

low impact development technical workshop series

Bioretention Soil Mixes

Topics

Composition

Water Quality Issues

Application

WASHINGTON STATE UNIVERSITY EXTENSION

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Soil mixes for bioretention areas need to balance three primary design objectives for optimum performance:

- High enough infiltration rates to meet desired surface water drawdown and system dewatering.
- Infiltration rates that are not too high in order to optimize pollutant removal capability.
- A growth media to support long-term plant and soil health and water quality treatment capability.

- Balance nutrient availability and retention and copper retention at low effluent levels.

Common bioretention soil mix guidelines

- 40% topsoil, 30% sand, 30% compost common recommendation nationally and in this region (there can be issues with this guideline).
- < 5% fines passing the #200 sieve.
- Minimum organic matter content 10% by dry weight per ASTM D 2974.
- 1.0 inch/hour minimum long-term hydraulic conductivity per ASTM D 2434 at 85% compaction per ASTM D 1557.

- 18” minimum soil depth—24” minimum for improved nitrogen or phosphorus removal.
- Current guideline in LID manual 60% sand and 40% compost (this will likely be changing).

Bioretention soil mix reviews

- Top soil specifications can be difficult to apply consistently.
- Investigate and recommend BSM using relatively consistent materials that are readily available, affordable and meet necessary criteria.

WSU soil analysis funded by Russell, Ecology, NOAA and the Puget Sound Partnership

WASHINGTON STATE UNIVERSITY
PIERCE COUNTY EXTENSION

Technical Memorandum

Bioretention Soil Mix Review and Recommendations for Western Washington

Prepared for: Puget Sound Partnership
Prepared by: Curtis Hinman WSU Extension Faculty

Date: January, 2009

Recommendations from Seattle and WSU

- WSU and Seattle have conducted extensive aggregate analysis.
- Seattle guidelines available and 2012 LID manual.
- WSU lab, meso- and full-scale BSM testing in progress.

Initial bioretention Soil Mix Data Summary

	Organic Matter Content of Soil Mix			Aggregate Grain Size Summary	
Sample ID	Percent Compost (volume)	Percent Aggregate (volume)	Percent OM Content (weight)	Percent Fines	Average Permeability (in/hour)
Fred Hill (screen sand + compost)	40	60	8.3	4.6	1.3
Green Earth (C33 washed sand + compost)	40	60	8.8	1.0	27
Green Earth (screen sand + compost)	40	60	9.6	2.4	13
Miles S&G (utility sand + compost)	40	60	8.9	3.7	5.6

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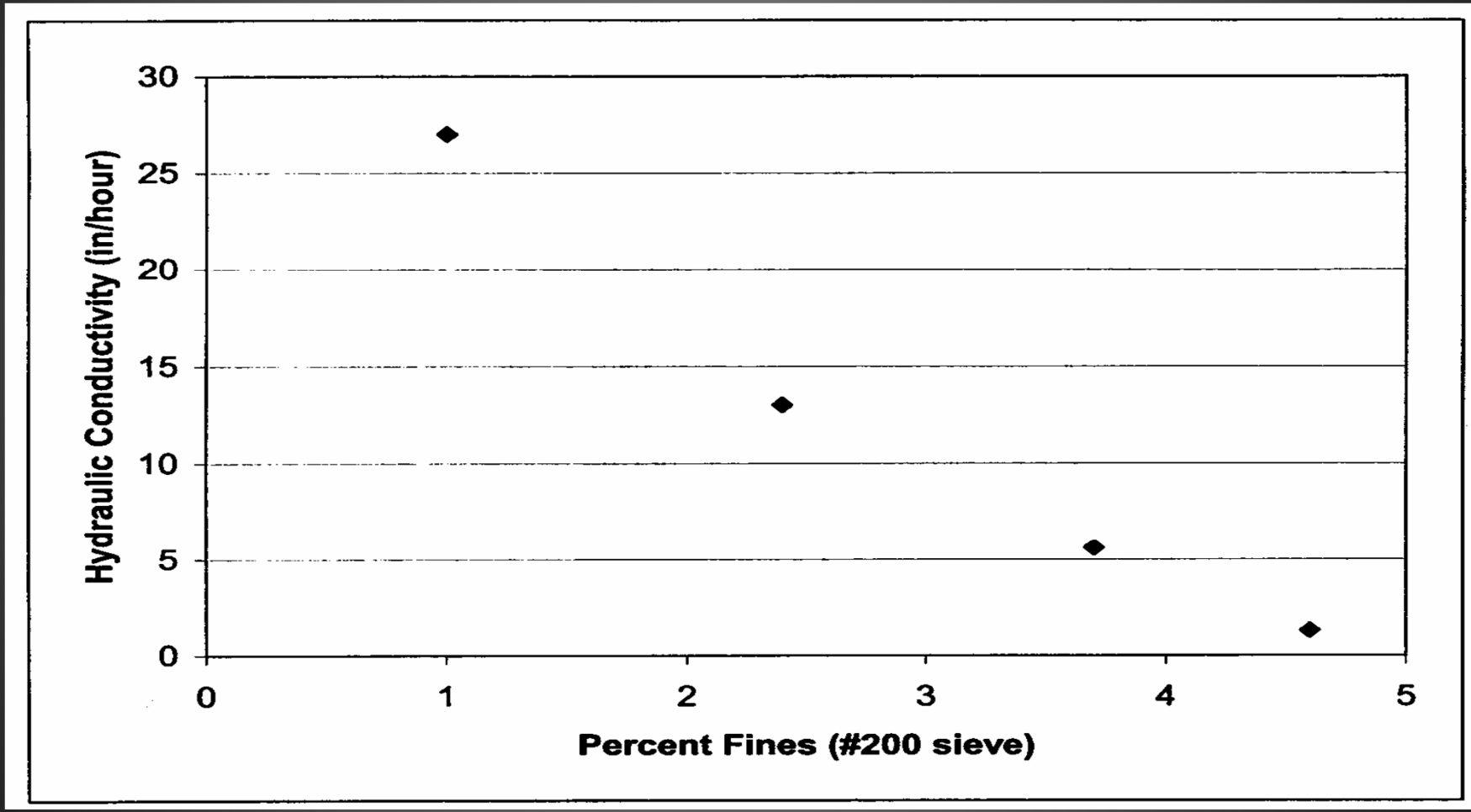
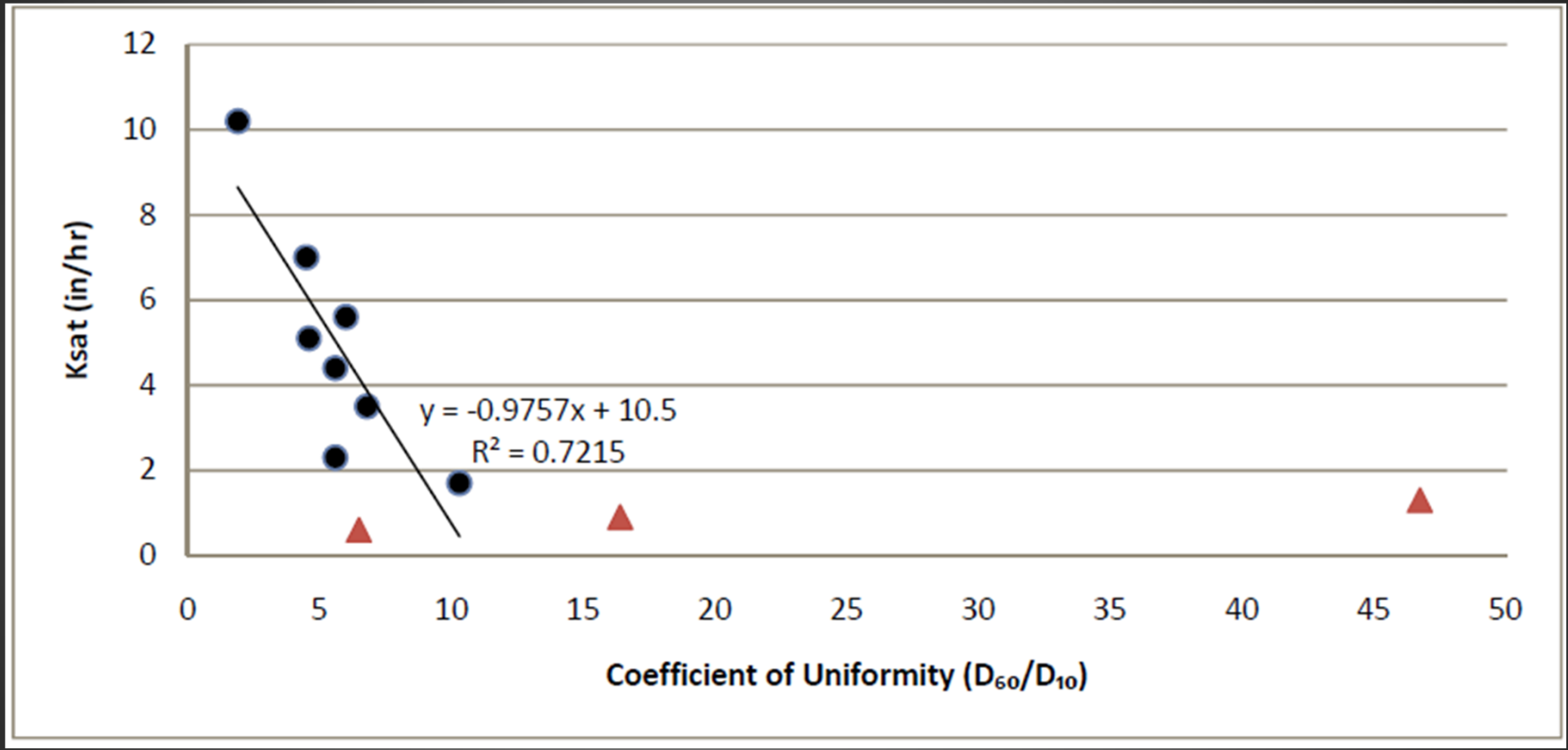
Initial tests: hydraulic conductivity strongly related to percent fines (passing #200 sieve)



Second tests: hydraulic conductivity strongly related to coefficient of uniformity



The coefficient of Uniformity is a measure of variation in particle sizes of mineral aggregate. The coefficient is defined as the ratio of the sieve size that will permit passage of 60% of the mineral aggregate by weight to the sieve size that will permit passage of 10% of the mineral aggregate by weight

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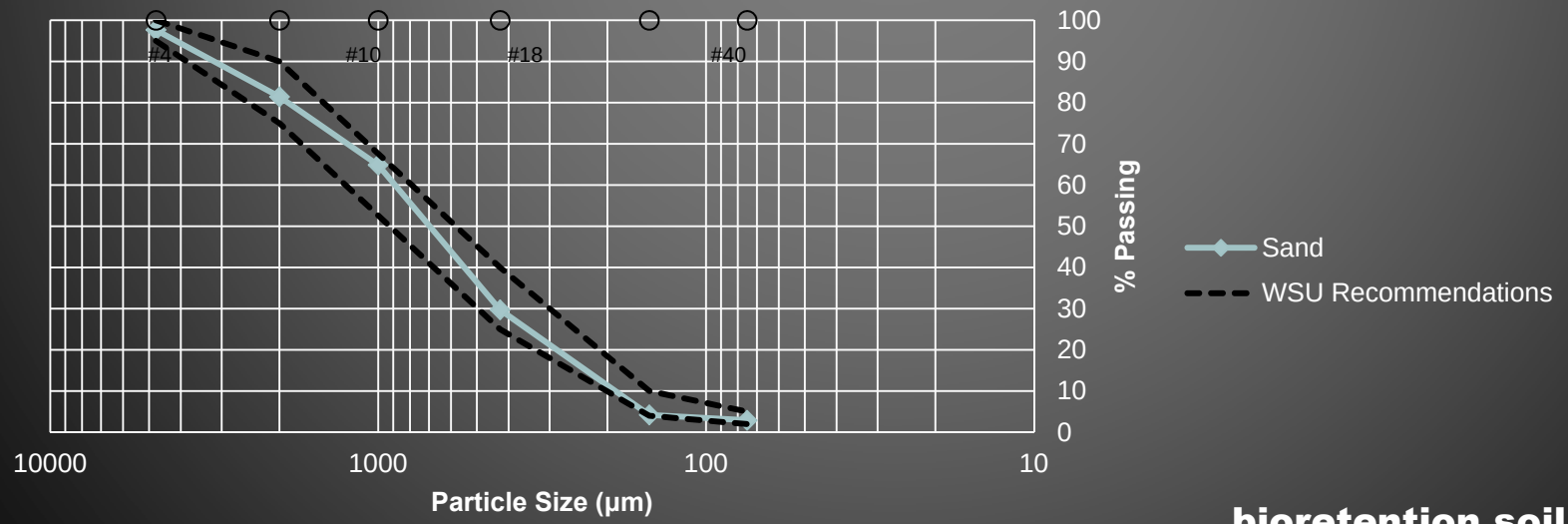
Mineral aggregate specification

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

The following gradation provides a consistent Ksat and CU for bioretention soil mixes…is the primary mineral aggregate spec in 2012 LID manual and prescribed by Ecology.



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Infiltration rates: methods and correction factors for sizing bioretention areas

- The accepted/optimum infiltration rate for bioretention areas is between 1 and 12 inches per hour.
- Determining long-term infiltration rate for sizing and flow control capacity.
  - 1 in/hr minimum for acceptable ponding and system de-watering in typical setting (long-term hydraulic conductivity per ASTM D 2434 at 85% compaction per ASTM D 1557).
  - If contributing area has <5,000 ft^2 of PGS; and <10,000 ft^2 TIA; and < ¾ acre landscaping then use correction factor of 2.
  - If over the above thresholds use correction factor of 4.

Infiltration rates: methods and correction factors for sizing bioretention areas

- The accepted/optimum infiltration rate for bioretention areas is between 1 and 12 inches per hour.
- Determining sizing and water quality treatment flow rates.
  - 2.4 in/hr was maximum rate…guideline likely established for existing native soils not designed soil mixes.
  - Research indicates that higher infiltration rates provide performance necessary to meet DOE enhanced treatment.
  - DOE now accepts maximum measured (initial) WQ treatment rate of 12 in/hr with an OM content of 5-8% by weight, CEC ≥ 5 milliequivalents/100 grams dry soil, 2-5% mineral fines content, and 18” minimum soil depth.
  - Apply same correction factor as for flow control capacity.

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Sandy aggregates and compost provide an effective BSM that will:

- Have high enough hydraulic conductivity (K) to meet draw-down requirements.
- Have low enough K and high enough CEC and provide excellent Zn, hydrocarbon, organic and bacteria removal.

However:

- Sandy compost media may export nitrate, phosphate and Cu from under-drains.
- There needs to be some fines for effective pollutant removal, healthy plant growth and appropriate K.

Recent Updates and Recommendations

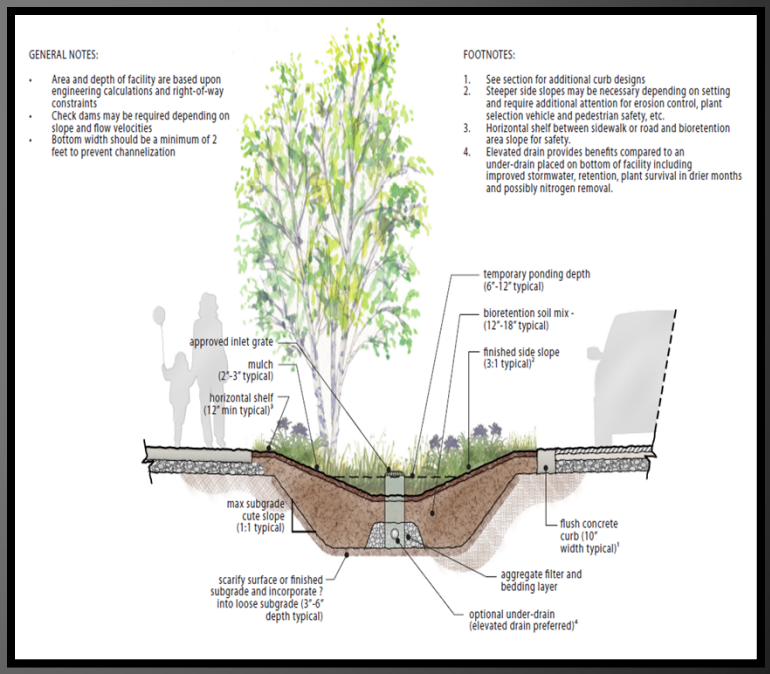
- Recommended modifications to permeability testing (ASTM 2434) of bioretention soil media.
- If 60% aggregate/40% compost specification in LID manual followed then use a measured Ksat of 6”/hr (1.4” to 3”/hr depending on correction factor).
- Initial results of new blends (less compost and amendments (60-15-15-10) with saturated zone show promise for reduced nitrate and phosphate export.
- Previous recommendation of 10% OM content too high. Current recommendation 4 or 5% to 8% max.

Recommendations

- Sandy bioretention soil mixes should provide excellent water quality performance. Design with caution for systems with under-drains in P and N sensitive basins.
- Also important: coefficient of Uniformity (Cu) ≥ 4. Cu is the measure of variation in particle sizes of mineral aggregate (D_{60}/D_{10})
- 2 to 4 percent passing the 200 sieve ideal. Fines should not be above 5 percent for a proper functioning specification.
- Small variations in grain size distributions and uniformity can result in large variations in K values.

Recommendations

- Monitor carefully if topsoil used for mineral component.
- Sandy soil mixes are very well drained…select plants carefully.
- Question of best soil mixes for bio-available P retention unresolved. Increasing depth likely improves nutrient removal. New mixes?
- Saturated zone improves nitrate removal.
- More work needed on Cu capture and retention.



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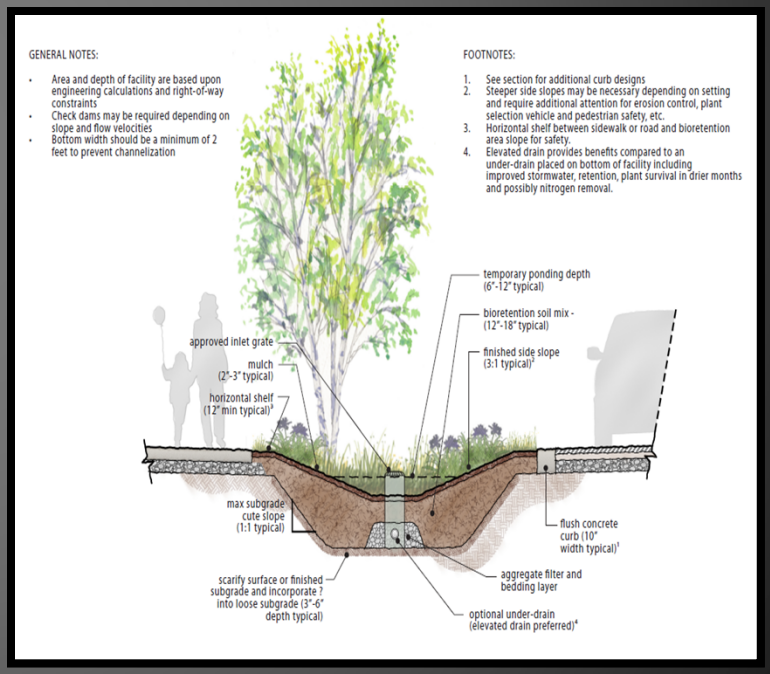
Recommendations

Compost

- Likely that current compost guidelines in WAC did not consider use in stormwater filters.
- Questions remain for best ratio of mineral to compost, feedstock, amendments and age.
- Significant research in progress at WSU to determine optimized media.



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WSU LID Research Program: Bioretention Soils

bioretention: mesocosms

research

- water quality focus.
- 152 cm tanks, same plant palette.
- various bioretention soil mixes to optimize for metals, hydrocarbon, bacteria, organics, as well P and N management.
- hydraulic soil properties.

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Application

- Mixing on-site vs. importing depends on existing soil type, working area and time of year.
- Do not compact subgrade. Till subgrade and incorporate compost before BSM placement. Place soil in 12” lifts with machinery adjacent to facility.
- 12” minimum soil depth generally and 18” minimum depth for WQ treatment recommended.
- Do not place or work if soil is saturated.
- Settling: allow to settle naturally, boot pack lifts or water lifts until just saturated (~85% compaction effort).