Item No. 661S

Soil Decompaction

661S.1 - Description

This work shall consist of performing all required activities for soil decompaction in areas shown on the Drawings or as directed by the Engineer, Landscape Architect, or authorized City of Austin representative. The scope of work includes all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with Soil Decompaction, complete as shown on the drawings and as specified herein.

A. The scope of work in this section includes, but is not limited to, the following:

1. Modify existing site soil.
   a. Modify existing in-situ site soil in place for use as Planting Soil.
   b. Install existing or modified existing stockpiled soil for use as Planting Soil.
2. Install compost and/or other amendments into existing site soil as part of decompaction.
3. Clean up and disposal of all excess and surplus material.

B. Definitions

1. Air tillage, fertilizer, mulch (AFM), as coined by Fite, Smiley, McIntyre & Wells (2011 [i]), is a soil decompaction and amendment process for trees involving decompaction with a pneumatic air tool while simultaneously incorporating organic matter and fertilizer into the soil.
2. **A** horizon: Mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material.
3. Bulk Density Method: A method for measuring soil compaction where bulk density is an indicator of compaction, calculated as the dry weight of soil divided by its volume. Bulk density reflects a soil's ability to function for structural support, water and solute movement, and soil aeration. Threshold results that determine critical bulk density are different for each soil texture. Typical measurement is done with bulk density cores, and the units are in lb./cf or g/cc ^{3} dry weight.
4. Compacted soil: High density soil lacking structure and porosity and characterized by restricted water infiltration and percolation (drainage), and limited root penetration.
5. Critical Root Zone (CRZ): The amount of ground around a tree protected from impacts by the City ordinance. This is defined as a radius around the tree trunk equal to one (1) foot of ground for every one (1) inch of tree trunk diameter when measured four-and-a-half (4.5) feet above the ground (DBH). This area is depicted in the plan as a circle centered on the location of the tree's base.
6. Diameter Breast Height (DBH): Tree diameter measured at breast height, defined as 4.5 feet above average ground level. Field Capacity: The amount of water held in the soil after drainage due to the force of gravity. The volumetric soil moisture content remaining at field capacity is about 15 - 20% for sandy soils, 35 - 45% for loam soils, and 45 - 55% for clay soils.
7. Graded soil: Soil where the A horizon has been stripped and relocated or re-spread; cuts and fills deeper than twelve (12) inches.
8. Penetration Resistance Method: A method for measuring soil compaction based on penetrometry, or soil strength, measuring the resistance of soil surface to vertical force by inserting a rod or penetrometer into the soil. Threshold results that determine critical bulk density are somewhat the same for each soil texture. The typical measurement tool is a penetrometer, and the units are PSI (pounds of pressure per square inch).

9. Permanent Wilting Point: Water content of a soil when most plants growing in that soil wilt and fail to recover their turgor upon rewetting.

Table 661S.1 Wilting Point and Field Capacity by Soil Type

Soil type	Permanent wilt point v/v	Field capacity v/v
Sand, Loamy sand, Sandy loam	5 - 8%	12 - 18%
Loam, Sandy clay, Sandy clay loam	14 - 25%	27 - 36%
Clay loam, Silt loam	11 - 22%	31 - 36%
Silty clay, Silty clay loam	22 - 27%	38 - 41%

Volumetric soil moisture shall be measured with a digital, electric conductivity meter. The meter shall be the Digital Soil Moisture Meter, DSMM500 by General Specialty Tools and Instruments, or approved equivalent meter.

Source: 015639 Tree and Plant Protection Specification (www.isa-arbor.com)

10. Planting Soil: Approved topsoil and topsoil mix as defined in Standard Specification 601S.
11. Scarify: Loosening and roughening the surface of soil and sub soil prior to adding additional soil on top.
12. Soil Ripping: Loosening the soil by dragging a ripping shank or chisel through the soil to the depths and spacing specified.
13. Soil Tilling: Loosening the surface of the soil to the depths specified with a rotary tine tilling machine, roto tiller, or spade tiller.
14. Solvita compost maturity test: A patented environmental measurement system for carbon dioxide and ammonia, the results of which can be used to assess soil health (biology), compost maturity, ammonia volatilization in manure, or grain spoilage due to fungal respiration.
15. Standard Proctor Method ASTM D 698: A method for measuring soil compaction, determining the optimal moisture content at which a given soil type will become most dense, achieving its maximum dry density. Threshold results that determine critical bulk density are the same for each soil texture. A proctor test will typically also provide results as bulk density lb/cf dry weight. Typical measurement tool is a densitometer, and the units are percentage maximum dry bulk density as tested by the standard proctor method.
16. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing Planting Soil.
17. Subsoiling: A soil decompaction method that fractures compacted soil without adversely disturbing plants or topsoil.
18. Surface Soil Compaction: A maximum of six (6) inches deep and the result of traffic, light grading, or other impacts. The original A horizon may have been previously removed or graded but the lower profile is intact with acceptable compaction levels and limited grading. The soil

organic matter, pH and chemistry in the A horizon may not be suitable for the proposed plant and may need to be modified.

19. Subsoil or Deep Soil Compaction: Deeper than six (6) inches, and may be the result of previous grading, filling and dynamic or static compaction forces.

20. Topsoil: Naturally produced and harvested soil from the A horizon or upper layers or the soil.

21. Vertical Mulching: A soil decompaction method for tree root zones involving drilling or air spading a series of shallow holes in the root zone and filling them with compost or other materials.

22. Undisturbed, ungraded soil: Soils with the original A horizon intact that have not been graded or compacted. Examples of undisturbed soils are those that have been farmed by no-till methods; those subjected to fire or logged but not graded; and natural forested land.

Footnotes:

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Fite, K., E. Thomas Smiley, J. McIntyre, & C.E. Wells. 2011. Evaluation of a Soil Decompaction and Amendment Process for Urban Trees. Arboriculture & Urban Forestry 37(6).

661S.2 - Submittals

The submittal requirements of this specification item shall include the test results, information about proposed equipment, and samples necessary for approval of decompaction techniques and methods.

A. Soil compaction testing shall be performed both before and after modification of soil, unless otherwise specified by the Engineer or Landscape Architect.

1. Soil compaction testing shall include written results and mapped locations of tests provided to the Owner. A minimum of two tests per 1,000 square feet are required. Test results shall be reported in PSI or bulk density (g/cm3) unless otherwise specified by the Engineer or Landscape Architect. For surface decompaction, measure at both the surface and at six (6) inches depth. For subsurface decompaction, measure at both six (6) inches depth and three-quarters of the maximum depth of decompaction. For example, if maximum depth of desired decompaction is 15 inches, measure at both 6 inches and 11 inches below finished grade.

B. Provide written information on type and size of equipment proposed to produce the desired decompaction.

C. For any required compost and mulch, provide a one gallon sample of the material with a lab analysis supplied by the producer to the inspector showing that the product(s) meets the requirements. Lab analyses for compost shall be no older than ninety (90) calendar days at the time of submittal.

1. Submit samples a minimum of two (2) weeks before the anticipated date of the start of the compost installation.

2. Samples shall be submitted at the same time as the lab analysis of the material.

3. Producer shall provide a letter stating the length of the composting period for compost, and listing the source materials by volume for compost and mulch.

D. For decompaction work under trees, provide qualified arborist credentials, including proof of certification from the International Society of Arboriculture, licenses, resume and/or references.

661S.3 - Materials

The Contractor shall be responsible for supplying all supplies and equipment in sufficient quantities so as to perform soil decompaction as necessary without delaying construction progress.

A. Compost: Blended and ground leaf, wood and other plant based material, composted for a minimum of nine (9) months and at temperatures sufficient to break down all woody fibers, seeds and leaf structures, free of toxic material at levels that are harmful to plants or humans. Source material shall be yard waste trimmings blended with other plants or other materials designed to produce compost high in fungal material. Non-vegetal source materials may be acceptable upon approval by the Owner. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived.

1. Compost shall be commercially prepared compost and meet US Compost Council STA/TMECC criteria or as modified in this section for "Compost as a Landscape Backfill Mix Component".

   http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/191/LandscapeArch_Specs.pdf

2. Compost shall comply with the following parameters:

PARAMETERS [1]	REPORTED AS (UNITS OF MEASURE)	GENERAL RANGE
pH	pH units	6.0 - 8.5
Soil Salt (electric conductivity)	dS/m (mmhos/cm)	Maximum 10
Moisture Content	%, net weight basis	30 - 60%
Organic Matter Content	%, dry weight basis	30 - 65%
Particle Size	% passing a selected mesh size, dry weight basis	98% pass through ¾ inch screen
Stability Carbon Dioxide Evolution Rate	mg CO2-C per g OM per day	<8
Solvita Compost Maturity Test	Solvita units	>6
Physical Contaminants (inerts)	%, dry weight basis	<1%
Chemical Contaminants [2]	mg/kg (ppm)	Meet or exceed US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3 levels
Biological Contaminants Select pathogens Fecal coliform bacteria or	MPN per gram per dry weight MPN per 4 grams per dry	Meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) levels

Salmonella [3]	weight	

[1] Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, The US Composting Council).

[2] US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3 levels = Arsenic 41 ppm, Cadmium 39 ppm, Copper 1,500 ppm, Lead 300 ppm, Mercury 17 ppm, Molybdenum 75 ppm, Nickel 420 ppm, Selenium 100 ppm, Zinc 2,800 ppm.

[3] US EPA Class A standard, 40 CFR § 503.32(a) levels = Salmonella <3 MPN/4grams of total solids or Fecal Coliform <1000 MPN/gram of total solids.

B. Mulch (hardwood): Mulch shall be coarse-ground and derived from hardwood (e.g., oak, elm) trees and woody brush sources. No more that 25% of the total volume shall be fine particles and no more than 20% of total volume shall be large pieces, where fine particles are defined as less than 3/8 inch in size and large pieces are defined as either larger than 1½ inch in diameter or longer than eight (8) inches. The mulch shall be free from foreign materials.

661S.4 - Construction Methods

A. General. Before initiation of decompaction activities, all required erosion control and environmental measures shall be in place as indicated on the drawings, and the depth(s) and location(s) of underground utilities shall be verified. The surface of the subgrade shall be shaped in general conformity with the typical sections, lines, and grades indicated on the drawings by the removal of existing material or by the addition of approved material as established by the Engineer or Landscape Architect.

This specification covers decompaction of (1) surface soils (0 - 6 inches) and/or (2) subsoil (below 7 inches) as show on the drawings. Requirements for decompaction of soils within the critical root zones of existing trees are also described.

B. The following are general threshold levels of compaction as determined by three compaction testing methods, including the bulk density method, standard proctor method, and penetration resistance method. The penetration resistance values were derived from the measurement of reference and degraded riparian sites across Austin, Texas studied in the Watershed Protection Department's Riparian Functional Assessment project.

Compaction levels that are detrimental to root growth are dependent on soil type, which typically varies from site to site and must be determined by an Engineer or Landscape Architect before testing occurs.

Excellent to Good Compaction: Good rooting anticipated, but increasing settlement expected as compaction is reduced and/or in soil with a high organic matter content.

Fair Compaction: Root growth is limited with fewer, shorter and slower growing roots.

Poor Compaction: Roots not likely to grow but may penetrate soil when soil is above field capacity.

Table 661S.4.1 Comparison of Compaction limits by various methods.

COMPACTION RATING	BULK DENSITY [1]	STANDARD PROCTOR (%)	PENETRATION RESISTANCE (PSI) [2]

	(g/cm ^{3})		
Excellent	<1.10 to	75 - 85%	75 - 125 [3]
Good	<1.60		126 - 175
Fair	1.39 to 1.69	>85%	176 - 225
Poor	>1.47 to >1.80		>225

[1] Root limiting bulk density varies by soil type. See Table SS-661.4.2 for specifics.

[2] Acceptable test methods include ASTM D3441 Standard Test Method for Mechanical Cone Penetration or methods described in references such as Methods for Soil Analysis, Part 1, Physical and Mineralogical Methods, 2 nd ed., EA Klute, ed. (Soil Science Society of America: Madison, WI 1986).

[3] Penetration resistance method: Below 75 psi soil becomes increasingly unstable and will settle excessively.

Table 661S.4.2 Comparison of Root Limiting Bulk Density for Different Soil Types. Source: NRCS 1998 in Dallas and Lewandowski (2003).

Soil texture	Ideal bulk densities (g/cm ^{3})	Bulk densities that may affect root growth (g/cm ^{3})	Bulk densities that restrict root growth (g/cm ^{3})
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams, loams, clay loams	<1.40		>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.10	1.55	>1.65
Sandy clays, silty clays, some clay loams (35 - 45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

C. All soil management activities including amendment and/or decompaction must occur at a soil moisture content between 5 - 20% measured at the depth of the work.

D. Compacted Surface Soil **(0 - 6 inches)** : Tilling. Surface tilling shall not be considered adequate to reduce compaction at depths seven (7) inches or greater below finished grade.

1. After rough grading and removing all plants and debris from the surface, till top six (6) inches with a roto tiller, spade tiller, or other equipment approved by the Engineer or Landscape Architect. Spread three (3) inches of compost on the surface of the tilled soil.
2. Till the compost into the loosened soil. Smooth out grades with a drag rake or drag slip. An even bed, with limited irregularities, lumps or soil clods shall be prepared. Clods or rocks larger than two (2) inches shall be removed.

E. Compacted Subsoil **(7 - 24 inches)** : Soil Ripping

1. After rough grading and removing all plants and debris from the surface, loosen the soil by dragging a ripping shank or chisel through the soil to depths of twenty-four (24) inches maximum. The Engineer or Landscape Architect shall specify the appropriate depth of ripping based on site conditions. Shank spacing varies with soil moisture, soil type, and degree and depth of compaction. Shank spacing shall be as specified by the Engineer or Landscape Architect.
2. At least three (3) separate series or patterns of movement are required.

   (1) The first series or pattern of passes is applied lengthwise, parallel with the longest spread of the site; gradually progressing across the site's width, with each successive pass.

   (2) The second series runs obliquely, crossing the first series at an angle of about 45 degrees.

   (3) The third series runs at right angle or 90 degrees to the first series.

3. Spread three (3) inches of compost or other specified amendment over the ripped area and till the material into the top six (6) inches of the soil surface using a roto-tiller or other approved method. An even bed, with limited irregularities, lumps or soil clods shall be prepared. Clods or rocks larger than 2" shall be removed.

F. Compacted Subsoil **(7 - 24 inches)** : Subsoiling.

1. Drag a ripping shank or chisel thru the soil to depths of twenty-four (24) inches maximum. The Engineer or Landscape Architect shall specify the appropriate depth of ripping based on site conditions. Shank spacing varies with soil moisture, soil type, and degree and depth of compaction. Shank spacing shall be as specified by the Engineer or Landscape Architect. Do not disturb soil or plants in the areas between subsoiled trenches.
2. Fill subsoiled trenches with compost to create a uniform surface grade.

G. Compacted Soil within the critical root zone of existing established trees: Full AFM or Vertical Mulching.

Two techniques are described based on tree location relative to the floodplain and potential for adverse erosion. An International Society of Arboriculture (ISA) certified arborist should oversee work under trees at all times.

Under no circumstances should decompaction work be done in the one-quarter (¼) critical root zone.

1. Remove the tops of all plants to be removed from the root zone. Remove sod with a walk behind sod cutter. Do not grub out the roots of plants to be removed.

2. Prior to beginning work, the proposed area shall be sufficiently wetted twenty-four (24) hours in advance to minimize dust to the greatest extent possible.

3. Use a pneumatic air tool such as an air knife or air spade.

4. Method 1 - Full AFM: In a location outside the floodplain and on slopes of 3:1 or less, use a pneumatic air tool to loosen the top nine (9) to twelve (12) inches of the soil in the entire dripline. In cases where nine (9) to twelve (12) inches is not attainable (i.e., shallow soil), apply aeration to the depth of soil present. Surface roots may move and separate from soil during this process but the bark on roots should not be broken. Make chemical adjustment as recommended by the soil test and as recommended by an ISA arborist or Landscape Architect. Any fertilizer treatment should be per a certified arborist. Add three (3) inches of compost over the soil immediately after aeration. Use a pneumatic air tool to mix the compost into the top six (6) to eight (8) inches of the loosened soil. Apply a minimum of three (3) inches of shredded hardwood mulch across the entire treatment area, but kept back one (1) foot from the trunk.

5. Method 2 - Vertical Mulching: This technique is suitable for a floodplain or other location subject to adverse erosion. Use a pneumatic air tool to make one (1) inch minimum diameter holes to a depth of ten (10) to twelve (12) inches with holes three (3) feet on center from the half critical root zone (CRZ) to the dripline. Funnel compost into the holes. Apply three (3) inches of shredded hardwood mulch across the entire treatment area, but kept back one (1) foot from the trunk.

6. Work in sections such that the entire process - including any proposed irrigation - can be completed in one day for each section. Apply ten (10) gallons of water per inch in diameter of DBH over the loosened soil at the completion of each day's work except during precipitation events of half inch or greater. During drought or other prolonged dry periods, continue to provide supplemental water for one (1) to three (3) weeks minimum after treatment.

7. Decompacted tree root zones should be access-restricted for one year using aluminum posts and chain barriers, at minimum, or approved equal. The barriers shall be erected at the edge of the decompacted zones around an entire tree or tree cluster, per the plans, without driving posts into major roots (3-inches diameter or greater).

H. Protection of Decompacted Soils: After any decompaction activities have taken place do not pass motorized equipment or stockpile construction materials or equipment on previously decompacted soil.

The Contractor shall protect decompacted soil from damage including contamination and re-compaction due to other soil installation, planting operations, and operations by other Contractors. Maintain protection of decompacted areas until project acceptance. Utilize fencing and matting as required or directed to protect the finished soil work. Treat, repair or replace damaged decompacted soil immediately.

I. Repair of Re-compacted Soils: After decompaction has taken place, any soil that becomes re-compacted to a density greater than 225 psi shall be decompacted again.

1. Loosen compacted soil and replace soil that has become contaminated as determined by the Engineer or Landscape Architect. Re-compacted and/or contaminated soil shall be loosened or replaced at no expense to the Owner.

2. Where modified existing soil has become compacted or contaminated and needs to be replaced, provide imported soil that is of similar composition, depth and density as the soil that was removed.

661S.5 - Measurement

All acceptable surface and subsurface decompaction will be measured by the square yard.

Existing soil that is modified by tilling, or ripping shall have a density to the depth of the modification, after completion of the loosening, such that the compaction readings at each tested location are in the

Excellent to Fair ranges as defined above, at soil moisture approximately the mid-point between wilting point and field capacity. Soil that is modified by subsoiling shall have trenches of uniform depth and spacing throughout the subsoiled area.

661S.6 - Payment

Payment for Soil Decompaction shall be made according to the unit price for completion of all components necessary to decompact work areas, and shall include all labor, tools, equipment, water, measuring devices, testing, materials, supplies, and incidentals to complete the work:

Item No. 661S-A	Compacted Surface Soil: Tilling	Per Square Yard
Item No. 661S-B	Compacted Subsoil: Ripping to a depth of (x) inches	Per Square Yard
Item No. 661S-C	Compacted Subsoil: Subsoiling to a depth of (x) inches	Per Square Yard
Item No. 661S-D	Compacted Surface Soil: Root Zone - AFM	Per Square Yard
Item No. 661S-E	Compacted Surface Soil: Root Zone - Vertical Mulching	Per Square Yard
Item No. 661S-F	Aluminum post and chain barriers for trees	Per Linear Foot

End