STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL SPECIFICATIONS FOR ROADWAY DESIGN

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APPENDIX 1. - GUIDELINES AND BACKGROUND INFORMATION FOR PROVIDING SOIL CLASSIFICATION INFORMATION

Purposes: The purpose of these guidelines is to describe a systematic practice for providing a Pedological Survey report. These guidelines will include methods for providing the most up to date and meaningful soil classification information. Soil samples are to be taken from within named, mapped units as contained in County Soil Survey report. Every soil series associated with the named map unit(s) is to be sampled and tested. Therefore, for proper and current classification of the sampled soil, a copy of the official soil series description must be provided. The description includes the classification. The included description shall be the most current version of the sampled soil series as certified by the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Services (SCS). For example, a 1968 soil survey report map unit symbol CrE, red clay land, "probably has been recorrelated to "Vernon clay loam, 8-20% slopes, " or similar soil series. Thus, an official copy of the Vernon soil series is to be provided in the pedological report. If in the extent of alignment the map unit repeats a soil series, it need not be sampled again. However, borings must be made in the subsequent map unit to verify that the soil series is indeed the same within the allowable ranges as stated in the official soil series description paragraph, "Range in Characteristics."

Scope. This method covers that portion of the Pedological system used for identification and classification of natural soil profiles in their undisturbed state as developed in their natural environment. This system includes topographic and drainage characteristics as well as those particular features that are influenced by broader climatic factors, such as temperature and rainfall.

Soil Profile:

1. A vertical cross section of soil layers constitutes the soil profile which is composed of six master horizon layers designated O, A, E, B, C, and R.

2. The O horizon is a surface horizon dominated by organic matter. It is composed of partially decomposed leaves, needles, twigs, etc., left on the surface. Soils of forested areas of southeastern Oklahoma commonly contain O horizons.

3. The A horizon is the usual topsoil layer. It is dark by virtue of an accumulation of organic matter but is not dominated by it. It is mostly mineral matter. This layer is usually present in all Oklahoma soils.

4. The E horizon is a subsurface horizon. It's the leached horizon. It's usually lighter in color than the A or the underlying B horizon. It contains predominantly uncoated sand and silt particles. These layers are common in flat-lying clay soils and forested soils of the eastern ½ of Oklahoma.

5. The B horizon is a subsurface horizon. It's often called the subsoil. It is a layer or accumulation of silicate clay, iron, aluminum, humus, carbonates, gypsum, or silica or combinations of these. In most Oklahoma soils the accumulation of clay causes the B horizon to be "heavy" or more clayey than the above horizons. Often a fairly new soil

will have a B horizon that it is just forming and will have a structure B prior to the many years it takes for clay, etc. accumulation to occur.

6. The C horizon lies below the B horizon and is little affected by the processes that formed the horizons above. It's usually unconsolidated or uncemented and related to the horizons above. However; it may not be related to the horizons above. It could be alluvial sediment or weakly cemented rock.

7. The R horizon is hard bedrock. If the R horizon is shale, it's still usually too firm to be easily dug with hand tools. Shale is usually rippable, other rock types are generally not.

8. Transitional layers are common. These include AB, EB, BE, or BC. These occur in soils with thick transition layers in which the properties of one horizon dominates over the other. They generally occur in deep, gently sloping to flat soils.

Soil Classification:

1. The primary purpose of soil classification is to describe a soil in sufficient detail to permit engineers to recognize features significant to design and if need be, to obtain samples in the field.

2. Highway engineers have found that the soil classification system with its wide range of soil information could be used in the general identification of soil, after which he could classify the various soil materials for engineering purposes. The U.S. Department of Agriculture classification system is used primarily for agronomic purposes. However, after testing and correlation with engineering properties and performance, it then becomes a system of classification suitable for use by the highway, railroad, or airport engineer.

USDA Classification System:

1. This system of soil classification or identification is based on the fact that soils with the same weather (rainfall and temperature rages), the same topography (hillside, hilltop, valley, etc.), and the same drainage characteristics (water-table height, speed of drainage, etc.) will grow the same type of vegetation (either oaks or bluestem grasses or a combination) and will generally be the same kind of soil.

2. This classification system is important basically because a subgrade or a particular soil series, horizon and particle size (texture) will perform the same wherever it occurs since such important factors as rainfall, freezing, groundwater table, capillarity of the soil, etc., are factors in the identification and classification. This is the only system which directly employs these important factors. Its value and use can be extended widely as soon as the engineering properties, such as load-carrying capacity, susceptibility to moisture change, or general performance has been established for a particular soils series. This is because soils of the same particle size, horizon and series name are the same and will, under comparable conditions, behave the same wherever they occur. Thus, engineers operating within designated soil geographic regions, after identifying similar soils, through the system, could exchange accurate pavement-design and other performance data.

3. The classification currently being used is described in the 2nd Edition of "Soil Taxonomy" 1999, as shown below.

SOIL ORDERS COMMONLY FOUND IN OKLAHOMA BY AREA RANKING

Order	Formative Syllable	Derivation	Meaning
Mollisols	oll	mollis, soft topsoil	dark topsoil
Alfisols	alf	pale, thin, topsoil	none
Inceptisol	ept	inception	new soil
Ultisol	ult	last, ultimate	old soil
Entisol	ent	recent	very new soil
Vertisol	ert	vertical	heaving/swelling
Aridisol	id	arid	dry

Mollisols are the prairie soils and thus are the most common in Oklahoma, occupying about 18 million acres. Alfisols occupy about half of that or 9.8 million acres. Inceptisols and Ultisols occupy 6.1 and 4.0 million acres respectively. The remaining are the Entisols, Vertisols, and Aridisols, which occupy 2.6, 0.59, and 0.25 million acres respectively.

Other soil Orders that are not commonly found in Oklahoma include Gelisols (frozen soils), Spodosols (wood ash), Andisols (volcanic, e.g. ash, lava), Oxisols (tropical conditions), and Histosols (organic matter, bogs).

4. Soils Orders are subdivided into Suborders, Groups, Subgroups, Families, Series, and Phases. Each classification has significance for engineering. These subgroupings are based on such things as water tables, moisture regimes, and particle sizes

5. Suborders are based on those characteristics that seem to produce genetic similarities. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of the water table or soil differences resulting from the climate and vegetation. The suborders have names composed of only two syllables. For example, Aquolls are the Mollisols resulting from high water tables (aquic + oll = wet Mollisol), while the Udolls are the moist Molllisols because of a moist climate (udic + oll = moist Mollisol). These suborder names are the endings of the great groups in each suborder.

6. Groups or "Great Groups" are divided on the basis of uniformity in the kinds and sequences of major soil horizons and features. The horizons on which the divisions are based are those in which clay, iron, or humus has accumulated. The features on which the divisions are based are the properties of clays, soil temperature, and major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium). Another syllable or two is added in front of the suborder name to indicate how each great group differs from others in the same suborder. The name of each group is the last word in the name of the subgroup. An example of a Great Group

names would be Argiaquoll. An Argiaquoll is a wet, prairie soil that has a clay accumulation B (subsoil) horizon.

7. Groups are divided into subgroups. One of the subgroups in each great group represents the central (typic) segment or concept of the group and the others, called intergrades, have properties of another great group, suborder or order. Subgroups may also be made in those instances where soil properties intergrade outside the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example classification is: Typic Hapludalf. Thus, a Typic = typical, Hapl = minimum horizon development, ud = moist; alf = Alfisol soil order. So, the names are connotative of major properties of the kinds of soil included in each category. The names also indicate how they are related to each higher classification category.

8. Subgroups are divided into families primarily on the basis of properties imported to the growth of the plants or to the behavior of soils used in engineering. Among the properties considered important are texture (particle size distribution), mineralogy, reaction, soil temperature, permeability, thickness or horizons, and consistence. Each family name also shows the placement of these soils in every higher category of the system and tells how the family differs from other families in the subgroup. For example, the Miami series is in the "fine-loamy, mixed active mesic" family of Oxyaquic Hapludalfs. This means that their subsoils contain 18 to 35% clay (fine Loamy) a mixture of minerals (mixed), the ratio of cation exchange capacity over clay content percentage of the soils is between 0.40 and 0.60 (active), and has a mean annual soil temperature between 47 and 59 degrees F (mesic). Oxyaquic connotes redox features (mottles) in the upper part of the B horizon and is saturated for short periods during each year. The Hapludalf great group has a minimum number of horizons characteristic of the Udalf suborder and are the more moist soils in the Alfisol order.

9. Soils within each family are divided into soil series and the soil series are further broken down into soils phases. Similar soils within a family that developed in the same age, climate, vegetation, and local environment acting on parent material are given a soil series designation. All soil profiles of a certain soil series are similar in all respects with the exception of possible variation of slope or particle size distribution (texture) of the surface horizon. The soil series were originally named after a town, county, stream or similar geographical source, such as "Clarita" or "Denise", where the soil was first identified and mapped. There are many exceptions today. For instance, a Gasil soil series is related to the Galey soil series but there is no such location as "Gasil".

10. The texture of the surface soil or A horizon may vary slightly within the same soil series. The soil mapping unit is therefore a result of subdividing into the final classification unit, which includes the soil series name, surface texture and slope or other observable surface characteristic useful for describing map delineations. The description of the slope, stoniness, and similar easily observable surface features is called the soil phase. This was formerly called the soil type. For example, if the texture of the A horizon of an Enterprise soil series is very fine sandy loam, then the soil map unit will be described as an Enterprise very fine sandy loam. Other landscape observable characteristics, such as

slope, or stoniness will be phase criteria. Thus the Enterprise map unit or soil phase may now be described an Enterprise very fine sandy loam, 5-20 percent slopes.

11. The description of the soil series provides the key to identification and classification. It gives the significant characteristics involved in most design, construction, and maintenance problems. Characteristics of importance are the nature of the parent material, including geological origin, texture, and chemical constituents. No less important are environmental conditions which influence soil behavior. Local environment including topography, drainage, and location of the ground water table are dominating factors. For instance, a soil map unit soil series name classified as a "fine, smectitic, superactive, thermic Udic Haplustert" can quickly state that the soil is shrinking/swelling soil (ert), on the dry side but moist in the growing season, commonly cracking and containing slickensides (ust + Udic), and has minimal horizon development (Hapl). The term thermic denotes a warm temperature regime, 47 to 59 degrees F, smectitic denotes the dominant clay mineral type, namely smectite (an expansive clay type), superactive is the ration of cation exchange capacity over clay content, and fine indicates a soil high in clay content. . Fine describes particle size and amount; in this case the clay content of the soil massive is less than 60 per cent. Thus, classification with its subsequent interpretation gives strong clues toward the engineering properties and performance of a given soil series.

12. The classification is present in every official soil series description obtained from the NRCS database web site. This is why it's important to identify and sample the correct soil series within map unit.

13. If the Pedological investigator encounters a significant extent of a soil dissimilar or not fitting the one described for the map unit, the soils(s) is to be sampled according to the convention set forth in Appendix 3. Such dissimilar soils are called "inclusions". For example, the soil inclusion may be described and labeled as "red clay soil similar to Vernon clay loam occurring in the KaA, Kirkland silt loam 0-1% slope, map unit". Make sure the location is properly noted, e.g. Station 457 + 16, 11 feet right of CL. Horizons of the inclusion are to be estimated as closely as possible, labeled, and samples taken and submitted for laboratory analysis.

The Role of NRCS: All of Oklahoma has been mapped by the NRCS. The more recently published surveys have the soil series classifications listed therein. Copies of the county soil survey reports are available in the counties where the construction activity is to take place. These can be obtained at the local county NRCS filed offices or the County Cooperative Extension Office. These are usually located in the county seat cities. The reports contain maps based on aerial photographs. If copies are not available in the counties, then contact the NRCS State Soil Scientist in Stillwater, OK to locate a source of the required information.

The NRCS Web Soil Survey, http://websoilsurvey.nrcs.usda.gov/app/ is also a good source for county soils maps and information.

The county soil survey reports, with their included maps, are the basic publications for discovering the soil series at a given location or roadway alignment. The NRCS is constantly working to update and recorrelate the soil series in Oklahoma. The most current NRCS county soil legend must be used to ensure that the mapped unit(s) and its classification and sampling are current to the date of the Pedological report.

Locating a current legend can be done in at least three ways:

1) By contacting the local NRCS field office, usually in the county seat,
2) By contacting the Geotechnical Branch, Materials Division, Oklahoma Department of Transportation, 200 NE 21st Street, Oklahoma City, Oklahoma 73105, phone (405) 522-4998 or,
3) By calling the NRCS State Soil Scientist

Please provide to them the county, map symbol, and soil series name. They will provide, from soils legend, the most current unit name.

Once the current soil series name has been attained, contact the Natural Resources Conservation Service database to obtain the most current official soil series description(s). Their web site address is: http://soils.usda.gov/technical/classification/osd/index.html . Select the category "soil series by name". Descriptions of the Soil Series are to be included in the Pedological report.

Summary: The Pedological Survey report consists of the following required elements:

1. Aerial photographs at 1:20,000 scale, (or the scale as utilized by NRCS in their county soils reports) with delineated map units and proposed location or CRL/CL alignment plotted thereon (reproduction from county soil survey report) are required. Obtaining copies of Digital Orthophoto Quad sheets, at a website address of the Oklahoma Conservation Commission, may allow a greater accuracy and ease of plotting.

2. The traversed distance of each alphabetized map unit is to be summed and reported in feet.

3. A set of official soil series description sheets from the official NRCS national database source (Iowa State) is to be included. These are for the soil series found along the alignment extent or at the location of interest.

4. A numerical listing in alphabetical order of the soil series found long the alignment and their classification is to be provided in the report, for example: 1. Burleson Soil Series, Fine, smectitic, thermic, Udic Haplustert.

5. Soil samples from all horizons, according to the official soil series description, are to be taken. Also, a large composite sample of the major horizons, excluding the A horizon, are to be taken and listed. The sampling method is described in paragraph 1.c. of the Geotechnical Specifications for Roadway Design. This is to be done for each soil series present along the alignment. The samples are then to be submitted to a certified laboratory for testing.

6. The required laboratory tests for the above samples as listed in paragraphs 1.f. and 1.g. of the Geotechnical Specifications for Roadway Design.