10 Amend Soils for Bioretention

Bioretention is the practice of using plants and soil to manage stormwater. Examples include rain gardens, swales, and vegetated filter strips. Soil plays a major role in watershed function, because it conveys rainfall through voids (i.e. air pockets), delivering that water to waterways hours, days, or even weeks after a rainfall event. Healthy soil not only contains critical nutrients to support plant life, but also has sufficient voids for water *and* air, which are needed by microbe-sized and larger soil animals. Healthy soil critters means healthy plants and long-term permeability (ability of water to enter), which results in stormwater facilities that are less likely to clog than those without plants and healthy soil.

To install a rain garden or vegetated filter strip, many guidance documents will ask or require you to remove the first 12" – 18" of soil and replace it entirely with an engineered soil mix. This is an expensive and not very efficient approach in most cases. Many designers and jurisdictions have excellent results when they simply amend the native soils.

This guide will step you through that process to ensure that your bioretention facilities are protecting water quality. Soils outside your stormwater facility may also benefit from soil restoration. For more information, see *"3 Restore Disturbed Soils"*.

Design

Never fold sand alone into clayey soils. With insufficient quantities of sand, doing this is likely to cement the soil, creating a barrier to water and infiltration.

To ensure adequate water quality treatment, healthy soil that infiltrates water at a good rate (not too fast and not too slow) is needed for a depth of 18". For more information on how to perform an infiltration test on your native soils, see "7 *Test Your Soils"*.

Construction

Steps to amend native soils are as follows:

1. Remove the top 12 inches of soil where your infiltration facility will be. Leftover materials can be used in compost piles or DIY projects or disposed. If you would like to use it as fill, consult with a geotechnical engineer licensed in the State of California to make sure that the material is suitable for its intended use.
2. **For soils infiltrating 1 inch/hour or slower:** Amend 6" of native soil with a mix of one part imported organic compost and one part gravelly sand, such that there are equal parts compost, sand, and native soil (aka three-way mix).
3. **For soils infiltrating 12 inches/hour or faster:** Amending soils to drain slower can be tricky and potentially expensive. Most designers will send a soil sample to a laboratory and request a "recipe" of what to mix in and in what quantities. A more cost-effective solution is to simply replace the first 18" of native soil with an engineered soil mix (see Figure 1 and specifications below).
4. Till the mix thoroughly together on-site, using a portable soil mixer, hand-digging, or roto-tilling at multiple depths.

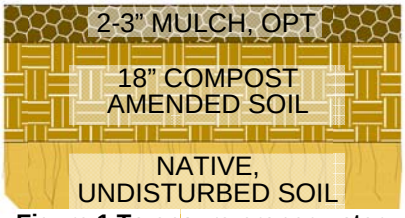

Figure 1 To ensure proper water quality treatment, an 18" layer of healthy soil is needed in all bioretention facilities.

5. Place mix in 9 – 12 inch depths (aka lifts) and spray water over the entire lift to speed up settlement and achieve final desired elevations.
6. If building a rain garden, test the infiltration rate of the facility (how well it absorbs and allows water to pass through). It should be capable of infiltrating water without ponding more than 30 hours on the surface. If ponding occurs, organic compost and sand must be added and re-tilled until the infiltration rate improves. More information is found in "*4Build a Rain Garden*".

Specifications

Compost

Care should be taken to ensure that compost is clean and free of weeds, pollutants, or other harmful materials that may impact plant health and water quality.

Organic compost should have the following properties:

- Weed seed and pollutant free.
- 100% of material should pass a ½" screen.
- pH between 5.5 and 7.0. If the pH isn't quite right, it may be lowered by adding iron sulfate and sulfur or raised by adding lime or recycled, ground gypsum board.
- Carbon nitrogen ratio of 35:1.
- Organic matter content between 40 and 50%.
- Fully composed. Earthy is good. Avoid compost that smells like ammonia.

Organic compost may consist of the following:

- Mushroom Compost. The used bedding material from commercial mushroom production.
- Local nursery or garden supply's stock of organic compost. There is US Compost Council Seal of Testing Assured (STA) compost. Visithttp://compostingcouncil.org/participants to find a participating supplier near you. The STA program is no guarantee of quality, only that the compost has been tested and those test results are available for review.

Organic compost may NOT be:

- Composted Yard Debris. This is because excessive pollutants, mostly herbicides, pesticides, and fertilizers, have historically been found in these materials. "Cides" can kill beneficial soil life, reduce stormwater benefits, and increase maintenance.
- Peat Moss. Peat moss is extracted from wetlands; this has negative impacts on the watershed from which the peat moss was removed.

Gravelly Sand

Gravelly sand should be free of organic material, contaminants, and hazardous materials, and should conform to the following size composition category (gradation), which you can compare against the gradation provided by your quarry's material:

U.S. Sieve Size	Percent Passing
2-inch	100
3/4-inch	70-100
1/4-inch	50-80
No. 40	15-40
No. 200	0-3

Mixing
Mix soil and amendments to a homogeneous (i.e. all the same) consistency. Do not mix compost, sand, and native soil in the rain or wet conditions. Even in dry weather, soils and amendments themselves should not be overly wet.

Storage
Protect and cover stored stockpiles of organic soil mix in a manner that prevents them from becoming:

- wet from rain, stormwater runoff, leaks, or other sources of water, or
- contaminated by fine soil or other undesirable materials.

Placement
Place amended soil mix in rain gardens and stormwater planters in lifts/layers not exceeding 6 inches in loose thickness. After all lifts have been placed, grade soil to finish grades as specified on the plans. Do not over compact soil mix with mechanical equipment after placement. After following the construction steps above, soils have already been water compacted.

Engineered Soil Mix
Engineered Soil Mix (aka 3-way mix or bioretention soil mix) should have the following properties:

- Free of contaminants & hazardous materials
- 60% Loamy sand
- 40% organic compost
- Organic matter content from 8-10% by weight
- 2 – 5% mineral fines
- Cation exchange capacity (CEC) greater than 5 millequivalents/100 grams of dry soil
- Minimum long-term hydraulic conductivity of 1 inch/hour per ASTM D2434 at 85% compaction per ASTM D2668
- Conform to the following gradation:

U.S. Sieve Size	Percent Passing
3/8-inch	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

- Meet specifications above for organic compost, mixing, storage, & placement.

Mulch
Wood chips or coarse compost (not bark dust or chips) can be used in a layer a minimum of 2-inches thick over the amended soil mix and between the plantings to completely cover the soil and prevent erosion or weed intrusion. After plants have established and soil is covered, mulching is probably not needed for erosion control or weed suppression.

Figure 1 Avoid bark mulch. It floats, carrying pollutants adhered to its surface to downstream waterways.

Post-Construction Facility Infiltration Testing
To test a recently constructed or existing bioretention facility:

1. Wet the surface of the rain garden with a sprinkler or hose until saturated. The full scale of small rain gardens or cells separated by check dams(<100 square-feet in surface) area can be tested at once. For large rain gardens, vegetated filter strips, and swales, use isolated falling head tests (minimum 2 per 100 square feet of area). For instructions on how to perform a falling head test, see *"7 Test Your Soils"*.
2. Fill the testing area to a depth of 4-inches and track the time it takes for the water to completely draw down.

3. Repeat test 3 times. If the water in any of the tests fails to draw down in less than an hour, add compost and gravelly sand to the mix and re-till.
4. Repeat this procedure until favorable test results – see *"7 Test Your Soils"* – are achieved.

Permits

A permit is probably not needed to perform infiltration testing. But, check with your jurisdiction's building or development services department. If information in this guidance conflicts with your jurisdiction's requirements or approach, then follow their guidance instead.

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Photo Credits

Figures 1 & 2: Maria Cahill