Protecting Urban Soil Quality:
Examples for Landscape Codes and Specifications

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Introduction and purpose

The choices made during construction and landscaping projects can impact soil functions for decades. The impact of those choices will be felt in long-term irrigation costs, flooding and storm water management costs, and landscape plant health. The objective of this document is to encourage planners and developers to prevent damage to soil quality and soil function by helping them target critical points in the construction and development process.

The principles and specifications contained in this document are not official standards. They are meant to be a guide for the development of local standards.

The intended audience for this publication includes landscape architects, contractors, developers, and planners – especially those who are preparing to write contracts, codes, or specifications. The document focuses on the planning and care of soil during the construction process and does not address on-going soil quality management issues.

Part I of this document describes the key issues for enhancing and protecting soil quality during urban/suburban development and construction activities. Part II provides an example of specifications that address these key issues. These specifications can be used as a starting point for planners writing codes and for developers writing contracts. The example specifications were written for Utah. “Regionalization notes” are provided in boxes to help adapt the specifications to other parts of the country.

Certification programs

Local entities may choose to implement a certification program to certify that sites, homeowners, or contractors have met specifications such as these. Certifications could increase sale values of homes because of the lower input and maintenance requirements.

The inspection form at the end of this document can be used as a basis for certification or as the basis of inspections to sign off on each phase of the project.

Acknowledgements

In addition to sources cited within the text, the information in Part I is drawn from materials from the “Soils for Salmon” program in Washington state. Specifications related to compaction and subsoiling were based on those from Dwayne Stendlund, Erosion Control Engineering Unit, Minnesota Department of Transportation. Additional contributions were received from Jeremy Fillmore, Northland Design; and Greg Graham, Earthscape Design Associates.

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PART I: Urban Soil Quality Issues

The importance of soil quality

What is soil quality?

Healthy soil performs valuable functions that we often take for granted. Soil quality is the ability of soil to perform these functions:

- Effectively cycling nutrients, making nutrients available to plants, and minimizing leaching of nutrients into ground and surface water.
- Minimizing runoff and erosion and maximizing water-holding capacity so water enters the soil and is available for plant growth. Healthy soil helps reduce surges of storm water by efficiently taking up and storing water.
- Adsorbing and filtering excess nutrients, sediments, and pollutants so water does not carry these contaminants to groundwater or surface water.
- Providing a healthy rooting environment and creating habitat for diverse plants, animals, and microbes living in and above the soil. In this way, healthy soil supports vigorous plant growth, suppresses many plant diseases, and reduces the costs of caring for turf and landscape plantings.
- Providing a stable foundation for structures. Soil stability can mean a compacted subsoil under buildings and roads, and healthy soil and vegetation next to structures to prevent sliding and erosion. Obviously, the ideal soil parameters for supporting roads and houses are different than the ideal parameters for good plant growth and hydrology.

Many common development practices severely damage the long-term ability of soil to function. Often, large tracts of land are cleared of vegetation and left bare and unprotected for extended periods. The valuable topsoil erodes away or may be deliberately removed. Heavy equipment is driven over much of the soil, causing long-term deep compaction that reduces the ability of soil to absorb and hold water, and the ability of roots to penetrate through the soil. The layer of topsoil and sod placed on top of the compacted subsoil may be too thin to support healthy turf and landscape plants. The plantings require frequent fertilizer applications and irrigation because the soil cannot hold adequate water and nutrients.

Much of this damage can be prevented by preserving existing soil and vegetation if it is healthy (functioning well), limiting construction traffic to as small a portion of the development tract as possible, and ensuring adequate topsoil quality and depth.

Key practices for soil quality

Efforts to improve soil function in urban and suburban settings should address the following four objectives.

Preserve existing soil and vegetation

Why?

Restoring soil functions lost during construction is critical, but can never fully recreate the structure and function of natural soil. Where healthy soil and trees are present, it is more effective to preserve existing soil. Soil is not just a random mixture of mineral and organic particles. It has structure and porosity and a complex biological community that develops over long periods of time. Soil structure is important to hydrologic function of soil. Soil biology is important to nutrient cycling. Much of this physical and biological structure is lost when soil is moved. By protecting patches of healthy soil and vegetation, soil functions are preserved and soil flora and fauna can later repopulate the neighboring disturbed areas.

How?

Good soil management planning should be part of the earliest stages of construction planning.

- While examining soil types and interpretations, note whether soils are natural or highly disturbed.
- Identify critical areas such as steep slopes, waterways for peak flow, and vegetated buffers along streams, lakes, and wetlands.
- Consider how water will flow off of the planned impervious surfaces (roofs, pavement), and where the water could be absorbed.
- Determine which trees and other healthy vegetation can be preserved.
- Test the soil to determine its existing depth and quality and decide what treatments are appropriate.
- Based on these observations, make a soil management plan that divides the area into:
  1. Protected zones where existing soil and vegetation will not be disturbed.
  2. Zones that will be amended or treated with minimal disturbance.
  3. Zones where construction traffic will be allowed.
  4. Space for stockpiling topsoil and imported amendments.

Make the first two zones as large as possible and fence them off from construction traffic.

- Plan to strip off and stockpile existing topsoil from the areas that will be impacted by construction activities. In rare cases, subsoil has desirable properties for plant growth and can be mixed with topsoil. Normally, however, the existing topsoil should not be mixed with or buried by subsoil.
- Specify the amount and type of compost and other amendments needed.

Prevent and control erosion

Why?

During construction, erosion and compaction are typically the two most serious threats to soil quality. Erosion removes topsoil and exposes subsoil that is less suitable for plant growth. It reduces soil organic matter levels, making soil more susceptible to compaction and further erosion, and reducing nutrient levels and nutrient holding capacity. Erosion disrupts soil structure and soil biological communities. Eroded soil and runoff carries excess nutrients, pollutants, and sediments to surface waters. Sedimentation buries topsoil and causes expensive damage to ditches and streams.

These on-site and off-site damages are often expensive or impossible to fix completely. Prevention is worthwhile.

How?

An erosion and sedimentation plan is an important component of a construction project 1) because of the potential for severe erosion damage during construction and 2) because the development itself changes the long-term susceptibility of the site to erosion. The erosion and sediment control planning process is described in Craul (1999, pp. 260-273).

Many standards for sedimentation control already exist and describe effective use of barriers to slow and capture overland flow. The specifications in this document focus on protecting the soil surface to prevent the initial detachment and transport of soil particles. (NRCS Practice Standards are indicated in parentheses.)

- Plan the development to fit the site.
- Minimize the length of time that soil is left bare and unprotected. Especially avoid bare soil during periods of seasonally high precipitation or wind. Provide special protection to critical areas such as steep slopes and stream borders.

- Clear only those areas where construction will begin soon. Avoid creating large expanses of cleared areas.
- Plant temporary vegetation to hold soil in place. (Critical area plantings (342), Cover crops (340))
- Use compost berms and blankets to prevent soil movement, and silt and sand fences to capture overland flow.
- Use mulch for temporary erosion control and as part of the final landscaping plan. (Mulching, (484))

Prevent and treat compaction.

Why?

For practical purposes, compaction is permanent. This is especially true of deep compaction caused by heavy construction equipment driving across soil even once. Annual freeze-thaw cycles are not adequate to relieve deep compaction. Compaction increases soil strength and therefore is valuable under roads and other structures. However, compaction also restricts root growth and interferes with air and water flow through soil. These changes impact soil drainage and reduce the ability of plants to acquire water and nutrients and to withstand drought. Trees are especially sensitive to compaction and low soil oxygen levels. The impact on tree health of construction-caused compaction may not become obvious until a few years after the construction.

How?

- Traffic control is critical for preventing compaction. Ensure that some parts of the landscape are left free of traffic to ensure good water absorption and drainage.
- Compaction down to 20 inches can often be treated with ripping (subsoiling) before applying topsoil or planting. Reducing compaction to 1400kPa or less is a reasonable standard. The strength of a typical soil after construction may be 6000kPa. The limit of root growth is defined as 3000kPa, but roots are restricted at much lower levels. Subsoiling is only effective if done correctly on adequately dry soil, and if no subsequent traffic recompacts the soil. Some common tillage tools should not be allowed because they are too shallow (e.g. disk, chisel plow), can compact the soil just beneath the depth of tillage (e.g. disk), or are not built to pull through densely compacted layers (e.g. spring-loaded equipment).
  If deep subsoiling is planned, consider the location of utility lines, tree roots, and potential archeological artifacts.
- Compaction that is less severe than that created by heavy construction equipment can be remedied with the use of deep-rooted perennials rather than subsoiling. However this approach takes several years.

Example of a ripper suitable for treating deep compaction.

Ensure topsoil quality

What is topsoil?

Soil is not dirt. Dirt is analogous to weeds – it is misplaced material. Soil is a complex structure built of four main components – air, water, minerals, and organic matter. Balance among these components is necessary for soil to function properly. Ideally, soil is about half minerals and organic matter and about half pore spaces. The pore spaces allow for the flow of air and water through soil, and are habitat for microscopic organisms that are essential to healthy plant growth.

How to ensure topsoil quality?

- If healthy soil and vegetation exists on site, the best option is to protect as much as possible from impacts of construction.

- For areas that must be disrupted, the final topsoil should meet the parameters described in Table 1. Adequate depth and organic matter are especially important.
- Testing of soil and amendments is essential for ensuring a quality end product. Soil tests are necessary to identify problems such as salinity or extreme pH, and to determine the appropriate amounts of added lime, fertilizer, compost, and other amendments.
- Amend generously with compost. This is important for good plant growth, water uptake, and water storage. The optimal level of soil organic matter (SOM) depends somewhat on climate and desired use. In most cases, the required level for urban/suburban uses should be set higher than SOM levels found in native or agricultural soils.
- Both subsoil and topsoil must be free of excessive compaction to allow good root growth and water permeability. Subsoiling is often necessary to relieve compaction after construction and before topsoil application.
- Topsoil must be applied in such a way that it is "bonded" or "zipped" with the underlying soil so water can flow freely from one layer to the other. This bonding can be accomplished by applying two to three inches of topsoil, tilling it into the underlying soil, and then applying the remaining topsoil.
- If irrigation water will come from a source other than a municipal water supply, a simple water test should be used to determine its suitability for irrigation. If inorganic fertilizers will be used, consider promoting injection pump fertigation systems, which can efficiently deliver minimal amounts of nutrients at the precise time and location in the root zone for optimal plant growth. Injection pump fertigation is the preferred equipment if acidic liquid fertilizers will be applied to lower the pH of alkaline soils.
- Applying and maintaining a mulch layer is important for protecting the soil and providing an annual supply of fresh organic matter for the soil. Mulch prevents soil crusting, reduces evaporation, moderates temperature extremes, controls erosion, and creates a habitat for a healthy soil biological community.

Implementing soil quality standards

Part II provides sample language for specifications. It can be used as a template to write local contracts, codes, guidelines, or standards. See the list of resources for other examples.

Many contractors and developers are unaware of or disinterested in the significant long-term economic impacts of common construction practices. Therefore, any effort to improve urban hydrology and soil quality must include a persistent education component. Homebuyers need to learn that careful construction can substantially reduce long-term maintenance costs associated with irrigation, fertilizer, and plant replacement. Planners need to understand that preserving soil function will pay off in more effective and less expensive stormwater management systems. Builders need to know the direct cost savings of applying these practices such as easier planting, better initial plant growth, fewer callbacks to replace dead plants, and happier customers who will sell the next job.

Multiple site inspections are a key part of ensuring correct soil treatment. Use inspections to educate and to ensure optimal resource conservation and plant growth. Inspections should include tests of all soil and soil amendments. These tests provide the information needed to decide how to amend the soil and to ensure that delivered amendments are what was ordered and paid for. Inspectors should be present to ensure the correct implementation of key processes, including subsoiling and topsoil installation.

PART II: Sample Specifications for Protecting Urban Soil Quality

1. Site design

1.1. Identify critical areas.

Identify areas that are critical to landscape functions such as managing water flow. Critical areas include but are not limited to existing watercourses, drainage routes, wetlands, and riparian areas; collection areas from impervious roofs and roads; steep or erosion-prone areas; and established, desirable vegetation such as mature trees. Plan to prevent damage to these areas during construction.

1.2. Test existing topsoil.

1.2.1. Standards: A complete horticultural soils analysis will be conducted on the topsoil for the site before excavation begins. Owner's representative will analyze the soil and make the determination as to its quality according to criteria listed in Table 1 of this document. If topsoil is to be used on project for vegetative growth, it must meet minimum specifications defined in Table 1. Owner reserves the right to refuse or require amendment of any topsoil that does not meet the specifications in Table 1.

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1.2.2. Method: Owner's representative will take topsoil samples concurrently with the geotechnical engineering samples. One soil sample will represent a maximum of 3 undisturbed acres of on-site topsoil, or wherever surface soil conditions obviously change. The soil sample shall comprise 10 representative core samples taken in a random zig-zag pattern across the 3 acres to be represented. The core samples will be obtained and placed in a container using a ¾-inch soil probe (Figure 1). The cores samples shall be mixed thoroughly and a quart of the mixed core samples shall be preserved for analysis purposes.

1.2.3. Cost of this testing will be paid by Contractor.

1.3. Create a soil management plan

The plan will include a map and will specify:

1.3.1. those areas that will be fenced off and protected from the impacts of construction,

1.3.2. required soil amendments and treatments,

1.3.3. measures for controlling erosion and sedimentation during construction,

1.3.4. how stormwater and erosion will be controlled in the final landscape, by maximizing on-site infiltration and absorption of water, and by protecting soil through the use of vegetative and mulch covers.

2. Construction site operations prior to seedbed preparation

2.1. Fence off critical areas identified in section 1.1.

2.1.1. Restrict heavy equipment traffic and stockpiles of materials to as small an area as is practical.

2.1.2. Trees shall be fenced off to a distance of 1.5 times the radius of the drip line.

2.1.3. Areas to be vegetated will be fenced off and designated as non-traffic areas.

2.1.4. Designate areas for disposal of construction materials, and stockpiles of subsoil and topsoil. Materials cannot be placed anywhere else.

2.2. Protect existing topsoil quality

2.2.1. Excavation companies on site will protect topsoil quality and manage soil movement, such that they will not integrate soil not meeting topsoil criteria into designated topsoil stockpiling area.

2.2.2. If existing on-site soil fails in any of the requirements listed in Table 1, Contractor must remove soil from vegetative growth areas, or amend soil to meet specifications of Table 1, and/or import topsoil that meets the criteria. This work shall be in the contract and the Contractor will not be compensated for it on a Time and Materials basis. See section 3.3.

2.3. Minimize erosion

2.3.1. Avoid excavation during periods of high rain or wind.

2.3.2. Necessary silt or sand fences shall be erected as directed by local building ordinances.

2.3.3. Excavate only areas that will be built on or planted immediately.

2.3.4. Use temporary seeding to protect bare ground with inert or sterile hybrid grasses that will not produce viable seed.

2.3.5. As needed, establish stable grades for water conveyance channels and ditches, armored with gravel or cobble. Or establish drop structures, detention ponds, or stabilized outlets.

Regionalization notes

In humid parts of the country, water conveyance channels may be lined with vegetation instead of cobbles.

2.3.6. All areas involved in or disturbed by the construction shall be finished in reasonably close conformity with the established lines and grades.

2.3.7. Earthwork and topsoil operations shall be correlated as closely with the grading operations so as to permit completion of erosion control items at the earliest practicable time.

2.4. Subsoil treatment.

2.4.1. Excavated soil. All soils excavated for foundations or sidewalks that are B horizon (subsoil) soils shall be moved to non-plant growth area, or amended to meet all specifications in Table 1.

2.4.2. Topsoil covering operations shall be carried out as soon as possible after the subsoil has been finished to grade on any significant area.

2.4.3. Before topsoil is placed, all areas that receive plantings will meet compaction specifications in Section 3.1.

3. Seedbed preparation.

3.1. Subsoiling to relieve compaction

3.1.1. Before the time the topsoil is placed and preferably when excavation is completed, the subsoil shall be in a loose, friable condition to a depth of 20 inches below final topsoil grade and there shall be no erosion rills or washouts in the subsoil surface exceeding 3 inches in depth.

3.1.2. To achieve this condition, subsoiling, ripping, or scarification of the subsoil will be required as directed by the owner's representative, wherever the subsoil has been compacted by equipment operation or has become dried out and crusted, and where necessary to obliterate erosion rills. Subsoiling shall be required to reduce soil compaction in all areas where plant establishment is planned. Subsoiling shall be performed by the prime or excavating contractor and shall occur before topsoil placement.

3.1.3. Subsoiled areas shall be loosened to less than 1400 kPa (200 psi) to a depth of 20 inches below final topsoil grade. When directed by the owners representative, the Contractor shall verify that the subsoiling work conforms to the specified depth. To test for conformance, the Contractor shall use a cone penetrometer that meets standard ASAE Soil Testing Specifications of a 13/16 inch insertion rate per second.

3.1.4. Subsoiling shall form a two-directional grid. Channels shall be created by a commercially available, multi-shanked, parallelogram implement (solid-shank ripper). The equipment shall be capable of exerting a penetration force necessary for the site. No disc cultivators, chisel plows, or spring-loaded equipment will be allowed. The grid channels shall be spaced a minimum of 12 inches to a maximum of 36 inches apart, depending on equipment, site conditions, and the soil management plan. The channel depth shall be a minimum of 20 inches or as specified in the soil management plan. If soils are saturated, the Contractor shall delay operations until the soil will not hold a ball when squeezed. Only one pass shall be performed on erodible slopes greater than 1 vertical to 3 horizontal. When only one pass is used, work shall be at right angles to the direction of surface drainage, whenever practical.

3.1.5. Exceptions to subsoiling include areas within the dripline of any existing trees, over utility installations within 30 inches of the surface, where trenching/drainage lines are installed, where compaction is by design (abutments, footings, or inslopes), and on inaccessible slopes, as approved by the owner's representative. In cases where exceptions occur, the Contractor shall observe a minimum setback, as directed by the owner's representative. Archeological clearances may be required in some instances.

3.2. Preparations for topsoil installation

3.2.1. Before topsoil installation, contractor shall ensure area to be covered is free from debris including deleterious materials, such as, but not limited to, building materials, plaster, paints and stains, concrete and stucco, road base type materials, petroleum based chemicals, oils, and other harmful materials. Contractor shall designate an area for these materials to be disposed in and shall follow local ordinances for disposal of said materials.

3.2.2. Contractor shall give owner's representative sufficient notice before topsoil installation to allow inspection of the site to ensure that subsoil is free of debris and meets penetrability standards.

3.3. Topsoil quality and amendments

3.3.1. The final, resulting topsoil must meet all of the mandatory criteria in Table 1. If existing topsoil fails in any of these requirements, Contractor must amend soil and/or import soil according to owners representative recommendations in order to meet listed requirements.

3.3.2. Testing imported soil - Contractor will deliver ½ cubic foot representative sample of proposed topsoil to owner's representative for analysis. Owner's representative will analyze the soil and make the determination as to its quality according to criteria listed in Table 1. Owner reserves the right to refuse any topsoil that does not meet the specifications in Table 1. Results from these samples must be obtained before delivery can be made.

3.3.3. Amending topsoil - If imported or on-site topsoil fails in any of the requirements listed above, Contractor must amend soil according to owner's representative recommendations in order to meet listed requirements.

3.3.4. Topsoil and subsoil will be free from deleterious materials such as, but not limited to, building materials, plaster, paints and stains, concrete and stucco, road base-type materials, petroleum based chemicals, oils and other materials as specified by owner's representative.

3.3.4.1. Any soil contaminated as listed above will be excavated and transported to a non-vegetative area or disposed in accordance with local ordinances.

3.3.5. Mix amendments into soil before spreading. Suitable amendments shall meet the criteria in Table 2.

3.4. Topsoil installation

3.4.1. Spread 2- 3 inches of approved topsoil on existing soil. Till added soil into existing soil with a rotary tiller that is set to a depth of 6 inches. Add an additional 4 inches of approved topsoil to bring the area up to grade.

3.4.2. Contractor shall give notice to owner's representative 48 hours before topsoil installation to allow inspection of the site during placement of topsoil. Owner will pay fees for site inspection.

3.5. Seedbed finishing operations

3.5.1. Remove all fragmented material over ¾ inch in diameter.

3.5.2. Bring soil up to grade with additional topsoil.

3.5.3. If owner's representative recommends fertilizer, apply and mix fertilizer into installed topsoil to a depth of 3 inches.

3.5.4. The seedbed shall then be smoothed with a cultivator-type tillage tool. Soil shall be prepared to seedbed standards which include compaction levels not to exceed 1400kPa according to ASAE cone penetrometer measurement guidelines.

3.5.5. All tilling shall be parallel to the contours.

3.5.6. Ruts and wheel tracks in the seedbed from seedbed preparation are to be removed just prior to seeding.

3.5.7. The owner's representative must approve seedbed preparation before planting or seeding begins. Site shall be inspected for ruts and deleterious materials; and for penetrability, infiltration, and depth as specified in Table 1.

3.5.8. Before or after planting, 2-3 inches of mulch will be applied to all areas not protected by grass or other plants.

3.6. Water quality

3.6.1. Water to be used for irrigation that is not from a municipal water supply must be tested for salinity, SAR, boron, bicarbonate, chloride, residual sodium carbonate, sulfate, and pH. To submit sample, use a clean 16 oz glass or plastic container with a leak-proof lid. Samples from wells shall be taken from water source (pump) that has been running for at least 30 minutes. Samples from streams shall be taken from running water. Sample shall be refrigerated until it is submitted to owner's representative for analysis.

4. Compliance with testing

4.1. Rights to test and inspect.

4.1.1. Owner's representative reserves the right to inspect jobsite for conditions that would prevent execution of work as specified.

4.1.2. Owner's representative reserves the right to take and analyze sample/s of materials for conformity to specifications at any time. Contractor shall furnish samples upon request of the owner's representative.

4.1.3. Contractor agrees to immediately remove rejected materials from the site, at Contractor's expense. The Contractor shall pay cost of testing materials.

4.2. Mandatory test points.

4.2.1. Before grading. As described in Section 1.2, existing topsoil must be tested before any excavation activities. Inspector will verify the fencing off of soils and vegetation identified in section 1.1 and as described in the soil management plan. Inspector will review with general contractor that topsoil stockpiling and other specified measures are incorporated into the work plan.

4.2.2. During grading. Verify that proper erosion control methods are being used and that excavation and stockpiling of topsoil follows the soil management plan.

4.2.3. After construction. As described in Sections 3.1.3 and 3.2, the subsoil shall be inspected before topsoil placement to ensure adequate penetrability and lack of debris. As described in Section 3.3, delivery tickets and test results of all imported soils and amendments will be examined to ensure that quantity and quality matches the soil management plan and the standards in Tables 1 and 2.

4.2.4. During topsoil placement. As described in Section 3.4, contractor shall give owner's representative 48 hour notice to inspect site during topsoil placement.

4.2.5. After topsoil placement. As described in Section 3.5.8, topsoil shall be tested on-site before planting.

4.2.6. Mulch verification. Verify placement of mulch as described in section 3.5.9.

APPENDICES

Appendix A: Tables of Soil Quality Standards

Table 1. Required soil tests and required parameters for final topsoil condition.
(Based on Koenig and Isaman 1997)

Depending on site history, additional tests may be required including tests for zinc, copper, manganese, boron, cadmium, arsenic, lead, and sulfate.

Topsoil characteristic	Test Method	Required final condition
Laboratory tests		
Soluble salts (EC) dS/m or mmho/cm	saturated paste	<2.5
Sodium adsorption ratio (SAR)	saturated paste	< 2
pH (-log [H+])	saturated paste	6.0 to 7.5
Sand (%)	Hydrometer	< 70
Silt (%)	Hydrometer	< 70
Clay (%)	Hydrometer	< 30
Texture class*		Texture must be L, SiL, SCL, SL, or CL
Organic Matter (%)	Loss on Ignition / Ash	≥ 5
Coarse fragments (%) - up to 2cm	Sieving	< 10
Nitrate-nitrogen (ppm or mg N/kg soil)	$Ca(OH)_2$ extract	Report level to allow proper fertilization
Phosphorus (ppm or mg P/kg soil)	Olsen $NaHCO_3$	> 20
Potassium (ppm or mg K/kg soil)	Olsen $NaHCO_3$	> 150
Iron (ppm or mg Fe/kg soil)	DTPA	> 10
Carbon:Nitrogen Ratio	Combustion / Leco Instrument	<20:1
On-site tests		
Penetrability	ASAE Soil Testing Specifications of a 20 mm (13/16 inch) insertion rate per second and soil moisture at field capacity	<1400kPa (200 psi) down to a 10” depth
Bulk density (alternative to penetrability)		See notes below.
Infiltration rates (inches/hour)	ASAE Soil Testing Specifications	>0.6 - 2
Topsoil depth		>4”

*L = loam; SiL = Silt loam; SCL = sandy clay loam; SL = sandy loam; CL = clay loam; SiCL = Silty clay loam; LS = loamy sand; SC = sandy clay; SiC = silty clay; S = sand; Si = silt; C = clay. ** soil fragments > 2 mm in diameter. This guideline also includes no fragments larger than 1 inch in diameter.

Regionalization Notes for Table 1

Preserving vs. manipulating soils

If an existing soil is functioning well, it may be better to leave it undisturbed even if it does not meet standards such as those for texture, % organic matter, or coarse fragments.

Soluble salts

Ideally, the limit for soluble salts should be set at 2 dS/m. However, this standard may be impractical in arid regions. Salinity levels of 1.5 dS/m can affect growth of some sensitive plants.

Sodium adsorption ratio (SAR)

Interpretation of SAR values depends in part on Ca levels.

pH

Depending on local conditions and the desired plantings, a pH as low as 5.5 may be acceptable.

In some regions, undesirable acid sulfate materials can be a problem. They may appear like black "topsoil" and are near neutral when freshly excavated. To prevent their use, require that the pH of topsoil be > 4.5 after drying, re-wetting, and incubating for 7 days.

Texture

This document uses agronomic rather than engineering terminology to describe soil texture. Most soil test labs will use these agronomic terms.

If soil textures outside of these standards are allowed, special consideration must be given to plant choices, irrigation systems, and minimizing traffic.

Topsoil texture should not be significantly different than the texture of the underlying material. It is especially important to "zip" together the two layers if they have different textures.

Organic matter

Many naturally productive soils contain less than 5% organic matter, but more can be required for disrupted urban/suburban soils. The higher levels substantially improve soil function and amendments are practical to add at the time of construction. Guidelines from the Soils for Salmon program in the high rainfall areas of Washington and Oregon require 10% organic matter in planting beds and 5% for turf areas. Levels greater than 5% could cause salt problems in arid regions. Levels greater than 10% could result in subsidence if organic matter decomposes faster than it is replenished.

Organic matter requirements might be adjusted for soil texture because coarse, sandy soils can hold less organic matter than heavy, clayey soils. On the other hand, organic matter is especially beneficial for improving the naturally low nutrient and water holding capacities of coarse soils.

Nutrients

When setting local standards, specify the type of test appropriate to the region.

Bulk density

Penetrometer and infiltration measurements are better indicators of soil structure and function than bulk density. Bulk density is an acceptable alternative to a penetrability test if it is measured in place (*in situ*). For instructions, see Chapter 4 of the Soil Quality Test Kit Guide available from the USDA-NRCS at http://soils.usda.gov/sqi. Measuring *in situ* bulk density can be less expensive but more time consuming than measuring penetrability. *Ex situ* bulk density tests, in which a soil sample is sent to a lab, provides little information because much of the soil structure is lost before bulk density is measured. If bulk density is used, use the following table for standards (NRCS 1998).

Soil texture	Ideal bulk densities (g/cm3)	Bulk densities that may affect root growth (g/cm3)	Bulk densities that restrict root growth (g/ cm3)
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams, loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.10	1.55	>1.65
Sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

Topsoil depth

A depth standard of 4" is minimal, and is suitable for turf. Greater topsoil depths should be required for other landscaping vegetation including trees, shrubs, and flowerbeds.

Soil structure

Consider adding a soil aggregation standard. Some materials such as dredge spoils can be doctored to meet all the topsoil requirements, but are utterly structureless. The infiltration test might fail to indicate this problem if the material has just been loosely installed. For examples of soil structure tests, see chapters 8, 9, and 11 in the NRCS Soil Quality Test Kit Guide (NRCS 1998).

Qualitative measures

If some of these tests are considered cost prohibitive, some may be replaced with qualitative measures. For example, the Soils for Salmon program in Washington and Oregon developed a "Field Guide for Verifying Soil Depth & Quality in New Landscapes" which describes a systematic method for testing topsoil and mulch depth and penetrability using a shovel and a rod penetrometer.

Table 2. Required parameters for compost or soil amendments. (Based on Farrell-Poe et al. 1997)

Characteristics	Compost soil amendment	Mulch or topdressing
Color	Dark brown to black	Light to dark brown – resembles shredded bark
Odor	Should have good earthy odor	Should have no objectionable odor
Particle Size	< ½ inch	> ½ inch
pH	4.5 – 8.0	4.5 – 8.0
Soluble salt (EC) dS/m	< 5	< 6
Carbon-to-Nitrogen Ratio	< 20:1	> 50:1

Regionalization Notes for Table 2

pH

In some regions, undesirable acid sulfate materials can be a problem. They may appear like black "topsoil" and are near neutral when freshly excavated. To prevent their use, require that the pH of amendments be > 4.5 after drying, re-wetting, and incubating for 7 days.

Soluble salt

Note that this soluble salt limit can preclude the use of manure in arid regions. In areas with >25" annual precipitation, a salt standard may not be necessary.

Stability

Compost stability is an important characteristic of compost, but is not included in Table 2 because standards have not been established. In a well-aerated pile, "unfinished" or "unstable" compost has a high rate of biological activity, consumes nitrogen and oxygen, and generates heat, CO_2, and water vapor. "Finished" or stable compost has higher levels humic substances and low levels of nitrate and ammonium. Depending on the feedstock used, some unstable composts may trigger nitrogen deficiency in plants. If stored anaerobically (without mixing), unstable compost may develop odors and growth-inhibiting compounds.

Indicators of stability may include a growth screening test and a respiration test.

Further resources

For more detail about compost parameters contact the U.S. Composting Council.

Table 3. Standards for Irrigation Water

INTERPRETIVE GUIDELINES FOR IRRIGATION WATER ANALYSIS				
Parameter	Units	Potential Problems		
		None	Increasing	Severe
Sodium (Na)	mg/l	< 70	71 - 180	> 180
Chloride (Cl)	mg/l	< 70	71 - 300	> 300
Conductivity	mmhos/cm	< 0.75	0.76 - 3.0	> 3.0
pH	—	5.5 - 7.5	< 5.5 or > 7.5	< 4.5 or > 8.5
Bicarbonate (HCO_3)	mg/l	< 40	41 - 180	> 180
Carbonate (CO_3)	mg/l	< 15	16 - 20	> 20
Boron (B)	mg/l	< 0.5	0.6 - 2.0	> 2.0
Sodium Absorption Ratio (SAR)	—	< 3	4 - 6	> 6

Table from A & L Great Lakes Laboratories:
http://algreatlakes.com/FactSheets/pdf/ALGLFS20_Interpreting_Irrigation_Water_Analysis.PDF

Regionalization Notes for Table 3

Sodium adsorption ratio (SAR)
Interpretation of SAR values depends in part on Ca levels.

Water analysis standards from non-commercial labs:
Utah State University Analytical Labs http://www.usual.usu.edu/
University of Nebraska - Lincoln: http://www.ianr.unl.edu/pubs/water/g328.htm
Wyoming Department of Agriculture: http://wyagric.state.wy.us/aslab/IrgWExpl.htm

Appendix B: Soil Quality Inspection Form for Landscapes

Site ____

Owner's name and contact info ____

Contractors' name(s) and contact info ______________________________________

____

Date passed	Criteria	Notes. If criteria are not met after initial inspection, include: • date of initial test, • criteria failed, and • follow-up.
Prior to start of construction		
	Site history has been conducted. Prior uses have been analyzed.	Specify any additional hazardous materials tests.
	Cleared for Hazardous Materials	
	Existing topsoil meets standards in Table 1.	List test results for standards that were not met, and list amendments that must be added to bring existing topsoil up to standards:
	No-traffic areas have been correctly fenced off.	
During grading		
	Proper erosion control methods are being used	
	Excavation and stockpiling of topsoil is being done correctly.	
Prior to topsoil placement		
	Imported soil meets criteria in Table 1.	
	Imported amendments meet criteria in Table 2. Specify amendments: ____________________ ____________________	
	Subsoil penetrability is less than 1400 kPa down to 12".	
	Water to be used on the site meets criteria listed in Table 3.	

	Irrigation system plan and equipment is approved for efficiency. Consider: Topography, climate, erosion, equipment, scheduling, vegetation to be grown, soil, and other.	
	Area is free from debris including materials such as building materials, plaster, paints and stains, concrete and stucco, road base type materials, petroleum based chemicals, oils, all rock larger than ¾ inch in diameter, and other harmful materials.	
	Contractor has disposed of above materials in accordance with local ordinances.	
	Contractor has provided 48 hours prior notice and made arrangements with owners representative to inspect site during topsoil placement.	
	At time of topsoil placement contractor has supplied copies of soil/s report/s to inspector.	
Prior to planting, after topsoil installation.		
	Soils meet criteria in Table 1 for penetrability.	Range of measured values: ____________________
	Soils meet criteria in Table 1 for infiltration rates.	Range of measured values: ____________________
	Soils meet criteria in Table 1 for topsoil depth.	Range of measured values: ____________________
After planting.		
	Mulch has been applied.	

Appendix C: Resources

Many local entities have standards, ordinances, and specifications related to the soil quality issues raised in this document. Look for them by contacting local offices of highway departments, landscaping divisions, USDA-Rural Development, USDA-Natural Resources Conservation Service, US EPA, and others. The list below is a small sample of existing resources.

Some key words to use in searches include:

Bioretention, rain gardens – The use of green space to manage runoff within small, depressed landscaped areas.

Compost berms and blankets – The use of organic materials to control sediment runoff from construction sites.

Erosion and sedimentation control

Low impact development

Stormwater management – Stormwater management often focuses on controlling and directing flow only after it leaves a property. Look for management approaches that consider hydrologic functions on the landscape, including soil properties such as infiltration, water holding capacity, drainage, recharge, discharge, and evaporation.

Topsoil materials

Urban conservation

Regional resources

Soils for Salmon

http://www.soilsforsalmon.org (Washington)
http://www.soilsforsalmonoregon.org (Oregon)

Soils for Salmon is a highly-developed program addressing soil quality issues in the context of stormwater management and urban/suburban development. Look to the *Soils for Salmon* program for detailed examples for implementing most of the issues raised in this document.

Guidelines are formalized in their "Stormwater Management Manual for Western Washington" http://www.ecy.wa.gov/programs/wq/stormwater/manual.html. Especially note Volume II: "Construction Stormwater Pollution Prevention," and Volume V, Chapter 5: "On-site Stormwater Management," including BMPT5.13 Soil quality and depth.

A good place to start is the companion document: "Guidelines and resources for implementing soil depth and quality BMPT5.13," and the associated "Field Guide for Verifying Soil Depth & Quality in New Landscapes". Look for these on the Soils for Salmon sites (http://www.soilsforsalmon.org).

Other Pacific Northwest resources

"Restoring Soil Health to Urbanized Lands." Oregon Department of Environmental Quality. http://www.deq.state.or.us/wmc/solwaste/documents/restoringsoilhealth.pdf

Washington State Department of Transportation. http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Index.html. Includes information on soil amendments and specifications.

Ecologically Sound Lawn Care Report. http://www.seattle.gov/util/lawncare/LawnReport.htm. Includes information on the effect of practices on the soil.

Iowa State University, Agricultural and Biosystems Engineering http://www.eng.iastate.edu/compost/index.html. Describes research on the use of compost in roadside projects.

USDA-NRCS Illinois Urban Manual

http://www.il.nrcs.usda.gov/technical/engineer/urban/. Copies available from the Lake County Soil and Water Conservation District. Includes detailed NRCS practice standards for urban settings.

Compost berms and blankets

Texas Department of Transportation compost specifications. http://www.dot.state.tx.us/des/landscape/compost/specifications.htm

"Compost Utilization for Erosion Control." Cooperative Extension Service, University of Georgia. http://www.ces.uga.edu/pubcd/B1200.htm

"Compost Coverage." Erosion Control Magazine. http://www.forester.net/ec_0105_compost.html

"Erosion Control and Environmental Uses For Compost" http://www.p2pays.org/ref/11/1015810.pdf. From "Composting in the Southeast" conference. Full proceedings at http://www.p2pays.org/ref/11/10158.htm.

Biofiltration, bioretention, rain gardens

Street edge alternatives http://www.ci.seattle.wa.us/util/SEAStreets/default.htm (Click on "technical information" to view soil specifications.)

Rain gardens of West Michigan. http://www.raingardens.org/

Rain gardens in Minnesota. http://www.mninter.net/~stack/rain/. See the list of links.

Low Impact Development

Prince George's County, Maryland. http://www.goprincegeorgescounty.com Use the left navigation bars to go to: Government/Agency Index/Environmental Resources/Programs and Planning/Low Impact Development. This focuses on stormwater management through hydrology management.

Puget Sound Action Team, Low Impact Development http://www.psat.wa.gov/Programs/LID.htm.

National resources

Composting Council

US Composting Council
4250 Veterans Memorial Highway, Suite 275
Holbrook, NY 11741
Phone: 631-737-4931
Email: admin@compostingcouncil.org

http://www.compostingcouncil.org/

"Field Guide to Compost Use" describes parameters for assessing compost.

The International Society of Arboriculture

http://www.treesaregood.com/

US EPA: Compost Use on State Highway Applications

http://www.epa.gov/epaoswer/non-hw/compost/highway/

Includes state compost specifications.

See also the EPA composting page: http://www.epa.gov/epaoswer/non-hw/compost/index.htm

US EPA: Model ordinances to protect local resources http://www.epa.gov/owow/nps/ordinance/index.htm

Includes ordinances related to stormwater management and erosion control.

USDA-NRCS Urban Soils web page

http://soils.usda.gov/use/urban/

USDA-NRCS: TR-55 Hydrologic model

Used to analyze hydrology on a landscape.

See: SCS. 1986. *Urban Hydrology for Small Watersheds*. Technical Release 55, US Department of Agriculture, Soil Conservation Service, Engineering Division, Washington, DC.

USDA-NRCS: Conservation Practice Standards

See NRCS Conservation Practice Standards http://www.ftw.nrcs.usda.gov/practice_stds.html for the following practices:

- Anionic Polyacrylamide (PAM) Erosion Control (Ac.) (450)
- Channel Stabilization (Ft.) (584)
- Channel Bank Vegetation (Ac.) (322)
- Constructed Wetland (Ac.) (656)
- Cover Crop (Ac.) (340)
- Critical Area Planting (Ac.) (342)
- Deep Tillage (Ac.) (324)
- Grade Stabilization Structure (No.) (410)
- Heavy Use Area Protection (Ac.) (561)
- Mulching (Ac.) (484)
- Runoff Management System (No. and Ac.) (570)
- Toxic Salt Reduction (Ac.) (610)

Also, see those listed in the *Illinois Urban Manual:*
http://www.il.nrcs.usda.gov/technical/engineer/urban/

Appendix D: References

ASAE soil testing specifications. http://www.asae.org/

Craul, Phillip J. 1999. Urban Soils: Applications and Practices. John Wiley & Sons, Inc., New York.

NRCS. 1998. Soil Quality Test Kit Guide. (Available on-line at http://soils.usda.gov/sqi. Verified 3Nov03.)

Rich Koenig and Von Isaman.1997. Topsoil quality guidelines for landscaping. Utah State University Cooperative Extension. AG/SO-02. (Available on-line at http://extension.usu.edu/files/agpubs/topsoil.htm. Verified 3Nov03.)

USU Extension Bulletin - HG/Compost/02

Kitt Farrell-Poe, James Barnhill, Rich Koenig, and Bruce Miller. 1997. Using compost in Utah gardens. Utah State University Extension. HG/Compost/02. (Available on-line at http://extension.usu.edu/files/gardpubs/compos02.pdf Verified 3Nov03.)