

TOPSOIL MANAGEMENT GUIDANCE



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INTRODUCTION

Grading and construction activities can leave the ground surface devoid of adequate or suitable topsoil to support desirable vegetation communities. This document provides guidance to create favorable topsoil characteristics through proper assessment, design, and construction. The intent is to help establish healthy, dense vegetation in soil that provides necessary organic matter, nutrients, and moisture availability. This combination of good soil and healthy vegetation encourages infiltration and retention of rainwater – in turn reducing stormwater runoff, enhancing water quality, and conserving irrigation water. This guidance will also help projects achieve revegetation goals more quickly and consistently.

Favorable topsoil has the following characteristics:

- 1 Loamy soil textures, consisting of a balanced blend of sands, silts, and clays that promotes infiltration while retaining moisture and nutrients.
- 2 Appropriate soil chemistry with adequate organic matter and soil nutrients, appropriate pH, low sodium/salinity, and no contaminants.
- 3 Uncompacted soils provide structure and ample porosity to maintain air and water permeability and facilitates deep root penetration.
- 4 Supportive of soil floral and faunal communities, with an emphasis on microbiological contributions to nutrient cycling.
- 5 Minimal weed seeds and free of noxious and potentially damaging invasive species.

There are beneficial relationships between soil, vegetation, and organisms within the root zone. High quality, porous soil promotes healthy, self-sustaining vegetation instead of relying on supplemental inputs such as irrigation and fertilizer. Healthy vegetation, in turn, stabilizes the soil surface against erosion, creates surface roughness to slow the runoff of water, provides pathways for water and air to enter the soil, and returns organic matter to the soil. Microorganisms help create a supportive environment for soil and roots, aiding plant growth and helping to improve soil characteristics over time.



ASSESSMENT

DESIGN

CONSTRUCTION

In general, two factors influence how topsoil performs as a growth medium. One is the quality of the topsoil (as detailed in Table 2). The other is the depth of the topsoil. The higher the quality of the topsoil and the greater the depth in relation to the root zone, the better the soil will support healthy plant growth and encourage infiltration.

Creating Favorable Topsoil Conditions

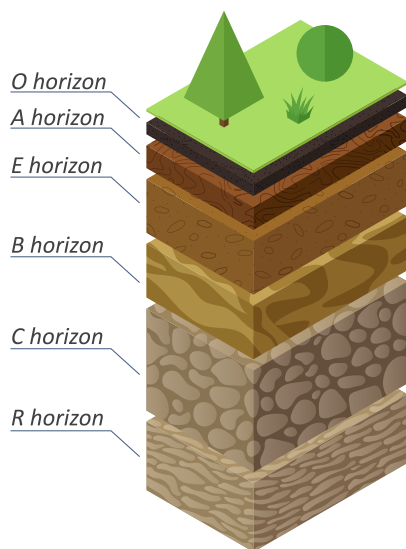
Creating favorable topsoil conditions for a project takes place within three phases:

- **Assessment.** Assess existing topsoil conditions to identify the location, depth, and quality of existing topsoil.
- **Design.** Prepare a topsoil plan showing the area and depth of topsoil stripping and the area and depth of topsoil placement. Specify amendments, decompaction, weed management, and irrigation requirements.
- **Construction.** Implement the topsoil plan during construction by establishing good communication and coordination with the contractor to ensure a clear understanding of the plan requirements. Preserving favorable topsoil and placing it per the drawings and specifications are critical and construction methods should avoid compaction.

Description of Soil

Soil is a natural substance comprised of various solids (minerals and organic matter), liquid, and gases that occur on the land surface. It is characterized by layers or horizons that form the soil profile. Among other things, soil horizons differ from one another based on their thickness, color, texture, and mineral and organic content. Generally, soil profiles include the following horizons (starting at the ground surface):

- **O – Humus or organic.** Dark, mostly organic matter such as decomposing leaves. May or may not be present.
- **A – Topsoil.** Mineral and organic matter. This horizon is where most root activity occurs and is usually the most productive layer of soil.
- **E – Leaching layer.** Light in color due to water leaching out and transporting minerals and nutrients as it moves through the layer. May not be readily apparent.
- **B – Subsoil.** Lighter, denser, and with less organic material than the A horizon, although roots may extend into the B horizon. Horizon in which clay from above accumulates. In arid climates, the B horizon can contain high levels of calcite (caliche).
- **C – Substratum.** Partially disintegrated parent material (bedrock) and mineral particles.
- **R – Bedrock**



BENEFITS OF GOOD TOPSOIL

- Promotes the establishment of healthy, resilient vegetation.
- Reduces stormwater runoff.
- Enhances stormwater quality through filtration, adsorption, and plant uptake.
- Aids water conservation by increasing moisture retention and reducing the need for supplemental irrigation.
- May increase deep infiltration and groundwater recharge.
- Helps achieve revegetation goals on disturbed sites, thereby reducing erosion.

LIMITATIONS

- Additional effort is needed to assess existing soil conditions and to create favorable topsoil conditions on a finished site.



APPLICABILITY

This guidance applies to commercial and residential development projects, public works projects, and all other types of land-disturbing activities. Selection and placement of favorable soils is particularly essential where the stormwater management goal is to reduce the water quality capture volume (WQCV) by directing runoff from roofs and pavement to receiving pervious areas (grass buffers, rain gardens or bioretention, swales, or other vegetated

areas) using the methodology in the Urban Storm Drainage Criteria Manual (USDCM) (See Fact Sheet T-0 in Chapter 4 of Volume 3). This guidance document does not apply to urban agriculture sites (e.g., community gardens), as these soils will need to meet a higher standard for human health (e.g., contaminant type and concentration). Guidance on soil criteria for urban agriculture can be found in EPA (2011).

ASSESSMENT

During the assessment phase of the project, investigate existing topsoil by reviewing readily available information and then collecting and analyzing field samples. Include texture and nutrients in the lab analyses. See Table 1 for detailed recommendations. Use these results to determine if the topsoil is suitable as-is, needs amendments, or (in some cases) is unsuitable for use.

ASSESSMENT

DESKTOP ANALYSIS

- NRCS Soil Surveys
- Other Soil Reports
- Prior Land Use

SOIL SAMPLING

- Field Sampling Plan
- Collection of Soil Samples

AGRONOMIC LAB TESTING

- Test soil samples for:
 - » Texture
 - » Nutrients

INTERPRET RESULTS

- Assign Topsoil Category
- Assess Soils for Amendments

The goal of the evaluation of the NRCS Web Soil Survey is to develop an initial understanding of the location and extent of the most desirable site soils. This information should always be verified onsite.

Desktop Analysis

Investigate various sources of information and determine if favorable topsoil might exist on the site. Three main categories of information may exist: U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) soil surveys, other soil reports such as geotechnical investigations, and prior land-use records and documents. This initial analysis can be helpful in understanding what to expect at the project site, although a site-specific assessment will still be required to inform the design process with accurate information; all other sources provide indirect and possibly outdated data and are thus considered less reliable. The benefits of investing resources in the proper assessment of a site will likely outweigh capital losses (e.g., poor project outcomes) due to a lack of accurate data at the front-end of the project.

NRCS Soil Survey: For many sites outside of heavily urbanized areas, data on soils are available in published soil surveys from NRCS. These surveys typically cover the geographic extent of an individual county. However, urban soils are typically not well-described nor characterized in county soil surveys. Further, land-use change since the published date of the soil survey may have significantly altered the surficial soils. Some areas may be excluded from the surveys, and, in some cases, surveys cover narrower or broader geographic extents. This information has been published in paper form for several decades, but data for most areas can be most efficiently accessed using the NRCS Web Soil Survey.

Use the Web Soil Survey Reports to create customized reports specific to project needs and your area of interest. The following parameters are useful (when available) to give a general idea of the characteristics the on-site soil may possess if applicable to the site, but each parameter must be field verified.

- Map unit soil description (describes texture – clay loam, loam, etc. and other general information).
- Hydrologic Soil Group (HSG): Map units are assigned to HSGs based on runoff potential and similarity of physical characteristics. B and C soils are generally a good starting point for favorable topsoil; A and D soils are generally unsuitable as a growth medium (A soils being too sandy to hold moisture needed for plants and D soils being too clayey to enable desirable infiltration).
- Depth to the seasonal high water table.

Project sites may contain several different soil types that can vary widely with respect to quality. The goal of the evaluation of the NRCS Web Soil Survey is to develop an initial understanding of the location and extent of the most desirable soils on site. Validation of any initial conclusions based on the Web Soil Survey (indicating good or poor soils) in the field is vital.



Soil Report and Prior Land Use Review

Geotechnical investigation reports prepared for a site may provide useful information. This is especially useful to understand the nature of (subsoil and parent) materials at the proposed depths of excavation and the possible composition of fill materials. The reports may provide the depth of existing topsoil; however, these investigations primarily focus on geotechnical rather than agronomic characteristics of soil and require supplementary sources of information to determine topsoil quality. Keep in mind that geotechnical descriptions of soil characteristics are based on a different vocabulary — nomenclature that differs from how soils are described for agricultural, landscaping, or restoration applications. A consulting soil scientist or geotechnical consultant can help translate these different frameworks.

In addition to geotechnical investigations, a search of prior land uses may prove beneficial to locate potential areas of poor-quality topsoil to avoid. Recently demolished properties may contain significant amounts of construction debris and fill, and possibly underground foundations may still be present (EPA, 2011). Historical records may indicate previous structures. Agricultural or livestock land use results in high salt levels, or other contaminants within the upper soil layers. This guidance document does not address the process for site remediation of contaminated soil. This may be necessary when the history of a location (previous industrial use) indicates the possibility of contamination by hydrocarbons, heavy metals, lead, pesticides, or other contaminants. The Colorado or USEPA Brownfields program can provide further information about remediation.

Prior Land Use

Researching prior land uses can help inform topsoil quality and potential contamination issues.

Resources:

- » Google Earth historical imagery
- » Photogrammetric services
- » Real estate photos
- » County tax and permit records

What to look for:

- » Land-disturbing events
- » Irrigation patterns
- » Flooding/alluvial events
- » Seeps/high groundwater
- » Spatial & temporal changes in vegetation
- » Contamination sources

Soil sampling in the field

Having acquired a preview of the types of soil that may exist onsite using the NRCS Web Soil Survey and other references, the next step is to field verify what type of soils are onsite by developing a soil-sampling plan and collecting samples.

Soil sampling plan: Observe the site. Take note of land cover, the extent of vegetative cover, any obvious signs of poor quality fill (debris, etc.), the total area requiring fill, and other data that will inform the type and volume of topsoil. Aerial photography may provide this information but observing a site during a field visit is ideal. Combine information from the NRCS Soil Survey and other surveys with this information to create a soil sampling plan. Before sampling, estimate the amount of topsoil needed and scale the scope for the topsoil investigation accordingly. The number of samples will vary from site to site and depends on how much topsoil is needed. The sampling plan can be a simple markup of the soil survey mapping information or as detailed as an overlay of soils data (GIS/CAD) on the development plan.

Collection of soil samples: A soil auger (Photo 2) will collect soil samples several feet deep, deep enough to extend through the topsoil and into the subsoil. Use extension rods if a deeper profile is desired. Although a full detailed verification of the exact soil series present would require digging a pit and exposure of an undisturbed profile, the auger samples allow determination of texture and horizon depths.

Besides providing a means to visually observe the soils, the purpose of augering is to gather samples for laboratory analysis of parameters listed in Table 1. Although skilled practitioners may be able to determine soil texture in the field by sight and feel, a soil particle size analysis (by laboratory analysis) will confirm the soil textural class (e.g., sandy loam, loam, etc) based on plotting the percent sand, silt, and clay on a US Department of Agriculture (USDA) soil triangle, discussed in the following section.



Photo 2.
Example of an auger used for clayey soils. Augers for sandy soils do not have side openings.
(Muller Engineering)



Photo 3. Soil profile re-creation using a 4" PVC cut in half.
(Muller Engineering)

Augering depth: To assess surface soils for suitability as a growing medium, auger to a depth of at least 2 feet, going deeper if needed to penetrate 6 inches into the underlying subsoil (distinct from topsoil). Use this to identify if soils under the organic layer can be used to supplement topsoil (with some amendment) and determine if the subsoil is suitable for the root zone or if problematic issues such as high salinity are present. Auger deeper if needed to supplement information on the water table (in the absence of or to supplement geotechnical borings). A helpful technique is to lay cores of soil material in a section of half-round 4" PVC to recreate and photograph the soil profile (Photo 3). Photographs help document clear transitions between color, soil structure, or soil texture and separate soil samples by the horizon.

Number of holes to auger. The following guidelines are useful to determine how many holes to auger based on the size of the area that will need to be revegetated and the number of distinct types of soils anticipated.

- With the initial site plan in mind, determine which locations/areas will be disturbed, will need revegetation, and will be used for infiltration practices (infiltration practices require sandy textures such as sandy loam).
- Identify areas with different topography, vegetation, known disturbance history, and general soil condition; sample approximately one borehole for each area or up to three for a larger homogeneous site.
- Vegetation type or density can provide clues as to the presence of various types of soil conditions. Not surprisingly, the healthiest, most dense vegetation is often an indicator of suitable soils (and indicate a good location for sampling) and sparse growth of desirable species and prevalence of weedy or invasive species can indicate poorer soils.
- Verify the general correspondence to the soil survey information (if applicable).



Sampling tools must be clean and free of rust. Collect the subsamples in a plastic or stainless steel container. Do not use galvanized or brass equipment of any kind as they may contaminate the samples with micronutrients. (Soil Sampling Fact Sheet No. 0.500, CSU)

Number of samples for each auger hole. Place samples from 6-inch depth increments in labeled and plastic bags (4 cups of soil for each sample in quart or gallon size sealable bags). Use a waterproof marker to label the hole number and the depth of the sample on each bag.

As mentioned, auger to a depth of at least 2 feet, going deeper if needed to auger 6 inches into the underlying subsoil (distinct from topsoil). Collect at least one separate sample of the underlying subsoil.

Sample handling. Air-dry soil samples within 12 hours. Air drying samples prevents microbes from mineralizing soil organic matter that can cause less accurate results. (Soil Sampling Fact Sheet No. 0.500, CSU)

Number of samples for testing. Not all the sample bags need to be analyzed by the lab. Although the number of samples sent to the lab is up to best professional judgment, here are some guidelines.

- Mix several uniform depth samples to create one representative topsoil sample for an auger hole.
- If surface soils appear uniform for more than one 6-inch depth unit and distinct from any underlying soils, the uniform samples can be combined. However, when in doubt concerning uniformity at various depth intervals, send several depth samples from a single auger hole to the lab and let the test results indicate the degree of uniformity over depth.
- Test at least one sample from at least one auger hole within each distinct soil surface type.
- Send at least one sample of each distinct subsurface soil type per auger hole to the lab for testing. This is to check the suitability of the subsoil as a growth medium for the roots that penetrate this zone. Review to determine if problematic issues such as high salinity or otherwise incompatible parent material are present.

Agronomic lab testing

MHFD recommends two categories of soil tests by the agronomic lab – texture and nutrients. These tests are performed to identify soil texture, salts, pH, organics, and available nutrients. Table 1 provides a list of recommended soil test parameters, all of which are routine for agronomic soil analysis labs in Colorado.

Interpret results

After receiving lab analysis, organize test results into groups corresponding to each NRCS mapping unit or unique soil type found in the field. The variability or uniformity of results will identify how many distinct soil types were encountered.

Classifying soils based on Table 2. For each soil type, use the results of the lab analyses to classify the tested parameters as Unsuitable, Marginal, Suitable, or Ideal based on Table 2. If several samples from the same soil unit or type were tested separately, it is acceptable to average the results to classify the soil for that type.

Soil texture. Determine soil texture using the test results for percent sand, silt, and clay-based on particle size and the USDA Soil Triangle in Figure 1. For example, to classify a soil with 35% sand, 45% silt and 20% clay, first find the percent sand on the bottom of the triangle (35%). Follow the line up and to the left until it reaches the horizontal line on the clay axis (20%). Note that the line that goes up and to the right is equal to the silt concentration (45%). Based on the soil triangle, this combination is loam soil.

The other soil parameters listed in the table contain ranges for each soil category (Unsuitable, Marginal, Suitable and Ideal). A particular soil sample may have parameters falling in more than one category. The results provide a sense of the overall quality of the based on the majority of parameters falling in a particular category.

Soil Parameter Classification	Properties Tested and Reported
Texture (Particle Size Analysis)	<ul style="list-style-type: none"> » % Gravel (material retained in #10 Sieve) » % Coarse Sand (passing #10 and retained in #35 Sieve) » % Medium Sand (passing #35 and retained in #60 Sieve) » % Fine Sand (passing #60 and retained in #270 Sieve) (the sum of Coarse, Medium, and Fine Sand comprises % Sand) » % Silt (by Hydrometer Method) » % Clay (by Hydrometer Method)
Nutrient related tests	<ul style="list-style-type: none"> » Salts (Salinity electrical conductivity (EC) in mmhos/cm) » Sodium Adsorption Ratio (meq/100g soil) » Organic Matter % » pH (units) » Calcium Carbonate Equivalent (%) » Available Nutrients (ppm) <ul style="list-style-type: none"> • Nitrate Nitrogen • Phosphorus • Potassium • Iron • Copper • Zinc

Table 1. Soil test parameters and properties tested and reported.



Figure 1. USDA Soil Triangle (Soil Texture Calculator). (Source: Natural Resource Conservation Service)

Parameter Classification	Parameter No.	Soil Parameter	Test Name	Topsoil Category			
				Unsuitable	Marginal	Suitable	Ideal
Texture							
	1	Texture: % material retained in #10, #35, #60, #270 sieves % Silt % Clay	Sieve sizes based on the USDA soil classification system, silt and clay percent	sand, clay (>45%)	sandy clay, loamy sand, silty clay, silt loam, silt, clay (40-45%), and silty clay loam	sandy clay loam, and clay loam	sandy loam, loam ¹
	2	Gravel >2 mm or #10 sieve	based on the hydrometer method	>70	>40 - 70%	10 - 40%	<10%
Salts/Sodium							
	3	Salinity/Salts (EC) dS/m or mmhos/cm	Saturated Paste	>4	>3 - 4	2 - 3	<2
	4	Sodium Adsorption Ratio (SAR)	USDA 60 6(20b)	>13	>8 - 13	8 - 4	<4
Organic Matter Content							
	5	Organic Matter (%)	ASTM D2974	N/A ²	<1%	1% - 2%	>2%
Soil pH							
	6	pH	ASA/ASHTO	<5.0 or >9.0	5.0 - <5.5 and >8.5 - 9.0	5.5 - 6.0 and 8.0 - 8.5	>6.0 - <8.0
Nutrients							
	7	Calcium Carbonate (CaCO ₃)/Lime	Calcium Carbonate Equivalent (USDA 60 6(23c))	>10%	>2% - 10% (High)	1 - 2% (Medium)	<1% (Low)
	8	Nitrate Nitrogen (ppm)	ASA2 33-3	N/A ²	<10, >30 ³	10 - <20	20 - 30
	9	Phosphorus (ppm)	Ammonium bicarbonate-DTPA test	N/A ²	<8	8 - 15	>15
	10	Potassium (ppm)		N/A ²	<60	60 - 180	>180
	11	Copper (ppm)		N/A ²	<0.2	>0.2	>0.2
	12	Zinc (ppm)		<0.5	0.5 - 1	>1.0 - 1.5	>1.5
	13	Iron (ppm)		N/A ²	<5	5 - 10	>10

Table 2. Soil Test Parameters and Quality Classification

Note: This table is intended to evaluate native soils without amendments

¹ This table is for use regarding plant growth and establishment; if selecting topsoil for its erosion resistivity in a stream channel or area subject to the flow of water, a sandy clay loam or clay loam may be more desirable than sandy loam or loam due to its greater cohesive strength.

² N/A -No value is unsuitable and the soil parameter can be amended.

³ Excess nitrogen in the soil can lead to excessive weed growth. Weed management following construction is always critical, especially if topsoil contains high nitrogen levels.

Assess soils that could be improved by amendments.

Several of the parameters, such as organic matter, nutrients, or even pH, can be amended to change the quality from Marginal to Suitable or Ideal. Listed below are options for amendments to improve the quality of topsoil. A qualified soil scientist or ecological consultant should be engaged to specify amendments.

If soil is classified as Unsuitable in any soil parameter, it may not be feasible to amend and should not be used as topsoil or placed within the top 18 inches of the final grade; it may be placed below non-vegetated areas (as long as it is acceptable for subgrade material) or located below the planting zone (deeper than 18 inches). If soil is found to be contaminated, it should not be used as topsoil or amended; depending on the level of contamination, it may need to be removed from the site and properly disposed of.

Use existing onsite topsoil when feasible and consider alternate sources from offsite areas to supplement inadequate amounts or quality of onsite soil. Imported topsoil will still require the desktop analysis, sampling, and testing steps described above. Mix imported topsoil with stored topsoil at the project site (even if onsite topsoil is marginal) to lessen the biological restart time of the imported soil.

Texture. Sandy and clayey soils in the Marginal category are addressed below.

Sand texture. Sandy soils are problematic due to poor moisture-holding capacity (relatively low field capacity). Sandy topsoil in the Marginal category comprised of fine sand (at least 70% passing the #35 (0.5 mm) sieve) may be mixed with finer-textured topsoil (loams) to move from Marginal to Suitable. However, this requires a mixing facility, a quality assurance process, and adds cost.

Clay texture. Clayey soil in the Marginal category is problematic due to extremely low infiltration rates and the tendency to lead to wet, boggy conditions that are difficult to manage. The addition of weed-free Class A (per STA Certification) compost may be useful in improving clayey soil textures from Marginal to Suitable.

Salts/Sodium. Amending soils high in salts or sodium that are in the Marginal category will not make them suitable; however, mixing with other soil low in salts may. MHFD recommends testing again after mixing. Consider salt-tolerant species of vegetation when selecting plantings. In situ application of gypsum followed by irrigation may also remove soluble salts. However, importing topsoil may be necessary.

pH. If a soil has a low pH and is in the Marginal category, adding agricultural lime per the specifications of a qualified soil scientist or environmental professional may raise the pH to suitable levels.

Organic Matter. Amending soils low in organic matter with an approved Class A compost, humate, or biochar may help move the soil into the Ideal category. Amending with compost is a common practice; refer to the Revegetation Chapter of the Mile High Flood District's Urban Storm Drainage Criteria Manual, Volume 2 for more information on amending with compost.

Nutrients. Amending soils low in nitrogen or phosphorus with fertilizer can improve nutrient composition. However, take care when specifying fertilizer types and application rates to avoid stimulating excessive weed growth. Use a slow-release organic fertilizer such as Biosol.



DESIGN

The goal of the design phase is to develop a topsoil plan to incorporate onsite or imported topsoil at the project site.

Estimate quantity needed

Determine areas of grading and new vegetation from the site plan. Estimate the quantities of topsoil required based on an initially assumed depth of topsoil placement, or a range of possible depths. The recommended minimum depth of topsoil is 6 inches. However, if adequate quantities of topsoil are available, 9 to 12 inches will provide more optimum growing conditions.

Compare quantities needed for the proposed site with quantities of available topsoil types of the highest quality. Confirm the total quantity of topsoil needed and the individual quantities of each soil type to be used. Use the highest quality topsoil in the areas where healthy vegetation establishment is most critical.



DESIGN

DETERMINE QUANTITIES OF AVAILABLE AND REQUIRED TOPSOIL

- Determine proposed areas of grading and vegetation and depth of topsoil required
- Compare required topsoil quantity with available topsoil

DEVELOP TOPSOIL PLAN

Stripping

For each distinct topsoil type define: areas, depths, quantities

Replacement:

For each distinct topsoil type define: areas, depths, quantities

Specifications:

Topsoil handling (stripping, storage, phasing, etc.) Define amendments



Develop topsoil plan

Prepare Topsoil Stripping and Replacement Plans. First, delineate areas that will not be disturbed and specify construction fence and markers to prevent equipment access in these areas. This could be done as part of the Erosion and Sediment control plan or could be part of the Topsoil plans. Prepare, a Topsoil Stripping Plan delineating the areal extents of each distinct topsoil type and respective topsoil depths (stripping depth may be a constant number or point depths can be indicated for a variable stripping depth) and quantities. Label each soil type with an identifier. Next, prepare a Topsoil Replacement Plan delineating the aerial extents of each topsoil type and indicating topsoil placement depths and quantities using the best available topsoil in the most strategic locations. Depending on site complexity, determine if these two drawings can be combined or kept separate for clarity.

Avoid general notes for stripping and replacement instead of detailed plans showing specific areas and depths to strip/salvage/replace topsoil. Reflect these quantities in cubic yards in the bid list for the project.

Determine Amendments and Prepare Topsoil Specifications.

Prepare construction specifications by addressing the following items.

- **Stripping Operations:** Salvage soils in a moderately moist to dry condition. Stripping wet soils (greater than field capacity) or overly dry soils will damage the soil structure and make it very difficult to create suitable seedbed conditions.
- **Phasing/rotation plan:** Strip only a portion of a site of topsoil at any one time. Where feasible the plan should identify an initial area to be stripped and stockpiled and subsequent areas to be stripped and directly replaced in single operations on completed portions of the site grading. Include this plan in the stormwater management plan as per the Construction General Permit for Colorado (COR400000).
- **Storage procedures and protection:** If necessary, to store soils, place the storage piles in protected "no drive" areas and placard as "topsoil" or "subsoil". Piles should be uncompacted, seeded, and low in height, ideally no higher than four feet. Temporary seeding of stockpiles with a sterile grass allows biological processes to continue, reduces moisture losses, protects against wind and other types of soil movement/losses, and reduces the proliferation of undesirable weeds. Specify seeding of stockpiles and seed immediately after construction with a locally approved mix (e.g., 2 lb per 1000 sq.ft. of Italian Rye (*Lolium multiflorum*)). Italian rye is an annual with no significant chance for reseeding itself in the Denver area. No other rye should be used and under no circumstances should cereal rye (*Secale cereale*) be used. This is an invasive weed.

- **If present, leave woody material in topsoil:** Tree roots, rotting bark, etc. Woody material provides an inoculum of beneficial fungi and bacteria that will help the site restore biological balance and support new plant life. If existing topsoil is scarce, it is better to mix it with imported topsoil for the same reason.
- Do not use topsoil to create berms, access ramps, etc.
- Do not apply chemicals (e.g., fungicide) that would damage the biota of the topsoil.
- **Decompaction of subgrade and topsoil:** Soil compaction is a very serious problem on construction sites. The process of soil placement must include repeated ripping of subgrade prior to topsoil placement to relieve compaction within the planting zone (within the upper 18 inches of final grade). Although the relationship of growth-limiting bulk density to "Standard Proctor" compaction specifications is somewhat loose, a "percent of Standard Proctor" value of 85% is generally the upper limit for any significant plant growth suitability. Target values below this threshold within the planting zone. Contractors should place topsoil in a manner that precludes having to continuously drive over or repeatedly compact the newly placed topsoil. Newly exposed soil should be stabilized to prevent erosion.
- **Specifications for amendments:** Tailor specifications for amendments to the particular requirements of the existing onsite soils. Use the amendments to move certain topsoil parameters from the Marginal range into the Suitable or Ideal range.

Determine the need for import

Identify potential sources of imported topsoil and obtain, test, and evaluate samples using the same procedures as described for onsite sources of topsoil. Take care to assess the presence of problematic weeds and invasive species in imported sources of topsoil.



CONSTRUCTION

During the construction phase, discuss the topsoil plan with the contractor before grading operations. This type of plan may be a new concept for the contractor. Ensure a good understanding before disturbing the soil.

Pre-bid and Pre-construction meetings

Meeting with the owner and contractor to review plans and specifications is an important step before construction begins. Clear communication of the topsoil-related topics below will help convey expectations and verify that the topsoil plan is understood. Depending on the complexity of the site or specifications, additional topics may be required. Suggested topsoil-related topics:

- Stripping plan and salvage of suitable topsoil.
- Clearing and grubbing and allowable woody and organic material in salvaged topsoil.
- Replacement plan/placement depth; the rationale for using the best available topsoil in strategic locations.
- Construction phasing/topsoil phasing to encourage “rotational” stripping and placement to reduce stockpiling and double handling.
- Compaction avoidance and decompaction of subgrade and replaced topsoil.
- Stockpile locations, depths, temporary seeding.
- Amendment types and quantities.
- Observation milestones.
- Inspection requirements and documentation.
- Points of contact.

CONSTRUCTION

PRE-BID/PRE-CONSTRUCTION MEETING

- Develop agenda of topics based on project specific needs
- Review plans and specifications

OBSERVATION

- Determine frequency of observation
- Determine key points of observation

Observation

The following milestones in the implementation of the topsoil plan merit field observation (perhaps multiple times) on the part of the designer to ensure that the intent of the plan is achieved:

1. Before disturbance: Use construction fence and markers to prevent equipment access in areas that will not be disturbed. Ensure these areas are sufficiently restricting construction traffic.
2. During stripping operations: Verify depths of stripping to confirm the type and extents of topsoil and to coordinate any field adjustments to stripping locations and depths.
3. After a portion of the site subgrade is at finished grade and scarified: Approve scarified subgrade before placing topsoil. This will facilitate rotational stripping and placement and reduce topsoil stockpiling and handling.
4. As the contractor stockpiles: Confirm maximum height, decompaction efforts, and erosion control/seeding approaches.
5. During (ongoing) subgrade preparation and decompaction/scarification: Accept prepared subgrade before topsoil placement.
6. During amendment: Confirm types, rates, and depth of mixing.
7. Before placement of imported topsoil: Observe topsoil before placement and confirm that topsoil conforms to the submitted and approved imported topsoil characteristics.
8. During topsoil placement: Confirm placement locations, depths, decompaction efforts, and adherence to maximum density specifications.
9. During seeding and mulching operations: Confirm appropriate application rates and methods.



CASE STUDY

LEMON GULCH TOPSOIL MANAGEMENT PLAN

The Lemon Gulch project in Parker, Colorado followed these topsoil management recommendations to assess, design and implement a topsoil plan. The existing topsoil within the channel corridor was sparse, coarse, and granular, which did not support a desirable grass cover or offer much resistance to erosion during flow events. The adjacent development needed additional fill dirt that made it attractive for the developer to excavate material to widen the floodplain. The development area contained excess topsoil which could be placed in the floodplain to help establish vegetation and stabilize streambanks. The design team used methods in this guidance document to determine if the topsoil was appropriate for the stream portion of the project and what (if any) amendments were needed.

ASSESSMENT

Desktop Analysis

During the assessment phase, the NRCS web soil survey helped define potential areas to investigate in the field (Figure 2). The predominate soil textures according to the soil survey were sandy loam and clay loam. No historical photos of development or known contaminate sources were available.

Soil Sampling

Based on a field visit, no significant topographic features were identified. The land was relatively flat, existing vegetation was predominantly grasses, and in some locations, there were large stands of invasive species (mullein) which can often indicate poor soils. The team plotted four sample/auger locations based on web soil survey information (two samples per NRCS soil type), topography, and vegetation. (See Figure 3.)

Soil Analysis

The soil from each auger hole was placed in quart-size plastic bags (Photo 4) and sent to the lab for analysis. Generally, samples from the following depths were placed in separate bags: 0" to 6", 6" to 15", and 15" to 36". Results are reported in Table 3, Table 4, Figure 4, and Figure 5 for one of the representative auger hole samples.

The results indicated that minimal amendments were needed for this source of topsoil. The plan to strip topsoil from the adjacent development area and place it within the stream project area would help create more stable floodplain benches and stream banks. Even though the texture of the topsoil in the development area was rated suitable (rather than ideal) in the parameter table, the clay loam topsoil is better suited than sandy loam or loam for resisting water erosion due to its greater cohesive strength. This is noted in the footnotes of Table 2.



Figure 2. Web soil survey map



Figure 3. Soil Sampling Plan



Photo 4. Auger hole sampling in the field.

CASE STUDY CONTINUED

LEMON GULCH TOPSOIL MANAGEMENT PLAN

Parameter	Result	Units
Texture	Clay Loam	Unitless
Gravel	0%	Percent
Salts	0.5	mmhos/cm
SAR	0.9	Ratio
Organic Matter	2.1%	Percent
pH	7.5	Unitless
Lime	Medium	Qualitative or Percent
Nitrate-Nitrogen	0.5	ppm
Phosphorus	19.2	ppm
Potassium	258	ppm
Copper	0.4	ppm
Zinc	1.7	ppm
Iron	11.4	ppm

Table 3. Parameter results



Figure 4. USDA Soil Triangle (Soil Texture Calculator). (Source: Natural Resource Conservation Service)

Soil Separate	Particle Size Range (mm)	Percent Retained on Sieve	Lab Method
Gravel	>2.0	0%	Retained on #10 sieve
Sand (Coarse)	0.5 - 2.0	5%	Retained on #35 sieve
Sand (Medium)	0.25 - 0.5	8%	Retained on #60 sieve
Sand (Fine)	0.05 - 0.5	11%	Retained on #270 sieve
Silt	0.002 - 0.05	41%	Hydrometer
Clay	<0.002	35%	Hydrometer

Table 4. Particle size results

Design

A topsoil plan was developed that accounts for how much topsoil was needed for the stream project and how much topsoil the adjacent development could supply. The plan defined areas, depths, and quantities of topsoil stripping and replacement. Notes specify requirements for topsoil handling and amendment. For Lemon Gulch, an ecologist reviewed the soil test results and recommended a slow-release organic fertilizer before seeding.

Construction

In a preconstruction meeting that included the engineer, the contractor for the stream project, and the contractor for the development, the group discussed the intent of the topsoil plan and identified appropriate contacts. During construction, several site visits were made to conduct the observations identified in the guidance document, including verifying that the correct areas and depths of topsoil were stripped and placed appropriately (Photo 5).



Photo 5. Depth of topsoil placement verification in the field.

CASE STUDY CONTINUED

LEMON GULCH TOPSOIL MANAGEMENT PLAN

Parameter Classification	Parameter No.	Soil Parameter	Test Name	Topsoil Category			
				Unsuitable	Marginal	Suitable	Ideal
Texture							
	1	Texture: % material retained in #10, #35, #60, #270 sieves % Silt % Clay	Sieve sizes based on the USDA soil classification system, silt and clay percent	sand, clay (>45%)	sandy clay, loamy sand, silty clay, silt loam, silt, clay (40-45%), and silty clay loam	sandy clay loam, and clay loam	sandy loam, loam ¹
	2	Gravel >2 mm or #10 sieve	based on the hydrometer method	>70	>40 - 70%	10 - 40%	<10%
Salts/Sodium							
	3	Salinity/Salts (EC) dS/m or mmhos/cm	Saturated Paste	>4	>3 - 4	2 - 3	<2
	4	Sodium Adsorption Ratio (SAR)	USDA 60 6(20b)	>13	>8 - 13	8 - 4	<4
Organic Matter Content							
	5	Organic Matter (%)	ASTM D2974	N/A2	<1%	1% - 2%	>2%
Soil pH							
	6	pH	ASA/ASHTO	<5.0 or >9.0	5.0 - <5.5 and >8.5 - 9.0	5.5 - 6.0 and 8.0 - 8.5	>6.0 - <8.0
Nutrients							
	7	Calcium Carbonate (CaCO ₃)/Lime	Calcium Carbonate Equivalent (USDA 60 6(23c))	>10%	>2% - 10% (High)	1 - 2% (Medium)	<1% (Low)
	8	Nitrate Nitrogen (ppm)	ASA2 33-3	N/A2	<10, >30 ³	10 - <20	20 - 30
	9	Phosphorus (ppm)	Ammonium bicarbonate-DTPA test	N/A2	<8	8 - 15	>15
	10	Potassium (ppm)		N/A2	<60	60 - 180	>180
	11	Copper (ppm)		N/A2	<0.2	>0.2	>0.2
	12	Zinc (ppm)		<0.5	0.5 - 1	>1.0 - 1.5	>1.5
	13	Iron (ppm)		N/A2	<5	5 - 10	>10

Figure 5 Topsoil test results outlined in red to indicate topsoil quality.

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