Soil Improvement for Stormwater Management, Erosion Control, and Landscape Success

David McDonald
Seattle Public Utilities
david.mcdonald@seattle.gov

with slides from

Howard Stenn, Stenn Design
howard@stenndesign.com

Soils for Salmon Project
Washington Organic Recycling Council
www.soilsforsalmon.org www.buildingsoil.org

WSU , UW & DOE Low Impact Development courses
- last updated August 2014

Handouts for this presentation

- **Building Soil**: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Manual for Western WA
  www.soilsforsalmon.org/pdf/Soil_BMP_Manual.pdf

- **Natural Landscaping**: Design, Build, Maintain
  www.buildingsoil.org/tools/Landscaping_Guide.pdf

- **Managing Stormwater Onsite**: LID practices for landscape & building professionals
  www.buildingsoil.org/tools/Managing_Stormwater_Onsite.pdf

Summary of Soil Best Management Practices

New Construction

- Retain and protect native topsoil & vegetation (esp. trees!)
  - Minimize construction footprint
  - 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), and topdress turf with compost
- Avoid overuse of chemicals, which may damage soil life

Building Soil
Foundation for Success

Builders, developers, and landscapers

are adopting practices that preserve and improve the soil on building sites, grow healthier landscapes, and protect waterways. Local governments are beginning to require these practices.

5 Steps to Building Soil

Best management practices (BMPs) during construction:

1. **Retain and protect native topsoil & vegetation where practical**
2. **Restore disturbed soils, to restore healthy soil functions, by:**
   - **stockpiling & reusing good quality site soil, or**
   - **tilling 2-3" of compost into poor site soils, or**
   - **bringing in 8" of compost- amended topsoil**
3. **Loosen compacted subsoil, if needed, by ripping to 12" depth**
4. **Mulch landscape beds after planting**
5. **Protect restored soils from erosion or [illegible] by heavy e**

Why build healthy soil?

- More marketable buildings and landscapes
- Better site erosion control
- Reduced need for water and chemicals
- Less stormwater runoff, better water quality
- Healthy landscapes = satisfied customers

Washington State's stormwater permits require these soil BMPs. That requirement is taking effect locally as towns and counties around Western Washington update their stormwater codes (as required by law). Some jurisdictions already require the soil BMPs – all will soon.

The good news is, it's easy, and customers want it. New home buyers say they are happy to pay more for a healthy, easy to care for landscape – and that starts with the soil.

Successful Project

Learn more about thes

preserving vegetation, stockpiling topsoil

Building Soil
Foundation for Success

amending existing soil with compost

placing compost amended topsoil

Tools for builders

View slide show (PDF 5MB) Why, how-to tips, and successful projects, or brochure

Watch video (on King County's website)

Building Soil Manual
the builder's guide:
– summary (PDF) with links to compost calculator, suppliers, specs, and more
– full Building Soil Manual (PDF, 4MB)

Soil BMP requirements in state and local codes, or text of State BMP (PDF)

Landscaping guide (PDF) Design, building, and maintenance tips for professionals

When to amend? (PDF) Construction sequencing for soil protection and restoration

Erosion control with compost (PDF) Meet your TESC requirements, build healthy soil, work faster, and save money.

Homebuyer factsheet (PDF) Print and use to promote your healthy soil and landscape practices to your customers. It sells!

Learn More – Background, science, specs and resources for designers, and related information are available on our partner website:
www.soilsforsalmon.org

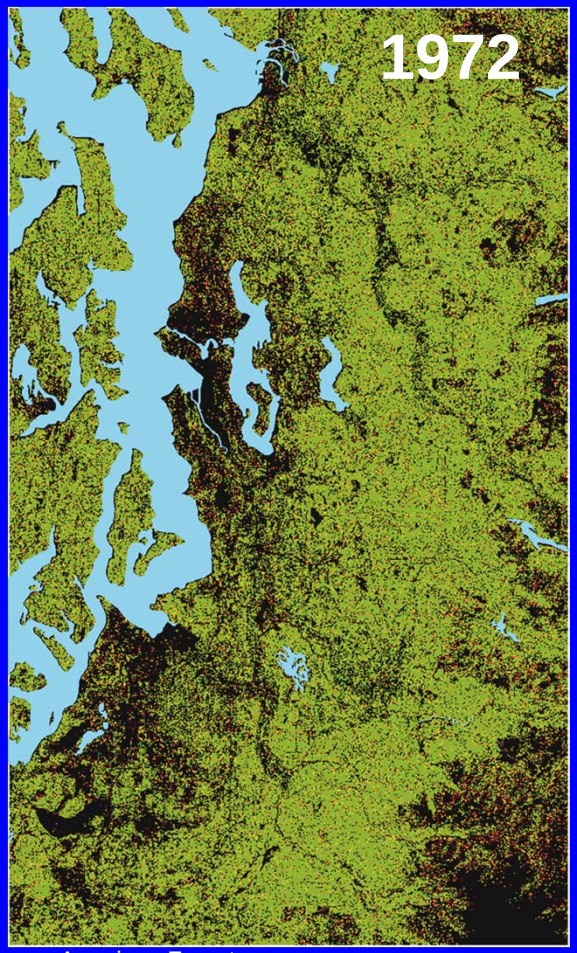
Science and design: www.SoilsforSalmon.org

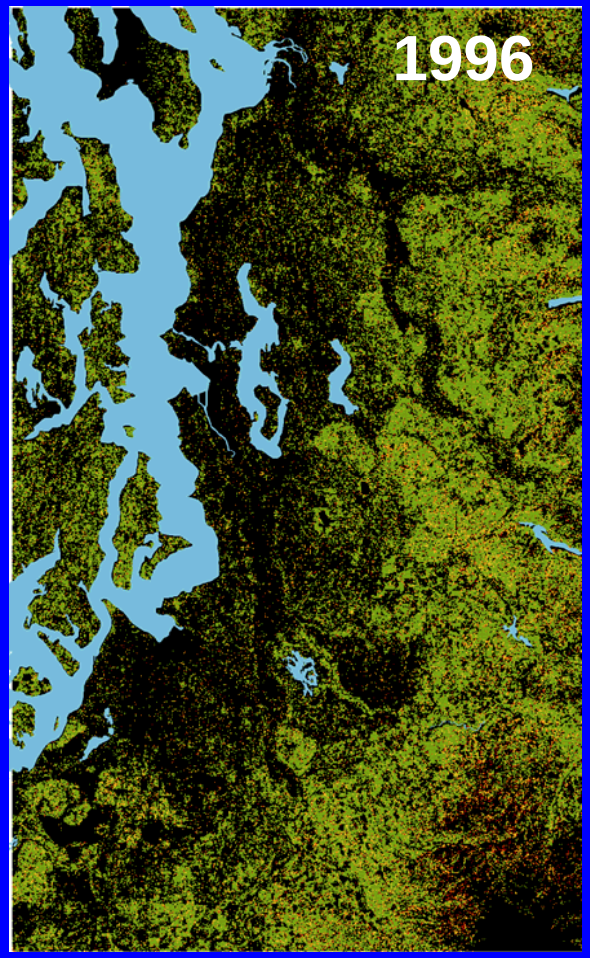
Builder's info: www.BuildingSoil.org

Why a Soil Strategy is Essential: The Connection Between Soil and Water

The Stormwater Problem:
Impacts of turning spongy forests into cities

1972-1996: Amount of land with 50% tree cover decreased by 37% in Puget Sound region (from 42% of land down to 27%).





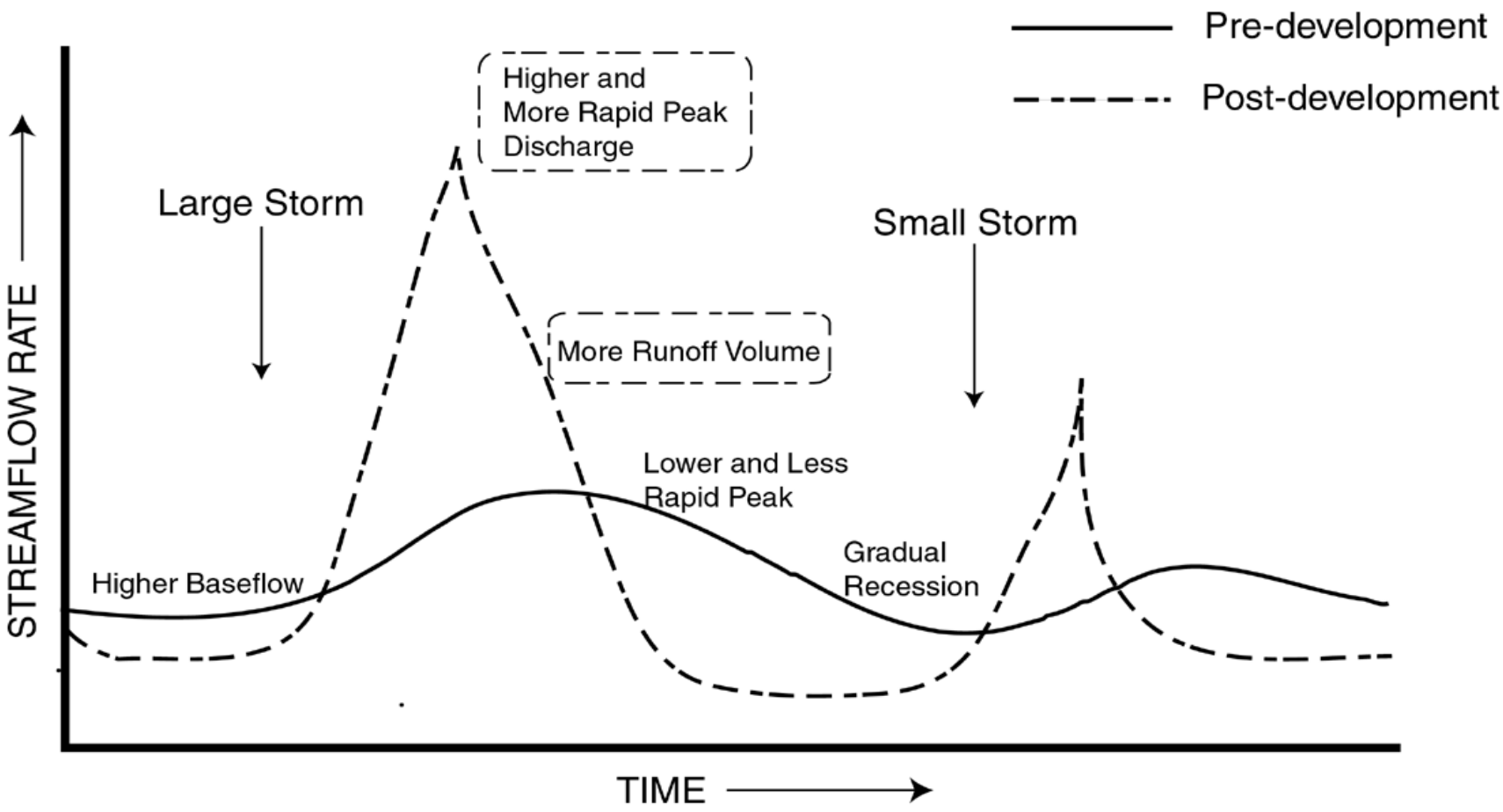
American Forests

Impervious surface increased proportionately.

WA population doubled 1962-1998– more coming.

Our climate is changing – more intense rain events?

Changes in hydrology (runoff vs. infiltration) after development



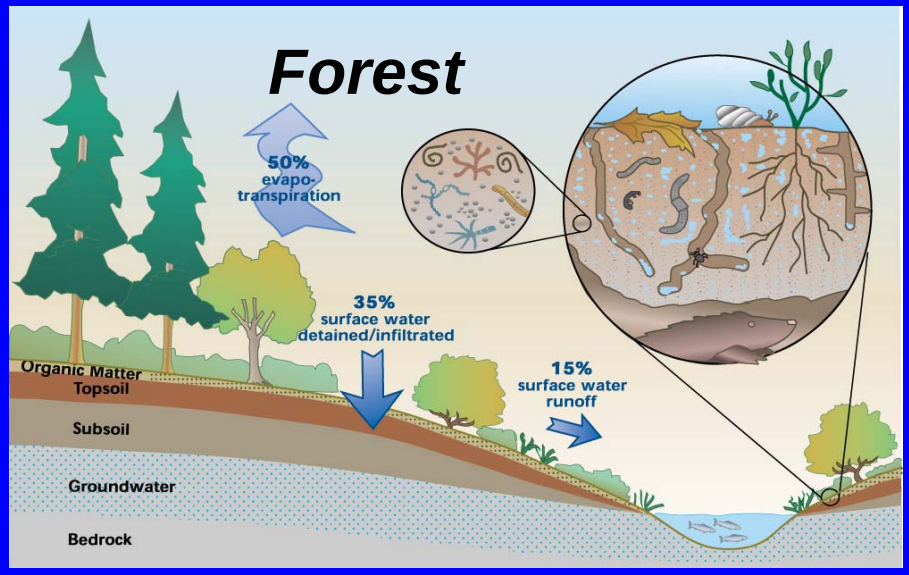
Changes in stream hydrology as a result of urbanization (Schueler, 1992).

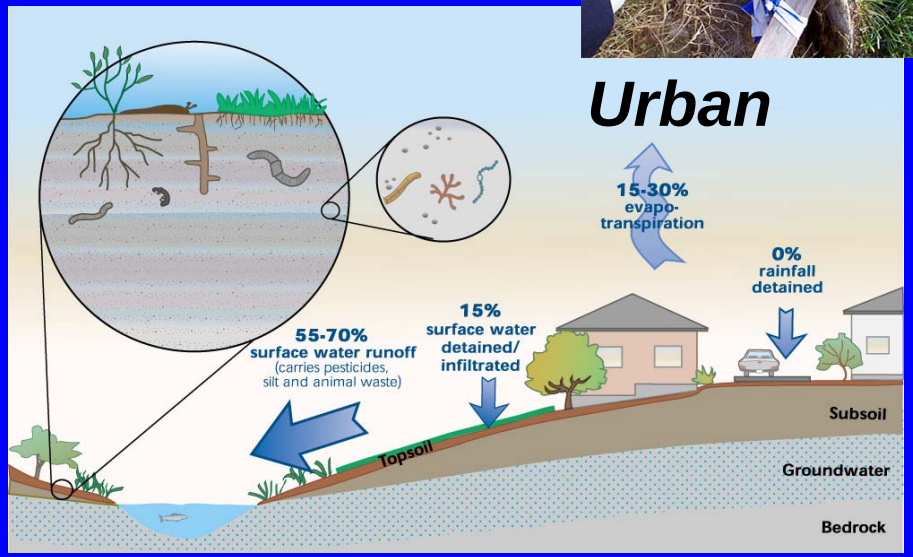
What happens to soils and soil functions as we turn forests into cities?

↑compaction
↑erosion
↑loss of topsoil
↓soil organisms
↓soil structure
↓natural fertility & disease prevention
↑impervious surface

<u>cause:</u>

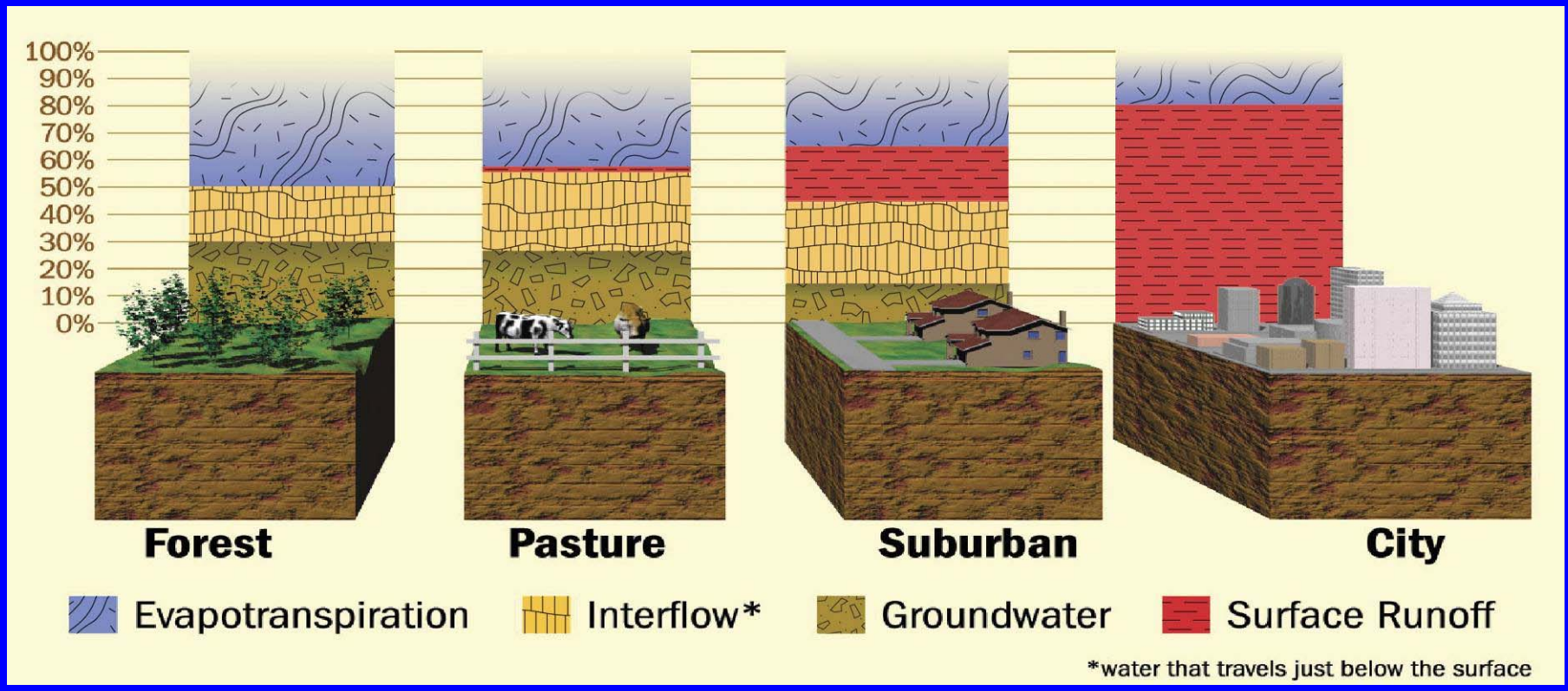
↑winter runoff
↑need for irrigation & chemicals
↓biofiltration of pollutants





www.SoilsforSalmon.org

Where the Rain Goes



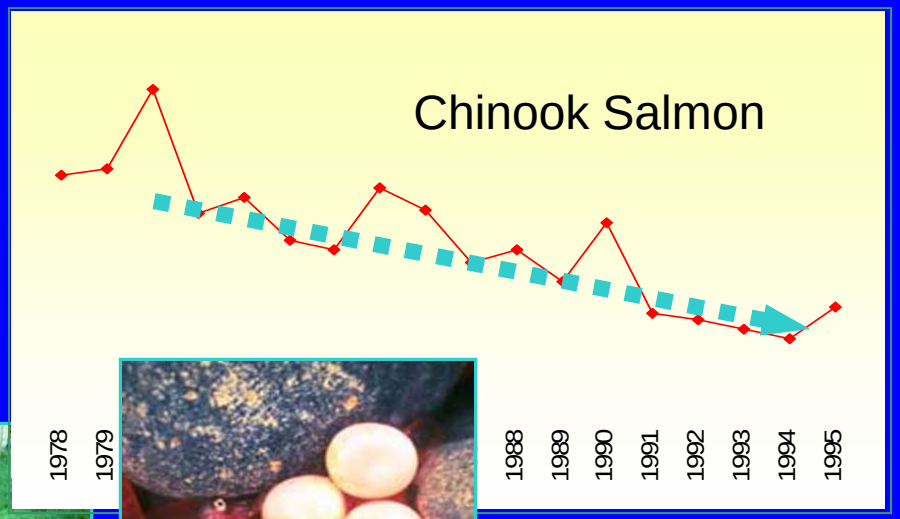
www.SoilsforSalmon.org

What happens to streams as we turn forests into cities?

- ↑**runoff = ↑peak storm flows**
- ↑erosion of stream bank and bed
- ↑fine sediment choking spawning gravels
- ↑pollutants (automotive, landscape fertilizer and pesticides)
- ↓**groundwater recharge**
- ↓summer low flows
- ↑summer stream temperature
- ↓oxygen in spawning gravels
- ↓LWD - logs and rootwads that young salmon need
- ↓food supply for young salmon

What are the impacts?

- Salmon decline
- Pollution
- Erosion
- Flooding & property damage
- Failing landscapes, resulting in more chemical use



What does current science tell us?

- Biological integrity of streams decreases rapidly when total impervious area in watersheds exceeds 5-10%.
- Traditional stormwater detention structures in developed areas are insufficient to prevent storm damage to streams.
- Salmon are in trouble unless we change our development practices.

- We need to:
  - decrease construction footprint
  - decrease impervious area (roads, houses)
  - maintain natural “buffer zones” along streams
  - preserve native soils and forests
  - restore ability of disturbed landscapes to detain & infiltrate rainwater
- A soil strategy can help.

Restoring Soil Functions with Organic Amendments

Stormwater management

- Incorporate 15-30% compost (by volume) into soil before planting
- Compost amendment 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

Erosion and sediment management

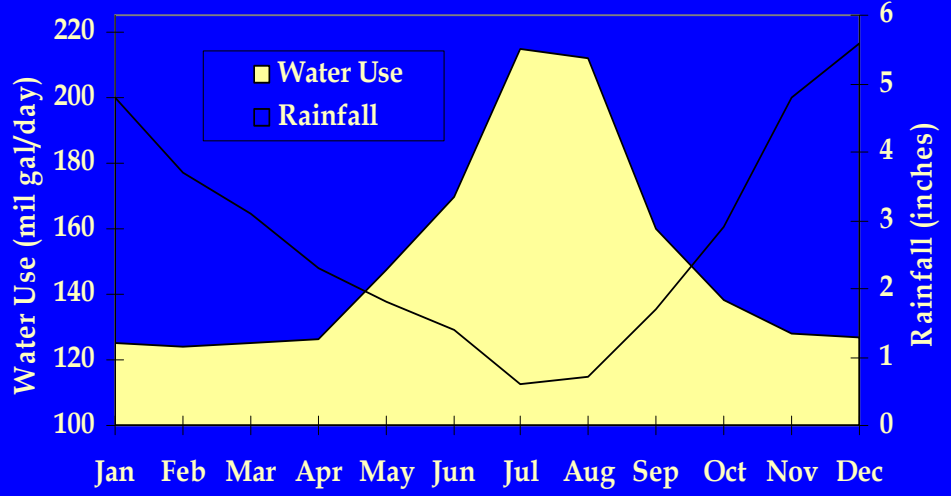
- Compost berms or blankets – slow water, bind surface soil, and reduce erosion immediately
- Enhance survival/growth of plantings, helping to stabilize slopes over long term.

Berms instead of silt fence

Compost blankets on steep slopes

Added benefits of soil amendment

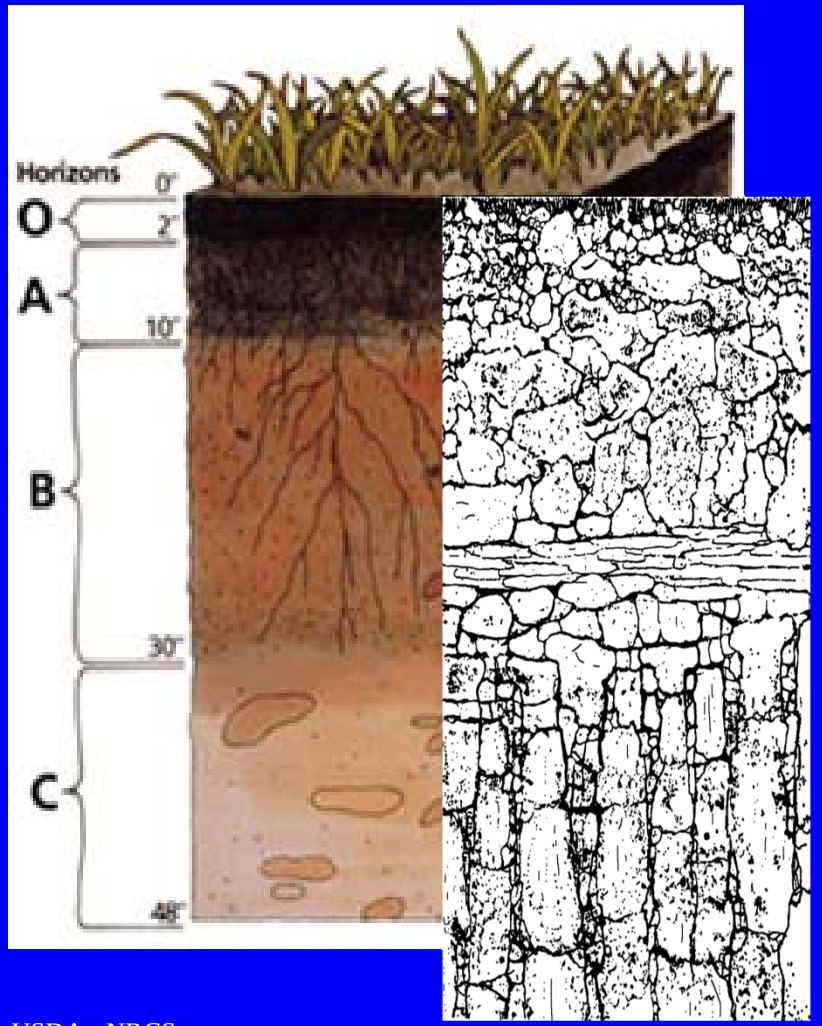
- Bio-filtration of urban pollutants
- Improved fertility & plant vigor:
  - less need for fertilizers and pesticides
  - reduced maintenance costs
  - Increased regrowth of protective canopy
- Reusing “wastes” (yard waste, manure, biosolids, construction, land clearing waste)
- Reduced summer irrigation needs



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

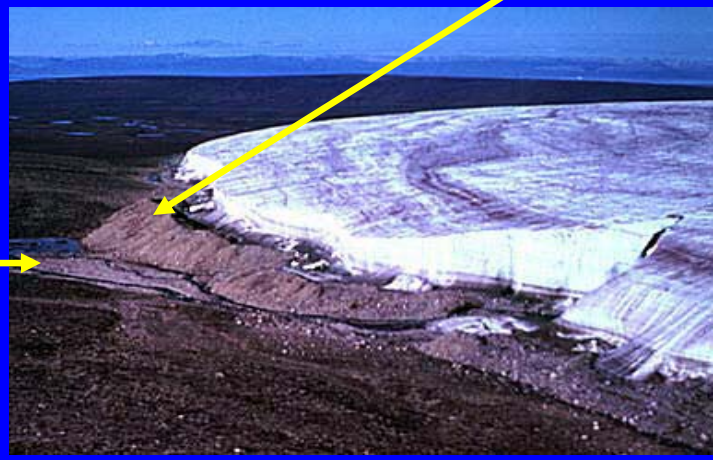
Sub-Soils in the Puget Sound Basin: Leftovers from glaciers & volcanoes

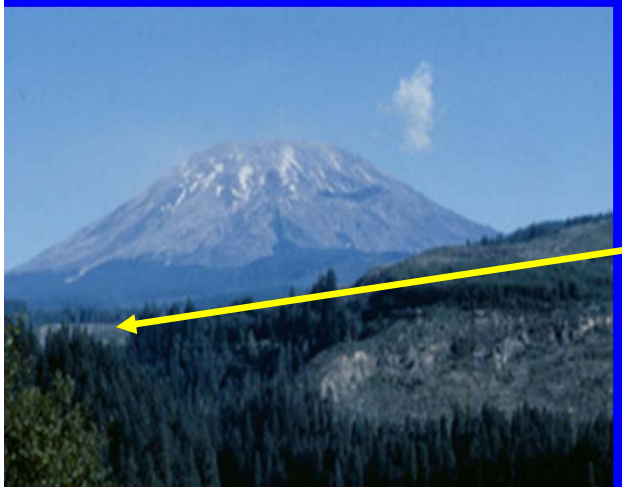
glacial till: unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders; deposited under ice, or in moraines

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

Glacial till

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

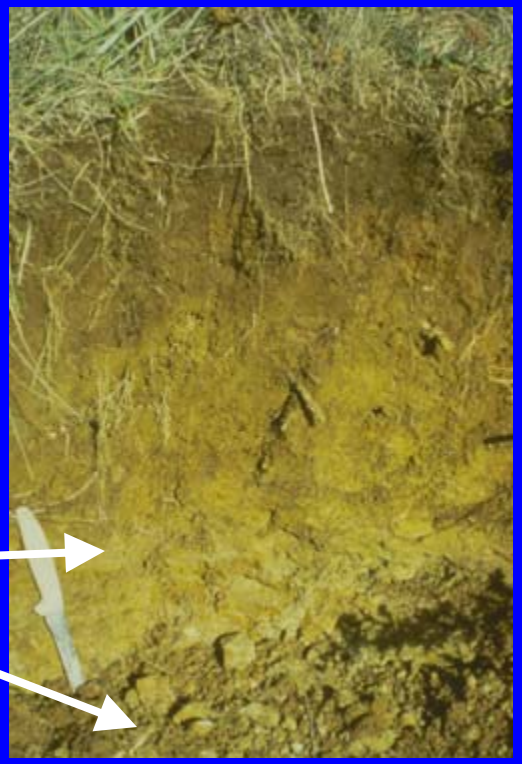
- *Basal till* from under the glacier (1/2 mile of ice over Seattle!) has been compressed into **hardpan**

- Good for foundations, but low permeability and hard for roots to penetrate

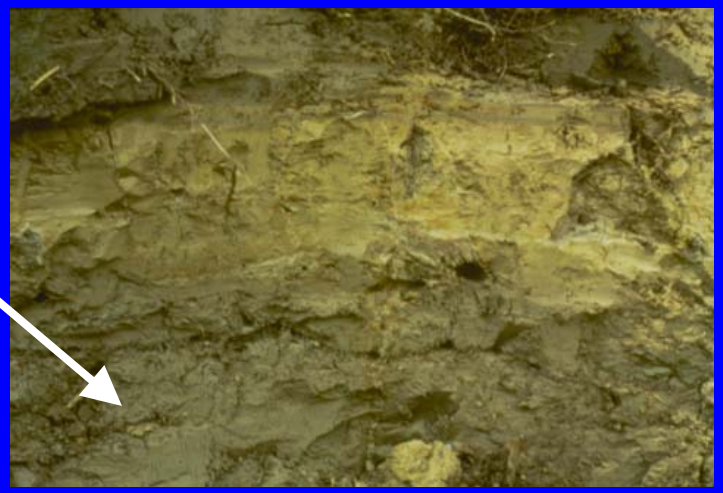
Glacial outwash

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

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!



Volcanic ash or mudflows

- *Tephra* (ash) – light, fertile, holds moisture, erodable

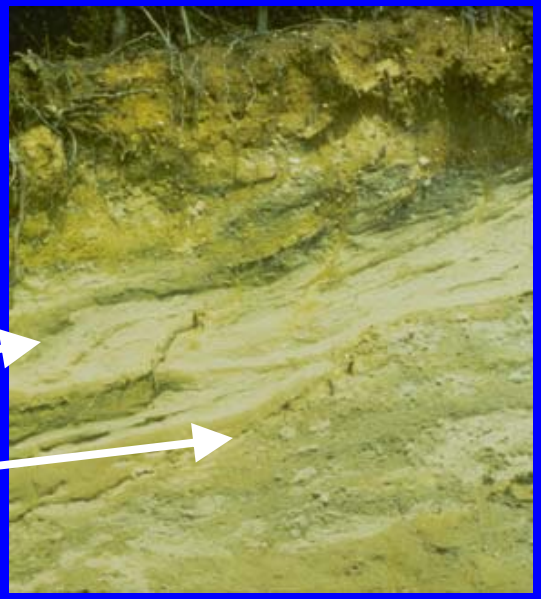
- Mudflow – compact, mixed fines and boulders, low permeability, looks and acts like basal till, but more fertile

Alluvial soils

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

Layers upon layers…
ignore them at your peril!

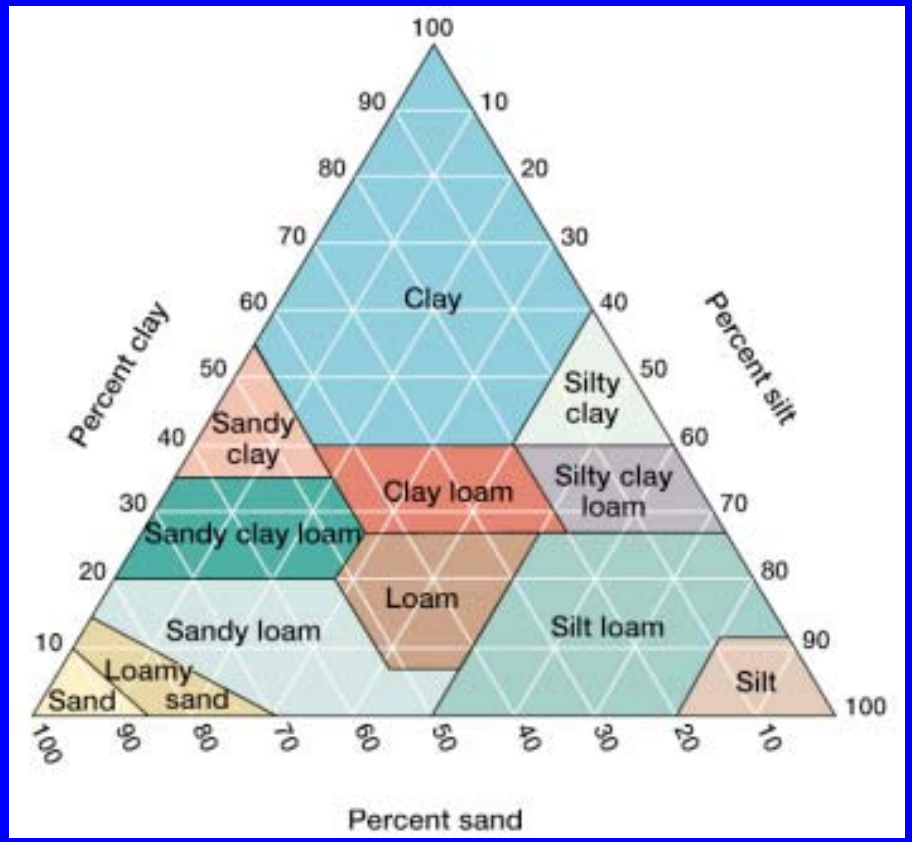
- Sandy outwash over compacted basal till hardpan
- Thin soil over bedrock
- Clay lenses over hardpan, or inter-layered with sand (unstable!)



Disturbed soils in urban areas

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

Soil Texture
(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

How Does Soil Texture Impact Water Infiltration and Storage?

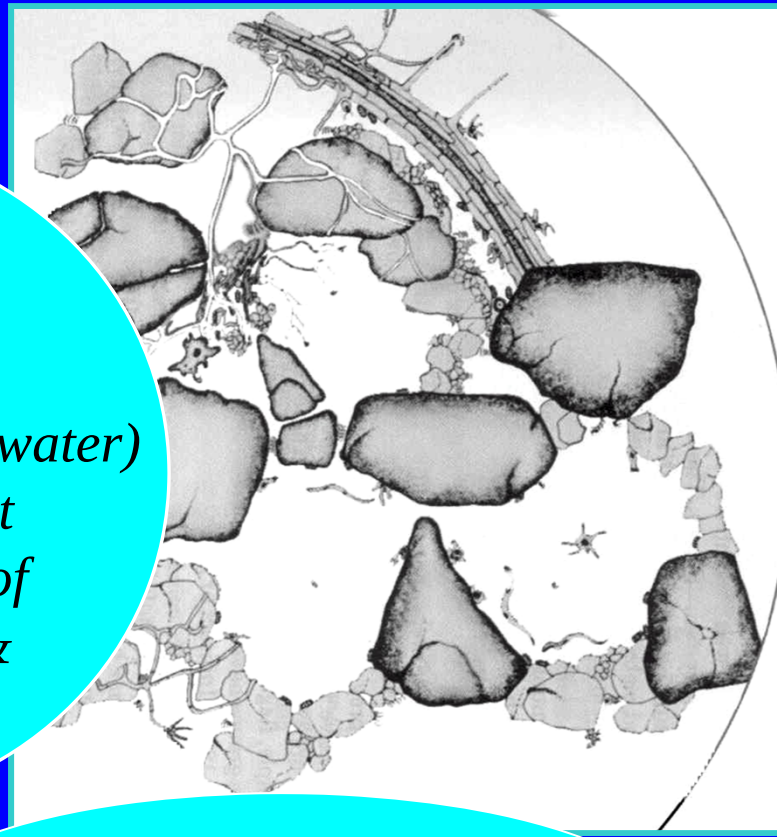
Soil Texture	**Total Water Storage** inches/foot depth	**Plant-Available Water Storage** inches/foot	**Infiltration Rate** inches/hour
Sand	1.2	0.9	2.0
Sandy loam	1.9	1.6	0.7
Fine sandy loam	2.5	1.7	
Loam	3.2	2.0	0.5
Silt loam	3.5	2.1	
Sandy clay loam	3.7	2.1	
Clay loam	3.8	2.0	0.3
Silty clay loam	3.8	1.7	
Clay	3.9	1.5	0.1

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

Soil components:

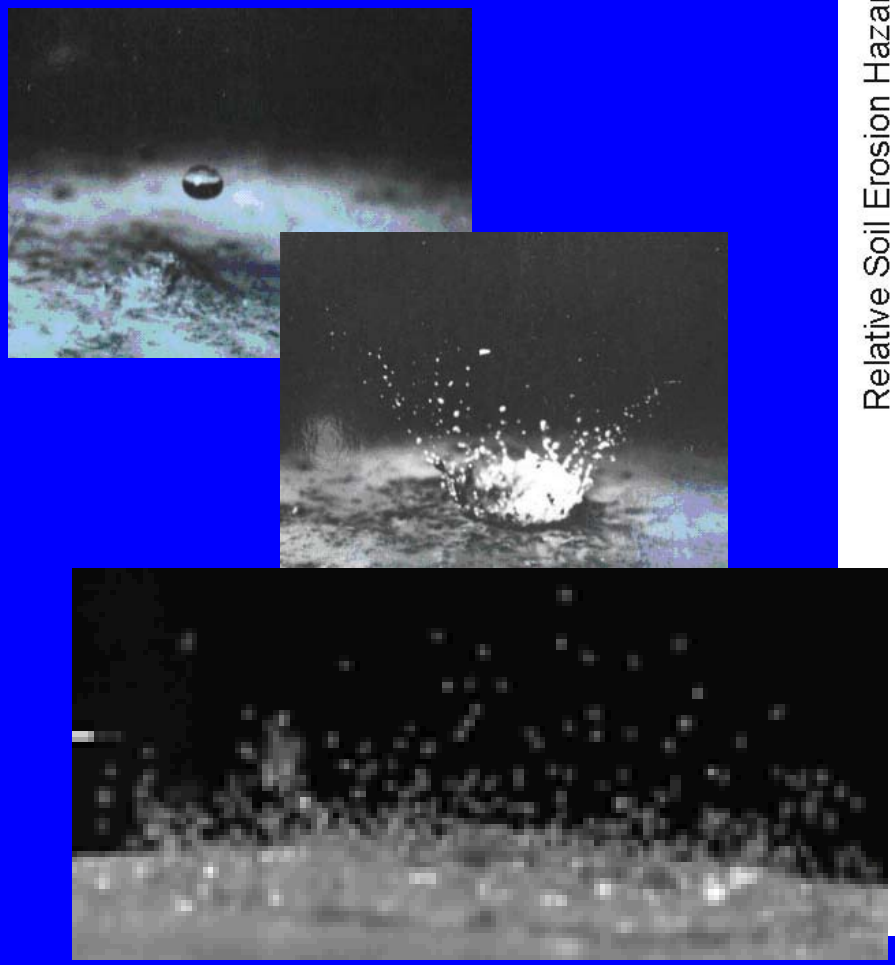
- "The Dirt" (mineral part)
  - sand
  - silt
  - clay
- Air and Water
- Organic Matter and Soil Life (create aggregates & pores)

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

Understanding soil: how erosion starts



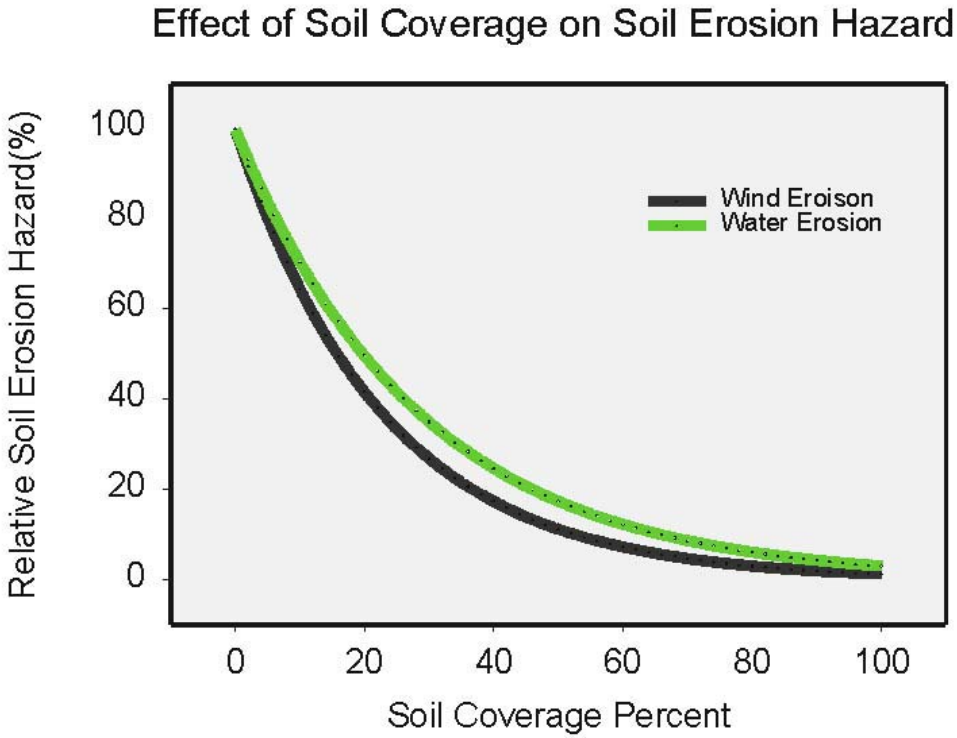


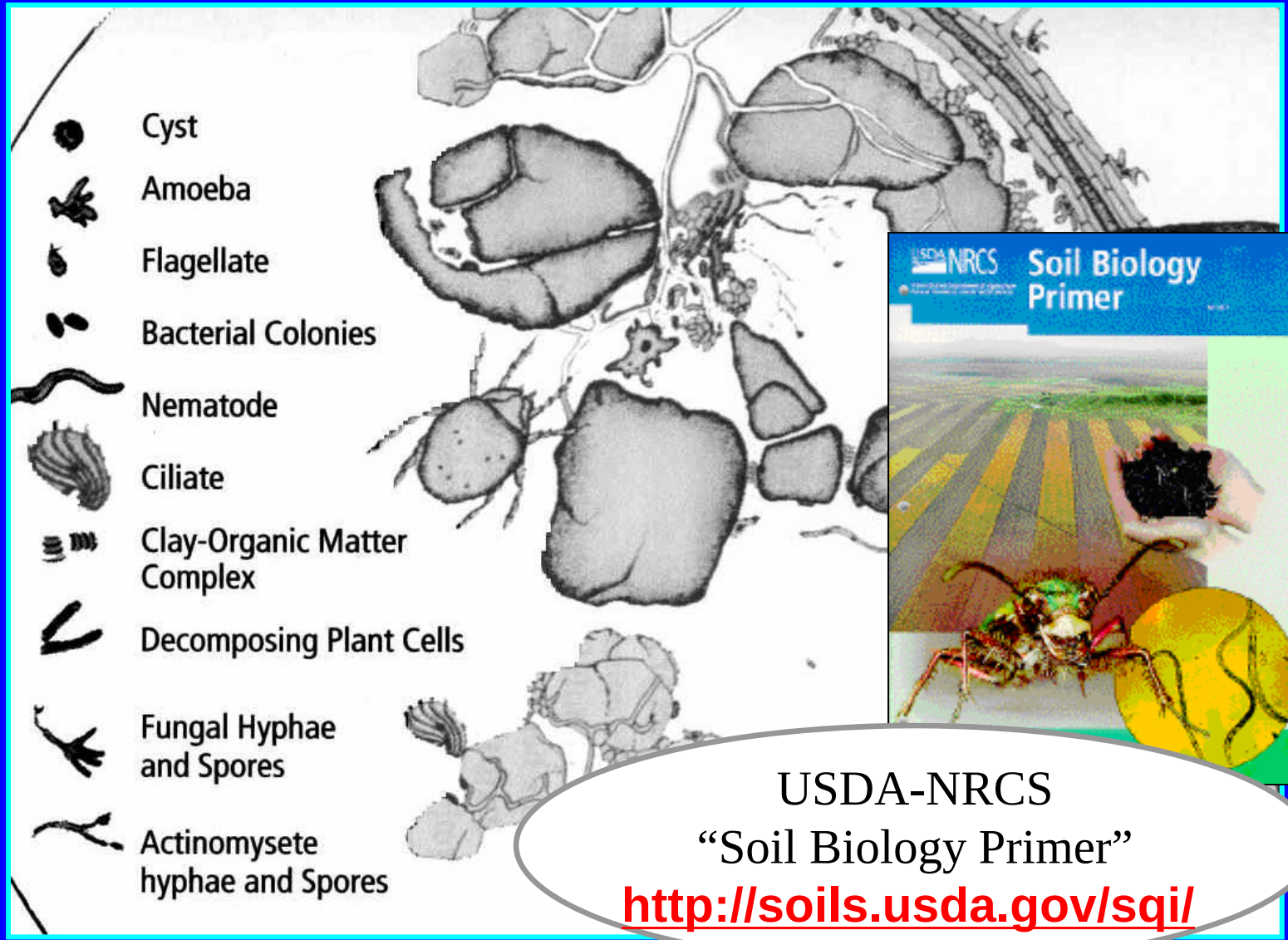
Fig. 3. The relative effect of soil residue coverage on wind and water erosion potentials. The wind erosion function is taken from the Revised Wind Erosion Equation (RWEQ) model and the water erosion function comes from the Revised Universal Soil Loss Equation (RUSLE) model. (Merrill et al., 2002)

Compost particles are much bigger and harder to move than most soil particles, and much stickier

Understanding Soil Biology

Soil life provides essential functions

Soil
is
alive!

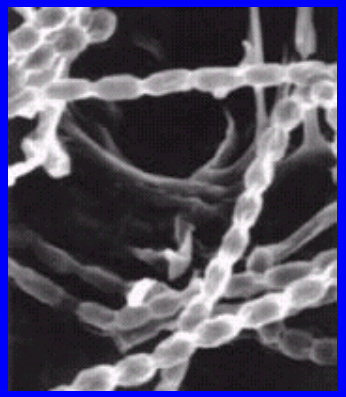


USDA-NRCS
"Soil Biology Primer"
http://soils.usda.gov/sqi/

S. Rose & E.T. Elliott

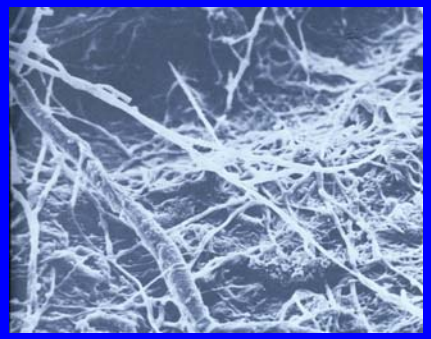
Common organisms in the soil foodweb

- Bacteria



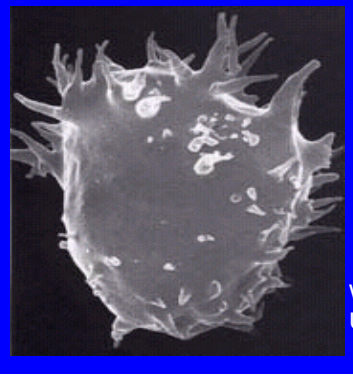
Paul R. August, University of Minn

- Fungi



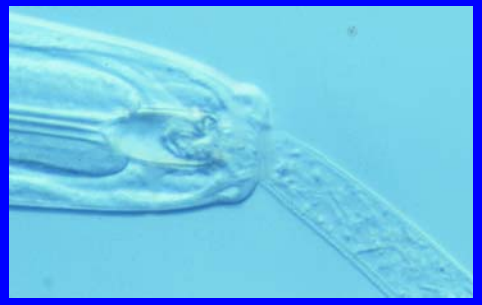
Soil Foodweb Inc.

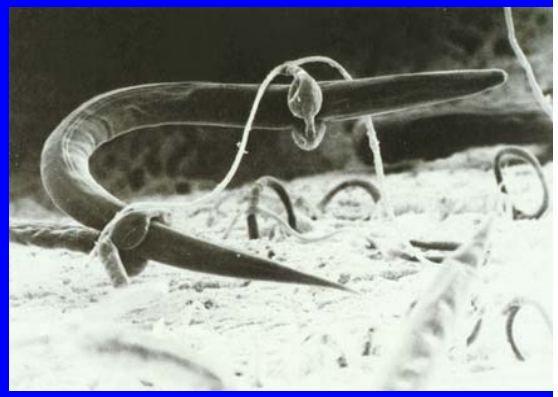
- Protozoa



Wilhelm Foissner,
University of Salzburg

- Nematodes





Soil Foodweb Inc.

- Arthropods

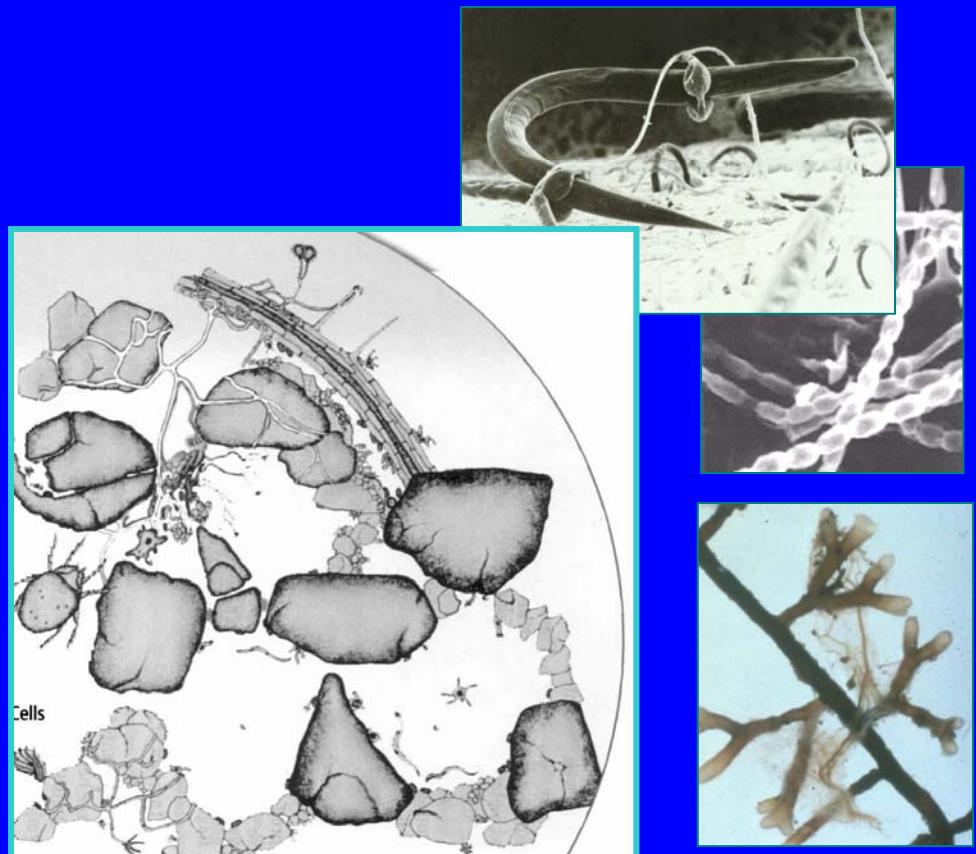
SSSA

- Earthworms

Restoring soil life, to restore soil functions

Soil organisms create:

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



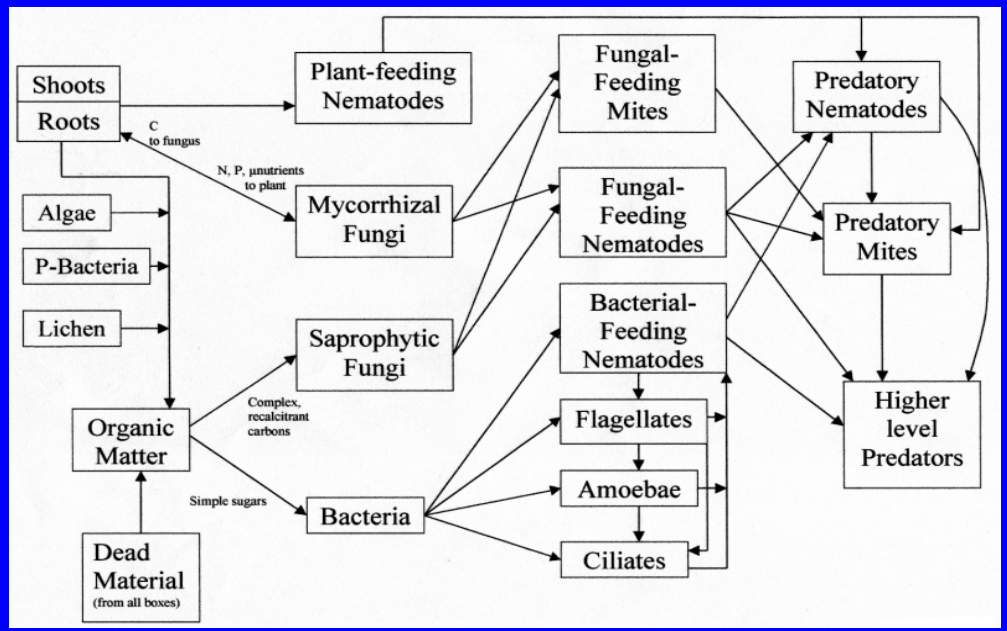
Compost kickstarts the soil ecosystem!
(Provides food and home for organisms)

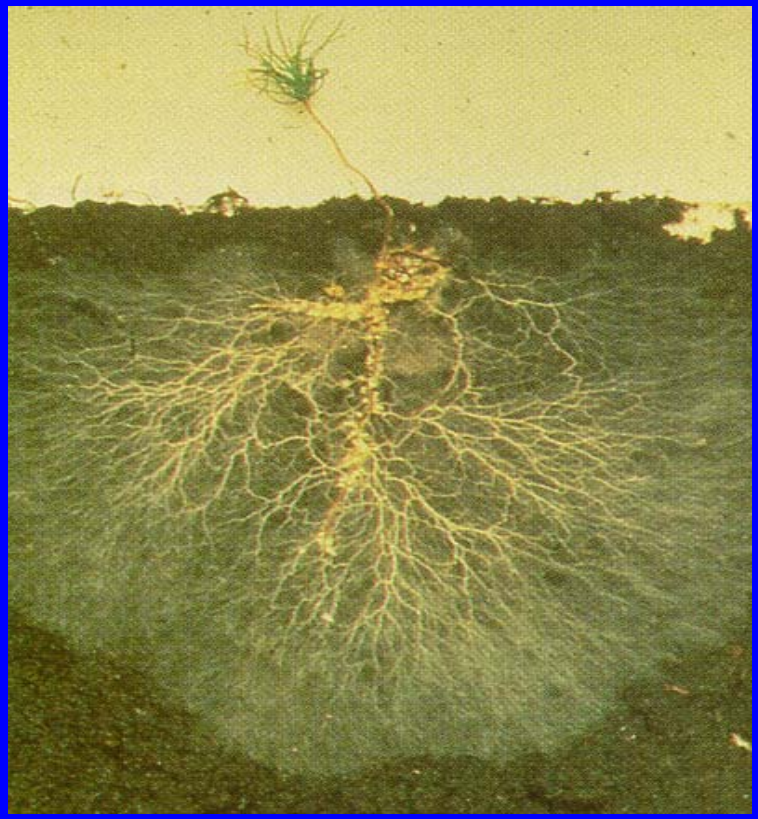
How does soil life create soil structure?

- 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.

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



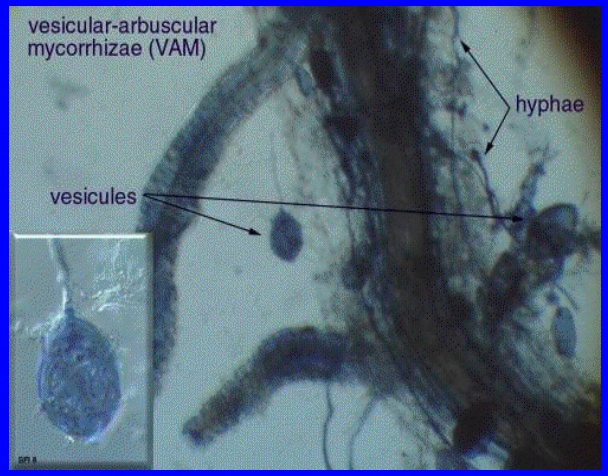


Dr. Michael P. Amaranthus, Mycorrhizal Applications Inc.

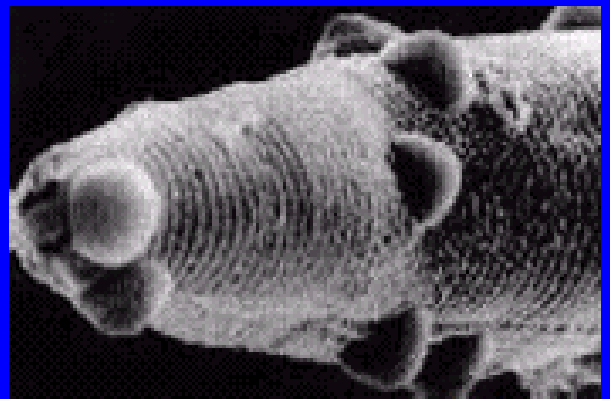
How does soil life provide plant disease protection?

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

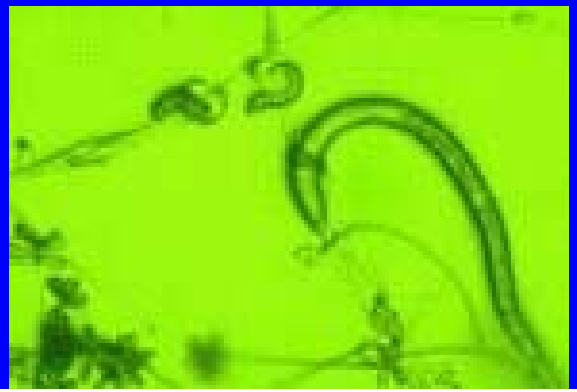
- Bacteria cover leaf surfaces, block infection
- Ecto- and endo-mycorrhizae prevent root infection
- Many organisms prey on the few disease-causing organisms



Soil Foodweb Inc.



SSSA

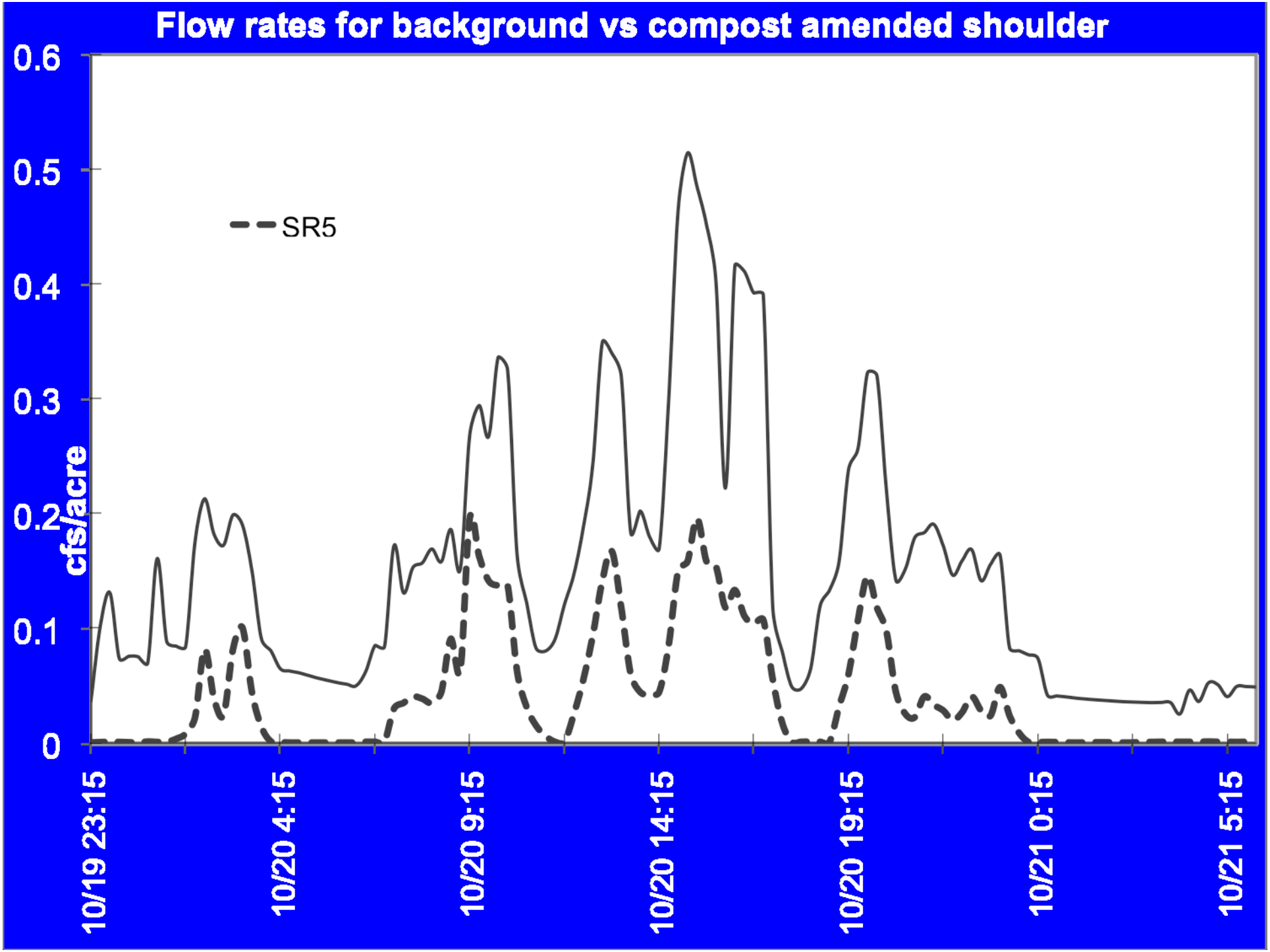


How does soil life filter out urban pollutants?

- 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

WsDOT: Compost Amended Vegetated Filter Strip - 2004 pollutant & flow reduction trials along I-5

These slides courtesy of:
Mark Maurer
WSDOT Design Office
Roadside and Site Development Manager
360-705-7242 maurerm@wsdot.wa.gov

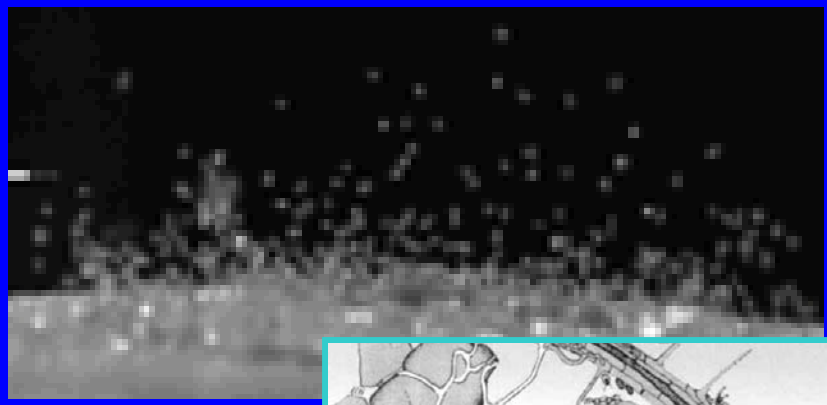

Flow rates for background vs compost amended shoulder
0.6
0.5
0.4
0.3
0.2
0.1
0
cfs/acre
SR5
10/19 23:15
10/20 4:15
10/20 9:15
10/20 14:15
10/20 19:15
10/21 0:15
10/21 5:15

10 ft wide compost strip treats stormwater from 2 lanes of roadway

Parameter	Untreated Runoff	Compost filter strip treated	% Concentration Reduction	% Load Reduction
	mg/l			
TDS	52.7	55.5	-5	63
T. Phosphorus	0.089	0.26	-192	-2
COD	73.5	49.6	33	76
TSS	81	23	72	90
	ug/l			
Total Copper	28.18	9.14	68	89
Dissolved Copper	7.85	5.77	26	74
Total Lead	12.62	3.54	72	90
Dissolved Lead	0.5	0.05	90	97
Total Zinc	129.70	31.57	76	91
Dissolved Zinc	64.22	20.71	68	89

TDS=Total Dissolved Solids, COD=Chemical Oxygen Demand, TSS=Total Suspended Solids

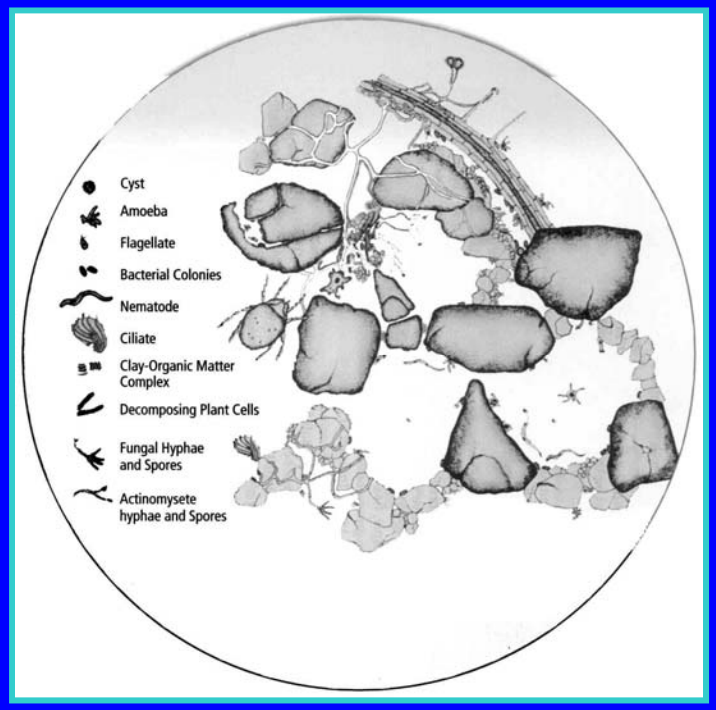
How does soil life control erosion?



- 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

How does soil life provide stormwater detention / infiltration?

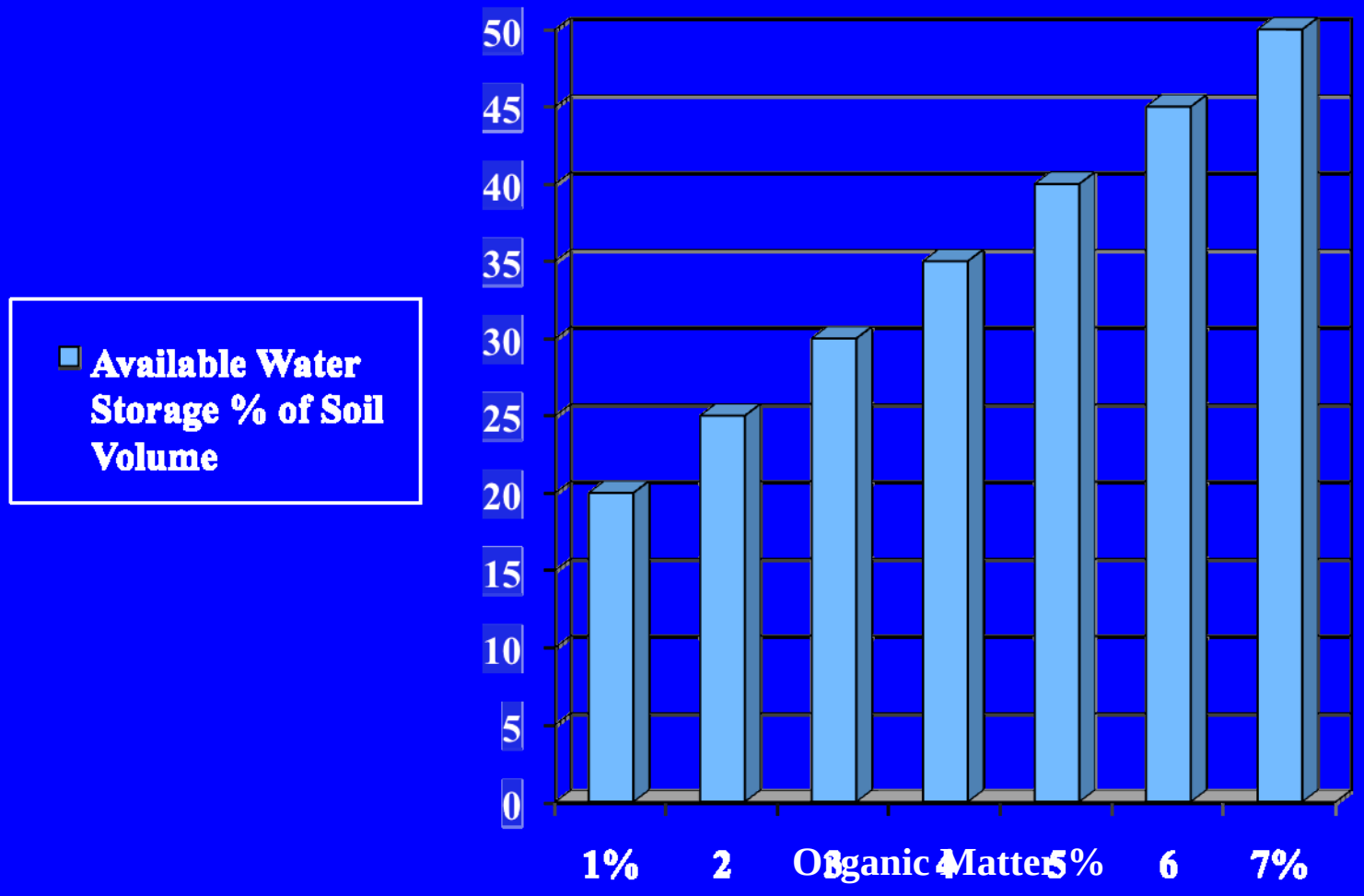
- Builds soil structure, moisture-holding capacity
- Increases surface porosity



UW trials, turf on glacial till soil

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

Effect of OM Content on Available Soil Moisture Storage



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

- 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

Soil Amendment: A cost-effective solution for new development

- Much better plant survival
  = fewer callbacks

- Easier
  planting

- Can cut irrigation needs by 50%
  = 3-7 year payback on
  irrigation savings alone

Improving soil function in existing development

- Amend soil when re-landscaping
- Plant native trees & shrubs, especially near waterways
- Mulch beds annually with leaves, chips, compost, etc.
- Topdress turf areas with compost (aerate, topdress, rake in)

Exercise – soils and amendment rates

Match the numbered soil samples with their correct descriptions

1.	**____**	**A.**	**Sandy subsoil (0% OM +/-)**
2.	**____**	**B.**	**Sandy loam topsoil (5-10% OM +/-)**
3.	**____**	**C.**	**Clay subsoil (0% OM +/-)**
4.	**____**	**D.**	**Clay pasture topsoil (10% OM +/-)**
5.	**____**	**E.**	**Glacial Till (0% OM +/-)**
6.	**____**	**F.**	**Yard Debris Compost (50% OM +/-)**
7.	**____**	**G.**	**Compost/Sand "Topsoil" (10-15% OM +/-)**
8.	**____**	**H.**	**Sandy subsoil w/compost (10% OM +/-)**
9.	**____**	**I.**	**Glacial Till w/compost (10% OM +/-)**
10.	**____**	**J.**	**Forest duff (80% OM +/-)**

Plus an 11th mystery sample – what is it?

Summary of Soil Best Management Practices

New Construction

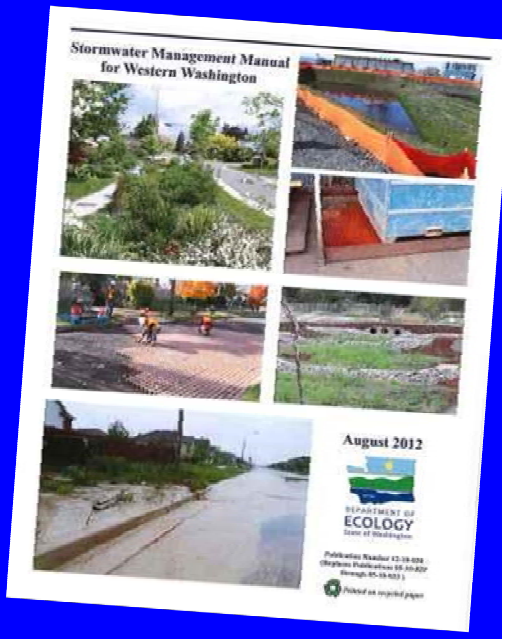
- Retain and protect native topsoil & vegetation
  - Minimize construction footprint
  - Store and reuse topsoil from site
  - Retain vegetation "buffer" along waterways
- Restore disturbed soils by tilling in compost, and loosen compacted subsoil.

Existing Landscapes

- Till in compost when re-landscaping
- Mulch beds and topdress turf with compost
- Avoid overuse of chemicals, which may damage soil life

WA DOE Guidance on soil & LID BMPs: *Stormwater Mgmt. Manual for Western WA*

- Equivalency required for Phase I & II NPDES permittees
- Volume V, Chapter 5 - "On-Site Stormwater Mgmt."
  - Downspout, sheet, & concentrated flow dispersion
  - **BMP T5.13 Post-Construction Soil Quality and Depth**
  - Other Site Design BMP's include preserving vegetation, cisterns, rain gardens, porous paving, soil compaction prevention, & T5.41 "Better Site Design"
- Volume III, Chapter 3 - "Flow Control Design"
  - Downspout infiltration and dispersion
- Flow model credits for amended soils



www.ecy.wa.gov/programs/wq/stormwater/manual.html

BMP T5.13: Runoff Model Representation

- Areas meeting the design guidelines may be entered into approved runoff models as “Pasture” rather than “Lawn.”

- Flow reduction credits can be taken in runoff modeling when BMP T5.13 is used as part of a dispersion design under the conditions described in:
  - BMP T5.10B Downspout Dispersion
  - BMP T5.11 Concentrated Flow Dispersion
  - BMP T5.12 Sheet Flow Dispersion
  - BMP T5.18 Reverse Slope Sidewalks
  - BMP T5.30 Full Dispersion (for public road projects)

DOE BMP T5.13
Post-Construction Soil Quality and Depth

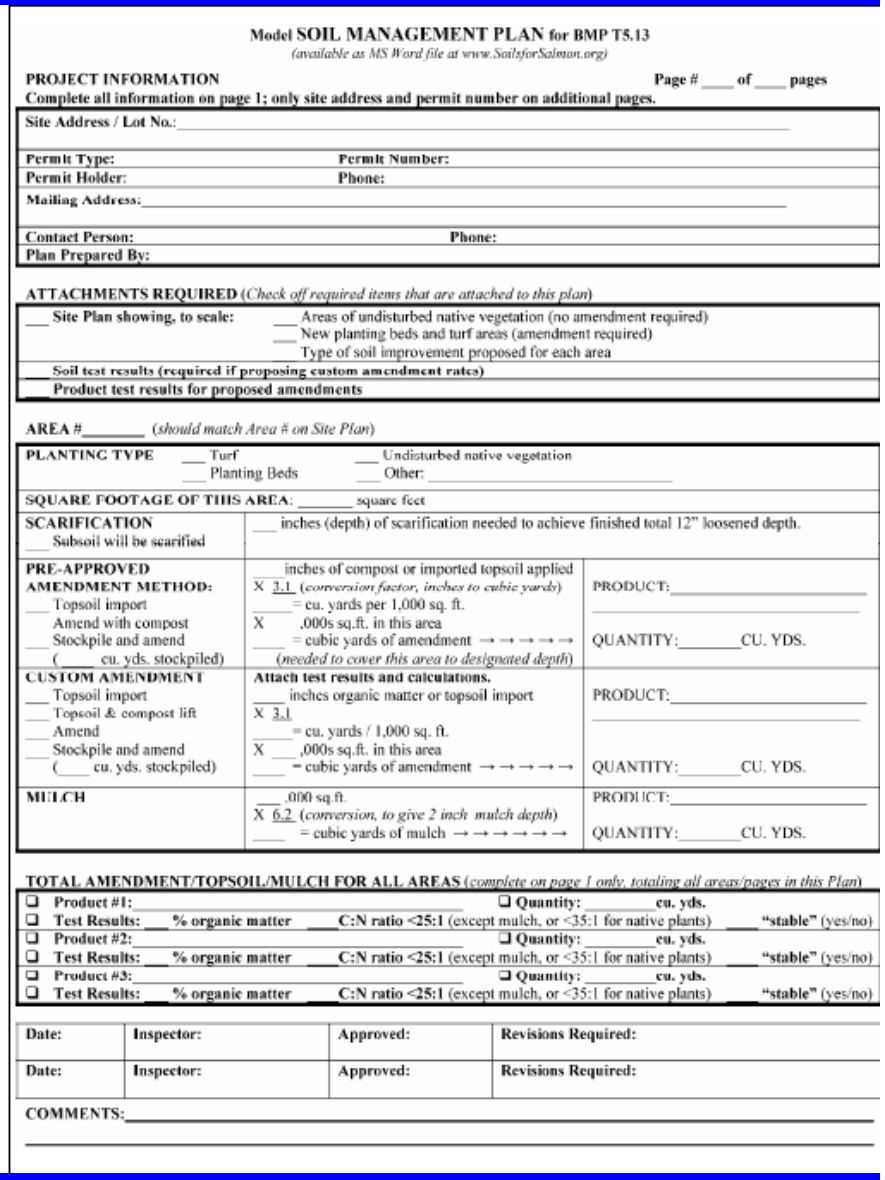
- Retain native soil and duff wherever possible
- All areas cleared and graded require 8 inch soil depth:
  - Organic matter content ≥ 10% dry weight (now ≥ 5% for turf)
  - Use native topsoil, amend existing soil with compost, or import topsoil blend
  - Subsoil scarified 4 inches below 8-inch topsoil layer
  - Protect amended soil from compaction
  - Mulch after planting
  - Maintenance practices to replenish organic content

Guidelines Manual for Implementing BMP T5.13

- Manual developed regionally with experts
- 10% O.M. for landscape beds; 5% for turf
- 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
- Includes model specs written in CSI and APWA formats
- Available **www.soilsforsalmon.org** or **www.buildingsoil.org**

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



Model SOIL MANAGEMENT PLAN for BMP T5.13

(available as MS Word file at www.SoilsforSalmon.org)

PROJECT INFORMATION Page # ____ of ____ pages

Complete all information on page 1; only site address and permit number on additional pages.

Site Address / Lot No.:

Permit Type: **Permit Number:**

Permit Holder: **Phone:**

Mailing Address:

Contact Person: **Phone:**

Plan Prepared By:

ATTACHMENTS REQUIRED *(Check off required items that are attached to this plan)*

___ **Site Plan showing, to scale:** ___ Areas of undisturbed native vegetation (no amendment required)
___ New planting beds and turf areas (amendment required)
___ Type of soil improvement proposed for each area

___ **Soil test results (required if proposing custom amendment rates)**

___ **Product test results for proposed amendments**

AREA #_____ *(should match Area # on Site Plan)*

PLANTING TYPE ___ Turf ___ Undisturbed native vegetation
___ Planting Beds ___ Other:

SQUARE FOOTAGE OF THIS AREA: _____ square feet

SCARIFICATION ___ Subsoil will be scarified	___ inches (depth) of scarification needed to achieve finished total 12" loosened depth.	
PRE-APPROVED AMENDMENT METHOD: ___ Topsoil import ___ Amend with compost ___ Stockpile and amend (____ cu. yds. stockpiled)	___ inches of compost or imported topsoil applied X 3.1 *(conversion factor, inches to cubic yards)* ____ = cu. yards per 1,000 sq. ft. X ____,000s sq.ft. in this area ____ = cubic yards of amendment → → → → → *(needed to cover this area to designated depth)*	PRODUCT: QUANTITY:_____CU. YDS.
CUSTOM AMENDMENT ___ Topsoil import ___ Topsoil & compost lift ___ Amend ___ Stockpile and amend (____ cu. yds. stockpiled)	**Attach test results and calculations.** ____ inches organic matter or topsoil import X 3.1 ____ = cu. yards / 1,000 sq. ft. X ____,000s sq.ft. in this area ____ = cubic yards of amendment → → → → →	PRODUCT: QUANTITY:_____CU. YDS.
MULCH	____,000 sq.ft. X 6.2 *(conversion, to give 2 inch mulch depth)* ____ = cubic yards of mulch → → → → → →	PRODUCT: QUANTITY:_____CU. YDS.

TOTAL AMENDMENT/TOPSOIL/MULCH FOR ALL AREAS *(complete on page 1 only, totaling all areas/pages in this Plan)*

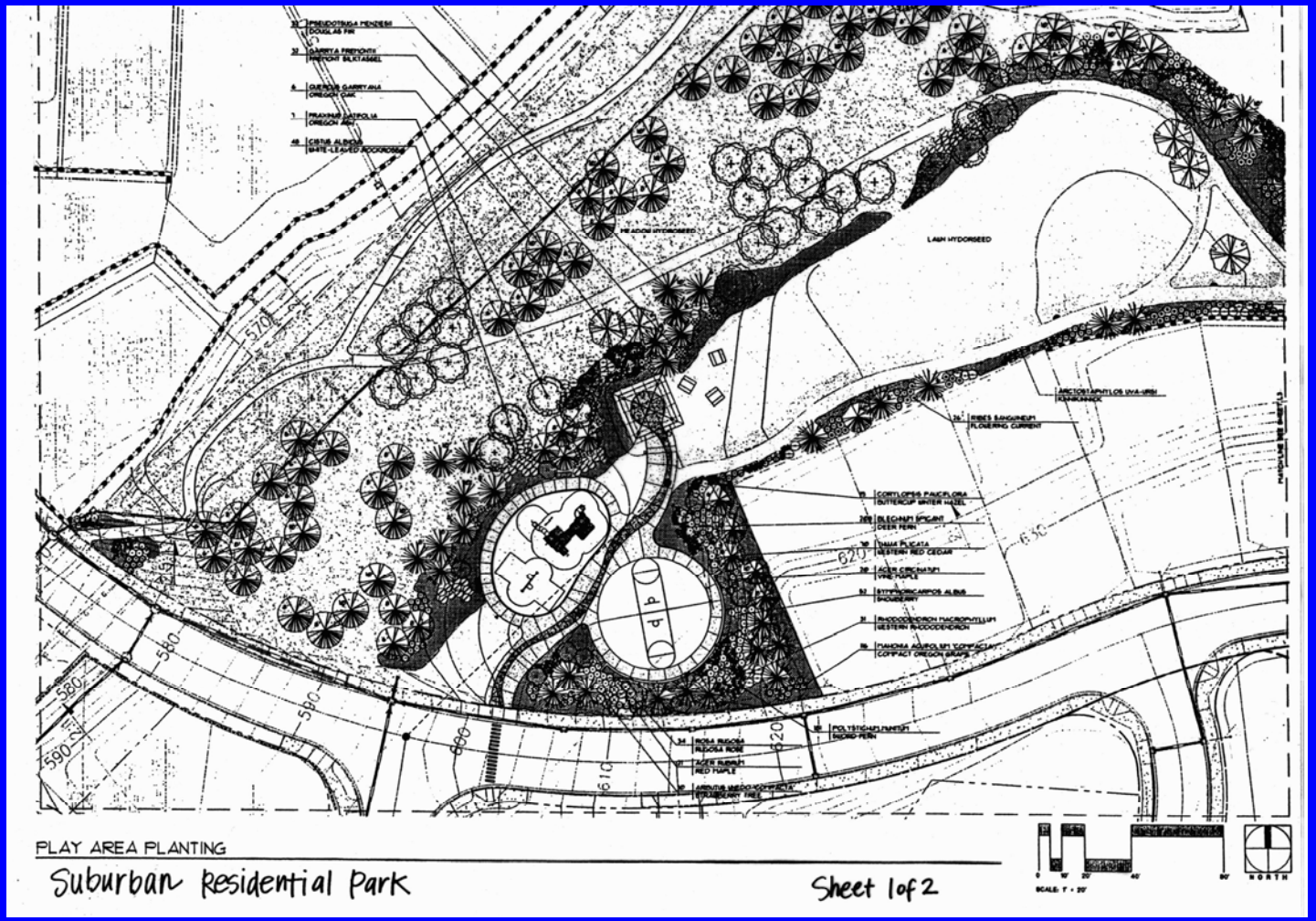
❑ **Product #1:** ❑ **Quantity:** _____ **cu. yds.**
❑ **Test Results:** ____ **% organic matter** ____ **C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)
❑ **Product #2:** ❑ **Quantity:** _____ **cu. yds.**
❑ **Test Results:** ____ **% organic matter** ____ **C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)
❑ **Product #3:** ❑ **Quantity:** _____ **cu. yds.**
❑ **Test Results:** ____ **% organic matter** ____ **C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)

Date:	**Inspector:**	**Approved:**	**Revisions Required:**
Date:	**Inspector:**	**Approved:**	**Revisions Required:**

COMMENTS:

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.	**Pre-approved Amendment Rate** Turf: Mix 1.75 compost into 6.25” soil. Beds: Mix 3” compost into 5” 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 5 or 10% organic content

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

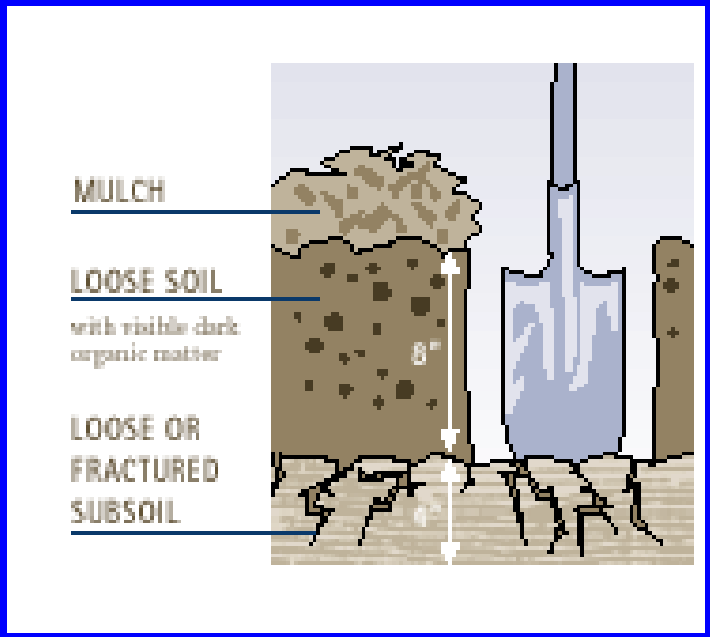
?

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

2. Identify Areas Suitable for Each Option

- Established “native” plants and duff– to be left undisturbed.
- Areas to be protected from compaction during construction.
- Areas to be cleared of native vegetation but not graded – may be amended at reduces rate.
- 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

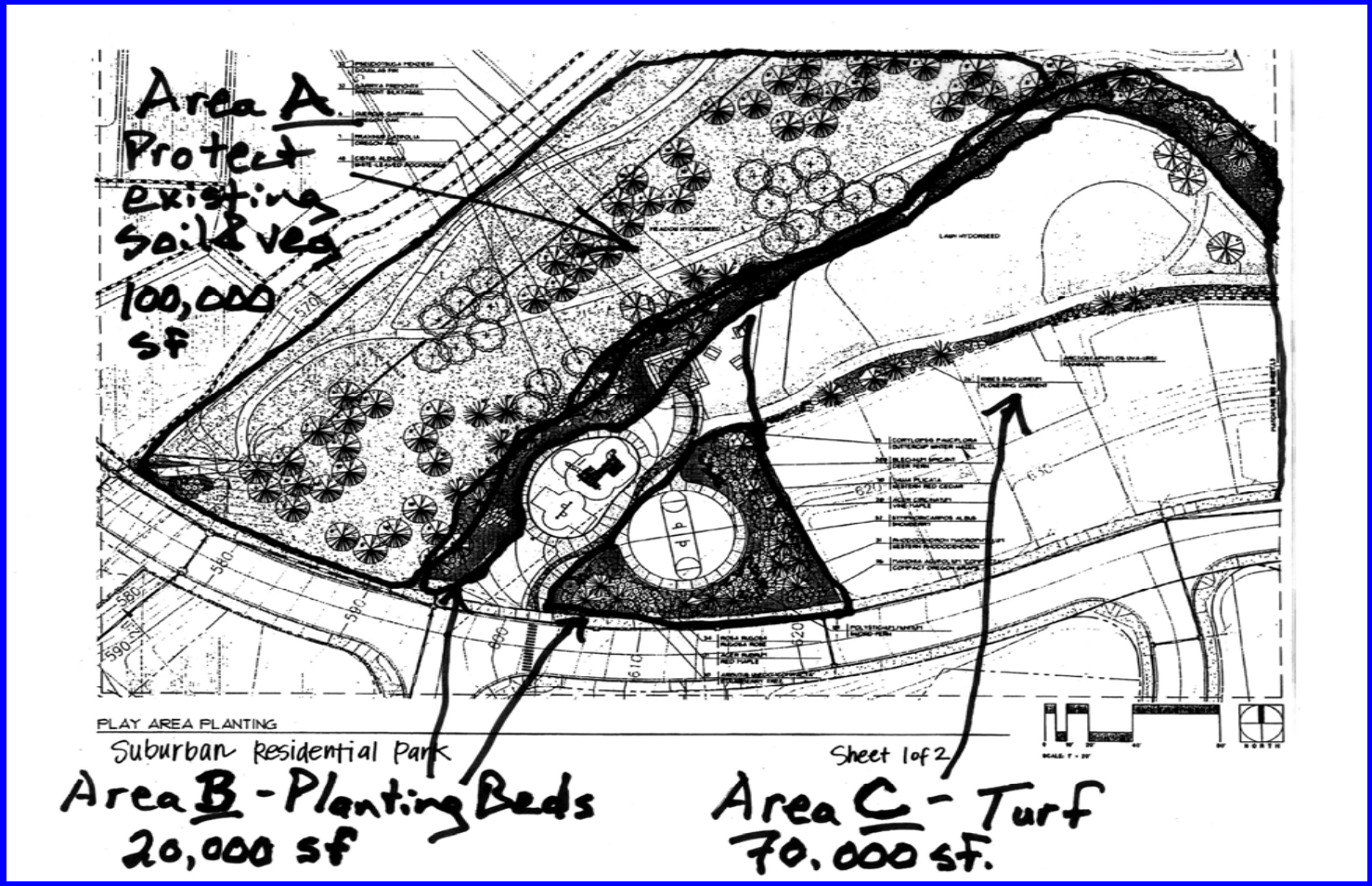
Compost

- 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.

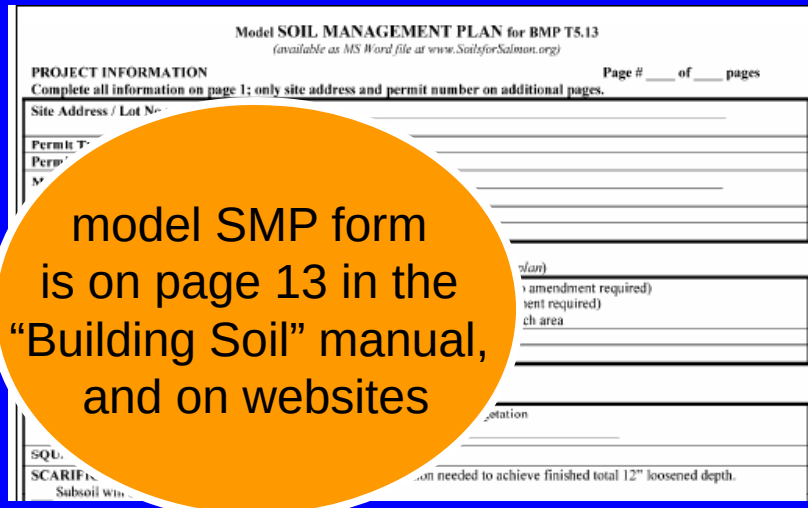
4. Select Amendment Options

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.



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 SOIL MANAGEMENT PLAN for BMP T5.13

(available as MS Word file at www.SoilsforSalmon.org)

PROJECT INFORMATION Page # ___ of ___ pages

Complete all information on page 1; only site address and permit number on additional pages.

Site Address / Lot No

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on needed to achieve finished total 12" loosened depth.

model SMP form is on page 13 in the "Building Soil" manual, and on websites

Amendment calculators at:

www.buildingsoil.org

www.soilsforsalmon.org

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

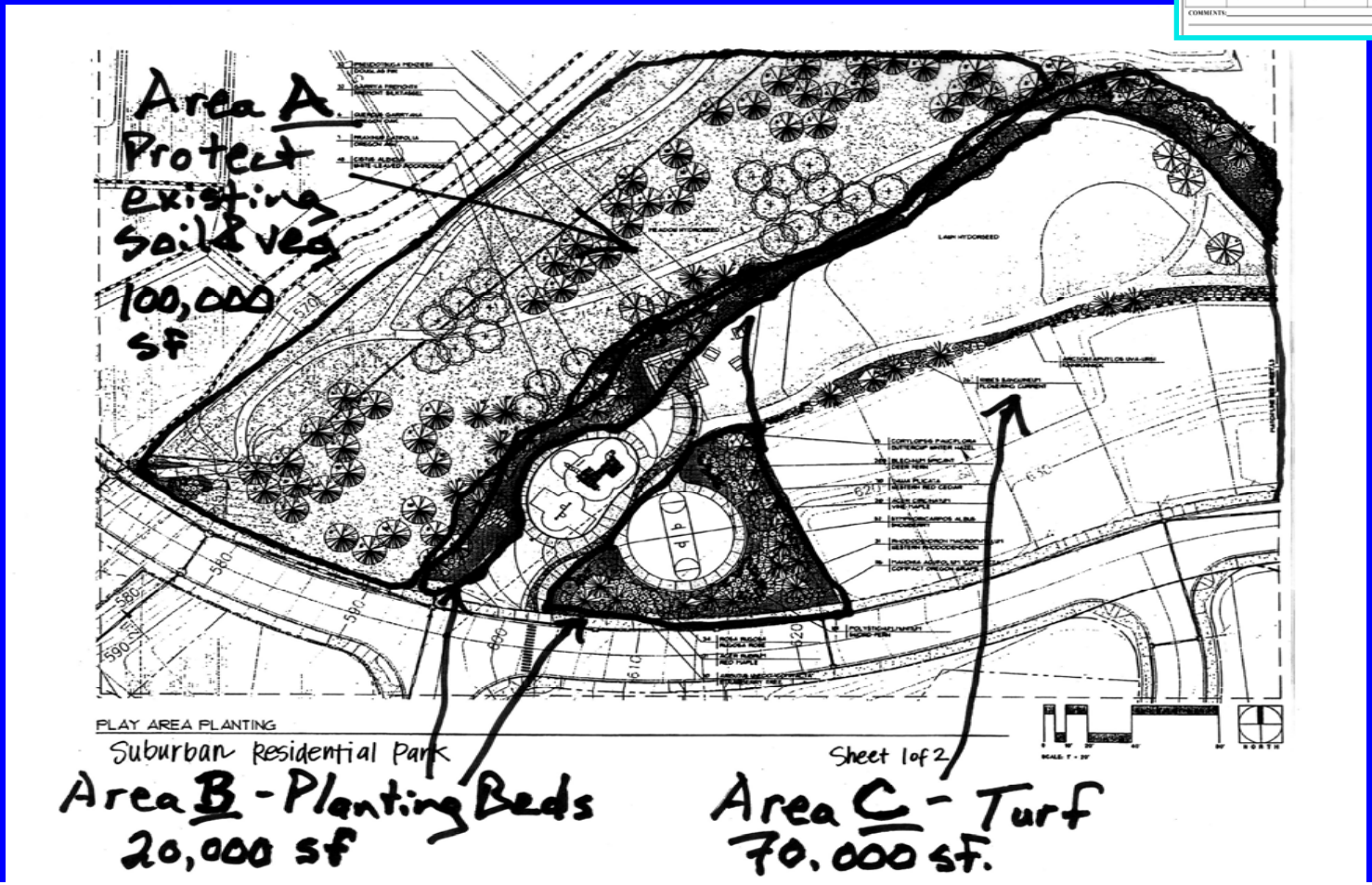
or (Seattle soil amendment std. plan)
http://www.seattle.gov/dpd/codesrules/codes/stormwater/default.htm

Exercise – Soil Management Plan

Fill in the SMP worksheet,

using the pre-approved amendment rates:

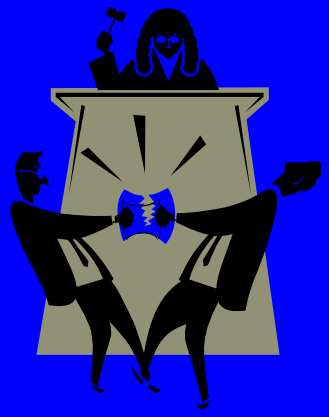
- Turf – 1.75 inches of compost tilled in 8 inches
- Planting Beds – 3 inches of compost tilled in 8”



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 Landscape Architect

Independent Inspection to Resolve Disputes

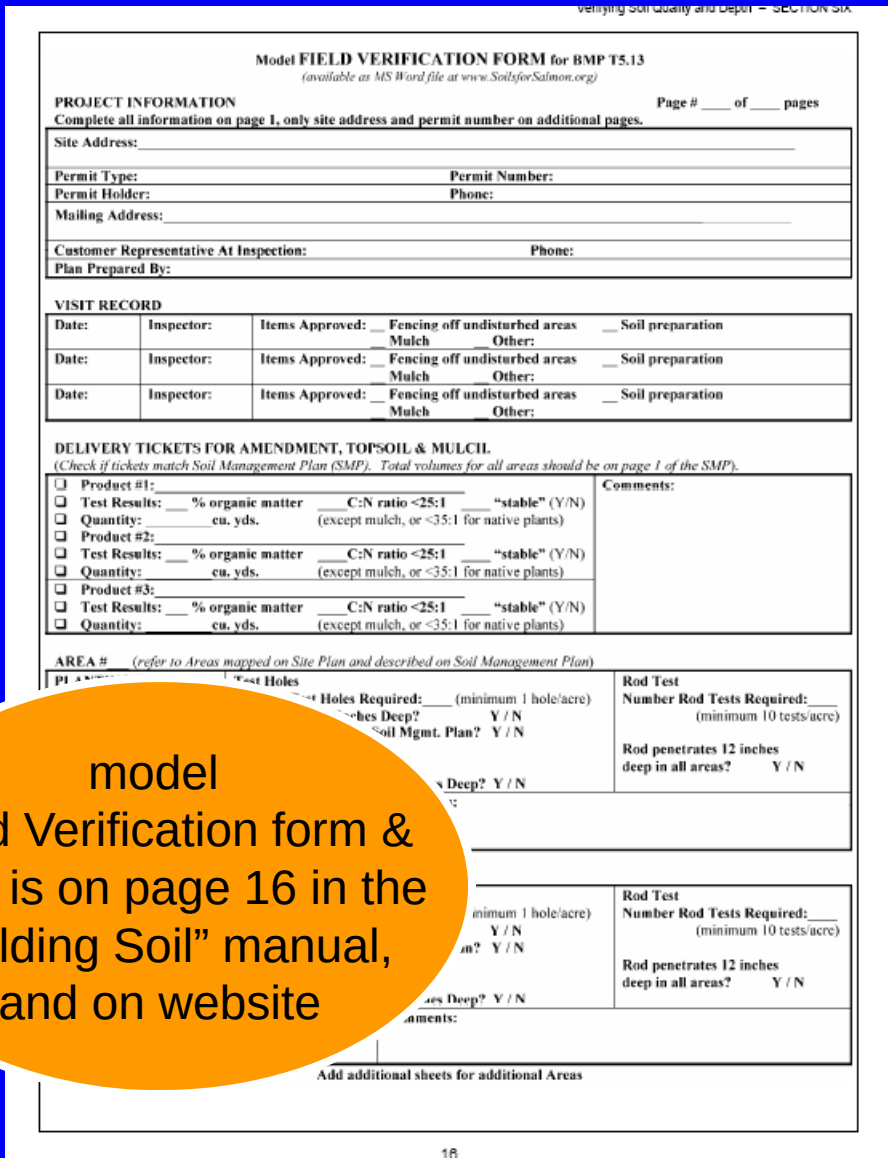
- Certified Soil Scientist, Crop Advisor or Agronomist
- Licensed Landscape Architect, Civil Engineer or Geologist

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 form and guide at www.soilsforsalmon.org



Model **FIELD VERIFICATION FORM** for BMP T5.13

(available as MS Word file at www.SoilsforSalmon.org)

PROJECT INFORMATION Page # ____ of ____ pages

Complete all information on page 1, only site address and permit number on additional pages.

Site Address:

Permit Type: **Permit Number:**

Permit Holder: **Phone:**

Mailing Address:

Customer Representative At Inspection: **Phone:**

Plan Prepared By:

VISIT RECORD

Date:	Inspector:	Items Approved: __ Fencing off undisturbed areas __ Soil preparation __ Mulch __ Other:
Date:	Inspector:	Items Approved: __ Fencing off undisturbed areas __ Soil preparation __ Mulch __ Other:
Date:	Inspector:	Items Approved: __ Fencing off undisturbed areas __ Soil preparation __ Mulch __ Other:

DELIVERY TICKETS FOR AMENDMENT, TOPSOIL & MULCH

(Check if tickets match Soil Management Plan (SMP). Total volumes for all areas should be on page 1 of the SMP).

	Comments:
❑ Product #1:	
❑ Test Results: ___ % organic matter ____C:N ratio <25:1 ____ "stable" (Y/N)	
❑ Quantity: _____ cu. yds. (except mulch, or <35:1 for native plants)	
❑ Product #2:	
❑ Test Results: ___ % organic matter ____C:N ratio <25:1 ____ "stable" (Y/N)	
❑ Quantity: _____ cu. yds. (except mulch, or <35:1 for native plants)	
❑ Product #3:	
❑ Test Results: ___ % organic matter ____C:N ratio <25:1 ____ "stable" (Y/N)	
❑ Quantity: _____ cu. yds. (except mulch, or <35:1 for native plants)	

AREA # ___ *(refer to Areas mapped on Site Plan and described on Soil Management Plan)*

Test Holes	**Rod Test**
Holes Required:____ (minimum 1 hole/acre)	**Number Rod Tests Required:**____ (minimum 10 tests/acre)
Soil Mgmt. Plan? Y / N	**Rod penetrates 12 inches deep in all areas? Y / N**
Deep? Y / N	

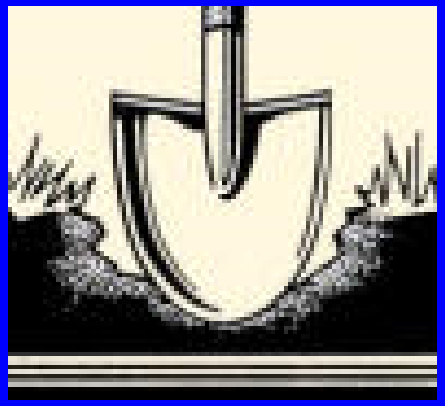
inimum 1 hole/acre)	**Rod Test**
Y / N	**Number Rod Tests Required:**____ (minimum 10 tests/acre)
Deep? Y / N	**Rod penetrates 12 inches deep in all areas? Y / N**
ments:	

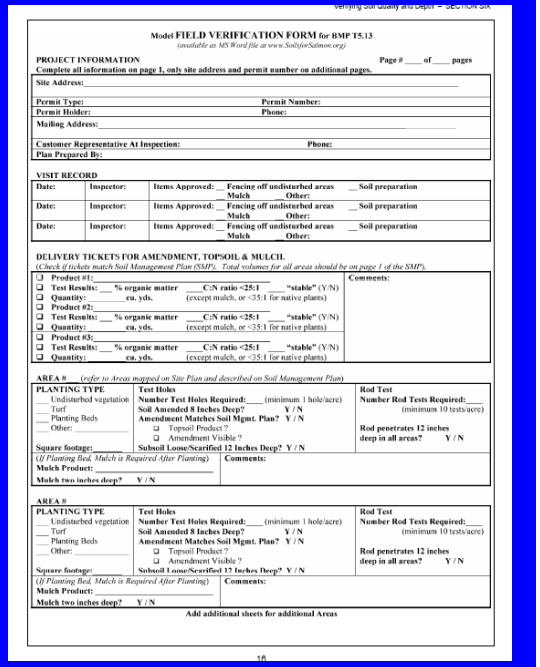
Add additional sheets for additional Areas

model Field Verification form & guide is on page 16 in the "Building Soil" manual, and on website

Inspection / Verification Supplies

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





Model **FIELD VERIFICATION FORM** for BMP T5.13

(available as MS Word file at www.SoilsforSalmon.org)

PROJECT INFORMATION Page # ____ of ____ pages

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Plan Prepared By:

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Date:	Inspector:	Items Approved: __ Fencing off undisturbed areas __Soil preparation __ Mulch __ Other:
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DELIVERY TICKETS FOR AMENDMENT, TOPSOIL & MULCH.

(Check if tickets match Soil Management Plan (SMP). Total volumes for all areas should be on page 1 of the SMP).

❑ **Product #1:**_____ **Comments:**
❑ **Test Results:** ___ **% organic matter** ____ **C:N ratio <25:1** ____ **"stable"** (Y/N)
❑ **Quantity:** ____ **cu. yds.** (except mulch, or <35:1 for native plants)
❑ **Product #2:**_____
❑ **Test Results:** ___ **% organic matter** ____ **C:N ratio <25:1** ____ **"stable"** (Y/N)
❑ **Quantity:** ____ **cu. yds.** (except mulch, or <35:1 for native plants)
❑ **Product #3:**_____
❑ **Test Results:** ___ **% organic matter** ____ **C:N ratio <25:1** ____ **"stable"** (Y/N)
❑ **Quantity:** ____ **cu. yds.** (except mulch, or <35:1 for native plants)

AREA # ___ *(refer to Areas mapped on Site Plan and described on Soil Management Plan)*

PLANTING TYPE	**Test Holes**	**Rod Test**
___ Undisturbed vegetation ___ Turf ___ Planting Beds ___ Other: _____	**Number Test Holes Required:**____ (minimum 1 hole/acre) **Soil Amended 8 Inches Deep?** Y / N **Amendment Matches Soil Mgmt. Plan?** Y / N ❑ Topsoil Product ? ❑ Amendment Visible ?	**Number Rod Tests Required:**____ (minimum 10 tests/acre) **Rod penetrates 12 inches deep in all areas?** Y / N
Square footage: ____	**Subsoil Loose/Scarified 12 Inches Deep?** Y / N	
(If Planting Bed, Mulch is Required After Planting) **Mulch Product:** _____ **Mulch two inches deep?** Y / N	**Comments:**	

AREA #

PLANTING TYPE	**Test Holes**	**Rod Test**
___ Undisturbed vegetation ___ Turf ___ Planting Beds ___ Other: _____	**Number Test Holes Required:**____ (minimum 1 hole/acre) **Soil Amended 8 Inches Deep?** Y / N **Amendment Matches Soil Mgmt. Plan?** Y / N ❑ Topsoil Product ? ❑ Amendment Visible ?	**Number Rod Tests Required:**____ (minimum 10 tests/acre) **Rod penetrates 12 inches deep in all areas?** Y / N
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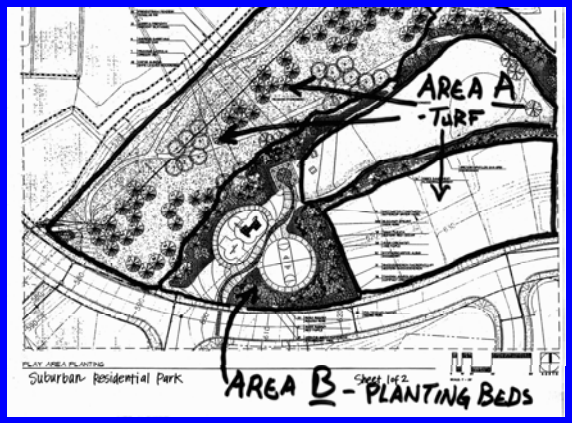
(If Planting Bed, Mulch is Required After Planting) **Mulch Product:** _____ **Mulch two inches deep?** Y / N	**Comments:**	

Add additional sheets for additional Areas



Pre-Grading / Grading Progress Inspection

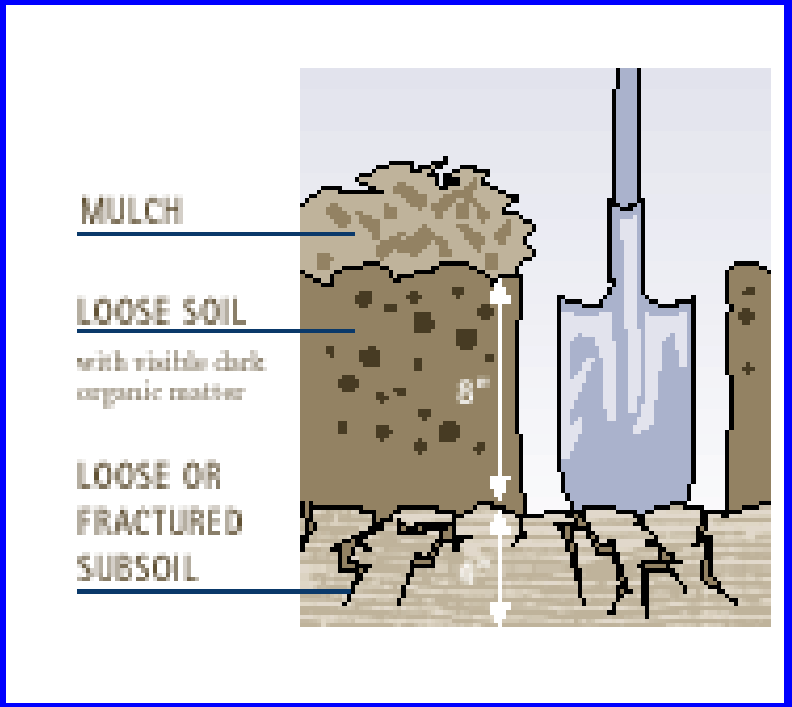
- Verify native soils & vegetation delineation and protection per SMP
- Review SMP with general contractor and/or grading equipment operator
- Verify erosion controls in place
- Verify excavation & stockpiling of native soils consistent with SMP
- Check sub-grades consistent with SMP

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

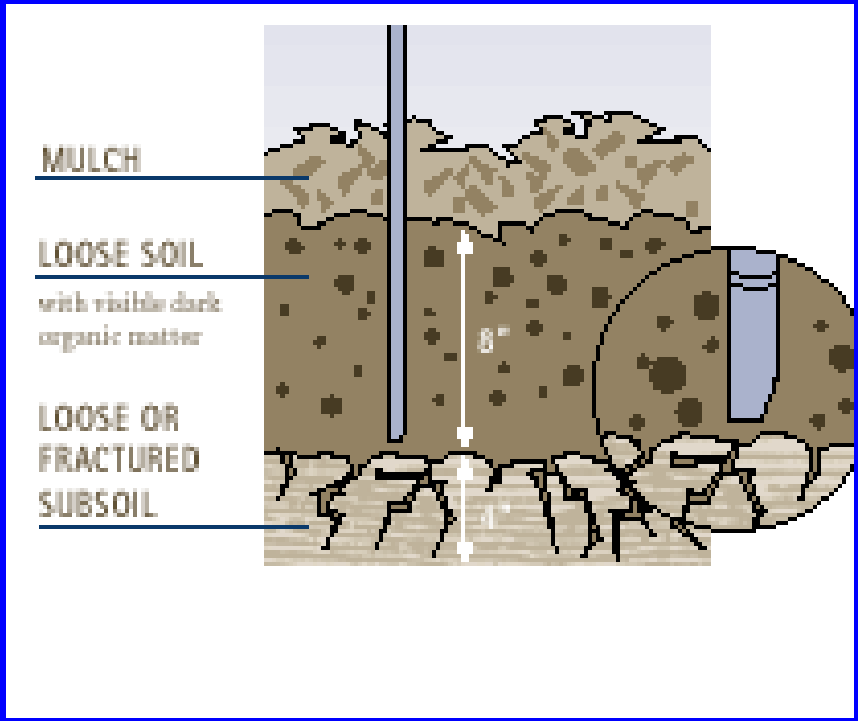
Dig Test Holes to Check Depth of Amended Soil & Scarification

- At least three 12 inch deep test holes per acre (3 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).



In Case Of Dispute

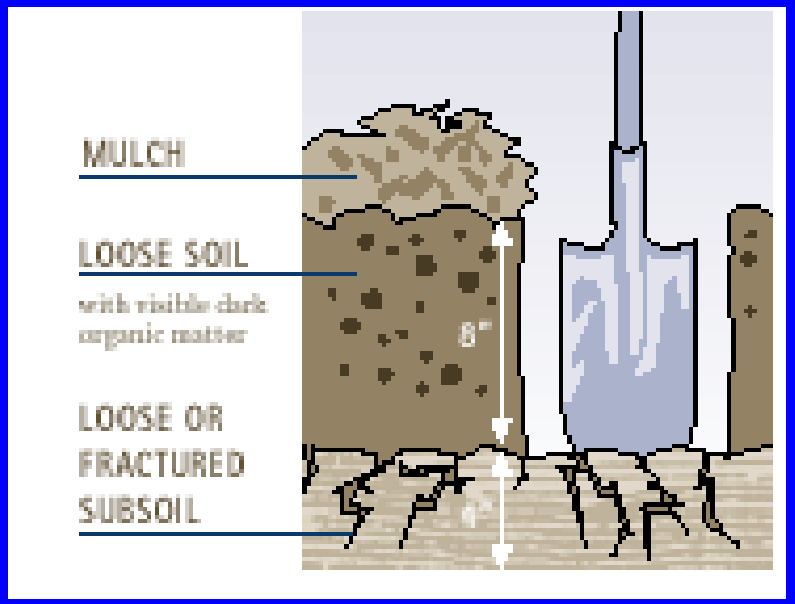
Referred to third party for sampling and testing of organic matter:

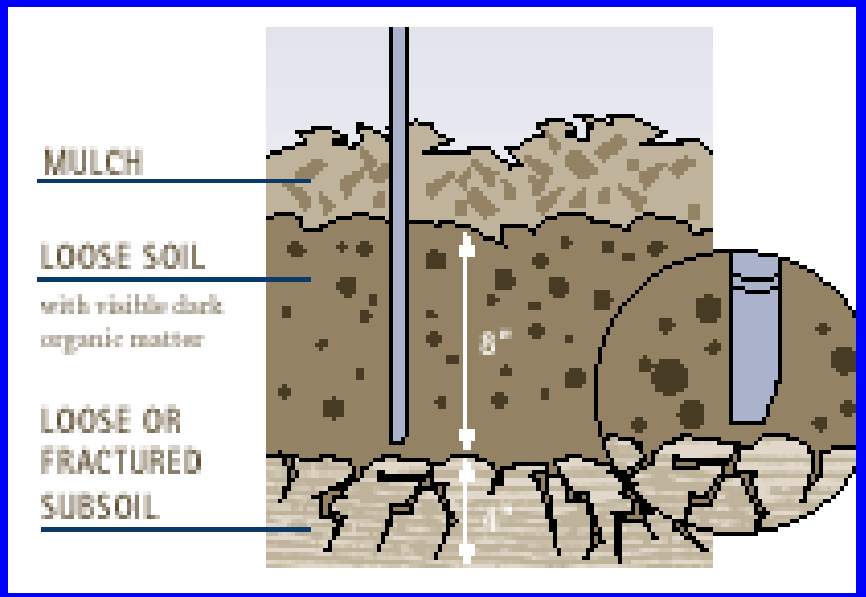
- Independent Certified Agronomist, Crop Advisor or Soil Scientist; Licensed Civil Engineer, Landscape Architect or Geologist
- Accredited Soil Testing Lab

Dispute Resolution

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

➢ **Best to rely on delivery tickets and field tests**





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:
  - Meets US Compost Council (STA) "Seal of Testing Assurance", State & WsDOT specs
  - C:N ratio
  - Weed-seed trials
  - Nutrients, salinity, contaminants
  - Size: "screen", % fines
- Specifications:
  - WsDOT
  - Bioretention Soil: Compost spec

www.seattle.gov/util/GreenInfrastructure

"Composted Material" per WAC 173-350-220

- Produced at "Permitted Facilities" with environmental safeguards to protect streams and groundwater (except very small producers).
- Process monitored to ensure temperatures that destroy most pathogens.
- Tested at frequencies dictated by feedstock & output, for:
  - Heavy metals
  - Pathogens
  - Physical contaminants
  - Biological stability (affects odors and plant response)

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

Compost Application Methods

Compost application & incorporation methods:

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

Blowing & spreading

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

Issaquah Highlands – the big scale

PB
PORT BLAKELY
COMMUNITIES
Integrity and Innovation

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

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

Redmond Ridge, Quadrant Corp.

- Large, master-planned development
- Forest left undisturbed where possible - no compaction
- Cleared vegetation & duff stockpiled for use as soil amendment
- Removed topsoils stockpiled

- All soils amended to 12” depth with organics
- **Early Problems:** Too much organic esp. for turf areas, organic materials not composted (landclearing & duff) - soft soil, excessive water retention, low N, plant/turf problems as result

Redmond Ridge: current method

- Grade site 12 in. below finish
- Install foundation, along with driveway & walkway rock pads
- Spread 14 in. amended soil mix, (will settle to 12 inches) rip in first lift to mix with subsoil
- Soils blended offsite from native duff plus compost
- Soil organic matter controlled to ~10%, pH and C:N ratio for optimal plant growth

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 under “Stormwater code”

Erosion Control Compost Applications for the Northwest

- Blankets
- Berms
- “Socks” (tubes)

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
- Learn more at www.buildingsoil.org/tools/Erosion_Control.pd

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

WsDOT: Erosion control, water quality, successful landscapes with lower mtce. costs

SR 14, Vancouver
Coarse compost, blown in
Note erosion where not applied

Compost amendment,
ripped in

Extensive soil bio-engineering info at:
http://www.wsdot.wa.gov/Design/Roadside/

Combine methods as needed for best water quality and flow control

WsDOT - Protecting Wetland Area from I-5 Runoff

USING MULCHES
After planting and for annual maintenance

BENEFITS:

Mulches limit weed growth, and make weeds that sprout easier to pull or cultivate.

Mulches conserve water, moderate soil temperature, and reduce erosion.

Mulches replenish soil organic matter, enhancing soil biodiversity, structure, and nutrient cycling
= increased plant vigor.

Mulching

WHEN After planting, and once every year or two:

- Spring or fall on trees and shrubs to prevent weeds.
- Early summer on gardens. (Let soil warm up.)
- Fall on beds to prevent erosion and compaction.

WHERE Whole beds, paths, 3 ft. or larger ring around trees & shrubs in lawns.

HOW Remove weeds & grass before spreading mulch. Keep mulch away from plant stems. Use weed barriers or cardboard to control aggressive weeds.

Mulching

WHAT

Woody mulches (wood chips, bark) for woody plants (trees & shrubs).

Non woody mulches (compost, leaves, grass clippings, composted manure or biosolids) for non-woody plants (annuals, perennials, berries, roses).

HOW MUCH

Compost, leaves, sawdust, fine bark, grass clippings: 1-2” deep.

Wood chips or coarse bark: 2-4” deep.

Putting Organic Amendments to Work:

- Restoring soil functions
- Protecting watersheds

Putting organics to work - SEA Streets

Street Edge Alternative onsite detention demo, Seattle Public Utilities and SDOT.

- Compost in wet and dry zones
- **98% reduction in runoff.**

www.seattle.gov/util/GreenInfrastructure

Broadview Green Grid, Seattle

Compost-amended soil in bio-retention swales

Broadview -

Erosion control with compost blankets, berms, and socks

WsDOT projects around Washington

Erosion control and plant establishment on steep site using compost blankets

Chelan

Photos courtesy of Sandy Salisbury, WSDOT

Compost

No Compost

I-5 Marvin Rd. Interchange

Selling soil BMP's to builders, landscape contractors, & homeowners:

Value to builder/contractor

- Less plant loss = fewer callbacks
- Making money on materials and labor
- Quicker planting in prepped soil
- Easier maintenance
- Better appearance sells next job

Sell quality & savings to customer

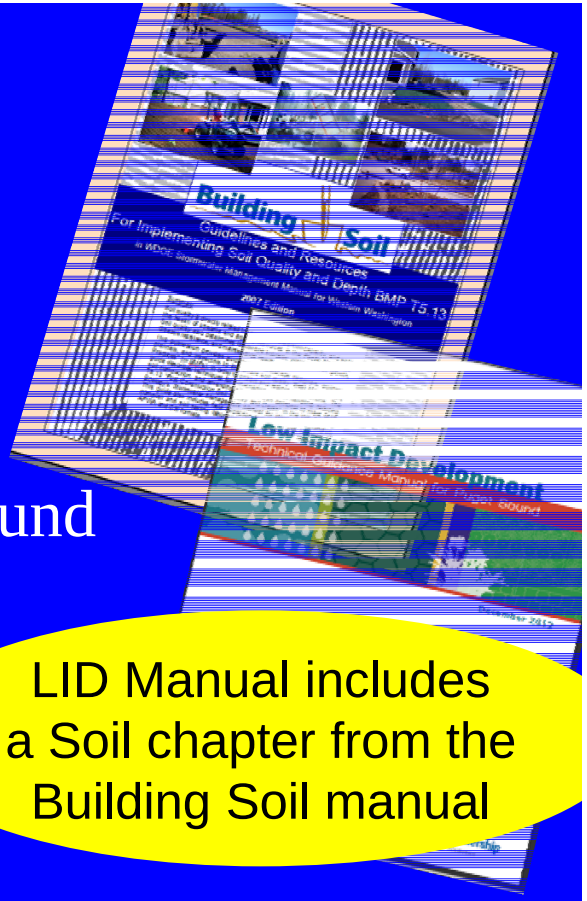
- Better plant survival/ health/ growth/ appearance
- Lower water bills
- Lower maintenance costs
- Reduced chemical needs
- Better for salmon because:
  - reduced storm runoff
  - improved water quality

Links to useful soil specifications:

Building Soil: Guidelines for Implementing
WDOE Soil Quality & Depth BMP
(includes APWA & CSI specs)
www.soilsforsalmon.org or www.buildingsoil.org

LID Technical Guidance Manual for Puget Sound
www.psp.wa.gov/stormwater.php
Eastern WA: www.wastormwatercenter.org

WsDOT "Soil Bioengineering" specs
www.wsdot.wa.gov/Design/Roadside/



LID Manual includes
a Soil chapter from the
Building Soil manual

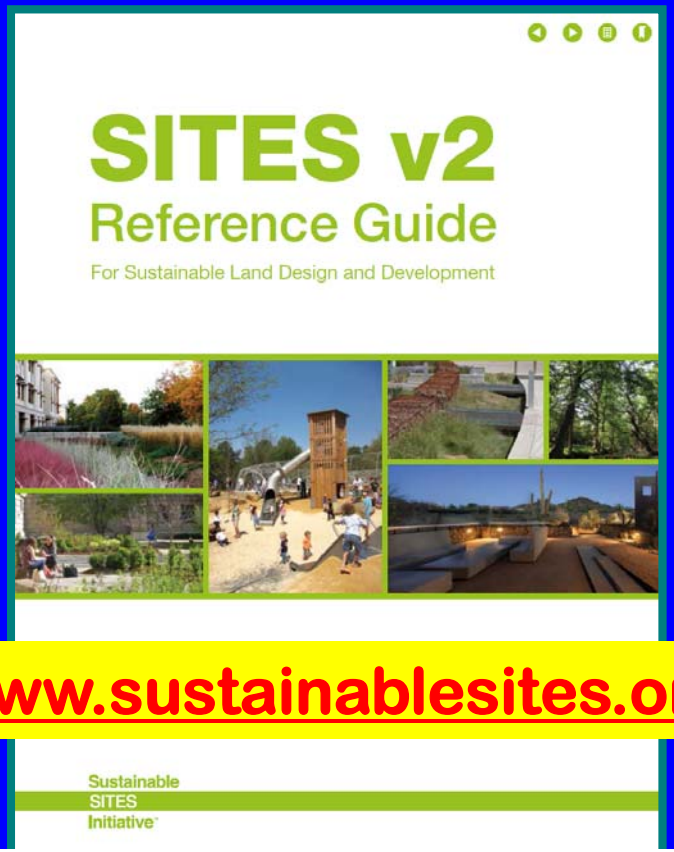
Seattle "Natural Drainage Systems" projects & "Green Stormwater Infrastructure" specs www.seattle.gov/util/GreenInfrastructure

King County soil regs (in Grading code)
http://your.kingcounty.gov/solidwaste/greenbuilding/soil-standard.asp

City of Seattle soil regs (in Stormwater code)
http://www.seattle.gov/dpd/codesrules/codes/stormwater/default.htm

Related national standards: 2014 Sustainable Sites (SITES™)

- **SITES is the new national site & landscape equivalent to the USGBC's LEED™ green building certification system.**
- SITES includes soil protection and restoration requirements modeled on Washington's
- Includes Soil Management Plan requirement
- Similar Green Stormwater BMP requirements to WA LID & DOE stormwater manuals

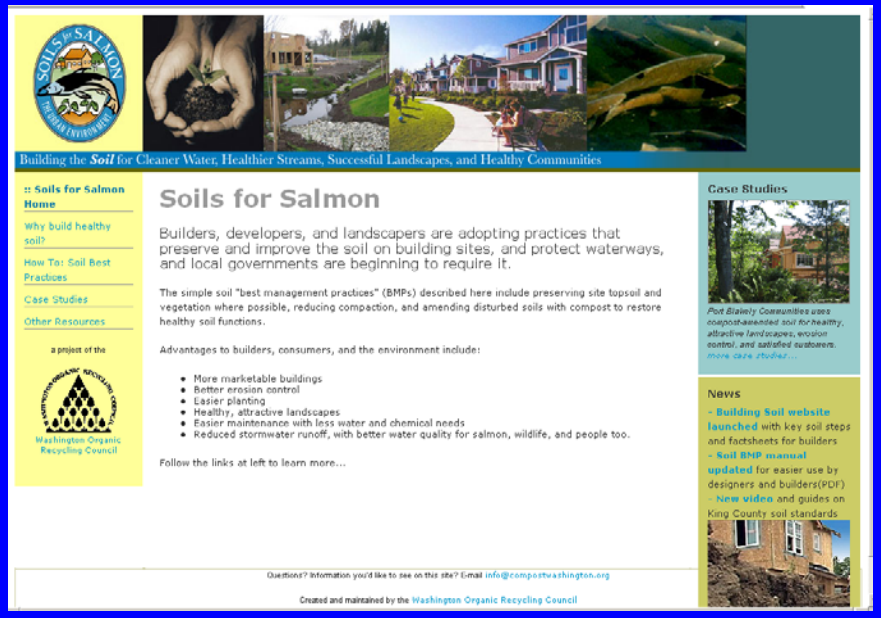


www.sustainablesites.org

A natural solution -
for healthier streams, and healthier landscapes

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

www.BuildingSoil.org



www.SoilsforSalmon.org