Making Urban Trees Count: A Project to Demonstrate the Role of Urban Trees in Achieving Regulatory Compliance for Clean Water

Center for Watershed Protection

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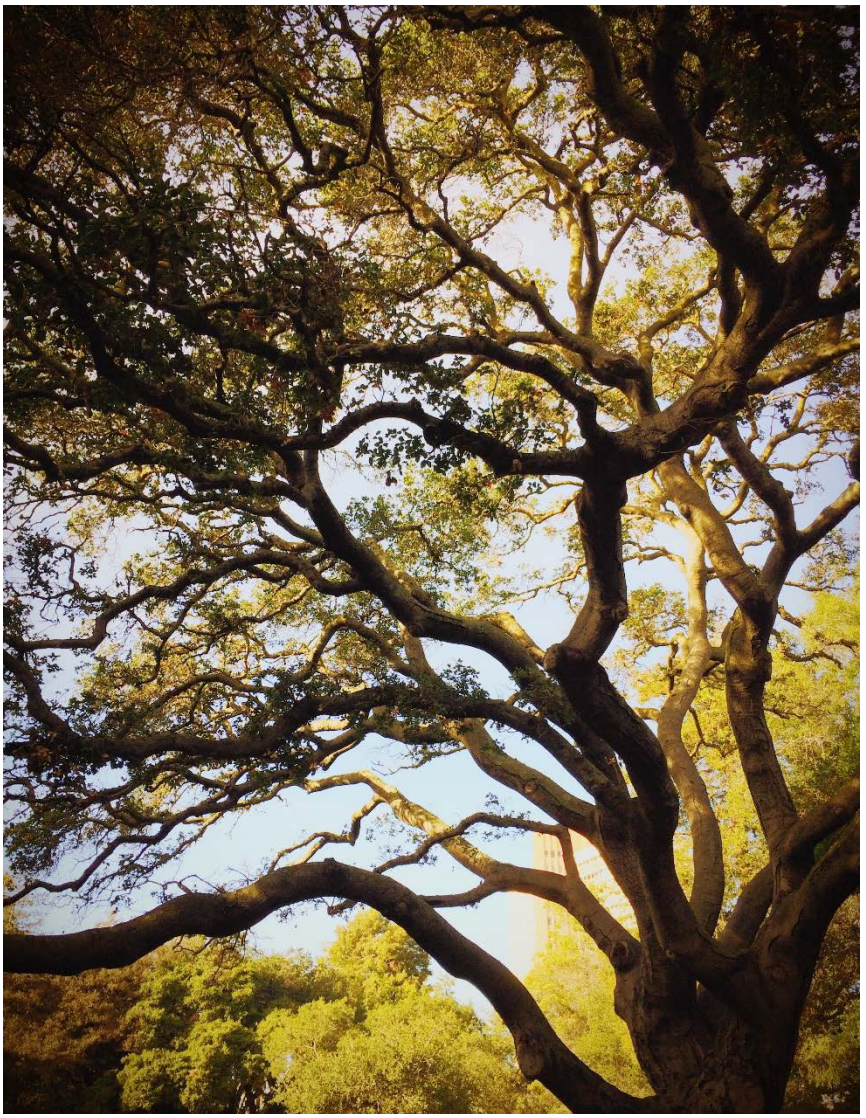

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CREDITING FRAMEWORK PRODUCT #8:

Design Specifications for Urban Tree Planting

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Design Specifications for Urban Tree Planting

Purpose

The design specifications for urban tree planting presented here are designed to serve as a base level specification for communities who are adopting pollution reduction credits for tree planting for stormwater or TMDL requirements. The intent of these specifications is to produce healthy trees that can provide water quality benefits in a variety of urban settings. These specifications are intended to be generic and flexible to be applied at a national scale and allow communities to adopt and adjust as needed to reflect local growing conditions and climate. Communities should adopt and adjust the specifications as needed to reflect local growing conditions and climate. Resources are also provided to allow for more refined and detailed specification if desired.

Definition

Urban tree planting can be used as a stormwater best management practice (BMP) to reduce runoff and pollutants. It is defined as all upland tree planting in developed landscapes that does not result in a forest-like condition. Exceptions include: trees planted in other stormwater BMPs (e.g., ponds, bioretention) to enhance performance, trees planted in engineered soils (e.g., structural soils or cells), and trees that are designed to accept and treat runoff from an adjacent impervious surface or defined upland drainage area. Tree planted in these situations as well as trees planted in riparian zones and reforestation projects are typically eligible for credit under a separate BMP.

Physical Feasibility and Design Applications

Tree planting is widely applicable across the urban landscape, even where other water quality BMPs may not be feasible. Planting trees in certain locations can also provide other needed benefits, such as shading a walkway, screening or noise reduction.
The two main applications include: 1) trees planted over turf and 2) trees planted over impervious cover. Trees planted over turf include most yard and park trees, with the defining feature being that, at maturity, the majority of the canopy area overhangs turf grass or other landscaping, rather than an impervious surface. Trees that are primarily surrounded by impervious surfaces (e.g., street trees and parking lot trees) are considered “trees over impervious cover.” These applications have differing runoff reduction and pollutant removal performance as well as different considerations for design.

The urban landscape can be a harsh environment for trees, with compacted soils, increased temperatures, inputs of pollutants such as chloride from road salt, and limited space in which the trees can grow (Table 1). However, appropriate species selection and other design factors can address most of these specific site constraints as well as

the site conditions (see Section 4). The minimum requirements of a site to be feasible for tree planting include:

- Adequate planting area size and soil volume (see Section 4)
- Adequate soil quality, or ability to amend the soil (see Section 4)
- Access to the site for watering and other maintenance
- No land use, utility or other infrastructure conflicts

Table 1 presents typical constraints to urban tree planting as well as potential resolutions.

Table 1. Urban Tree Planting Site Constraints and Impacts

Site Constraint	Potential Resolution
Limited soil volume	• Provide minimum recommended soil volume per tree • Use planting arrangements that allow shared rooting space • Increase dimensions of planting area (e.g., parking lot islands)
Poor soil quality	• Test soils and perform appropriate restoration (e.g., ripping, fracturing or trenching for very compacted soils) • Select species tolerant of soil pH, compaction, drainage etc. • Replace or amend very poor soils if necessary
Air pollution	• Select tolerant species
Damage from lawnmowers	• Use mulch to protect trees
Vandalism	• Use tree cages or benches to protect trees • Select species with thorns or inconspicuous bark • Install lighting nearby to discourage vandalism
Damage from vehicles	• Provide adequate setbacks between vehicle parking stalls and trees
Damage from animals (e.g., deer, rodents)	• Use protective fencing or chemical retardants
Exposure to pollutants in stormwater and snowmelt runoff	• Select species that are tolerant of specific pollutants, such as salt or metals
Soil moisture extremes	• Select tolerant species • Select appropriate backfill soil and mix thoroughly with site soil • Improve drainage with amendments and tillage if needed
Increased temperature	• Select drought tolerant species
High winds	• Select drought tolerant species
Invasive species	• Control invasive species prior to planting • Monitor for and remove invasive plants after planting
Conflict with infrastructure	• Design the site to keep trees and infrastructure separate

Table 1. Urban Tree Planting Site Constraints and Impacts	
Site Constraint	**Potential Resolution**
	• Consult local guidance to ensure compliance with setbacks from infrastructure such as streetlights, traffic signs, fire hydrants, driveways, street intersections, overhead utilities and underground utilities • Select appropriate species for planting near infrastructure • Use alternative materials to reduce conflict
Disease or insect infestation	• Select resistant species
Steep slope	• Follow planting guidance for steep slopes • Use erosion control measures if needed

Design Criteria

This section describes general design criteria for urban tree planting that help to ensure the project will provide the intended water quality benefits.

Species Selection

Growing conditions and microclimates can vary from location to location. Final tree variety selection is determined by site conditions and design goals. Species diversity to promote resiliency and sustainability of the urban tree community should also be a factor when selecting specific species. When planting multiple trees at least 3 different species of trees should be planted and larger projects should consider the larger urban forest diversity. Urban foresters, arborists, or other tree experts should be consulted when choosing specific species.

Table 2: Tree Species Selection Considerations			
Characteristic	**General Considerations**	**Specific Considerations**	
		Trees over Impervious Cover	**Trees over Turf**
Mature Height and Spread	Proximity to overhead utility lines, buildings, signs, and property	Species with columnar, oval or vase shapes crowns and strong branch angles	Maximization of shade and interception area
Rooting Habit	Deep or shallow roots, tap root	Resistant to compacted soils and low impact to sidewalks	Deep root systems that facilitate infiltration and healthy soils
Light Requirements	Sun/Part Sun/Shade	High heat tolerance	Matches current and/or expected conditions
Soil: Type/Structure/Condition	Soil structure, level of compaction, amount of organic matter	Highly disturbed compacted urban soils, amended soils, or engineered soils	Low organic matter compacted subsoil, lightly impacted soils with topsoil layer, well developed functional soil
Leaf Structure	Needles/Compound Leaf/Simple Leaf	Leaf litter in street/storm sewer systems, winter ice and snow damage	Maximization of shade and interception area, winter cover for birds, aesthetics
Flowers Fall/Colors	The color and timing of the boom and fall leaf color	Species with foul smelling flowers	Pollinator trees, aesthetics, and
Fruit	Type and size of fruit, edibleness, quality of wildlife forage	Species with foul smelling fruit, large fruit, and impacts from birds	Produce fruit, hard mast, and seeds for various wildlife species, fruit for human consumption
Exposure to Pollutants	Resilience to impacts from air and water pollution	Salt tolerance, air quality	Air quality, adjacent land based activities

Table 2: Tree Species Selection Considerations			
Characteristic	**General Considerations**	**Specific Considerations**	
		Trees over Impervious Cover	**Trees over Turf**
Potential Pest and Disease Issues	Susceptibility to specific diseases or pests known to be in the area	Increases susceptibility of stressed urban trees	Susceptibility to wildlife damage
Human Activity	Vandalism, compaction of soils, health and safety	Road safety requirements, proximity to signs and intersections.	Soil compaction, lawn mower/weed eater damage, level of turf management, adjacent land activities
Native Range	Tree species commonly found in the region	Relative urban heat island impact	Potential impacts of climate change

Soil Volume

Available soil volume is one of the most commonly cited factors affecting urban tree growth and survival. The amount of soil available to the tree will, in large part, determine the maximum size that the tree will achieve during its life span. The available rooting depth for trees should be a minimum of 3 feet (1 m). The available rooting volume for trees should be a minimum of 400 cubic feet with an optimum volume of 1500 cubic feet. Planting area dimensions for street, parking lot and other trees planted in highly impervious areas should be designed to achieve this volume for each tree planted, although some rooting space can be shared. Refer to the figure from Urban (1992) in the Resources Section for specific guidance on soil volume based on expected tree size.

Soil Specification

From Smiley, Thomas "Soil for Urban Tree Planting"

Texture. Both top and subsoil should be a sandy loam soil with 50-80% medium and coarse sand (<25 % fine sand), 5-20% cay, 5-35% silt.
Stones and rocks. No stones larger than 1 inch in the longest dimension are permitted. Stones ranging from 0.5 to 1 inch (1.25 to 2.5 cm) shall not exceed 5% of the soil volume, and gravel ¼ to ½ inches (0.6 to 1.25 cm) shall not exceed 5% of the soil volume.
Debris content. Particles greater than 1 inch in the longest dimension are not allowed. This includes fragments of brick, concrete, wood, glass, metal, stone and plastic. The total volume less than 1 inch long should not be more than 5% of the soil volume.
Contaminants. The soil should have no herbicides, heavy metals, biological toxins, or hydrocarbons that will impact plant growth or are at levels exceeding the EPA's standards for soil contaminants.
Clod size. Clods from 1-3 inches (2.5-7.5 cm) should make up less than 10% of the soil volume and clods 3-6 inch (7.5-15 cm) should be < 5%. Unlimited amount of Soil peds that are less than 1 inch long are allowed.
Organic matter content. The top soil shall have 4-6% OM by weight. If additional organic matter is needed, compost can be added to the soil. A well composted yard waste or wood chips compost can be used, as long as there is 10% OM by volume in the compost. Subsoil should have between 1-3% OM.
Density Top soil should have a density of 1.0 to 1.4 g/cc and subsoil 1.2 to 1.5 g/cc.
Soil pH Optimal pH is highly dependent on the tree species to be planted and should be tested and adjusted based on species prior to planting.
Soluble salt content shall be less than 2 dS/m.

Execution

This section provides a step by step summary of how to execute the planting project, from obtaining and storing plant materials to site prep, planting, tree protection, inspection and maintenance.

It is important to prevent the spread of plant diseases, exotic insects, and noxious weeds. Ensure that all procurement and purchasing specifications follow federal and state laws and require inspection for plant disease, pests, and noxious weeds.

Selection of Planting Stock

Project objectives, location, budget, and preference play a significant role in selecting the appropriate planting stock. The most common categories for urban tree planting include: Balled and Burlapped and Container.

Balled and Burlap Stock

Balled-and-burlapped trees are grown in the field for a number of years and are dug up, and the root ball is wrapped. "Balled" refers to the root ball (i.e., soil plus roots), "burlapped" refers to the wrapping material typically used for transporting tree and shrubs and may also include a wire basket for additional support. Balled and burlap trees are typically used in a landscape setting or for specimen trees because of their immediate visual impact, however because much of its root system was severed and removed during the transplant process B&B trees are susceptible to transplant shock and can be slow to re-establish their growth rate.

Container Stock

Containerize trees are grown in a container which vary in design and size and allow separately grown plants to be transplanted with the roots and soil intact. Containerized trees can be grown to a variety of sizes depending on the species and the size of the container and can be used in both landscape and reforestation settings depending on the size of plant material. Larger caliper trees with small containers are susceptible to circling roots which can girdle and kill other roots. ANSI general requirement "Container grown nursery stock shall have a well-established root system reaching the sides of the container to maintain a firm ball, but shall not have excessive root growth encircling the inside of the container".

Size Specification

Tree planting specifications should adhered to ANSI Z60.1-2014. "*Specifications for field grown Type 1 shade trees shall include plant size, by caliper. Specifications for container grown Type 1 shade trees shall include plant size, by height, through 7-8' size designation, and container class or box size equivalent. Thereafter, plant size specification shall be by caliper. Slower growing Type 2 shade trees shall include plant size, by caliper. Specifications for container grown Type 2 shade trees shall include plant size, by height, through 7-8' size designation, and container class. Thereafter, plant size specification shall be by caliper.*"

Delivery

The buyer shall stipulate how many days prior to delivery that delivery notification is needed and stipulate any special considerations to the nursery prior to shipment.

Transporting Plant Material

Tree planting material should be transported with breathable mesh covering. All plants should be well watered prior to transport. All trees should be properly secured to prevent movement. If necessary, tree trunks should be protected to avoid wounds from mechanical impacts. Trees should always be picked up by the root ball or container, never by the stem or trunk

Storing Plant Material

Bare Root Trees: Keep storage time to a minimum. Store in package in a cool location between 34-38 degrees. Keep tree roots covered and moist. Keep top dry and cool to reduce mold.

B&B and Containerized Trees: Store plants in a shady location and grouped together. Ensure tree roots are watered regularly and may require frequent irrigation during summer months. If stored for a longer period of time containers should be "heeled" into mulch or soil.

Site Preparation

Urban sites identified for tree planting are frequently in highly disturbed and may require some level of site preparation before tree planting activities can take place.

Soil

Most urban soils have been repeatedly disturbed and as a result have lost natural soil horizons contain very little organic matter, are excessively stony and coarse-textured, and can contain significant amounts of construction and building debris. Urban soils are often severely compacted and as a result lose soil porosity impacting aeration, drainage, storage of plant-available moisture, and root growth. Soil condition should be evaluated during the site selection process and restoration measure put in place if needed. If the soil condition problem cannot be addressed over the full site, the soil immediately around each tree should be thoroughly loosened and amended (if needed) to allow for adequate root growth.

Competing vegetation

Undesirable competing vegetation, such as non-native invasive plants, is also a common occurrence at urban tree planting sites. Undesirable vegetation shall be identified and controlled prior to tree planting activities. There are four primary ways of controlling undesirable vegetation at tree planting sites.

- Herbicides – Some plants only respond to chemical treatments or the site may be so invaded that herbicides are needed as part of the treatment strategy. Herbicides must be applied according to the manufacturer's label and by a licensed application if required based on the types of herbicide.
- Smothering – For small areas weed-suppressing fabric, dark plastic, or layers of cardboard secured over the planting area for 2 to 3 weeks during the growing season can effectively kills grass and some weeds. The fabric or plastic sheet should be removed before planting.
- Manual removal – For smaller sites or where herbicides are not allowed manual removal of invasive plants may be required. Manual removal is labor- and time-intensive, and depending on the type of vegetation may not be fully effective and require additional "treatments".
- Mechanical Removal – In some cases it may be desirable to mechanically remove the vegetation with specialty equipment such as sod cutters, backhoes, and mulching heads

Planting

Installation

The hole of the tree shall be a minimum of 18" larger than the largest diameter (twice the diameter of the root ball is preferred), no deeper than the depth of the root ball. of the root ball and no deeper than the ball, the sides of the hole should be sloped. The tree should be installed as plumb as possible. The tree container should be removed and circling roots should be cut and loosened to prevent girdling roots in the future. For B&B trees the burlap, poly ties, and the wire cage should be removed if possible. If removing the cage and fully removing the burlap could result in damage to the tree roots only cut and remove the burlap from the upper 1/3 of the root ball and cut the top of the wire basket and fold down in the pit after positioning for back-fill planting. Backfill soil should be installed firmly around ball to remove air pockets, however take care to avoid over compacting the soil. Backfilling material should consist of existing soil from the excavation. Large rocks, construction debris, litter etc. should be removed. All spoil material from the tree planting holes and not used should be removed from the site and disposed of. Soil amendments or replacements should follow the guidelines found in the **SOILS** section.

Installation on Slopes

Trees can be planted on most slopes with some installation modifications. When installing trees on slopes first mark the center point where the tree is to be installed. Excavate half of hole into the hill and use the material from the excavation to create a terrace on the down slope half of the planting hole. The depth and width requirements of the planting hole should follow standard installation procedures. Once the tree is installed in the hole backfilling can begin following standard procedures. Once the root ball is completely planted additional native top soil should be used to build a water retention mound on the lower side of the planting hole. The height of the water retention mount and the amount of soil required will depend on the steepness of the slope. The mound should rise up several inches above the top of the root ball. Mulch the tree heavily to hold the soil in place until the tree is established. Watering newly trees planting on slopes is particularly important as gravity pulls rain water both down and away from the tree. Trees on slopes should be watered daily to weekly depending on the season and rainfall pattern.

Mulching

2 to 4 inches of organic mulch should be spread over the soil surface out to the drip line of the tree. If planting a cluster of trees, mulch the entire planting area. Mulch should be derived from green material consisting of slow-decomposing chipped, shredded, or ground vegetation or clean, processed, recycled wood products. A mulch-free area, near the base of the tree, must be provided to avoid moist bark conditions and prevent rot.

Pruning

At installation pruning should be restricted to removal dead, damaged, or diseased branches and cross branches that may rub.

Staking

In some cases, depending on the species or location, trees may require stakes to maintain stability and stay erect typically on slopes and locations where the tree is exposed to high wind. Tree stakes should consist of a minimum of two wood posts that have minimum dimensions of 2" x 2". The minimum length of the posts shall be the depth of the hole plus one-half the height of the tree. The posts should be installed at least one foot outside the diameter of the tree-planting hole. The tree shall be connected to the posts with a strap designed and installed to prevent damage the tree. All stakes should be removed within one year of planting (or as directed by an arborist or forester) as the wires may girdle tree if not removed when tree is established.

Watering

All trees should be thoroughly watered immediately after installation. Water shall not be applied in a manner that damages plants, plant mulch bed, stakes or adjacent areas. Watering shall not cause uprooting or exposure of plants roots to the air.

Maintenance

Periodic tree maintenance is required to ensure long term survival and health of urban trees, particularly during the establishment period.

Maintenance Agreement and Plan

A maintenance agreement and plan is required. The maintenance agreement should specify the party responsible for maintenance, stipulate the length of time which the agreement is valid, and identify minimum standards for care and any required submittals. The maintenance plan will prescribe the specific maintenance activities and their frequency and will often include a checklist. The key maintenance activities for urban tree planting include regular watering for the first few growing seasons, weeding and mulch replacement, removing staking and tree protection as needed, pruning, and fertilization. Maintenance can also include periodic inspection and tree replacement.

Establishment Maintenance

During the first growing season trees should receive 5-20 gallons of water per week (more for larger trees). Irrigation bags may be used to achieve a slower deeper soaking, however irrigation bags need periodic maintenance to ensure they are full of water and functioning; empty, unmaintained bags can prevent rainwater from soaking into the critical rooting zone. Watering frequency should be increased or reduced based on weather conditions. During the establishment pruning should be limited to branches that interfere with pedestrians, vehicles, or critical site lines.

Long-term Maintenance

Once established urban trees should be periodically (every 2-3 years) inspected for signs of disease or insect damage/infestation. Trees should be periodically pruned to prevent branches from rubbing, prevent conflicts with utilities, roads, structures, or walkways, to promote healthy form, and/or to remove dead or dying branches. Trees may require replacement or supplemental mulch to insulate the soil, retain moisture,

and block weeds; keep grass and weeds out of mulched areas. Trees that are exposed to salt and de-icers may require additional soil management, including additional irrigation, to maintain health.

Pruning

Pruning is important to ensure the health and shape of a tree, as well as to safeguard public safety and maintain visibility. Pruning should follow ANSI A300 (Part 1)-2001 Pruning standards. When pruning an established tree never remove more than one third of the trees canopy. Do not flush cut to the tree trunk, rip branches away from the tree, or stub cut branches, doing so can harm trees by causing decay or by delaying or preventing proper healing. Do not apply paint or wound dressing to pruning cuts. Do not cutting lateral branches between nodes, to reduce crown width. Do not top trees.

Fertilization

Most established trees do not require additional fertilization and newly planted trees should not be fertilized until at least the second growing season and only if needed. If fertilization is required trees should be fertilized in the fall using slow release fertilizers at recommended rates to promote root growth and tree health. Injectable fertilizers may be used in place of broadcast fertilizer however the fertilizer must be injected in the root zone and care must be taken to avoid injecting fertilizer below the trees root zone.

Tree Protection

Some newly planted trees may need additional protection from wildlife and maintenance equipment to facilitate establishment. Typical tree protection measures in the urban environment include cages and tree wraps. Cages cordon off the area where wildlife browse. Cages are usually constructed from chicken wire or other wire or plastic mesh materials, and may need to be expandable to allow for tree growth. Tree Wraps protect the tree's trunk from sun scald, moisture loss, insects, rodents and maintenance equipment. There are several types of tree wraps including a waterproof crepe-type wrap, plastic wrap, and metal mesh. Tree wraps should only be used for short periods and only when necessary to protect tender tree bark.

Resources

- Details for planting, staking, soil modifications, inspection, correction, and irrigation are provided at: http://urbantree.org/details_specs.shtml

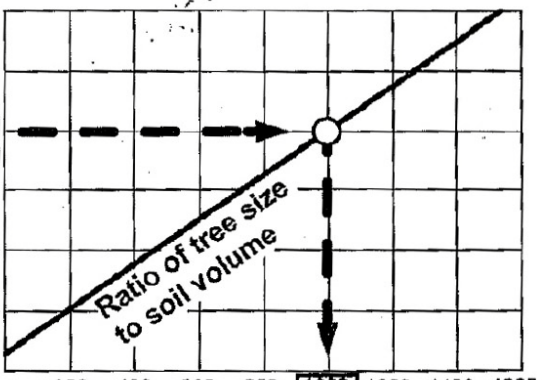
- Summary of soil volume requirements in tree planting specifications from jurisdictions in the U.S. and Canada have incorporated requirements for minimum soil volume into their tree planting specifications. http://www.deeproot.com/blog/blog-entries/soil-volume-minimums-organized-by-stateprovince.

- Soil volume table prepared by James Urban (Up by Roots, ISA Press, 2008):

Ultimate tree size

Crown Spread Sq Ft / *m2*	DBH-Trunk Diameter Inch / *mm*
1200 / *111*	24 / *610*
1000 / *92*	20 / *508*
800 / *74*	16 / *406*
550 / *51*	12 / *305*
350 / *32*	8 / *203*
150 / *14*	4 / *102*

Example: A 16 inch/406 mm diameter tree requires 1000 cu ft/28.3 m3 of soil.



200 / *5.7*	400 / *11.3*	600 / *17.0*	800 / *22.7*	1000 / *28.3*	1200 / *34.0*	1400 / *39.7*	1600 / *45.3*

Soil Volume Required Cu ft / *m3*