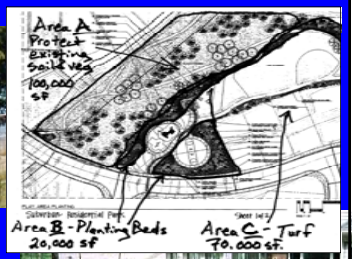
The Science and Practice of Sustainable Sites:

Practical Implementation of Soil Protection & Restoration



David McDonald – Seattle Public Utilities
Howard Stenn – Stenn Design
Jim Berger – Port Blakely Communities

9/27/2011 seminar sponsored by the WA Chapter of the American Society of Landscape Architects, UW Botanic Gardens, and Seattle Public Utilities

1

Why a Soil Standard? – **Multiple Benefits**

Environmental/sustainability benefits
- Protect/restore stormwater infiltration
- Bio-filtration of urban pollutants – protect waterways
- Protect existing vegetation, improve tree & plant growth
- Reusing organic "wastes" to restore soil function
- Reduced irrigation use, less need for fertilizers & pesticides

Value to builder/contractor
- Quicker planting in prepped soil
- Less plant loss = fewer callbacks
- Better appearance sells next job

Value to property owner
- Better plant health & appearance
- Lower water bills
- Reduced chemical needs
- Lower maintenance costs

2

Sustainable Sites Initiative (SITES™) Rating System

- Prereq. 1.1 Protect farmland soils
- Credit 1.5 Select brown/grey-fields
- Prereq. 2.1 Conduct pre-design site assessment (incl. soil)
- Prereq. 2.2 Use integrated site development process
- Credit 4.4 Minimize soil disturbance (minimize grading)
- **Prereq. 4.3 Create a Soil Management Plan**
- **Prereq. 7.2 Restore soils disturbed during construction**
- Credit 7.3 Restore soils disturbed by previous development
- Prereq. 8.1 Plan for sustainable site maintenance
- Credit 8.3 Recycle organic matter in operations & maintenance

www.sustainablesites.org

WA State "Post Construction Soil Quality & Depth" BMP

in Dept. of Ecology Stormwater Manual; coming into local codes

- Soil management plan showing areas to be protected, or disturbed & restored, and soil/compost/mulch import amounts for each area
- Keep all impacts off protected veg. & soil areas
- Restore disturbed areas by amending with compost, stockpiling & reusing topsoil, or importing amended soil. Scarify subsoil, for 12" uncompacted depth.
- Mulch, and Maintain to replenish organic content.

www.buildingsoil.org

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Summary of Soil Best Management Practices

New Construction
- ➢ Retain and protect native topsoil & vegetation (esp. trees!)
  - Choose sites to conserve good quality existing veg. & soil
  - Minimize construction footprint
  - Establish veg. & soil protection zones - fence & protect
  - Store and reuse topsoil from site
  - Retain "buffer" vegetation along waterways
- ➢ Restore disturbed soils by tilling 2-4" of compost into upper 8-12" of soil. Rip to loosen compacted layers.

Existing Landscapes
- Retrofit soils with tilled-in compost when re-landscaping
- Mulch beds with organic mulches (leaves, wood chips, compost), topdress turf with compost, and mulch-mow to maintain organic content that supports soil ecosystem.

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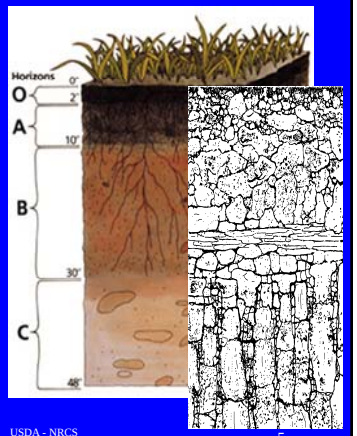
Understanding Soil:
development from parent "dirt" & rock

Soil horizons & their evolution

- Substratum (C) or bedrock (R) weathers physically & chemically to subsoil (B)
- Primarily biological processes create topsoil (A) and organic (O) horizons



USDA - NRCS

http://soils.usda.gov

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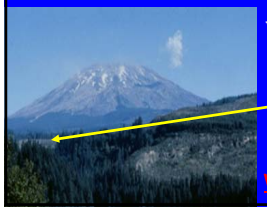
Sub-Soils in the Puget Sound Basin:
Leftovers from glaciers & volcanoes

glacial till: unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders; deposited under ice, or in moraines

hardpan: till compacted under glacier

outwash soils: layers sorted by particle size by water - sand / gravel / rocks

lake/marine bed soils: clay or silt that settled out in lakes & estuaries



volcanic ash: light, fertile, holds moisture - mostly blown east of Cascades

mudflows: mixed size, compact - like till

Learn about Puget Sound soils at:
www.puyallup.wsu.edu/soilmgmt/Soils.htm

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Glacial till

- May be piled, uncompressed and unsorted, in *moraines* at edge or terminus of glacier

- *Basal till* from under the glacier (1/2 mile of ice over Seattle!) has been compressed into **hardpan**
- Good for foundations, but low permeability and hard for roots to penetrate

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Glacial outwash

- May be sorted boulders, gravel
- …sand and fines…..
- Or a mix!

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Lake beds, lenses, and layers

- Silts and clays settle out…
- And then may be overlain in lenses with sand or gravel from succeeding outwash
- Grey-yellow color when saturated and anaerobic
- Great for farming, (best nutrient capacity) but unstable in slopes or foundations!

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Volcanic ash or mudflows

- *Tephra* (ash) – light, fertile, holds moisture, erodable
- Mudflow – compact, mixed fines and boulders, low permeability, looks and acts like basal till, but more fertile

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Alluvial soils

- Flat, loamy deposits in river floodplains (or ancient rivers)
- Best for farming, often wasted on development because they're flat

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Layers upon layers…

ignore them at your peril!

- Sandy outwash over compacted basal till hardpan
- Thin soil over bedrock
- Clay lenses over hardpan, or inter-layered with sand (unstable!)

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Disturbed soils in urban areas

- **Topsoil layer removed**
- **Compaction**
- **Subsoil (or worse) fill layers.**
- **Debris or toxins?**

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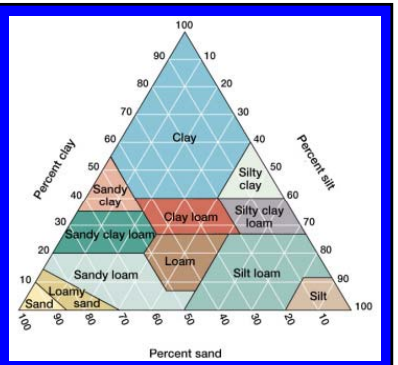
Soil Texture
= mineral particle size
(sand and finer particles)



Ribbon + feel test:

Moisten soil, roll between hands, then squeeze out with thumb

- Sand: no ribbon, grainy
- Sandy loam: ½ inch ribbon
- Loam: thick 1 inch ribbon
- Silt: makes flakes rather than ribbon
- Silty clay loam: thin, breaks easily, floury feel
- Sandy clay loam: stronger, grainy
- Clay: long (3 inch) ribbon, smooth feel

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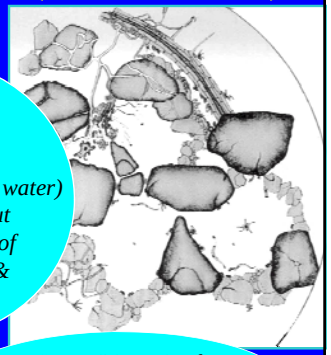
Understanding soil:
texture, structure, & pore space (thus infiltration)

Soil components:

- "The Dirt" (mineral part)
  - sand
  - silt
  - clay
- Air and Water
- Organic Matter and Soil Life (create aggregates & pores)

Good soil is about
- half mineral
- half space (air & water)
- plus a smaller but essential amount of organic matter & soil life



"Loam" is a mix of sand, silt, clay and organic, formed over time by nature

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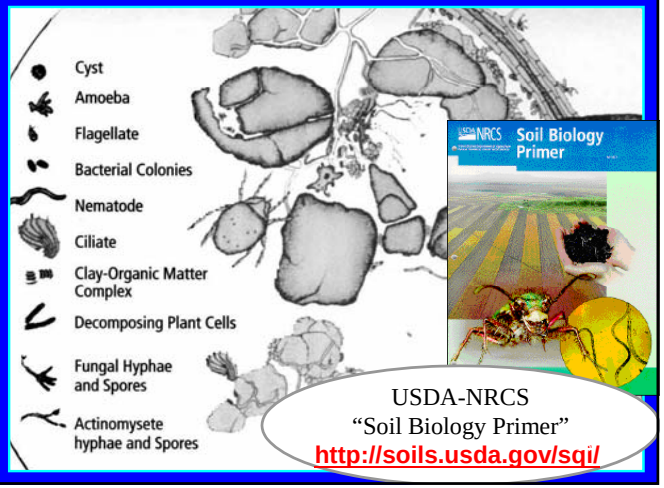
Understanding Soil Biology
Soil life provides essential functions

Soil is alive!

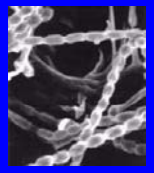


S. Rose & E.T. Elliott

USDA-NRCS
"Soil Biology Primer"
http://soils.usda.gov/sqi/

Common organisms in the soil foodweb

- Bacteria

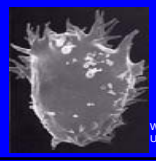


- Fungi

Paul R. August, University of Minn

Soil Foodweb Inc.

- Protozoa



Wilhelm Foissner, University of Salzburg

- Nematodes

Soil Foodweb Inc.

- Arthropods

SSSA

- Earthworms

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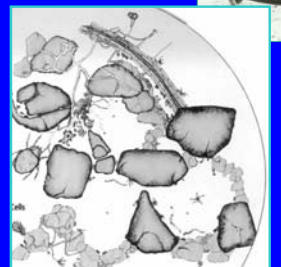
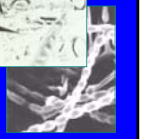
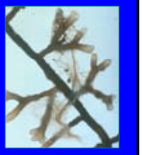
Restoring soil life, to restore soil functions

Soil organisms create:

- soil structure
- fertility = nutrient cycling
- plant disease protection
- biofiltration
- erosion control
- stormwater detention







Compost kickstarts the soil ecosystem!
(Provides food and home for organisms)

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How does soil life create soil structure?

- Bacteria secretions glue clays, silts and sands together into micro-aggregates.
- Micro-aggregates are bound together by fungal hyphae, root hairs and roots.
- Spaces are made by moving arthropods & earthworms, and decaying roots.
- Only when all organisms are present can roots and water move into the soil with ease.

S. Rose & E.T. Elliott

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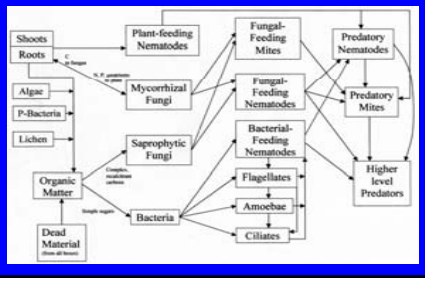
How does soil life provide fertility (nutrient cycling)?

- Soil foodweb stores nutrients in living & dead organic matter
- Nutrients are released in root zone as organisms eat and excrete “waste” (nitrogen, etc.)
- Mycorrhizal fungi bring nutrients and water to roots of plants



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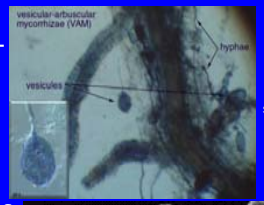
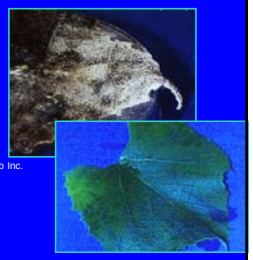
Dr. Michael P. Amaranthus. Mycorrhizal Applications Inc.

How does soil life provide plant disease protection?

Diversity ⇒ predation, parasitization & competition with the few disease-causing organisms

- Bacteria cover leaf surfaces, block infection
- Ecto- and endo-mycorrhizae prevent root infection
- Many organisms prey on the few disease-causing organisms





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How does soil life filter out urban pollutants?

- Creates structure
- Breaks down hydrocarbons, pesticides
- Converts fertilizers to stable forms, so they are available to plants but won't wash away
- Binds heavy metals in soil, so they don't wash into streams

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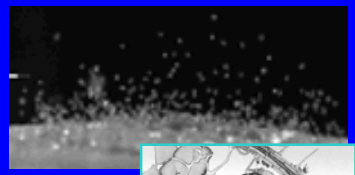
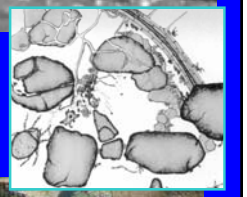
How does soil life control erosion?

- Creates pore spaces, increases infiltration
- Sticks soil particles & aggregates together with bacterial slime, fungal hyphae, & root hairs (bigger aggregates are harder to move)
  → "aggregate stability"
- Promotes rapid plant growth & deep root development





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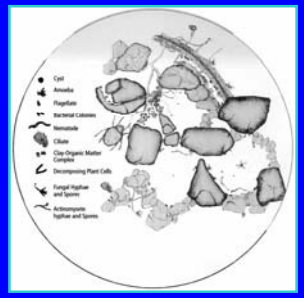
How does soil life provide stormwater detention / infiltration?

- Builds soil structure, moisture-holding capacity
- Increases surface porosity



UW trials, turf on glacial till soil

Compost-amended till soil – up to 50% reduction in storm water runoff

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How can we enhance & restore soil biodiversity, to improve plant growth, water quality, and reduce runoff?

- Protect existing soil & vegetation where possible
- Prevent /reduce compaction (keep heavy machinery off)
- Reduce intensive use of pesticides & soluble fertilizers
- Incorporate compost into soil to feed soil life

organic matter + soil organisms + time
creates ⇒
soil structure, biofiltration, fertility, & stormwater detention

Site selection & planning to protect good soils

- Select previously disturbed sites instead of greenfields.
- Infill to enhance communities, connect with transit.
- Start early to identify site values, and locate development on site to maximize protection of best soils, trees, habitat, natural drainage, etc. Involve arborists, soil & habitat experts. Sell these values to developers/ decision makers.
- Plan to minimize grading, soil export/import.

THE SUSTAINABLE SITES INITIATIVE

Select locations to preserve existing resources and repair damaged systems

Prerequisite 1.1: Limit development of soils designated as prime farmland, unique farmland, and farmland of statewide importance
Prerequisite 1.2: Protect floodplain functions
Prerequisite 1.3: Preserve wetlands
Prerequisite 1.4: Preserve threatened or endangered species and their habitats
Credit 1.5: Select brownfields or greyfields for redevelopment (5–10 points)
Credit 1.6: Select sites within existing communities (6 points)
Credit 1.7: Select sites that encourage non-motorized transportation and use of public transit (5 points)

Protecting soil & vegetation during construction

- Fence ***vegetation & soil protection zones***
- Inform all contractors & subs: no stockpiling, trailers, etc.
- If temporary vehicle access required, place steel plates over 6” coarse wood chip.

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Street tree protection measures in action

Box trunks, protect root zones from compaction

- Avoiding cutting roots – by using air spade & vactor, or boring to place conduits.

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Sustainable Sites soil requirement: THE SUSTAINABLE SITES INITIATIVE

Prereq. 7.2 Restore soils disturbed during construction

Ecology *Stormwater Mgmt. Manual for Western WA*:

BMP T5.13 Post-Construction Soil Quality and Depth

- Retain & protect native soil and vegetation wherever possible
- Areas cleared or graded required to restore min. soil depth:
  - Organic matter content (SITES ≥ 3%; Ecology ≥ 10% planting beds, 5% for turf – driven by stormwater performance in NW)
  - SITES: ≥ 12-inch amended soil depth. Use native topsoil, amend existing soil with compost, or import topsoil blend.
  - Ecology: Subsoil scarified 4 inches below 8-inch amended soil, for 12" finished uncompacted depth
  - Protect amended soil from compaction
  - Mulch after planting
  - Maintenance practices to replenish organic content

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Manual for Implementing BMP T5.13

- also referenced by SITES 4.3 Soil Mgmt. Plan and 7.2 Restore Soils Disturbed by Construction

- Manual developed regionally with experts
- Develop a "Soil Management Plan" for each site
- Four options for soil management (can use 1 or more / site):
  1) Retain undisturbed native soil & vegetation, protect from compaction
  2) Amend existing soil in place with compost
  3) Stockpile topsoil prior to grading, and reuse on site (amend if needed)
  4) Import topsoil meeting organic matter content requirements
- Choose pre-approved or custom calculated amendment rates
- Simple field inspection and verification procedures

Available www.soilsforsalmon.org or www.buildingsoil.org

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How to Select Compost

Know your supplier!

- Field tests:
  - earthy smell - not sour, stinky, or ammonia
  - brown to black color
  - uniform particle range
  - stable temperature (does not get very hot if re-wetted)
  - not powdery or soaking wet
- Soil/compost lab test info:
  - Nutrients
  - Salinity
  - pH
  - % organic content (OM)
- Mfr.-supplied info:
  - Permitted WA composting facility – meets WAC 173-350 requirements
  - Meets US Compost Council (STA) "Seal of Testing Assurance"
  - C:N ratio
  - Weed-seed trials
  - Nutrients, salinity, contaminants
  - Size: "screen", % fines

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Carbon to Nitrogen ratio of composts

- For turf & most landscapes
  C:N ratio of 20:1 to 25:1 - good nutrient availability for first year of growth (no other fertilizer needed)
- For native plants and trees
  C:N ratio of 30:1 to 35:1, and coarser (1" minus screen)
  - less Nitrogen better for NW natives, discourages weeds
  - for streamside, unlikely to leach nitrogen

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Clearing up the confusion about **"% organic"**

"% Soil Organic Matter Content" in lab soil tests is by loss-on-ignition method

- Most composts are 40-60% organic content by this method ?

Recommended soil amendment rates
(for low-organic soils or sand-compost topsoil mixes):

- 5% Soil Organic Matter Content for Turf
  =15-25% compost amendment by volume
- 10% Soil Organic Matter Content for Landscape Beds
  =30-40% compost amendment by volume

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Compost Application Methods

Compost application & incorporation methods:

- Blowing
- Spreading
- Tilling / ripping
- Blending off-site

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Blowing & spreading

- Blower trucks
- Various construction grading equipment
- Other equipment : golf course & farm spreaders

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Issaquah Highlands – the big scale

PORT BLAKELY COMMUNITIES

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Incorporating amendments into soil

- Range of equipment for different-sized sites
- Till in to 8” depth
- If compacted, rip to 12” depth before/while amending




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Stockpile site soils & amend, after road & foundation work

- Allows mass grading
- Can reduce hauling & disposal costs
- Set grade to allow re-application of topsoil & allow for settling
- Amend stockpile to spec offsite, or after reapplication
- Spread after concrete work
- Rip in first lift, to reduce sub-grade compaction



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Importing “Topsoil”

- “Topsoil” is not a defined, regulated product. Topsoil products often include subsoil, uncomposted organic material, land-clearing and construction debris…
- Best to use mixes containing only clean compost and mined sand or “sandy loam” as defined by USDA.
- Important to avoid clay that can inhibit drainage – spec <5% passing #200 sieve
- See Seattle/WSU/PSP “Bioretention Soil” specification at www.seattle.gov/util/GreenInfrastructure

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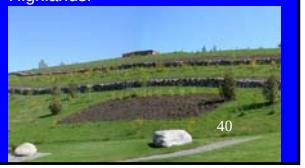
Compost Based Erosion Control BMPs

- EPA-approved BMPs: **blankets**, **berms**, and **socks** see www.buildingsoil.org
- “2 for 1” – use compost for erosion control, then till in at end to meet soil BMP:
  - No disposal costs
  - Faster planting, better growth
- Costs: blankets similar to rolled products, but savings on disposal, plus 2 for 1 benefits



“2 for 1” – construction erosion control and soil quality BMPs are met with compost at Issaquah Highlands.



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Combine methods as needed for best water quality and flow control

WsDOT - Protecting Wetland Area from I-5 Runoff

MULCHING: after planting, & annual maintenance

BENEFITS OF MULCHES:

- Limit weed growth, & make weeds that sprout easy to pull.
- Conserve water, moderate soil temperature, and reduce erosion.
- Replenish soil organic matter, enhancing soil biodiversity, structure, and nutrient cycling = increased plant vigor.

WHAT: Arborist Wood Chip Mulch is best – see spec **9-14.4(5)**

www.seattle.gov/util/Engineering/Standard_Plans_&_Specs/index.asp

- Bark can inhibit air & water, doesn't build soil
- Coarse compost builds soil but doesn't suppress weeds.

HOW MUCH: 2-4 inches wood chips, replenish annually until plant canopy closes.

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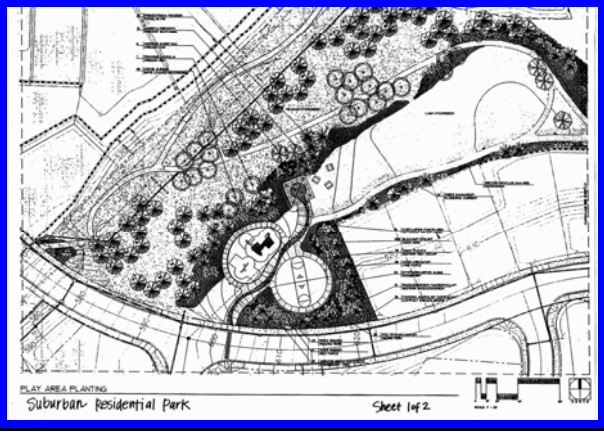
Developing A Soil Management Plan (SMP)

- A scale-drawing identifying areas where each soil treatment option will be applied.
- A completed SMP form identifying treatment options, amendment products and calculated application rates for each area.
- Copies of laboratory analyses for compost and topsoil products to be used, with OM content and C:N

1: Review Landscape and Grading Plans

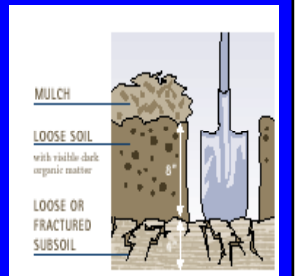
Working with plans, check the soil in each area to assess how grading will impact soil conditions and potential for reuse of topsoil excavated for building foundations, stormwater detention facilities and pavement.



Soil Treatment Options	Amendment Rate Options
Option 1. Retain undisturbed native vegetation and soil, and protect from compaction during construction. **Option 2. Amend** existing soil at pre-approved or custom calculated rates based on soil and amendment tests. **Option 3. Import** topsoil mix of sufficient organic content and depth. **Option 4a. Stockpile** native topsoil during grading, and reapply after construction. (import soil if needed to achieve depth). **Option 4b. Amend stockpiled** soil if needed to meet 5-10% o.m.	**SITES™:** Min. 3% OM = 1.5" compost into 12" soil **WA DOE:** **Pre-approved Amendment Rate** Turf: Mix 1.75 compost into 8" soil. Beds: Mix 3" compost in to 8" soil. **Pre-Approved Topsoil Import Rate** Place 8 inches of topsoil (or enough to provide 8 inch depth with existing soil). Turf: 5% OM = 20-25% compost + 75-80% sand or loam. Beds: 10% OM = 35-40% compost + 60-65% sand or loam. **Custom-Calculated Rate** Test soil and amendment for organic content and density to determine amendment rate needed to achieve organic content

2. Identify Areas Suitable for Each Option

- Establish ***vegetation and soil protection zones*** where "native" plants and duff– will be left undisturbed and protected from compaction during construction.
- Excavated or graded topsoil suitable for stockpiling and reuse on site.
- Compacted layers less than 12 inches deep (after grading) – require scarification or soil import.
- Existing organic content in soil to be retained or stockpiled and reapplied – reduced amendment rate.



3. Tests to Conduct for Custom Calculated Amendment Rates

If planning to use calculated amendment rate, sample and test soil. Request compost test results from supplier.

Soil
- Bulk density
- Percent organic matter

Compost
- Bulk density
- Percent organic matter
- Moisture content
- Carbon to nitrogen ratio

Sampling and calculations must be performed by licensed Soil Scientist, Geologist, Civil Engineer or Landscape Architect.

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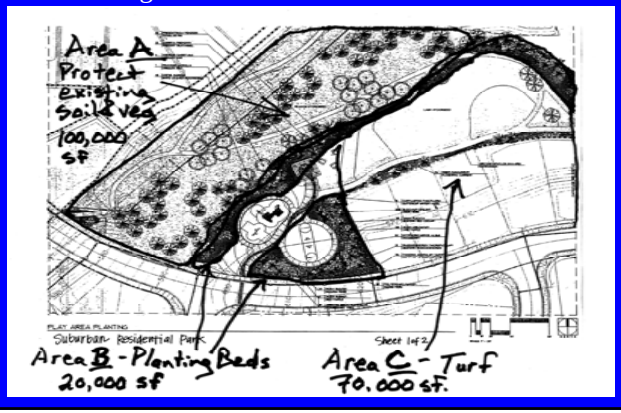
4. Select Amendment Options

Outline areas where each amendment option will be applied on plan. Assign each area a letter (A, B, C…) on the plan and Soil Management Plan form.



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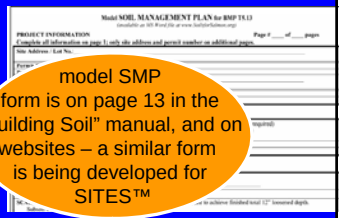
5. Calculate Amendment, Topsoil & Mulch Volumes on Soil Management Plan Form

- **For Pre-Approved Amendment Rates:** Calculate the square footage of each area, and complete calculations for each area to convert inches of amendment into cubic yards.
- **To Compute Custom Calculated Amendment Rates:** Use soil and amendment test results, and the *Model Amendment Rate Calculator*.
- List products on the Soil Management Plan form.
- Procure recent product test sheets showing that compost or other organic materials specified meet requirements.



model SMP form is on page 13 in the "Building Soil" manual, and on websites – a similar form is being developed for SITES™

Amendment calculators at:
www.buildingsoil.org
www.soilsforsalmon.org

or (King County example)
http://your.kingcounty.gov/solidwaste/compost_calculator.htm

or (Seattle soil amendment std. plan)
http://www.seattle.gov/dpd/Codes/StormwaterCode/Forms/

Verification of Post-Construction Soil Quality and Depth BMP

Inspections

Verification

Dispute Resolution

Who Will Verify BMP?

Primary

- Code Enforcement Inspector
- May be assigned to Licensed Landscape Architect

Independent Inspection to Resolve Disputes

- Certified Soil Scientist, Crop Advisor or Agronomist
- Licensed Landscape Architect, Civil Engineer or Geologist

Suggested Inspection Procedures

- **Pre-Grading Inspection**
- **Grading Progress Inspection**
- **Post-Construction Inspection**
- **Mulch Verification**

Exact number of inspections will vary between jurisdictions and project type.

Example verification forms at www.soilsforsalmon.org


Field Verification Form

Suggested Inspection Procedures

- **Pre-Grading Inspection**
- **Grading Progress Inspection**
- **Post-Construction Inspection**
- **Mulch Verification**

Exact number of inspections will vary between jurisdictions and project type.

Example verification forms at www.soilsforsalmon.org


Field Verification Form

Inspection / Verification Supplies

- Field Verification Form
- Soil Management Plan
- Site drawing
- Shovel
- Tape measure

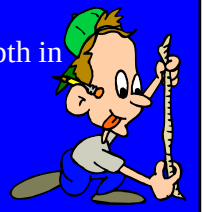


Pre-Grading / Grading Progress Inspection

- Verify native soils & vegetation delineation and protection per SMP
- Review SMP with general contractor and/or grading equipment operator
- Verify erosion controls in place
- Verify excavation & stockpiling of native soils consistent with SMP
- Check sub-grades consistent with SMP

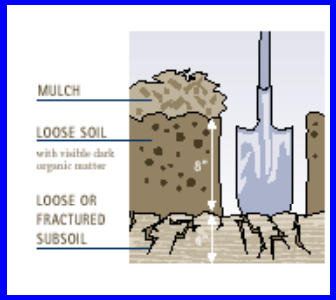
Post Construction (prior to planting)

- Compare conditions to SMP / drawings
- Confirm volumes on amendment delivery tickets match approved SMP
- Dig test holes to check depth of amended soil & scarification
- Use shovel test to check uncompacted depth in multiple locations



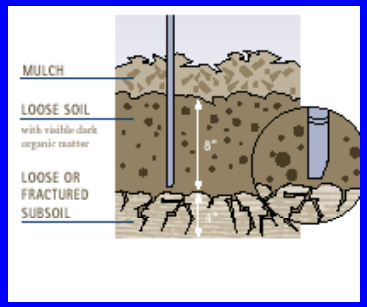
Dig Test Holes to Check Depth of Amended Soil & Scarification

- At least three 12 inch deep test holes (3 per acre minimum) for each treatment
- 8” depth of amended soil (excluding mulch layer)
- Scarified subsoil



Check Soil Depth

- Use shovel or rod “driven only by inspectors weight” to test for compaction
- Test 10 locations per landscaped acre (10 minimum per site).



Dispute Resolution

- Organics verified using Loss On Ignition method
- No analytical method to verify scarification

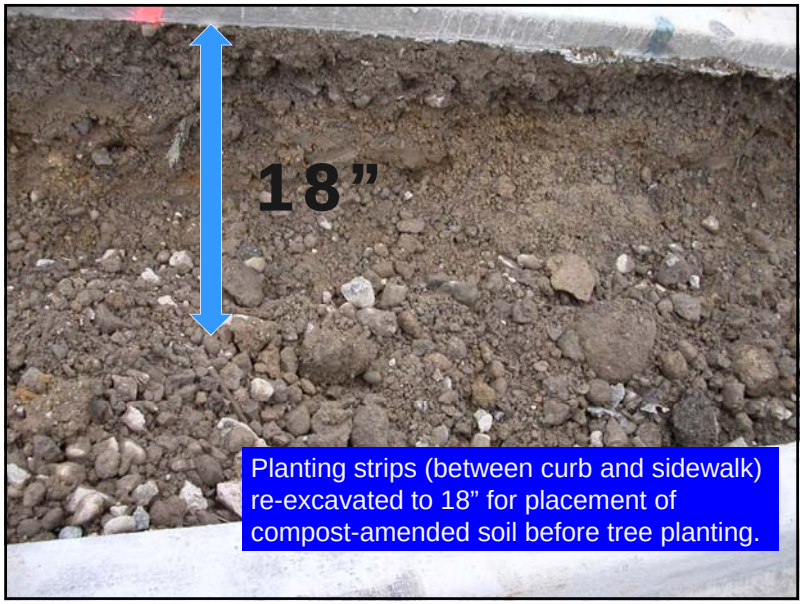
Field Inspection and Verification guide available at www.soilsforsalmon.org (in *Building Soil* manual and as separate PDF)

Issaquah Highlands

1000 ft. elevation change, dense “urban village” development. 700 acres developed, 1400 acres deeded to King County as permanent open space.

Spreading compost on prepared (track-walked) slope.

The next spring. 100% plant cover on compost-amended slope.



Planting strips (between curb and sidewalk) re-excavated to 18” for placement of compost-amended soil before tree planting.

Blowing coarse compost on 2:1 slope.

Repairing erosion with blown-in compost blanket and seed.


Compost blanket protects a steep slope as well as coir fabric over compost – expensive fabric not necessary.

Project Sequencing

- GMA-vs-Soil Conservation
  - GMA mandates higher density
  - Less opportunity for conservation on smaller lots and compact development
  - There may be no native soil & vegetation to conserve
  - Restoration more appropriate?

Soils Planning and Coordination

- Challenges
  - Is the soils plan practical?
    - Dirt Cheap??? Hauling dirt is expensive!
    - Room to stockpile topsoil?
- Cost
  - Stockpile-vs-export/import:
    - Stockpile & reuse is cheaper, if there's room
- Cost of compost
  - Save compared to hauling more topsoil

RESULTS

Park establishment, using amended stockpiled topsoil.

Stormwater pond as amenity: compost-amended soil makes the difference.

Hydroseed and straw mulch: the next spring – no growth.

Same slope, same seed, but applied with compost blanket: next spring – slope's stabilized, job's done.

Compost and seed blown over rock road-cut face: superior erosion protection, and long-term plant success.

The green sells the project. Good soil makes the green.

Construction Sequencing for Soil Protection

Design phase

- Choose site & program to minimize impacts.
- Identify vegetation & soil protection areas; verify they fit into development program and site access routes.
- Identify areas to be graded, and soil restoration options. Calculate compost amendment, topsoil, & mulch on Soil Management Plan.

Site grading through construction phases

- Communicate Soil Management Plan to managers & contractors.
- Fence vegetation & soil protection areas prior to first disturbance.
- Stockpile topsoil to be reused with breathable cover.
- Grade below finish grade to allow placing topsoil/amendments.
- Compost based erosion BMPs can be reused as soil amendment.
- Place rock road bases ASAP and keep vehicle traffic on them.

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Construction Sequencing for Soil Restoration (cont.)

Post construction, pre-planting phase

- Amend all disturbed soil areas or place amended topsoil.
- Avoid tilling through tree roots, or raising soil height on trunk.
- Plan for amended soil to settle, by placing amended soil higher, or retain/import amended topsoil to meet final grades.

After planting, end of project phase

- Remove protection area barriers. Have arborist evaluate trees for stress/ need for remediation.
- Mulch all planting beds (& tree root zones with exposed soil).
- Protect amended/restored soils from compaction.
- Communicate a landscape management plan to property owners.

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Learn More:

- Protect existing soils and vegetation where possible.
- Restore natural functions in disturbed soils, by reducing compaction and using organic amendments.

www.SustainableSites.org

www.BuildingSoil.org

www.SoilsforSalmon.org

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