Appendix A
Consultant Geotechnical (Soils Design) Work Requirements

Design Manual
Chapter 200
Geotechnical Design
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1.0 GENERAL

A. **Consultant geotechnical work requires that the Consultant be pre-qualified in Category 321 during the duration of their geotechnical work.** Consultant geotechnical (soils design) work may include any

B. combination of S1, S2, S3, or S4 work, and possibly other types of geotechnical work. The **Geotechnical Sections of the Design Manual** include definitions of S1, S2, S3, and S4 work, along with detailed discussion of numerous items associated with each S-date event and submittal requirements. The **Geotechnical Sections of the Design Manual** shall be used with the **Consultant Geotechnical (Soils Design) Work Requirements** herein to document work performed as part of the S1, S2, S3, and S4 effort, including submittal items. Plan sheet portions of consultant submittals shall be prepared in accordance with the Office of Design's **Design Manua**l and the **Road Design Specifications**.

C. The borings, lab testing, etc., as discussed in these **Consultant Geotechnical (Soils Design) Work Requirements** should not be considered a definitive definition of the borings, lab testing, analysis, etc., that are necessary for and must be performed for S1, S2, S3, or S4 purposes. All geotechnical work shall be sufficient, full, and complete to cover all geotechnical aspects of the project.

D. All S1, S2, S3, and S4 work shall be accomplished in general accordance with that included, discussed, and described in the **Geotechnical Sections of the Design Manual**. This includes fulfillment of the basic intent of each of the S events, the basic steps taken with each of the S events, the analysis to be performed in each S event, and all submittals associated with each "S" event.

2.0 PURPOSE

The purpose of the geotechnical field, lab and office work (i.e., soil survey) is to provide sufficient information for full geotechnical analysis and design of the following items:

A. The final location of the road, bridge, and/or other improvements, both vertical and horizontal.

B. The suitability of materials obtained from project cuts, borrows, channel changes, and/or other locations for use in embankments or other project features.

C. The design of the roadway and pavement sections, including foreslopes and backslopes.

D. The need for subgrade treatment, the type of treatment required, the location of select soils and quantities available, the need for and design of drainage features, the need for and design of geotechnical remediations, and other items as needed.

E. The foundation conditions for proposed embankments, bridges, and/or other structures, with the strength, consolidation, and other characteristics of the subsurface profile sufficiently determined for geotechnical analysis and design of all necessary geotechnical remediations.

F. Stability of cuts, embankments, and/or other project features.

G. Other items as may be necessary.

3.0 SCOPE

A. The work outlined and discussed herein consists of furnishing all labor, material, equipment, machinery, transportation, services, facilities, etc., as may be needed, and performing all operations necessary for completing the geotechnical work in accordance with the requirements, etc., as specified herein and discussed in the **Geotechnical Sections of the Design Manual**. Unless specified otherwise, this geotechnical work shall include the entire length of the project applicable to the Consultant's current project.

B. Unless scoped otherwise, the Consultant shall be responsible for all subsurface investigation, lab testing, analysis, and geotechnical design, including the reconnaissance and planning of the borings, the borings and sampling, the testing of samples, the necessary reporting of all soil survey information, and all necessary analysis, geotechnical plan sheets, and geotechnical submittals. This is to include all necessary final S1, S2, S3, or S4 submittal items, with documentation of all recommendations pertaining to the design, construction methods, construction control, and other items that are necessitated by the subsurface conditions that were identified and the geotechnical analysis that was performed.

C. The subsurface findings and recommendations shall be utilized for and incorporated into the final design, plan sheets, and other project documents submitted by the Consultant. This shall be accomplished in accordance with these **Consultant Geotechnical (Soils Design) Work Requirements** and the **Geotechnical Sections of the Design Manual**.

4.0 WORK PLANS/SITE RECONNAISSANCE

A. On complex or large projects, a Work Plan and Site Reconnaissance can be beneficial and may be needed. When implemented, the office review/preliminary planning phase can be used to develop an efficient geotechnical work plan and to maximize the amount of information obtained during each phase of the geotechnical work and minimize the number of site visits required to obtain information. In these instances, the geotechnical designer should become familiar with the proposed project elements by reviewing, if available:

1. Proposed corridor/project limits.
2. Plan/profile sheets.
3. Project cross sections.
4. Final borrow need and distribution.
5. Location of all structures (i.e., bridges, culverts, etc.).
6. Anticipated project breaks (termini).

B. In addition, the geotechnical designer should become familiar with the site and geologic conditions. Soils deposited by a particular geologic process assume characteristic topographic features or landforms that can be readily identified by the geotechnical designer. A landform contains soils with generally similar engineering properties and typically extends irregularly over wide areas of a project alignment. Identification of geologic landforms can be used to optimize the subsurface investigation program. However, this generalized information cannot be used as an acceptable substitute for appropriate soil borings, sampling, etc.

The following can be used to identify landforms and aid in development of the subsurface investigation:

1. GIS information:
   - i. Topographic maps.
   - ii. Aerial photographs.
   - iii. Soil survey maps.
   - iv. Wetland maps.
   - v. Geologic maps.

2. Other information that should be reviewed includes:

i. As-built plans, construction records.
ii. Previous DOT borings.

C. When implemented, the field reconnaissance should be performed by the geotechnical designer and/or field exploration supervisor with available project information for reference. Permission to enter private property must be obtained for the site reconnaissance before entering any private property. Railroad right-of-way should never be entered at anytime without specific prior approval. During the site visit, the observer should note the site conditions as they relate to the proposed roadway, structures, and access to boring locations. In addition, it may be beneficial to contact and interview local residents/landowners, if available, to provide information on past land use. A record of the field visit should be kept and included in the project file. The record should list and describe significant site features as discussed above along with approximate stationing. The following items are to be included in the site reconnaissance, if appropriate:

1. Relate site conditions to proposed boring locations.

2. Check access for exploration equipment and make an initial determination of what type of equipment might be best suited to the site conditions.

3. Preliminary right of entry discussions with landowners.

4. Note proximity of residences and buildings for possible difficulties due to noise and other disturbances during the subsurface exploration.

5. If site preparation is necessary, note the type of equipment, such as a bulldozer, that may be needed for drilling equipment access.

6. Note potential problems with utilities such as overhead and underground power, site access, private property, or other obstructions.

7. Note any water sources that could be used during drilling. If coring or mud rotary methods are anticipated, availability of water should be determined.

8. Note traffic control needs to accomplish the field exploration program, considering the practical aspects of the proposed drilling plan with regard to impact to the public.

9. If borings are to be located in a stream bed, note the size of the barge best suited for the job, details of anchoring, depth of water, locations for launching the barge, etc.

10. Notes should be made as to which type of drilling (i.e., hollow stem, mud rotary, etc.) is best suited to the site.

11. Also note potential problems with borings such as shallow groundwater table, loose sands below groundwater table, cobbles and boulders, etc.

12. Special sampling equipment needed, such as undisturbed sampling equipment, should be noted.

13. Compare the topography of the site with that shown on preliminary plans and obtained maps.

14. Observe and note natural occurring exposures such as river banks, natural escarpments, quarries, highway or railway cuts and rock outcrops. Measure the inclination of any existing steep slopes.

15. Note and describe the type and amount of fill that has been placed on the site.

16. Note the extent of any existing unstable slopes or erosion features.

17. For unstable slopes or landslides, note the length and width of the area affected.

18. Note the presence of any wetland or other surface water.

19. Identify existing structures and note condition.

20. Photographs are valuable records of the site visit and should be labeled with the approximate stationing, direction of view, date, and a brief title. Photos should be

obtained of all the site features listed above and of the probable exploration locations.

D. Prior to performing any geotechnical work on a project where a work plan is used, the proposed geotechnical work plan shall be reviewed by the Iowa DOT Soils Design Section, and approved before field operations are initiated.

5.0 DEVELOPMENT OF A FIELD EXPLORATION

A. For larger projects, it may be beneficial to conduct the field exploration in a phased sequence, consisting of: 1) preliminary subsurface investigation during the project definition phase; and 2) more detailed exploration conducted during the project final design. All phased studies and activities shall include enough documentation so that another engineer picking up the project would not need to go through the same search for information. A phased exploration program should be coordinated with and approved by Iowa DOT before it is implemented. If approved, the phased program should be outlined and described in the Scope of Work for the geotechnical effort.

B. The field exploration program on all projects shall include and properly address the following items:

1. **Traffic Control.** The Consultant shall provide traffic control and associated services as required by and included in any applicable Standard Road Plan, the Manual on Uniform Traffic Control Devices, the current Standard Specifications for Highway and Bridge Design, and other applicable publications, requirements, etc.

   CARS 511 NOTIFICATION FOR LANE CLOSURES: Any time there is a lane/shoulder closure, or any time drilling in done on shoulder without an actual lane closure, for either Soils Design Section or consultant drilling, a CARS 511 Notification needs to be filed before the lane closure is put in place or the shoulder work is performed. Notification should be filed with the Traffic Operations Center at least one day before the closure. For Soils Design Section work, the CARS511 Notification will also usually be performed by the local maintenance office. The Soils Design Section will do the CARS511 Notification for consultants, but the Consultant must let the Soils Design Section know about the closure or shoulder work a minimum of two working days (preferably 3 days) before the work is done.

2. **Clearing.** The Consultant shall carry out all clearing, grubbing, and similar activities that may be necessary to provide access to and working space at and around the location of each boring. However, no clearing, grubbing, etc., may be performed without prior approval from the affected private or public property owner, including the Iowa DOT.

3. **Right-of-Way and Damage to Property.** Except as included in the next section, the Consultant shall obtain all permits and licenses from all applicable authorities having jurisdiction, including a Permit To Work On DOT Right Of Way. On certain projects, the Iowa DOT will obtain or assist in obtaining certain permits, etc. (see next section). Prior to entry on any private property for any reason, the Consultant shall obtain permission from the private property owner and other applicable individuals (such as renters) for any and all work to be done on private property. The Consultant should not enter Railroad right-of-way at anytime without specific prior approval. The Consultant shall comply with all local laws and ordinances of the area in which the work is being done.

   The Consultant shall take every precaution against injury to any public or private property and shall promptly repair or pay for any such damage to the satisfaction of the Iowa DOT and all applicable private property owners or other applicable individuals (such as renters).

   The Iowa DOT does not currently have a consent or other form to use to document access or permission, and possible associated stipulations, etc., from private property owners. Consultants should develop such a form for their own documentation and other use.

4. **Permits for Drilling In and Around Streams and Rivers.** Any time borings are planned in or around a stream/river, and sometimes even in the floodplain area close to a stream/river, a boring location plan will need to be submitted to Office of Location and Environment (OLE) to determine what permits might be necessary (404 Permits, Sovereign Land, Wetland, and/or others) to conduct the borings within these areas. If needed, OLE will apply for and obtain the permits, but the affected borings cannot be performed until the permit has been received by the Consultant.

5. **Utility Clearances** After boring locations are clearly staked in the field, call IOWA ONE-CALL. Notifications must be made at least 48 hours prior to all excavations (excluding Saturdays, Sundays and legal holidays). A "Joint Meet With Locate To Follow" is recommended to insure that all utility companies are contacted and to determine the length of time needed to clear utilities.

6.0 LOCATION OF EXPLORATION POINTS

A. General Requirements. Prior to performing any subsurface investigations in the field, the Consultant shall submit a boring location plan and other applicable documentation showing the location, the anticipated depth, and the type of exploration (boring, cone penetrometer soundings, etc.) for all exploratory locations. This plan will be reviewed by the Iowa DOT Soils Design Section, and all comments from this review must be addressed before the geotechnical work is initiated.

The suggested minimum number and depth of borings are provided in Tables 1 thru 4. The Consultant shall evaluate all available information to determine whether the exploration program, lab testing, etc., discussed in these **Consultant Geotechnical (Soils Design) Work Requirements** are adequate and proper for all applicable and necessary geotechnical design purposes. Engineering judgment should be applied by a licensed and experienced geotechnical professional to adapt the exploration program to the projects as a whole, to the foundation types and depths needed, and to the variability in the subsurface conditions observed. The depth of borings indicated in Tables 1 thru 4 should also take into account the potential for changes in the type, size and depth of the planned foundation elements. If more or less exploration and/or lab testing is considered necessary for full geotechnical analysis and design of the project than is discussed herein, this shall be documented to the Iowa DOT by the Consultant on a timely basis.

Similarly, if additional subsurface investigative techniques such as cone penetrometer, dilatometer, pressuremeter, geophysical (seismic, resistivity, etc.) are considered necessary or beneficial for full and optimal geotechnical analysis and design of the project, the Consultant shall discuss this with the Iowa DOT as part of the contract and/or as part of setting up the geotechnical work.

B. Boring Terminology. The Iowa DOT uses the words/phrases "core hole", "dig hole", and "drill hole" in describing or documenting the types of borings (i.e., the purpose of the borings). These three words/phrases correspond to:

1. Core Hole - subgrade-type borings: Borings are typically along a shoulder for existing roadway and along the proposed centerline for new construction. Occasionally or where the need may be anticipated, an in-place density should be obtained at the depth of the proposed subgrade. The depth to the subgrade will also serve to guide any further sampling. Loose samples are obtained from these borings for suitability determinations. For depths, see Cut Slopes in Table 4. Core borings do not stop in fill, but are drilled down and into the natural ground. Blow Counts are not part of the standard practice for these borings.

2. Dig Hole - borrow-type and backslope borings: Backslope borings are typically located at or near the top of the backslope cut. Loose samples are obtained from these borings for suitability determinations. For depths, see Borrow Area and Backslopes in Table 4. Blow Counts are not part of the standard practice for these borings.

3. Drill Hole - foundation-type borings: Borings are typically located near the toe of slope of the fill areas and at proposed culvert locations. For depths, see Other than Cut in Table 4. Shelby samples are taken for each compressible soil layer greater than 5 feet in thickness (or if thinner and is of potential concern) and shall be obtained from all necessary and appropriate depths. Loose samples are obtained from each significant shallow soil layer (within ±8 feet below natural ground). Blow Counts are generally done only when these borings are drilled for bridges, other structures, and occasionally culverts, and are not standard practice for borings along mainline.

C. Bridges. All bridges shall have soil borings/soundings taken at each abutment and at interior bents to meet the minimum geotechnical site investigation indicated Table 1 and 2.

D. Roadway and Other Structures. Other structures shall have soil borings/soundings taken at the specified intervals and depths to meet the minimum geotechnical investigation requirements outlined in Table 3 and 4. The spacing of all borings may need to be adjusted to adequately identify the locations of rock, unsuitable soils, problematic soils, peat, geologic features, and/or other specific subsurface conditions that could affect the geotechnical design of the project. In addition, the boring spacing may need to be adjusted to be compatible with the proposed locations of culverts, road intersections, frontage roads and other features.

7.0 EQUIPMENT AND METHODS

A. The equipment used shall generally be power drilling and/or driving equipment and/or other tools or equipment as necessary and suitable for determining subsurface characteristics, and for obtaining representative samples for examination and laboratory testing. The equipment shall meet the requirements of the Iowa DOT with respect to ability to accomplish the necessary work. All exploration methods shall be performed in accordance with the current ASTM specifications.

B. Sampling. Sampling of subsurface materials should obtain representative undisturbed and disturbed soil samples for classification and laboratory testing. The following sections outline the typical methods used by the Iowa DOT for sampling. Other methods may be used if pre-approved by the Soils Design Section.

1. Split spoon: All split spoon sampling shall be in accordance with the current ASTM D-1586 specification. Automatic hammers are to be used if available, with manual hammers using rope and cats head devices allowed only if acceptable to the Soils Design Section. Hammers shall have had a calibration within the previous 3 years to determine hammer efficiency, with the results provided to Iowa DOT if requested. The Iowa DOT may require testing to correlate Standard Penetration Testing to Iowa DOT results. Standard Penetration Test N values should be reported both uncorrected and corrected to 60 percent efficiency. The efficiency used in the correction should also be indicated on the logs.

The following equipment or methods will not be permitted in taking split spoon samples: Walking beam, crank, or spudding arm type machinery for raising the 140 pound weight, a wire hoisting cable, a reversible hoisting winch, more than two wraps of the hoisting line over the cats head, or split spoon samplers equipped with damaged drive shoes in which the diameter of the opening has been reduced by more than 0.06 inches from the opening diameter as manufactured.

2. Shelby Tube: Thin-walled metal Shelby tube sampling should be performed in accordance with ASTM 1587 and should be used to recover intact soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Shelby tube sampling is not recommended for sampling soils containing gravel or larger size soil particles, cemented, or very hard soils. The Shelby tubes should be properly sealed at the soil surfaces as soon as possible after sampling to prevent soil movement and moisture gain or loss. Soil contained within a Shelby tube shall be extruded only in the laboratory (not in the field). A Shelby tube may be reused only if there is no damage of any kind, and only after full and proper cleaning.

For a Shelby tube sample used to determine in-place density, an undisturbed sample not

less than 2 inches in diameter and not less than 4 inches in length should be used. In-place density data should be obtained for each major soil layer and each select soil layer.

3. Thick Walled (California Type) Sampler: Thick walled, split barrel drive sampling of soil with inner rings/liners can also be used to obtain representative samples of soil for classification and laboratory testing in accordance with ASTM D3550. The sampler is either pushed or driven, and the penetration resistance data may be recorded. The penetration resistance may differ from ASTM D1586 and sampler/equipment specific correlations should be provided to the Soils Design Section to determine Standard Penetration Test N values. Obtaining samples using a thick walled sampler may or may not provide a suitable sample (undisturbed) for advanced laboratory tests such as in-place density, shear, or consolidation testing. See the description for in-place density core under Shelby Tube above. The Consultant's geotechnical engineer is to determine if the sample quality is suitable for advanced laboratory testing for engineering properties.

4. Bulk: A loose sample (a Bulk/Bag sample) of sufficient size (at least 30 pounds) for multiple testing shall be obtained from each significant soil layer. Samples may represent no more than 600 feet of the alignment. Samples are used for suitability evaluations and testing is for Description and Classification. Test results include:

- Atterberg Limits,
- Percent Gravel, Sand, Silt, and Clay,
- USDA Textural Classification,
- AASHTO Classification with group index; Sieve Analysis,
- Munsell Color Comparison,
- Proctor density and optimum moisture (not every sample), and occasionally
- Percent Carbon Content.

C. Drilling: For borings where the hole fails to stand open, a casing, a hollow stem auger with an inside diameter no less than 0.5 inch greater than the outside diameter of the sampler, or other acceptable procedure shall be used. The casing (auger) shall in no case be advanced ahead of the horizon to be sampled. In general, the casing (auger) shall be stopped approximately 6 inches above the horizon to be sampled. The inside and bottom of the hole shall be cleaned of all loose material before the sample is taken. The boring log shall indicate where water has been used to stabilize boreholes.

D. In Situ Testing: Electro-piezocone (CPTu) soundings and/or dilatometer (DMT) soundings can also be used to supplement traditional borings. No more than half of the testing locations can be CPT or DMT soundings. DMT soundings are typically performed in areas of settlement and stability concern such as at abutments or where soft clays are anticipated (i.e., oxbows). Other methods of in situ testing can also be used with approval of the Soils Design Section.

E. Elevations. If the elevation of the ground surface at each exploration point location cannot be determined or documented from project information or other acceptable existing information, the elevation of the ground at each exploration location (referred to plan datum) must be accurately determined and recorded by acceptable means.

F. Water Level Readings. Both "time-of-drilling" and "delayed" water level readings shall be obtained in all borings and exploratory holes where safe, practical, and feasible. Proper cover over the holes shall be provided during the delay. The depth or elevation of the top of free water is to be logged on the boring log, and should include at what hour after completion of the boring/exploration the water level is determined (such as 24 hours after drilling), including if water is not present. The 24 hour water level reading is preferred. Plugged or collapsed conditions should also be noted.

Water level readings within exploration points at stream-crossing bridges shall be obtained and included in bridge plan sheets for the contractor's information. If drilling fluid is used to advance the exploration, a secondary open-hole boring/exploration shall be drilled adjacent to initial exploration point to obtain delayed water level readings. After delayed water level readings have been obtained from the adjacent boring/exploration, all exploratory holes shall be backfilled as outlined in other portions of these **Consultant Geotechnical (Soils Design) Work Requirements.**

G. **Backfilling and Patching Holes.** After the water level and boring information is obtained and recorded, the holes shall be backfilled as outlined herein in accordance with all applicable local or State regulations. All boring holes shall be completely and fully backfilled in a manner acceptable to the property owner and any applicable regulatory agencies, including tamping to avoid settlement, refilling, and other procedures as may be necessary. Dispose of excess soil in an acceptable manner. All holes drilled through existing streets or similar features and through bridge decks or similar structures shall be patched to the satisfaction of all applicable property owners, including the Iowa DOT.

H. **Environmental and Other Concerns.** If items are discovered which are potentially of environmental, archeological or similar concern, the Consultant shall immediately notify the Iowa DOT.

8.0 FIELD RECORDS

All depth and other details pertaining to all types of samples taken must be fully and clearly identified on the boring logs.

A. The soils and rock encountered in each boring or exploration, where obtained, shall be carefully examined at the time of the exploration and a written record, or log, prepared, which must include a complete description (geologic origin if identifiable, the best interpretation of Unified classification and/or USDA Textural Classification, color, moisture, consistency, etc.) of the soils, rock, and other materials encountered in each significant layer. This includes the thickness and relative position of all layers in the overall profile. The location (depth of) and identification of all samples taken shall also be recorded. A determination shall be made at the time of drilling on whether the logs of the borings/soundings through a specific area need to be plotted in a longitudinal or other profile in order to evaluate uniformity or variation of the subsurface conditions, and to help determine whether additional borings/soundings are necessary to address undefined or problematic areas.

B. If rock is encountered, it shall be fully described geologically, with Recovery and RQD (Rock Quality Designation) values if rock coring is done, and other pertinent information fully recorded. Rock cores must be carefully placed in acceptable and properly labeled rock core boxes, photographed, preserved as needed for subsequent lab testing (depending on the type of rock), and protected from transportation damage, drying out, and/or other detrimental effects until all subsequent examination, testing, and/or other actions are completed.

9.0 SAMPLING AND LABORATORY TESTING

A. In all of the borings discussed herein, samples shall be obtained as the drilling progresses from all significant and major soils horizons for all necessary laboratory testing. All sampling and testing shall be sufficient in number to confirm field classifications and to provide sufficient soils-related and rock-related information that may be needed for all necessary analysis, and/or as may be needed in the preparation of final soils plan sheets as outlined in the **Geotechnical Sections of the Design Manual**.

B. All lab tests shall be conducted in accordance with applicable Iowa DOT, ASTM, AASHTO, or other test standards and methods as referenced in the **Geotechnical Sections of the Design Manual**. The results of laboratory tests and all other pertinent data shall be sufficient to determine the grain size classifications (soil type) and the AASHTO M145 and USDA Textural

classification for all significant soil types and all significant soil layers in the profile, plus other applicable and necessary purposes. These classifications shall be used for determination of soil usage (Class 10, unsuitable, select, topsoil, etc.), for presentation on plan sheets and cross sections as outlined in the **Geotechnical Sections of the Design Manual**, and for other purposes as applicable.

C. The following provides the minimum sampling and laboratory testing requirements:

1. **Cut Areas.** The following samples shall generally be obtained in each cut area for subsequent lab testing as outlined below, but additional sampling and associated lab testing may be necessary to adequately define and characterize variations that are encountered. This includes borings performed for project cuts, and also borings performed for possible borrow areas.

A loose sample of sufficient size shall be obtained from each significant soil layer encountered and representing no more than 600 linear feet of the alignment or borrow area, and shall be tested for:

i. Atterberg Limits (AASHTO T89 and T90, or ASTM D4318).

ii. Percent Gravel, Sand, Silt, and Clay (AASHTO T88 or ASTM D422).

iii. Textural classification (USDA).

iv. AASHTO classification with group index (AASHTO M145).

v. Percent Carbon Content, where applicable (Office of Materials Test Method No. Iowa 111).

vi. Full Sieve analysis (Percent Passing: ¾, ⅜, 4, 10, 40, 100, 200) (AASHTO T88 or ASTM D422).

vii. Munsell Color comparison.

At least two samples from each major soil layer encountered in each cut area representing no more than 600 linear feet of the alignment or borrow area shall be obtained and tested for Standard Proctor maximum density and optimum moisture (AASHTO T99).

For each cut area representing 600 feet or more of the alignment or borrow area, at least two undisturbed cores not less than 2 inches in diameter nor less than 4 inches in length from each major soil layer and each select soil layer shall be obtained and tested for:

i. Determination of in-situ dry density.

ii. Moisture content.

Rock core specimens from rock cores that are suitable for subsequent lab testing and use in design shall be fully preserved in the field for transport to the lab. A sufficient number of Unconfined Compression tests and other appropriate lab tests (i.e., point load, slake durability, etc.) shall be performed on rock core specimens.

2. **Other than Cut Areas (i.e., Fill areas/Embankments).** The following samples shall be obtained from each area or location other than cuts for subsequent lab testing as outlined below, but additional sampling and associated lab testing may be necessary to adequately define and characterize variations that are encountered.

A loose sample of sufficient size shall be obtained from each significant soil layer encountered above non-compressible soil strata if any portion of such a soil layer through a non-cut area might be excavated as part of the proposed construction (e.g., ditches), or if that soil layer is within 8 +/- feet of existing ground through the length of the applicable fill section. Such samples are generally not required for deep soil layers

since they will not be excavated. A sufficient number of these samples shall be tested per the above section.

Undisturbed "Shelby" type samples of each compressible soil layer that is greater than 5 feet thick, or is of potential concern with subsequent geotechnical analysis (i.e., settlement, slope stability, etc.), shall be obtained from at all necessary and appropriate depths in a sufficient number of borings encountering this compressible soil, to be used for:

i. Consolidation testing.

ii. Strength testing (such as Triaxial Compression tests, as discussed below).

iii. Atterberg Limits.

iv. Dry density and moisture content.

v. Other test as applicable.

3. **Bridges.** Split spoon sampling and Standard Penetration Testing (N Value) shall be performed at intervals of 5 feet or as otherwise specified or required in substantial compliance with ASTM D-1586. The N values are obtained by counting the number of blows required to drive the split spoon sampler a distance of 12 inches. Under normal conditions, the spoon shall be driven 6 inches below the bottom of the hole, which has been cleaned out by means of a water jet, auger, or other procedure, before the 12 inch penetration test is started and recorded. All values shall be recorded (first 0.5 foot seat, second 0.5 foot, and third 0.5 foot) in increments of penetration.

Rock core specimens from rock cores that are suitable for subsequent lab testing and use in design shall be fully preserved in the field for transport to the lab. A sufficient number of Unconfined Compression tests and other appropriate lab tests (i.e., point load, slake durability, etc.) shall be performed on rock core specimens for subsequent drilled shaft and/or pile design, with an average of one test for every 5 feet of rock core usually required.

4. **Specialized Laboratory Tests.** Specialized laboratory tests shall be performed as needed to better and to adequately characterize the materials for use in the geotechnical analysis of the project. The type(s) of tests should be selected to best match the analysis that is needed and the condition being evaluated. Additional specialized tests beyond those discussed herein should be approved by the Soils Design Section. Pocket penetrometer and similar test devices will not be allowed as substitutes for laboratory testing unless approved by the Soils Design Section. All tests shall be conducted and performed in accordance with applicable DOT, ASTM, AASHTO, or other laboratory test standards.

5. Examples of normally performed specialized tests include:

i. One-Dimensional Consolidation tests.

ii. Unconfined Compression (UC) tests.

iii. Unconsolidated Undrained (UU) Triaxial Compression tests.

iv. Consolidated Undrained (CU) Triaxial Compression tests.

v. Direct Shear (DS) tests.

vi. Other strength tests (as approved by the Soils Design Section).

10.0 FINAL RECORDS

Minimum information that should appear on every boring log is the boring number, project information, location information, elevation, the soil classification, water level information, field test information, and lab testing results, if performed. Other applicable drilling and sampling information and driller's notes should also be placed on the log. For projects where rock cores are obtained, all appropriate rock core information should appear on the boring logs, and scaled photographs of the rock core boxes should be obtained and presented in digital format.

11.0 STORAGE OF SAMPLES

All samples shall be properly preserved until the final submittal or report is accepted. All rock cores shall be retained until after construction of the project unless other specific arrangements have been made.

12.0 REPORT AND SUBMITTALS

A. **Submittals.** The geotechnical submittal from consultants shall include and follow Soil Design guidelines outlined and documented in the **Geotechnical Sections of the Design Manual** for S1, S2, S3, and S4 event work, plus other work as applicable. A formal written report that may be typical for non-Iowa DOT consultant geotechnical work is typically not needed for roadway, borrow, and associated geotechnical work (such as culverts). The Consultant's report and all submittal items, including recommendations and plan items, will be reviewed and must be accepted by the Iowa DOT District Offices and/or Soils Design Section prior to final plan incorporation. For projects where a rock core is obtained, scaled photographs of the rock core boxes should be obtained and presented in digital format.

All lab test results should generally be reported or included in the submittal, but the raw lab test data does not typically need to be reported. Similarly, all analysis summary/printout sheets (such as summary input/output sheets for slope stability analysis) should generally be reported or included in the submittal, but all computer calculation or other print-outs do not typically need to be reported.

B. **Plan Incorporation.** Some of the Consultant's submittal items, and specifically those that include plan sheets, must be signed by a Professional Engineer licensed in the State of Iowa and must be ready for direct inclusion into project letting plans. This typically includes S3 work and S4 work, as included in and discussed in the **Geotechnical Sections of the Design Manual**. This includes not only the plan sheets themselves (including applicable tabulations), but also soil layer usage information (soil layer lines) on cross sections. Any borings that are not included on the primary geotechnical plan sheets must be included in the cross sections. Inclusion of all borings on the cross sections is desired, and may be required on certain projects. All geotechnical designs, etc., resulting from the Consultant's geotechnical analysis and recommendations must be included on the plan sheets and the cross sections as needed for letting, construction, and other purposes.

C. **Number of Copies.** The number of copies of the Consultant's report and submittals that are required shall be in accordance with the Contract and the **Road Design Specifications**.

13.0 FILE RETENTION

Certain information shall be maintained in the geotechnical consultant's file for the minimum period of time specified in the Contract or in the **Road Design Specifications.** This includes the following items.

1. The location of the project beginning and ending by station, township and range, or by streets and name of city in urban areas, and county or counties.

2. A general description of the proposed improvement, including surface type and width, number of traffic lanes, median, intersections, or grade separations, etc., and any other information which may be of value in the proper interpretation of the survey data.

3. A detailed description of the investigation consisting of:

i. Date (month and year) when the field soils survey and investigation was made.

ii. Climatic conditions during the investigation and for a period prior to the investigation as may be necessary to document dry vs. wet conditions.

iii. General description of terrain with special emphasis on springs and drainage and erosion patterns. Any conditions of high water, flooding, etc., which may have been noted and which might be of value in the design of bridges or culverts.

4. Boring logs providing field descriptions (i.e., geologic origin if identifiable, the best estimation/interpretation of Unified classification and/or USDA Textural Classification), the elevation or depth of all samples obtained, in-place moisture conditions, measured water table elevations, and drilling data.

5. Data, analysis, calculations, background information, etc., leading up to the Consultant's recommendations relative to the design and construction of embankments, subgrade treatment requirements, availability and use of select soils, placement or disposal of unsuitable soils, placement or disposal of unsuitable soils, drainage installations, subgrade removal and replacement, the use of channel change materials, the special handling of unusual soil types or conditions, foundation design, geotechnical remediations, and/or other pertinent factors affecting the design or construction of the section.

6. Settlement estimates for all design structures, including concrete pipes 36 inches in diameter and larger. Also, time vs. settlement curves shall be plotted for all areas where settlements are estimated to be one foot or greater.

7. A map showing the location of each boring.

8. All laboratory test information on samples obtained during the survey, recorded on acceptable forms.

9. Full information on all analysis performed, including all computer generated information.

Table 1: Bridge Foundation Minimum Requirements

Bridge Foundation Type	Minimum Geotechnical Site Investigation
Pile Foundation	Minimum one drill hole location per bent for widths less than or equal to 100 feet. Minimum two drill holes at bent locations having widths greater than 100 feet.
Single Foundation - Drilled Shaft	Minimum one drill hole location per foundation element.
Multiple Foundation – Drilled Shaft	Minimum two drill hole locations per bent location. Additional drill holes should be performed at each shaft location for variable rock conditions.
Shallow Foundation – Founded on Soil[1]	Minimum three drill hole locations per bent location.
Shallow Foundation – Founded on Rock	Minimum two drill hole locations per bent location.
Note: [1]-Currently rarely used on Iowa DOT projects, may be used on future special projects	

Table 2: Minimum Drill Hole Depths for Bridges

Bridge Foundation Type	Minimum Geotechnical Site Investigation
Deep Foundation supported in soil	All drill holes shall extend below the anticipated pile or drilled shaft tip elevation a minimum of 20 feet or deeper as deemed necessary for foundation design. If specific preliminary foundation type is not available, the borings shall extend to a depth equivalent to that necessary to provide a minimum nominal geotechnical resistance of 120 tons in skin friction only (no end bearing) on a 10 inch driven H-pile as determined using the "Driven Pile Foundation Soils Information Chart", plus an additional 20 feet.
Deep Foundation supported in rock	Piles Bearing on Rock: In addition to the split spoon sampling necessary for pile design, a minimum of 10 ft. of rock core shall be obtained in at least one drill hole or two drill holes in cases where significant unexplainable variations in top-of-rock exist in order to verify that the drill hole has not terminated on a boulder. Other drill holes with appropriate split spoon sampling can be terminated at auger refusal provided the rock elevation between drill holes does not vary by more than 10 feet or other reasonable and acceptable amounts. If necessary, a minimum of 10 feet of rock core should be obtained at additional drill holes to verify the presence of suitable rock materials. Drilled Shaft with Rock Sockets: All drill holes shall have a minimum length of rock coring below the proposed or estimated shaft tip elevation equal to 10 feet or a length of rock core equal to at least 3 times the shaft diameter. *Note: For highly variable bedrock conditions, or in areas where very large boulders are likely, more than 10 ft. of rock core may be required to verify that adequate quality bedrock is present. A rock coring depth of around 30 feet is common and adequate for most bridges.*
Shallow Foundation supported in soil	See Table 3
Shallow Foundation supported in rock	All drill holes shall have the necessary and appropriate amount of split spoon sampling and in most cases a minimum of 10 feet of rock coring below the anticipated footing bearing elevation.

Table 3: Minimum Drill Hole Depths-Spread Footings on Soil

Spread Footing Case	**Minimum Drill Hole Depth below anticipated bearing elevation**
L ≤ 2B	2B
L ≥ 5B	4B
2B ≤ L ≤ 5B	3B

L = Length of spread footing; B = Width of spread footing (minimum side dimension of footing)

Table 4: Minimum Geotechnical Investigation Requirements

Exploration Area	Minimum Geotechnical Investigation
Borrow Area	Dig holes at up to 300 foot intervals, depending on the shape, etc. of the proposed acquisition area as determined in the S1 submittal. Min Depth: > 10 feet below anticipated bottom of borrow. *Note: The borings* shall *be spaced to adequately and accurately define the major soils layers encountered within the possible borrow area. If at the time of drilling, there is no borrow design and the bottom of borrow is not known, boring depths* should *be liberal, and* should *reflect the terrain, etc. (for instance, borrow borings on hilltops* should *be deeper than borings in low areas, and in flat areas where a pond borrow is the only feasible type of borrow, borings* should *generally be at least 30 feet deep). Adequate samples* shall *be taken for full identification and delineation of all major and significant soil strata in the borrow area. Any areas of select granular or glacial till soils* shall *also be sufficiently reviewed by the Consultant to determine if additional borings are necessary to evaluate potential borrow sources and/or potential select soil sources.*
Backslopes	Dig holes at about 400 foot intervals in each backslope area, with a staggered pattern (alternating on each side of alignment). Minimum of two dig holes in any significant backslope. A significant backslope is generally several stations in length and at least 10 feet above the bottom of the proposed ditch grade in height. Min Depths: > 6 feet below proposed ditch elevation. *Note: Adequate samples* shall *be taken for full identification and delineation of all major and significant soil strata in the borrow area. Any areas of weak soils, potential sliding planes, and/or other problematic areas* shall *be investigated thoroughly by the Consultant. This* shall *include additional borings and sampling as necessary to adequately define the problematic area.*
Cut Slopes	Soil Cuts < 10 feet: <u>Single lane:</u> Core holes at about 200 foot intervals along centerline. <u>Multiple lanes:</u> Core holes at about 400 foot intervals in each lane, staggered pattern. Soil Cuts > 10 feet: <u>Single lane:</u> Core holes at about 100 foot intervals along centerline. <u>Multiple lanes:</u> Core holes at about 200 foot intervals in each lane, staggered pattern. Min Depths: > 6 feet below proposed ditch elevation. *Note: The spacing of all borings may need to be adjusted to fully identify the locations of rock, select soils, unsuitable soils, problematic soils, geologic features/conditions, and other specific subsurface conditions that could affect the geotechnical design of the project. The boring spacing may also need to be adjusted to be compatible with the proposed locations of culverts and other features.* *Any areas of weak soils, potential sliding planes, and/or other problematic areas* shall *be investigated thoroughly by the Consultant. This* shall *include additional borings and sampling as necessary to adequately define the problematic area.* Rock Cuts: Core hole at various intervals along centerline or backslope, dependent on encountered conditions (see note below). Min. Depth: Various depths, must extend a minimum of 6 feet below anticipated ditch elevation. *Note: Where material is encountered which would geologically classify as rock, the borings* shall *in all instances be carried to a depth sufficient to determine the presence and characteristics of solid rock that may be present within the depth ranges outlined above. Sufficient borings* shall *be made on centerline and on backslopes to definitively outline the surface of the rock material. Where rock exists at 8 feet or higher above profile grade, at least one boring per lane in each cut will be cored to proposed ditch grade. The rock coring and borings* shall *be sufficient to determine if pre-splitting is feasible.*

Table 4: Minimum Geotechnical Investigation Requirements (continued)

Other than Cut (i.e., fill areas & embankment)	Fills < 10 feet: Drill holes at up to about 400 ft. intervals along centerline. Fills > 10 feet: Drill holes as close as about 100 ft. intervals along centerline. Min Depths: 10 feet into firm non-compressible material (such as glacial till with "N" values greater than 10) or to auger refusal in bedrock. *Notes: The spacing and depth of all borings may need to be adjusted to adequately identify the locations of rock, unsuitable soils, problematic soils, geologic features, and/or other specific subsurface conditions (i.e., oxbows, etc.) that could affect the geotechnical design of the project and to be compatible with the proposed locations of culverts and other features. Determining the subsurface conditions is particularly important for embankment fills having heights of 20 feet or more. The locations of proposed culverts (pipes and RCB's) are typically sufficiently defined at the time roadway borings are performed, and all necessary borings for those structures can generally be performed at the same time as the roadway borings.* *Where an area of weak subsoil is encountered, borings* shall *be made in the weak area near the toes of the proposed foreslopes and/or at other appropriate locations that will facilitate all necessary geotechnical analysis, and at intervals as close as 100 foot, or as deemed necessary. The Engineer* shall *be notified immediately of the presence of weak subsoil which may affect the horizontal or vertical alignment of the project.*
Peat Deposits (Organic Soils)	Drill holes as necessary within and adjacent to the proposed alignment or structure such that the lateral extent of the peat deposit is delineated to within a maximum of 25 feet throughout the area where it could affect the project. Min Depths: 10 feet into firm non-compressible material (i.e., such as glacial till with N value > 10 bpf) or to auger refusal in bedrock.
Channel Change	Dig holes at about 100 foot intervals along centerline. *Note: Materials in channel change areas do not ordinarily exhibit normal profiles; therefore, sufficient samples must be obtained for laboratory testing to ensure their suitability for such use on the project, and additional borings may also be necessary.* Min Depths: minimum 3 feet below anticipated bottom of channel change.
Retaining Walls	Drill holes at beginning and end wall, plus at about 75 foot intervals along the wall. Min. Depth: Minimum 5 feet below bottom of wall, plus 10 feet into firm non compressible materials (i.e., such as glacial till with N value > 10 bpf). *Note: If it is known at the time of drilling that a retaining wall will be supported by a deep foundation rather than spread footings, borings of adequate depth with appropriate sampling and testing for deep foundations* shall *be performed.*
Culverts	New Culvert: Drill holes at each culvert end and at about 75 foot intervals along centerline, or as appropriate and needed. Extensions: Drill hole at end of extension and at about 75 foot intervals along alignment, or as appropriate and needed. Min. Depth: Minimum 5 feet below bottom of culvert, plus 10 feet into firm non compressible materials (i.e., such as glacial till with N value > 10 bpf).

Table 4: Minimum Geotechnical Investigation Requirements (continued)

Misc. Structures:	<u>Sound Barrier:</u> Drill holes at about 200 foot intervals along alignment and at beginning and end of structure or as needed and appropriate. Min Depths: Shallow foundations: Generally 10 feet below bearing level plus 10 feet into non-compressible materials (i.e., such as glacial till with N value > 10 bpf). <u>Light Poles/High Mast Structures that will be supported on deep foundations:</u> Drill hole at each structure. Min Depths: see Table 2.

Chronology of Changes to Design Manual Section:

200I-001 Appendix A Consultant Geotechnical (Soils Design) Work Requirements

5/19/2015	Revised
	Emphasized RR ROW not to be entered without prior approval. Expanded on boring terminology and sampling. Changes in Table 4 to define a "significant backslope"
7/22/2014	Revised
	Add in Notification to be filed at least one day before the closure should be filed with the Traffic Operations Center (page 4).
1/15/2014	NEW
	New