ATTACHMENT A – SCOPE OF SERVICES

GEOTECHNICAL INVESTIGATION

The consultant may perform geotechnical investigations consisting of soil borings, laboratory testing, optional cone penetrometer test (CPT) soundings, soil classification, and a Geotechnical Data Report (GDR). The geotechnical exploration services to be provided shall include, but are not limited to:

- Performing field reconnaissance (including obtaining all rights of entry, utility locations, access, etc.);
- Obtaining and coordinating traffic control;
- Mobilization/demobilization of all equipment necessary to perform the work;
- Performing deep borings, CPT soundings, and shallow subgrade soil survey borings;
- Performing Thin-Walled Tube Sampling of Soils (ASTM D1587) and Standard Penetration Tests and Split-Barrel Sampling of Soils (ASTM D1586);
- Reporting water table readings;
- Sealing boreholes in accordance with all applicable regulations;
- Reporting surveyed latitude and longitude and natural ground elevation of boring locations surveyed by a Professional Land Surveyor licensed in Louisiana;
- Performing relevant laboratory testing;
- Classifying soils according to the visual-manual method (field/extrusion logs), Unified Soil Classification System (deep/bridge borings), and AASHTO classification system (soil subgrade survey borings);
- Drafting soil boring logs;
- Digital submittal of all test data in the LADOTD's standard format; and
- Submittal of Geotechnical Data Reports.

1.1 Field Investigation - Deep/Bridge Soil Borings

The field investigation may consist of traditional soil borings with laboratory testing, or a combination of that along with Cone Penetrometer Testing (ASTM D3441, ASTM D5778). Cone Penetrometer Testing may be proposed in lieu of a portion of the soil borings, but shall not be utilized where the geology does not permit the CPT rig to acquire data to the depth needed to perform foundation design for the bridge. It is the consultant's responsibility to conduct a desk study prior to commencing fieldwork in order to determine the adequacy of the proposed fieldwork for that particular site.

1.1.1 Sampling

Soil borings shall be made using wet/mud rotary methods below the water table, with solid-stem augering (ASTM D1452) permissible above the water table. Sampling shall consist of pushing thin-walled Shelby tubes in cohesive soils (ASTM D1587) and Standard Penetration Testing (SPT) in cohesionless soils (ASTM D1586). Continuous sampling shall be performed within the upper 10 feet, followed by either:

- Sampling at 5-foot centers in cohesive soils, or
- Sampling at 3-foot centers in cohesionless soils.

Shelby tube sampling in cohesionless soils and SPT sampling in cohesive soils will not be allowed, except on a case-by-case basis where Shelby tubes cannot be pushed into hard cohesive soils. When a Shelby tube is retrieved with no recovery, the hole shall be cleaned out and a SPT shall be performed directly below the previous sampling interval.

1.1.2 Water Level

Water level observations shall be made in all soil borings. If the field investigation requires multiple days to complete, at least one long-term (24-hour) water level observation shall be made. Final boring locations and elevations shall be surveyed.

1.1.3 SPT Hammer Calibration

All SPT hammers used shall have been calibrated within the past 2 years using methods described in ASTM D4633.

1.1.4 Borehole Abandonment

Boreholes and CPT soundings shall be backfilled in accordance with all local, State, and Federal regulations. Refer to the *Construction of Geotechnical Boreholes and Groundwater Monitoring Systems Handbook* for State regulations in the making of boreholes.

1.1.5 Sample Storage and Transport

The following practices shall be observed during transport and storage of the samples:

- Cohesive samples may be extruded in the field provided they are stiff enough to be wrapped and transported, otherwise, samples shall be extruded at the laboratory;
- Shelby tubes not extruded in the field shall be sealed using expansion packers to prevent moisture loss and disturbance;
- Samples shall be extruded using a continuous pressure hydraulic ram. Extrusion by any other method, such as water pressure, is prohibited;
- Samples shall be extruded directly onto a sample trough, not caught by the hand; and
- Samples shall be transported vertically in the same orientation that they were sampled.

Follow ASTM D4220 for sample transportation except as noted herein.

1.1.6 Field Logs

Soil borings shall be logged in the field or in the laboratory and shall use the visual-manual method for classification (ASTM D2488). Pocket penetrometer readings shall be made on representative portions of the samples.

1.2 Field Investigation – Subgrade Soil Survey

A subgrade soil survey boring shall be made within 100 feet of each bridge end. Subgrade soil survey borings can be made utilizing continuous-flight augers, pneumatic, or direct-push sampling. The depth of each boring should be at least 8 feet below the finished roadway elevation or natural ground, whichever is greater, with additional sampling and testing requirements for areas of cut/fill greater than 10 feet. In cases of excessive cut/fill heights, deep soil borings may be more appropriate.

1.3 Laboratory Testing

All laboratory testing shall conform to applicable ASTM test designations. Alternative test methods may be proposed on a case-by-case basis. Dry preparation methods shall only be used when performing tests for subgrade soil survey (pavement) borings or when requested by DOTD.

1.1.1 Bridge Boring Testing

The following laboratory tests shall be performed, at a minimum:

- Moisture content (ASTM D2216) – all samples;
- Unconsolidated-undrained Triaxial compressive strength (ASTM D2850) – 75% of all cohesive samples;
- Atterberg Limits (ASTM D4318) – 75% of all cohesive samples; and
- Grain size testing (ASTM D1140 and ASTM D6913) – 50% of all samples or more as needed.

One-dimensional consolidation tests (ASTM D 2435) shall be performed where significant settlement is expected due to fill and at all pile group foundation locations. A minimum of 2 consolidation tests shall be performed per applicable boring.

1.1.2 Extrusion Logs

While extruding soil samples from deep borings in the lab, an extrusion log shall be made using the visual-manual classification method. New pocket penetrometer readings shall be made on representative portions of the samples.

1.1.3 Subgrade Soil Survey Testing

The soil stratigraphy shall be identified every foot or stratum break at the discretion of the lab engineer of record using the AASHTO classification system (ASTM D3282, AASHTO M 145) and the following tests:

- Atterberg Limits (ASTM D4318) – 100% of all cohesive samples;
- Moisture content (ASTM D2216) – all samples;
- Grain size testing (ASTM D1140 and ASTM D6913) – as needed to classify granular soils;

- Hydrometer tests (ASTM D7928) – 75% of samples;
- Percent Organics (ASTM D2974) – as needed; and
- pH (ASTM G51) and resistivity (AASHTO T 288) – as needed, at applicable pipe crossings.

Dry preparation methods (ASTM D421) shall be used for applicable testing of shallow subgrade soil survey samples.

GEOTECHNICAL DELIVERABLES

The following items shall be submitted upon completion of the project:

1.4 Geotechnical Data Report

For each project with a subsurface investigation, the consultant shall furnish a final Geotechnical Data Report (GDR) detailing the results of the subsurface investigation. The GDR will be included in the bid documents and shall contain only factual information and no opinions or engineering recommendations. The GDR shall include, at a minimum:

1) Cover letter with executive summary describing the subsurface investigation;
2) Table of contents;
3) Report Body containing the following sections, at a minimum:
    a. Project Description;
    b. Summary of subsurface investigation, including description of methods and standards used; and
    c. Summary of laboratory testing performed, including description of methods and standards used.
4) Appendix containing the following items, at a minimum:
    a. Boring plan;
    b. General bridge plan & profile sheet used to establish the boring locations;
    c. Soil boring logs;
    d. Plots of grain size distribution curves and consolidation tests, as applicable; and
    e. Laboratory test data sheets, including extrusion logs, stress vs. strain plots for triaxial testing, consolidation test deformation vs. time plots (when applicable), Atterberg Limit worksheets, etc.

1.5 Geotechnical Interpretation Report (Geotechnical Design Report)

For each project where design is performed, the consultant shall furnish a final Geotechnical Interpretation Report (GIR) detailing assumptions, design methodologies, and final recommendations. The report shall be signed and sealed by a Professional Civil Engineer registered in the State of Louisiana, and shall include the following items, at a minimum. Additional deliverables are discussed in the subsection for each type of engineering analysis and design element.

1) Cover letter with executive summary describing the structure type, loads, and recommended foundation lengths. All plan-related notes, quantities, and tables shall be provided in the cover letter;
2) Table of contents;
3) Report Body containing the following sections, at a minimum:
    a. Project Description:
        i. Summary of structure type; and
        ii. Summary of geotechnical investigation performed.
    b. Subsurface Conditions:
        i. Generalized subsurface profile; and
        ii. Summary of groundwater conditions.
    c. Foundation Analyses:
        i. Summary of design codes and specifications followed;
        ii. Description of analysis method(s) used as well as any relevant assumptions;
        iii. Discussion of the evaluation of various LRFD resistance factors, field verification methods, and associated costs;
        iv. Recommended foundation tip elevations/lengths;
        v. Brief construction recommendations, identification of potential difficult installation conditions, etc.
    d. Slope Stability Recommendations including assumptions and design methods used (if applicable);
    e. Embankment Settlement Recommendations including assumptions and design methods used (if applicable);
    f. Earth Retaining Structures Recommendations including assumptions and design methods used (if applicable);
4) Appendix containing the following items, at a minimum:
    a. Any documents revised since the GDR, such as boring plans or soil boring logs;
    b. Plots of relevant soil data versus elevation including the interpreted design profile for each design site;
    c. Nominal foundation resistance versus elevation plots for each design site and pile size/type;
    d. Pile/shaft data table; and
    e. Input and output from settlement, slope stability, and ERS analysis software.

1.5.1 Plan Sheets & Special Provisions

Note that the GIR is used to document assumptions and recommendations; however, the GIR will not be a bid document. Any recommendations needed to build the project shall be reflected in the plans and, if necessary, special provisions. As such, the Consultant shall also develop these items as necessary. The

Consultant shall also compute quantities for each pay item applicable to the geotechnical elements in the project.

1.5.2 Cost-Benefit Analysis

The resistance factor selection and associated field verification (where applicable) are generally at the discretion of the Consultant. However, these should be selected practically, considering cost of the field testing and the value of the testing relative to the engineering uncertainty of the subsoil parameters. Recent bid histories for estimating the costs of the various resistance factor scenarios may be found at:

http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Project_Management/Pages/Cost_Estimating_Tools.aspx

The Consultant shall conduct a cost-benefit analysis for the applicable resistance factors for all deep foundation designs. The Consultant shall coordinate with LADOTD when selecting resistance factors for design that require the consultant to perform field testing (PDA, static load testing, etc.). LADOTD does not provide construction phase testing for Consultant designed projects.

1.5.3 Constructability

All engineering analyses shall consider the constructability of the proposed solution. Any special phasing, temporary slopes, temporary earth retaining structures, etc. needed to construct a particular solution shall be discussed in the GIR and reflected in the plan sheets.

1.6 Report Format

Each report shall be submitted in electronic format as a searchable .pdf file with bookmarks denoting the various sections of the report. Report body, charts, and figures shall be generated directly from the source applications in order to minimize file size. Documents scanned as raster images shall only be used when no other option exists for their inclusion into the report. All pages shall print to either 8.5" x 11" or 11" x 17" without scaling or adjustment.

1.7 Soil Boring Logs

Soil boring logs shall be presented in the GDR adhering to either the standard LADOTD boring log format, or the Consultant's own 8.5" x 11" format.

1.7.1 Deep/Bridge Borings

At a minimum, the following results must be displayed on the boring logs in the specified units:

- Scales for Elevation and Depth Below Ground Surface (ft);
- Graphical representation of Soil Stratigraphy and Sample Type;
- Stratigraphy classified according to the Unified Soil Classification System (USCS) (ASTM D2487), including observations such as soil consistency/strength, color, inclusions such as seams, nodules, organics, etc.;
- Graphical and text representation of Groundwater Table;

- Sample Identification;
- Wet Density (pcf);
- Moisture Content and Atterberg Limits (%);
- Percent Passing the No. 200 Sieve (%);
- Compressive Strength (tsf), Triaxial Cell Pressure (psi), and Failure Mode;
- SPT results for each 6-inch increment, reported N Value (blows/ft), and SPT Termination Code;
- Date of Boring;
- Crew Chief, Drill Rig Model, SPT Hammer Type & Efficiency;
- Drilling Method, Hole Diameter, and Backfill Type;
- Latitude, Longitude, Elevation, and other relevant location information;
- Bridge Recall Number; and
- Other relevant notes describing observations made during drilling or laboratory testing.

1.7.2 Cone Penetrometer Test Soundings

Cone penetrometer test soundings shall be presented in the GDR on logs adhering to either the standard LADOTD CPT log format or the Consultant's own 8.5" x 11" format. The standard format presents tip resistance, side friction, pore water pressure, and classification based on the Zhang and Tumay method. Examples of boring logs and CPT logs can be furnished upon request.

1.7.3 Shallow Subgrade Soil Surveys

Shallow Subgrade soil survey borings shall be presented in a tabular format containing all test results and classified using the AASHTO soil classification method.

1.7.4 Plan Sheets

In addition to including boring logs in the GDR, the logs shall also be furnished on full-size plan sheets (22"x34") submitted in .pdf format. Boring logs included on the plan sheets may be the Consultant's own format pasted onto a plan sheet, or the standard LADOTD boring log format.

1.8 Geotechnical Data

All geotechnical data shall be furnished to LADOTD in a gINT file cloned from LADOTD's standard gINT file. Other formats or gINT files containing a modified schema/structure will not be accepted. A copy of the standard template will be provided upon request. Raw data files from all CPT soundings shall also be furnished.

2.0 GEOTECHNICAL ENGINEERING ANALYSIS AND DESIGN

All geotechnical engineering shall be performed in accordance with present LRFD design requirements and standard engineering practice. In addition to the referenced ASTM designations, refer to FHWA Geotechnical Engineering Circular No. 5 (GEC 5) for best practices pertaining to geotechnical site characterization. Geotechnical engineering services may include, but are not limited to:

- Design of embankments and slopes (stability & settlement);
- Design and load testing of deep foundations (piles, drilled shafts, and other);
- Design of earth retaining structures (MSE, cantilever walls, sheet pile walls, etc.);
- Design of culverts;
- Construction monitoring; and
- Geotechnical instrumentation.

2.1 Embankments & Slopes

Design and recommendations for embankments and slopes shall be provided as follows:

2.1.1 Slope Stability

Embankment slopes steeper than 3(H):1(V) shall be analyzed for slope stability using the Spencer method. The following maximum resistance factors and equivalent factors of safety shall be considered for slope stability:

- Typical conditions: $\phi = 0.75$ (equivalent minimum FoS ≈ 1.3);
- Critical slopes (Interstate, slopes with structures, etc.): $\phi = 0.65$ (equivalent minimum FoS ≈ 1.5); and
- Rapid drawdown: $\phi = 0.85$ (equivalent minimum FoS ≈ 1.2).

All potential governing geometry, groundwater, surface water, and other loading conditions shall be considered for drained and undrained conditions as applicable.

Report deliverables shall include graphical representations of all stability models used for design, showing cross-section geometry, model/soil parameters, critical failure surfaces, and factors of safety. Initial and final (improved) conditions shall be shown, where applicable.

Plan sheets shall include notes, layouts, and details for slope monitoring/instrumentation (inclinometers, SAAs, etc.) and mitigation measures (ground improvement, walls, regrading, berms, etc.).

2.1.2 Settlement

The placement of new embankment fill and/or earth retaining structures may induce settlement of existing subsurface soils. Analyses shall be performed to estimate the total magnitude of consolidation settlement, time-rate of settlement, and effect of settlement on adjacent structures, utilities, or improvements. The goal of the analyses shall be to limit the post-construction settlement to 1 inch or less under new embankments and earth retaining structures, prevent damage to existing improvements, and limit the effects of downdrag on adjacent (new or existing) foundations. If necessary to meet these design goals, recommendations shall be made for mitigation measures such as ground improvement, load transfer platforms, lightweight fills, surcharging, and/or wick drains.

Report deliverables shall include site characterization data and plots of selected design parameters versus elevation, interpretations of consolidation test data, input and output from settlement analysis software, plots of time-rate of settlement, evaluations of settlement/stress increase on adjacent structures, downdrag analyses, etc.

Plan sheets shall include notes, layouts, and details for settlement monitoring/instrumentation (settlement plates, liquid settlement cells, etc.) and recommended improvements/mitigation measures (wick drains, load transfer platforms, surcharges, etc.). Recommendations for settlement monitoring programs shall be provided if measures other than those in the Louisiana Standard Specifications for Roads and Bridges (LSSRB) are needed. Any construction sequencing differing from the LSSRB shall be clearly defined in the plan notes.

2.2 Pile Foundations

Pile tip elevations shall be designed using the static equilibrium methods presented in FHWA Geotechnical Engineering Circular No. 12 (GEC 12). Specifically, the Nordlund and α methods shall be used in cohesionless and cohesive soils, respectively.

If CPT soundings are made, pile design shall also be evaluated by the Schmertmann, LCPC, and DeRuiter & Beringen Methods, which are presented in the final report for LTRC Project 98-3GT, Evaluation of Bearing Capacity of Piles from Cone Penetration Test Data (Hani and Abu-Farsakh, 1999). The computations can be automated using the Louisiana Pile Design by Cone Penetration Test software, published by LTRC and located at http://www.ltrc.lsu.edu/downloads.html. In general, the most conservative pile capacity curves generated from the GEC 12 and CPT direct methods should be used in design in the absence of site-specific load test data.

Report deliverables shall include site characterization data and plots of selected design parameters versus elevation, discussion of pile drivability/constructability including predrilling and jetting recommendations, discussion of cost-benefit analysis for resistance factor selection, plots of nominal pile resistance versus elevation for all design methodologies used, and discussion of other relevant design assumptions. Pile load test recommendations shall be provided where applicable, including location, depth of casing, test pile tip elevation, maximum test load, and any instrumentation requirements.

Plan sheets shall include pile data tables and appropriate notes in accordance with LADOTD Bridge Design Technical Memorandum 32.3. For load testing procedures not covered by the LSSRB, special provisions for the construction and testing of the test foundation shall be provided.

2.2.1 LRFD Design

The load and resistance factor design (LRFD) method shall be used to set pile lengths. Subsurface data for each bridge site shall be evaluated and divided into design "sites" (design reaches) based on the variability of the data. Refer to GEC 5 for best practices on selecting sites for LRFD design. At a minimum, all of the following resistance factors (ϕ) and corresponding pile resistance verification methods shall be evaluated based on costs and engineering benefits:

- ϕ = 0.80: One Test Pile per design site with 2% (or a minimum of two) production piles tested using dynamic monitoring and signal matching;

- ϕ = 0.65: One Indicator Pile per design site with 2% (or a minimum of two) production piles tested using dynamic monitoring and signal matching; or
- ϕ = 0.50: No Test/Indicator Piles, end-of-drive pile resistance verification using the Modified Gates equation.

2.2.2 Scour

Pile design shall consider scour in accordance with Bridge Design Technical Memorandum 21 (BDTM.21). Per Bridge Design Technical Memorandum 32, Rev. 3 (BDTM 32.3), required nominal resistances shall be computed for two cases and presented on the Pile Data Tables:

- The case where the pile is driven to the required tip elevation without the benefit of predrilling, and thus developing full side friction along its entire embedment length; and
- The case where the contractor performs predrilling to the scour elevation in order to advance the pile; thus eliminating side friction within the predrill/scour zone.

Note that the Louisiana Pile Design by Cone Penetration Test software does not take scour into account; therefore, for sites with a significant overburden effect (sand profiles), pile design using CPT may not be appropriate.

2.2.3 Other Considerations

Additional design considerations such as lateral loading, uplift, group effect, downdrag, etc. shall be addressed in accordance with GEC 12.

Note that LADOTD has observed inconsistencies in the published SPT vs Phi angle correlations for certain areas of the state, specifically the Florida Parishes and northern part of the state near the Ouachita River. For design of pile foundations in these regions, the Consultant shall first discuss the design parameters with LADOTD to determine whether alternative correlations may be warranted.

2.3 Drilled Shaft Foundations

Shaft tip elevations shall be designed using the static equilibrium methods presented in FHWA Geotechnical Engineering Circular No. 10 (GEC 10).

Report deliverables shall include site characterization data and plots of selected design parameters versus elevation, discussion of shaft constructability, plots of nominal shaft resistance versus elevation for all design methodologies used, and discussion of other relevant design assumptions. Shaft load test recommendations shall be provided where applicable, including location, depth of casing, test shaft tip elevation, maximum test load, and any instrumentation requirements. If bidirectional testing is recommended, load cell balance points shall be recommended for the test shafts.

Plan sheets shall include pile data tables and appropriate notes in accordance with LADOTD Bridge Design Technical Memorandum 32.3. Any special instrumentation details and notes shall also be provided in the plans. For load testing procedures not covered by the LSSRB, special provisions for the construction and testing of the test foundation shall be provided.

2.3.1 LRFD Design

The load and resistance factor design (LRFD) method shall be used to set shaft lengths. Subsurface data for each bridge site shall be evaluated and divided into design "sites" (design reaches) based on the variability of the data. Refer to GEC 5 for best practices on selecting sites for LRFD design.

Drilled shafts shall be designed with a resistance factor, ϕ, of 0.70, corresponding with field verification using bi-directional load testing. Refer to LTRC Project 07-2GT, Calibration of Resistance Factors Needed in the LRFD Design of Drilled Shafts (Abu-Farsakh et al., 2010) to determine appropriate locally calibrated resistance factors for static design methods without load testing.

2.3.2 Other Considerations

Additional design considerations such as lateral loading, uplift, group effect, downdrag, etc. shall be addressed in accordance with GEC 10.

2.4 Other Foundations

If other types of foundations are recommended for the specific project conditions, the standard procedure format and the deliverables format outlined for piles and drilled shafts shall be followed with specific design details for the type of foundation recommended. Design methodologies should follow AASHTO LRFD and FHWA Geotechnical Engineering Circulars, where possible. Special provisions, plan sheets, and notes shall be provided as needed for foundation types not covered by the LSSRB.

2.5 Earth Retaining Structures

When adequate space is not available for a slope, an earth retaining structure may be necessary. The DOTD has used mechanically stabilized earth (MSE) walls, gravity concrete walls, sheet pile walls, and others. If necessary, the consultant shall select the most appropriate wall type for the specific project and evaluate the following, at a minimum:

- Global stability check of ERS;
- External stability check of ERS;
- Settlement analysis of ERS;
- Deflection, section type, and anchor system recommendations for sheet pile walls;
- Analysis of governing load conditions under drained and undrained soil conditions; and
- Analysis of any other critical/governing configurations of the ERS.

Report deliverables shall include settlement and global slope stability output, as discussed in previous sections. Input and output for analysis of external stability of MSE walls and sheet pile wall analysis (stability, shear, moment, & deflections) shall be provided.

Plan deliverables for MSE walls shall include typical sections (including drainage), profiles indicating the top of leveling pad elevation, wall locations, minimum reinforcing lengths, and backfill and other material requirements. Plan deliverables for sheet pile walls shall include typical sections (including drainage), wall locations, required section types, wall top and tip elevations, required anchor force per foot of wall (for anchored walls), backfill and other material requirements, and any specialized notes needed for anchored wall systems. Phasing and removal of temporary wall systems shall be addressed in the plan notes.

Report and plan deliverables for other types of retaining walls shall follow generally recognized design procedures and the requirements stated in this document for MSE and sheet pile walls.

2.5.1 MSE Walls

The DOTD developed "MSEW Design Guide, GEDG. No. 8," latest edition may be used as a reference. The design procedures in FHWA Geotechnical Engineering Circular No. 11 (GEC 11) shall be used except where superseded by GEDG No. 8. Only DOTD approved wall systems will be allowed.

2.5.2 Sheet Piles

Sheet pile wall calculations should include appropriate undrained and drained soil conditions and estimated long-term and short-term deflections. The resistance factors from the AASHTO Bridge Design Specifications, latest edition, shall be used to design sheet pile walls. A minimum factor of safety of 1.5 shall be applied to the passive resistance when evaluating sheet pile walls. The USACE Design Guide titled "EM-1110-2-2504- Design of Sheet Pile Walls" may be used as a reference.

2.5.3 Other Retaining Wall Types

Other types of retaining walls that may be appropriate for DOTD transportation projects are drilled shaft walls, soldier pile & lagging walls, slurry walls, anchored (tied-back) walls, soil nailed walls, reticulated micro pile walls, jet-grouted walls, and deep soil mixing walls. These walls shall be designed using generally recognized design procedures applicable to the specific type of wall used.

Note that reinforced soil slopes may, in some cases, be an economical alternative to a retaining wall.

2.6 Culverts

The geotechnical design culvert locations shall consist of the following, when applicable: earth pressure calculations, bearing capacity analyses, settlement analyses, evaluation of constructability.

Report deliverables shall include the input and output of such analyses. Plan deliverables shall include recommendations for bedding material, details and notes for ground improvement or foundation support, and notes for phasing or any special construction procedures needed.

3.0 CONSTRUCTION MONITORING

The following sections describe the various types of construction monitoring that can be expected on DOTD projects:

3.1 Pile Foundations

The Consultant shall provide construction phase review, engineering, and testing for pile foundation projects where the Consultant is the geotechnical engineer of record.

- Review of Contractor submittals such as Pile Installation Plan, wave equation analysis, and pile driving logs;
- Dynamic monitoring of Test, Indicator, and Monitor Piles with the Pile Driving Analyzer (PDA), including providing all equipment and sensors needed to perform the monitoring;
- Analysis and presentation of PDA data using CAPWAP, GRLWEAP, and PDI PLOT;
- Pile driving logs for all piles tested with dynamic monitoring;
- Recommending pile driving acceptance criteria, including bearing capacity graphs (inspector's charts);
- Analysis and interpretation of all static load test data; and
- Recommending final pile tip elevations based on the results of load tests and/or dynamic analyses.

A final report shall be provided for each project summarizing the results of all pile load testing, dynamic monitoring, and other field observations.

3.2 Drilled Shaft Foundations

The Consultant shall provide construction phase review, engineering, and testing for drilled shaft foundation projects where the Consultant is the geotechnical engineer of record.

- Review of Contractor submittals such as Drilled Shaft Installation Plan, excavation logs, slurry logs, concrete placement logs, etc.;
- Review of integrity test data such as cross-hole sonic test logs or thermal integrity profiling test logs;
- Analysis of static (bi-directional) or dynamic (drop hammer) test results;
- Recommending final shaft tip elevations based on the results of load testing.

A final report shall be provided for each project summarizing the results of all shaft load testing and other field observations.

3.3 Other Foundations

The scope of work for other foundations and the deliverables shall be as recommended in the Consultant's Geotechnical Interpretation Report and special provisions.

4.0 GEOTECHNICAL INSTRUMENTATION

The objective of geotechnical instrumentation in construction monitoring is to record and interpret the Instrumentation data and compare actual soil behavior to that predicted by design. Each type of Instrumentation has an intended purpose and allows major decisions to be made by Construction Managers that affect construction safety (prevent major failures), scheduling, and construction costs. No instrumentation shall alter the performance of the geotechnical design. The usual Instrumentation specified to monitor foundation performance on projects where stability and settlement are critical are slope inclinometers, piezometers, and settlement devices. The geotechnical interpretation report should recommend an instrumentation layout and the frequency of readings.

4.1 Deliverables

The deliverables for geotechnical instrumentation shall include:

- Plan and elevation location, details, and applicable notes for all instrumentation;
- Specifications for furnishing, installation, monitoring, and reporting for all instrumentation;
- Graphical presentation of lateral movement data and action recommendations;
- Graphical presentation of actual field settlement data and action recommendations; and
- Interpretation of other instrumentation data as recommended in the GIR.

5.0 LIST OF PUBLISHED GEOTECHNICAL DOTD REPORTS AND FORMS PLUS OTHER TECHNICAL REFERENCES

Most of the following can be obtained at the DOTD web site (www.dotd.state.la.us) or at the FHWA Bridge/Geotechnical web site (www.fhwa.dot.gov/bridge).

5.1 DOTD Reports and Forms "Latest Editions"

DOTD references include, but are not limited to, the following:

1. AASHTO LRFD Bridge Design Specifications, latest edition and supplements;
2. Standard Specifications;
3. Bridge Design Manual;
4. Road Design Manual;
5. Hydraulics Manual;
6. Drilled Shaft Foundation Construction Inspection Manual;
7. Drilled Shaft Construction Logs;
8. MSEW Design Guide, Geotechnical Engineering Design Guide (G.E.D.G.) No. 8;
9. LTRC "PILECPT" Software;
10. Pile and Driving Equipment Data Form;
11. LADOTD Geotechnical Design Manual (In Progress)

5.2 Other Technical References:

The DOTD has used the following as technical references and guidelines in the design and construction monitoring of Geotechnical features for DOTD projects in the past and are recommended for use by the Geotechnical Engineering consultant community. This list is not all encompassing and other publications may be used and referenced. Additions will be made as this Document is updated.

1. FHWA. (1997). *Soils and Foundations Reference Manual Vol I and Vol II.* Washington, D.C.: Federal Highway Adminstration, U.S. Dept. of Transportation. Retrieved from https://www.fhwa.dot.gov/engineering/geotech/library_listing.cfm?sort=default
2. FHWA. (1998). *Geosynthetic Design and Construction Guidelines Manual.* Washington, D.C.: Federal Highway Adminstration, U.S. Dept. of Transportation. Retrieved from https://www.fhwa.dot.gov/engineering/geotech/library_listing.cfm?sort=default
3. FHWA. (1998). *Geotechnical Instrumentation Manual.* Washington, D.C.: Federal Highway Adminstration, U.S. Dept. of Transportation. Retrieved from https://www.fhwa.dot.gov/engineering/geotech/library_listing.cfm?sort=default
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