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AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

DISCUSSIONS ON LOW IMPACT DEVELOPMENT (LID) BIOSWALES AND BIORETENTION SOLUTIONS

SAN DIEGO ASLA STEWARDSHIP COMMITTEE WORKSHOP
March 14, 2014

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WORKSHOP AGENDA

2:00 pm – 3:15 pm

Introduction: Tim Smith, ASLA Stewardship Committee Chair, Wynn-Smith Landscape Architecture

Bioswale Basics and Regulations: Jim Kuhlken, Rick Engineering Company

What Makes A Good Bioswale Media: Garn Wallace, Wallace Labs

Storm Water Treatment: Craig Kolodge, Filtrexx

Plant Material for Bioretention: Mike Klaerich, Green Meadow Growers

Bioretention Maintenance: Chris Cutler, Steve Smith Landscape

3:15 pm – 3:30 pm Break

3:30 pm – 4:15 pm

Bioswales and Bioretention Case Studies & Discussion

4:15 pm – 5:00 pm Question & Answers

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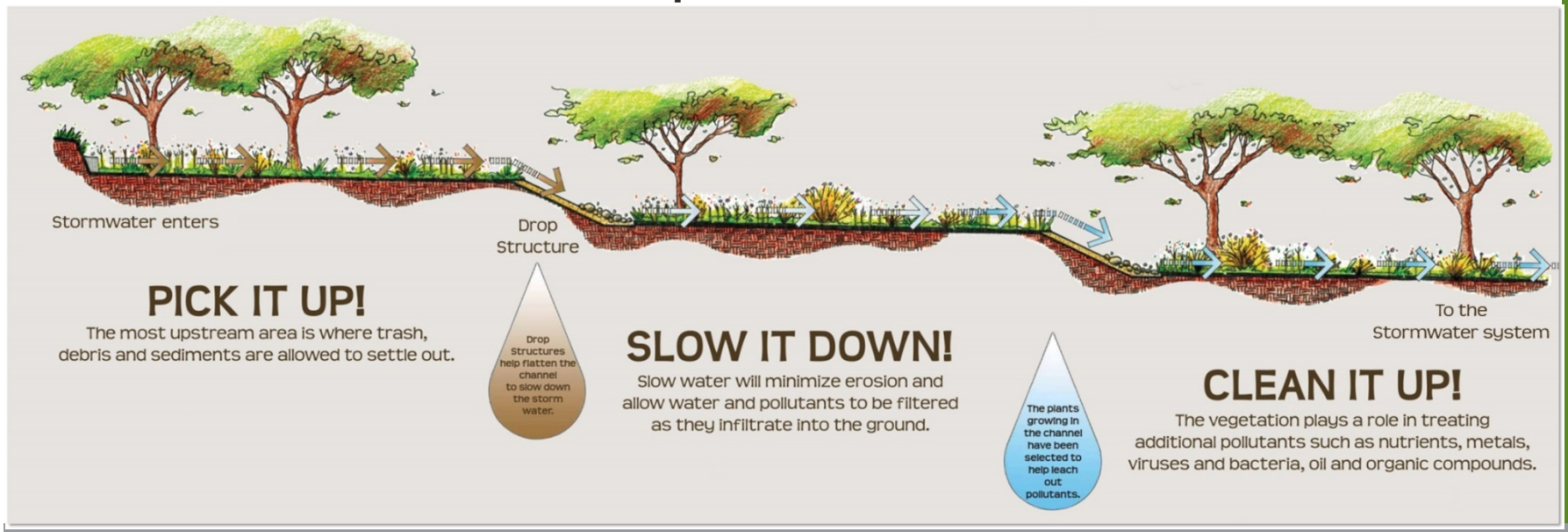
Jim Kuhlken

Principal of the Landscape Architecture Division

RICK ENGINEERING COMPANY

(RICK) is a full-service, multi-disciplinary planning, design, and engineering firm with more than 59 years of local San Diego experience.



BIOSWALE BASICS & REGULATIONS

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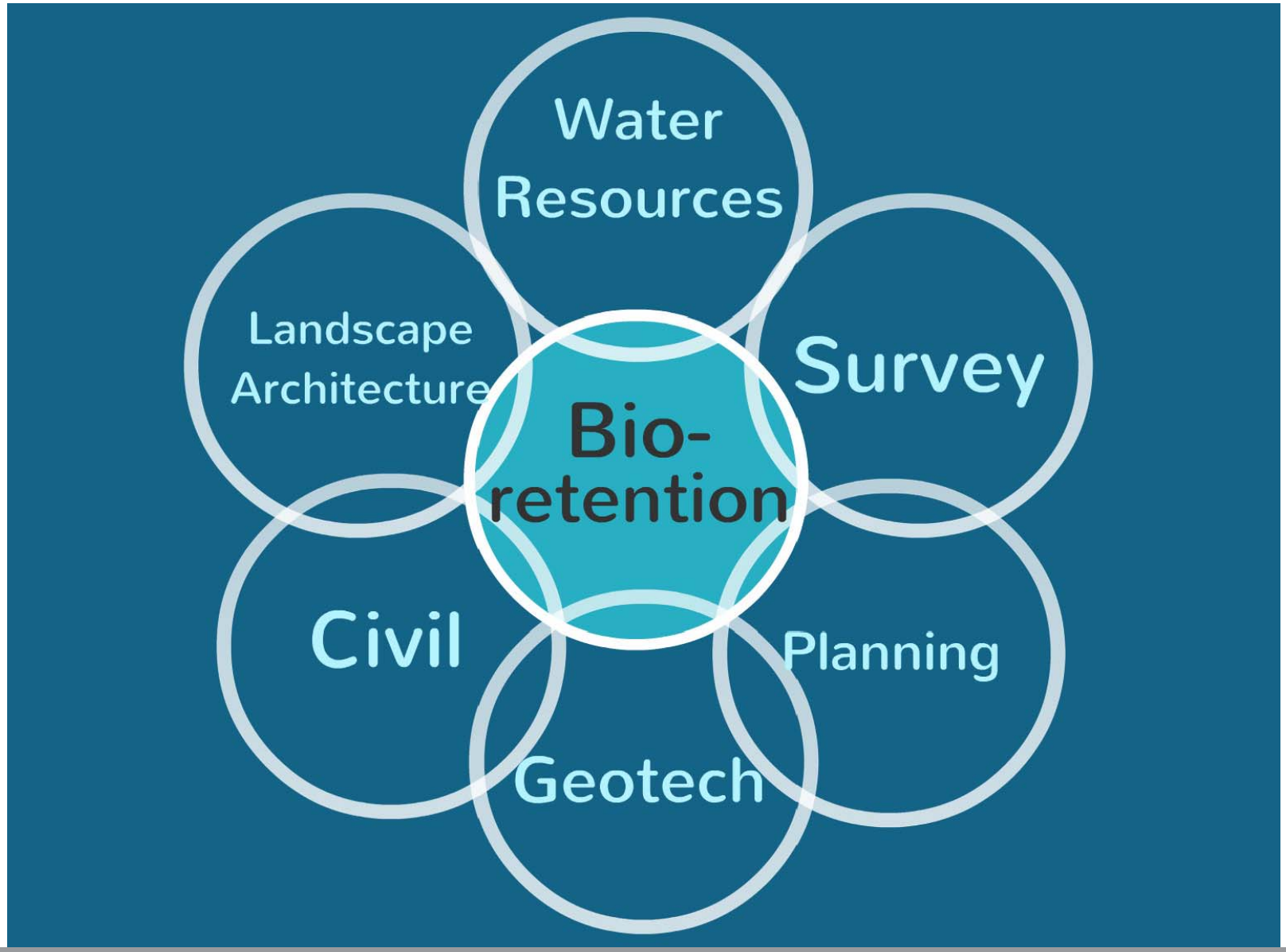
BIOSWALE BASICS & REGULATIONS



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DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

Where have we been?

Changes to Storm Water Treatment Standards (2007)

- Projects over 1 acre and 5,000 s.f. of hardscape removal and replacement
- Infiltration or bioretention preferred
- Filtration and/or extended detention also accepted
- Can treat and release runoff

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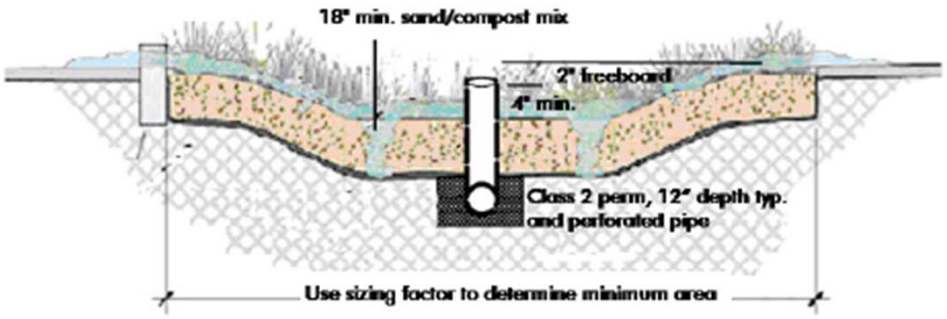
Typical Bioretention Systems



Countywide Model SUSMP "Bioretention" Facility
(treatment-only)

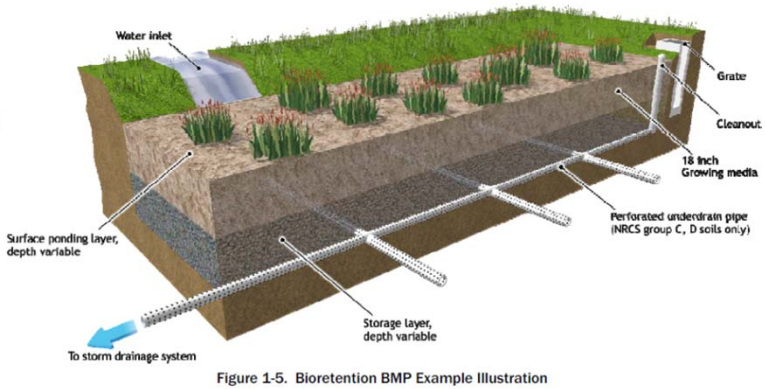


Figure 1-5. Bioretention BMP Example Illustration

San Diego BMP Sizing Calculator Methodology
"Bioretention" Facility
(treatment plus flow control)

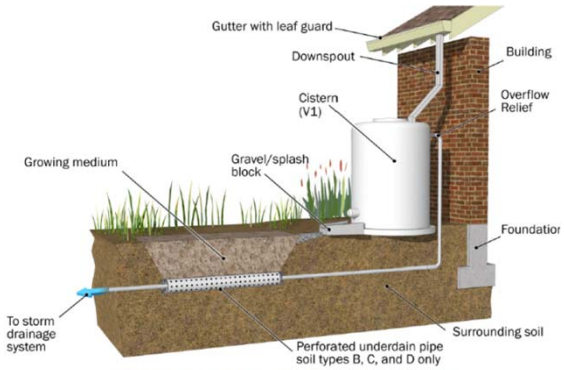


Figure 1-6. Cistern with Bioretention BMP Example Illustration

"Cistern with Bioretention" or "Bioretention Plus Cistern"
(treatment-only or treatment plus flow control)

What have we done?

CONSTRUCTED:

- SWMP for Poinsettia Properties (The Tides), dated April 5, 2011 - WQ
- SWMP for San Pasqual Academy - WQ
- WQTR for California Proton Therapy Center – WQ
- WQTR for National City Streetscape – WQ
- SWMP for Palomar Airport Auto Parking Lots – WQ (pre-bioretention)
- WQTR for Illumina – WQ and HMP (for one building)
- SWMP for Camp Pendleton Dining Facilities - WQ
- SWMP for Brighton Place Housing – LID (pre-treatment)
- Valencia Library - Santa Clarita, CA
- Newhall Parking Lot Expansion : Bioretention and Permeable Pavement
- Westfield West Covina Mall Expansion: Permeable Pavement
- Habitat for Humanity – Central Coast, CA
- Century City Parking Garage - Los Angeles, CA

UNDER CONSTRUCTION:

- WQTR and HMP for Casa Aldea II, dated January 24, 2013 (Most solutions are LID) – WQ and HMP
- WQTR for Torrey Reserve Phase III (Some solutions are LID) – WQ and DET
- Westfield Century City Parking Garage Biofiltration System: WQ
- City of Santa Clarita Valencia Library: Bioretention

FINAL COMPLETE DESIGN
(Not Yet Constructed):

- WQTR and HMP for Santaluz Memory Care Facility, dated April 26, 2013 – WQ and HMP
- USMP for H Street – WQ
- WQTR for Millenia Streetscape – WQ + some HMP

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Miramar Water Treatment Plant

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March 14, 2014

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Scripps Proton Therapy Center

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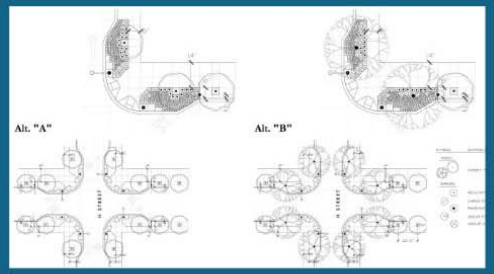
Millenia



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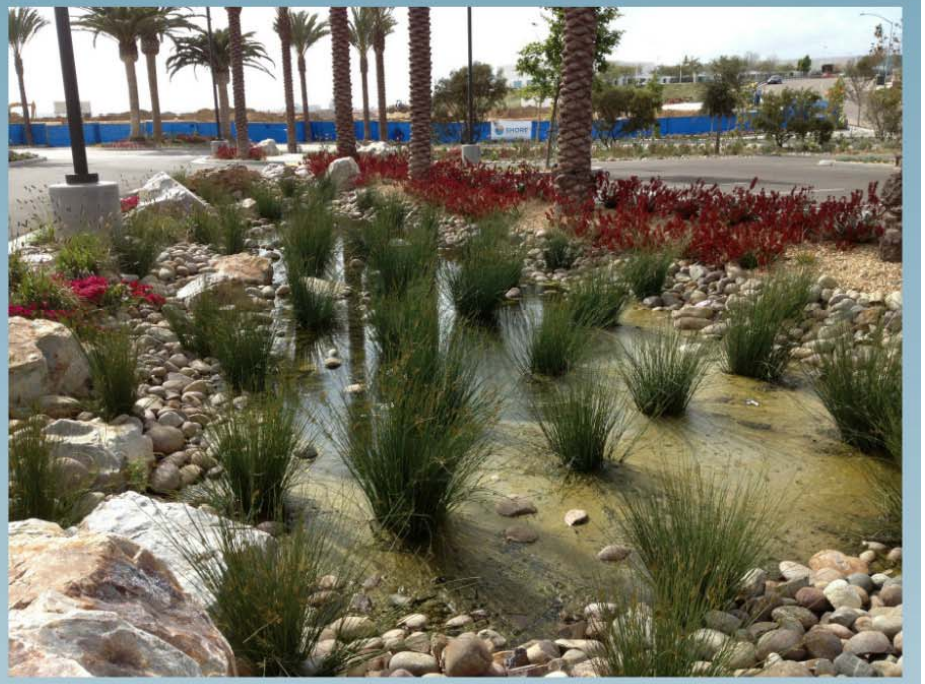
What have we learned?

SOIL MIX

- ~~70% Sand~~
- ~~30% Compost/ Sandy Loam~~

SOIL PLACEMENT

- long term, in place infiltration rate of at least 5 inch per hour
- ~~Compact 85% - 90%~~



"Task Force" of Professionals

RICK Engineering Company

Brendan Hastie, Water Resource Engineer
Laura Henry, Water Resource Engineer
John Goddard, Civil Engineer/QC Chairperson
Tim Gabrielson, Civil Engineer
Tim Pruss, Landscape Architect
Jim Kuhlken, Landscape Architect

Outside Consultants

Trevor Myers, Geotechnical Engineer, GEOCON
Mary Matava, Agronomist, AGRI Services
Garn Wallace, Wallace Laboratories

Regional Task Force

Jeremy Fantaroni, County of San Diego
Stuart Kuhn, County of San Diego
James Nabong, City of San Diego
Yvana Hrovat, Tetra Tech
Jason Wright, Tetra Tech
Laura Lord, Tetra Tech
Brad Wardynski, Tetra Tech
Mary Matava, AGRI Services
Glenn Schmidt, Schmidt Design Group
Jeff Justus, Schmidt Design Group
Tim Pruss, RICK Engineering
Jim Kuhlken, RICK Engineering
Brendan Hastie, RICK Engineering

Where are we going?

Changes to Storm Water Treatment Standards (2013)

- Projects with 10,000 s.f. of non-porous surfaces or more, driveways over 5,000 s.f., but all projects require LID treatment
- Implement LID BMP designed to retain onsite 85th percentile runoff (infiltrate, evaporate, evapotranspire, harvest and use)
- If not feasible to retain runoff on-site, use biofiltration sized with new sizing criteria given in R9-2013-0001
- If not feasible to RETAIN or use biofiltration, use flow-through treatment control BMPs AND mitigate (off-site) for the design capture volume that was not retained on-site

Capture & Reuse

Feasibility vs. Infeasibility

- Irrigation Demand- Parks
- Toilet Flushing - Commercial/Industrial

Infeasibility Analysis

- Required capture Volume vs. Demand
- Letter Report for Landscape Architect demonstrating infeasibility

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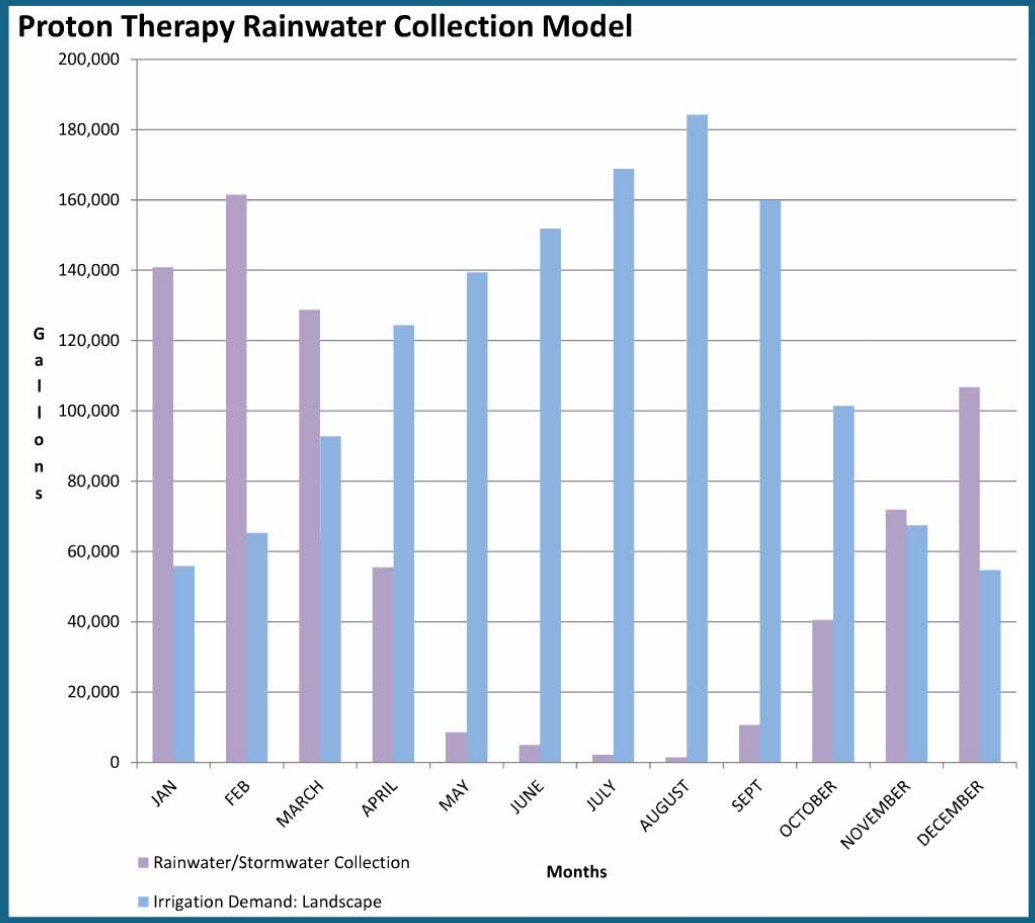

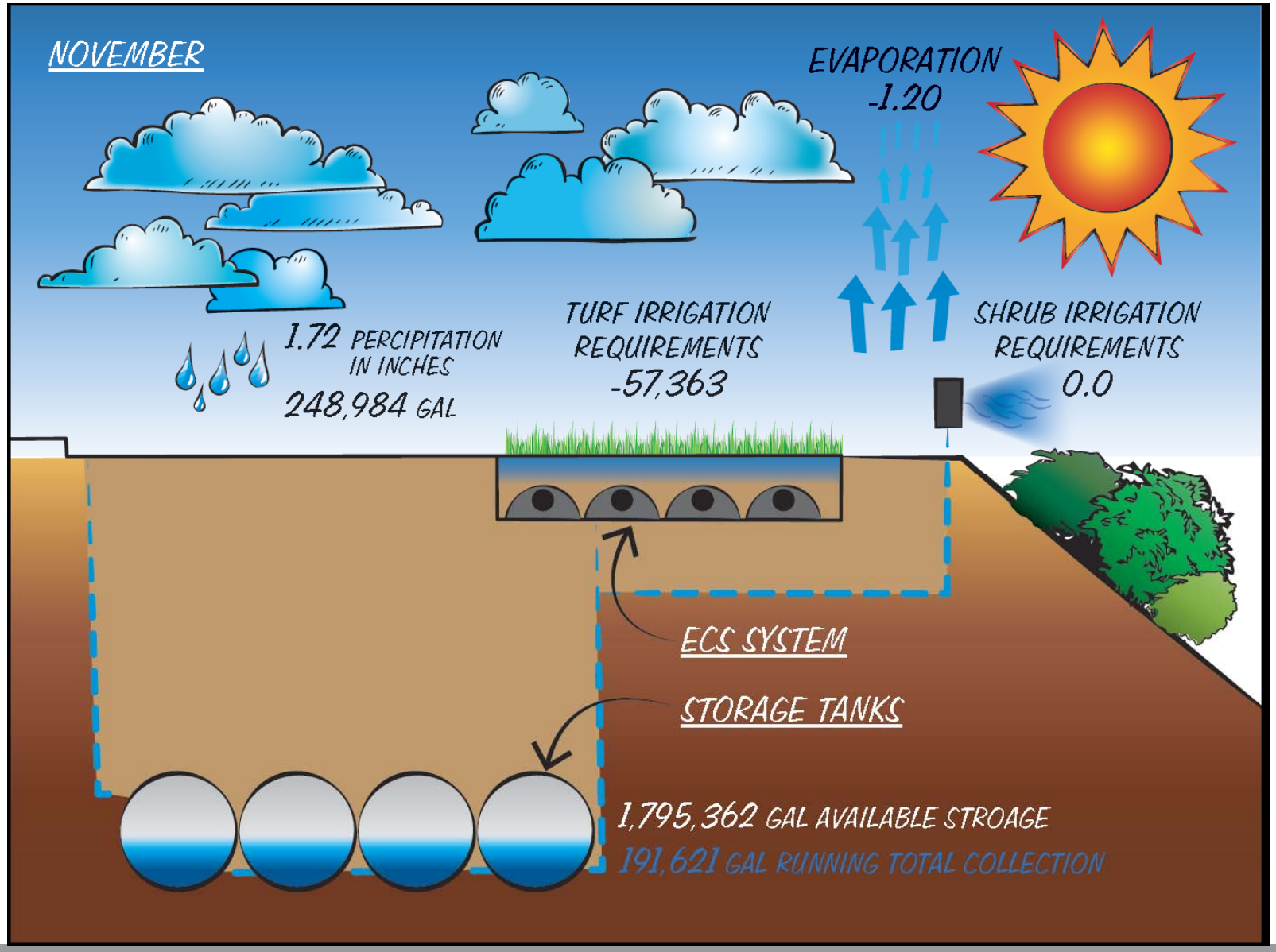
NOVEMBER
EVAPORATION
-1.20
1.72 PERCIPITATION
IN INCHES
248,984 GAL
TURF IRRIGATION
REQUIREMENTS
-57,363
SHRUB IRRIGATION
REQUIREMENTS
0.0
ECS SYSTEM
STORAGE TANKS
1,795,362 GAL AVAILABLE STROAGE
191,621 GAL RUNNING TOTAL COLLECTION

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BIOSWALE MEDIA

Assessment of Existing Roadside Swales with Engineered Filter Soil: I. Characterization and Lifetime Expectancy

Garn Wallace, President
Wallace Labs

- Simon T. Ingvertsen, Karin Cederkvist, Yoann Régent, Harald Sommer, Jakob Magid, and Marina B. Jensen
- University of Copenhagen

J. Environ. Qual. 41, 1960-1969, 2012

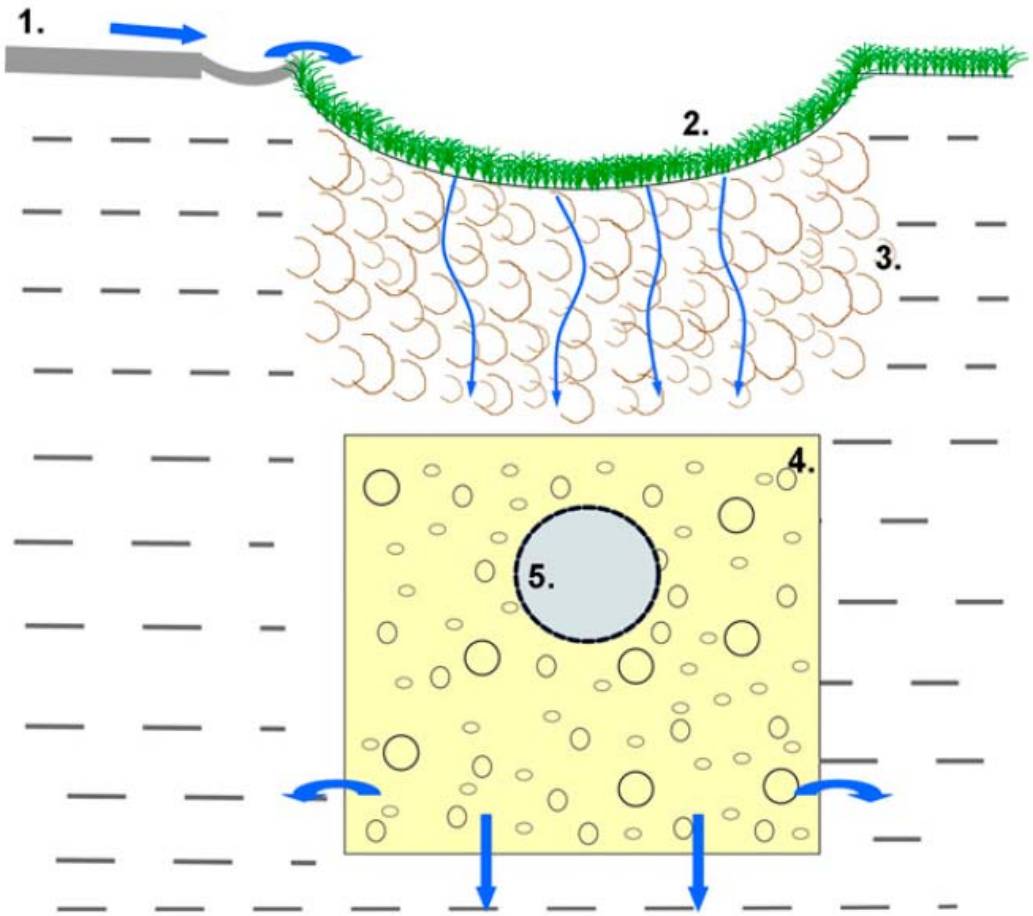
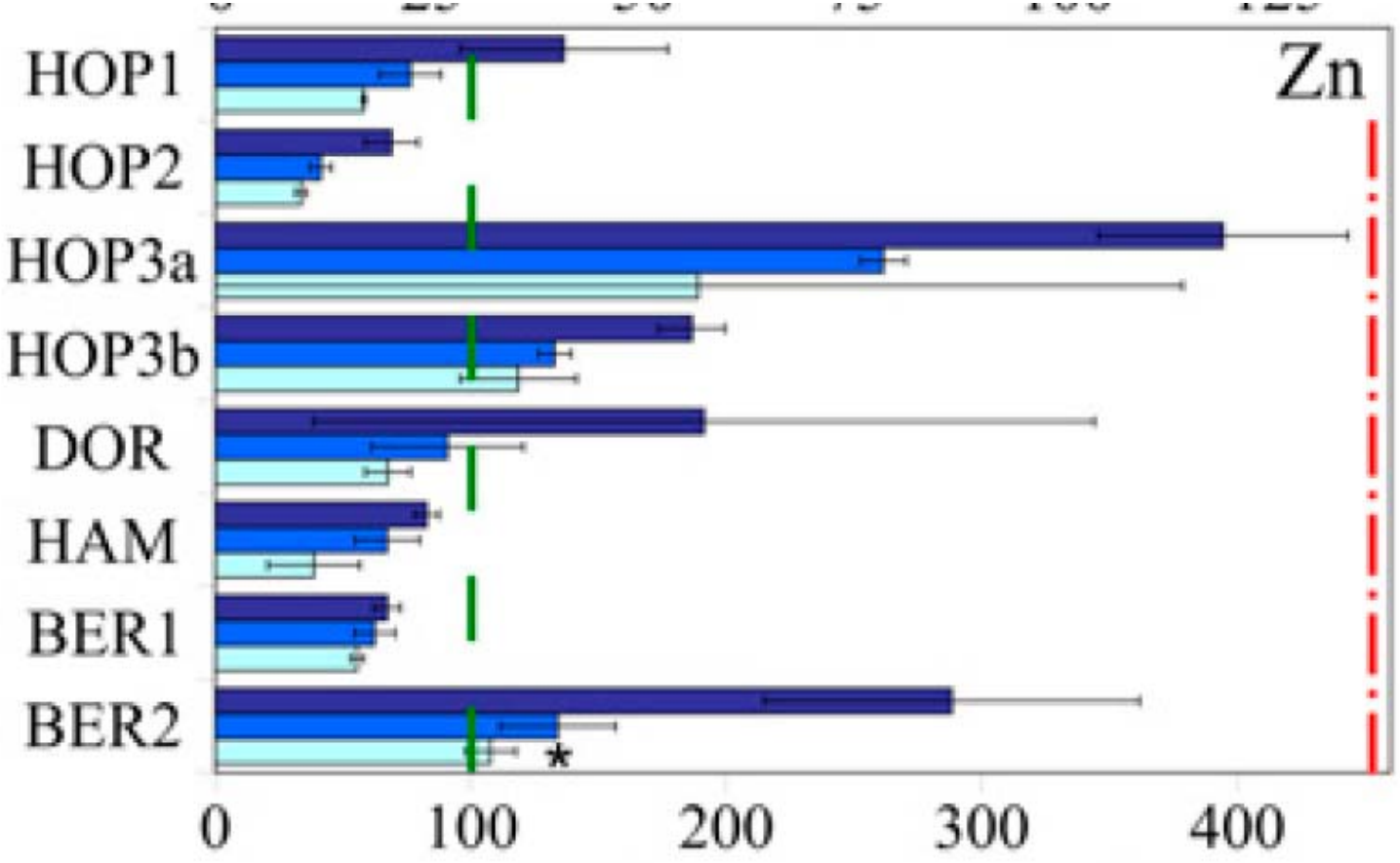


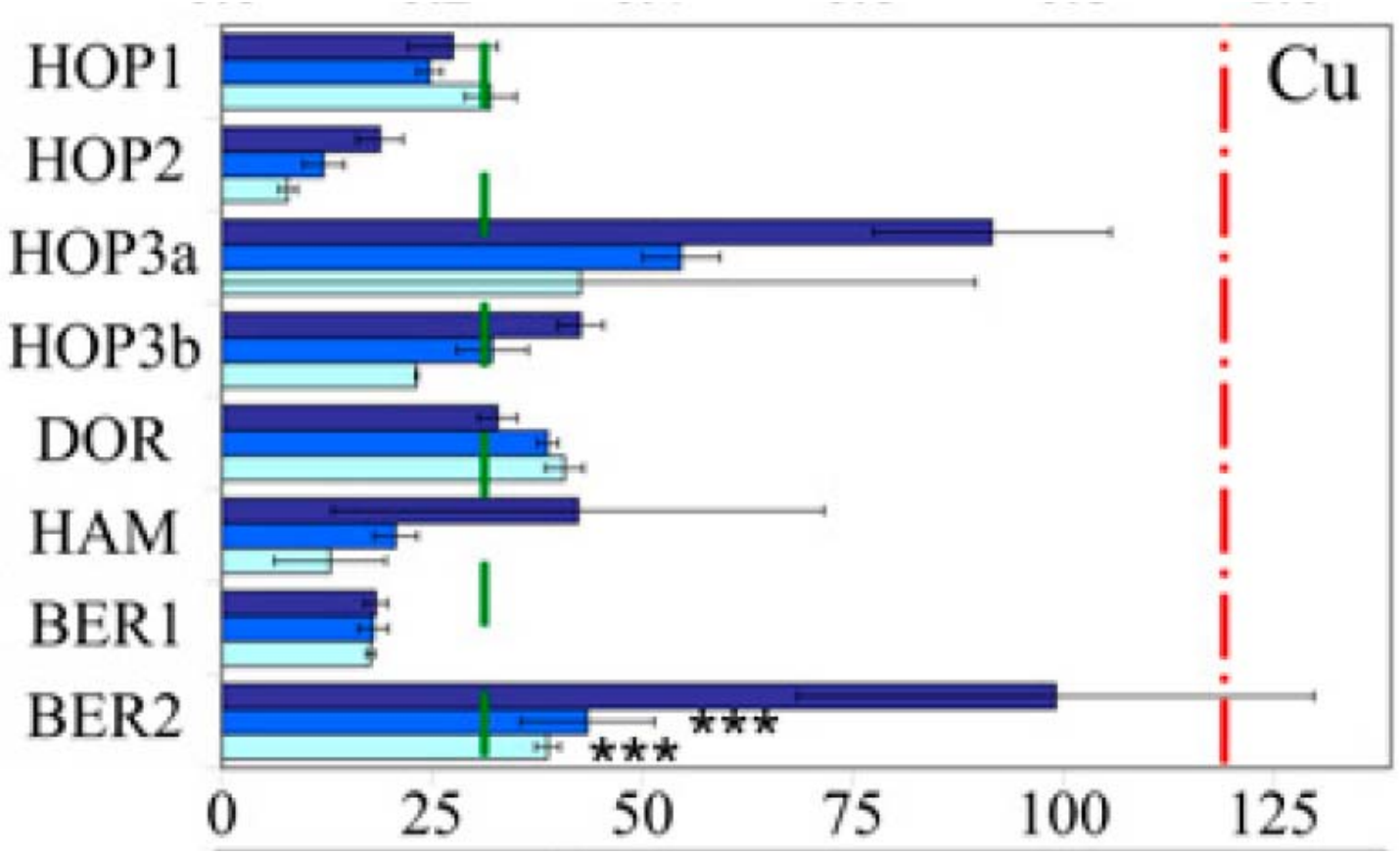
Fig. 1. Schematic diagram of a typical German swale-trench infiltration system. (1) road surface, (2) grassed swale, (3) engineered soil mixture (~30 cm), (4) gravel filled trench, and (5) drainpipe.

Table 1. German guidelines for the design and construction of infiltration swales and basins (DWA, 2005).

Parameter	Criteria
Depth	10–30 cm, depending on the anticipated need for treatment and the treatment capacity of the soil
pH	6–8; if adjusted, this should be done with slowly soluble lime
Infiltration rate	Not lower than 10^{-5} and not higher than 10^{-3} m/s on construction
Clay + silt	Not more than 10% of the total soil mass
Organic matter	1–3% of the total soil mass

10^{-5} m/s is 1.42 inches per hour


Zn
HOP1
HOP2
HOP3a
HOP3b
DOR
HAM
BER1
BER2
*
0
100
200
300
400


HOP1
HOP2
HOP3a
HOP3b
DOR
HAM
BER1
BER2
Cu
***
***
0
25
50
75
100
125

- For roofs consisting of zinc or copper material, very high metal concentrations can be expected in the runoff water; hence, the topsoil is recommended to be replaced every 2 to 4 yr.

Assessment of Existing Roadside Swales with Engineered Filter Soil: I. Characterization and Lifetime Expectancy

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Hope Street
Dec. 2008

BIOSWALE MEDIA

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March 14, 2014

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Hope Street
Feb. 2010

BIOSWALE MEDIA

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March 14, 2014

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Hope Street
June 2011

BIOSWALE MEDIA

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Trace Metal Contamination Influenced by Land Use, Soil Age, and Organic Matter in Montreal Tree Pit Soil

J. Environ. Qual. 42:1527–1533 (2013)

- Short life span of many street trees in the Montreal downtown area may be due in part to higher than standard concentrations of trace metals in the tree pit soils.

- Significantly higher concentrations of Cu, Cd, Zn, and Pb were observed in soils from commercial streets, possibly as a result of heavier traffic as compared with residential streets.

SANDS

- The best sand size for horticultural purposes is clean, narrowly graded, sized sand with particles about 0.5 - 0.8 millimeter in diameter (20 to 30 mesh). Coarser sand has insufficient water holding capacity and finer sand has insufficient air porosity when moist. Cement sand and plaster sand are designed to cement. They contain widely graded sands in order to more fully fill the voids with sand.

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March 14, 2014

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CHAPTER

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DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

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LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE MEDIA

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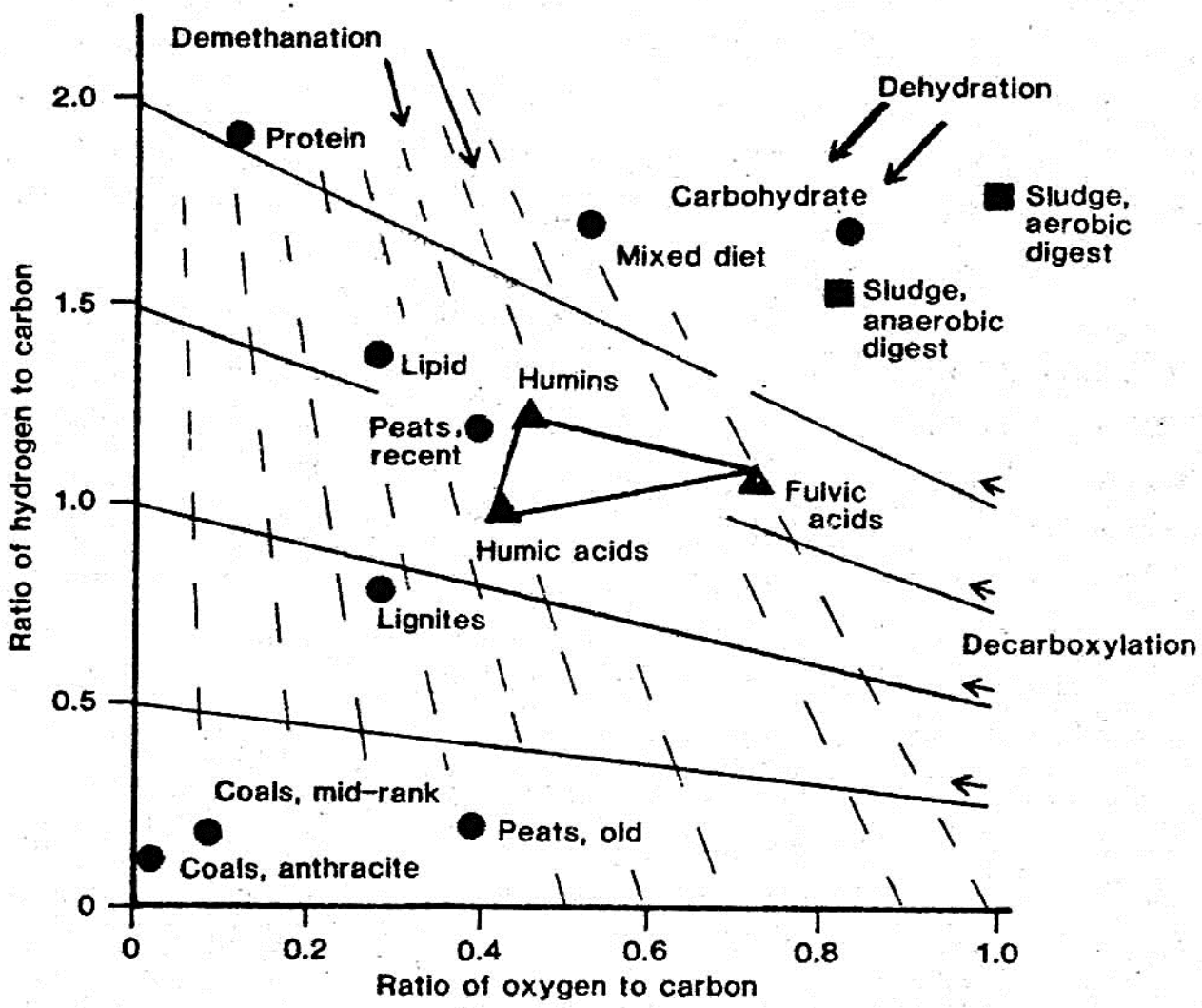
BIOSWALE MEDIA



Cation Exchange Capacity to bind soluble metals

- Clays
- Peats
- Organic matter
- Zeolites

Cation Exchange

- Calcium
- Magnesium
- Potassium
- Sodium
- Hydrogen

Available but not soluble – decreases salinity but does not limit availability

Zinc

	Parts per million
• EPA 503 limit	2,800
• UK limit	400
• Canada limit	315
• German limit	300

Copper

	Parts per million
• EPA 503 limit	1,500
• UK limit	200
• Canada limit	100
• German limit	70

EPA 503 Regs

- These regulations were adopted for the use of biosolids applied as a nitrogen source for farm soils where several tons are applied per acre at the agronomic rate for nitrogen mineralization

EPA 503 Regs

- The EPA 503 Regulations also assumed that the initial heavy metal loading of farm soil was zero. They calculated the number of years that would be required to increase the concentrations of heavy metals with annual applications of biosolids to the point of being toxic.

Clayey Soil Benefits

- High nutrient content
- High water holding capacity
- High cation exchange capacity

Clayey Soil Disadvantages

- Slow rate of water infiltration
- Slow rate of water percolation
- Low porosity and low aeration
- Difficult to till and to amend

Sandy Soil Benefits

- High porosity
- High aeration
- High infiltration and percolation
- More tilth and workability

Sandy Soil Disadvantages

- Low water retention
- Low nutrient retention
- Low cation exchange capacity

Growth Factors/Inhibitors

- Moisture
- Acidity
- Salinity
- 14 mineral nutrients
- Soil porosity/texture/compaction
- Soil organic matter
- Absence of toxicity - minerals
- Absence of toxicity - organic
- Pathogens

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STORMWATER TREATMENT

Compost-Based Stormwater Best Management Practices

Using Compost to Improve Stormwater Management and Erosion Control On Roadsides

Craig Kolodge, Filtrexx

Chris Newman, US EPA Region 5, Chicago, IL

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March 14, 2014

Compost-Based BMPs

- Compost-based stormwater best management practices (BMPs) control both stormwater quantity and quality
  - They meld two important EPA initiatives
    - Resource Conservation Challenge (RCC)
    - National Pollutant Discharge Elimination System (NPDES)

  - EPA developed fact sheets for three compost-based BMPs—compost blankets, compost filter berms, and compost filter socks
    - See EPA Stormwater Phase II (NPDES) Menu of BMPs

Resource Conservation Challenge

- Focus of the RCC is to increase waste recycling and reuse in the U.S.
  - One focus of the RCC is to increase recycling of municipal solid waste (MSW)
    - Goal: Increase recycling of MSW to 35 percent by 2008
    - Goal: Increase recycling of MSW to 40 percent by 2011
- Organic materials (green yard waste and food waste) are a focus area to increase recycling of MSW
  - Increasing high-value markets for compost is one way to support increased recycling of organic waste

National Pollutant Discharge Elimination System

- NPDES regulates the quantity and quality of stormwater discharges to waters of the U.S.
  - Control of stormwater quality is a particular concern at construction sites
  - Large disturbed areas may contribute sediment and other pollutants to stormwater
- Municipal separate storm sewer systems (MS4s) and construction site operators must control stormwater quantity and quality from construction and post-construction activities

RCC and NPDES Working Together

- Compost-based BMPs bring these two programs together
- Benefits to NPDES program
  - Compost BMPs help control sheet-flow runoff
  - Compost provides effective stormwater treatment
- Benefits to RCC program
  - High-value markets can drive demand for more compost
  - Increased recycling of organic waste will help increase the national MSW recycling rate

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Benefits of Compost in Stormwater BMPs

- Compost retains a large volume of water
  - Prevents or reduces rill erosion
  - Reduces runoff volume
  - Promotes establishment of vegetation

- Compost improves downstream water quality by retaining/adsorbing pollutants
  - Heavy metals, nitrogen, phosphorus, oil and grease, fuels, herbicides, and pesticides
  - Nutrients and pollutants are decomposed by naturally occurring microorganisms

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Benefits of Compost in Stormwater BMPs, cont.

STORMWATER TREATMENT

- Compost improves soil structure and nutrient content
  - Reduces need for chemical fertilizers, pesticides, and herbicides
- Compost-based BMPs remove as much or more sediment and pollutants from stormwater as traditional perimeter controls, such as silt fence
  - Allow a larger volume of clear water to pass through

Compost Quality

- Use sanitized, mature compost with no identifiable feedstock constituents or odors
- Must meet all local, state, and federal quality requirements
- U.S. Composting Council certifies compost products
  - Seal of Testing Assurance program
  - Products certified under program have a standard product label for comparison of products

- Some composts contain metals and/or nutrient concentrations that are higher than topsoil; these do not result in higher stormwater concentrations

Compost Quality, cont.

- American Association of State Highway Transportation Officers (AASHTO) standards
  - Quality and particle size specifications for compost to be used in compost blankets, compost filter berms, and vegetated compost filter socks

- Quality and particle size specifications for unvegetated compost filter socks provided in EPA fact sheet

- Many State Departments of Transportation (DOT) also have specifications for compost quality and particle size used in BMPs

Compost BMP Fact Sheets

- Fact sheets provide the following information about the compost BMPs:
  - Description of how the BMP is used
  - Applicability of the BMP (e.g., sheet flow only or some more concentrated flow)
  - Siting and design
  - Installation, limitations, and maintenance
  - Effectiveness
  - Costs
  - References for further information

Compost Blankets

- What is a compost blanket?
  - Loosely applied compost placed on soil in disturbed areas
- Controls erosion and retains runoff resulting from sheet flow
- Typically used in place of hydromulch, geotextiles, or drill-seeding with straw matting

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Benefits of Compost Blankets

- Can be used on any soil surface
  - Rocky or frozen ground
  - Steep slopes (1:1)

- Seed mixed into compost before it is placed allows even seed distribution
- Compost retains water, which helps seed germination
- Compost provides soil nutrients and aids in plant growth
- Blanket can be blown onto surface, so equipment and workers do not need to access slope

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Example—Installation on a Steep Slope

- Construction of an addition disturbed a slope adjacent to a church
- A compost blanket was installed to stabilize and revegetate the slope
- Netting provided additional slope stabilization before the seeded compost blanket was installed
- Filtrexx products installed:
  - Lockdown netting
  - EcoBlanket

Prepared Slope

Installation of compost blanket over lockdown netting

Revegetated slope

STORMWATER TREATMENT

Effectiveness of Compost Blankets

- Study conducted by Iowa State University for Iowa DOT
- Study compared:
  - Direct seeding into embankment topsoil
  - Imported topsoil/seeding of embankment Compost blankets also suppressed weed growth
  - Seeded compost blanket
    - Erosion rate from blanket area was 0.02 percent that of the topsoil areas
    - Compost blankets also suppressed weed growth

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Compost Filter Berms

STORMWATER TREATMENT

- What is a compost filter berm?
  - A dike of compost placed perpendicular to sheet flow runoff in a disturbed area
- Controls erosion, retains sediment, and adsorbs pollutants
  - Use in concentrated flow conditions if drainage area is small
- Replaces traditional BMPs such as straw waddles and silt fence

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Benefits of Compost Filter Berms

- Can be used on rocky or frozen ground
- Does not require trenching for installation
- Low profile is not blown down by high winds
- Seed mixed into compost before placement allows even seed distribution
- Compost retains water, which helps seeds germinate and anchor berm to soil surface
- Berm has higher permeability than silt fence, allowing more clean water to pass through

Example Sediment Control in Road Ditch

- Texas DOT installed a compost filter berm and a silt fence to compare their effectiveness in removing sediment

Compost filter berm, US HWY 281 (Texas) on 1/30/2001

Silt fence, US HWY 281 (Texas) on 1/30/2001

- Stormwater is backed up behind silt fence
- Clean stormwater passed through filter berm; sediment retained on upstream side

Effectiveness of Compost Filter Berms

- Study conducted for Metropolitan Service District (Portland, Oregon)
- Tested yard debris compost for erosion control
- Compared silt fence and filter berms made of yard-debris compost
- Study results showed filter berm was:
  - 90 percent effective in removing suspended and settable solids, when compared to control plot
  - 66 percent more effective than silt fence in removing suspended and settable solids

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Compost Filter Socks

STORMWATER TREATMENT

- What is a compost filter sock?
  - A mesh tube filled with compost placed perpendicular to runoff
- Controls erosion, retains sediment, and adsorbs pollutants
  - Use to treat sheet flow runoff or concentrated runoff from small drainages

- Replaces traditional BMPs such as silt fence, rock berms, and straw waddles

Benefits of Compost Filter Socks

- Can be used on rocky or frozen ground or on paved areas; does not require trenching for installation
- Shorter socks can be removed and reused
- Low profile is not blown down by high winds
- Can be placed in many environments:
  - Steep slopes
  - Small drainageways
  - Storm drain inlet protection on pavement
  - Stacked to provide slope stability

- Higher permeability than silt fence, allowing more clean water to pass through

Examples—Texas DOT

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STORMWATER TREATMENT

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March 14, 2014

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LANDSCAPE ARCHITECTS
CHAPTER

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DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

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Effectiveness of Compost Filter Socks

- Qualitative studies: filter socks are effective in removing settleable and total suspended solids
  - At least as effective as traditional BMPs, such as silt fence
- Quantitative study performed by Filtrexx International:
  - Laboratory test of filter socks with 13 types of compost
  - All filter socks removed over 50 percent of motor oil in simulated stormwater (1,000 to 10,000 mg/L)
  - Seven removed over 95 percent of motor oil

STORMWATER TREATMENT

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Need More Information?

- Full-length fact sheets for each BMP are available on EPA's National Menu of Stormwater BMPs
- http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm
- At menu, type in name of BMP (compost blanket, compost filter berm, compost filter sock)

- Fact sheets provide many references and links to other sites with information about compost BMPs
  - Chris Newman
    - US EPA Region 5
    - newman.christopherm@epa.gov
    - 312-353-8402

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BIORETENTION PLANT MATERIAL

Plant Material for Bioretention

Mike Klaerich
Green Meadow Growers

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Bioswale Grass Ideas 2013

Bio Swale Grasses ideas 2013

Bio Swale Grasses		California Native Grass	Evergreen	Time to cut back	Plant Height	Foliage Color	Showy Flowers	Sun or Part Sun	Lawn substitute / Meadow	Water Needs	Grass Forms	Erosion Control / Slopes
Acorus gramineus 'Ogon'	.		E		Low	Var.		S&P		Med	Mound	
Acorus gramineus 'Variegatus'	.		E		Low	Var.		S&P		Med	Mound	
Bouteloa gracilis 'Blond Ambition'	.	New	Semi	Winter	Med.	Green	Yes	Sun	Yes	Low	Mound	Yes
Bouteloa gracilis 'Blue Grama Grass'	.	Yes	Semi	Winter	Med.	Green	Yes	Sun	Yes	Low	Mound	Yes
Buchloe dactyloides 'UC Verde' Buffalograss	.		D		Low	Green		Sun	Yes	Low	Spreading	Yes
Calamagrostis foliosa 'Leafy Reed Grass'	.	Yes	D	Winter	Med.	Blu/Green	Yes	Sun		Med.	Mound	
Carex granularis 'Golden Fruited Sedge' aurea												
Carex barbarae 'Santa Barbara Sedge'	.	Yes	E		Med.	Green		S&P		High	Mound	
Carex pansa 'California Meadow Sedge'	.	Yes	E	any	Low	Green		Sun	Yes	Low	Spreading	Yes
Carex praegracilis 'California Field Sedge'	.	Yes	E	any	Low	Green		Sun	Yes	Low	Speading	Yes
Carex (Divulsa) tumulicola 'Berkley Sedge'	.	Yes	E	after/flwr	Low	Green		S&P	Yes	Low	Mound	Yes
Carex spissa 'San Diego Sedge'	.	Yes	E		Tall	Green	Yes	Sun		High	Mound	
Chondropetalum tectorum 'Small Cape Rush'	.		E		Tall	Green	Yes	Sun		Med.	Upright	
Cyperus 'Alternfolius Gracilis' Dwarf Umbrella Plant	.		D	Spring	Med.	Green		S&P		High	Mound	
Cyperus 'Isocladus' Dwarf Papyrus Plant	.		D	Spring	Med.	Green		S&P		High	Mound	
Cyperus involucratus 'Baby Tut'	.		D	Spring	Med.	Green		S&P		High	Mound	
Deschampsia cespitosa 'Tufted Hair Grass'	.	Yes	E		Low	Green	Yes	S&P	Yes	Low	Mound	
Distichlis spicata 'Salt Grass'	.	Yes	D		Low	Green		Sun	Yes	Low	Spreading	
Dianella caerulea 'Casa Blue'	.		E		Med	Blue	Yes	S&P		Low	Upright	
Dianella revoluta 'Little Rev'	.		E		Low	Blue	Yes	S&P		Low	Upright	

BIORETENTION PLANT MATERIAL

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Bioswale Grass Ideas 2013

Festuca californica 'California Fescue'	.	Yes	E		Med	Blu/Green	Yes	Sun		Med.	Mound	Yes
Festuca idahoensis 'Siskiyou Blue'	.	Yes	E		Low	Blue		S&P	Yes	Low	Mound	
Festuca mairei 'Maire's or Atlas Fescue'	.		E	Fall	Med	Green	Yes	Sun	Yes	Med.	Mound	Yes
Festuca paniculata 'Meadow Fescue'												
Festuca rubra 'Creeping Red Fescue' no mow	.	Yes	E		Low	Green		S&P	Yes	Med.	Spreading	Yes
Festuca rubra 'Molate Creeping Red Fescue'	.	Yes	E		Med	Green		S&P	Yes	Med.	Spreading	Yes
Juncus acutus 'Spiny Rush'	.	Yes	E		Tall	Green		Sun		High	Upright	
Juncus effusus 'Quartz Creek' Rush	.	Yes	E		Med	Green		S&P		High	Upright	
Juncus inflexus 'Blue Arrows'	.	Yes	E		Med	Blue		S&P		Med	Upright	
Juncus patens 'Elk Blue' compact	.	Yes	E		low	Blue		S&P		High	Upright	
Leycesteria formosa 'Golden Lanterns'												
Juncus patens 'Will Flemming'	.	Yes	E		Med	Gray		S&P		High	Upright	
Leymus (Elymus) arenarius 'Findhorn Wild Rye' compact	.		Semi	Winter	low	Blue	Yes	Sun		Med.	Spreading	Yes
Leymus condensatus 'Canyon Prince'	.	Yes	E		Tall	Blu/Green	Yes	Sun		Med.	Mound	Yes
Leymus triticoides 'Creeping Wild Rye'	.	Yes	E E		Med	Green		Sun		High	Spreading	Yes
Lomandra hystrix 'Katie Belles'	.		E E		Med	Green	Yes	S&P		lo/high	Mound	Yes
Lomandra longifolia 'The Breeze'	.		E		Med	Green		S&P		Low	Mound	
Lomandra longifolia 'Tropic Belle'	.		D D		Med	Green		S&P		Low	Mound	
Lygeum sparteum 'Esparto Grass'	.		D D		Med	Gray	Yes	S&P		Low	Upright	
Muhlenbergia capillaris 'Pink Muhly Grass'	.		D	Winter	Med	Green	Yes	Sun		Low	Mound	
Muhlenbergia dubia 'Pine Muly Grass'	.		D E	Winter	Med	Green	Yes	Sun		Low	Mound	Yes
Muhlenbergia 'Lindheimer Muhley Grass'	.			Winter	Tall	Gray	Yes	Sun		Low	Mound	Yes
Muhlenbergia rigens 'Deer Grass'	.	Yes		Winter	Tall	Green	Yes	Sun		Low	Mound	Yes
Nessella pulchra 'Purple Needle Grass'	.	Yes		Fall	Med	Green	Yes	Sun		Low	Mound	Yes
Pennisetum orientale 'Oriental Fountain Grass'	.			Winter	Med	Green	Yes	Sun		Low	Mound	
Pennisetum 'Fairy Tails'	.				Med	Green	Yes	Sun		Low	Mound	
Pennisetum spathiolatum 'Slender Veldt Grass'	.		Semi	after/f|wr	Low	Green	Yes	Sun	Yes	Low	Mound	Yes
Scirpus cernuus 'Fiber Optic Grass'	.	Yes	E		Low	Green		Sun		High	Mound	
Sesleria autumnalis 'Autumn Moor Grass'	.		E		Med	Green	Little	Sun	Yes	Low	Mound	Yes
Sesleria hybrid 'John Greenlee'	.		E		Low	Blu/Green		Sun	Yes	Low	Mound	Yes
Sisyrinchium bellum 'Blue Eyed Grass'	.	Yes	D	Fall	Low	Blu/Green	Yes	Sun		Low	Mound	

BIORETENTION PLANT MATERIAL

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CHAPTER

BIORETENTION MAINTENANCE

Bioretention Maintenance

Chris Cutler
Steve Smith Landscape, Inc.

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CHAPTER

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DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

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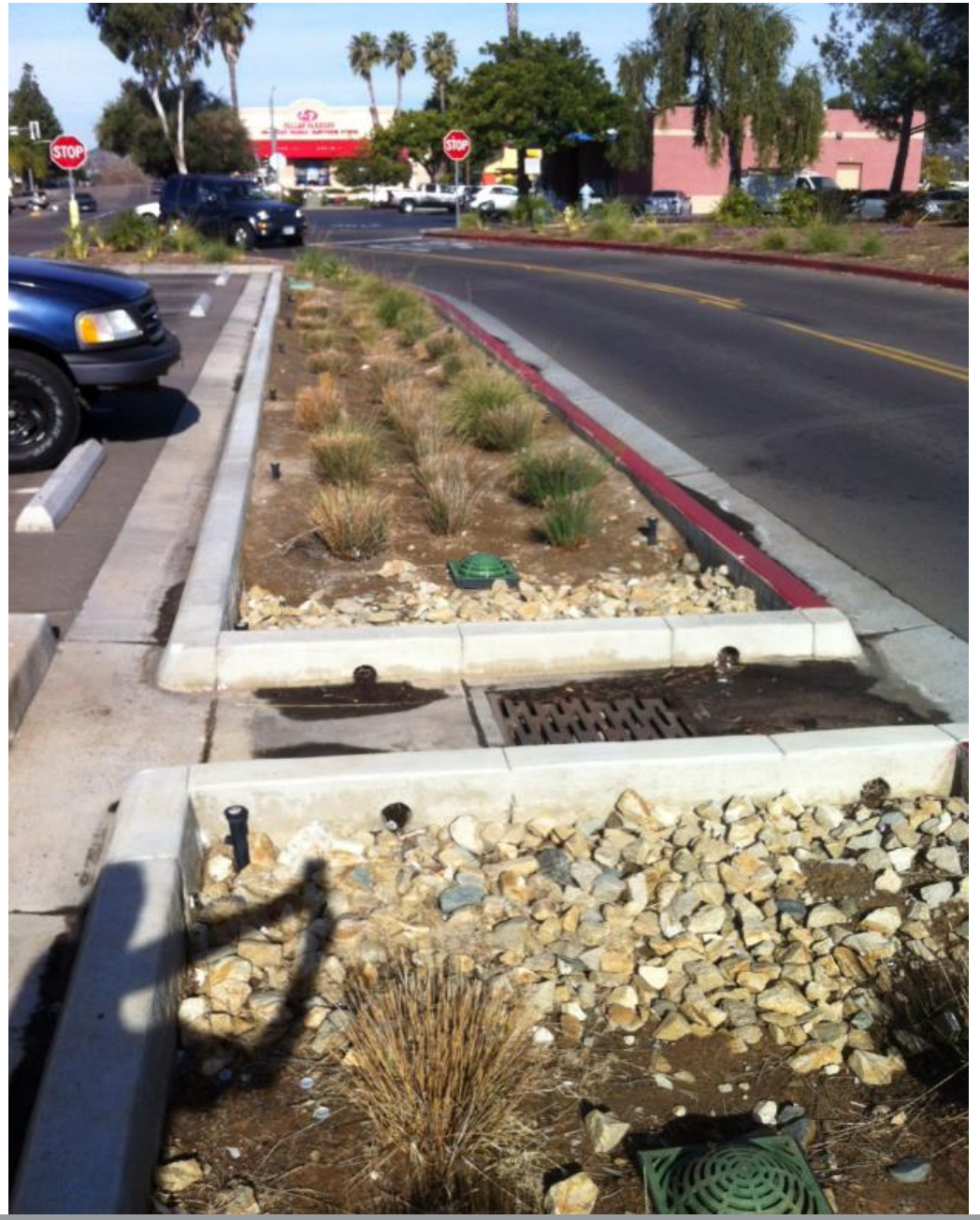
LANDSCAPE ARCHITECTS
CHAPTER



BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIORETENTION MAINTENANCE

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

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CHAPTER

BIOSWALE WORKSHOP

Bioswale

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CHAPTER

Bioswale Project

Case Studies

BIOSWALE CASE STUDIES

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LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
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LANDSCAPE ARCHITECTS
CHAPTER

Marina Gateway Bio-swale

BIOSWALE CASE STUDIES

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LANDSCAPE ARCHITECTS
CHAPTER

Marina Gateway Bio-swale

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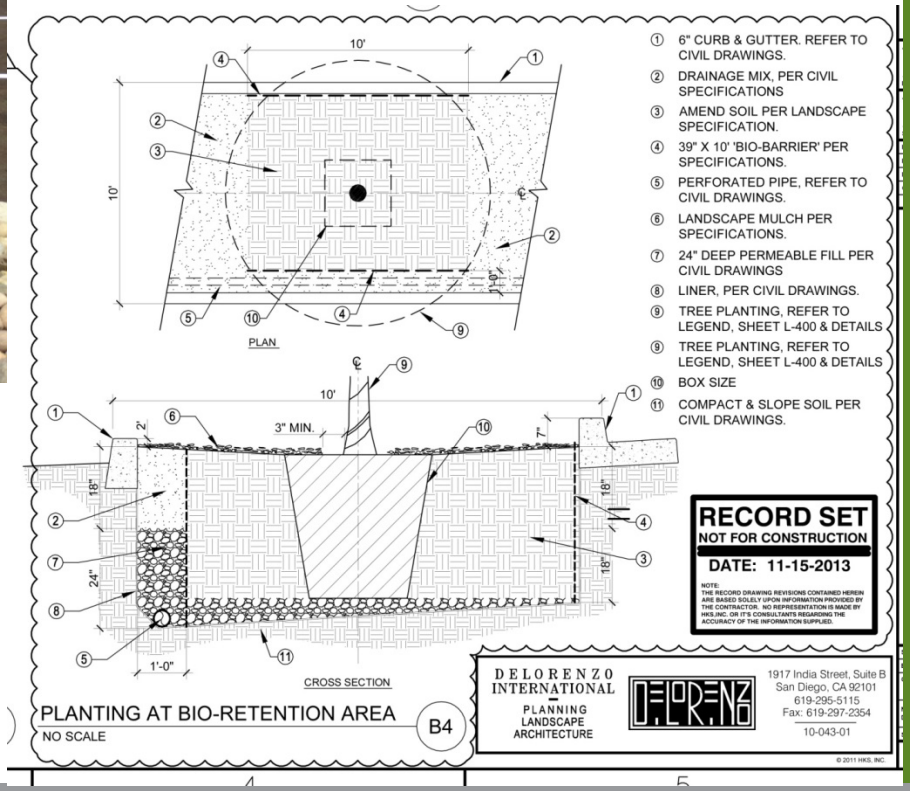
CHAPTER

BIOSWALE CASE STUDIES

Replacement Naval Hospital Camp Pendleton



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LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

Replacement Naval Hospital Camp Pendleton

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014

SAN DIEGO
AMERICAN SOCIETY OF
LANDSCAPE ARCHITECTS
CHAPTER

BIOSWALE CASE STUDIES

SAN DIEGO ASLA STEWARDSHIP COMMITTEE

DISCUSSIONS ON LID DEVELOPMENT BIOSWALES AND BIORETENTION

March 14, 2014