Memorandum

To: The Low Impact Development Initiative
From: Rick Engineering
Subject: Summary of Bioretention Soil Specifications for the San Diego Region

OVERVIEW

As part of ongoing implementation of Low Impact Development (LID) requirements throughout the State of California and various regions throughout the nation, Bioretention (aka Biofiltration) has become a preferred Best Management Practice (BMP) to meet both water quality treatment and water quantity storage criteria (i.e. – detention/retention/hydromodification management). In recent years, the specification of the Bioretention Soil Mix (BSM) component for Bioretention BMPs has evolved based on lessons learned from the design, construction, and maintenance of these facilities.

This Technical Assistance Memo (TAM) is intended to provide background to the process that went into the recent development of BSM specifications in the San Diego Region, as well as the use of similar specifications to provide guidance within the Central Coast Region. As implementation of Bioretention BMPs continues to increase and additional information becomes available, these BSM specifications are anticipated to evolve over time.

BACKGROUND

Typical BSM specifications have been released over the past several years in numerous regions along the West Coast, including Washington State, Portland, Oregon, San Francisco, Ventura, and Los Angeles. Each of these seemed to have been adopted based on its predecessor, resulting in the following typical mixture of Sand and Compost:

60% - 70% Sand
30% - 40% Compost

Subsequent concerns for high levels of nutrients leaching from Bioretention BMPs became apparent, including a moratorium in Washington State associated with the issue. As a result, a BSM with more sand and less compost was desirable; however, this needed to be counterbalanced with enough organics to sustain healthy soil and plant growth. In addition to the appropriate mix of sand and compost, another significant issue that was identified related to methods of placement to help prevent over-compaction and low percolation rates.

DEVELOPMENT OF BSM SPECIFICATION IN SAN DIEGO REGION

In the San Diego Region, the 2007 MS4 Permit provided further emphasis on LID-based BMPs, including bioretention. The permit requirements were phased in over time, and local BMP design manuals (i.e. - Countywide Model SUSMP in early 2008 and subsequently updated in early 2011) called for Bioretention BMPs to prove an 18-inch layer of “sandy loam” with a long-term percolation rate of 5 inches/hour. There had not been any further guidance provided for the actual BSM percentages of sand, sandy loam, or compost. As a result of lessons learned through the bidding of construction documents that included Bioretention BMPs and issues that occurred during and after construction, several local efforts began to develop BSM specifications.

One of these efforts was led by Rick Engineering Company (RICK), a Civil Engineering firm that had been very involved with LID design and construction based on the San Diego Region requirements. RICK convened a “Task Force” to convene input from local civil engineers, landscape architects, geotechnical engineers, and soil agronomists. At the tail end of finalizing these BSM specifications that would be used for in-house design projects, the County of San Diego was in the process of updating their LID Handbook, which provides supplemental guidance to the local SUSMP Manuals. As part of the

effort, the County and their consultant team (Tetra Tech), were also developing a set of BSM specifications for all of the same reasons, and the City of San Diego had also been evaluating similar issues for use with CIP projects. Based on these parallel efforts, representatives from each of these efforts met several times to discuss common issues, potential solutions, elements of common agreement and differences, and ultimately led to each effort revising their BSM specifications to be very similar.

Due to growing demand in the region for both private and public works projects, several suppliers had starting mixing and providing bioretention soil media. As part of the research, one such supplier had already started to deviate from the typical 60-70% Sand and 30-40% Compost, having introduced a portion of Sandy Loam, resulting in 50% Sand, 25% Sandy Loam, and 25% Compost. The sandy loam soil will bind with the compost and provide water retention, which is good for root growth, especially in a highly porous soil in an arid climate (whereas a mix of only Sand and Compost does not bind well, resulting in less water retention). However, one concern with adding sandy loam soil to the soil media was a potential reduction to infiltration rates. The amount of infiltration provided through the BSM layer was critical to the design of Bioretention BMPs in the San Diego Region since local design criteria called for them to provide a long term in-place infiltration rate of at least 5 inches per hour. In addition to identifying an appropriate mix, the method of placement and amount of compaction was critical to ensuring a successful installation. A challenge associated with the issue of compaction was whether or not to include a percent compaction (i.e. – 80%, 85%, etc.), however, it was ultimately agreed that the level of compaction was not a driving force in the design intent or long-term effectiveness; however, the need for "in situ" testing of infiltration rates was seen as necessary so that corrective action could be taken prior to project closeout.

The draft BSM specification originally developed by the County's consultant had come up with a BSM mix of 5% compost and 95% sand at 85% to 90% compaction. The RICK BSM specification had identified a mix of 50% Sand, 25% Sandy Loam and 25% Compost. Based on everyone's input it was collectively agreed to develop a mix that included Sand, Sandy Loam, and Compost, with a goal of reducing the amount of organic matter within the BSM to a minimum level that would still allow for good plant growth but significantly reduces the potential leaching of nutrients associated with high levels of organics within compost. As mentioned earlier, it was also deemed important to introduce the Sandy Loam component for an arid region. The collective agreement resulted in the following mixture (by volume), which results in approximately 1.5% to 5% organic matter (by weight), once mixed:

65% Sand
20% Sandy Loam
15% Compost

In terms of material submittals, contractors were submitting agricultural soil testing results for the soil mix, but yet most of the previous sets of specifications had only provided separate specification and testing requirements for each sand and compost, but none of them had specifications and testing requirements for the soil mix media itself. For example, for a BSM with a ratio of 30% compost, the compost will include 35% to 70% organic matter, but when mixed with 70% sand, the result is a much lower rate of organic matter. With a desired goal of 5% organic matter (by weight) in the BSM itself, it was important to develop a set of testing requirements for the mixed soil media.

These parallel and collaborative efforts resulted in the adoption of BSM specifications in the County of San Diego LID Handbook, dated June 2014; as well as adoption of very similar BSM specifications by RICK.

ADDITIONAL REFERENCE

County of San Diego LID Handbook, June 2014 –
http://www.sandiegocounty.gov/content/sdc/dpw/watersheds/susmp/lid.html

BIORETENTION SOIL SPECIFICATION

1. BIORETENTION SOIL

Bioretention soil shall achieve an initial infiltration rate of at least 8 inch per hour nor more than 20 inches per hour “in situ” and a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth. Bioretention Soil shall be a mixture of fine sand, and compost, measured on a volume basis:

65% Sand
20% Sandy Loam
15% Compost

A. SUBMITTALS

Product Data: Submit manufacturer's product data and installation instructions. Include required substrate preparation, list of materials, application rate/testing and percolation rates.
Certifications: Manufacturer shall submit a letter of certification that the products meet or exceeds all physical property, endurance, performance and packaging requirements.
Submittals for Bioretention Soil: Tests must be conducted within 120 days prior to the delivery date of the bioretention soil to the project site.
Batch-specific test results and certification will be required for projects installing more than 100 cubic yards of bioretention soil.

The contractor must submit the following for approval:

1. A sample of mixed bioretention soil.
2. Grain size analysis results of the sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
3. Grain size analysis results of the sandy loam component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
4. Grain size analysis results of compost component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
5. Agricultural soil analysis of results for the Bioretention Soil as specified in Section 2.03 E
6. Provide the following information about the testing laboratory(ies) name of laboratory(ies) including
    a) contact person(s)
    b) address(es)
    c) phone contact(s)
    d) e-mail address(es)

B. Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be non-plastic.

Sand for Bioretention Soil shall be analyzed by an accredited lab using #200, #100, #40, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

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

Note: all sands shall consist of natural sand, manufactured sand, or a combination thereof.

C. Sandy loam for Bioretention Soil shall be free of wood, waste, coating such as stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be non-plastic.

Sandy loam soil should comply with the following specifications on USDA soil textural classification scheme by weight:

a. 50-74% sand
b. 11-48% silt
c. 2-15% clay

Note: all sandy loam shall consist of natural sand, manufactured sand or a combination thereof.

D. Compost for Bioretention Soil shall be a well decomposed, stable, weed free organic matter source derived from waste materials including yard debris, wood wastes or other organic materials. Compost shall have a dark brown color and a soil like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable. Compost shall be produced at a facility inspected and regulated by the Local Enforcement Agency for CalRecycle. The past 3 inspection reports shall be submitted verifying compliance with Title14 requirements of the Process to Further Reduce Pathogens (PFRP), Fecal coliform and Salmonella testing and pathogen and EPA, 40 CFR 503 regulations.

Composite Quality Analysis:

Property	**Method**	**Requirement**
pH, Units	Saturation Paste	6 to 8.5
EC, dS/m	Saturation Extract	0 to 10
Boron, ppm	Saturation Extract	less than 2.5
Moisture content, %	Gravimetric	30 to 60
Bulk Density, lbs/cubic yard		500 to 1100
Organic Matter, % of Dry Wieght	Loss on Ignition	35% to 75%
Carbon to Nitrogen Ratio		15:1 to 25:1
Maturity	Solvita	5 or above
Stability	Solvita	5 or above
Particle Size	Sieve Analysis	
Pass 1/2 inch sieve		≥80%
Pass #200 sieve		max 5%
503C Metals	Title 14	
Arsenic (As)		20
Cadmium (Cd)		15
Chromium (Cr)		100
Copper (Cu)		150
Lead (Pb)		300
Mercury (Hg)		10
Nickel (Ni)		100
Selenium (Se)		30
Zinc (Zn)		300
Pathogen		
Salmonella	Title 14	< 3 MPN per 4 gms
Fecal Coliform		<1000 MPN per 1 gm
Physical contaminants		

Plastic Metal and Glass, %> 4mm	% by Weight	< 1
Sharps, % > 4mm	% by Weight	0

E. Bioretention Soil shall be free of roots, clods, and/or stones larger than 1-inch in the greatest dimension, pockets of coarse sand, noxious weeds, sticks, lumber, brush and other litter. It shall not be infested with nematodes, or undesirable disease-causing organisms such as insects and plant pathogens. Bioretention soil mix shall be friable and have sufficient structure in order to give good tilth and aeration to the soil.

Gradation limits – The definition of the soil should be the following USDA classification scheme by weight:

Sand 85-92%
Silt 14% maximum
Clay 5% maximum

Permeability Rate - Hydraulic conductivity rate shall be not less the 8 inch per hour nor more than 20 inches per hour when tested in accordance with USDA Handbook Number 60, method 34b or other approved methods.

Analysis for pH, salinity and nutrient levels shall be submitted for approval prior to acceptance. Nutrient tests should include the testing laboratory recommendations for supplemental additions to the soil as calculated by the amount of material to be added per volume of soil for the type of plants to be grown in the soil.

Property	**Method**	**Requirement**
pH, Units	Saturation Paste	6.0 to 8.0
EC, dS/m	Saturation Extract	0.5 to 2.5
Boron, ppm	Saturation Extract	less than 2.5
Chloride, ppm	Saturation Extract	less than 150
Sodium Adsorption Ratio		less than 3.0
Carbon to Nitrogen Ratio		10 to 20
Organic Matter, % of Dry Weight	Loss on Ignition	1.5 to 5
Extractable Nutrients, dry weight basis	Ammonium Bicarbonate/DPTA Extraction	
phosphorus, ppm		10 to 40
potassium, ppm		100 to 200
iron, ppm		24 to 35
manganese, ppm		0.6 to 6
zinc, ppm		1 to 8
copper, ppm		0.3 to 5
magnesium, ppm		50 to 150

sodium, ppm		0 to 100
sulfur, ppm		25 to 500
molybdenum, ppm		0.1 to 2
aluminum, ppm		less than 3.0

Bioretention Soil shall be analyzed by an accredited lab using #200, 1/4 inch, 1/2 inch, and 1 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	Percent Passing (by weight)
1 inch	99-100
1/2 inch	90-100
1/4 inch	40-90
No. 200	Less than 5%

2. BIORETENTION SOIL PLACEMENT

A. Imported backfill material for the bioretention zones should be placed in a relatively loose condition, no rolling or other heavy equipment, to promote the planned infiltration of water, through the bioretention soil mix layer.

B. Bioretention soil shall be installed in six (6) to twelve (12) inch lifts and lightly watered to provide settlement and natural compaction. No mechanical compaction is allowed. After natural compaction has been completed, add, if needed, additional bioretention soil to proposed finish grade as indicated on the plans.

C. Rake bioretention soil as needed to level out.

D. Vehicular traffic, construction equipment shall not drive-on, move onto, or disturb the bioretention soil once placed and water compacted.

E. The geotechnical engineer shall perform at least one percolation test per bioretention basin/swale in accordance with the County of San Diego Department of Environment Health Percolation Testing Criteria or other approved methods “in situ” prior to planting the Bioretention area (the engineer of work may require more than one in situ test depending on size of bioretention area). “In situ” percolation test(s) shall have an initial rate of at least 8-10 inches per hour to insure a long term infiltration rate of at least 5 inches per hour. If the percolation rate does not meet at least 8-10 inches per hour, the contractor shall provide and submit corrective action to the geotechnical engineer for approval, such as rototilling or hand cultivation to improve the percolation rate. Once the approved corrections are determined, the contractor will perform the required corrective action to improve the percolation rate and re-test at his expense.

F. Erosion and Sediment Control practices during construction shall be employed to protect the long-term functionality of the bioretention basin/swale. The following practices shall be followed for this reason:

1. Provide erosion control in the contributing drainage areas to the facility and stabilize upslope areas.
2. Facilities should not be used as sediment control facilities, unless installation of all bioretention-related materials are withheld towards the end of construction

allowing the temporary use of the location as a sediment control facility, and appropriate excavation of sediment is provided prior to installation of bioretention materials.

G. A two-inch layer of well-aged shredded hardwood mulch shall be installed on the surface of the bioretention soil if planting of container stock is installed (i.e. - no hydroseeding is to be installed), which will also help reduce foot compaction of the bioretention soil. Alternative "non-floating" mulch may be used if specified by the landscape architect. Bark or wood chip mulch may be used on the side slopes of basins/swales above the maximum water line, if specified by the landscape architect.

H. If hydroseeding is to be installed on the surface of the bioretention soil, no stabilized matrix shall be used in the hydroseed components or mix.