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CHAPTER 18
GEOTECHNICAL

18.1 PURPOSE

This section establishes the minimum standards for performing geotechnical explorations on MSD projects. Geotechnical explorations are required on all MSD projects, unless otherwise directed by MSD. Reasons for performing geotechnical explorations include, but are not limited to, the following:

a. To establish the bedrock depth along the alignment of proposed sewers or at the location of proposed structures.

b. To determine the subsurface profile and properties (texture, moisture content, density, shear strength, compressibility, etc.) of soil and bedrock materials. This information is needed for the design of below grade structures, (wetwells, junction structures, tanks, etc.) building foundations, sheeting and bracing systems, retaining walls, stable channel slopes, pavements, and embankments. Additionally, this information is necessary when unsuitable foundation conditions are at the trench subgrade level or when unstable trench wall conditions are anticipated.

c. To investigate the subsurface conditions at tunnel or boring and jacking sites. The composition and nature of materials at underground crossings is needed to establish the conditions to be encountered (soft ground, hard ground, or mixed face tunneling) and the appropriate construction method.

d. To provide information regarding groundwater so that the contractor can plan for an adequate dewatering system.

e. To determine pavement section makeup, layer thickness and condition.

18.2 GENERAL

18.2.1 Right of Entry

When the geotechnical exploration work will require entry onto private property, the property owner shall be contacted, the work described, and permission to enter obtained. Efforts to contact property owners shall include telephone calls and the leaving of letters for those who are not at home. In some instances, MSD may deem it necessary to issue a letter of introduction and identification (on MSD's letterhead), which the geotechnical field party will provide to the owner. In the event that the owner does not grant permission, and it is evident that the

geotechnical work will be delayed, MSD should be notified, in writing, immediately. It is the responsibility of MSD to take whatever course of action is deemed necessary to obtain the legal right of entry in accordance with state statutes.

18.2.2 Protection of Underground Structures and Utilities

Prior to drilling and sampling in public rights-of-way and easements, the Kentucky Underground Utility Protection Center (BUD) shall be called at 1-800-752-6007 and requested to mark the locations of existing underground facilities. At least 2-business days notice is required for service. BUD confirmation numbers should be documented so that a record for the request is available. Drilling should not begin until clearance has been provided or notification that all underground utility lines are marked has been received.

On private property, the BUD does not normally maintain records. It then becomes necessary to employ the property owner's assistance and knowledge of service lines, underground storage tanks, septic tank facilities and/or use visible surface features, such as meter vaults, shut-off valves, etc., to estimate the locations of underground facilities. Borings should be offset accordingly, if necessary, to avoid any conflicting utilities.

If there is any reason to believe that an underground facility exists in an area to be drilled, and its location cannot be determined with reasonable accuracy, then that boring should not be advanced.

18.2.3 Erosion Prevention and Sediment Control/Ground Restoration

All efforts should be extended to avoid rutting, especially in residential areas. Ruts should be repaired with leveling the area with topsoil and seeding or sodding as required by MSD or as agreed upon with the property owner.

When using a truck-mounted drill rig, efforts should be made to access boring locations without crossing streams. In the event that crossing a stream is necessary to access a critical boring location, a ford in the stream, which is regularly used by the property owner, should be used after receiving approval from the property owner and MSD. Any rutting should be repaired with seeding and sodding as described above.

Dozer roads cut to permit access to boring and sounding locations should be leveled and seeded and strawed immediately following completion of the work.

Upon completion, borings should be completely backfilled from the bottom to the ground surface, using excavated cuttings. Reversed auger rotation or down

pressure on the drill tools should be used to achieve compaction. In sodded areas, the sod should first be carefully cut, lifted from the boring site, and set aside. After backfilling, the sod should be replaced over the boring and tamped. Asphalt cold patch or concrete should be used to repair borings in pavements.

When drilling around sinkholes or at a site with the potential to drain storm water directly into a water feature (including streams, lakes or impoundments, or along steep slopes), special care should be taken to place all auger cuttings back into the hole. If excess cuttings remain, they should be removed from the site.

18.3 DRILLING AND SAMPLING

18.3.1 Methods and Equipment

Unless otherwise authorized by MSD, power equipment shall be utilized to obtain geotechnical data. In most cases, this will involve a truck or skid-mounted soils drilling rig equipped with continuous flight mechanical augers. In some instances it may be advantageous to use an air track rock drill if only rock soundings are being performed. In areas where drilling rig access is restricted with steep slopes, heavy woods, soft ground, or where the rock surface is known to be shallow with reasonable assurance (for example, next to a rock bottom stream), MSD may permit the use of manually driven sounding rods or hand augers.

In general, all soil test borings shall be performed in accordance with ASTM D 1586 "Standard Method for Penetration Test and Split Barrel Sampling of Soils". Split-barrel samples shall be taken at five-foot depth intervals and at changes in strata. When undisturbed samples in clay soils are required (for example, when shear strength determinations are needed), samples should be obtained in accordance with ASTM D 1587 "Standard Practice for Thin-Walled Tube Sampling of Soils".

Observation wells should be installed in completed soil borings whenever groundwater is encountered during the drilling process. Casing should be of 1-inch diameter field slotted PVC pipe. Water table readings should be obtained from observation wells no sooner than seven days from completion of the boring.

Rock core drilling shall be performed in accordance with ASTM D 2113 "Standard Practice for Diamond Core Drilling for Site Investigation", except when wire line drilling is permitted. The diameter of the rock core shall not be less than 2-1/8 inches.

Limestone formations are prevalent across much of Jefferson County. Rock remnants and hard clay soils are sometimes encountered above the top of rock in these formations. Accordingly, when performing rock line soundings with

mechanical augers, the field crew should note the depth intervals of any rock remnants or hard clay soils encountered above the top of rock.

18.3.2 Location, Frequency and Depth Requirements for Soundings and Borings

When required, rock soundings should be performed at intervals of 50 feet where rock is encountered and 100 feet where rock is not encountered along the proposed alignment of collector and interceptor sewers, manholes, pump stations, and underground structures. The soundings should be advanced to a maximum depth, which corresponds to one foot below the invert elevation or to auger refusal, whichever occurs first. The requirements for rock soundings may be waived by MSD in areas of the Jefferson County where the bedrock surface is known to be deeper than excavation depths.

The requirements for soil test borings will be evaluated by MSD on a project-by-project basis. In general, soil test borings will be required for sewers located in areas with deep, potentially unstable soils or where high groundwater may be expected. When required, soil test borings should be drilled at approximate intervals of 500 feet and should be terminated 4 feet below the invert elevation or at auger refusal, whichever occurs first. If bedrock occurs higher than the invert elevation, then rock core drilling should extend the boring to 2 feet below the invert elevation.

Whenever possible, the boring plan should be developed to position test borings at locations of special interest. For example, test borings should be sited at the deepest excavation or where the open trench may affect existing buildings or major utilities. Borings should be drilled at the access pits or shafts of tunnels. If access is available, intermediate borings along the tunnel alignment should be advanced at 100-foot intervals. For large pump station and wastewater treatment plants, the number of borings needed may vary based on the number and layout of the individual facilities.

18.4 LABORATORY ANALYSES

Representative split-barrel samples should be analyzed for Atterberg limits, (ASTM D 4318) particle size distribution (ASTM D 422), specific gravity (ASTM D 854) and moisture content (ASTM D 2216). The samples should then be classified in accordance with ASTM D 2487 "Test Method for Classification of Soils for Engineering Purposes". Representative samples of soil materials, which are to be placed and compacted to controlled moisture-density conditions, should be subjected to Standard Proctor moisture-density tests (ASTM D 698) to determine the maximum dry density and optimum moisture content. Additionally, for any projects requiring pavement design, representative samples of proposed subgrade soils should be subjected to laboratory California Bearing Ratio tests (ASTM D 1883) to provide design CBR values.

When shear strength parameters are required for geotechnical analyses, these parameters should be determined as follows. The shear strength for non-cohesive materials (sand and sand-gravel mixtures) should be measured in accordance with ASTM D 3080 "Standard Test Method for Direct Shear Test of Soils under Consolidated-Drained Conditions". The undrained shear strength for cohesive soils (clays) should be measured in accordance with ASTM D 2166 "Standard Test Method for Unconfined Compressive Strength of Cohesive Soil". The drained shear strength for cohesive soils should be measured in accordance with ASTM D 4767 "Standard Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils."

18.5 REPORT DEVELOPMENT AND DRAFTING

Reports of geotechnical explorations should include discussions on the project, general site conditions, site geology, scope of work, results of the exploration, and conclusions and recommendations relative to the proposed design and construction. More specifically, the site description should include discussions of the site topography, site drainage characteristics, any existing improvements, etc. Descriptions of the site geology should include underlying soil types and rock formations. Other geologic features such as faults or susceptibility to sinkholes should also be included. A description of the scope of work should also be provided and should include a complete description of the drilling, sampling, and laboratory analysis programs. The results of the exploration should include descriptions of soil types, depths, the presence of any groundwater, etc. Descriptions of rock cores should note the presence of joints, voids, mudseams, recovery ratios and rock quality designation values. References to site locations should also be included. In addition, any engineering analysis performed (slope stability, settlement, etc.) should be discussed. Finally, the conclusions and recommendations relative to design and construction from a geotechnical standpoint should be included.

When submitting the results of rock line soundings, the depth intervals of any rock remnants or hard clay soils encountered above the top of rock should be reported.

Geotechnical exploration data, including boring locations, graphical boring logs, sounding symbols, penetration test blowcounts, unconfined compressive strengths, natural moisture contents, groundwater elevations, top of rock elevations, etc., should be placed on the plan and profile drawings by the Design Engineer. The drawings should reflect the difference between soundings performed with mechanical augers and soundings performed with manually driven sounding rods. For intervals that have been sounded by mechanical augers and by manually driven soundings rods, report both sets of data. The elevations of any rock remnants or hard clay soils encountered above the top of rock should also be noted on the drawings. Refer to the MSD Geotechnical Legend Sheet, Exhibit 18-1, for the appropriate symbols. MSD's drafting standards as outlined before should be followed.

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MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty St., Louisville, Ky.
40203-1913

EXHIBIT 18-1
GEOTECHNICAL LEGEND SHEET

EFFECTIVE DATE: JANUARY 1, 2001

RQD (%)	Rock Quality
90–100	Excellent
75–90	Good
50–75	Fair
25–50	Poor
0–25	Very Poor

LIMESTONE

SANDSTONE

NONDURABLE SHALE (SDI≤89)

DURABLE SHALE (SDI≥90)

Description of Soil Relative Density or Consistency

SOIL TYPE	RELATIVE DENSITY OR CONSISTENCY	RANGE OF PENETRATION RESISTANCE	RANGE OF UNCONFINED COMPRESSIVE STRENGTH
Fine grained soils (More than half of material is smaller than No. 200 sieve size)	Very Soft Soft Medium Stiff Very Stiff Hard	Less than 2 blows per foot 2 – 4 4 – 8 8 – 15 15 – 30 >30	Less than 0.25 tsf 0.25 – 0.50 0.5 – 1.0 1.0 – 2.0 2.0 – 4.0 >4.0 tsf
Coarse grained soils (More than half of material is larger than No. 200 sieve size)	Very loose Loose Medium Dense Very Dense	Less than 4 blows per foot 4 – 10 10 – 30 30 – 50 >50	Not Applicable

Unified Soil Classifications

MAJOR DIVISIONS		SYMBOL		NAME
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Well-graded gravels or gravel-sand mixtures, little or no fines
		GP		Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM		Silty gravels, gravel-sand-silt mixtures
		GC		Clayey gravels, gravel-sand-clay mixtures
	SAND AND SANDY SOILS	SW		Well-graded sands or gravelly sands, little or no fines
		SP		Poorly graded sands or gravelly sands, little or no fines
		SM		Silty Sands, sand-silt mixture
		SC		Clayey sands, sand-clay mixture
FINE GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH		Inorganic clays of high plasticity, fat clays
UNCLASSIFIED MATERIAL		NONE		Non-classified material (i.e. concrete, asphalt, crushed stone, cinders, slag, rubble, talus, etc.) Include visual description

Symbol	Meaning
AI	Activity Index
LI	Liquidity Index
N	Penetration Resistance
S+C(%)	Material finer than No. 200 sieve
•S	Location of Sounding
•SB	Location of Soil Boring
●	Location of Soil Boring and Rock Core
▽	Water Elevation
▮	Thin-walled Tube Sample
<	Standard Penetration Test Sample
Qu	Unconfined Compressive Strength
w(%)	Moisture Content
RQD(%)	Rock Quality Designation
SDI(%)	Slake Durability Index
Rec.(%)	Core Recovery
ϕ	Angle of Internal Friction
$\bar{\phi}$	Effective Angle of Internal Friction
c	Cohesion
$\bar{c}$	Effective Cohesion
γ	Total Unit Weight
⊻ M	Manual Rod Sounding – No Rock Encountered
⊻ M (filled)	Manual Rod Sounding to Rock
⊻ A	Auger Sounding – No Rock Encountered
⊻ A (filled)	Auger Sounding to Rock

PLANS PREPARED AND SUBMITTED BY:

CONSTRUCTED BY:

FINAL RECORD DRAWING BY:

MSD
Louisville and Jefferson County Metropolitan Sewer District
GEOTECHNICAL LEGEND
PROJECT NAME
PROJECT DESCRIPTION