Preserving and Restoring Healthy Soil: Best Practices for Urban Construction

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Sustainable Technologies Evaluation Program

Toronto and Region Conservation for The Living City

THE SUSTAINABLE TECHNOLOGIES EVALUATION PROGRAM

The Sustainable Technologies Evaluation Program (STEP) is a multi-agency program, led by the Toronto and Region Conservation Authority (TRCA). The program helps to provide the data and analytical tools necessary to support broader implementation of sustainable technologies and practices within a Canadian context. The main program objectives are to:

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- assess barriers and opportunities for implementing technologies;
- develop supporting tools, guidelines and policies; and
- promote broader use of effective technologies through research, education and advocacy.

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FOREWORD

Application of improved soil management practices during urban construction can reduce stormwater runoff and outdoor water use, produce more lush yards and landscaped areas that are easier and cheaper to maintain, and provide the growing environment needed by urban trees to reach maturity. As an organization with an interest in ensuring that healthy, functioning soils are maintained or restored, and remain pervious following construction for the many environmental benefits they provide, the Toronto and Region Conservation Authority has prepared this guidance document that describes some recommended best practices and minimum standards for soil management during urban construction. The document was prepared based on guidance provided in several jurisdictions throughout the United States (e.g., Western Washington, Maryland, Minnesota, Pennsylvania, Virginia, New York) and green building certification system guidelines (e.g., The Sustainable Sites Initiative™) with adaptations to suit an Ontario context. This best practices guide is intended to provide both the rationale and practical guidance needed to improve soil management practices during construction in Ontario. It has been prepared to provide guidance to designers and engineers involved in urban and landscape design, government agencies involved in the permitting and inspection of urban construction projects and contractors involved in urban construction and landscaping.

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TORONTO & REGION
REMEDIAL ACTION PLAN

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1.1 Introduction

Urban development alters the ways by which water flows through the local environment (i.e., the hydrologic cycle) as a result of clearing vegetation and topsoil, compacting subsoils during construction and creating impervious surfaces (e.g., pavement and buildings) and enhanced drainage systems (e.g., ditches, gutters, catchbasins, storm sewers). These changes decrease the portions of rain and snowfall that return to the atmosphere as water vapour via evapotranspiration, and that infiltrate into the soil to become groundwater, while greatly increasing the portion that runs off the landscape into storm sewers and ultimately into our rivers, lakes and wetlands (Figure 1.1). Urban runoff picks up a variety of contaminants along its flow path to the waterbodies that receive it, which negatively impacts water quality. Increased runoff changes the pattern and volume of flow in urban streams to conditions radically different from those which formed the watercourse in the past, resulting in accelerated channel erosion and potential impacts to infrastructure located in or near stream corridors. Without the application of best management practices to control runoff and improve its quality, the health of natural ecosystems that our urban streams, lakes and wetlands support declines. While conventional stormwater best management practices such as detention ponds and constructed wetlands successfully control the rate of flow to receiving waters and improve runoff quality, they do not fully address fundamental changes to the hydrologic cycle brought about by urbanization.

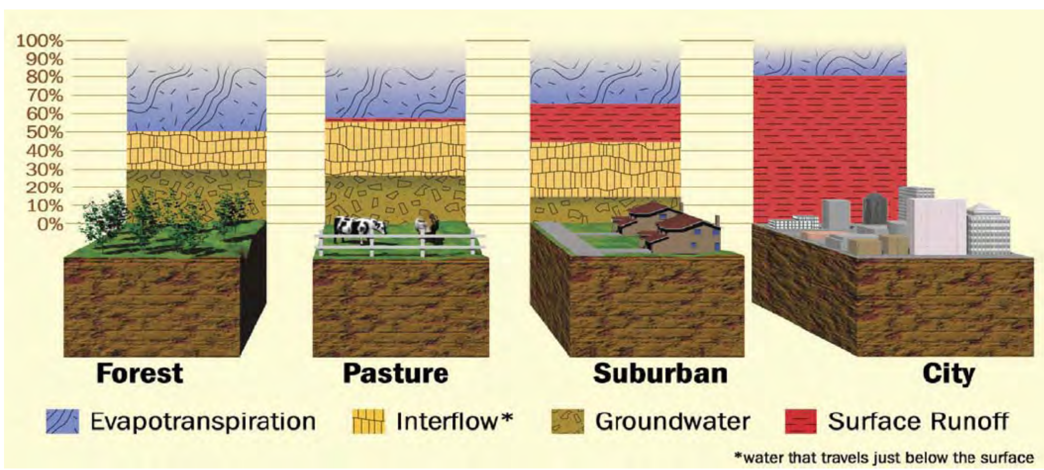
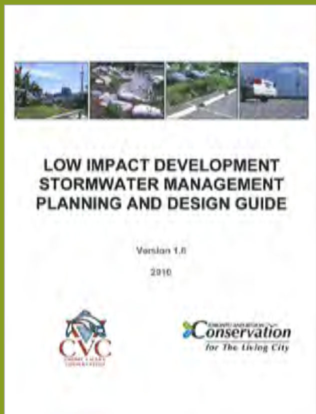


Figure 1.1 Effects of Land Cover Changes on the Hydrologic Cycle

(Source: Soils for Salmon, 2010).

One approach to reducing the impacts of urbanization on the hydrologic cycle is to implement soil management best practices during construction that help maintain the capacity of landscaped areas to absorb rain and snowfall and prevent runoff directed to them from adjacent impervious surfaces from leaving the site where it is generated. The lawns, gardens, sports fields, parks and open space components of our urban environments all contribute to how absorbent our urban landscapes are to rain and snowfall. The principle of creating more absorbent urban landscapes is central to Low Impact Development (LID) approaches to stormwater management (CVC & TRCA, 2010).



The Low Impact Development Stormwater Management Planning and Design Guide (CVC & TRCA, 2010) provides engineers, ecologists and planners with up-to-date information and direction on landscape-based stormwater management planning and low impact development (LID) practices, and thereby helps ensure the continued health of the rivers, lakes, wetlands and terrestrial habitats in the CVC and TRCA watersheds. It is also intended to help streamline and focus the design and review process, as well as ensure that the goals, objectives and targets outlined in watershed plans and subwatershed studies are being met. It addresses not only the planning, selection and design of LID stormwater management practices, but also the costs of implementing them.

The way in which landscaped portions of urban environments are constructed and managed affects how absorbent they are in addition to the level of effort that will be required to re-establish and maintain healthy vegetation and the lifespan of the plantings. If best practices to preserve or restore healthy functioning soils in these areas are not applied during construction, changes to soil structure, biology and organic matter content and the effects of compaction can cause them to function more like impervious surfaces. This makes the standard practice of directing roof drainage to them (i.e., roof downspout disconnection) less effective than it could be at reducing urban runoff and contaminant loads to receiving waters. Furthermore, poorer quality planting environments are produced that require more irrigation, fertilizer and effort to re-establish and maintain vegetation. Application of soil management best practices that preserve or restore soil quality and depth in landscaped areas can reduce runoff as well as outdoor water use, produce more lush yards and landscaped areas that are easier and cheaper to maintain, and provide the growing environment needed by urban trees to reach maturity. Properties where healthy soils have been preserved or restored can be marketed as a premium product featuring low maintenance landscaped areas which could provide developers with an advantage over competitors that do not implement such best practices.

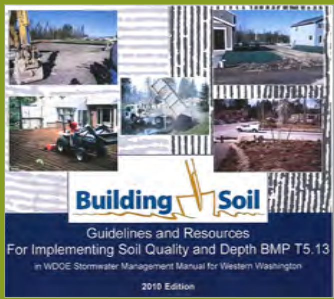
If healthy, functioning soils are not preserved or restored post-construction, directing roof drainage to landscaped areas is much less effective than it could be at reducing stormwater runoff and contaminant loads to receiving waters. Source: D. Young

Examples of poor quality planting environments produced without application of soil management best practices to preserve and restore healthy functioning soils. Source: C. Morrison

This document provides detailed guidance on:

- Recommended standards for post-construction soil quality and depth in Ontario;
- Soil management best practice options for meeting the recommended standards;
- Soil testing needed to select, design and implement appropriate best practices;
- Preparing soil management plans that describe the practices to be implemented;
- Implementing soil management plans and best practices in the field;
- Inspections and testing needed to verify that the post-construction soil quality and depth standards have been met; and
- Short term and on-going maintenance requirements for restored soil areas.

This document has been prepared through a review of best management practice guidelines from several jurisdictions in the United States that are leaders in the implementation of low impact development techniques and practices (WDOE, 2005; PDEP, 2006; MPCA, 2008; Soils for Salmon, 2010; VA DCR, 2010; NYS DEC, 2010) and other guidelines on green building best practices (CWP, 2006; The Sustainable Sites Initiative, 2009; Tyler *et al.*, 2010). In many of these jurisdictions minimum standards for post-construction soil quality and depth are included in municipal engineering or urban design standards. The standards apply to all development proposals or construction sites that involve clearing vegetation, topsoil stripping and changes to grading that require a permit either from the municipality or other government agency. Typical approaches to implementing the standards involve municipalities or local governments requiring that a Soil Management Plan be prepared and submitted as part of the development proposal, or clearing/grading/fill placement/construction permit application that demonstrates how the post-construction soil quality and depth standards will be met on the site (e.g. City of Bellevue, 2011). Upon completion of construction activities, inspection and testing by municipal by-law enforcement officers or other government agency staff is undertaken to confirm that the best practices described on the Soil Management Plan have been properly implemented and that that soil quality and depth standards have been met.



Soils for Salmon is a project of the Washington Organic Recycling Council that promotes the adoption of simple soil management best practices to developers, builders and landscapers that preserve site topsoil and vegetation, reduce compaction, and amend disturbed soils with compost to restore healthy soil functions. Their guideline, Building Soil, helps professionals in the land development and landscaping industries understand and implement the Washington State Department of Ecology's best management practice for soil quality and depth, designed to improve stormwater retention and water quality, and was a primary resource during the development of this guide.

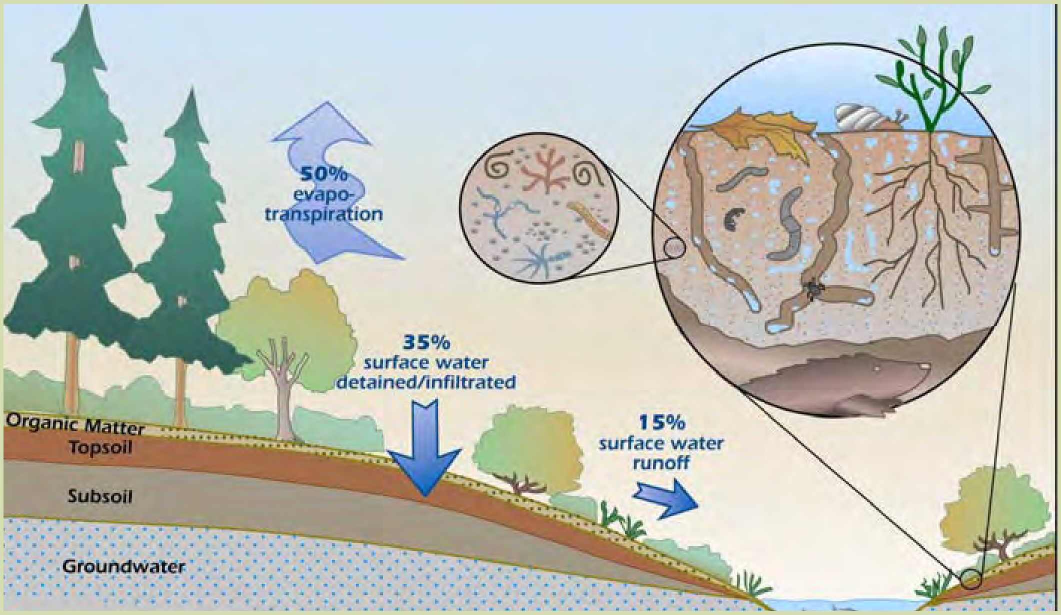
In other jurisdictions, soil management best practices are voluntary with inspection and testing done by a construction site supervisor or manager. However, if they are not proposed as part of the development application submission, when designing the stormwater management system for the development, the portions of the site to remain pervious (i.e. landscaped portions) should be modeled as a less permeable Hydrologic Soil Group than the native soils were classified as prior to grading and construction (e.g., WDOE, 2005b). Where soil management best practices are to be implemented, the pervious landscaped area, and in many cases any impervious area draining to it in a dispersed manner (according to stormwater management best practice design guidelines; e.g. WDOE, 2005b), can be modeled as having the same runoff characteristics of the native soil (WDOE, 2005a). This reduces the required treatment capacity of end-of-pipe stormwater management practices located downstream and can reduce the area of land needed for surface facilities (e.g. detention ponds, swales, bioretention cells, etc.) and increase the developable portion of the site (i.e. higher lot yields).

Other approaches to encouraging implementation of improved soil management best practices in urban construction include qualifying for credits in green building certification programs (e.g., Leadership in Energy and Environmental Design – LEED®, The Sustainable Sites Initiative™), promotion through professional associations or accreditation systems, training courses and technology transfer workshops.

Regardless of the approach taken, this document and the guidance it contains will be a useful resource to all organizations and individuals interested in improving conventional urban construction soil management practices.

1.2 Benefits of Healthy Soil

Healthy soil provides important stormwater management functions including efficient water infiltration and storage, adsorption of excess nutrients, filtration of sediments, biological decomposition of pollutants, and moderation of peak stream flows and temperatures. In addition, healthy soils support vigorous plant and tree growth that intercepts rainfall, returning much of it to the atmosphere through evaporation and transpiration and supports urban tree canopy cover. The health of the soil, vegetation and the receiving waters (e.g. rivers, lakes and wetlands) they drain to are intrinsically related and these relationships must be recognized in land development planning and urban construction processes in order to produce functional landscaped areas.



- Provides high rates of water infiltration and retention;
- Minimizes surface water runoff and erosion;
- Traps sediments, heavy metals and excess nutrients and biodegrades chemical contaminants;
- Encourages vigorous growth of vegetation which provides protective cover;
- Supports beneficial soil organisms that fight pests and disease and supply plant nutrients, thereby reducing the need for chemical fertilizers and pesticides that may contaminate surface and groundwater;
- Increases the lifespan of trees in the urban canopy.

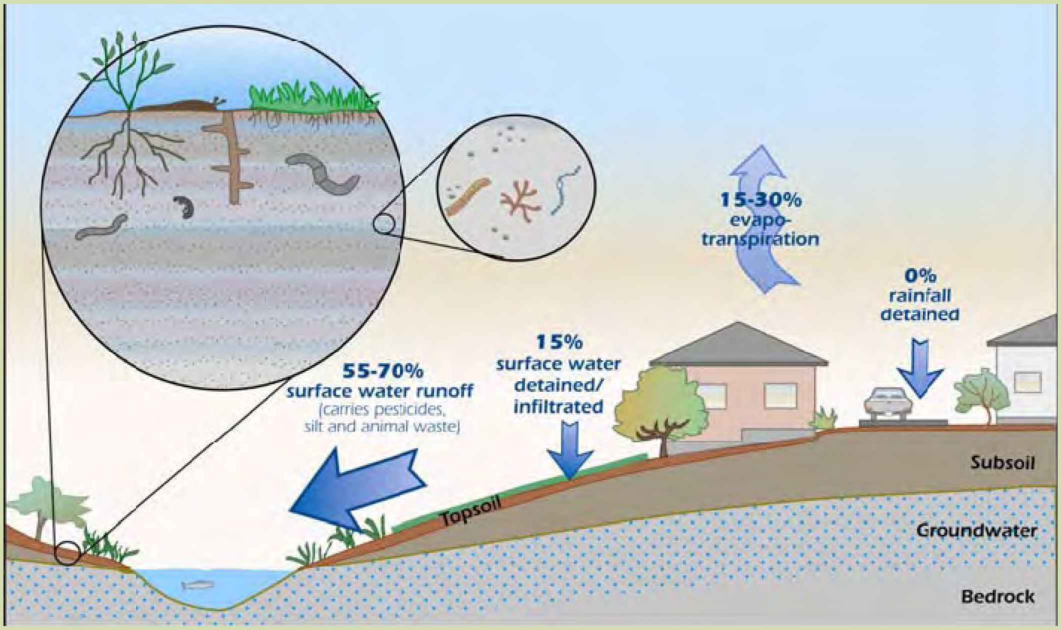
Figure 1.2 Functions of healthy native soil .Source: Soils for Salmon, 2010.

To be a functioning, healthy soil it must have adequate pore space (i.e. porosity) to allow for the transport and storage of air and water. When soil is compacted, porosity decreases and bulk density (dry mass divided by volume) increases, which affects the soil's ability to infiltrate and store water, limits diversity of soil organisms and nutrient uptake by vegetation, and impedes root growth. Generally, once bulk density exceeds 1.7 grams per cubic centimetre (g/cm^3), roots are no longer able to penetrate through the soil (Morris and Lowery, 1988). Likewise, compacted soils have lower oxygen transfer, extreme summer temperatures, less nutrient retention, and less mycorrhyizal fungi compared to uncompacted soils (Bethenfalvay and Linderman, 1992).

Urbanization of forest and farmland in southern Ontario has reduced the capacity of the landscape to absorb, filter and store rain and snowfall and support vigorous tree and plant growth. Conventional clearing and grading practices in the land development industry involve stripping and stockpiling site topsoil (on-site if sufficient space is available) in large mounds for periods of 6 months to a year or more while construction proceeds. These stripping and stockpiling practices tend to compact the topsoil and deplete it of beneficial soil organisms at depths below about 30 centimetres from the top of the mound, which results in stockpiles of topsoil that are either poor or highly variable in quality. All the benefits we expect from topsoil depend on its structure and the actions of microbes and other soil organisms (Figure 1.2).

Conventional topsoil stripping and stockpiling practices tend to compact the soil and deplete it of beneficial soil organisms which results in stockpiles that are either poor or highly variable in quality. Source: Dean Young

Near the end of construction, the stockpiled topsoil is replaced as-is in areas to be landscaped or screened to remove large stones and debris and then replaced, typically at a depth of 10 to 15 centimetres, representing only about 30% of the total amount stripped from the site. This poor or highly variable quality topsoil is commonly replaced on top of subsoil that has been compacted by construction equipment, vehicle traffic/parking or temporary storage of construction materials to the degree that inhibits penetration by the roots of plants and infiltration of precipitation to deeper soil horizons and underlying aquifers (Figure 1.3). These conditions produce unhealthy trees and plants that are short-lived, disease prone or require excessive irrigation, fertilizers and pesticides to maintain, representing an unnecessary cost to property owners and a potential source of contaminants to receiving waters. The roots of trees planted in compacted subsoils often cannot penetrate to significant depths but rather extend horizontally which adversely affects the health of the tree and can damage adjacent curbs and pavements leading to unnecessary repair costs for municipalities.



- Functions are often impaired through topsoil loss and compaction;
- Decreases water infiltration and storage and increases runoff and contaminant loads to receiving waters;
- Increases erosion and risk of flooding;
- Reduces beneficial soil organisms, impairs plant growth and pest/disease resistance;
- Increases need for landscape irrigation, fertilizers and pesticides, potentially further ` contributing to surface water pollution.

Figure 1.3 Typical impacts of urban construction practices on soil function and health (Adapted from Soils for Salmon, 2010)

Urban street trees where horizontal growth of roots caused by compacted subsoil resulted in damage to adjacent sidewalks, necessitating repairs and major trimming of roots which will lead to a decline in tree health. Source: C. Morrison.

Furthermore, these practices produce landscaped areas that are not as absorbent as they could be, functioning more like impervious surfaces than pervious ones. Landscaped areas constructed on compacted soils have been shown to contribute 40 to 60% of the total runoff from residential developments (Wignosta *et al.*, 1994). Residential lawns in newly developed areas have been shown to produce significantly larger runoff volumes than older lawns due to higher soil bulk density (i.e. loss of soil structure) and lower organic matter content (Legg *et al.*, 1996). While many natural processes act to loosen up soil, such as freeze/thaw cycles, activity of soil organisms and plant root penetration, they can take decades to substantially decrease soil bulk density. In addition, many of these processes are ineffective when soil compaction becomes severe (i.e. bulk density greater than 1.7 g/cm^3) because water, roots and soil fauna simply cannot penetrate the dense soil matrix (Schueler, 2000).

Addressing these issues through the application of soil management best practices during the urban construction process that restore structure and organic matter content and help re-establish the biotic community of a healthy, undisturbed soil can provide numerous and significant benefits.

Key Benefits of Preserving and Restoring Healthy Soils

- Restores porosity and organic matter which increases water infiltration and holding capacity;
- Decreases surface water runoff, soil erosion, peak flow rates in storm sewers and receiving waters, and risk of combined sewer overflows and flooding;
- Improves filtration and trapping of contaminants and excess nutrients in urban runoff;
- Aids in maintaining aquifer water levels and baseflows in streams;
- Restores conditions needed by beneficial soil organisms that fight pests and disease and supply plants with nutrients and water;
- Allows for the re-establishment of vigorous vegetative cover and deep root growth;
- Creates more marketable buildings and healthier, aesthetically pleasing landscapes;
- Minimizes on-going maintenance requirements of landscaped areas by reducing the need for irrigation and eliminating the need for fertilizers and pesticides and thereby saves money and helps to prevent pollution;
- Contributes to qualifying for credits in green building certification programs (e.g. Leadership in Energy and Environmental Design – LEED, Sustainable SITES).

1.3 Preserving and Restoring Soil Functions Through Best Management Practices

An obvious approach to avoiding impacts on soil function and receiving waters through the land development planning process is to minimize the portion of the site that will be covered in impervious surfaces (i.e. roofs, paved surfaces). Reducing the impervious area associated with a development is a principle of Low Impact Development approaches to site design and stormwater management (CWP, 1998; U.S. EPA, 2007; CVC & TRCA, 2010). Another way is to apply soil management best practices that preserve or restore healthy soil functions in areas to remain pervious (i.e. landscaped areas) during clearing, grading and construction. Such best management practices include:

- Leaving existing trees, vegetation and soil undisturbed to the greatest extent possible;
- Stripping, stockpiling and preserving existing topsoil on-site for reapplication in areas to be landscaped;
- Restoring post-construction soils in areas to be landscaped to meet minimum soil quality and depth standards.

The primary means of restoring healthy functions to degraded soils identified to date involve various approaches to reversing the effects of soil compaction involving the use of subsoiling or tilling equipment and application of organic amendments, such as compost and mulch, to increase soil organic matter content. The effectiveness and benefits of such approaches to restoring healthy soil functions have been documented through field monitoring and research in both agricultural and urban contexts (Table 1.1).

Table 1.1 Summary of Studies Evaluating Effectiveness of Soil Restoration Practices

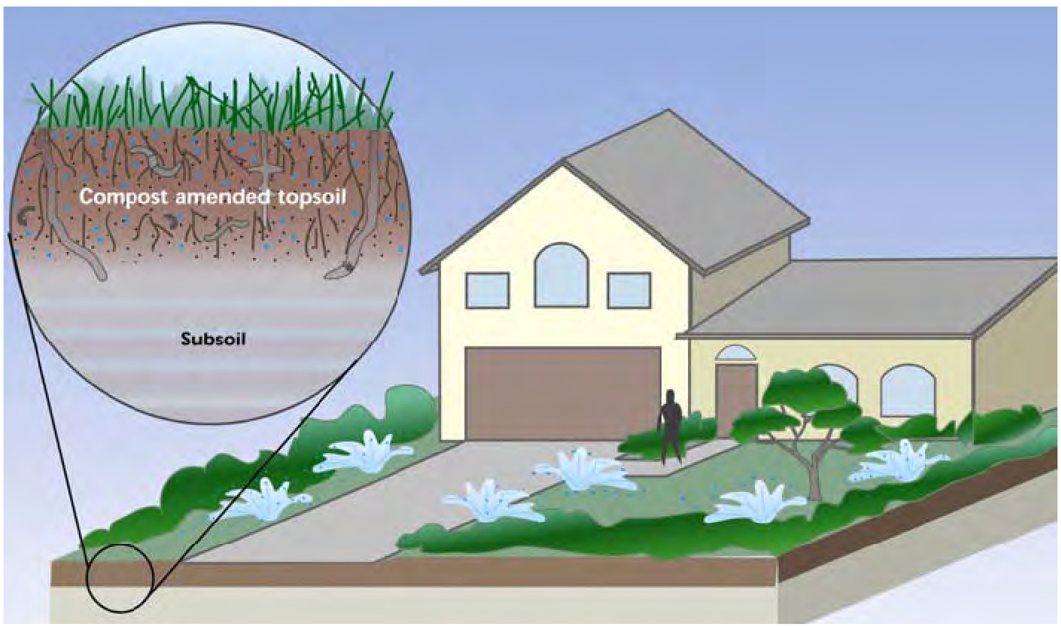
	REFERENCE				
PARAMETER	Malone *et al.*, 1996	Chow *et al.*, 2002	Balousek., 2003	Faucette *et al.*, 2005	Reinsch *et al.*, 2007
Study Type	Field plots, natural rainfall	Field plots, simulated rainfall	Field plots, natural and simulated rainfall	Field plots, simulated rainfall	Field plots, natural and simulated rainfall
Native Soil Type	Silty loam (% sand:silt:clay 13:75:12) with 1.3% carbon content	Gravelly loam (% sand:silt:clay 61:31:7) with 4.6% organic matter (2.7% carbon)	Silty clay loam compacted using a bulldozer	Sandy clay loam	Clay
Slope	10%	11.6%	10%	10%	33%
Rainfall Intensity & Duration	14 rain events; 5 to 35 mm total depth	106 mm/h for 27 minutes	100 to 130 mm/h for 30 minutes	77.5 mm/h for one hour	21 natural and 3 simulated event; 9 to 89 mm total depth
Treatment	Yard waste compost incorporation	Pulp fibre incorporation	Deep tilling, chisel plowing and yard waste compost incorporation	Compost blankets (four different compost source materials) with filter berms	Yard waste compost blanket; incorporation; incorporation with filter berm
Amendment Rate	115.7 ton/ha.	160 ton/ha. (increased organic matter content by 4%)	2:1 soil:compost by volume (75 mm compost blanket incorporated to 150 mm depth)	37.5 mm deep compost blankets; 60 cm width x 30 cm height filter berms	50 mm blanket; 1.5:1 soil:compost by volume (50 mm blanket incorporated to 76 mm depth)
Depth of Tillage	15 cm	20 to 25 cm	15 cm	n/a	7.6 cm
Vegetation Cover	Tomatoes	Bare soil	Grasses and herbs	Seeded with Common Bermuda grass	Seeded with turf grass seed mixture
Runoff Volume[1] Reduction	67%	23%	88%	30 to 55%	96% (blanket) 69% (incorporation) 74% (incorporation with filter berm)
Sediment Load[1] Reduction	77%	71%	n/a	97 to 99%	>99%
Nutrient Load[2]	n/a	n/a	n/a	29 to 62%	>99%

Notes:

1. *Values are percent reductions over all events monitored relative to a bare soil control.*
2. *Values are percent reductions of dissolved reactive phosphorus load after vegetation had become established, relative to a bare soil control.*

Tillage has been used in agriculture for thousands of years to prepare a soil for planting. The effectiveness of a variety of tilling equipment to decrease bulk density of compacted soil have been examined and shown to provide only minor improvements (Rolf, 1994; Paterson and Bates, 1994; Randrup, 1998; Chow *et al.*, 2000). In a review of methods for reversing urban soil compaction, Schueler (2000) reported that even the best tillage practices could only reverse one third of the expected increase in bulk density during construction. These studies have shown that tillage alone cannot return compacted soil to pre-construction condition.

One method with the potential to alleviate the effects of compaction, while improving fertility, is tilling or scarifying combined with amending the soil with compost. When compost is incorporated into the soil, bulk density can be reduced by as much as 0.35 g/cm^3 (Kolsti *et al.*, 1995), which is generally how much it is increased during mass grading (Randrup, 1998). Depending on the type and amount of compost incorporated, reductions in runoff volume have been found to vary. It is reported that every one percent of organic matter in a soil to 30 centimetres depth can hold up to 16 litres of plant available water per square metre (Tyler *et al.*, 2010). Compost also has soil binding properties, with the humus content acting like glue which aggregates and holds soil particles together, making the soil more resistant to erosion and improving moisture retention (U.S. Composting Council, 1997).



One method with the potential to alleviate the effects of compaction while improving fertility is tilling or scarifying combined with amending the soil with compost. Source: Soils for Salmon

The effectiveness of amending soil with organic material to improve water holding capacity of been demonstrated in several field studies. In a study of the effects on pesticide concentration and loading to surface water of various soil management practices, Malone *et al.* (1996) observed that runoff from agricultural plots amended with yard waste compost was less than from conventionally tilled soil but greater than from untilled plots. The effect on water-holding capacity and runoff quality of amending local subsoil with compost was examined at the University of Washington College of Forest Resources campus in Seattle using testing beds and a rainfall simulator. Amendment at a rate of 2:1 compost to subsoil was found to double water-holding capacity, increase lag times between the start of precipitation and the initiation of runoff, and reduce phosphorus and nitrate fluxes (Harrison *et al.*, 1997). Chow *et al.* (2003) observed that the incorporation of pulp fibre (a paper industry by-product) into soil on test plots reduced runoff from rainfall simulation by 23% and soil erosion by 71% compared to a bare soil control plot. Runoff reductions were attributed to increased soil moisture storage capacity resulting from lower bulk density and greater total porosity with increasing rates of organic matter amendment.

When subsoiling and tilling is combined with compost amendment, dramatic improvements in soil function have been observed. In a Wisconsin study, experimental plots of a compacted silty clay loam soil were subjected to different soil restoration practices and monitored in order to quantify decreases in runoff compared to untreated control plots (Balousek, 2003). The soil restoration practice combinations evaluated were deep tilling (to 90 centimetre average depth), chisel plowing (to 30 centimetre average depth) and compost amendment (to 15 centimetre average depth). Regardless of the size of the storm event, the plots subjected to the deep tilling and chisel plowing treatment showed large reductions in runoff volume (36 to 53%) compared to the control. Where compost amendment was added, the reduction in runoff volume increased substantially to between 74 and 91% compared to the control (Figure 1.5). The deep tilling only treatment was observed to increase runoff in the range of 11 to 64% (Balousek, 2003).

Recent research has examined the effects of using different compost sources on runoff quantity, quality and soil erosion and compared the effectiveness of different erosion control practices. Studies conducted by the University of Georgia have compared runoff and soil erosion characteristics of a variety of compost, mulch and erosion control treatments using test plots. Under simulated rainfall events equivalent to the 50 and 100 year return period one hour storm events for the location (76 and 102 mm/h respectively) application of a 37.5 millimetre deep blanket of compost has been shown to absorb (i.e., initial abstraction) 51 to 65% more water, reduce runoff volume by 30 to 60% and reduce soil erosion by about 95% compared to a bare soil control plot (Faucette *et al.*, 2005; Faucette *et al.*, 2007). Though compost was high in nutrient content, reduced runoff from compost blanket treatments resulted in lower total nutrient loads to surface water relative to other erosion control methods (i.e., straw mats and hydroseeding).

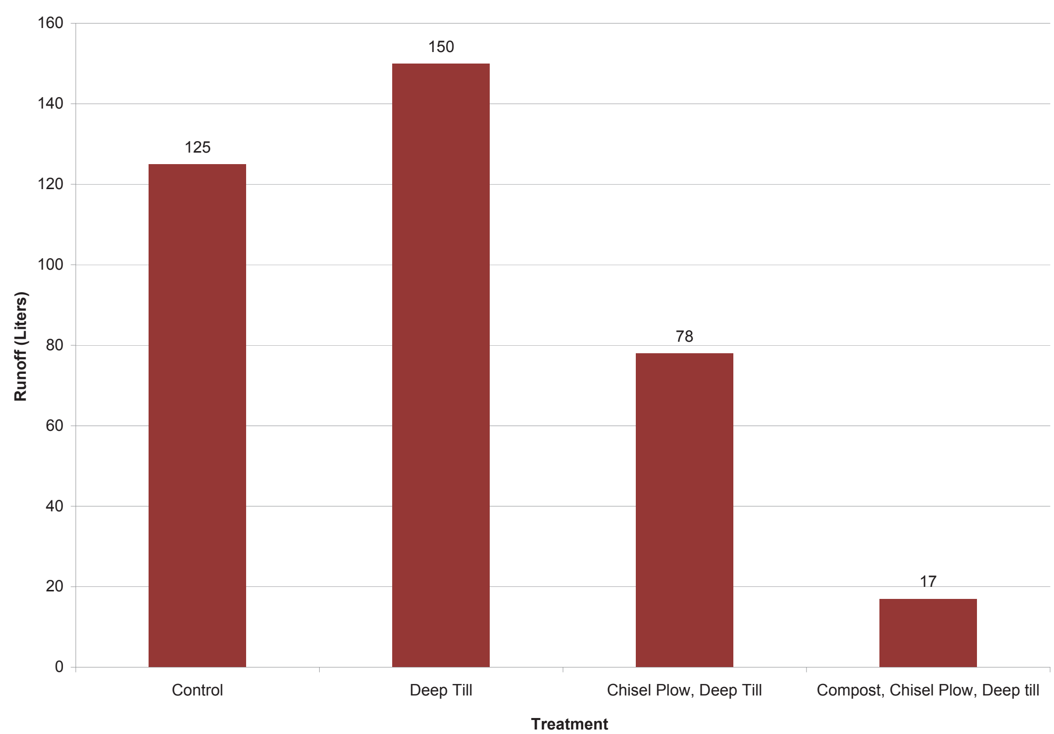


Figure 1.4 Comparison of cumulative runoff from field evaluations of soil restoration practices to alleviate the effects of compaction in Wisconsin. Source: Balousek, 2003

In a study comparing conventional erosion control methods (e.g., straw mats, silt fence) and several methods of applying yard waste compost (blankets, incorporation through tilling and berms) Reisch *et al.* (2007) examined effects on runoff volume and quality, biomass production, turf shear strength and compared installation costs. Compost treatments were shown to be the most effective at controlling runoff with incorporated compost and compost blanket treatments achieving 69% and 96% reduction respectively compared to a vegetated control plot. Sediment and reactive phosphorus loads were also lowest with compost treatments where nearly no soil loss was observed and greater than 99% dissolved reactive phosphorus load reduction was achieved compared to the control. The compost test plots also supported more biomass than other plots which was attributed to greater abundance of nutrients and better water-holding capacity. Turf shear strength test results indicated that the compost treatments promote better root development, leading to greater resistance to erosion. Installation costs of incorporated compost and compost blanket treatments were $5.17 and $4.63 per square metre (in US dollars).

Preserving and restoring healthy soils during construction also creates better quality planting environments in yards and landscaped areas which provides numerous benefits to the ultimate owners and managers of the properties. Such best practices can help property owners/managers minimize maintenance requirements of landscaped areas and prevent pollution by reducing the need for irrigation and eliminating the need for fertilizers and pesticides. The United States Environmental Protection Agency found in several field tests that compost addition to topsoil with no other fertilizer application resulted in superior vegetation establishment compared to conventional hydroseed mulch methods using chemical fertilizers (U.S. EPA, 1997). On a Colorado golf course where compost soil amendments were utilized on a portion of the course it was found that up to 30% less water, fertilizer and pesticides were used than that needed to maintain the unamended portions (U.S. EPA, 1997). When these saving are factored in, the payback period for practicing compost amendment has been predicted to range from one to six years, depending on plants and planting methods (Chollack and Rosenfeld, 1998).

Overall, published research on the performance of compost amended soils indicates this best management practice is highly effective at reducing runoff and contaminant loads to surface water and re-establishing healthy vegetation growth.

1.4 Regulatory Framework Governing Soil Management on Construction Sites in Ontario

In Ontario, municipalities, conservation authorities, and the Ministry of the Environment are the public bodies that administer regulations affecting soil management on construction sites. Municipalities have various legislative and regulatory mechanisms in the planning and development process that consider the removal of topsoil, impact of fill placement, and grading alterations within their communities. Through site alteration by-laws under the Municipal Act, municipalities ensure that impacts from such activities are mitigated; however, municipalities are restricted in the application of site alteration by-laws through Section 142(8) of the Municipal Act, which states that such by-laws have no effect where Conservation Authorities Act regulations are applicable. Therefore, municipal fill/site alteration by-laws do not apply to any land that is within a regulated area, as defined by regulations made under the Conservation Authorities Act.

Conservation Authorities (CAs) are empowered under Section 28 of the Conservation Authorities Act to administer individual "Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulations". These regulations specify regulated areas, including valley and stream corridors, Great Lakes shorelines, interconnecting channels, large inland lakes, wetlands and adjacent lands and regulated activities, including development, site grading, and temporary or permanent fill placement. CAs may only consider the potential impacts of development activities within the confines of the five tests as prescribed in the Conservation Authorities Act and set out in their Section 28 regulations (control of flooding, erosion, dynamic beaches, pollution, and the conservation of land). With respect to topsoil/fill, generally permit review by CAs under Section 28 is concerned with the timing and phasing of site stripping, grading and fill placement, proximity to natural features, impacts to the natural water balance, as well as restoration/site stabilization in order to avoid impacts to ecological functions, hydrologic functions and natural hazards. In light of Section 142(8) of the Municipal Act, coordination between CAs and municipalities is often necessary to ensure effective controls are in place to mitigate environmental impacts associated with topsoil/fill removal and placement.

Municipalities may also have topsoil requirements through engineering, landscaping and urban design standards in association with development applications under the Planning Act, such as a plan of subdivision, consent, site plan, or development permit. These requirements may be specified through agreements or conditions of approval.

The Ontario Ministry of the Environment (OMOE), under the Environmental Protection Act, is responsible for the legislative and policy framework governing excess excavated soil (i.e. fill), dredged sediment, contaminated soil, groundwater and sediment, and associated quality criteria, management requirements and legal liability. If there is contaminated soil, OMOE will respond to complaints, examine the material and have legal recourse if the material is found to be contaminated. The ministry also encourages the beneficial reuse of excess soils generated through construction activities in a manner promoting sustainability and protection of the environment. Where ever possible measures to minimize the amount of excess soil generated should be taken. For the soil that must be managed, the ministry encourages the reuse of excess soil as fill, where appropriate, provided that the use does not have potential to cause an adverse effect to the environment, human health or impair water quality, as described under the ministry's Acts and Regulations.

While the OMOE has legislated responsibility for addressing contamination, it is ultimately the land owner who is responsible for the quality of material and the potential impact that it may have on land and water. While municipalities and CAs may issue permits and inspect sites within the purview of their legislative abilities, it is the land owner who signs the declaration of fill quality, and is responsible for any material being imported and placed.

While these policies regulate topsoil/fill removal and placement, alterations to grading, and contaminated soil/sediment, there are typically no requirements to preserve or restore healthy functioning soils to landscaped portions of a development site following construction activities.

2.0 Post-Construction Soil Quality and Depth Standards

2.1 Overview

Naturally occurring, undisturbed soil, soil organisms and vegetation provide important stormwater management functions including water infiltration, retention and evapotranspiration, as well as nutrient, sediment, and pollutant retention and decomposition. These functions are largely lost through land development when native soils and vegetation are stripped and topsoil is stockpiled as part of conventional construction practices. Not only are these important functions lost, but such landscapes themselves become pollutant generating surfaces. This is because subsoils below the topsoil are left in a compacted condition, preventing infiltration of rain and snowmelt to deeper soil horizons and underlying aquifers. When stockpiled topsoil is replaced on areas to be landscaped, typically at a depth of 10 to 15 centimetres, it is often poor or highly variable in quality. Furthermore, the replaced topsoil is often too shallow to support deep rooting plants, leading to the need for irrigation and use of fertilizers and pesticides to re-establish vegetative cover. It also leads to unhealthy growth of vegetation and prevents establishing a mature urban tree canopy and the myriad of associated benefits that healthy urban trees and vegetation can provide.

Healthy soil functions are largely lost through land development when vegetation is cleared and topsoil is stripped and stockpiled as part of conventional construction practices. Source: S.Bietenholz, , Flickr Creative Commons

Requiring that a minimum quality and depth of soil be preserved or restored in all pervious, vegetated portions of development sites would result in healthier and more absorbent landscapes that have less impact on the health of our rivers, lakes, wetlands and aquifers. It would also produce more attractive and marketable sites that are easier to maintain than those being produced through conventional practices in the absence of minimum standards.

In general, the following standards for post-construction soil quality and depth are recommended:

At project completion, all areas to be landscaped where soil or vegetation has been disturbed should have at least 20 centimetres of topsoil containing 5 to 15% organic matter (by dry weight) depending on the type of vegetation to be established, a total uncompacted soil depth of at least 30 centimetres and a soil pH of 6.0 to 8.0. Higher standards for organic matter content and uncompacted topsoil depth are recommended for planting beds and tree pits than for turf areas because larger, deeper rooting plants need deeper and richer topsoil to thrive (see Section 2.3). Organic matter content is measured in a soil laboratory using the Loss-On-Ignition Test (ASTM International, 2007; USDA & USCC, 2002) described further in Section 3.2.3.

Soils found to not meet the organic matter content standard should be amended with compost that meets the most up-to-date Ontario guidelines for use as a soil conditioner on residential lands (e.g. OMOE, 2004). Use of uncomposted manure or other organic materials, sphagnum peat or organic amendments that contain sphagnum peat is not recommended (The Sustainable Site Initiative, 2009). If default compost amendment rates are used, as described in Section 5.2, laboratory testing of in-situ post-construction subsoil or topsoil is not needed. As a conservative estimate, it can be assumed that the organic matter content of the soil achieved through amendment with compost will decrease by 25% after the first growing season during which plantings are becoming established (Tyler *et al.*, 2010). Once planted vegetation is mature and healthy, and if leaf/plant litter and grass clippings are mulched back into the soil as a routine maintenance practice, soil organic matter content levels should stabilize over time. The default amendment rates, amendment volume calculation worksheet and electronic spreadsheet have been designed to take into account a 25% decline in organic matter content during the period that vegetation is becoming established.

Once soil quality and depth has been restored, planting areas should be protected from compaction and planting beds and tree pits should be covered with at least 5 and up to 10 centimetres of mulch derived from shredded woody material or bark chips. Mulch should be kept at least 10 centimetres away from contact with the stems of plantings.

The best management practices (BMPs) that will be implemented to meet the minimum post-construction soil quality and depth standards should be fully described on a Soil Management Plan (see Section 4) that could be required as part of the development proposal, clearing and grading, fill placement or construction permit application process.

Once soil quality and depth has been restored, planting areas should be protected from compaction and planting beds and tree pits should be covered with at least 5 and up to 10 centimetres of mulch. Source: D. Young

2.2 Application and Limitations

A minimum standard for post-construction soil quality and depth should apply to all development or construction projects that involve clearing vegetation, stripping topsoil, grading and/or soil compaction. The standard should apply to all soils disturbed during construction within a site that will not be covered by impervious surfaces, incorporated into a drainage facility nor engineered as structural fill or slope and will be maintained in a vegetated state (i.e. landscaped areas).

Restoration of soil quality and depth through measures to reverse compaction and amendment with compost should be undertaken in all landscaped areas to which roof runoff is directed and immediately downslope of other impervious areas contributing runoff and subsurface stormwater flows. Landscaped areas that will receive stormwater flow from impervious surfaces should receive runoff as sheet flow to the greatest extent possible. Otherwise, flow dissipating features such as splash pads, pea gravel trenches or other flow spreading devices should be incorporated to prevent concentration of flows and formation of rills on the landscaped areas.

Splash pads and gravel trenches are examples of flow dissipating features that help to deliver runoff to landscaped areas as sheet flow thereby reducing rilling and erosion and promoting infiltration.
Source: D. Young

Restoration of soil quality and depth should not be implemented on slopes greater than 3:1 (PDEP, 2006; Tyler *et al.*, 2010) and on slopes between 4:1 and 3:1, slope stabilization practices such as turf reinforcement grids or erosion control matting should also be applied (Tyler *et al.* 2010). Reversing soil compaction and amendment with compost should not be undertaken on wet or frozen soils because of difficulties working with soils in these conditions.

Soil restoration practices involving decompaction treatments (e.g. tilling, scarification, ripping) should not be implemented within 3 metres of building foundations to limit the risk of water damage or seepage into basements. Consideration should also be given to the locations of shallow underground utilities (e.g.,natural gas and cable lines) and root systems of existing trees and shrubs adjacent to disturbed soil areas to be restored and landscaped. Shallower uncompacted soil depths than those specified in Section 2.3 may be warranted to prevent damage to underground utilities and existing root zones of adjacent trees and shrubs.

2.3 Recommended Standards for Post-Construction Soil Quality and Depth

2.3.1 Turf Areas

Landscaped areas to be planted with turf grass should have a topsoil layer with an organic matter content of 5 to 10% by dry weight and a pH of 6.0 to 8.0. The topsoil layer should have a minimum depth of 20 centimetres except where existing tree roots limit the depth of incorporation of compost amendments needed to meet the criteria. Subsoil below the topsoil layer should be scarified to a minimum depth of 10 centimetres with some incorporation of the upper material to avoid stratified layers where feasible, to produce a total uncompacted soil depth of 30 centimetres. Soil management best practice options to achieve these standards are described in Section 3.1 and stepwise instructions regarding how to implement each option on construction sites are provided in Section 5.2.

Example of a newly landscaped residential subdivision. Source: cbcwilson, Wikimedia Commons

2.3.2 Planting Beds

Landscaped areas to be planted with shrubs, herbs, flowers, ornamental grasses and other groundcovers should have a topsoil layer with an organic matter content of 10 to 15% by dry weight and a pH of 6.0 to 8.0. The topsoil layer should have a minimum depth of 20 centimetres except where existing tree roots limit the depth of incorporation of compost amendments needed to meet the criteria. Subsoil below the topsoil layer should be scarified to a minimum depth of 10 centimetres with some incorporation of the upper material to avoid stratified layers where feasible, to produce a total uncompacted soil depth of 30 centimetres. Soil management best practice options to achieve these standards are described in Section 3.1 and stepwise instructions regarding how to implement each option on construction sites are provided in Section 5.2.

2.3.3 Tree Pits

Pits, trenches or planting beds that will be planted with trees should have a topsoil layer with an organic matter content of 10 to 15% by dry weight and a pH of 6.0 to 8.0. The topsoil layer should have a minimum depth of 60 centimetres. Compaction of subsoil below the topsoil layer should be reversed through tilling, scarification or excavation and replacement to a minimum depth of 30 centimetres with some incorporation of the upper material to avoid stratified layers where feasible, to produce a total uncompacted soil depth of 90 centimetres.

Soil management best practice options to achieve these standards are described in Section 3.1 and stepwise instructions regarding how to implement each option on construction sites are provided in Section 5.2. Where feasible, tree pits should be designed to provide a minimum soil volume of 30 cubic metres (m^3) for single trees and 20 m^3 for trees with shared rooting zones (Casey Trees, 2008).

Example of a newly landscaped industrial/commercial property. Source: D. Young

3.0 Selecting Appropriate Soil Management Practices

3.1 Soil Management Best Practice Options

Different soil management best practices can be used to achieve standards for post-construction soil quality and depth and may be applicable on different areas of the same site. For example, soil that has been protected from disturbance and compaction during construction and already meets the quality and depth standards does not need to be restored. The most convenient and economical method for achieving post-construction soil quality and depth standards depends on:

- site soil conditions, grading, and resulting subsoil compaction;
- the practicality of stockpiling and preserving topsoil during grading; and
- site access issues.

Soil management best practice options for different areas of the site include:

Option 1: Leave existing vegetation and soil undisturbed, and protect from compaction and sediment accumulation during construction (i.e. protect existing vegetation and soil from disturbance).

- To the greatest extent possible and where required by municipal tree protection policies or natural heritage system delineations, existing tree, vegetation and soil protection areas should be surrounded by fencing and erosion and control practices to prevent disturbance from construction machinery or vehicle traffic, parking, storage of materials and accumulation of sediment from adjacent areas of disturbed soils.
- Existing tree, vegetation and soil protection areas should be delineated on Grading Plans, Erosion and Sediment Control Plans and Soil Management Plans and construction personnel should be educated about the locations and protective measures that must be maintained throughout the construction period.
- Protection areas for trees should at a minimum extend out from the outside edge of the trunk to at least a distance of 6 centimetres per centimetre of trunk diameter at breast height (City of Toronto, 2010). A higher level of protection is afforded by restricting access to the area one (1) metre beyond the drip line of the tree and is recommended where ever feasible.
- Protection areas for shrubs and herbaceous vegetation should extend out from the stem to encompass the full diameter of the plant (i.e. the area beneath the outermost leaves of the plant).
- If topsoil within the undisturbed tree protection area is compacted apply core aeration to improve soil permeability.
- If a duff layer (i.e. layer of decomposing leaves and woody debris and other organic matter) is no longer present within the undisturbed tree protection area, apply 2 to 3 centimetres of compost followed by 5 centimetres of mulch.

A high level of protection is afforded to existing trees to be retained on the site by restricting access to the area one metre beyond the drip line of the tree, as shown in this example, and is recommended where ever feasible. Source: D. Young

Option 2: Strip, stockpile and preserve topsoil during grading and replace and amend (if necessary) before planting.

- If the proposed site grading activities require that the existing topsoil be stripped and removed, and if the construction site has space for it, stockpile and preserve the existing topsoil during construction and replace it before planting (see Section 5.2.2). Stockpile and preserve topsoil stripped by the first pass of the equipment separately from subsequent passes and draw on these mounds when replacing topsoil in planting areas as it will likely be of the highest quality available from the site.
- Till or scarify subsoil prior to replacement of stockpiled site topsoil if testing indicates it is compacted (see Section 3.3).
- Stockpiled topsoil may need to be amended to meet the organic matter and depth requirements, either at a default rate or at a custom calculated rate based on soil tests.
- Recommended amendment rates will vary depending on what type of vegetation will be planted (i.e. turf area, planting bed or tree pit; see Section 2.3).
- If soil laboratory tests show that stockpiled topsoil from the site already meets the standards for organic matter content and pH, amendment with compost is not needed provided the mound height and length of time stockpiled meets the guidelines in Section 5.2.2.
- Stockpiled topsoil requiring amendment can be blended with compost on-site and replaced at the recommended depth as an alternative approach.

Option 3: Amend site subsoil in place.

- Till or scarify subsoil if testing indicates it is compacted (see Section 3.3).
- Amend at either the default rates, or at custom calculated rates based on soil tests.
- Recommended amendment rates will vary depending on what type of vegetation will be planted (i.e. turf area, planting bed or tree pit; see Section 2.3).

Option 4: Import a topsoil mixture of suitable soil texture, organic matter content, pH and depth to meet the standards.

- If the proposed site grading activities require that the existing topsoil be stripped and removed, and if the construction site does not have space for stockpiling, imported topsoil that meets municipal fill by-law requirements and contains suitable organic matter content and pH can be used to meet the soil quality and depth standards.
- Till or scarify subsoil prior to application of imported topsoil if testing indicates it is compacted (see Section 3.3).

3.2 Soil Testing

Selecting the most appropriate combination of soil management best practices to meet the post-construction soil quality and depth standards in the most economical way will require some soil testing, which can be done on site using simple to use testing equipment (see Section 3.2.2). Some testing such as pre-construction topsoil depth and quality and subsoil quality should be done prior to clearing and grading activities to help prepare the Soil Management Plan (SMP) while other testing, such as stockpiled site topsoil quality and subsoil compaction is optional and best done after grading and construction is largely completed, just prior to commencing landscaping.

Testing of pre-construction topsoil depth and quality over the site is recommended if such information is not already available from other sources (e.g. geotechnical investigations) as it can inform the depth to which the first pass of stripping equipment should go to produce the highest quality topsoil stockpile. It also provides insight into whether or not site topsoil will require compost amendment and enables calculation of a custom amendment rate which could require less compost than called for by the default rate, potentially saving some costs associated with purchasing and transporting compost to the site. Topsoil depths should be determined at a minimum of five (5) locations evenly distributed over the site from soil core samples or dug test holes to a depth slightly greater than the full extent of the topsoil layer, with one (1) additional location for every 4000 m^2 of site area. These observations should be used to calculate a mean topsoil depth over the site which should be used to guide the depth of stripping during the first pass of equipment. Similarly, sampling of pre-construction topsoil quality can be done at the same time and locations that depth determinations are done. Collect and combine topsoil samples from soil cores or dug test holes, mix thoroughly and subsample to produce a 600 gram composite sample. Composite samples should be stored in a sealed, labelled container and can remain at ambient temperature while being transported to the laboratory. A list of accredited soil testing laboratories in Ontario is provided in Appendix A1. Submit the composite sample to a soil testing laboratory for the following parameters at a minimum:

- Particle size distribution (i.e. % sand, silt and clay sized particles) and soil texture classification;
- Bulk density (results are only suitable for use in calculating a custom compost amendment rate, not for evaluating degree of compaction);
- Organic matter content (by dry weight); and
- Soil pH.

If knowledge of site subsoil texture classification is not available from other sources, samples should be collected, combined and subsampled in a similar manner as described above and submitted to a soil testing laboratory for the following parameters at a minimum;

- Particle size distribution (i.e. % sand, silt and clay sized particles) and soil texture classification.

Rather than testing pre-construction site topsoil quality, another option is to test stockpiled site topsoil quality prior to reapplication, although obtaining representative samples may be more difficult. Again this is optional, but recommended, as results can determine if soils already meet the quality standards and do not require amendment. It also enables calculation of a custom amendment rate. A composite sample should be submitted to a soil testing laboratory for the quality parameters noted above for pre-construction site topsoil.

Alternatively, to avoid the need for laboratory testing of soil samples, stockpiled site topsoil or site subsoil can be amended with compost at default rates, depending on the type of vegetation to be planted (Section 5.2) regardless of soil texture and organic matter content.

The following sections describe acceptable soil testing methods and criteria for determining if undisturbed soil, stockpiled site topsoil, amended soil or imported topsoil meets the post-construction soil quality and depth standards.

3.2.1 Texture

On sites where prior knowledge of the texture classification of the undisturbed soil or stockpiled topsoil is not already available, it is highly recommended that samples be taken and tested at a soil testing laboratory to determine the particle size distribution (i.e. % sand, silt and clay sized particles) which provides the information needed to determine a soil texture classification. Acceptable test methods for determining particle size distribution and soil texture classification include the most current version of ASTM D6913 - 04 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis (ASTM, 2009). Using the results from particle size distribution analysis, soil texture classification can be determined using the United States Department of Agriculture (USDA) Soil Texture Classification System (Figure 3.1).

While soil texture classification is not used in determining if the disturbed soil or stockpiled topsoil meets the soil quality and depth standards, it provides information needed to interpret soil compaction test results and to calculate custom amendment rates.

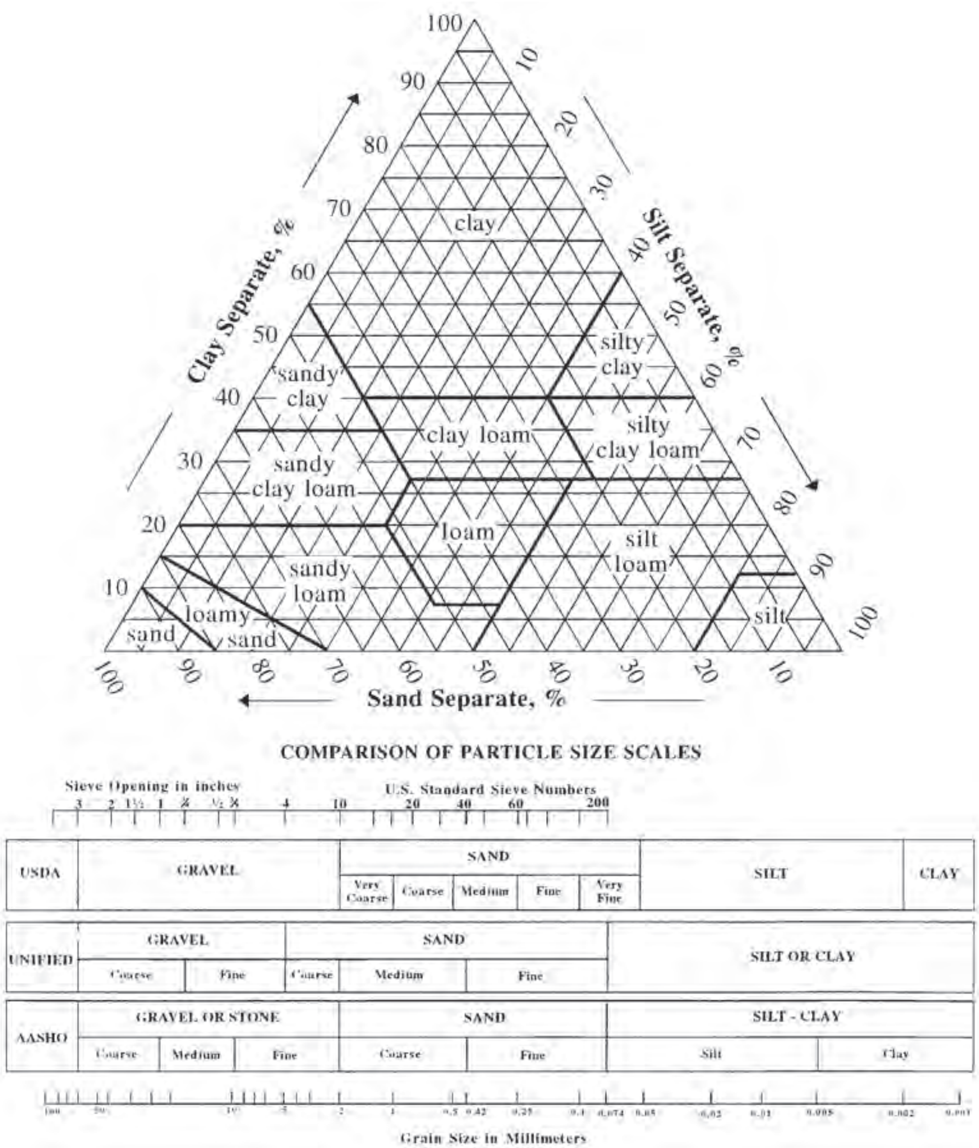


Figure 3.1 Soil Texture Classification Systems. Source: United States Department of Agriculture.

3.2.2 Compaction

Compaction testing is not required to develop a Soil Management Plan (SMP) as best management practice options could be based on what portions of the site will likely become compacted from construction activities. However, once grading and the majority of construction activities are completed, the opportunity exists to conduct compaction tests to confirm or refine the decompaction treatments prescribed in the SMP. Such testing could help limit the amount of tilling/subsoiling to only what is necessary to meet the recommended soil quality and depth standards.

If subsoil in the disturbed planting area will likely be (or has been) compacted through construction activities to a degree that limits root growth, steps should be taken to reverse compaction within the minimum total uncompacted soil depth recommended for the type of vegetation to be planted (Section 2.3). Several simple testing methods can be employed to determine if subsoils are compacted to the extent that will inhibit penetration of plant roots.

Cone Penetration Test

The cone penetration test (CPT) is an in situ testing method used to determine geotechnical engineering properties of soils and delineate soil stratigraphy. The CPT is one of the most used and accepted in situ test methods for soil investigation worldwide (CEMML, 2004). Cone penetration tests involve simple mechanical measurements of the total penetration resistance to pushing an instrument with a conical tip into the soil at a controlled rate (usually 2 centimetres per second). The instrument used to conduct the measurement is called a cone penetrometer. Readings depend on cone properties (angle and size) and soil properties (e.g., bulk density, texture, and soil moisture) (ASAEb,1999; Herrick and Jones, 2002). As cone penetrometer readings are strongly related to soil moisture, measurements should be taken within 24 hours after a heavy rainfall event (i.e. 15 millimetres total depth or greater in 24 hours) or when soils are at or near field capacity (i.e. fully wetted to the depth of interest with no ponding). There are two general types of hand-held cone penetrometers: static penetrometers and dynamic penetrometers (Figure 3.2). Both measure soil resistance to vertical penetration of a probe or cone of standard dimension and slope angle. The distinction between the two penetrometers lies in how force is applied to the cone.

Static cone penetrometers measure the force required to push a metal cone through the soil at a constant velocity (Figure 3.2). The force is usually measured by a load cell or strain gauge (e.g., proving ring) coupled with an analog dial or pressure transducer for readout (Herrick and Jones, 2002). The force is commonly expressed in kilopascals (kPa), an index of soil strength referred to as the cone index (ASAEa, 1999), or as surface resistance in kilograms per square centimetre (kg/cm^2) or pounds per square inch (PSI). As the operator pushes down on the penetrometer, the note keeper records values for each depth increment to evaluate the degree, depth, and thickness of compacted layers. Only enough pressure to advance the cone into the soil at a consistent rate of about 2 centimetres per second should be applied to the penetrometer during each reading. A static cone penetrometer with a 30 degree cone has been recommended by the American Society of Agricultural Engineers (ASAE) as the standard measuring device for characterizing the penetration resistance of soils (ASAEa, 1999). Acceptable test methods for cone penetration tests using a static cone penetrometer include the most current version of ASTM D3441 Standard Test Method for Mechanical Cone Penetration Test of Soils (ASTM International, 2005).

Dynamic cone penetrometers (DCPs) apply a known amount of kinetic energy to the cone, which causes the penetrometer to move a distance through the soil (Herrick and Jones, 2002). Dynamic penetrometers do not rely on constant penetration velocity, as most dynamic penetrometers use a slide hammer of fixed mass and drop height to apply consistent energy with each blow (Figure 3.2). Either the number of blows required to penetrate a specified depth, or the depth of penetration per blow are measured, and results can be calculated as a cone index. Soil resistance for each soil depth interval is calculated using standard equations that account for differences in hammer drop distance, weight, and cone size. Acceptable test methods for cone penetration tests using a dynamic cone penetrometer include the most current version of ASTM D7380-08 Standard Test Method for Soil Compaction Determination at Shallow Depths Using 5-lb (2.3 kg) Dynamic Cone Penetrometer (ASTM International, 2008).

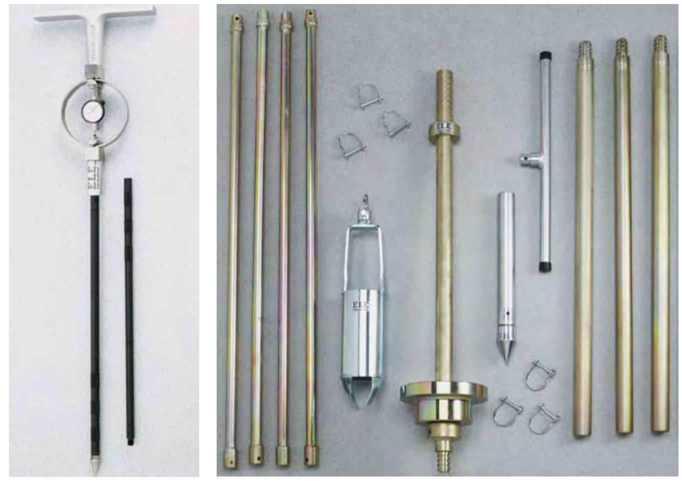


Figure 3.2 Examples of Static and Dynamic Cone Penetrometers Source: ELE International

Figure 3.3 Cone penetration testing with static and dynamic cone penetrometers. Sources: DGSI

Cone penetrometers maximum surface resistance readings should be taken between the soil surface to the minimum total uncompacted soil depth recommended for the type of vegetation to be planted (see Section 2.3). Readings should be taken within 24 hours after a heavy rainfall event (i.e. 15 millimetres total depth or greater in 24 hours) with at least five (5) readings taken per planting area and an additional reading for every 400 square metres of planting area. Maximum readings that exceed the values described in Table 3.1 indicate that soils have been compacted to a degree that limits root growth. If 50% or greater of penetrometer maximum surface resistance readings exceed the values described in Table 3.1, steps should be taken to reverse soil compaction down to the depths recommended for each soil management best practice option and variant as described in section 5.2. Compaction can be reversed through techniques such as tilling with a rototiller, scarifying with a subsoiler, chisel plow or backhoe, or excavation and replacement with uncompacted soil (see Section 5.1).

Table 3.1 Acceptable Cone Penetrometer Readings by Dominant Soil Texture

SURFACE RESISTANCE	SUB-SURFACE RESISTANCE		
All soil textures	Sandy (includes loamy sand, sandy loam, sandy clay loam and sandy clay)	Silty (includes loam, silty loam, silty clay loam, and silty clay	Clayey (includes clay loam)
≤ 110 PSI	≤ 260 PSI	≤ 260 PSI	≤ 225 PSI
≤ 7.7 kg/cm^2	≤ 18.3 kg/cm^2	≤ 18.3 kg/cm^2	≤ 15.8 kg/cm^2
≤ 758 kPa	≤ 1793 kPa	≤ 1793 kPa	≤ 1551 kPa

Source: Adapted from Gugino et al. (2007).

Notes:

1. PSI = pounds per square inch (lb/in^2)
2. kg/cm^2 = kilogram per square centimetre
3. kPa = kilopascal

BULK DENSITY

A more expensive but more accurate test of soil compaction is to take soil cores and send them intact to a soil testing laboratory for analysis of bulk density and grain size distribution (i.e., % sand, silt and clay sized particles). Bulk density is determined by dividing the dry weight of a known volume of soil by the volume. The bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction. Bulk density is not an intrinsic property of a soil as it can change depending on how the sample is handled. For example, if a soil core sample is disassociated through agitation during transport, this changes the bulk density of the sample. Therefore, to accurately determine bulk density from soil sampling, soil cores must be delivered to the laboratory intact. Acceptable methods for determining soil bulk density include ASTM D4564 Standard Test Method for Density and Unit Weight of Soil in Place by the Sleeve Method (ASTM International 2008b), ASTM D2167 Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method (ASTM International, 2008a) or ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil Aggregate by Nuclear Methods (ASTM International, 2010).

Five (5) soil cores should be collected for each type of planting area and one additional core should be collected for every 400 square metres of each type of planting area. Samples must be taken from the soils in place in the disturbed planting area after all grading operations have been completed and before placement of imported topsoil or addition of amendments. Figure 3.3 describes the relationship between grain size distribution and Maximum Allowable Bulk Density. Maximum Allowable Bulk Densities are based on 95% of the bulk density value at which growth limitations are expected for an average range of plant material (Daddow and Warrington, 1983). To calculate the maximum allowable bulk density for a soil:

1. Obtain a laboratory analysis of the grain size distribution (% sand, silt and clay);
2. Sketch a parallel line for each percentage along the appropriate axis, and;
3. At the point of intersection, interpolate a value between the isodensity lines.

If bulk density testing of soil cores at 50% or greater of sampling locations for each type of planting area exceed the Maximum Allowable Bulk Density values shown on Figure 3.3, steps should be taken to reverse soil compaction down to the depths recommended for each soil management best practice option and variant as described in section 5.2. Compaction can be reversed through techniques such as tilling with a rototiller, scarifying with a subsoiler, chisel plow or backhoe, or excavation and replacement with uncompacted soil (see Section 5.1).

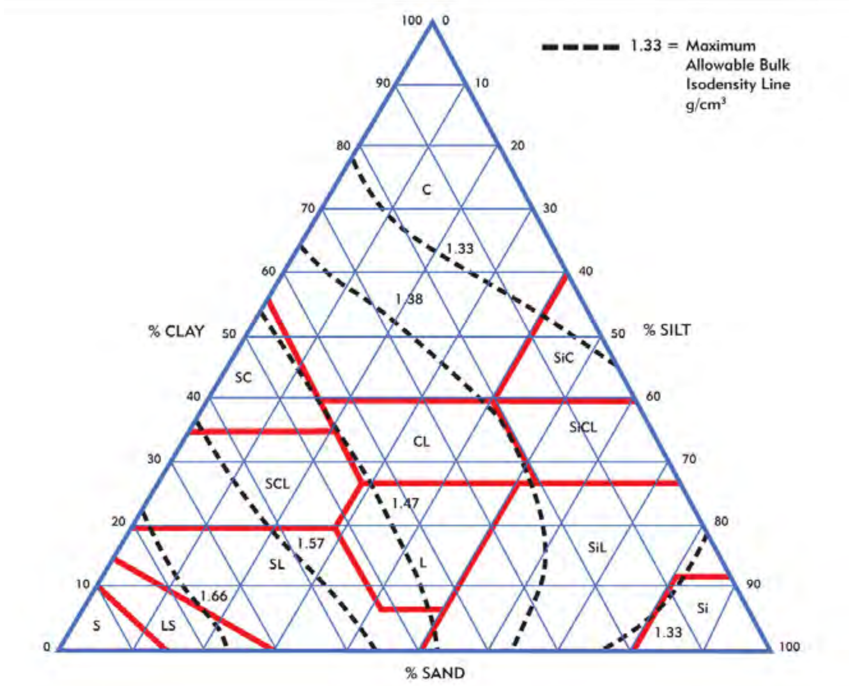


Figure 3.4 Maximum Allowable Bulk Densities. Source: The Sustainable Sites Initiative

3.2.3 Organic Matter Content

Organic matter is matter that has come from a once-living organism; is capable of decay, or the product of decay; or is composed of organic compounds. Organic matter in soil is derived from plants and animals. When it decays to the point at which it is no longer recognizable it is called soil organic matter. When the organic matter has broken down into a stable substance that resists further decomposition it is called humus. Soil organic matter comprises all of the organic matter in the soil, exclusive of the material that has not decayed (e.g., surface litter). It can be divided into three general pools (Figure 3.4): living biomass of microorganisms, fresh and partially decomposed residues (the active fraction), and the well-decomposed and highly stable organic material (USDA, 2011a).

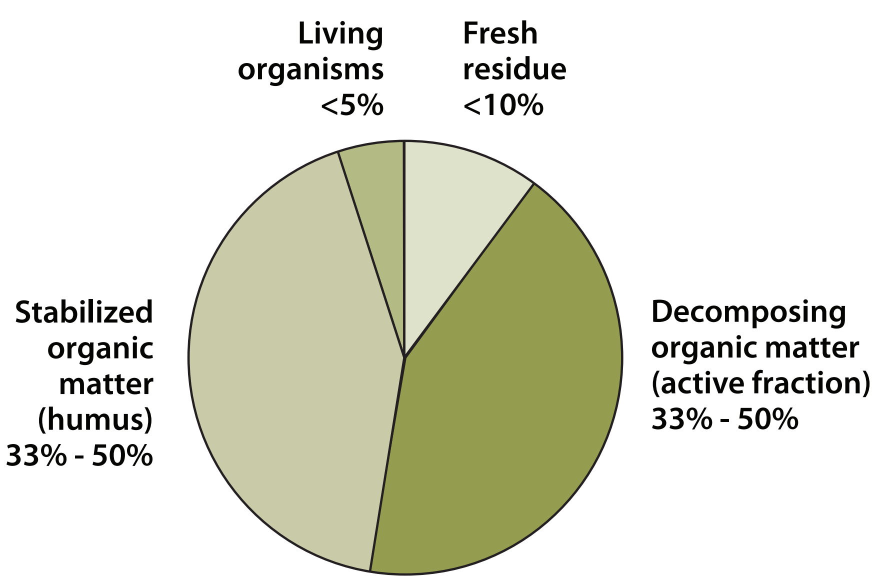


Figure 3.5 Components of soil organic matter. Source: USDA

To determine if the disturbed, stockpiled or amended soil meets the standard for organic matter content (see Section 2.3), samples should be collected and tested by a soil testing laboratory. Acceptable test methods for determining soil organic matter content include the most current version of ASTM D2974 Test Methods for Moisture, Ash and Organic Matter of Peat and Other Organic Soils (ASTM International, 2007a) and the Loss-On-Ignition Organic Matter Method TMECC 05.07A (USDA & USCC, 2002). The Loss-On-Ignition Organic Matter Method involves ignition and ashing a five (5) gram scoop of the soil sample at 360°C for two (2) hours in a muffle furnace. The loss by weight of the sample during this ignition is calculated as the organic matter content with results reported as percent organic matter by dry sample weight.

3.2.4 Soil pH

Soil pH is a measure of the acidity or basicity in soils. Soil pH ranges from 0 to 14, with 7 being neutral. A pH below 7 is acidic and above 7 is basic. Soil pH is considered a master variable in soil management as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of nutrients. The optimum pH range for most plants is between 6.0 and 8.0.

To determine if the disturbed, stockpiled or amended topsoil meets the standard for pH, samples must be collected and tested for pH. Soil pH can be determined in the field using inexpensive soil pH testing kits (Figure 3.5) where in a small sample of soil is mixed with water and reagents which change colour according to the acidity/alkalinity. The soil pH value is determined by comparing the colour and shade to calibrated scales. Soil pH can also be determined using a portable pH meter (Figure 3.5) which involves inserting a rod into moistened soil. Such soil pH tests should be conducted by creating a shallow (5 to 10 centimetre deep) hole in the soil and filling it up with distilled water to create a slurry mixture of soil and water, inserting the pH meter rod into the slurry mixture and recording the value displayed on the meter. Alternatively, samples can be submitted to a soil testing laboratory. An acceptable method for testing soil pH includes the latest version of ASTM D4972 - 01 Standard Test Method for pH of Soils (ASTM International, 2007b).

Figure 3.6 Examples of soil pH testing equipment

Clockwise from upper left: Soil pH test kit (Source: Luster Leaf Products); Soil pH meter (Source: Houston Gardening); Twin soil pH and moisture meter (Source: Biostim); Soil pH probe and meter (Source: Left Coast Hydroponics)

If testing indicates that the pH of the disturbed soil, stockpiled topsoil or amended topsoil is outside the acceptable range specified in the soil quality and depth standards (6.0 to 8.0), amendments should be added to bring the soil pH into the acceptable range of values. If the soil is too basic (i.e. pH greater than 8.0) compost should be added at a custom calculated rate determined by a qualified professional. If the soil is too acidic (i.e. pH less than 6.0) lime should be added at a rate of 24.4 to 48.8 kilograms per 100 square metres (Chollak and Rosenfeld, 1998) or a rate specified by a qualified professional and incorporated into the topsoil to the same depth as any compost amendments applied. Qualified professionals include certified Agronomists, Soil Scientists or Crop Advisors; and licensed Landscape Architects, Civil Engineers or Geologists

4.0 Soil Management Plans

4.1 Developing a Soil Management Plan (SMP)

To demonstrate how the post-construction soil quality and depth standards will be met in all disturbed planting areas of a construction site, a Soil Management Plan (SMP) should be prepared. The SMP should be prepared by the landscaping designer or installer and submitted as part of the clearing and grading or construction permit application documents, where required. The SMP should include at a minimum:

- A scale-drawing of the construction site (11 x 17" or larger) identifying areas where existing trees, vegetation and soil will be retained undisturbed and where other soil management best practice options will be applied in disturbed soil areas to be planted (i.e. areas to be landscaped).
- A completed Soil Management Plan Form (see Appendix A2) identifying treatments and products to be used to meet the post-construction soil quality and depth standards for each planting area.
- Calculations of compost or topsoil volumes to be imported (and/or stockpiled topsoil from the site) to meet default amendment rates; or calculations by a qualified professional to meet the soil quality and depth standards if using custom calculated rates.
- Copies of laboratory analyses for pre-construction topsoil quality over the site (optional) and compost and imported topsoil products to be used (required), documenting particle size distribution, bulk density, organic matter content, pH, how the compost to be used meets the most up-to-date Ontario guidelines for the use of compost as a soil conditioner (e.g. OMOE, 2004) and how any imported topsoil to be used meets the post-construction soil quality standards (Section 2.3) and any other topsoil or fill quality requirements specific to the municipality or Conservation Authority.

4.2 Stepwise Procedures for Developing a Soil Management Plan

Step 1: Review Site Grading and Landscaping Plans.
Examine all areas to be landscaped that will not be covered by impervious surfaces, incorporated into a drainage facility, nor engineered as structural fill or slope to understand how grading would likely impact soil conditions and determine areas where the following soil management best practice options may be applied:

Option 1: Leave existing vegetation and soil undisturbed, and protect from compaction and sediment accumulation during construction (i.e. protect existing vegetation and soil).

Option 2: Strip, stockpile and preserve topsoil during grading and replace and amend (if necessary) before planting.

Option 3: Amend site subsoil in place.

Option 4: Import a topsoil mixture of suitable soil texture, organic matter content, pH and depth to meet the standards.

Step 2: Visit Site to Determine Soil Conditions
Guided by site grading and landscaping plans, visit the site and assess pre-construction topsoil depth and quality conditions (quality testing is optional) across the site or confirm available information is accurate. At a minimum, information on the depth of topsoil (i.e. soil horizon A) over the site is needed to guide stripping activities so that the highest quality topsoil is obtained in the first pass of stripping equipment. Topsoil depth can easily be estimated through examination of soil core samples or test holes distributed evenly over the site. While testing of pre-construction topsoil quality is optional, it is recommended as it provides some insight into whether or not stockpiled and preserved topsoil from the site will require compost amendment to meet the post-construction soil quality and depth standards.

If information characterizing pre-construction topsoil depth and quality on the site is not already available from geotechnical investigations completed as part of planning and design of the development, it is recommended that soil core samples be collected down to 30 centimetres depth or a depth slightly greater than the full extent of the topsoil layer. To characterize pre-construction topsoil conditions, a minimum of five (5) soil core sample should be taken or test holes dug, distributed evenly, with an additional sample taken for every 4000 square metres of the construction site (Soils for Salmon, 2010). Each soil core should be examined to determine the depth of topsoil (i.e. soil horizon A) present with values recorded and used to calculate an average depth of topsoil over the site. Topsoil portions of each soil core sample should be combined together into a large bucket, crushed, thoroughly mixed and subsampled to produce a 600 gram composite sample that is representative of pre-construction topsoil quality conditions across the site. The composite sample should be stored in a sealed, labelled container and can remain at ambient temperature while being transported to a soil testing laboratory. Soil tests that should be completed on the composite topsoil sample at a minimum are as follows:

- Particle size distribution and soil texture classification;
- Bulk density (NB: results are only suitable for use in calculating a custom compost amendment rate, NOT for determining if the degree of compaction limits root growth);
- Organic matter content (by dry weight);
- Soil pH.

Information collected during the site visit should be used to produce the information described in Table 4.1, which should be included in the Soil Management Plan form or drawing(s).

Table 4.1 Site Soil Conditions to be Determined and Recorded on the Soil Management Plan (SMP)

TYPE OF AREA	SITE ASSESSMENT TASKS	INFORMATION TO BE INCLUDED ON SMP
Whole construction site	• Assess topsoil depth over the construction site through soil core sampling or test holes; • Assess or confirm topsoil quality over the construction site through soil core sampling and laboratory testing (optional).	• Average pre-construction topsoil depth over the construction site to guide the depth of topsoil stripping activities; • Characterization of pre-construction topsoil quality to provide insight into whether or not it will require amendment to meet the recommended standards (optional);
Existing trees, vegetation and soil protection areas to remain in an undisturbed state.	• Identify locations of existing trees, vegetation to be retained and the extent of the areas to be protected from disturbance (Section 3.2). • Determine suitable means of preventing disturbance and accumulation of sediment (e.g., construction fencing and/or erosion and sediment control practices)	• Delineate the existing vegetation and soil protection areas to be left undisturbed. • Indicate practices to be implemented to prevent disturbance and accumulation of sediment during construction.
Topsoil not requiring grading, but to be cleared of vegetation	• Check soil pH is between 6.0 and 8.0 by onsite testing (see Section 3.2.4). • (Optional) Sample topsoil to minimum topsoil depth recommended for the type of vegetation to be planted (Section 2.3) and submit for laboratory testing of particle size distribution, organic matter content and soil pH (if not tested in field).	• Indicate areas that can be protected from further disturbance and sediment accumulation during construction (Option 1) and recommended practices. • Indicate where steps to reverse soil compaction will likely be needed and recommended depths (Section 2.3) and procedures (e.g., tilling, scarifying, excavation and replacement; see Section 5.1). • If laboratory testing of soil samples is undertaken, test results should be used to indicate areas where topsoil needs to be amended (Section 2.3). • Indicate areas where topsoil depth will be increased using stockpiled topsoil, amendment rate (if necessary – Option 2) and quantities needed;

Areas to be cut during grading	• Determine suitable locations for stockpiling and preserving stripped topsoil. • Determine quantity of topsoil that can be stockpiled and re-applied. • Determine areas likely to be compacted through grading activities, construction machinery and vehicular traffic/parking and building material and topsoil storage.	• Indicate where steps to reverse soil compaction will likely be needed and recommended depths (Section 2.3) and procedures (e.g., tilling, scarifying, excavation and replacement; see Section 5.1). • Indicate areas where stripped topsoil will be stockpiled and preserved. • Indicate areas where stockpiled topsoil will be replaced and amended at default or custom calculated rates (Option 2) and quantities needed; • Indicate areas where subsoils will be amended in place with compost at default or custom calculated rates (Option 3). • Indicate areas where imported topsoil will be placed (Option 4) and quantities needed.
Areas to be filled during grading	• Estimate what subgrade conditions will be when fill is in place. • Determine areas likely to be compacted through grading activities, construction machinery and vehicular traffic/parking and building material and topsoil storage.	• Indicate where steps to reverse soil compaction will be needed and recommended depths (Section 2.3) and procedures e.g., tilling, scarifying, excavation and replacement; see Section 5.1). • Indicate areas where stockpiled topsoil will be replaced and amended at default or custom calculated rates (Option 2) and quantities needed; • Indicate areas where subsoils will be amended in place with compost (Option 3) at default or custom calculated rates. • Indicate areas where imported topsoil will be placed (Option 4) and quantities needed.

Step 3. Select Soil Management Best Practice Options

The most convenient and economical method for achieving the post-construction soil quality and depth standards depends on site soil conditions after grading and construction activities are completed and the resulting degree of subsoil compaction, the practicality of stockpiling and preserving topsoil during grading and construction, and site access issues (e.g. size and accessibility of planting areas affects the type of equipment that can be used to restore soils).

In selecting soil management best practice options to be applied, the following decision making approach is recommended to minimize costs:

1. Apply Option 1 where required by tree preservation bylaws or natural heritage system delineations and to the greatest extent feasible over other portions of the construction site to minimize the extent of disturbed soil areas;

2. Apply Option 2 at a custom calculated amendment rate to reuse existing site topsoil to the greatest extent feasible and to minimize amendment requirements;

3. Apply Option 2 at the default amendment rate to reuse existing site topsoil to the greatest extent possible and to avoid sampling and testing of the unamended site topsoil,

4. Apply Option 3 at custom calculated amendment rate to avoid the cost of importing topsoil and to minimize amendment requirements;

5. Apply Option 3 at the default amendment rate to avoid the cost of importing topsoil and sampling and testing of the unamended subsoil.

6. Apply Option 4 if all other options are infeasible or not preferred as this option will likely be the most expensive for large planting sites, but may be preferable to other options for smaller planting areas.

Use of default amendment rates may simplify planning. However, testing stockpiled site topsoil quality to enable calculation of a custom amendment rate could save substantial effort and expense in some cases - easily repaying the expense of soil laboratory testing and calculations (Soils for Salmon, 2010). Often pasture or woodland soils have adequate organic matter if existing topsoil is carefully stripped and preserved during grading and construction activities (see Section 5.2.2). Furthermore, compost will frequently provide the required soil organic matter content at lower application rates than the default rates, which are based on average conditions.

It is highly recommended to test subsoil compaction in planting areas prior to their construction at the end of grading and other construction activities, to confirm or refine the treatments prescribed in the SMP. This step can help avoid missing highly compacted areas in need of decompaction treatment and can help identify locations where such treatments are not actually required.

As a tool to assist urban and landscape designers in selecting and implementing appropriate soil management best practice options, a decision-tree diagram is provided in Appendix A3.

As indicated in Table 4.1, identify where each soil management best practice option (i.e., Option 1, Option 2, Option 3, Option 4) will be applied by outlining each area on the Soil Management Plan drawing(s). Indications should also be made regarding what type of vegetation will be planted (i.e. turf area, planting bed or tree pit), what soil decompaction treatment is proposed (if any) and what compost amendment rate will be applied (i.e. default or a custom amendment rate). Assign each planting area a unique identification number or letter on the Soil Management Plan drawing(s), and on the Soil Management Plan form that describes the type of planting area, the best practice option and variant to be implemented (e.g. Turf Area 1 – Option 2 with scarifying and custom rate; Planting Bed 1 - Option 2 with tilling and default rate; etc.).

4.3 Construction Permit Submission Documents

In jurisdictions where post-construction soil quality and depth standards are implemented as requirements for construction permitting, the Soil Management Plan and drawing(s) should be prepared and submitted to the permitting agency as part of the clearing and grading, fill placement or construction permit application prior to undertaking any clearing, topsoil stripping and grading. Areas where soil management best practice Option 1 (Leave existing vegetation and soil undisturbed) will be implemented, as well as locations where stripped topsoil will be stored must be represented on Grading, Erosion and Sediment Control and/or Site Plans, as well as measures to be put in place to prevent disturbance and accumulation of sediment from drainage from adjacent disturbed soil areas.

5.0 Implementing the Soil Management Plan

5.1 Materials and Equipment

Amendment Materials
Amendment of soils at default or custom calculated rates must use compost that meets the quality specifications described in the Ontario Ministry of the Environment (OMOE) Guidelines for the Production and Use of Aerobic Compost in Ontario (2004) for metals, organic chemicals, non-biodegradable particulate matter, and stability. Compost should only be accepted from Compost Quality Assurance (CQA) licensed and OMOE approved compost production facilities. Compost should also contain at least 30% organic matter by dry weight (OMOE, 2004). The OMOE compost quality criteria are derived from the 1996 Canadian Council of Ministers of the Environment's Guidelines for Compost Quality for Category "A" compost, which can be used in any application (i.e. unrestricted use), such as on agricultural lands, residential gardens, horticultural operations, the nursery industry, and other businesses. The CCME has subsequently updated their guidelines (2005) and OMOE are in the process of revising Ontario guidelines (2009). At such time that revised Ontario guidelines for compost quality are finalized, compost used to amend soils to meet the post-construction quality and depth standards should meet the updated OMOE quality criteria for compost suitable for unrestricted use as a soil conditioner. Use of uncomposted manure or other uncomposted organic materials, sphagnum peat or organic amendments that contain sphagnum peat is not recommended.

If topsoil will be imported to meet the post-construction soil quality and depth standards, documentation must be provided from the supplier describing, at a minimum, the organic matter content (by dry weight), and soil pH of the product. Suppliers should also provide documentation regarding the typical particle size distribution (% sand, silt and clay sized particles), soil texture classification and bulk density of the product also. Soil texture should be appropriate to support the type of vegetation to be planted. Topsoil with a particle size distribution that classifies it as a loam would be suitable in most cases. Any compost used in producing the topsoil blend must meet OMOE compost quality criteria (2004 or most recent update).

Mulch should not contain seeds or fragments of invasive species. Do not use uncomposted duff material from vegetation clearing. Mulch products should be derived from shredded trees or bark or wood shavings from untreated lumber.

Equipment
Types of equipment needed for implementing the soil management best practices described in this guide will depend on the BMP option and whether or not decompaction treatment is required, but includes the following:

1. Decompacting subsoil (e.g., tilling, scarifying, excavating and replacement)
2. Transporting and spreading topsoil, compost and mulch
3. Incorporating compost into topsoil or subsoil

More specific specification of equipment (e.g. size, weight) must be determined on a site by site basis, considering the size and accessibility of each planting area to be restored and the total area of each BMP/planting area type on the site. Ideally, all tracked or rubber tired equipment should be low ground pressure (LGP) rated to minimize the degree to which soils to be restored are compacted further through the process of applying the BMPs. The following sections provide examples of equipment appropriate for both small and large scale applications.

Decompacting subsoil

For small planting areas, decompacting subsoil could most economically be accomplished with equipment typically used for construction of landscaped areas (e.g. small backhoe to excavate, decompact and replace subsoil). A rototiller of appropriate size would also be suitable (Figure 5.1) and, if amendment is planned, could also be used for incorporating compost into topsoil or subsoil. On large planting areas, scarifying compacted subsoils to recommended depths could be accomplished using a tracked or rubber tired LGP rated excavator with a subsoiler or chisel plow (Figure 5.2). Compacted subsoils should be scarified in a direction perpendicular to slope where feasible.

From left to right: Walking rototiller (Source: MTD Products Ltd.); ATV pulling a rototiller (Source: Amazing Machinery); LGP rated tractor with rototiller (Source:Superior Tractor Services).

Figure 5.1 Examples of rototilling equipment appropriate for decompacting subsoil.

Transporting and spreading topsoil, compost and mulch

For both small and large planting areas, transporting of material could most economically be accomplished with equipment typically used for construction of landscaped areas. Tracked equipment (LGP rated) such as trim dozers or tracked skid steers (Figure 5.2) would be appropriate for transporting materials and a small excavator would be appropriate for spreading them. For large planting area, if the planting area is in close proximity to a road, a slinger truck could be used to transport and spread topsoil and a blower truck could be used for compost.

From left to right: Chisel plow (Source: J. Balousek); Subsoiler with roller (Source: Agrional); LGP rated tractor with subsoiler (Source: TRCA).

Figure 5.2 Examples of subsoiling equipment appropriate for decompacting subsoil

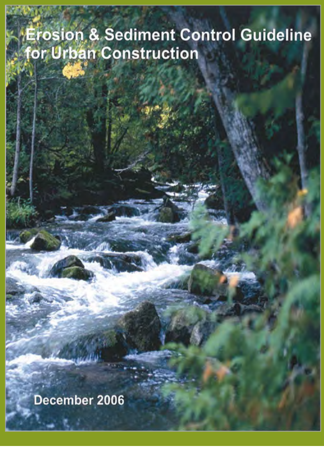
Incorporating compost into topsoil or subsoil

For small planting areas, compost incorporation could most economically be accomplished using a rototiller (Figure 5.1) or a LGP rated excavator to mix the layers to the recommended topsoil depth. For large planting areas or sites (e.g., entire subdivisions of planting areas) it may be more economical to blend stockpiled site topsoil with compost on-site using LGP rated excavators, skid steers or other equipment typically used for soil blending.

5.2 Stepwise Procedures

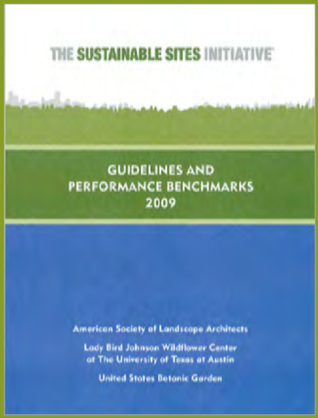
5.2.1 Option 1 – Protect Existing Vegetation and Soil From Disturbance

Portions of the site where existing trees or vegetation are to remain in place, leave native soil undisturbed to the extent prescribed by municipal tree preservation by-laws or natural heritage system delineations. The existing vegetation and soil should be protected from disturbance and compaction by construction machinery and vehicle traffic/parking, storage of construction materials and stockpiled topsoil and sediment accumulation from drainage of surrounding disturbed soil areas using fencing and erosion and sediment control practices (e.g. silt fencing or compost sock filters). Further guidance regarding appropriate construction traffic and erosion and sediment control practices for preventing disturbance of existing vegetation and soil areas to be retained can be found in the Greater Golden Horseshoe Area Conservation Authorities Erosion and Sediment Control Guidelines for Urban Construction (GGHACA, 2008) and municipal tree protection policies (e.g. City of Toronto, 2010). Protection areas for trees should extend out from the trunk to a distance of at least 6 centimetres per centimetre of trunk diameter at breast height (City of Toronto, 2010). A higher level of protection is afforded by restricting access to the area one (1) metre beyond the drip line of the tree and is recommended where ever feasible. Protection areas for shrubs and herbaceous vegetation should extend out from the stem to encompass the full diameter of the plant (The Sustainable Site Initiative, 2009).



The Erosion and Sediment Control Guideline for Urban Construction was created with regard for the principles and guidelines that best suit the Greater Golden Horseshoe Area (GGHA) Conservation Authorities. It outlines a consistent and improved approach to erosion and sediment control on construction sites in the GGHA and provides practitioners with greater certainty in the application of such controls.

The Sustainable Sites Initiative™ (SITES™) is an interdisciplinary effort by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at The University of Texas at Austin and the United States Botanic Garden to create voluntary national guidelines and performance benchmarks for sustainable land design, construction and maintenance practices. The Guidelines and Performance Benchmarks 2009 report describes criteria for sustainable practices and focuses on measuring and rewarding projects that protect, restore and regenerate ecosystem services.



If topsoil within the undisturbed tree protection area is compacted apply core aeration to improve soil permeability. If a 5 to 10 centimetre deep duff layer (i.e. layer of decomposing leaves and woody debris and other organic matter) is no longer present within the undisturbed tree protection area, apply 2 to 3 centimetres of compost followed by 5 centimetres of mulch.

5.2.2 Option 2 – Strip, Stockpile, Preserve, Replace and Amend Site Topsoil

STRIPPING, STOCKPILING AND PRESERVING SITE TOPSOIL

General environmental stewardship practices for earthwork and soil management recommended by the American Association of State Highway and Transportation Officials (AASHTO) Center for Environmental Excellence should be considered (AASHTO, 2011). Regarding stockpiling and preserving topsoil the following best practices should be implemented (adapted from AASHTO, 2011):

- Plant material and leaf litter generated by clearing the construction site of vegetation should be stockpiled separately from site topsoil. Large woody material (branches or trunks of 30 centimetres diameter or greater should be separated and set aside for use on natural heritage restoration sites. Remaining plant material and leaf litter should be used as an organic material source for composting operations.

- Information regarding pre-construction topsoil depth (i.e. soil horizon A) over the construction site should be used to guide the depth to which topsoil is stripped to minimize incorporation of subsoil in stockpiles.

- Soil stripped during the first pass of equipment should be placed into topsoil stockpiles at locations designated on the Grading and Erosion and Sediment Control Plans.

- When stockpiling topsoil, mound soil no higher than 1.3 metres (4 feet) high for less than one (1) year and preferably less than six (6) months (AASHTO, 2011), where feasible. Cover with tarps or woven geotextile material to prevent soil erosion and contamination by weeds during storage. Alternatively, topsoil stockpiles can be stabilized by temporarily establishing groundcover vegetation composed of non-invasive species (see OIPC, 2011 for list of suitable groundcovers) either by application of seeded compost or seeded biodegradable mats. To help keep topsoil stockpiles contained, mounds should be completely surrounded by erosion and sediment control fencing or compost filter socks.

- Where space limitations necessitate higher mounds, topsoil stockpile mound height should not exceed three (3) metres where feasible (AASHTO, 2011).

- Stockpiling topsoil will result in the disruption and partial loss of beneficial soil organisms, and if stockpiled in mounds over 1.3 metres in height over a length of time greater than six (6) months, may result in total loss of soil organisms. When reapplying stockpiled topsoil from mounds of 1.3 metres in height or less, the top 30 centimetres of the mound should be mixed with the remainder of the stockpile to help distribute living soil organisms throughout the topsoil material (AASHTO, 2011). Topsoil stockpiled in mounds greater than 1.3 metres in height for longer than six (6) months should be amended with compost to re-establish healthy soil structure and help restore soil organism populations;

- If custom calculated amendment rates are to be applied, a representative sample of the stockpiled topsoil should be obtained and submitted to a soil testing laboratory for bulk density and organic matter content analysis at a minimum.

Topsoil stockpiles should be kept between 1.3 to 3 metres in height and mixed prior to reapplication to help distribute living soil organisms in the top 30 centimetres throughout the stockpile. Source: D. Young

REPLACING AND AMENDING STOCKPILED SITE TOPSOIL

Replacing stockpiled topsoil and any soil amendments to meet the post-construction quality and depth standards should be undertaken when all grading activities are finished and near the end of construction, when landscaping work is typically scheduled. Site conditions should be dry (i.e. not raining), not frozen and soil should be well drained when incorporating compost. Stepwise instructions for best practice Option 2 will vary depending on the type of vegetation to be planted and whether default or custom calculated amendment rates will be applied. The following provides guidance on the sequential steps to follow for each type of planting area.

TURF AREAS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 10 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil to a depth of at least 10 centimetres (till or scarify in a direction perpendicular to ground slope to the extent possible).

3. If laboratory testing of stockpiled site topsoil indicates it already meets the post- construction soil quality standards and any municipal or CA topsoil/fill quality requirements, apply 20 centimetres of uncompacted site topsoil to the planting area.

4. If applying the default amendment rate, apply 15 centimetres of stockpiled topsoil followed by five (5) centimetres of compost and incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres. Alternatively, stockpiled site topsoil could be mechanically mixed on-site with compost at a ratio of 3:1 topsoil to compost by volume, and applied to a settled amended topsoil depth of 20 centimetres.

5. If applying a custom amendment rate, apply the depths of stockpiled topsoil and compost calculated using the Custom Compost Application Rate Calculation (Appendix A4) or Topsoil and Soil Amendment Calculator spreadsheet tool (www.sustainabletechnologies.ca) that is required to achieve a final topsoil containing 5 to 10% organic matter content. Incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres. Alternatively, stockpiled site topsoil could be mechanically mixed on-site with compost at the custom amendment ratio by volume, and applied to a settled amended topsoil depth of 20 centimetres.

6. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

Topsoil being reapplied to a construction site with a tracked low ground pressure (LGP) bulldozer. Source: D. Young

PLANTING BEDS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 10 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil to a depth of at least 10 centimetres (till or scarify in a direction perpendicular to ground slope to the extent possible).

3. If laboratory testing of stockpiled site topsoil indicates it already meets the post-construction soil quality standards, apply 20 centimetres of uncompacted topsoil to the planting area.

4. If applying the default amendment rate, apply 13 centimetres of stockpiled topsoil followed by 7 centimetres of compost and incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres. Alternatively, stockpiled site topsoil could be mechanically mixed on-site with compost at a ratio of 2:1 topsoil to compost by volume, and applied to a settled amended topsoil depth of 20 centimetres.

5. If applying a custom amendment rate, apply the depths of stockpiled topsoil and compost calculated using the Custom Compost Application Rate Calculation (Appendix A4) or Topsoil and Soil Amendment Calculator spreadsheet tool (www.sustainabletechnologies.ca) that is required to achieve a final topsoil containing 10 to 15% organic matter content and a pH of 6.0 to 8.0. Incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres. Alternatively, stockpiled site topsoil could be mechanically mixed on-site with compost at the custom amendment ratio by volume, and applied to a settled amended topsoil depth of 20 centimetres.

6. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

TREE PITS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 30 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil or excavate and replace with uncompacted subsoil to a depth of at least 30 centimetres.

3. If laboratory testing of stockpiled site topsoil indicates it already meets the post-construction soil quality standards, apply 60 centimetres of uncompacted topsoil to the planting area.

4. If applying the default amendment rate, apply 40 centimetres of stockpiled site topsoil followed by 20 centimetres of compost and incorporate the compost through deep tilling or excavation, mixing and replacement to a depth of 70 centimetres to produce a settled, amended topsoil depth of 60 centimetres and a total uncompacted soil depth of 90 centimetres. Alternatively, stockpiled site topsoil could be mechanically mixed on-site with compost at a ratio of 2:1 topsoil to compost by volume, and applied to a settled amended topsoil depth of 60 centimetres.

5. If applying a custom amendment rate, apply the depths of stockpiled topsoil and compost calculated using the Custom Compost Application Rate Calculation (Appendix A4) or Topsoil and Soil Amendment Calculator spreadsheet tool (www.sustainabletechnologies.ca) that is required to achieve a final topsoil containing 10 to 15% organic matter content. Incorporate the compost through deep tilling or excavation, mixing and replacement to a depth of 70 centimetres to produce a settled, amended topsoil depth of 60 centimetres and a total uncompacted soil depth of 90 centimetres. Alternatively, stockpiled site topsoil could be mechanically mixed on-site with compost at the custom amendment ratio by volume, and applied to a settled amended topsoil depth of 60 centimetres.

6. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

5.2.3 Option 3 – Amend Site Subsoil

Site conditions should be dry, not frozen and soil should be well drained when incorporating compost.
Source: S. Bietenholz, Flicker Media Commons

AMENDING SITE SUBSOIL IN PLACE

Amendments to site subsoil to meet the post-construction quality and depth standards should be undertaken when grading activities are finished and near the end of construction, when landscaping work is typically scheduled. Site conditions should be dry (i.e. not raining), not frozen and soil should be well drained when incorporating compost. Stepwise instructions for best practice Option 3 will vary depending on the type of vegetation to be planted and whether default or custom calculated amendment rates will be applied. The following provides guidance on the sequential steps to follow for each type of planting area.

TURF AREAS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 25 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil to a depth of at least 25 centimetres (till or scarify in a direction perpendicular to ground slope to the extent possible).

3. If applying the default amendment rate, apply five (5) centimetres of compost and incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres.

4. If applying a custom amendment rate, apply the depth of compost calculated using the Custom Compost Application Rate Calculation (Appendix A4) or Topsoil and Soil Amendment Calculator spreadsheet tool (www.sustainabletechnologies.ca) that is required to achieve a final topsoil containing 5 to 10% organic matter content. Incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres.

5. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

PLANTING BEDS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 25 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil to a depth of at least 25 centimetres (till or scarify in a direction perpendicular to ground slope to the extent possible).

3. If applying the default amendment rate, apply 7 centimetres of compost and incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres.

4. If applying a custom amendment rate, apply the depth of compost calculated using the Custom Compost Application Rate Calculation (Appendix A4) or Topsoil and Soil Amendment Calculator spreadsheet tool (www.sustainabletechnologies.ca) that is required to achieve a final topsoil containing 10 to 15% organic matter content. Incorporate the compost through tilling to a depth of 24 centimetres to produce a settled, amended topsoil depth of 20 centimetres and a total uncompacted soil depth of 30 centimetres.

5. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

TREE PITS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to at least a depth of 60 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil, or excavate and replace with uncompacted subsoil to a depth of at least 60 centimetres. Decompaction treatments should not be performed within the drip line of any existing trees, over underground utility installations within 60 centimetres of the surface grade or where soil compaction is by design.

3. If applying the default amendment rate, apply 20 centimetres of compost and incorporate the compost through deep tilling or excavation, mixing and replacement to a depth of 70 centimetres to produce a settled, amended topsoil depth of 60 centimetres and a total uncompacted soil depth of 90 centimetres.

4. If applying a custom amendment rate, apply the depth of compost calculated using the Custom Compost Application Rate Calculation (Appendix A4) or Topsoil and Soil Amendment Calculator spreadsheet tool (www.sustainabletechnologies.ca) that is required to achieve a final topsoil containing 10 to 15% organic matter content. Incorporate the compost through deep tilling or excavation, mixing and replacement to a depth of 70 centimetres to produce a settled, amended topsoil depth of 60 centimetres and a total uncompacted soil depth of 90 centimetres.

5. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

5.2.4 Option 4 – Import Topsoil

TURF AREAS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 10 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil to a depth of at least 10 centimetres (till or scarify in a direction perpendicular to ground slope to the extent possible).

3. If laboratory testing of the imported topsoil product indicates it meets the post-construction soil quality standards for organic matter content (5 to 10% by dry weight) and soil pH (6.0 to 8.0) and any municipal or CA topsoil/fill quality requirements, apply 20 centimetres of uncompacted imported topsoil to the turf area.

4. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

PLANTING BEDS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 10 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, decompact subsoil to a depth of at least 10 centimetres (till or scarify in a direction perpendicular to ground slope to the extent possible).

3. If laboratory testing of the imported topsoil product indicates it meets the post-construction soil quality standards for organic matter content (10 to 15% by dry weight) and soil pH (6.0 to 8.0) and any municipal or CA topsoil/fill quality requirements, apply 20 centimetres of uncompacted imported topsoil to the planting bed.

4. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

Demonstration of compost soil amendments at an industry training event. Source: TRCA

TREE PITS

1. (Optional) Check degree to which subsoil is compacted through cone penetration tests to a depth of at least 30 centimetres (see Section 3.2.2) to confirm Soil Management Plan assumptions regarding whether or not measures to reverse soil compaction are required.

2. If the Soil Management Plan indicates that measures to reverse soil compaction are required and/or if in-situ cone penetration tests of the disturbed subsoil exceed the values in Table 3.1, till or scarify compacted subsoil or excavate and replace with uncompacted subsoil to a depth of at least 30 centimetres.

3. If laboratory testing of the imported topsoil product indicates it meets the post-construction soil quality standards for organic matter content (10 to 15% by dry weight) and soil pH (6.0 to 8.0) and any municipal or CA topsoil/fill quality requirements, apply 60 centimetres of uncompacted imported topsoil to the tree pit.

4. Topsoil should be thoroughly wetted after reapplication, allowed to settle for one week and then checked to confirm the appropriate depth has been applied prior to compost amendment. Fine grading and hand rolling to produce an even soil surface may be required after compost amendment and before planting.

6.0 Verifying Post-construction Soil Quality and Depth

Inspection and testing to verify that the SMP was implemented as intended should be undertaken following completion of soil restoration best management practices and before application of mulch and planting, where feasible. Verification inspections should be undertaken either by a municipal or CA representative (where post-construction soil quality and depth standards are required through construction permitting) or by the construction site manager/supervisor as a quality control check of landscaping contractor work. Completion of these tasks should be required as part of contracts between development proponents or property owners/managers and the construction and or landscaping contractors providing the soil amendment and planting services.

The main conditions to be confirmed through inspection are:

1. That existing vegetation and soil protection areas remain undisturbed.
2. Provision of the depth of topsoil required for each type of planting area (20 centimetres for turf areas and planting beds; 60 centimetres for tree pits).
3. Provision of the total depth of uncompacted soil required for each type of planting area (30 centimetres for turf areas and planting beds; 90 centimetres for tree pits).

6.1 Site Inspection Materials and Equipment

Materials and equipment that are needed to conduct an inspection to verify implementation of the Soil Management Plan are as follows:

- Copy of the approved Soil Management Plan for the site including drawing(s).
- Sturdy shovel or garden spade;
- Tape measure;
- Cone penetrometer (static or dynamic) or simple rod penetrometer composed of a 3/8 inch (~1 centimetre) diameter, four (4) to five (5) foot (1.2 to 1.5 metre) long stainless steel rod with a 1/8 inch (3 millimetre) bevel cut into the tip at a 30 degree angle from the side and a 90 degree bend at the top to form a handle.
- Blank Field Inspection Form.

6.2 Inspection and Testing Steps

The following steps may be completed during multiple visits as construction at a site progresses or in one final project approval inspection (adapted from Soils for Salmon, 2010).

Step 1: Compare site conditions with approved Soil Management Plan (SMP)
The SMP approved with the site permit describes the soil management best practices to be implemented on the site. Inspectors should ensure that the following site conditions match the details in the SMP:

- Site location and permit holder;
- Areas to remain as undisturbed existing vegetation and soil have been protected during construction to prevent damage to plants, soil compaction and accumulation of sediment;
- Turf areas, planting beds and tree pit locations match approved drawings.

Step 2: Inspect delivery tickets for compost, imported topsoil and mulch
The permit holder must provide original delivery tickets for all compost, topsoil and mulch products applied on the site. Inspectors should compare delivery tickets with the SMP to ensure the following details match:

- Delivery location;
- Total quantities of each product;
- Product descriptions and sources.

If products other than those listed in the SMP were delivered, laboratory test results must be provided to confirm that they are equivalent to the products specified in the approved SMP.

Step 3: Verify depth of topsoil and total uncompacted soil depth
Use a shovel to dig at least one test hole in each BMP/planting area type combination on the site and one additional hole for every 4000 square metres of BMP/planting area type to verify that the required topsoil and total uncompacted soil depths (below mulch layer) have been provided (Soils for Salmon, 2010). Test holes should have a diameter of at least 30 centimetres and extend to at least the required total uncompacted soil depth for the type of landscaped area (i.e. 30 centimetres for turf areas and planting beds; 90 centimetres for tree pits). Topsoil layers should be easy to dig using a garden spade driven solely by the inspector's weight. The topsoil should be darker in colour than the unamended subsoil below and particles of organic matter are likely to be visible (Figure 6.1). The next soil horizon below the topsoil should also be

loose enough to penetrate with a shovel. Clay subsoils that have been saturated and dried may require jumping on the shovel step to penetrate but should yield easily when moist. Subsoil that requires vigorous chipping with the shovel to penetrate probably does not meet the uncompacted soil depth standard.

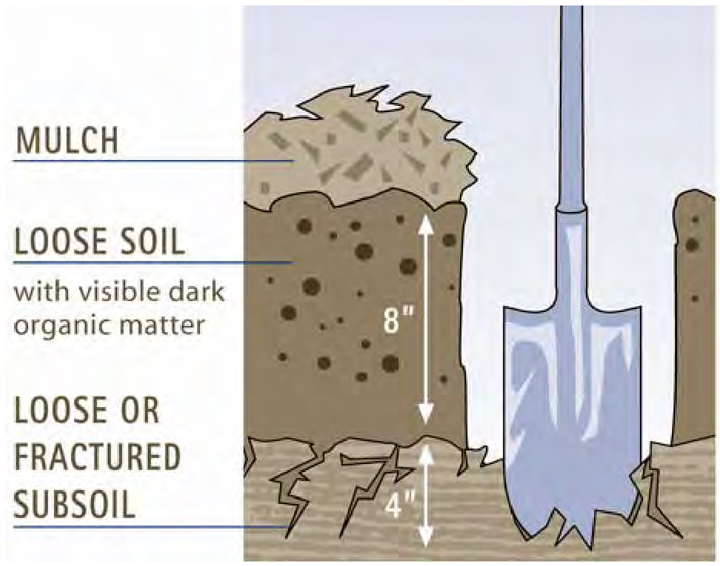


Figure 6.1 Illustration of a test hole for verifying topsoil and total uncompacted soil depths for turf areas or planting beds. Source: Soils for Salmon

Step 4. Check for soil compaction in several locations

Using a cone penetrometer (preferred) or simple rod penetrometer, confirm that the total uncompacted soil depth required for each type of planting area on the site has been provided. Perform five (5) cone penetration tests per BMP/planting area type and one additional test for every 400 square metres of each BMP/planting area type on the site (Soils for Salmon, 2010). The cone penetrometer or simple rod penetrometer should enter the soil to the required total uncompacted soil depth driven solely by the inspector's weight. Where a cone penetrometer is used, maximum readings should not exceed the values in Table 3.1. Irregular scarification or rocks in the subsoil layer may require probing a few spots at each location to reach the full depth.

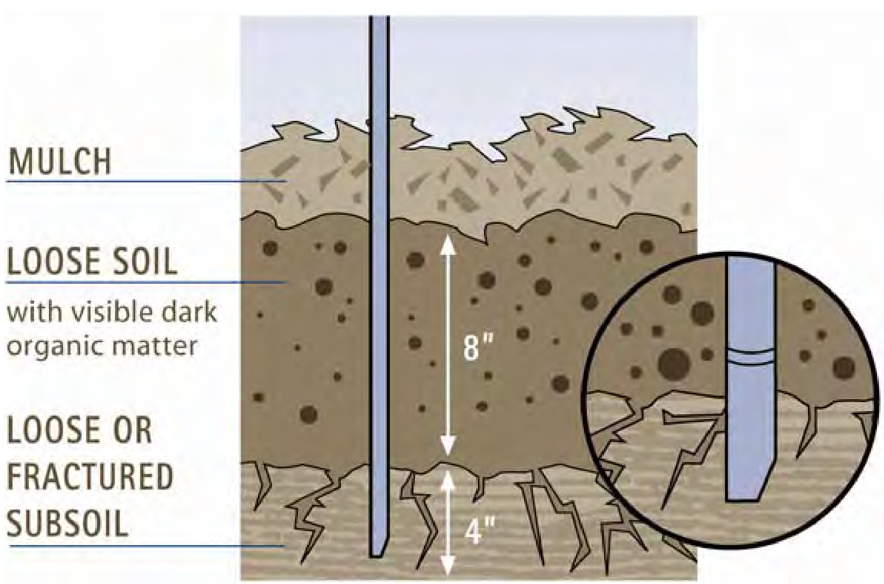


Figure 6.2: Illustration of cone penetration test for verifying total uncompacted soil depth for turf areas or planting beds Source: Soils for Salmon

Step 5. Record results on Field Inspection Form
Inspectors should record their observations by filling in a Field Inspection Form (see Appendix A5). If inspection indicates that a portion of the site does not fulfill the approved SMP, the permit holder or their agent should be notified of what steps are needed to comply (see Appendix A5 for examples). When results are unclear or disputed, an independent consultant should conduct sampling for soil laboratory testing of organic matter, bulk density and soil pH as described in Section 3.2. Qualified consultants include certified Agronomists, Soil Scientists or Crop Advisors; and licensed Landscape Architects, Civil Engineers or Geologists.

7.0 Maintenance

7.1 First Year Maintenance

In order to ensure the success of soil compost amendments, the following tasks should be undertaken in the first year following soil restoration. These tasks should be undertaken by the property owner/manager as part of routine maintenance of the property.

PROTECT FROM DISTURBANCE OR EROSION

Once disturbed soil areas have been amended to meet the soil quality and depth standards they should be protected from disturbance or compaction from construction machinery or vehicle traffic. To prevent erosion of topsoil, landscaped areas should be planted soon after amendments have been implemented, but after verification inspection and testing. Planting beds and tree pits should be covered with five (5) to ten (10) centimetres of mulch to protect the topsoil from erosion and crusting, to provide a lasting source of carbon to feed beneficial soil microbes and organisms and to inhibit invasive plant growth.

INITIAL INSPECTIONS

During the first six (6) months following incorporation of soil amendments the landscaped portions of the site should be inspected at least once and after each storm event that exceeds 25 millimetres of rainfall in 2 hours or the 2 year return period storm event for the location. Inspections should look for any bare, sparsely vegetated or eroding areas, rills, trash or sediment accumulation and invasive plant growth.

SPOT RESEEDING OR REPLACING FAILED PLANTINGS

Inspectors should stabilize any bare or eroding areas in the amended landscaped areas by spot reseeding turf areas or replacing failed plantings. Property owners/managers should consider warranty periods for plantings established in contracts between the property developer and construction contractor(s). If reseeding or replacement of plantings remains unsuccessful, soil pH should be tested and if observed to be outside the range of 6.0 to 8.0, should be adjusted through amendment with lime (to increase the pH of acidic soils) or compost (to decrease the pH of basic soils). Guidance regarding amendment rates using lime can be found in Section 3.2.4. If vegetation is being prevented from becoming established due to concentrated stormwater flows (e.g. rilling) runoff dispersion devices (e.g., splash pads, pea gravel trench, etc.) may be required.

IRRIGATION

During the first growing season, plantings should be watered once every three days for the first month and then once a week or as needed based on precipitation for the remainder of the growing season to ensure they become established.

7.2 On-going Maintenance

There are no major on-going maintenance needs associated with compost amended soil beyond routine maintenance that all landscaped areas require (i.e., trash removal, mowing, pruning, watering during drought conditions, etc.). Dethatching and core aerating turf areas every few years is recommended to maintain soil permeability and promote healthy turf growth. During routine maintenance of landscaped areas, plant debris (e.g., grass clippings, leaf litter, twigs) should be left on the soil surface or mulched into the turf to replenish soil organic matter content. Mulch layers on planting beds and tree pits will require replacement every three (3) years. It should be possible to reduce use of irrigation and eliminate the use of chemical fertilizers, herbicides and pesticides. These activities should be adjusted where possible, rather than continuing to implement formerly established practices.

8.0 Additional Resources

- For more information on soil management, see Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) resources
  http://www.omafra.gov.on.ca/english/crops/soils/manage.html

- For more information on soil and compost standards and best practices for beneficial reuse of excess soils see the Ontario Ministry of the Environment (OMOE) resources
  http://www.ene.gov.on.ca/environment/en/resources/index.htm

- For more information on planning and managing soils in urban areas see USDA Natural Resources Conservation Service's Urban Soil Primer
  http://soils.usda.gov/use/urban/primer.html

- For additional information on soil stockpiling best practices see AASHTO Center for Environmental Excellence, Environmental Stewardship Practices, Procedures and Policies for Highway Construction and Maintenance, Chapter 4 – Construction Practices for Environmental Stewardship.
  http://environment.transportation.org/environmental_issues/construct_maint_prac/compendium/manual/

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Appendix A1 Accredited Soil and Compost Testing Laboratories in Ontario

ACCREDITED SOIL TESTING LABS		
Laboratory Name	Address	Telephone/Fax/Email
A&L Laboratories Inc.	2136 Jetstream Road, London, Ont. N5V 3P	tel: (519) 457-2575 fax: (519) 457-2664 email: aginfo@alcanada.com
Exova Accutest Laboratory	8-146 Colonnade Road, Ottawa, Ont. K2E 7Y1	tel: (613) 727-5692, x.317 fax: (613) 727-5222 email: lorna.wilson@exova.com
SGS Agrifood Laboratories	503 Imperial Road, Unit #1 Guelph, Ont. N1H 6T9	tel: (519) 837-1600 1-800-265-7175 fax: (519) 837-1242 email: lab@agtest.com
Brookside Laboratories, Inc.	308 South Main Street, New Knoxville, Ohio 45871	tel: (419) 753-2448 fax: (419) 753-2949 email: jbrackman@blinc.com
FoReST Laboratory	955 Oliver Road BB1005D, Thunder Bay, ON P7B 5E1	tel: (807) 343-8639 fax: (807) 343-8116 email: soilslab@lakeheadu.ca
University of Guelph, Laboratory Services	University of Guelph, P.O. Box 3650, 95 Stone Rd., West, Guelph, Ont. N1H 8J7	tel: (519) 767-6299 fax: (519) 767-6240 email: aflinfo@uoguelph.ca
Stratford Agri-Analysis	1131 Erie St., Box 760, Stratford, Ont. N5A 6W1	tel: (519) 273-4411 1-800-323-9089 fax: (519) 273-2163 email: info@stratfordagri.ca
Activation Laboratories Ltd.	1480 Sandhill Dr., Unit 9, Ancaster, ON L9G 4V5	tel: 289-204-0515 ext. 102/104 fax: 289.204.0514 Laboratory@ActLabsAg.com

Appendix A2 Model Soil Management Plan Form

Section 1: Project Information

Site address:	
Lot number:	
Permit type:	Permit number:
Permit holder:	Phone:
Mailing address:	
Contact person:	Phone:
Plan prepared by:	Phone:

Section 2: Required Documentation *(Check off all required items that are attached to this plan.)*

☐	Soil Management Plan drawing to scale (minimum 11" x 17"), identifying: • Areas where existing trees, vegetation and soil will be protected from disturbance. • Planting areas by type and what Best Management Practice option and variant will be applied. • Areas where stripped site topsoil will be stockpiled and preserved (if applicable)
☐	Copies of laboratory analyses for proposed compost or imported topsoil products.
☐	Copies of laboratory analyses for pre-construction topsoil quality over the site ***(OPTIONAL. Required if proposing custom compost amendment rates).***

Section 3: Pre-construction Soil Conditions

Testing not required if information is already available from geotechnical investigations (Section 4.2 of the Soil Management Best Practices Guide).

Pre-construction topsoil depth	
Record depth of topsoil (soil horizon A) at a minimum of five (5) locations evenly distributed over the site (determined from soil core samples or dug test holes to 30 centimetres depth or a depth slightly greater than the full extent of the topsoil layer) with one (1) additional location for every 4,000 m^2 of site area. Calculate the mean depth of topsoil over the site.	
Location 1 topsoil depth (cm):	Location 6 topsoil depth (cm):
Location 2 topsoil depth (cm):	Location 7 topsoil depth (cm):
Location 3 topsoil depth (cm):	Location 8 topsoil depth (cm):
Location 4 topsoil depth (cm):	Location 9 topsoil depth (cm):
Location 5 topsoil depth (cm):	Location 10 topsoil depth (cm):
Mean topsoil depth (cm):	

Pre-construction topsoil quality *(OPTIONAL. Required if proposing custom compost amendment rates.)*	
Collect and combine a minimum of five (5) samples from soil cores or dug test holes evenly distributed over the site with one (1) additional sample for every 4,000 m^2 of site area. Mix thoroughly and subsample to produce a 600 gram composite sample and submit for laboratory testing. ***Attach a copy of the laboratory test results.***	
Parameter	**Result**
Particle size distribution	% sand % silt % clay
Soil texture classification	
Organic matter content (by dry weight) (%)	
Soil pH	
Soil bulk density (g/cm^3)	

Pre-construction subsoil quality *(OPTIONAL. Recommended if soil compaction testing following completion of grading and construction activities to confirm or refine prescribed treatments is proposed)*	
Parameter	**Result**
Particle size distribution	% sand % silt % clay
Soil texture classification	

Section 4: Total Amendments Required
(Sum the required quantities for all planting areas. Refer to Section 6.)

Product type (compost, imported topsoil, mulch)	Product name	Total volume required (m^3)	Total mass required (kg)	Product quality meets OMOE, municipal or CA requirements?*	Product quality meets *Soil Mgmt. Best Practices Guide* recommended standards?**
				Yes / No	Yes / No
				Yes / No	Yes / No
				Yes / No	Yes / No
				Yes / No	Yes / No
				Yes / No	Yes / No
Comments:					

* Applies to compost and imported topsoil products only. For compost quality requirements refer to the most recent OMOE guideline document. For imported topsoil quality requirements contact the relevant municipality or Conservation Authority. **Attach copies of all laboratory test results.**
** Applies to imported topsoil products only. Turf areas: 5 to 10% organic matter content and pH 6.0 to 8.0; Planting beds and Tree Pits: 10 to 15% organic matter content and pH 6.0 to 8.0. **Attach copies of all laboratory test results.**

Section 5: Approval

Date	SMP Approved (Y / N)	Name of Inspector	Signature of Inspector
Comments / Revisions Required			

Section 6: Soil Management Plan Details

(Complete a separate table for each BMP area. Copy and attach additional pages as needed.)

General information	
Area number or identification code *(Corresponding to the number/code on the Soil Management Plan drawing)*:	
Best Management Practice (BMP) to be implemented: ☐ Option 1 – Protect existing vegetation and soil from disturbance ☐ Option 2 – Stockpile, preserve and replace site topsoil (no amendment) ☐ Option 2 – Stockpile, preserve, replace and amend site topsoil ☐ Option 3 - Amend site subsoil ☐ Option 4 - Import topsoil	
Planting type: ☐ Undisturbed existing vegetation ☐ Turf area ☐ Planting bed ☐ Tree pit	
Size of area (m^2):	
Protection measures *(Complete this section for areas of undisturbed existing vegetation only)*	
Are protection measures required?	☐ Yes ☐ No
Describe protection measures to be implemented (e.g. erosion and sediment control practices, construction fencing).	
Subsoil decompaction	
Recommended total uncompacted soil depths for each type of planting area are as follows: *Turf area: 30 cm* *Planting bed: 30 cm* *Tree pit: 90 cm*	
Will a decompaction treatment likely be needed?	☐ Yes ☐ No
Depth of decompaction treatment (cm) required (refer to Section 5.2 of the *Soil Mgmt. Best Practices Guide for depths specific to the BMP and planting area type*)	
Proposed decompaction treatment:	☐ Tilling with a rototiller ☐ Scarifying with a chisel plow or backhoe ☐ Ripping with a subsoiler ☐ Excavation and replacement with uncompacted soil ☐ Other:

Proposed materials

Type	Product name	Application depth (cm)*	Volume required (m^3)**	Mass required (kg)***
Stockpiled site topsoil	Not applicable			
Compost				
Imported topsoil				
Mulch				

Topsoil depth	
Refer to Section 5.2 of the Soil Mgmt. Best Practices Guide for detailed guidance on options for achieving the recommended topsoil depth standards.	
Recommended topsoil depths for each type of planting area are as follows: *Turf: 20 cm* *Planting beds: 20 cm* *Tree pits: 60 cm*	
Compost amendment incorporation depth (cm):	
Method of compost incorporation (i.e. tilling; excavation, mixing and replacement; mechanical mixing of stockpiled site topsoil and compost on-site and placement:)	

*For default compost amendment rates for each planting type, refer to Section 5.2 of the *Soil Mgmt. Best Practices Guide*. Custom compost amendment rates can be calculated using the calculation worksheet in Appendix A3 of the *Soil Mgmt. Best Practices Guide* or the spreadsheet calculator available at www.sustainabletechnologies.ca.

**Volume of material required (m^3) = [Application rate (cm)/100] x Size of planting area (m^2)

***Mass of material required (kg) = [Volume of material (m^3) x $1x10^6$ x Bulk density of material (g/cm^3)]/1000

Section 7: Soil Compaction Testing

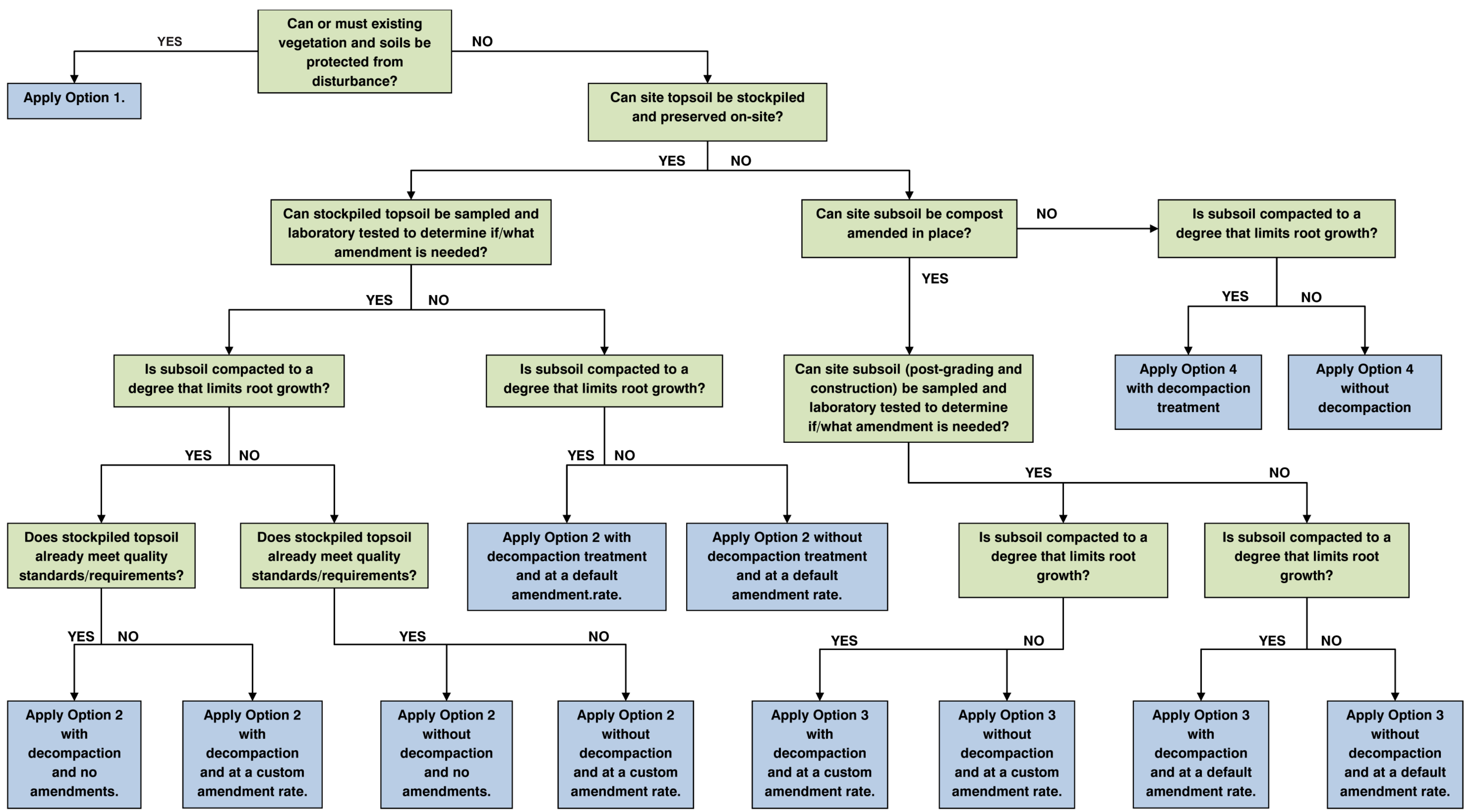
Cone penetrometer tests *(OPTIONAL. Recommended prior to implementation of prescribed treatments to confirm or refine where soil decompaction is needed)*			
Perform at least five (5) tests per planting area with an additional test for every 400 m^2 of planting area. ***If 50% or more of the tests exceed maximum acceptable penetrometer readings for the soil texture (see below), decompaction is needed.***			
Penetrometer test results	**Measured penetrometer reading**	**Result exceeded maximum acceptable reading?**	**Soil is uncompacted to the recommended depth?**
	Test 1:	Yes / No	Yes / No
	Test 2:	Yes / No	Yes / No
	Test 3:	Yes / No	Yes / No
	Test 4:	Yes / No	Yes / No
	Test 5:	Yes / No	Yes / No
	Test 6:	Yes / No	Yes / No
	Test 7:	Yes / No	Yes / No
	Test 8:	Yes / No	Yes / No
	Test 9:	Yes / No	Yes / No
	Test 10:	Yes / No	Yes / No

Acceptable cone penetrometer readings				
Dominant Soil Texture *(Refer to Section 3):*	**All Textures of Sand**	**Sandy** *(includes loamy sand, sandy loam, sandy clay loam and sandy clay)*	**Silty** *(includes loam, silty loam, silty clay loam, and silty clay*	**Clayey** *(includes clay loam)*
Surface Resistance:	≤ 110 PSI	≤ 260 PSI	≤ 260 PSI	≤ 225 PSI
	≤ 7.7 kg/cm^2	≤ 18.3 kg/cm^2	≤ 18.3 kg/cm^2	≤ 15.8 kg/cm^2
	≤ 758 kPa	≤ 1793 kPa	≤ 1793 kPa	≤ 1551 kPa

Notes:

4. PSI = Pounds per square inch (lb/in^2)
5. kg/cm^2 = kilogram per square centimetre
6. kPa = kilopascal

Appendix A3 Decision Tree Diagram To Assist In Selecting and Implementing Best Practice Options



Appendix A4 Custom Compost Application Rate Calculation

Where stockpiled site topsoil already contains some organic matter, it is often cost-effective to calculate the amount of compost amendment needed to achieve the recommended topsoil quality standard specific to the planting area type (i.e. 5 to 10% organic matter content for turf areas; 10 to 15% for planting beds and tree pits; see Section 2.3).

Custom compost application rates can be calculated using either the Equation below, or the Topsoil and Soil Amendment Calculator spreadsheet tool available for download at (www. sustainabletechnologies.ca). Alternatively, tables of custom compost application rates for some typical soil types are provided on the following pages.

Equation for Calculating Compost Application Rates:

Use this equation to calculate compost application rates to achieve the targeted final organic matter content (FOM) for a soil (either stockpiled site topsoil or site subsoil) with a known bulk density (SBD) and initial soil organic matter content (SOM) using a compost product of know bulk density (CBD) and organic matter content (COM).

CR = D x [SBD x (SOM% - FOM%)/SBD x (SOM% - FOM%) – CBD x (COM% - FOM%)]

Where:

CR = Compost application rate (centimetres) calculated to achieve the target final organic matter content (FOM).
D = Depth of incorporation or finished topsoil (centimetres)
SBD = Soil bulk density (grams per cubic centimetre, dry weight)
SOM% - Initial soil organic matter (percent, dry weight)1
FOM% - Final target soil organic matter (percent, dry weight)1, 2
CBD = Compost bulk density (grams per cubic centimetre, dry weight)
COM% = Compost organic matter (percent, dry weight)1

Notes:

1. All organic matter measurements must be based on the commonly used "Loss On Combustion Test"
2. The following values should be used, depending on the planting area type: 7.5% for turf areas; 12.5% for planting beds; 12.5% for tree pits.

Table A4.1 Table of custom compost application rates for turf areas by soil type

	SBD	SOM%	TOM%	CBD	COM%	D	CAR
Soil Type	Soil Bulk Density (g/cm^3 dry weight)	Initial Soil Organic Matter Content (%)	Target Soil Organic Matter Content	Compost Bulk Density (g/cm^3 dry weight)	Compost Organic Matter Content (%)	Depth of Finished Topsoil (cm)	Custom Compost Application Rate (cm)
Sandy Soil	1.5	0.0	7.5	0.7	50	20	5
	1.5	1.0	7.5	0.7	50	20	5
	1.5	2.0	7.5	0.7	50	20	4
	1.5	3.0	7.5	0.7	50	20	4
	1.5	4.0	7.5	0.7	50	20	3
	1.5	5.0	7.5	0.7	50	20	2
Clayey Soil	1.0	0.0	7.5	0.7	50	20	4
	1.0	1.0	7.5	0.7	50	20	4
	1.0	2.0	7.5	0.7	50	20	3
	1.0	3.0	7.5	0.7	50	20	3
	1.0	4.0	7.5	0.7	50	20	2
	1.0	5.0	7.5	0.7	50	20	2

Table A4.2 Table of custom compost application rates for planting areas by soil type

	SBD	SOM%	TOM%	CBD	COM%	D	CAR
Soil Type	Soil Bulk Density (g/cm^3 dry weight)	Initial Soil Organic Matter Content (%)	Target Soil Organic Matter Content	Compost Bulk Density (g/cm^3 dry weight)	Compost Organic Matter Content (%)	Depth of Finished Topsoil (cm)	Custom Compost Application Rate (cm)
Sandy Soil	1.5	0.0	12.5	0.7	50	20	8
	1.5	1.0	12.5	0.7	50	20	8
	1.5	2.0	12.5	0.7	50	20	8
	1.5	3.0	12.5	0.7	50	20	7
	1.5	4.0	12.5	0.7	50	20	7
	1.5	5.0	12.5	0.7	50	20	6
	1.5	6.0	12.5	0.7	50	20	5
	1.5	7.0	12.5	0.7	50	20	5
	1.5	8.0	12.5	0.7	50	20	4
	1.5	9.0	12.5	0.7	50	20	3
	1.5	10.0	12.5	0.7	50	20	3
Clayey Soil	1.0	0.0	12.5	0.7	50	20	6
	1.0	1.0	12.5	0.7	50	20	6
	1.0	2.0	12.5	0.7	50	20	6
	1.0	3.0	12.5	0.7	50	20	5
	1.0	4.0	12.5	0.7	50	20	5
	1.0	5.0	12.5	0.7	50	20	4
	1.0	6.0	12.5	0.7	50	20	4
	1.0	7.0	12.5	0.7	50	20	3
	1.0	8.0	12.5	0.7	50	60	3
	1.0	9.0	12.5	0.7	50	20	2
	1.0	10.0	12.5	0.7	50	20	2

Table A4.3 Table of custom compost application rates for tree pits by soil type

	SBD	SOM%	TOM%	CBD	COM%	D	CAR
Soil Type	Soil Bulk Density (g/cm³ dry weight)	Initial Soil Organic Matter Content (%)	Target Soil Organic Matter Content	Compost Bulk Density (g/cm3 dry weight)	Compost Organic Matter Content (%)	Depth of Finished Topsoil (cm)	Custom Compost Application Rate (cm)
Sandy Soil	1.5	0.0	12.5	0.7	50	60	25
	1.5	1.0	12.5	0.7	50	60	24
	1.5	2.0	12.5	0.7	50	60	23
	1.5	3.0	12.5	0.7	50	60	21
	1.5	4.0	12.5	0.7	50	60	20
	1.5	5.0	12.5	0.7	50	60	18
	1.5	6.0	12.5	0.7	50	60	16
	1.5	7.0	12.5	0.7	50	60	14
	1.5	8.0	12.5	0.7	50	60	12
	1.5	9.0	12.5	0.7	50	60	10
	1.5	10.0	12.5	0.7	50	60	8
Clayey Soil	1.0	0.0	12.5	0.7	50	60	19
	1.0	1.0	12.5	0.7	50	60	18
	1.0	2.0	12.5	0.7	50	60	17
	1.0	3.0	12.5	0.7	50	60	16
	1.0	4.0	12.5	0.7	50	60	15
	1.0	5.0	12.5	0.7	50	60	13
	1.0	6.0	12.5	0.7	50	60	12
	1.0	7.0	12.5	0.7	50	60	10
	1.0	8.0	12.5	0.7	50	60	9
	1.0	9.0	12.5	0.7	50	60	7
	1.0	10.0	12.5	0.7	50	60	5

Appendix A5 Model Field Inspection Form

Section 1: Project Information

Site address:	
Lot number:	
Permit type:	Permit number:
Permit holder:	Phone:
Mailing address:	
Customer representative at inspection:	Phone:
Inspector:	Phone:

Section 2: Required Equipment

- ☐ Copy of the approved Soil Management Plan (SMP) for the site including drawing(s)
- ☐ Cone penetrometer (static or dynamic) or simple rod penetrometer *(Refer to Section 6.1 of the Soil Management Best Practices Guide for Urban Construction for detailed specifications)*
- ☐ Sturdy shovel or garden spade
- ☐ Tape measure

Section 3: Verification of Site Conditions

Ensure that the following site conditions are consistent with the SMP:

- ☐ Site location and permit holder.
- ☐ Areas to remain as undisturbed existing vegetation and soil have been protected during construction to prevent damage to plants, soil compaction and accumulation of sediment.
- ☐ Turf areas, planting beds and tree pit locations match the approved drawings.

Section 4: Verification of Amendment Quality (Compost, Imported Topsoil, and Mulch)

Inspect delivery tickets for compost, imported topsoil, and mulch. Ensure the following details match the SMP. If products other than those listed in the SMP were delivered, laboratory test results must be provided to confirm that they are equivalent to the products specified in the approved SMP.

Product name	Source	Total quantity (m^3 or kg)	Product meets OMOE or municipal/CA requirements?*	Product quality meets *Soil Mgmt. Best Practices Guide* recommended standards?**	Details match the SMP?
			Yes / No	Yes / No	Yes / No
			Yes / No	Yes / No	Yes / No
			Yes / No	Yes / No	Yes / No
			Yes / No	Yes / No	Yes / No
			Yes / No	Yes / No	Yes / No
Comments					

* Applies to compost and imported topsoil products only. For compost quality requirements refer to the most recent OMOE guideline document. For imported topsoil quality requirements contact the relevant municipality or Conservation Authority. **Attach copies of all product delivery tickets.**

** Applies to imported topsoil products only. Turf areas: 5 to 10% organic matter content and pH 6.0 to 8.0; Planting beds and Tree Pits: 10 to 15% organic matter content and pH 6.0 to 8.0. **Attach copies of all product delivery tickets.**

Section 5: Inspection Results

Complete a page for each unique BMP and planting area type combination. Copy and attach additional pages as needed.

General Information

Area number or identification code *(Corresponding to the number/code on the Soil Management Plan drawing)*:

Best Management Practice (BMP) implemented *(Check all that apply)***:**

☐ Option 1 – Protect existing vegetation and soil from disturbance ☐ Decompact subsoil ☐ Option 2 - Stockpile, preserve and replace site topsoil (no amendment) ☐ Option 2 - Stockpile, preserve, replace and amend site topsoil ☐ Option 3 - Amend site subsoil ☐ Option 4 - Import topsoil

Planting area type:

☐ Undisturbed existing vegetation ☐ Turf area ☐ Planting bed ☐ Tree pit

Size of area (m^2):

Recommended Soil Depths

Planting area type	Depth of topsoil (cm)	Total depth of uncompacted soil (cm)
Turf area	20	30
Planting bed	20	30
Tree pit	60	90

Verification and Testing

Test Holes *(A minimum of one test hole per unique BMP and planting area type combination is required, with an additional hole for every 4,000 m^2 of each BMP/planting area type.)*

Number of test holes required:				
Results	**Yes**	**No**	**N/A**	**Comments**
Topsoil is the appropriate depth.	☐	☐	☐	
Organic matter is visible as dark coloured material in the topsoil.	☐	☐	☐	
Dominant soil texture *(Sand, Sandy, Silty,or Clayey. Refer to Section 3 of the SMP):*				

Penetrometer Tests *(Perform at least five (5) penetrometer tests per BMP/planting area type with an additional test for every 400 m^2 of BMP/planting area type.)*

For maximum acceptable penetrometer readings by dominant soil texture refer to Section 6

Penetrometer test method *(Cone or rod penetrometer)*	**Penetrometer test result** *(Provide maximum measured reading for cone penetrometer tests)*	**Result exceeded maximum acceptable reading?**	**Soil is uncompacted to the recommended depth?**
	Test 1:	Yes / No	Yes / No
	Test 2:	Yes / No	Yes / No
	Test 3:	Yes / No	Yes / No
	Test 4:	Yes / No	Yes / No
	Test 5:	Yes / No	Yes / No
	Test 6:	Yes / No	Yes / No
	Test 7:	Yes / No	Yes / No
	Test 8:	Yes / No	Yes / No
	Test 9:	Yes / No	Yes / No
	Test 10:	Yes / No	Yes / No
Soil is uncompacted to the recommended depth? *(if 50% or greater of penetrometer tests exceed the values in Section 6, further steps should be taken to reverse soil compaction)*			Yes / No

Section 6: Acceptable Cone Penetrometer Readings

Dominant Soil Texture *(Refer to Section 3 of the SMP)***:**	**All Textures of Sand**	**Sandy** *(includes loamy sand, sandy loam, sandy clay loam and sandy clay)*	**Silty** *(includes loam, silty loam, silty clay loam, and silty clay*	**Clayey** *(includes clay loam)*
Surface Resistance:	≤ 110 PSI	≤ 260 PSI	≤ 260 PSI	≤ 225 PSI
	≤ 7.7 kg/cm^2	≤ 18.3 kg/cm^2	≤ 18.3 kg/cm^2	≤ 15.8 kg/cm^2
	≤ 758 kPa	≤ 1793 kPa	≤ 1793 kPa	≤ 1551 kPa

Section 7: Required Actions *(Complete this section if the BMP/planting area type does not fulfill the approved SMP. Notify the permit holder of what actions are required to comply.)*

Required action***	Assigned to	Expected date of completion

***For BMP/planting area types that do not meet the recommended topsoil depth standard, potential corrective actions include; (i) removal of mulch (if already applied) and application of additional compost with incorporation to the recommended depth, or (ii) removal of mulch and addition of imported topsoil that meets the recommended topsoil quality standard.

For BMP/planting area types that do not meet the recommended total uncompacted soil depth standard, potential corrective actions include (i) removal of mulch (if already applied), removal of topsoil and treatment of subsoil to reverse compaction to the recommended depth (see Section 5.2 of the Soil Management Best Practices Guide) followed by replacement of topsoil and mulch, or (ii) removal of mulch, treatment of topsoil and subsoil to reverse compaction to the recommended depth and replacement of mulch.

Section 8: Affirmations

☐ I have inspected the site in accordance with the Field Inspection Form and the *Soil Management Best Practices Guide for Urban Construction.*

☐ The site fulfills all of the requirements outlined in the approved Soil Management Plan.

Date:	Inspector:	Signature: