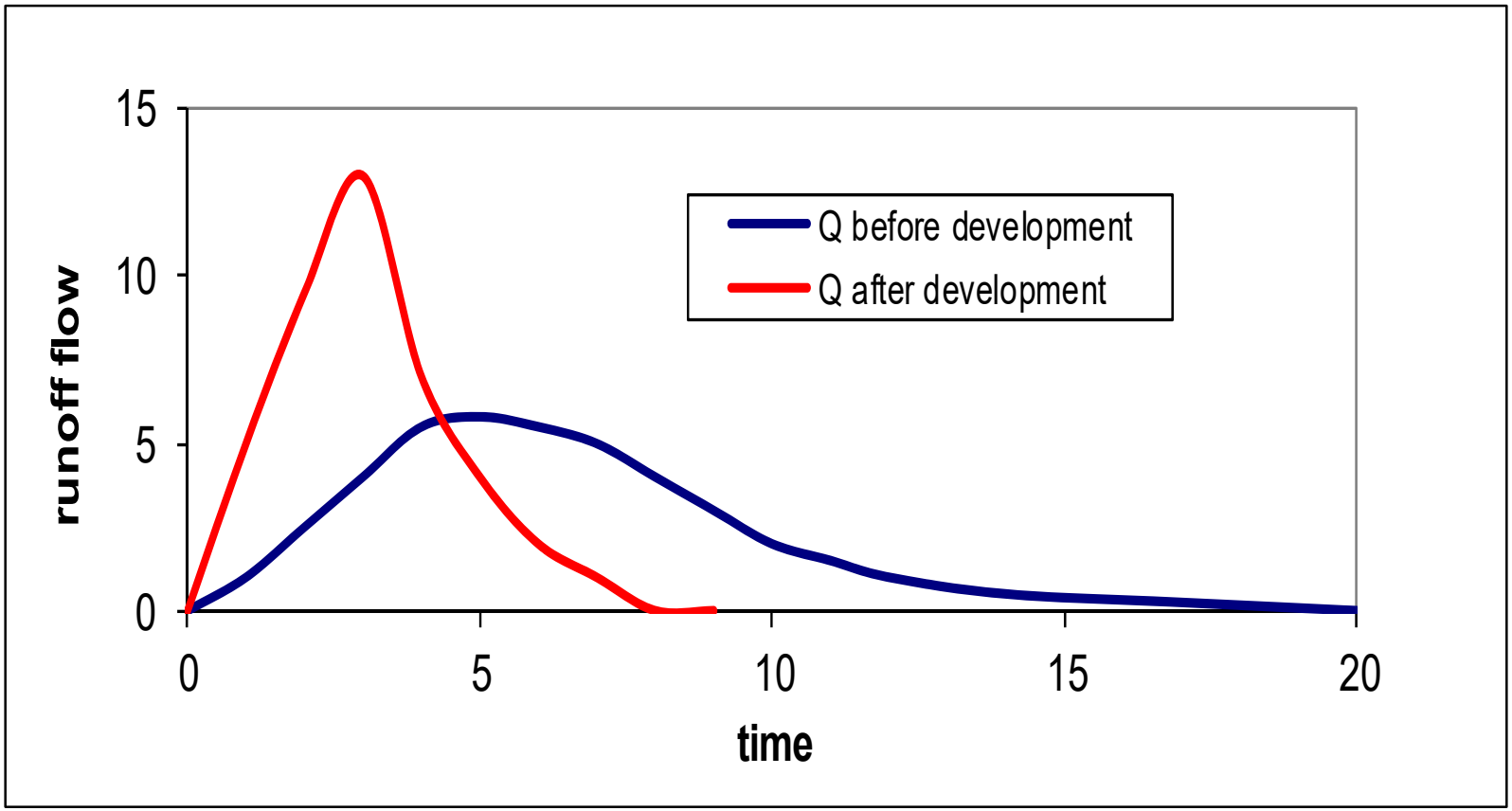
US EPA

Hydromodification



- Slow rise; slow fall

Hydromodification



- Higher flows
- Quicker peaks; faster drawdown

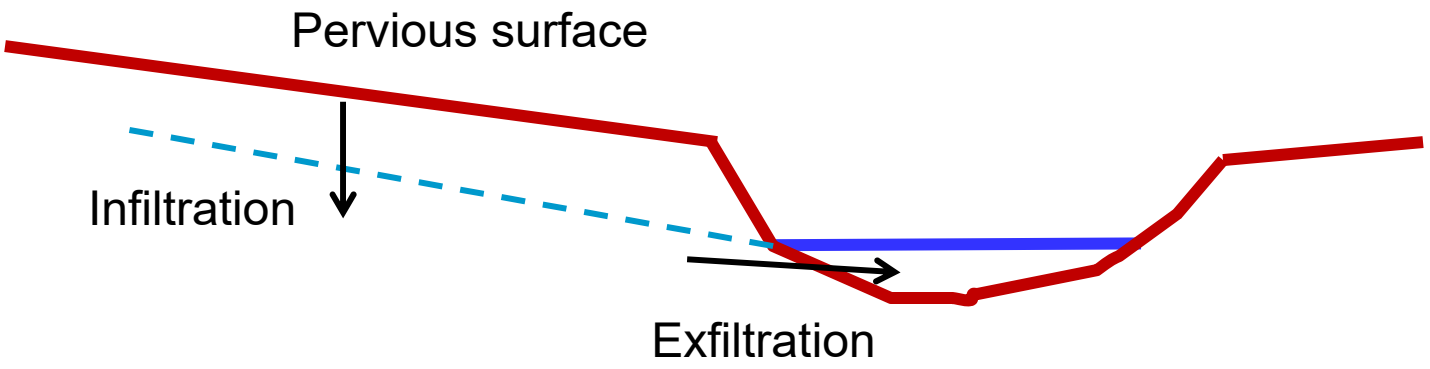
→

- More erosion
- More flooding
- Less infiltration

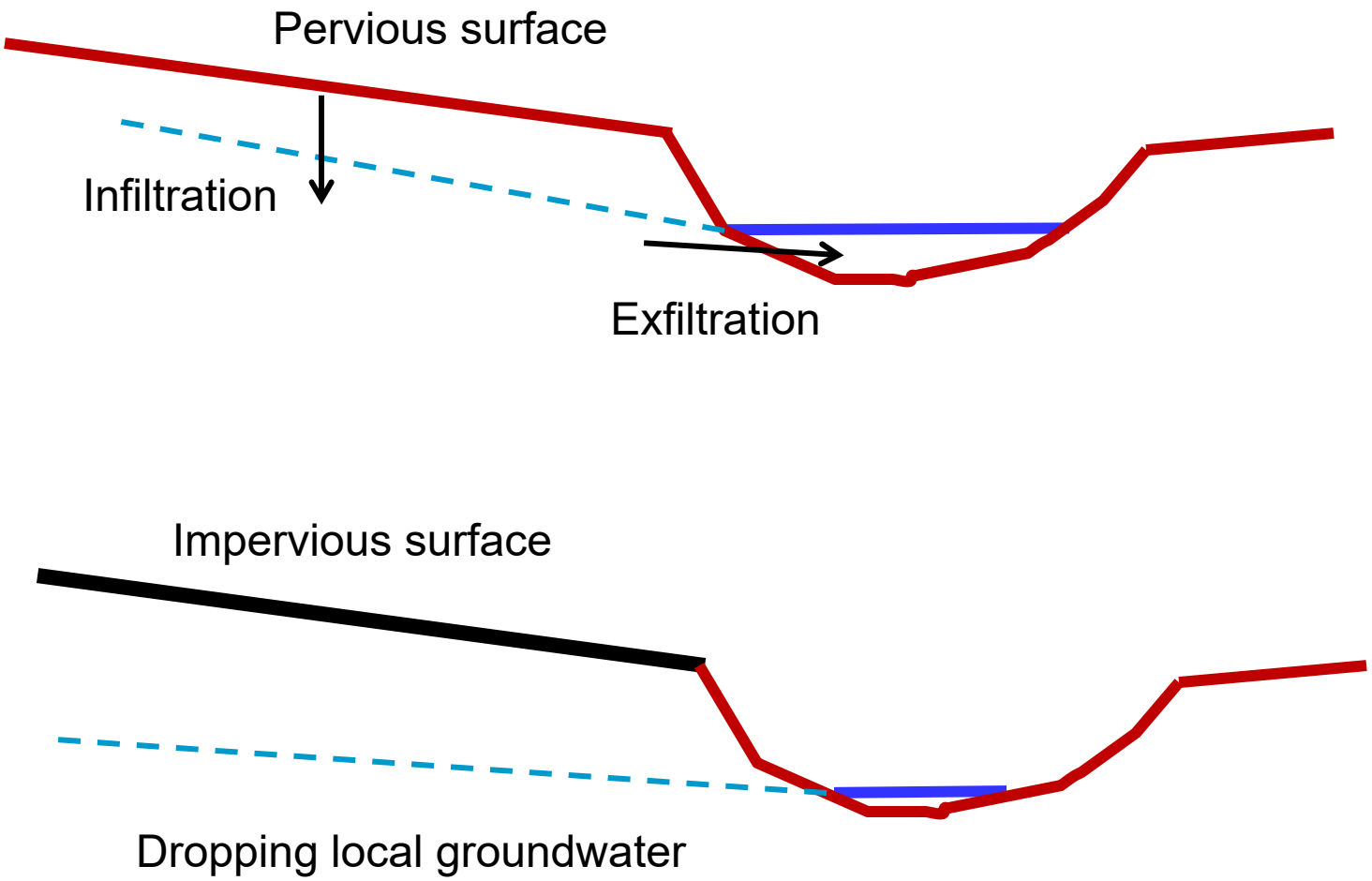
Hydromodification

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.anacostiaws.org/news/blog/tags/12.

Hydromodification (summer flows)



Hydromodification (summer flows)

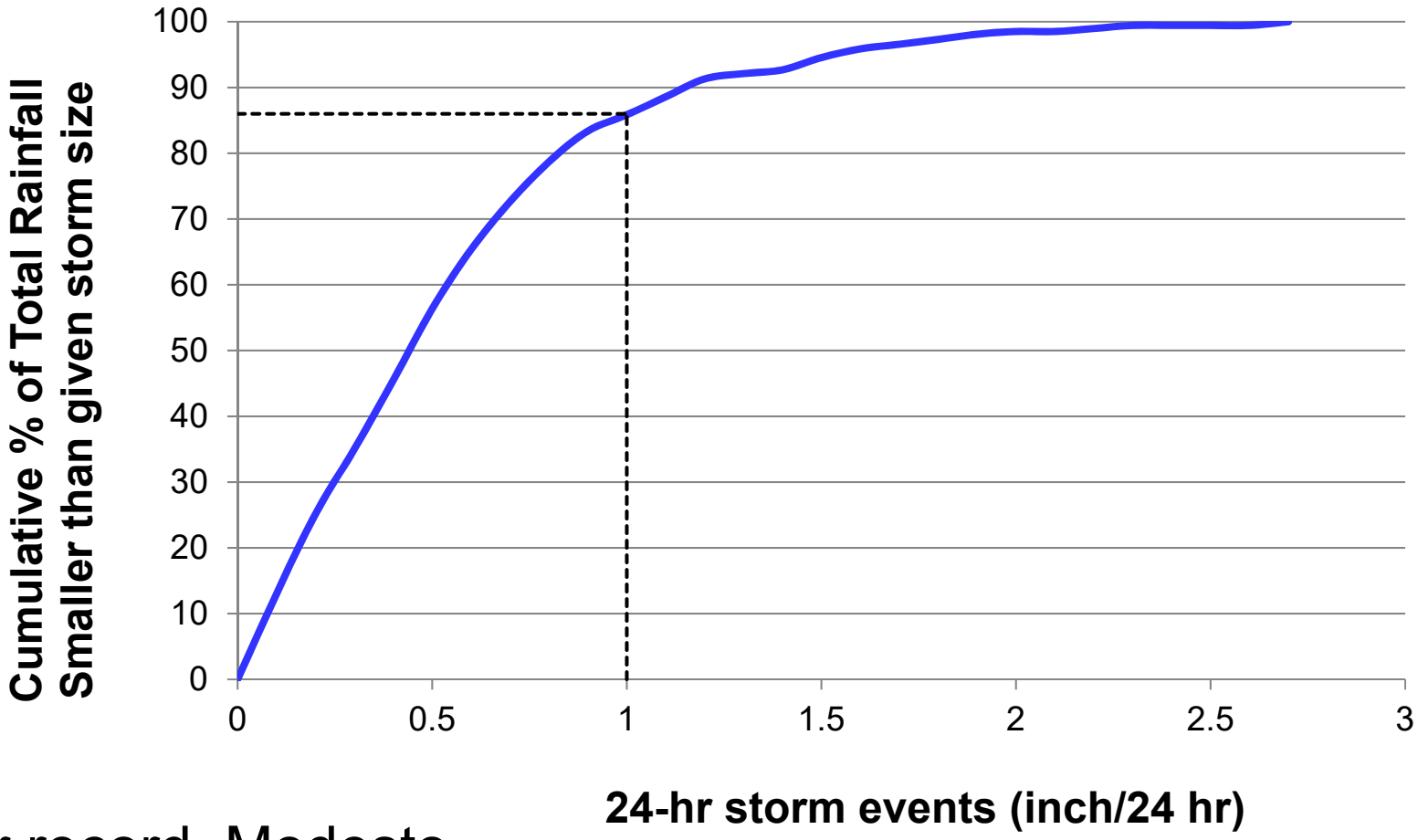


Low Impact Development (LID)

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

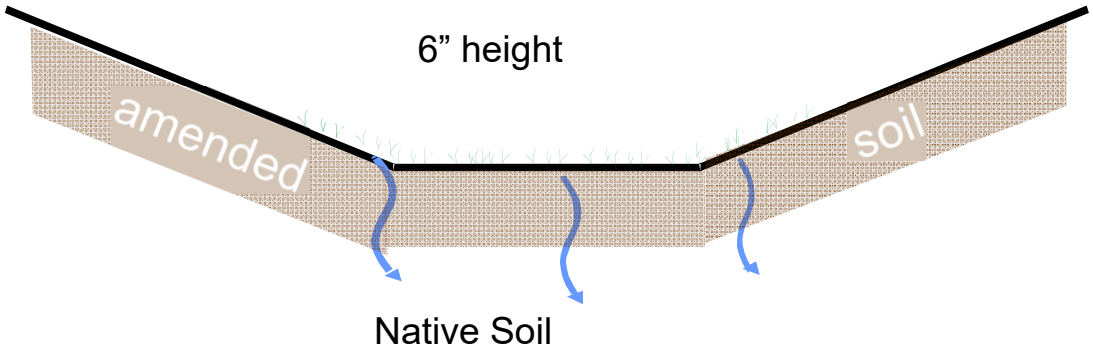


36-yr record, Modesto

Low Impact Development practices (BMPs)

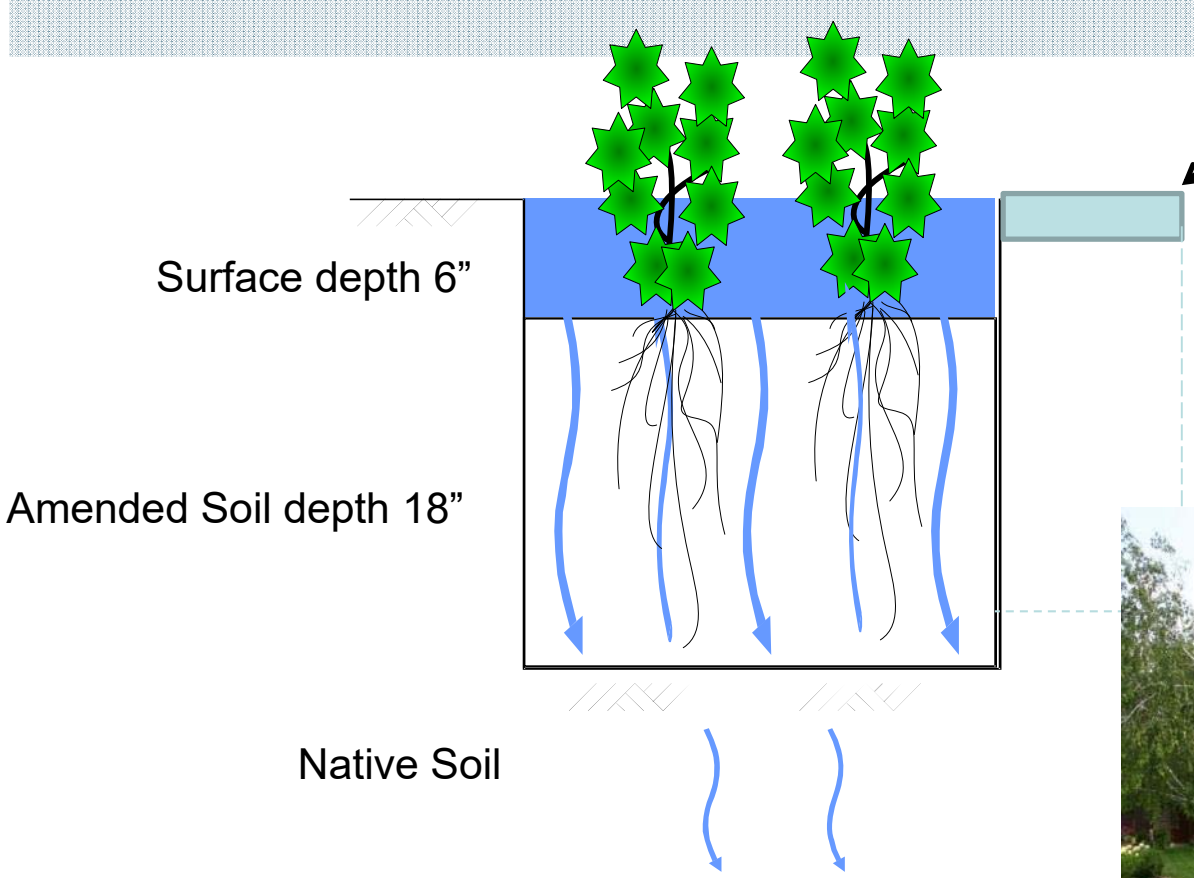
- Bioretention Planters
- Rain Gardens
- Bioswales
- Porous Pavement
- Biostrips
- Road Narrowing
- Cisterns or Rain Barrels
- Tree Box Filters
- Constructed Wetlands
- Green Roofs
- Infiltration Trenches
- Water-wise vegetation

Bioswale



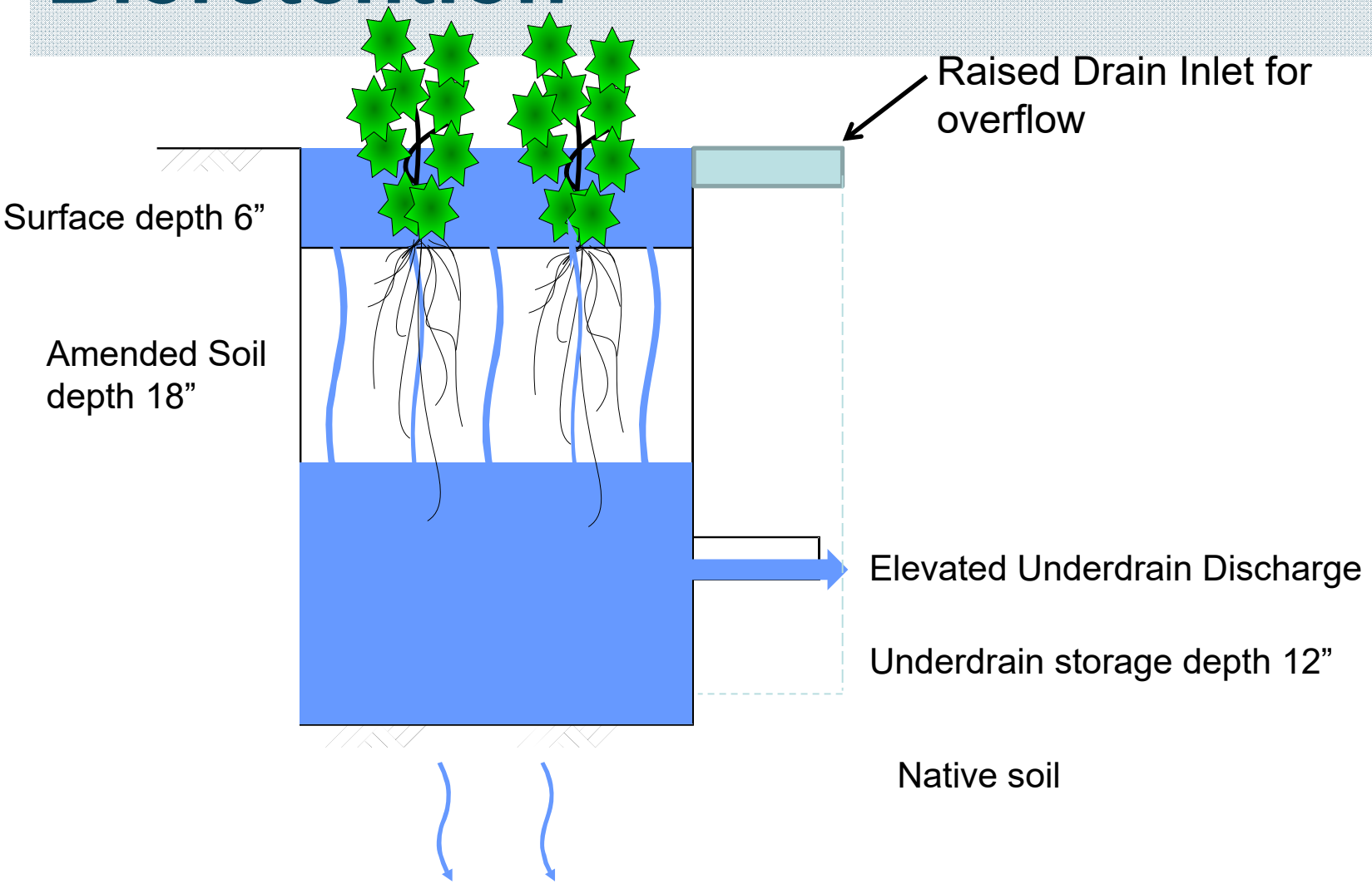
Amended Soil: 6” – 18”

Rain Garden



US EPA

Bioretention

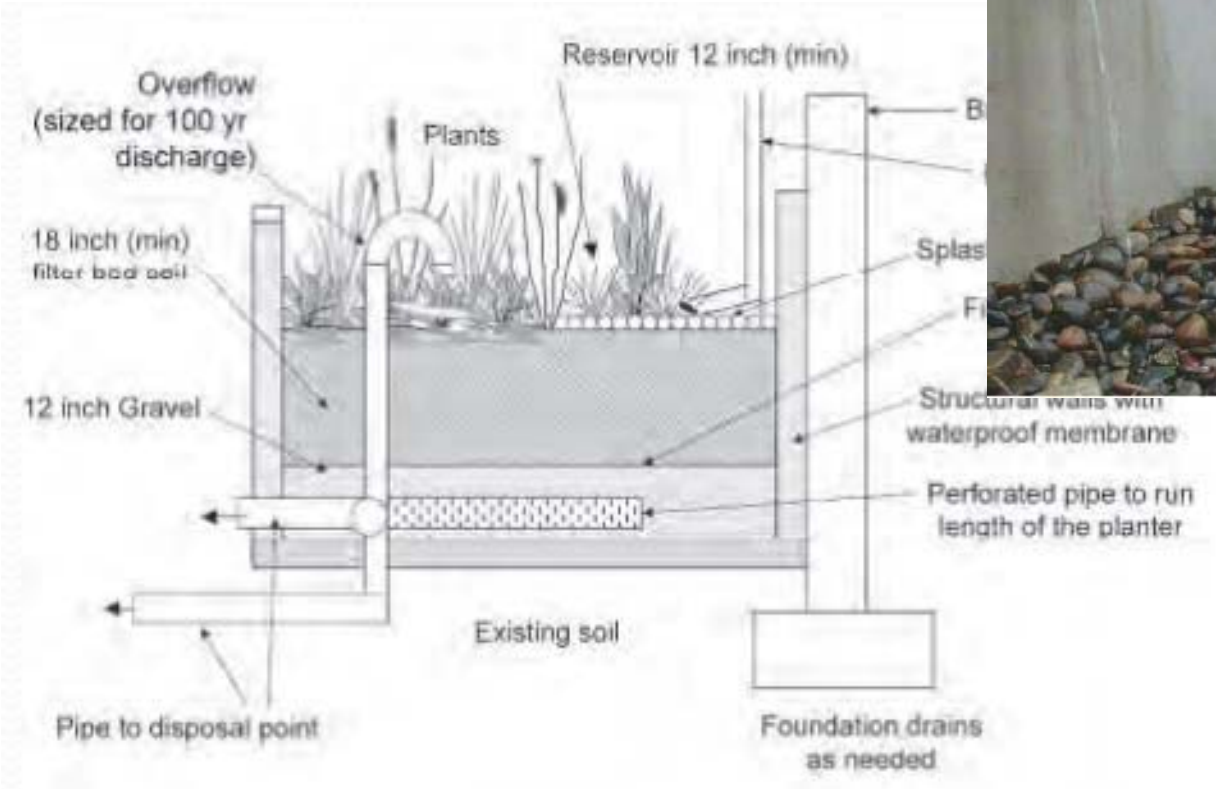


36

Bioretention

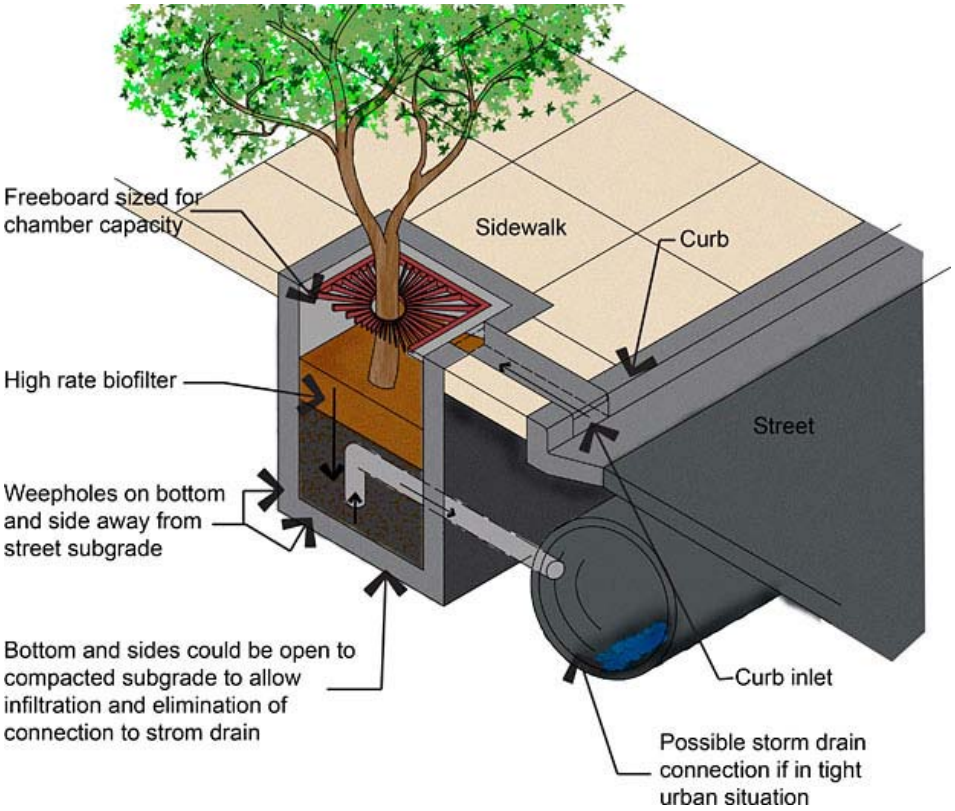
CASQA

Planters and tree boxes



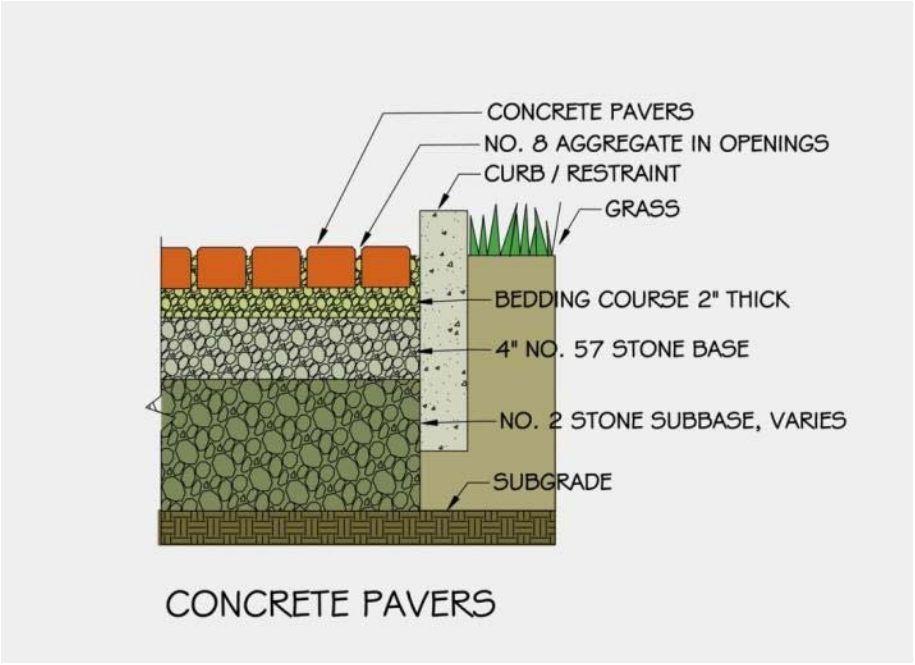
CASQA

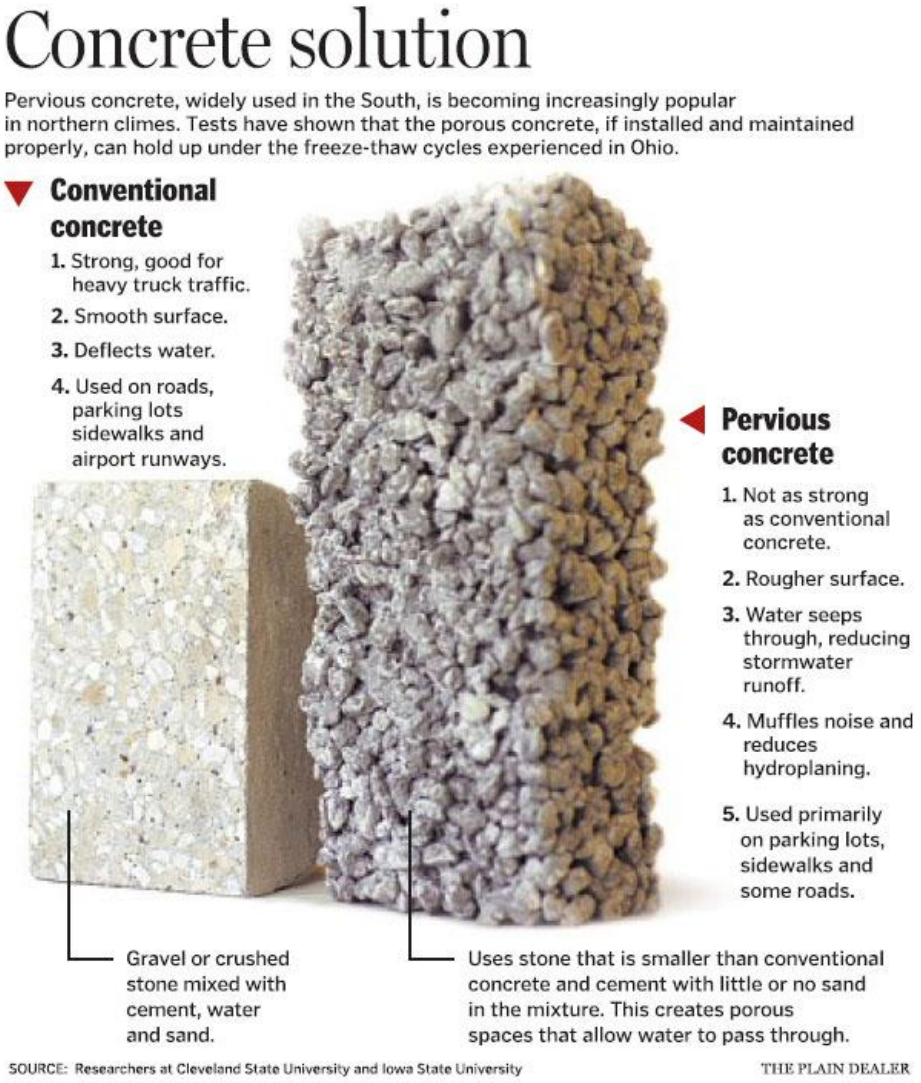
Planters and tree boxes



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

Porous pavement





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

C Street, Seattle, WA

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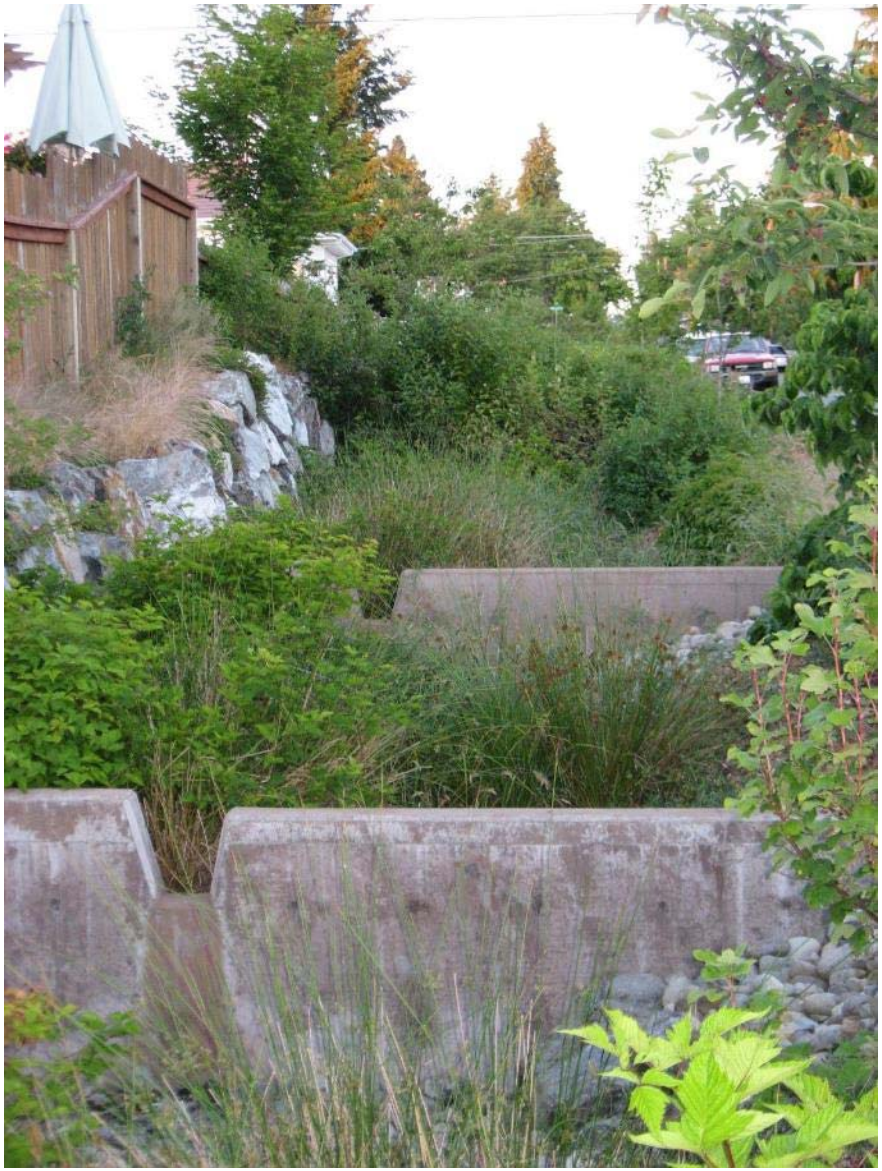


Village Homes, Davis, CA

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

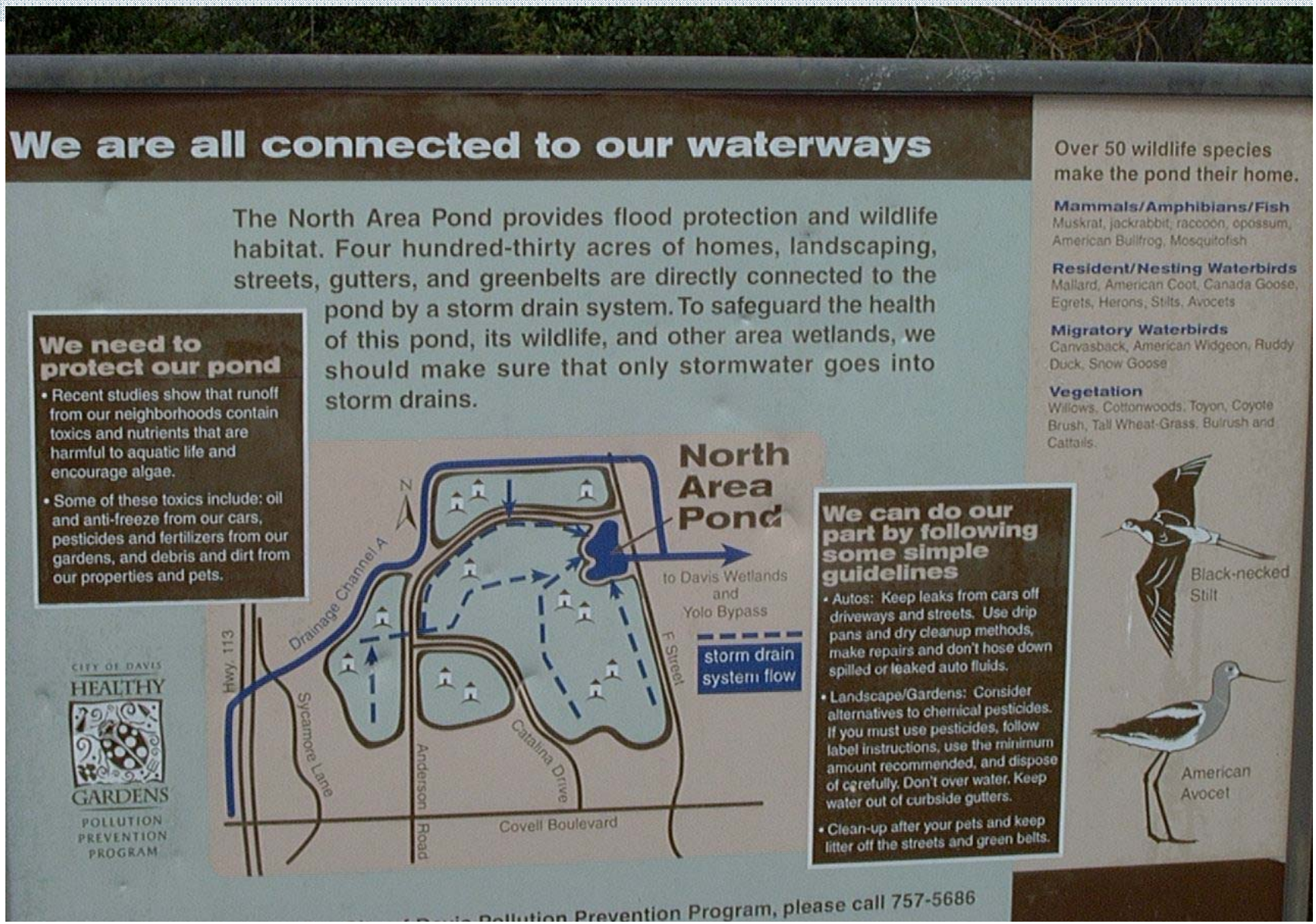
Rain garden

South Davis

South Davis

South Davis

Neighborhood-scale pond, Davis



Neighborhood-scale pond, Davis

Stormwater wetlands, Tahoe City

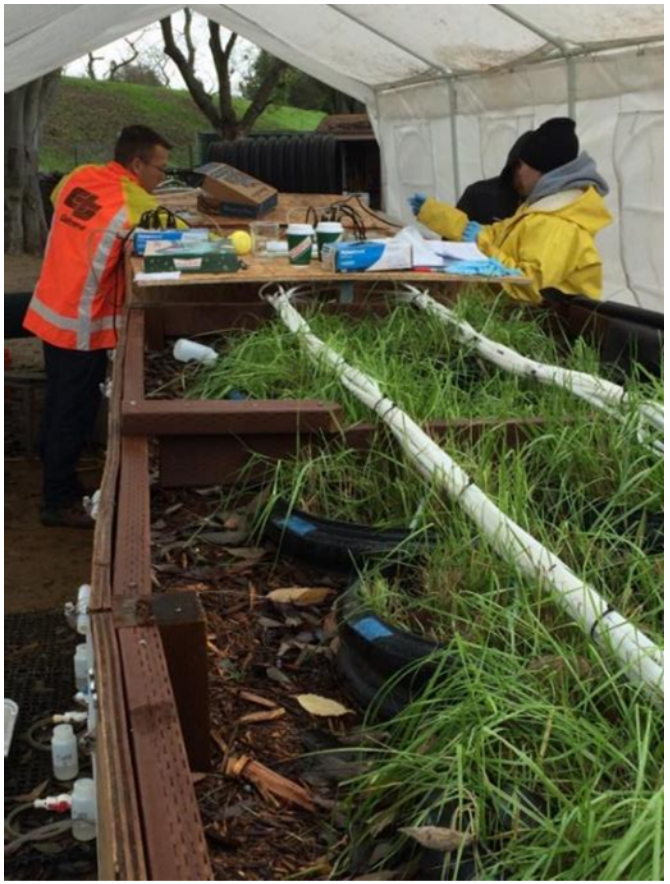
Are all the problems solved?

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

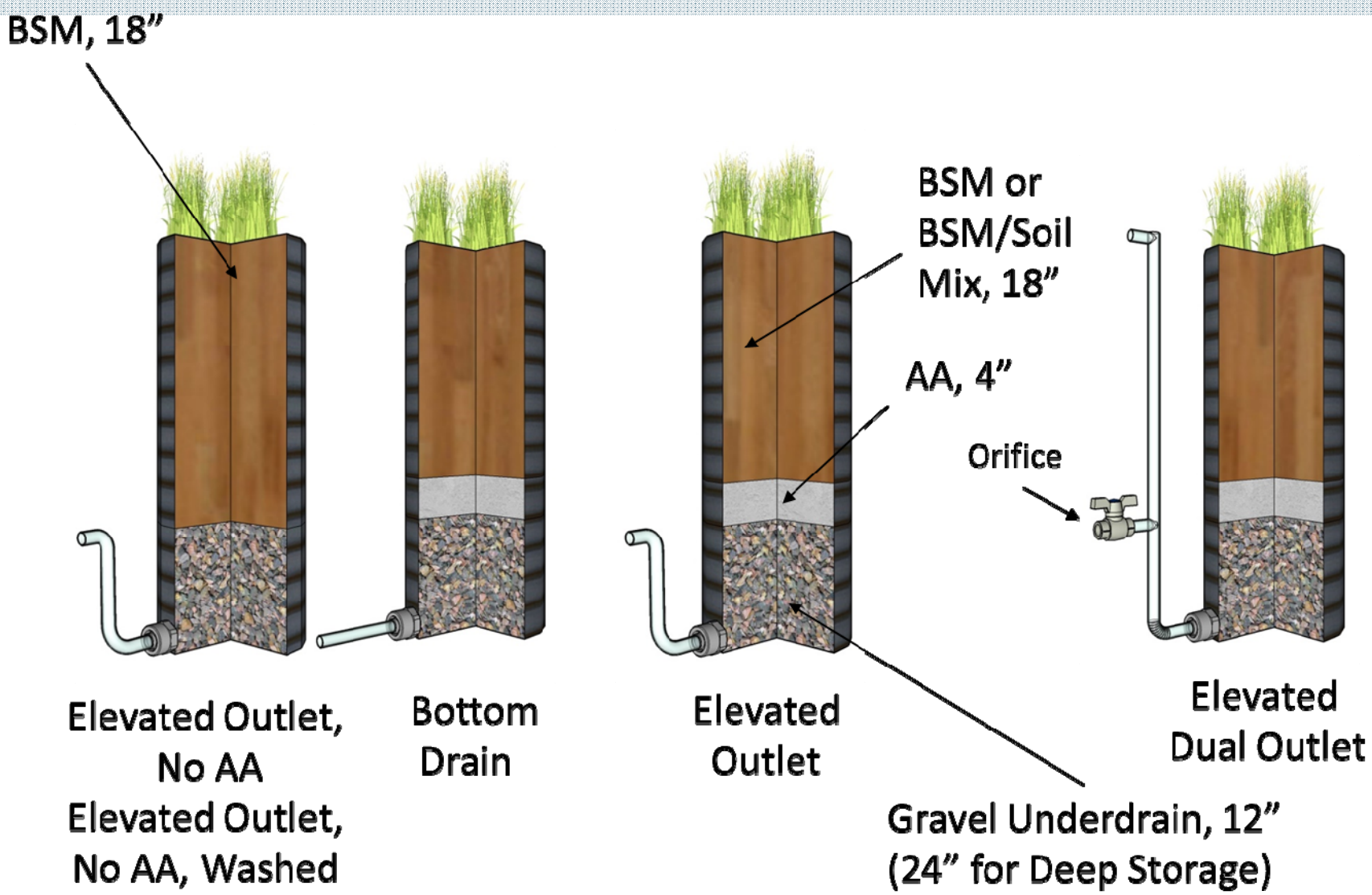
Engineered soils project (Sac State)

State Water Resources Control Board funding

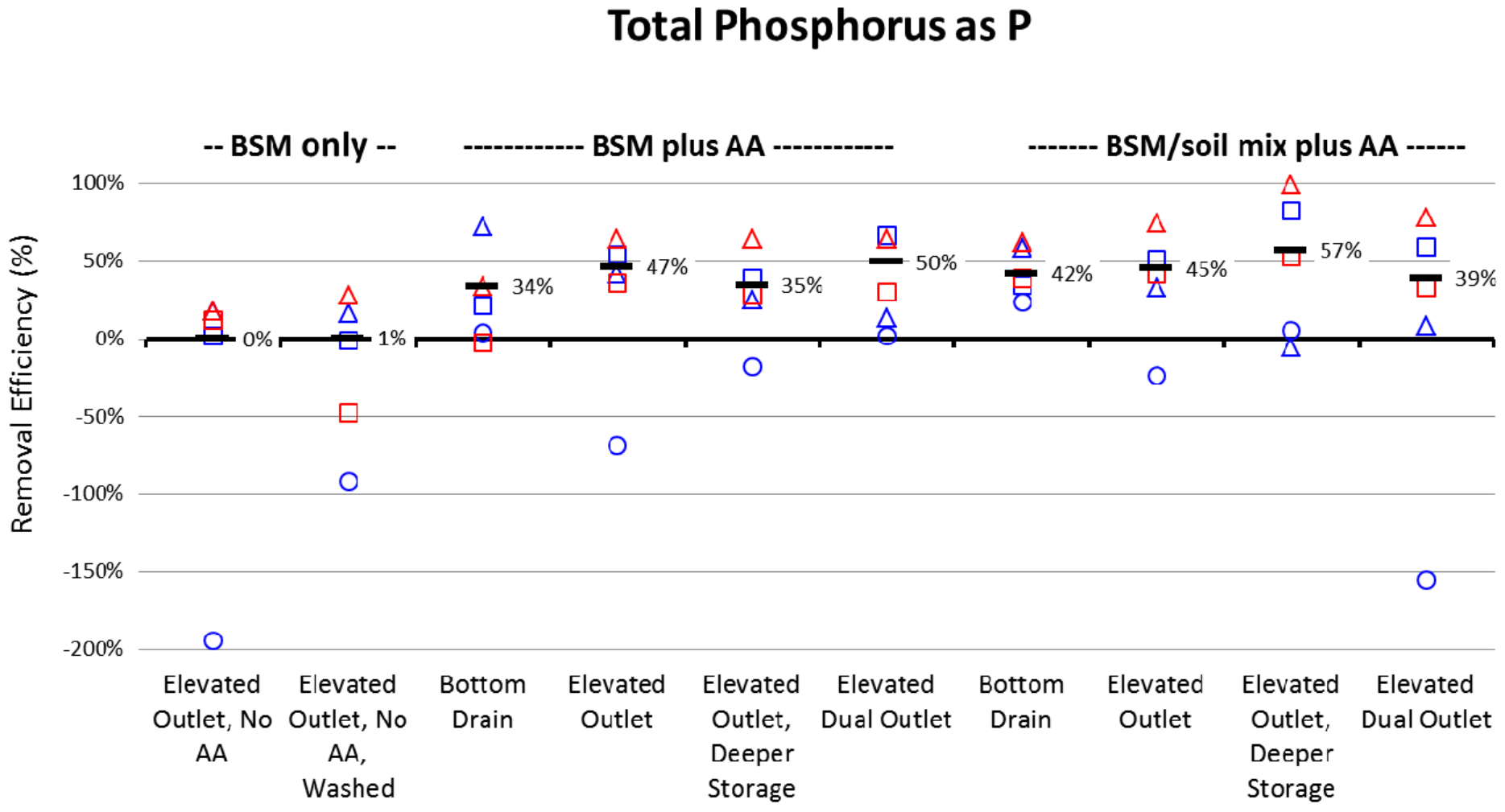
Engineered soils project



Engineered soils project



Configuration Comparisons (runs 2-6)



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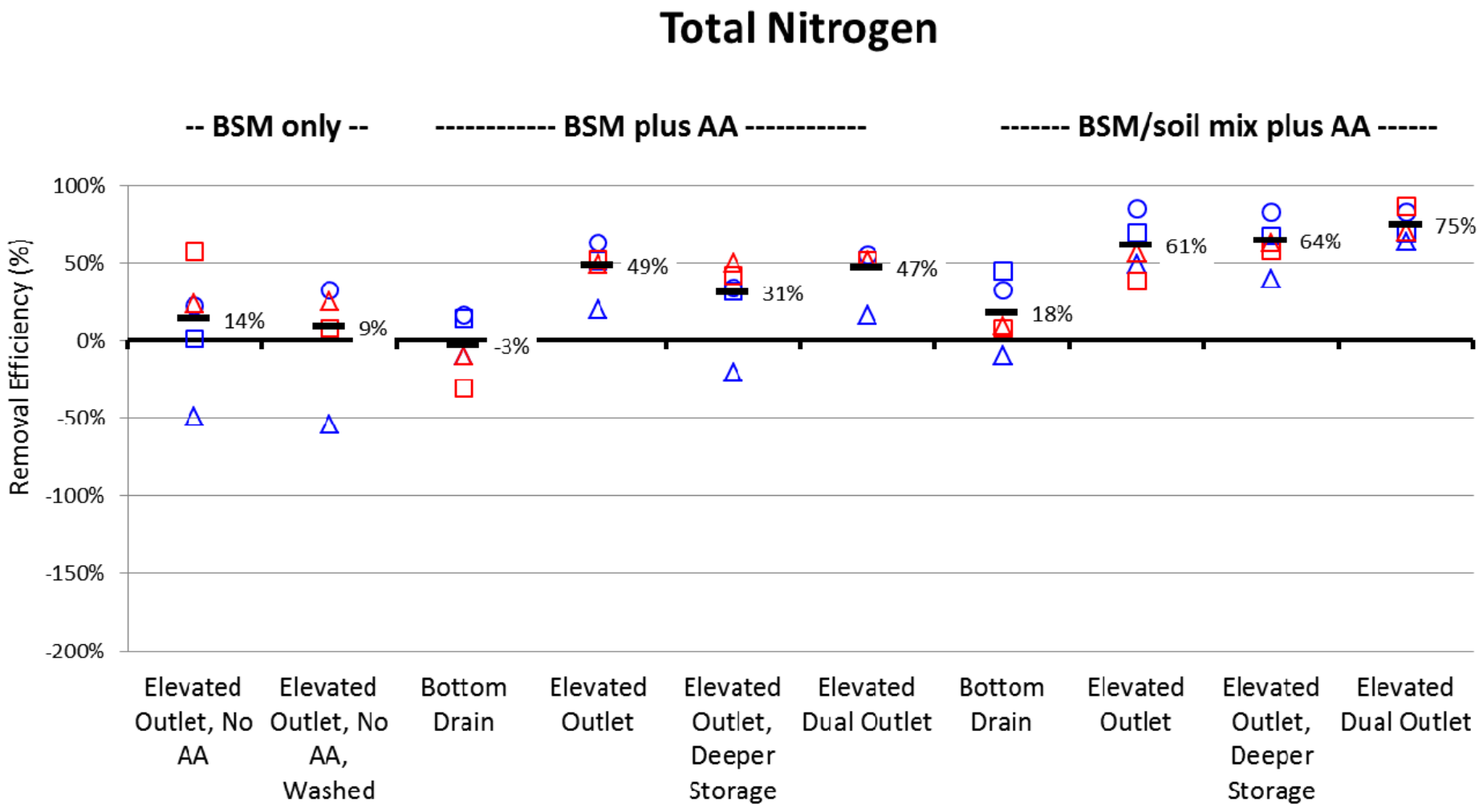
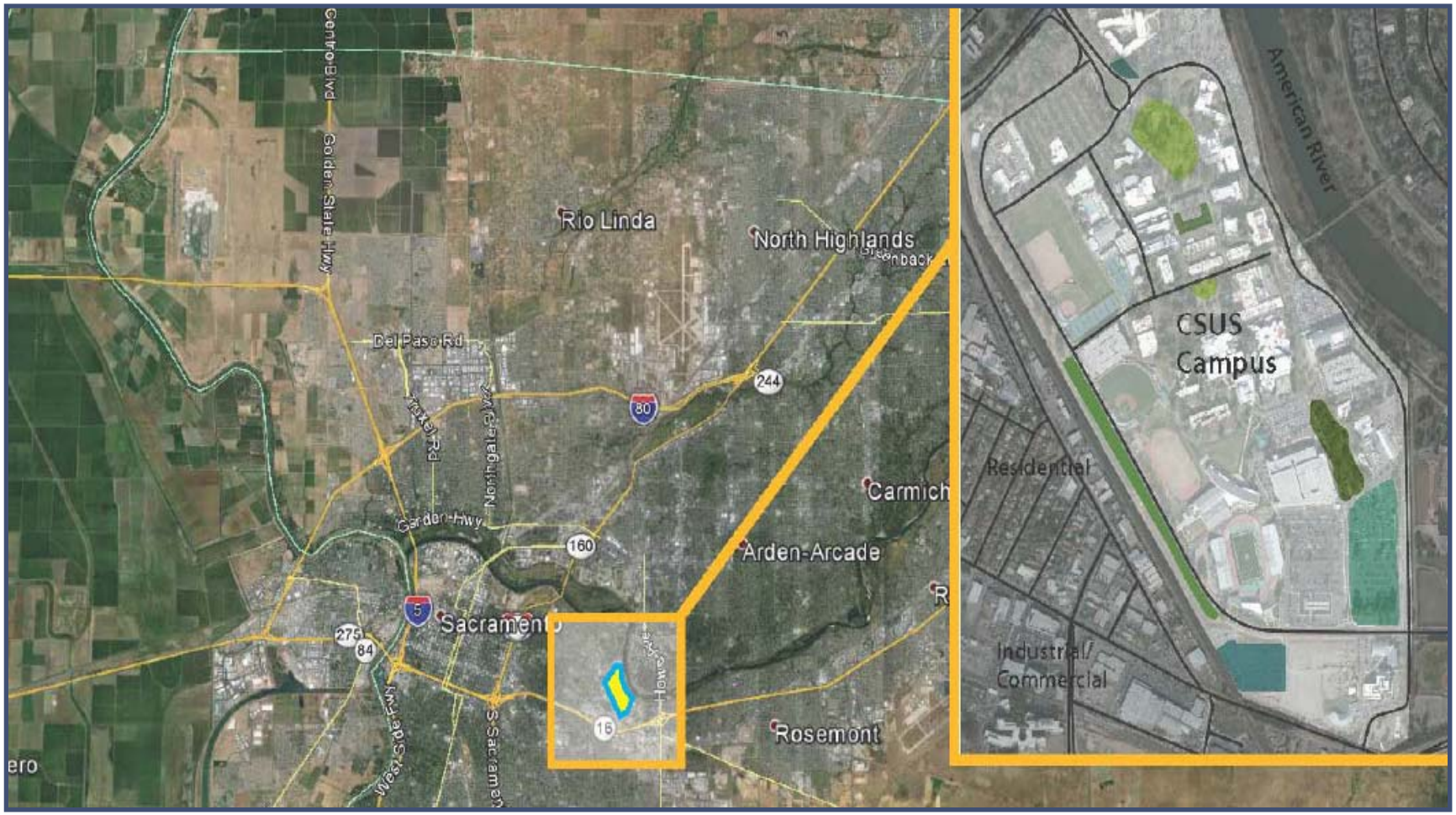


Are all the problems solved?

- ✓ 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

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

↕

Sacramento State Facilities Management

↓

Design and Construction Contractors

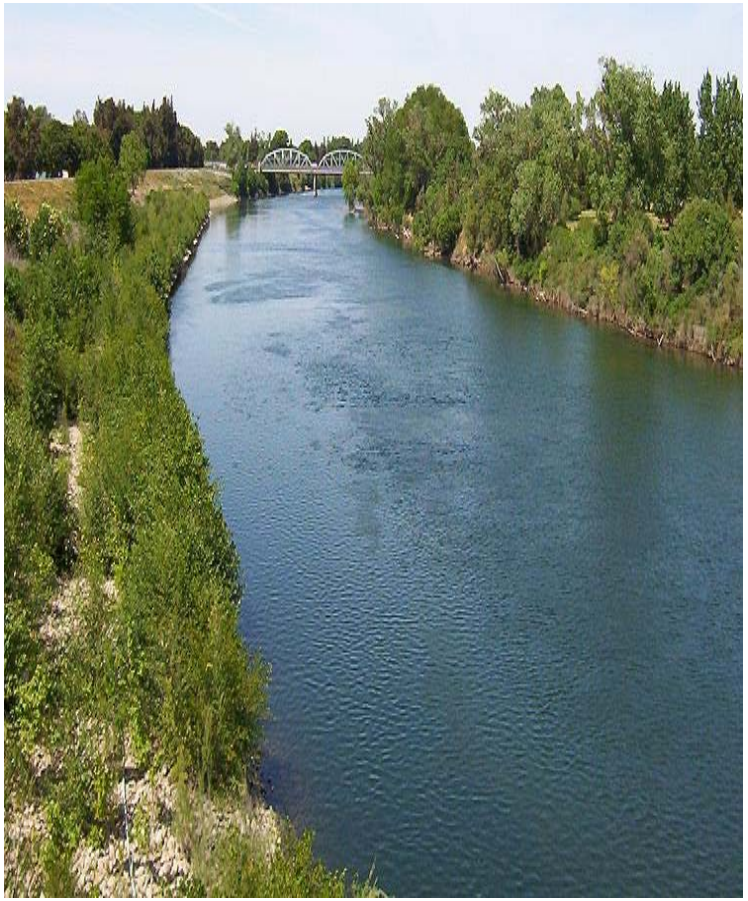
Project Funding

- ✓ 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

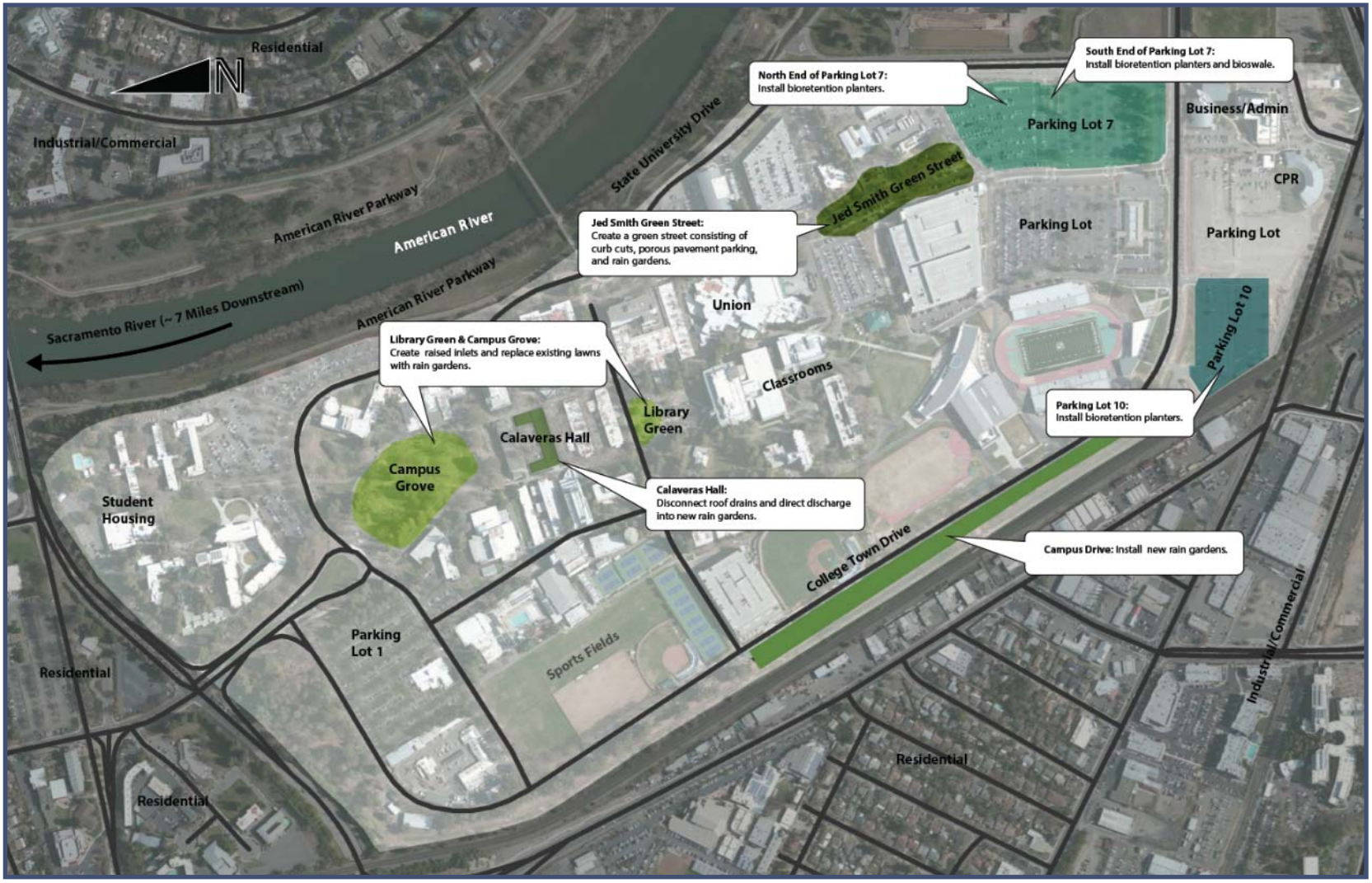


Site & BMP Selection: Bang-for-the-Buck

- ✓ **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

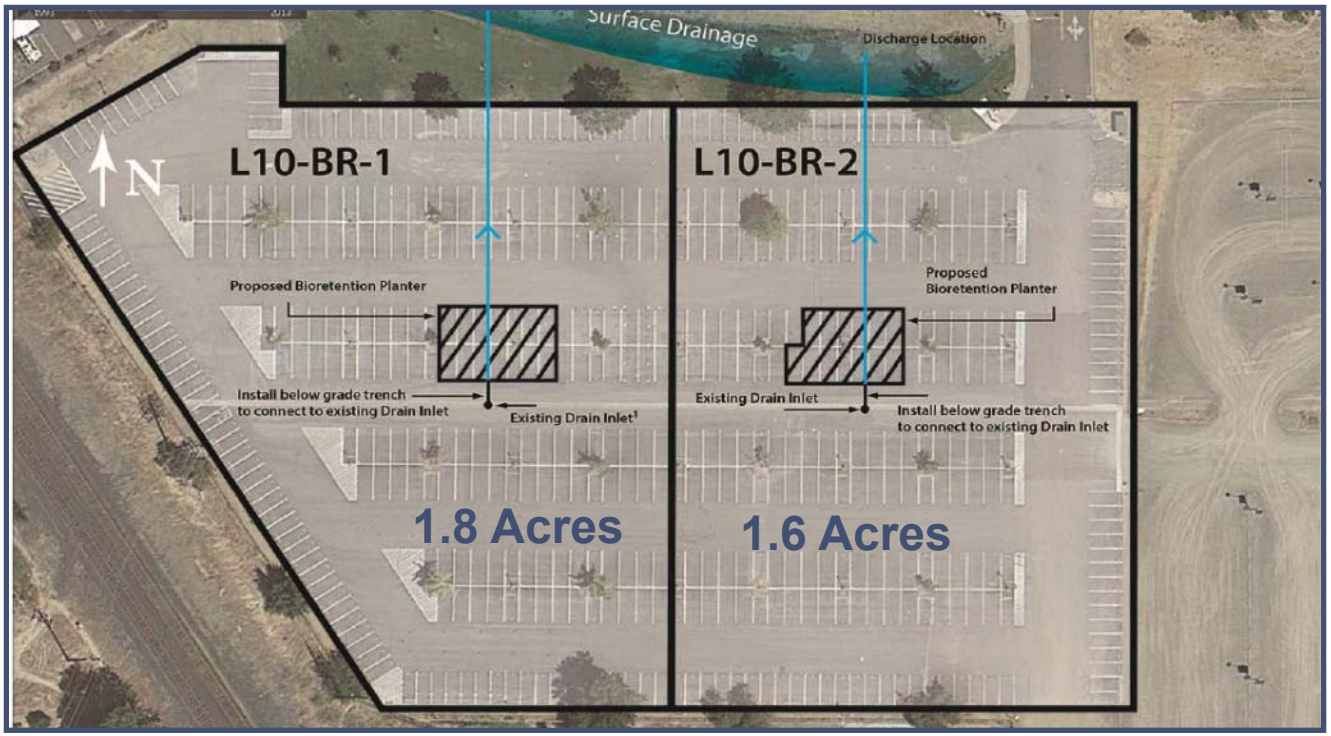
madremiraqueluna.blogspot.com

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

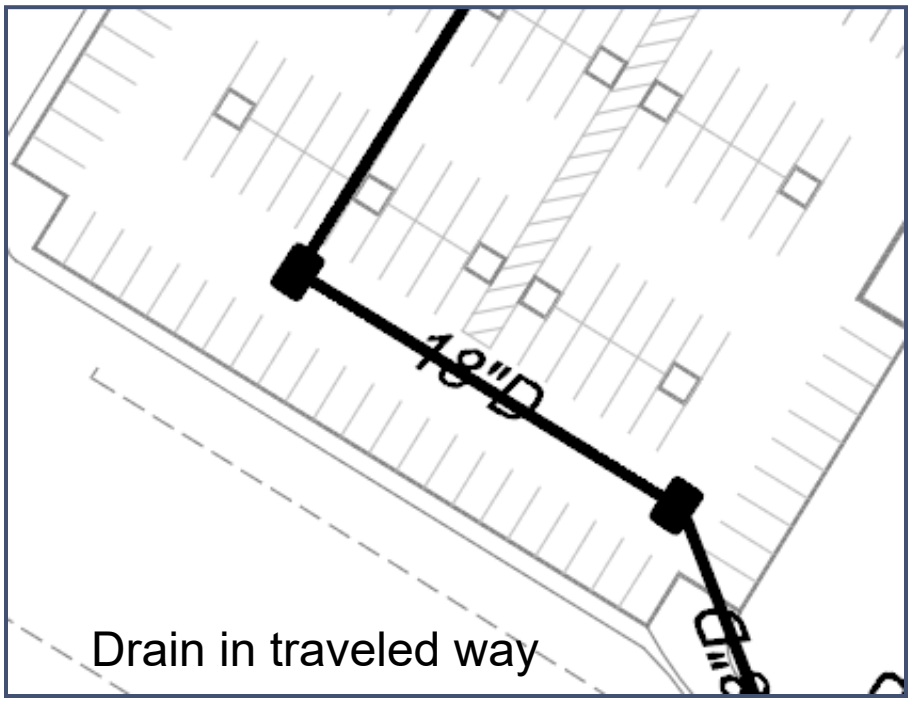
Site & BMP Selection – Existing Landscape

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

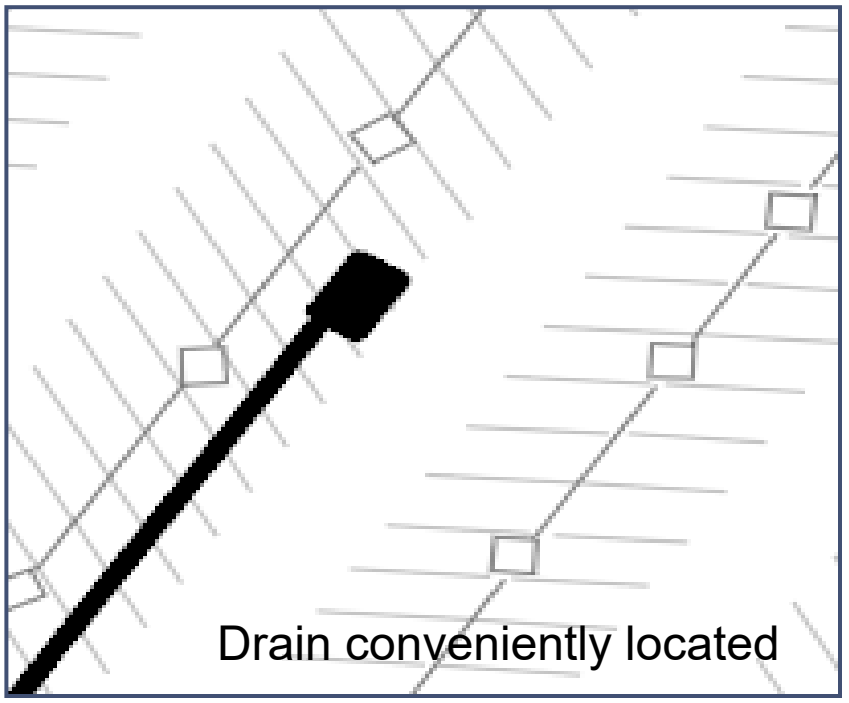
Design Challenges

✓ Fitting into the existing drainage system

- Horizontal



Drain in traveled way

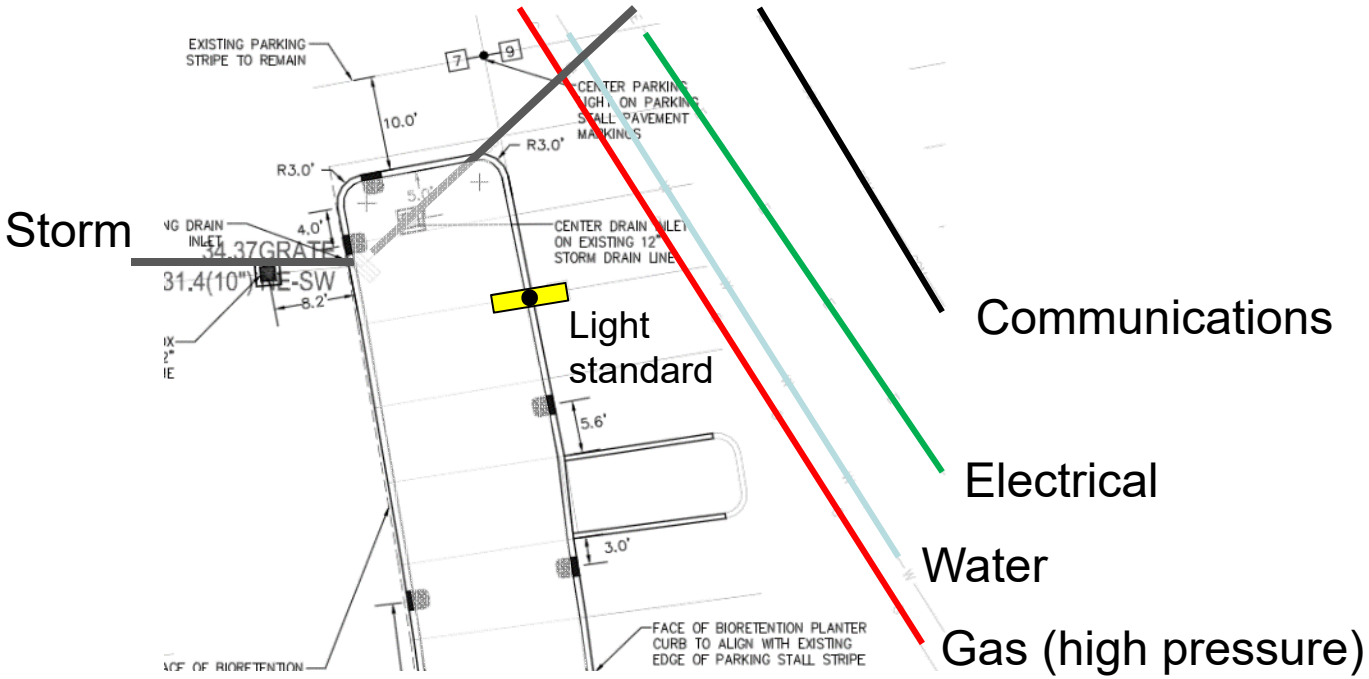


Drain conveniently located

Design Challenges

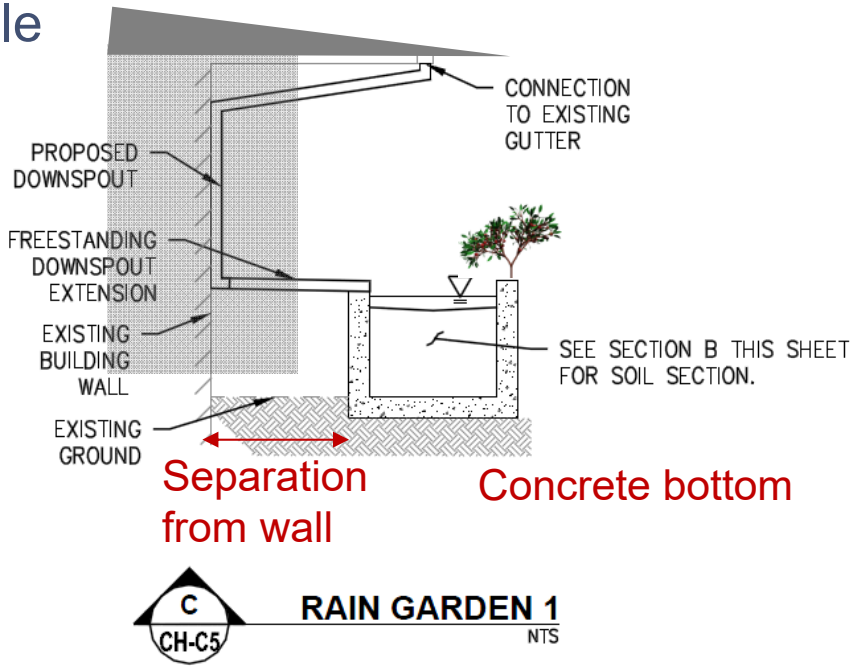
✓ Conflicts with other infrastructure

- 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

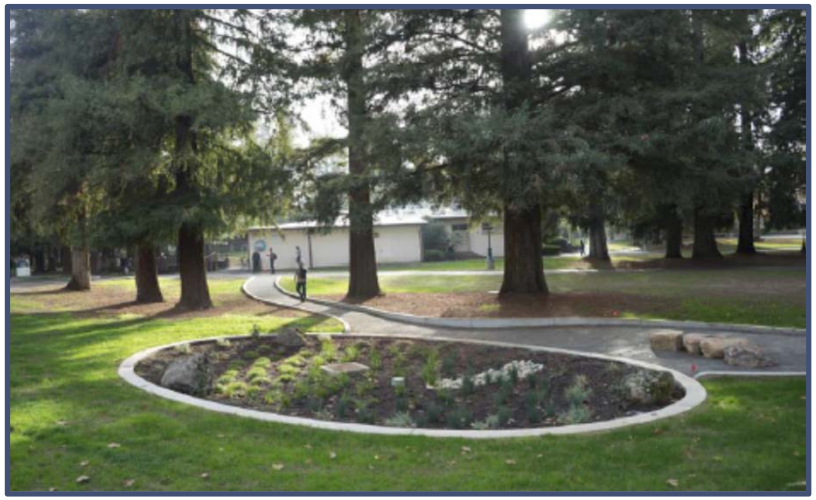
- ✓ Porous pavement and rain gardens

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


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Image by: Curtis Clark (Creative Commons Attribution-Share Alike 2.5 Generic)


Image by: OWP (Rich Parkhurst)

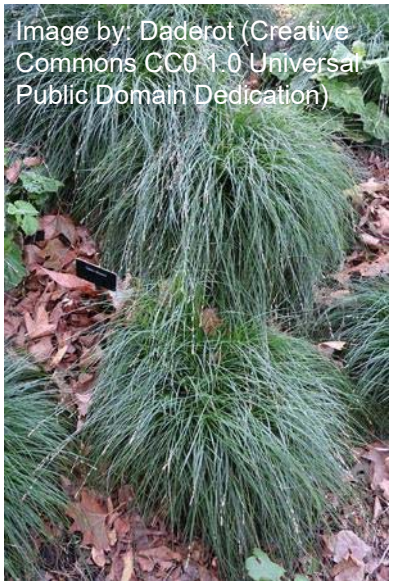
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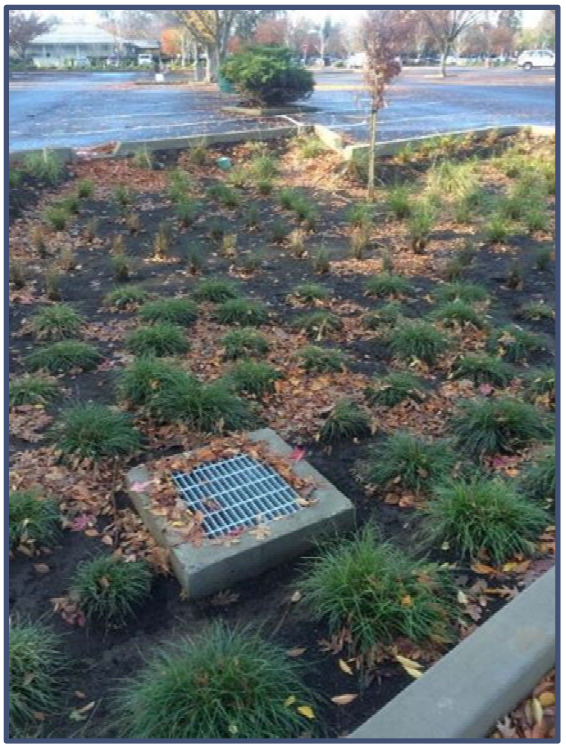
Image by: Evangele19 (Creative Commons Attribution-Share Alike 3.0 Unported)

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)



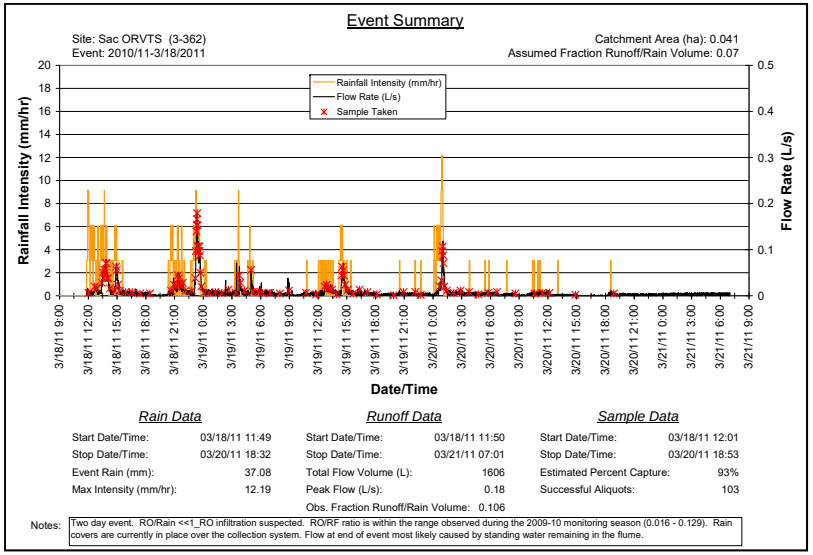
Existing Performance

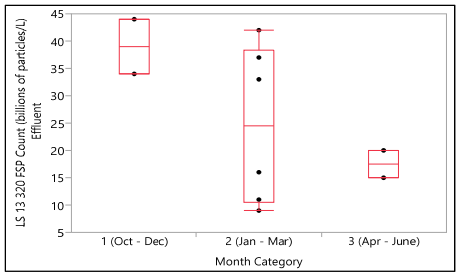
- ✓ Performing as designed
  - Runoff entering BMPs
  - Temporary ponding
  - Infiltrating within 48 hrs
  - Minimum overflow & discharge

PP video

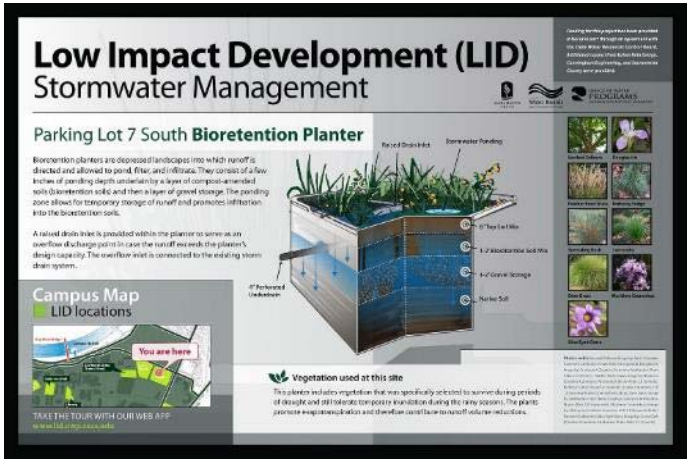
Monitoring & Reporting

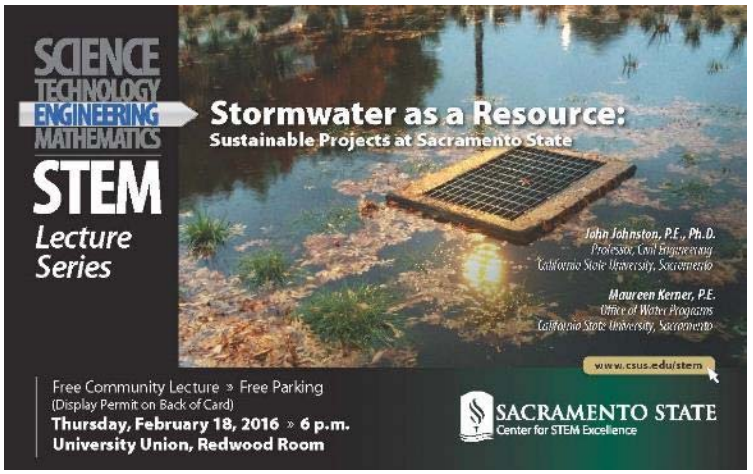
- ✓ Measure Flows
- ✓ Analyze Water Quality
  (sediment, pesticides, metals)
- ✓ Data Evaluation

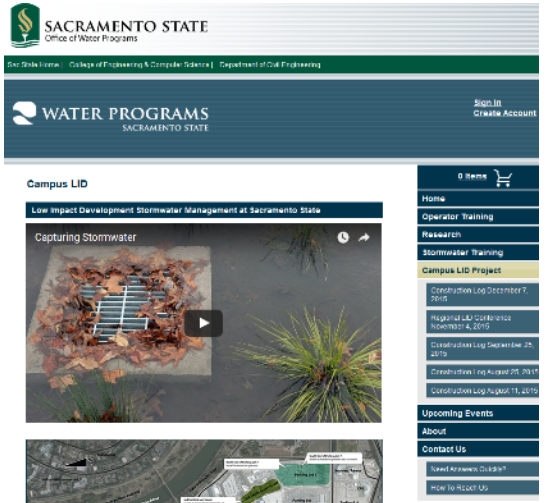




Education and Outreach





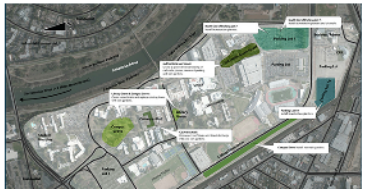



The State Hornet
A2 | News

Sustainability to boost water collecting efforts with drain

LID project plans to redirect rain from campus to river

By Alisha Garcin
@lishagarcin



More LID is Coming!!

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

LID & Sustainability

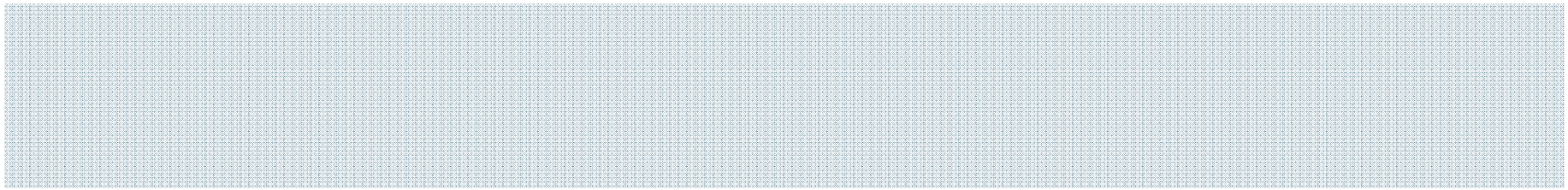
- ✓ Managing resources for tomorrow's generations
- ✓ Think globally. Act locally!
- ✓ LID is site scale approach
- ✓ Implement at home!

http://www.beriverfriendly.net/

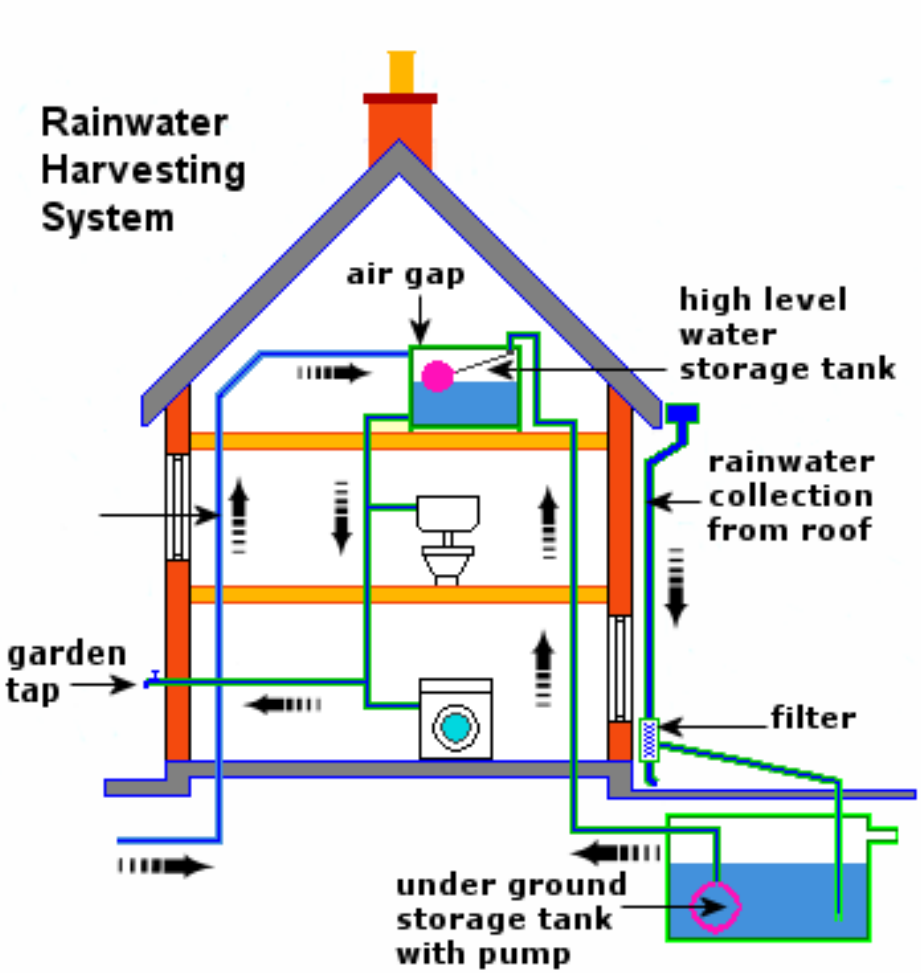
BLUE THUMB
Be Water Smart

Be WATER SMART
Regional Water Authority

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



Stormwater treatment and reuse



Stormwater treatment and reuse

PREPUBLICATION COPY

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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.