Restoring Soil Health To Urbanized Lands

The Crucial Link between Waste Prevention, Land Use, Construction, Stormwater Management and Salmon Habitat Restoration

DEQ

State of Oregon
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Summary

Construction activities disturb natural soils and hydrology and fish habitat. This document explains the link between land use planning, building and road construction, with pollution and waste prevention to improve endangered fish habitat. With a focus on stormwater management practices, it also provides current research on the benefits of amending soil with compost and information on technical specifications for using and applying compost to the various urban sectors, including existing residential dwellings and new construction.

Findings

Findings on the adverse stormwater impacts on endangered species reveal that:

- A direct relationship has been established between total impervious area (TIA) and stream health. The more TIA there is, the less biotic life and juvenile fish there are
- The more impervious surface, including rooftops, sidewalks and roadways, the more pollutants entering the waterways.
- One automobile is equal to 5000 square feet of impervious parking area (5 cars equal a football field of asphalt)
- More than thirty different studies have documented that 10% imperviousness is the threshold for fish habitat degradation. Many areas exceed that by tenfold.
- Research by May and Horner show that the stormwater recovery standards for development, set in 1990, are not helping the biotic life of our streams. However, when a riparian zone is protected directly (e.g., by zoning), a distinct improvement of biotic quality is measured.
- The mere presence of Best Management Practices (BMP) has had no positive impact on biotic life. Standards need to be raised to respond to ESA.
- Researchers on the East Coast have found that in many cases not all the required erosion control practices were being implemented.
- Riparian retention and natural infiltration of rainwater has the highest potential for enhancing salmon habitat.

The conclusions from healthy soil related research are that:

- Native (healthy) soils contain deep plant root growth, high evapotranspiration and surface water infiltration and detention.
- Disturbed soil impacted by human activity, compaction and development has limited organic life, promotes shallow root growth, has low rates of infiltration, and high surface runoff and erosion.
- Data demonstrate the positive effects of soil enhancement on remediating the cumulative effects of surface runoff created by urbanization.
- Data support the pollutant-binding properties of compost use, including suspended solids, turbidity, some metals and chemicals.

- Data demonstrate the effectiveness and the duration of the effectiveness of compost berms in controlling turbidity and total solids in runoff during construction activities.
- The use of compost for erosion and sediment control is beneficial and effective.
- Mulch and seeding results in 80% to 90% sediment reduction on construction sites.
- Compost berms can be more effective than sediment fences in controlling total solids in the stormwater runoff from a site. Additional research is needed to provide data on the ability of compost berms to control turbidity
- Compost soil amendment can decrease the runoff from a site, in addition to providing benefits to vegetation. Compost soil amendment may also significantly reduce the size of any required water detention facilities.
- Data are limited relating to the effects of compost on compaction and engineered fills; more research is needed. Additional studies are needed to better document the benefits of compost amendment of soils on slopes.
- A significant amount of expense can be reduced on construction projects when incorporating low impact and healthy soil practices.

Salmon Rely on Healthy Soil to Enable Healthy Water

Efforts to Increase Healthy Soil and Low-Impact Development (LID) Standards in Oregon

Regional Land Use Planning

Most approaches to land use planning and zoning address rivers, waterways and stormwater control as components of land use plans; these components are where the Endangered Species Act are addressed. However, past land use practices on aquatic habitat have not adequately addressed cumulative impacts of either runoff or the pollutant stress currently being witnessed on waterways. *Designated critical and sensitive areas along with riparian areas need to be managed as ecological systems, not incremental parcels.*

New approaches to development are now being developed. Low Impact Development (LID) analyzes the cumulative effect of development patterns that change the movement and storage of water. LID is a rethinking of conventional stormwater control management standards to incorporate the natural groundwater storage of storm events in development. A coordinated regional planning of shorelines and critical salmon habitat areas is beginning. New standards need to be adopted for redevelopment and new subdivisions that incorporate less land clearing, retain more native vegetation and reduce impervious areas. In the metropolitan Portland area, Metro land use planners are now considering how best to incorporate LID and healthy soils into the land use documents and codes.

Construction Standards

When the earth is disturbed of its natural ability to absorb and infiltrate rainwater, stormwater then needs to be collected, channeled, stored and filtered. These are significant costs to a project. By incorporating Low Impact Development features into a construction project, the soil's ability to perform those functions can be retained. In many cases, compaction is required to prepare a site. Often the topsoil is removed and treated as a waste material. *By restoring the biotic life to the top 12 inches of compacted and other disturbed soils, the natural absorption, filtration, and evapotranspiration characteristics, for most rain events in Oregon, can be restored.*

A standard needs to be set for restoring the biotic life and natural retention and filtering characteristics back to each construction site. Tilling in about 4" of compost is a simple, cost-effective way to restore organic health to a site. Retaining and using native topsoil, minimizing the construction footprint and retaining buffer vegetation along waterways also contribute to healthy soil. In the metropolitan Portland area, education workshops are being planned to educate local jurisdictions on the need to increase construction standards to include restoring the health of the soil.

A second area where standards need to be improved to address ESA is during construction projects. Currently used erosion and sediment control techniques have been shown to have a limited effectiveness, with significant amounts of turbidity and other pollutants migrating for a construction site. *By requiring the use of compost berms and blankets during construction in the rainy season, a significant amount of pollutants can be prevented from leaving the site.* A pilot project with Oregon Department of Transportation is being planned in the Metro region to demonstrate the uses and benefits of compost-related best management practices in stormwater management. See Appendix 3.

Pollution Prevention and Landscaping

Portland area Pollution Prevention Outreach Team (P2O) has developed a successful audit and best management practices (BMP) recognition program for the automobile industry called Ecobiz. The businesses that implement a desired number of BMPs get certified as a "green" business. This program is being expanded to provide an assessment and usage of BMPs for landscapers. The healthy soils and low impact development concepts will be included in the BMPs. The use of compost during construction can also benefit as prevention as well as control of pollution.

Natural Gardening

Many opportunities for preventing pollution exist in residential and commercial sectors. For both, natural gardening techniques can reduce the need for unnatural addition of pesticide and fertilizer on lawns and gardens. Many lawns and landscaped areas have been compacted over the years, thereby creating a surface that creates a direct pathway to the rivers when chemicals are applied near a rain event. *Aeration and compost provide for the biotic life necessary for healthy soils.* Healthy soils in turn provide for rainwater infiltration, plant nutrients and natural pesticides. This principle applies to existing landscaping as well as proposed. Use of compost during construction and in landscaping can also prevent or reduce runoff. Currently efforts include providing education materials the Natural Gardening programs on the benefits of healthy soil to healthy water and including a focus on the state grant programs that awards criterion points for natural gardening projects. Also considering ways to incorporate aeration and compost use in existing home composting programs.

Erosion & Sediment Control Manuals

State and local jurisdictions provide guidance for controlling sediment runoff and erosion. The concept of healthy soil needs to be incorporated into each agency field manual. Currently working with the Oregon Department of Transportation staff to amend their Erosion & Sediment Control Manual to include the restoration of the health of the soil and use of compost berms and blankets during construction activities.

Green Streets Handbook

Portland Metro Green Streets Handbook is an environmental design manual for transportation projects in the metropolitan Portland area. Healthy soil concepts and restoration of disturbed soils have been added in the implementation section providing standards for attaining healthy soils. Green Streets incorporates many LID principles. See Appendix 2.

Water Quality Model Code and Guidebook

The State of Oregon has a strong statewide land use planning law. This model code and guidebook provides some specific useful ordinances and plan language for incorporating some low-impact development standards into local plans and zoning codes. Work is now being done to include the healthy soil concept, as well as include the use of compost-related best management practices as components of zoning sections related to site design. See Appendix 1.

Leadership in Energy and Environmental Design (LEED)

The State of Oregon Energy Office is adopting the Green Building Rating System, developed by the US Green Building Council called the Leadership in Energy and Environmental Design (LEED) system. The green building standards require a baseline facility performance derived from a set of criteria (such as to maximize energy and water efficiency) to gain a level of recognition. One criteria area is siting and on-site stormwater and erosion control. Efforts are underway to include the healthy soil concept and some LID principles in the ranking standards.

Integrated Parking Lots

Parking lots are now being designed to take an integrated approach to stormwater management. Automobile stalls are made smaller and then the saved space along with the existing landscaping is incorporated into natural swales for filtering rainwater runoff. About 10% of the parking area is landscaped to manage the runoff infiltration. The cost savings has been determined to be about $4,000 less per acre for the integrated approach as compared to the paved approach. In addition, the maintenance is less than the conventional approach. The OMSI parking lot in Portland realized $78,000 savings in construction costs alone.

Eco-Roofs

By placing appropriate vegetation on a rooftop of a building, a significant increase in evapotranspiration and rainwater uptake occurs. Most of the rain from an average rain event can be managed through the natural biology. A saturated Eco-roof adds about 10 pounds per square foot to a structure, and the additional cost for a concrete structure is about $0.50 per square foot. In Portland, several sites are now being fitted with vegetative rooftop stormwater management systems.

Eco-Planting Strips

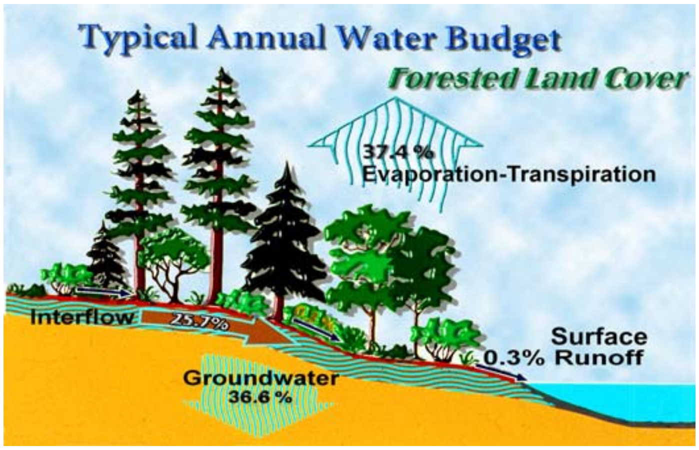
By retrofitting a planting strips along both sides of a street with the appropriate grade, vegetation, channeling, soils etc., rainwater that ordinarily needs to be piped to a natural waterway (often untreated) can be filtered, settled and infiltrated prior to entering natural drainage courses. In the metropolitan Portland area, planners are looking at options for retrofitting turnarounds and other roadway strips to act as active stormwater management components

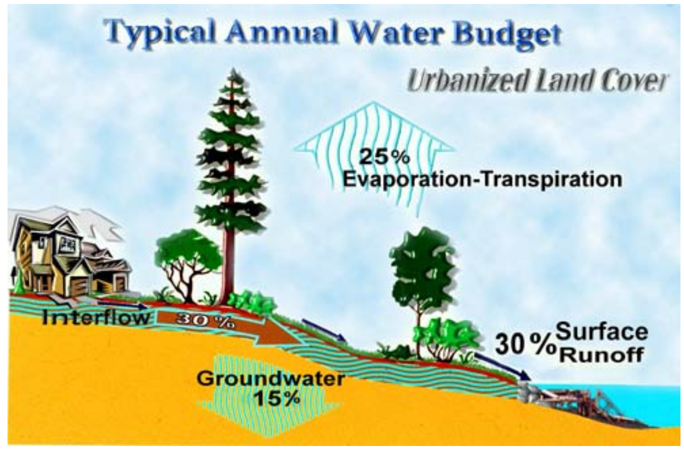
Soils For Salmon

Soils for Salmon (S4S) is a consortium of efforts to undertake education and research on applications for restoring the health of soil. It originated in King County, Washington by the Washington Organics Recycling Council and has spread to Oregon. The program is designed to increase awareness of soil improvement as a means to support salmon and other fish species recovery. A goal of S4S is to assist local government in adopting management practices that conserve native soils and improve disturbed soils.

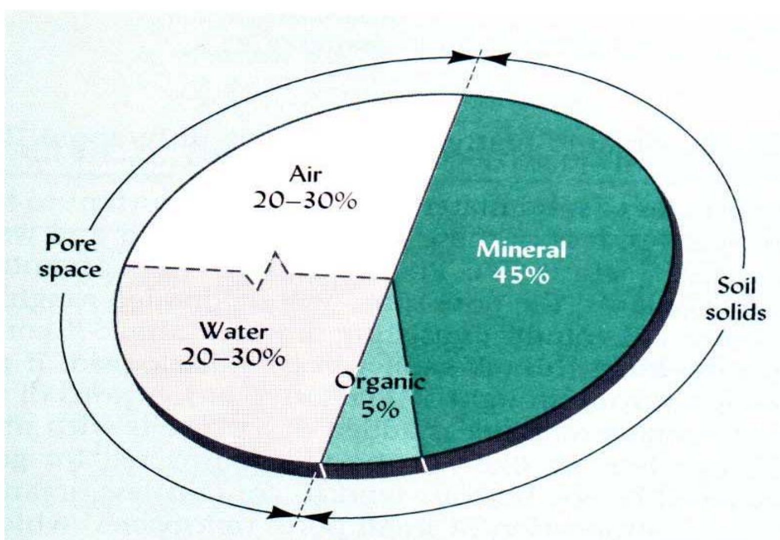
The Value of Native Soil

A healthy, vibrant soil and vegetation structure provides valuable plant nutrients, holds and retains water and oxygen, binds and degrades pollutants. Construction activities have caused adverse impacts to the environment in the past. Two aspects are: cumulative, long-term increased stormwater runoff due to engineered soil compaction and impervious surfacing, and the stormwater runoff generated during the construction itself. Both of these aspects contribute to polluting salmon habitat.





An undisturbed site typically has 40% to 55% pore space in the undisturbed soil. The bulk density of the soil is between 1.1 and 1.4 grams/cubic centimeter (g/cc). Rain or snowfall results in about 50% evapotranspiration, 35% infiltration, and 15% surface water runoff. After construction, the same site may end up with 15% to 30% evapotranspiration, 15% infiltration, and 55% to 70% surface water runoff. Soil bulk density typically increases to between 1.5 and 2.0 g/cc.

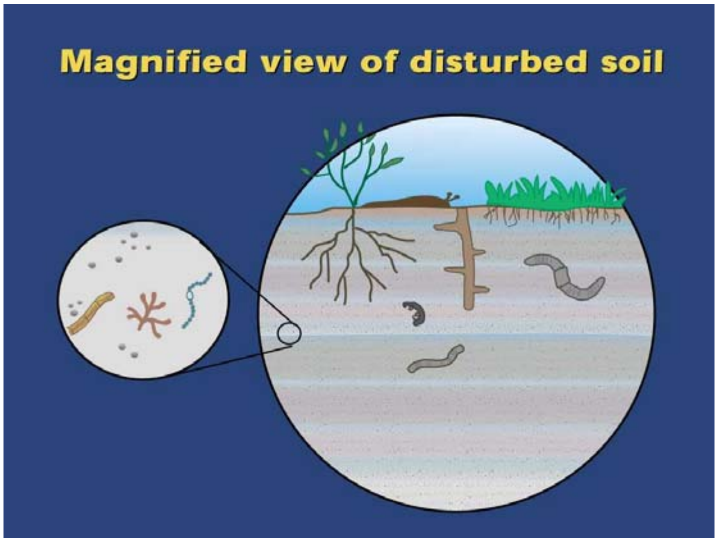


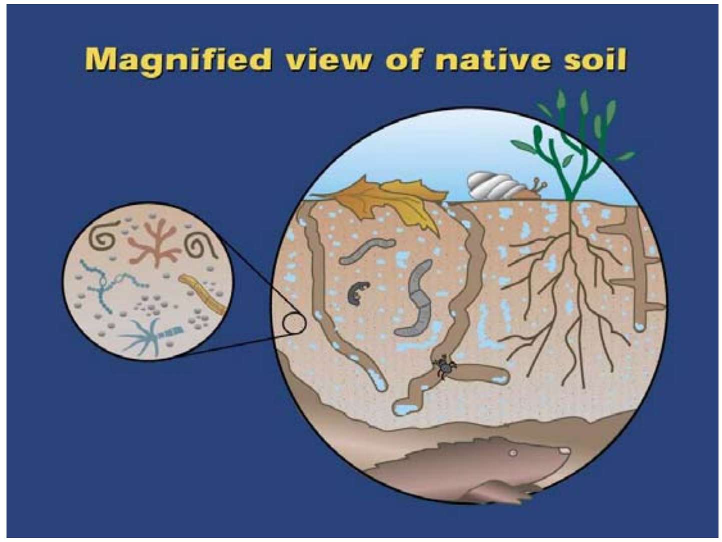
Healthy Soil Make-Up

This is a 20% reduction in infiltration and a 40 to 60% increase in surface water runoff. The pore spaces in the soil are the main pathways for water infiltration. Their loss in the soil takes decades to replenish, if then.

Soil invertebrates, such as mites, nematodes, and collembola, and soil microbes, such as bacteria and fungi, recycle all the carbon, nitrogen, and other mineral nutrients in plant and animal residues into forms that can be used by plants. The top 8 to 12 inches of soil account for most of the biological activity, nutrient cycling, and roots.

This depth of soil is called the rhizosphere. Compaction of the soil disrupts the established balance of the rhizosphere by destroying organisms, and since these are air-breathing organisms, eliminating or decreasing the amount of oxygen available for growth and color establishment.

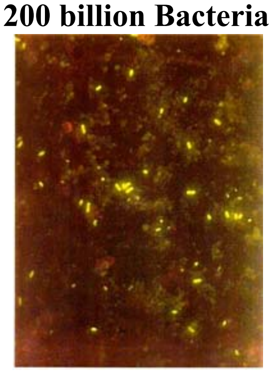




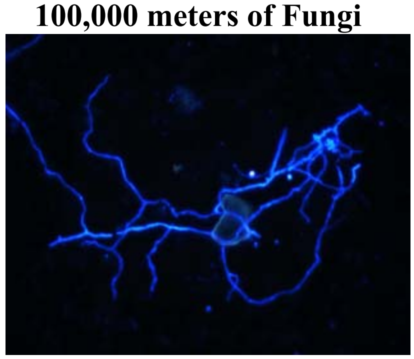
Soil Biota Enhancement

Soil contains macroflora, microflora, macrofauna, mesofauna and microfauna. A cup of undisturbed native topsoil can contain:

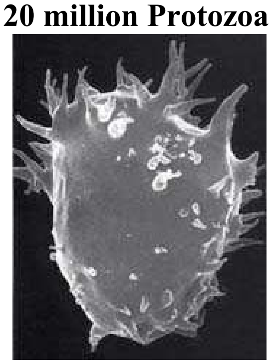
200 billion Bacteria



100,000 meters of Fungi



20 million Protozoa



100,000 Nematodes

Earthworms <1

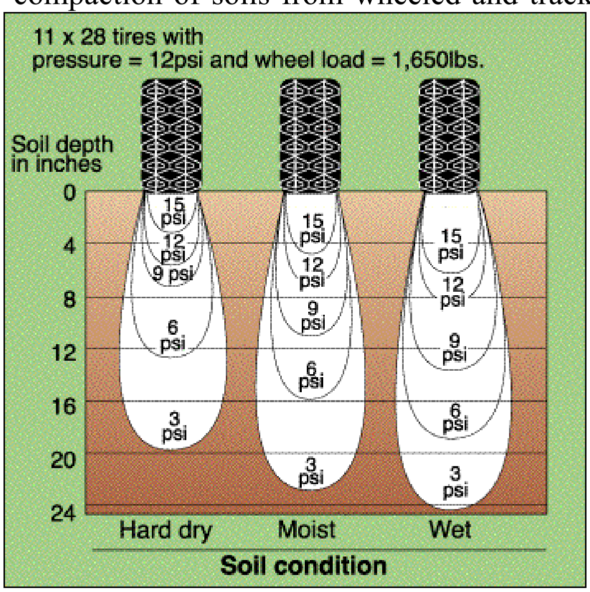
50,000 Arthropods

Disruption of soil can kill most of the beneficial biota and remove the air spaces in the soil that the aerobic biota need in order to live and thrive. Surface plantings, fertilizer and other nutrient supplements typically only help the first few inches of soil to develop a new biota. Chemical fertilizer addition can actually kill or restrict the development of this biota. The biota is necessary for healthy vegetation.

The Impacts of Human Activity on Soil

Disturbed soil occurs in urbanized areas, constructed areas, inhabited areas and any regularly frequented areas. This includes commercial, residential, transportation, agricultural, industrial areas and even animal trails. **Compacted soil** stresses the root structure of newly planted vegetation by making it difficult for root penetration. Newly established vegetation typically becomes stunted and remains smaller than vegetation established in undisturbed soil. With the lack of porosity in the soil, shrubs, trees and bushes remain root-bound and the rootball may become waterlogged and essentially drown in some areas.

Vehicle traffic also compacts soil. Vehicle traffic can be seen from a historical perspective. For only 28 years from 1841 to 1869, three thousand-pound plus wagons crossed the western half of the united States on a narrow stretch of land called the Oregon Trail. Some stretches of the trail still show ruts and stunted vegetation, today some one hundred thirty years later. Animal trails exist for hundreds of years in native forests. Localized compaction of soils from wheeled and tracked vehicles occurs up to 30 inches below the soil surface. The amount of compaction is dependent upon soil moisture content, soil type, and load distribution. The figure above shows a typical relationship between soil loading and the depth of the impact of the soil compaction. The wheels or tracks tend to push soil particles into the voids or pores in the soil. In wet soil the compaction is more severe than in dry soils.



The photo below left shows a typical result of soil compaction while the photo on the right shows sod after a few months of growth. A hard "pan" or layer, develops on, or just beneath the topsoil, and prevents water from filtering through the soil. The result is that the soils can become almost impervious and have runoff characteristics similar to pavement. Some of the consequences of compacted soils are that lawns requires more watering and fertilizers to survive, runoff increases, and poor soil conditions develop so that there is loss of plant vigor.

Effects of Soil Compaction

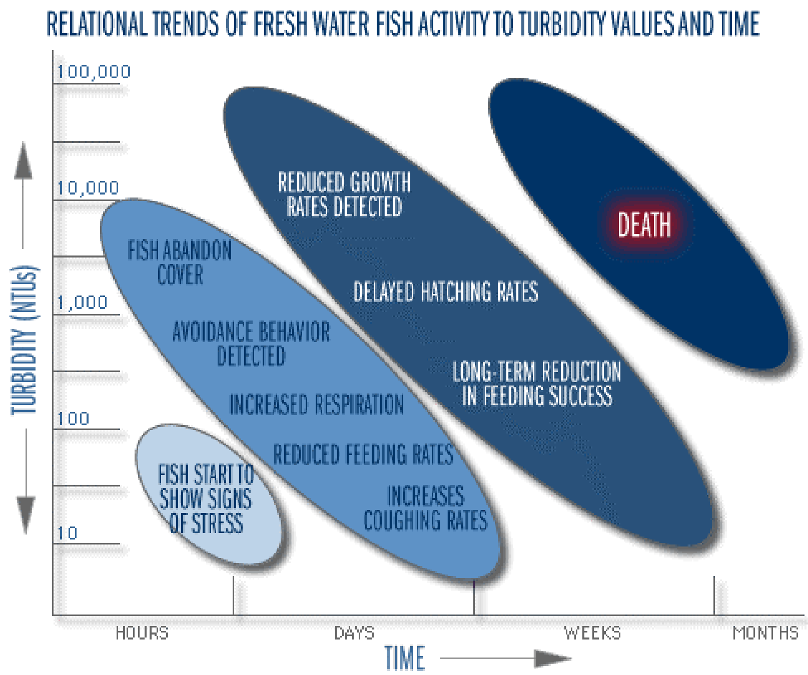
Impervious surfaces such as roof-tops, sidewalks, roadways and parking lots all have the effect of decreasing natural rainwater percolation and evapotranspiration and impervious surfaces increase stormwater runoff and velocity that leads to erosion. **Stormwater runoff** contains sediment, suspended solids, turbidity or dissolved solids, and other pollutants. Some of the sediment and suspended solids can usually be controlled using conventional methods including sediment traps (settling basins) or filters, such as sediment fences. **Pollutants** attach to soil particles. When sediment and suspended solids runoff is controlled, the remaining concern is the dissolved portion generally referred to as **turbidity,** which consists of submicron-sized soil particles. Reducing turbidity can be expensive to treat so is most cost effective to prevent it.

A Turbid Vs Clear Water Comparison

Sediment can silt over fish spawning beds and kill off aquatic animals that fish feed on. It can also raise stream temperatures to ranges in which the fish and other aquatic animals cannot survive. The impact of turbidity on fish and aquatic animals involves a relationship between the level of turbidity and the duration of the turbid event. This can be shown in the following graph.

Studies in the Pacific Northwest on salmonids show similar results. In many streams, there are periods when the water is relatively turbid and contains variable amounts of suspended solids. Larger juvenile and adult salmon and steelhead appear to be little affected by ephemerally elevated suspended solids associated with storms (Bjornn and Reiser 1991). However, older juveniles may avoid turbidity levels associated with severe erosion at 70 neophenlometric turbidity units (NTU). Berge and Northcoate (1985) reported that the feeding and territorial behavior of juvenile Coho is disrupted by short-term exposures (2.5 - 4.5 days) at a turbidity of 60 NTU.

Studies reported by Lloyd et al. (1987) describe rainbow trout avoidance of turbid water above 30 NTU. The avoidance of turbid water has been documented by both field and laboratory studies. Bilby (1982) observed Coho salmon avoidance at water turbidity levels above 70 NTU. The **fish avoidance behavior** has been associated with the fish's ability to see. Several studies discussed by Lloyd et al. (1987) suggest significantly reduced angler success at turbidities ranging from 8 - 50 NTU, which suggests a reduced ability of the fish to locate prey. The U.S.Environmental Protection Agency (EPA) (1977) reported that cutthroat trout abandoned redds, sought cover and stopped feeding when a turbidity of 35 NTU was encountered for two hours. In addition EPA (1977) reported reduced growth and feeding at 50 mg/l total suspended solids (TSS).



Summary of Turbidity (NTU) Cited Impairment Thresholds	
Turbidity	**Impairment**
5-25	Reduced primary production
8 (8-50)	Reduced angler success
11-49	Emigration (salmonids)
(3-30)	Cough response/Avoidance (salmonids)
21	Reduced salmonid population density
25	Reduced feeding and growth in salmonids, prolonged exposure
30	Trout avoidance
35	Redds abandoned
50	Juvenile displacement
60	Feeding and territorial behavior disrupted
70	Avoidance by older salmonids

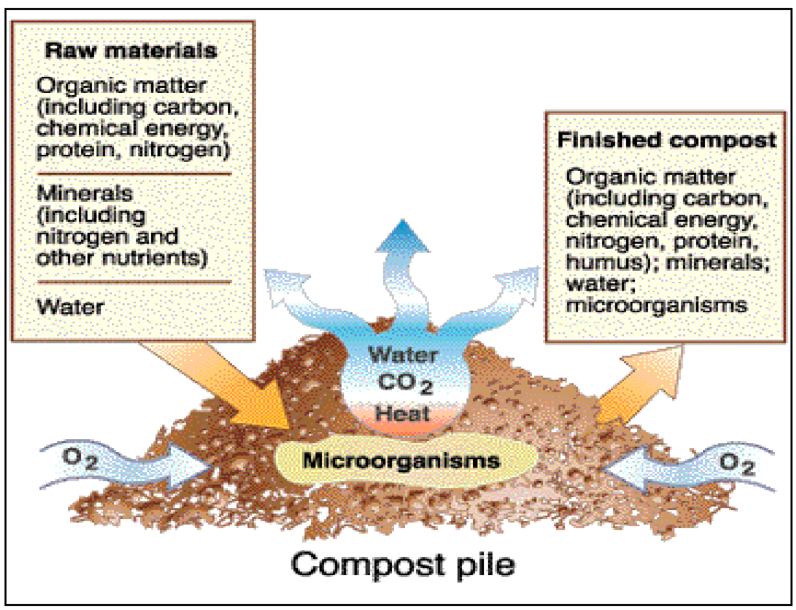
A Solution: Amending the Soil with Compost

Soil amendments, including compost, improve water quality and salmon habitat. In addition, compost can restore the health of the soil and its environmental functions of increased rainwater infiltration and natural detention, increased evapotranspiration and plant health. Compost can help prevent or minimize adverse stormwater runoff impacts to the environment during construction and help to approximate predevelopment flow rate, volume and timing of runoff to preserve riparian areas and stream banks.

Compost as a Soil Amendment:

Because vehicle traffic and engineered fills compact the soils thereby reducing or eliminating the pore space and the biodiversity of the soil, a method must be used to regain that porosity and biodiversity, or increased runoff will occur and new vegetation will be restricted. Using compost to amend soils increases the porosity of the soil and adds beneficial organisms and nutrients back to the soil.

In the U.S., compost amending is usually performed by spreading four inches of compost on the surface and tilling it in to a depth of eight inches of compacted soil for a total depth of twelve inches. The general rule is a 2:1 soil-to-compost by volume. The soil should be pre-tilled to loosen it before the compost is placed on top. Tilling the compost into the soil should be accomplished by tilling it twice, the second time perpendicular to the first.



To loosen up compacted soil to greater depths, deep tilling equipment can be used to till to 24 inches of depth or more. Caution should be exercised in the selection of the equipment to use because of the concern for the weight of the equipment recompacting the soil and for the time of year in which this process takes place. The latter part of the dry season is best.

Vegetation Establishment with Compost:

Various studies have established that vegetation establishment is more rapid and more complete when compost was used alone, without fertilizers. The addition of fertilizers with the seed and compost usually resulted in slower growth and less complete coverage of the vegetation than with just seed and compost. In both compost and fertilizer situations, the vegetation and coverage was superior to bare ground or to normal hydroseeding.

When applying compost in blankets of a thickness of four inches and greater, when seed is to be added, it is better to apply the compost in the top two inches. Seed mixed with compost in the top layer of compost will germinate, grow and usually provide good coverage well into the colder non-germinating season. This is probably due to the insulating aspect of compost. The benefits of using compost as a soil amendment are:

- Incorporation of organic matter improves the structure of the soil;
- Increased moisture holding capacity;
- Increased moisture retention ability;
- Source of nutrient supply for vegetation;
- Vegetation greens up faster and better than in unamended soils;
- Healthier vegetation established;
- Increased stormwater retention;
- Reduced irrigation requirement; and
- Increased pollutant retention.

Additional benefits of compost include: reduced waste to landfills, reduced need for fertilizers and pesticides, reduced watering costs, improved plant appearance and increased natural rainwater filtration. It should be noted that in the Pacific Northwest, soil amendment with compost in excess of 30% by volume in poorly draining areas (shallow sloped) should not be attempted, as this will likely result in waterlogging and be detrimental to lawns or other vegetation. In poorly draining areas, a subsurface collection system (French drain) may have to be designed and installed to prevent this waterlogging. Excessively steep slopes may have to be terraced to provide gentler slopes

Erosion and Sediment Control

Compost has beneficial properties during construction activities to reduce, eliminate and prevent off-site migration of sediments, suspended solids and other pollutants.

Compost Berms:

A compost berm can be used as a stand-alone erosion and sediment control or be combined with a layer of compost covering a slope. The minimum dimensions of a compost berm are a height of 12 inches and a width of 24 inches. Coarse-grade leaf compost works best for controlling turbidity. Medium- and coarse-grade yard debris can also be effective at controlling sediment and total suspended solids. Stormwater flow into the berm should be in sheet flow. Too high water retention or too high velocity flow behind the berm will cause a blowout of the berm, unless the compost is held in place by, say, an open weave geotextile fabric. Berms should be placed in similar locations as those chosen for sediment fencing, straw bales, etc.

All types of vegetative compost can greatly reduce total phosphorus and heavy metals, except zinc, in runoff. Compost berms should seriously be considered for use over consideration of using sediment fencing.

ODOT on U.S. Highway 26 at Sylvan Hill

Eugene, Oregon

Compost Blankets:

Compost covers, blankets have been successfully used on slopes exceeding 1:1.4. In numerous applications around the U.S., blanketing a disturbed site with 4 inches of compost provides a number of benefits including reduced runoff, improved vegetation establishment, restored soil health and retained moisture. SoilDynamics applied an enhanced compost mixture called EssentialSoil™ to a slope exceeding 100% in Medina, Washington to a depth of 12 to 15 inches with great success.

Amazon Creek, Oregon

Beef Bend Road, Oregon

Medina, Washington

Residential and Natural Gardening Use

Compost Tea:

Compost tea is the liquid that is derived from soaking compost in water. It is suspected that the use of compost tea can penetrate compacted soils and help reestablish the pores need for good infiltration. Further research is needed to establish or disprove this. The benefits of compost tea are:

- Increased disease suppression;
- Nutrients for plants and food resources for microorganisms;
- Injection of microorganisms into the soil which increases the retention of nutrients, recycles nutrients into plant-available forms, and accelerates decomposition of plant material and toxins:
- Increased nutritional quality of plant produce and improved plant growth; and

❖ Reduced negative impacts of chemical-based pesticides, herbicides, and fertilizers on beneficial microorganisms.

Most lawns and landscaping tend to get hard-packed if not aerated regularly. Hard-packed lawns and landscaping become impervious. A simple way to increase rain infiltration while saving money on water and fertilizer is to aerate the lawn or landscaping and rake in compost or use compost tea. The benefits will last multiple seasons.

Testing the Benefits of Compost

Field Test -St. Johns Landfill (Portland, Oregon), 1993

A study performed by W & H Pacific and CH2M-Hill, in 1993, showed that total solids (TS) could be reduced in runoff by 99.94% by using medium-grade mixed yard debris compost compared to that of bare ground, on a 34% slope. The W & H Pacific study showed a 55% reduction in turbidity in the runoff over that of bare ground. This study indicates that the performance of sediment fencing as a control for sediment and total suspended solids (TSS) is highly questionable. In this project sediment fencing reduced total solids (TS) in the runoff by 39% and coarse-grade mixed yard debris compost berm decreased TS by 83%. Compost berms cost approximately 30% less installed than sediment fences.

St. Johns Landfill (Portland, Oregon) Test Site

Lakeside Reclaimation, (Portland, Oregon), 2001

Metro and DEQ tested the application of compost berms and blankets on a closed portion of a construction and demolition landfill. The slope was 4 to 1 and is directly adjacent to the Tualatin River. Tests indicated that the berms held up over two full rainy seasons effectively absorbing rain and suspended solids. The compost blankets were applied at various thickness and while 4 inches was optimum, it was learned that a two inch blanket prevented rills and gullies from forming as compared to the control site of seeded clay-type cover. .,Establishment of ground cover was significantly enhanced in using the compost

1

(L)-Seeded Compost (R)-Seeded Clay **Rills Form on Surface w/out Compost**

Lab Testing:

SoilDynamics tested the EssentialSoil™ mix at the San Diego State University's Soil Erosion Research Laboratory. A 12 inch depth of the enhanced compost was used on a 50% slope. Total solids were reduced from that of bare soil by 98%, and runoff as measured from three consecutive 10 year storm events (Los Angeles) was 77%. Turbidity results using compost have been mixed, due to testing problems. It should be noted that mature compost should be used when trying to control turbidity. The ionic capture of the colloidal soil particles which cause turbidity could be offset by the release of tannins or tannic acid from immature compost.

San Diego University Testing Apparatus

Compost Installation Methods

Compost can be applied to a site by mechanical/manual, conveyor, or blower methods. The moisture content of the compost can greatly effect some of these methods. An application of too wet compost can impair the ability to manually or mechanically spread the compost on-site.

Compost Blower

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Appendix 1 – Water Quality Model Code and Guidebook - Healthy Soil Standards (DRAFT)

Chapter 3

Healthy soils lead to healthy waters. Low-impact development (LID), which uses or restores the existing hydrological properties during construction equals more cost-effective management of stormwater on-site. LID management standards are available for improving land use plans and zoning codes. Endangered salmon are now the crucial link between land use planning, building and road construction, and pollution and waste prevention. New development should now address a coordinated assessment of waterways, riparian zones and critical areas before proceeding. Existing structures can be retrofitted to include porous parking surfaces, bioretention areas, vegetative rooftops, and natural gardening practices. Environmental protection can be enhanced by using compost-related techniques to more effectively control stormwater runoff during construction activities.

The cumulative adverse impacts on fish habitat by constructed areas and impervious surfaces are significant. Restoring the health to soil can aide in salmon recovery. Microbes and other living organisms contribute to the process of soil porosity, and nutrient availability for plants. The soil food web and organic matter decomposition process is vital to water quality. Native soil and soil amendments provide the necessary environment for living organisms.

Chapter 4

Non-Structural BMP Solutions for Designated Pollution Factors

Native Soils and Soil Amendments

Retain Native Topsoil, incorporate compost into disturbed soils, and minimize compaction by limiting the construction activity "footprint." Use compost berms and blankets during construction.

Common Problems Associated with Designated Pollution Factors

Increased Erosion & Sedimentation

Reduces total suspended solids, turbidity and other pollutants from migrating off-site. Increases infiltration of rainwater. More infiltration to groundwater of rain results in less runoff and erosion & sedimentation.

Increased Runoff Volume

Decreases runoff by40% to 55% through increasing infiltration and evapotranspiration by the organic process of living, healthy soil.

Nitrogen, Phosphorous, Metals & Other Pollutants

Compost will bind many pollutants and incorporate them into the soil structure Healthy soil contains about 25% water and air and about 5% organic matter. The combination of the active process of composting binds most pollutants and in some cases renders them inert.

Increased water Temperature

Decreases water temperature by increasing natural infiltration of rainwater into the groundwater and limiting the amount of surface water that gathers heat as it makes its way to the waterways..

4.4.9 Erosion and Sediment Control

V.i Sample Soil Quality Performance Standards

Following these practices will minimize the amount of run-off migrating from individual lots and when used within rights of ways will increase the ability of the stormwater management facilities to retain water and bind pollutants.

A. Purpose

To ensure construction activities contribute to a healthy watershed by restoring disturbed soils to the original or higher level of porosity and water retention capacity.

1. Minimize disturbance of native soils and reduce the amount of native topsoil removed off-site.
2. Store topsoil on-site and restore all soils to original porosity by amending with 20% compost by volume to a depth of 8 inches.
3. Minimize compaction of soil by heavy equipment and limit activity "footprint" leaving as much area as possible undisturbed.
4. Grind organic land clearing material and use as mulch on-site to control mud and amend soil.
5. Incorporate 2-4 inches of compost into disturbed soils after construction during landscape development.
6. Improve damaged soils and surrounding soils impacted by construction with 30% compost by volume to a depth of 8 inches.
7. Retain or reestablish native vegetation as much as possible.
8. Cover soil during re-vegetation efforts using mulch materials from on-site or imported.
9. During construction use compost berms in place of silt fences to increase capture of total suspended solids and binding of other pollutants. Use a blanket of compost on scarred areas during construction to reduce erosion potential.

Chapter 5. Water Quality Protection Resources

Soils for Salmon

http://www.compostwashington.org/soilss2.asp
Includes information on education, government programs, and assistance programs. Includes *The Relationship Between Soil and water, How Soil Amendments and Compost Can Aid in Salmon Recovery*, an excellent guide to soil health.

http://www.deq.state.or.us/wmc/solwaste/composting.html
Includes a wide variety of information including facility contacts, technical and permitting information and links to rules and regulations. Includes *Restoring Soil Health to Urbanized Lands – The Crucial Link between Waste Prevention, Land Use, Construction, Stormwater Management and Salmon Habitat Restoration*, an excellent guide to low impact development and soil health.

Stormwater Best Management Practices

U.S. Environmental Protection Agency
http://www.epa.gov/owow/nps/urban2.html
The Office of Water has an on-line publication entitled *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures--Urban* containing technical information and methods for evaluating stormwater best management practices.

Water Research Commission
http://www.wrc.org.za/reports/tt95_98.htm
An online article entitled "The Removal of Urban Litter from Stormwater Conduits and Streams" includes information on the most appropriate and cost-effective methods for removing litter from drainage systems

Low Impact Development

Center for Watershed Protection's Stormwater Center
http://www.stormwatercenter.net/
The Stormwater Center offers resources to technically assist decision-makers and the public on stormwater management issues. Resources include publications and manuals, slide shows, ordinance information, monitoring and assessment methods, and best management practices factsheets.

Low Impact Development Center, Inc.
http://www.lowimpactdevelopment.org
The Low Impact Development Center is a non-profit water resources research group with a mission of conducting research and training on LID and sustainable stormwater management. Resources include publications, pictures, and other resources.

Urban Land Institute
http://www.uli.org
The homepage of the Urban Land Institute, an organization with the mission of providing responsible leadership in the use of land towards enhancing the environment, offers design resources for housing, retail, office, and transportation development.

Appendix 2 Green Streets Healthy Soil Standards

D. Native Soils and Soil Amendments

After planning new development, a jurisdiction should review its development regulations to ensure construction activities contribute to the restoration or maintenance of a healthy watershed. This includes efforts to maintain a healthy soil structure by maintaining native soils where possible and using soil amendments where appropriate. Code language and contractor education materials should address consideration of the following best management practices.

1) <u>Retaining Native Topsoil</u>

- Minimize disturbance of native soils
- Reduce the removal of native topsoil
- Restore retained soils to original or higher level of porosity and water retention capacity by amending retained topsoil with 20% compost by volume to a depth of 8 inches.

2) <u>Construction Practices</u>

- Minimize compaction of soil by heavy equipment, especially by limiting the construction activity "footprint" on sites leaving as much area as possible undisturbed.
- Store topsoil on-site for replacing after construction.
- Process vegetative land-clearing debris and use on-site for mulching, where practical to do so.

3) <u>Organic Amendments</u>

- Incorporate 2-4 inches of compost into disturbed soils after construction during landscape development.
- Amend soils with compost prior to landscape development.
- Improve soil quality of disturbed/damaged soils by amending with 30% compost by volume to a depth of 8 inches.
- Restore surrounding native soils impacted by construction with 30% compost and mulching with wood debris.

4) <u>Vegetation</u>

- Retain native vegetation as much as possible.
- Cover soil during re-vegetation efforts using mulch materials from 0n-site materials or imported materials.

Following these practices will minimize the amount of run-off entering the right-of-ways from individual lots and when used within the right-of-way will increase the ability of the stormwater management facilities to retain water and bind pollutants.

Appendix 3 Texas Compost Specifications

1993 Texas Natural Resource Conservation Commission SPECIAL SPECIFICATION - 1034

Mulch/Compost Filter Berm for Erosion and Sedimentation Control

1. Description. This work shall consist of furnishing, installing, maintaining and dispersing (if necessary) a water permeable windrow (berm) of a compost or mulch to contain soil erosion by removing suspended soil particles from water moving off the site and into adjacent waterways or storm water drainage systems.

2. Materials. Filter Berm Mulch or Filter Berm Compost.

Filter Berm Mulch. Where used without seeding or planting, use material derived from weed free bark/wood mulch that conforms to the following:

a. PH - 5.0 to 8.5.
b. Particle size - 98 percent passing one (1) inch sieve, 90 percent passing 3/4 inch sieve and not more than 30 percent passing the 3/8 inch sieve. Material shall not exceed four (4) inch in length.
c. Moisture content less than 60 percent.
d. No less than 30% to 60% percent organic matter.
e. Material shall be reasonably free (< 1 percent by dry weight) of man-made foreign matter.
f. A sample shall be submitted to the Engineer/landscape architect for approval prior to being used and must comply with local city, county or state regulations.

Filter Berm Compost. Where seeding or planting is planned or where biological filtration may be desired, use compost material derived from well decomposed organic matter source, or in combination with filter berm mulch (maximum of 50 percent). The compost material shall be an organic substance produced by the aerobic (biological) decomposition of organic matter. The compost material shall not contain any visible admixture of refuse and other physical contaminants nor any material toxic to plant growth. Composted matter may include, but are not limited to, leaves and yard trimmings, biosolids, food scraps, food processing residues, manure and/or other agricultural residuals, forest residues and bark, and soiled and/or unrecyclable paper. The use of mixed municipal solid waste compost or Class B Biosolids (as defined in 40 CFR part 503) will not be allowed. Compost materials furnished shall meet all applicable Federal (40 CFR part 503 Standards for Class A Biosolids) and Texas Natural Resources Conservation Commission (TNRCC) health and safety regulations (TAC Chapter 332). All compost material supplied shall be processed to meet the time and temperature standards in TAC Chapter 332 Subchapter B Part 23 to control noxious weeds, pathogen and vector attraction.

Filter berm compost shall conform to the following:

a. pH - 5.5 to 8.5.
b. Particle size - 98 percent passing one (1) inch sieve, 90 percent passing 3/4 inch sieve
and not more than 40 percent passing the 3/8 inch sieve. Material shall not exceed four (4) inch in length.
c. Moisture content less than 60 percent.
d. No less than 30-60 percent organic matter.

e. The compost portion shall be reasonably free (<1 percent by dry weight) of man-made
foreign matter.
f. The compost portion shall not resemble the raw material from which it was derived.
g. A sample shall be submitted to the Engineer/landscape architect for approval prior to being used and must comply with local city, county and state regulations.

3. Construction.
a. The erosion control berm shall be placed, uncompacted, in a windrow at locations shown on the plans or as directed by the Engineer.
b. Parallel to the base of the slope, or around the perimeter of other affected areas, construct a 1 to 1 1/2 foot high by 2 1/2 to three (3) foot wide berm as shown on the plans. For maximum water filtration ability or for steep slopes, construct a 1 1/2 to 2 foot high trapezoidal berm which is approximately two (2) to three (3) foot wide at the top and minimum four (4) foot wide at the base. In extreme conditions and where specified by the Engineer, a second berm shall be constructed at the top of the slope. (The Engineer
shall specify berm requirements).
c. If berm is to be left as a permanent filter or part of the natural landscape, the "compost
filter berm" may be seeded during application for permanent vegetation. The Engineer/landscape architect shall specify seed requirements.
d. Do not use filter berms in any runoff channels.

4. Maintenance. The Contractor shall maintain the erosion control filter berm in a functional condition at all times and it shall be routinely inspected. All deficiencies shall be immediately corrected by the Contractor. The Contractor shall make a daily review of the location of the berm in areas where construction activity causes drainage runoff to ensure that the berm is properly located for effectiveness. Where deficiencies exist, additional berm material shall be installed as approved or directed. Sediment retained by the berm shall be removed by the Contractor once it has reached 1/3 of the exposed height of the berm, or as directed by the Engineer. The berm shall be dispersed when no longer required, as determined by the Engineer. At the Engineer/landscape architect's discretion, berm material may be left to decompose naturally, or distributed over an adjacent area for additional use as a soil amendment or ground cover.

5. Performance.
a. Place berms on bare ground areas as soon as possible. Mulch/Compost and/or temporary or permanent vegetation shall be applied/established above the filter berms when necessary for additional erosion control.
b. The work specified in this Section consists of designing, providing, installing and maintaining sedimentation controls as necessary. All existing and foreseeable future conditions that affect the work inside and outside the site limits must be acknowledged as 3-3 1034 the Contractor's responsibility.
c. Contractor is responsible for providing effective sediment control measures based on performance, and may, with approval from the Engineer, exceed the minimum construction requirements to establish a working erosion control system.

6. Measurement. This Item will be measured by the cubic yard or linear foot, complete in

place.
7. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement", will be paid for at the unit price bid for "Filter Berm Mulch" or "Filter Berm Compost". This price shall be full compensation for furnishing all material; placement and grading; and for all tools, equipment, labor and incidentals necessary for the construction and maintenance of the filter berm mulch or filter berm compost. When the Engineer directs that the filter berm mulch or filter berm compost installation (or portions thereof) be replaced, payment will be made at the unit price bid for "Filter Berm Mulch (Remove and Replace)" or "Filter Berm Compost (Remove and Replace)". This price shall be full compensation for the removal and replacement of the filter berm mulch or filter berm compost, and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work. The removal of accumulated sediment deposits, as described under Article 4, "Maintenance", will be measured and paid for under the pertinent bid items of the Special Specification, "Earthwork for Erosion Control". The work performed in the final removal of the filter berm mulch or filter berm compost installation as described under Article 4, "Maintenance" and measured as provided above will be paid for at the unit price bid for "Filter Berm Mulch (Remove)" or "Filter Berm Compost (Remove)". This price shall be full compensation for removing the material from the existing location and properly disposing of it and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

FURNISHING AND PLACING COMPOST
Description. Furnish and place compost as shown on the plans or as directed.
Materials. The type of compost or compost mixture required, based on the intended use, is shown on the plans and consists of one or more of the following:

- Compost Manufactured Topsoil (CMT) consisting of 75% topsoil soil blended with 25% compost measured by volume. CMT will be Blended On-Site (BOS) or Pre-Blended (PB) as specified on the plans.
- Erosion Control Compost (ECC) consisting of 50% wood chips blended with 50% compost measured by volume. Use fresh or partially composted wood chips less than or equal to 3 in. in length with 100% passing a 2 in. screen and less than 10% passing a 1 in. screen.
- General Use Compost (GUC) consisting of 100% compost.

Furnish compost that has been produced by aerobic (biological) decomposition of organic matter. Compost feedstock may include, but is not limited to, leaves and yard trimmings, biosolids, food scraps, food processing residuals, manure or other agricultural residuals, forest residues, bark, and paper. Compost must not contain any visible refuse or other physical contaminants, material toxic to plant growth, or over 5% sand, silt, clay or rock material. Mixed municipal solid waste compost and Class B biosolids, as defined in the United States Environmental Protection Agency Code of Federal Regulations (USEPA, CFR), Title 40, Part 503 are unacceptable. Compost must meet all applicable USEPA, CFR, Title 40, Part 503 Standards for Class A biosolids and TNRCC health and safety regulations as defined in the Texas Administrative Code (TAC), Chapter 332. Compost must have been processed to meet the time and temperature standards in TAC Chapter 332 Subchapter B Part 23 (for control of noxious weeds, and pathogen and vector attraction), and the requirements shown in Table 1, “Physical Requirements for Compost.” All physical requirements are in accordance with the United States Department of Agriculture and the United States Composting Council, “Test Methods for the Examination of Composting and Compost” (TMECC).

Physical Requirements for Compost

Organic Matter Content: 30-65% (dry mass) in accordance with TMECC 05.07-A, “Loss on Ignition Organic Matter Method”
Particle Size: 100% passing 5/8 in., 70% greater than 3/8 in. in accordance with TMECC 02.02-B, “Sample Sieving for Aggregate Size Classification”
Soluble Salts: 5.0 max.* dS/m in accordance with TMECC 04.10-A, “Electrical Conductivity for Compost”
Fecal Coliform: Pass in accordance with TMECC 07.01-B, “Fecal Coliforms”
pH: 5.5 – 8.5 in accordance with TMECC 04.11-A, “Electrometric pH Determinations for Compost”
Stability: 8 or below in accordance with TMECC 05.08-B, “Respirometry”
Maturity: greater than 80% in accordance with TMECC 05.05-A, “Biological Assays”
Heavy Metals: Pass in accordance with TMECC 04.06, “Heavy Metals and Hazardous Elements” and TMECC 04.13-B, “Atomic Absorption Spectrophotometry”

* A soluble salt content up to 10.0 dS/m for compost used in Compost Manufactured Topsoil will be acceptable.

Before delivery of the compost, provide a notarized document that includes the following:

- the feedstock by percentage in the final compost product,
- a statement that the compost meets federal and state health and safety regulations,
- a statement that the composting process has met time and temperature requirements,
- a copy of the lab analysis, less than four months old, performed by a Seal of Testing Assurance certified lab verifying that the compost meets the physical requirements as described in Table 1, “Physical Requirements for Compost.”
- When requested, provide one Solvita Compost Maturity Test kit (six tests) for every 500 cubic yards of compost supplied. The Solvita Compost Maturity Test kit is available from: Woods End Research Laboratory Inc. info@woodsend.org or approved equal.

Construction.

- Compost Manufactured Topsoil (CMT). Remove and dispose of any trash, wood, brush, stumps or any other objectionable material from the topsoil before blending.

- Blended On-site (BOS). Apply in a uniform layer and incorporate into existing topsoil to the depth shown on the plans. When rolling is specified, use a light corrugated drum roller.
- Pre-Blended (PB). Furnish CMT and apply in a uniform layer to the depths shown on the plans. When rolling is specified, use a light corrugated drum roller.
- Erosion Control Compost (ECC). Use only on slopes 3:1 or flatter. Apply a 2" uniform layer unless otherwise shown on the plans or as directed. When rolling is specified, use a light corrugated drum roller.
- General Use Compost (GUC). Apply in a uniform layer as a top dressing on established vegetation to the depth shown on the plans. Do not bury existing vegetation. If GUC is used as a backfill ingredient, in a planting soil mixture, for planting bed preparation, or as a mulch, apply as shown on the plans.
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<u>Measurement</u>. This item will be measured by the following class as shown on the plans:

Class 1. By the 100 foot-station along the baseline of each roadbed.
Class 2. By the square yard complete in place.
Class 3. By the cubic yard in vehicles at the point of delivery.

<u>Payment</u>. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Compost Manufactured Topsoil (BOS)," "Compost Manufactured Topsoil (PB)," "Erosion Control Compost" and "General Use Compost" for the class and depth specified. This price is full compensation for securing any necessary source and for furnishing materials; for excavation, loading, hauling, stockpiling, and placing; furnishing and operating equipment; and labor, fuel, material, tools, and incidentals. "Sprinkling", "Rolling" and "Vegetative Watering" will not be paid for directly, but will be subsidiary to this Item.