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Chapter 5

GEOTECHNICAL REPORTS

This Chapter provides guidance on the preparation of MDT Geotechnical Reports. When used as described, this information will provide consistent and appropriately documented Geotechnical Reports.

5.1 GENERAL

5.1.1 Overview

The Geotechnical Report provides written documentation of findings from the field explorations, laboratory testing, preliminary geotechnical evaluations, final geotechnical evaluations, and construction planning reviews. It should also provide recommendations for alignment and right-of-way considerations.

In general, prepare all geotechnical project reports using standard MDT memorandum letterhead and organize the report using the format discussed in the following Section. The District Geotechnical Manager or project geotechnical specialist is responsible for the preparation of the Geotechnical Report. Use the following format when preparing Geotechnical Reports:

1. Addressee (To). Address the memorandum to the Section Engineer (e.g., Road Design Section, Bridge Design Section, Consultant Design Section, District Pre-Construction Engineer) responsible for the project oversight.
2. Signature (From). Prepare the Report for the Geotechnical Engineer's or District Geotechnical Manager's signature. Also, include the Report author and title directly underneath the author's signature line.
3. Date. Include the date the Report is submitted to the addressee.
4. Subject. In the subject, include the official project number, project description and uniform project number.
5. Distribution. After the Geotechnical Engineer or District Geotechnical Manager has signed the memorandum, copies of the Geotechnical Report will typically be distributed to the project file and to the following individuals, as applicable:
 - District Administrator,
 - District Pre-Construction Engineer,
 - Bridge Bureau Chief,
 - Highway Bureau Chief,
 - Materials Bureau Chief,
 - Hydraulics Engineer,
 - Environmental Services Bureau Chief,
 - Consultant Design Bureau Chief,

- Construction Engineering Services Bureau Chief, and
- any other individuals or units deemed appropriate.

5.1.2 **Investigation and Engineering Information**

Where applicable, include the following information in the Geotechnical Report:

1. **Subsurface Investigation.** When summarizing the subsurface investigation, consider including the following:
 - the number of borings taken and dates that the boring work took place;
 - a summary of the soil and rock types found;
 - a general description of the land formation;
 - the water table and location on the boring logs;
 - any additional subsurface testing that was conducted (e.g., groundwater monitoring, seismic), the equipment used, the stationing and other applicable information relative to the test;
 - the results of the site tests;
 - the boring logs, maps indicating the boring locations, data from site tests, etc., in the appendices; and
 - the location for material and borrow sources, if applicable.
2. **Laboratory Testing.** Indicate the laboratory tests that were completed on the soil and rock samples. Include a summary of the laboratory testing results. If deemed significant, discuss the results of these laboratory tests.
3. **Engineering Evaluations and Recommendations.** See the activity-specific requirements summarized in the following Sections.

5.2 PRELIMINARY GEOTECHNCIAL REPORTS

5.2.1 Preliminary Geotechnical Evaluation Report (Activity 460)

At the completion of [Activity 460](#), the project geotechnical specialist will prepare a memorandum describing the findings from the preliminary geotechnical evaluation and will provide recommendations that may affect the alignment, right-of-way or other design considerations. Not all of the subject areas listed below will be required for every preliminary geotechnical report and adjustments may be required as deemed necessary. The level of coverage for each item will also vary from project-to-project. Although in-depth coverage of the individual details is usually not provided in this Report, provide sufficient detail to allow the reader to fully understand the problem and any proposed recommendations.

[Section 5.1.1](#) provides the general transmittal requirements that should be followed when preparing the Report. The following provides the topic areas, in order, to be addressed in the Preliminary Geotechnical Evaluation Report:

1. Introduction. Identify the purpose of the Report (i.e., Preliminary Geotechnical Evaluation) and provide a very brief summary of what is included in the Report.
2. Project Information. Include the following in the project description:
 - the county where the project is located;
 - route number or street name;
 - nearby towns and/or cities;
 - the project location with respect to the highway reference posts;
 - intent of the project (e.g., bridge replacement, roadway reconstruction);
 - major features of the project (e.g., four-span structure, retaining wall, final roadway widths, design speed);
 - if preliminary drilling was conducted in [Activity 455](#) (critical projects only), include the results here; and
 - other applicable elements of the project (e.g., deep cuts or fills, special drainage considerations, detour requirements).
3. Area Geology. Note the topography of the project area. Identify the soil and rock type formations within the project area (e.g., Fort Union Formation, Tertiary Flaxville Formation). Note the predominate soil and rock types that can be found within the project area. If available, provide a description of the soil and rock formations (e.g., colluvial clastic deposits located in the valleys).
4. Seismic Summary. Include a summary of the seismic history for the area (e.g., seismic maps).

5. Site Reconnaissance. Note any geotechnical features found during the investigation, including, but not limited to, the following:
- outcrops of bedrock;
 - existing cuts and fills, including slope angles;
 - evidence of current or past landslides;
 - surficial soils;
 - groundwater conditions (e.g., springs, streams, irrigation);
 - wetland locations;
 - areas that may require subexcavation or other foundation stabilization/drainage measures;
 - locations that may require rock excavations, including areas that may require blasting;
 - locations that will require extensive excavations and/or fills;
 - roadway patching that may indicate subgrade problems;
 - the type of vegetation or lack thereof;
 - location of nearby buildings, drainage structures, bridges, utilities, etc.; and
 - other features that may affect the project alignment, right-of-way and/or design.
6. Preliminary Recommendations and Comments. This section of the Report should contain the following:
- a. Existing Data. Provide a list of the applicable documents reviewed for the project, previous or nearby project Geotechnical Reports, correspondence files for past geotechnical review requests, geological maps, seismic maps, etc. Provide a summary of the recommendations and the results in these documents.
 - b. Minor Features. If geotechnical problems are not expected or considered to be minor, indicate this in the Report. Provide a list of possible solutions that may be used to resolve these issues (e.g., subexcavation, use of geotextile materials, rock containment measures).
 - c. Major Features. Provide a more in-depth discussion of each item requiring significant geotechnical investigation and engineering (e.g., near dams, extensive rock cuts, high embankments, landslides, construction in wetlands or wetland mitigation). Indicate where the geotechnical feature may affect the roadway alignment, right-of-way and/or design.

- d. Subsurface Investigation. Indicate any special considerations required for the subsurface investigation (e.g., location of utility lines, steep terrain, nearby structures, wetlands, private property, required permits). Include the proposed scope of the field and laboratory work that appears to be necessary for future phases of the project.
 - e. Preliminary Foundation Design Concepts. Provide a concept-level discussion of the foundation types that may be required for bridges, including the basis for preliminary recommendations and factors that could lead to significant construction costs. For alignments that involve roadway embankments or roadway cuts, identify potential issues related to ground stabilization, construction staging, or other factors that could affect construction costs.
7. Contact. Provide the name, telephone number and email of the individual(s) that can be contacted for additional information or questions.
 8. Appendices. If available, include the following in the appendix of the Report:
 - a. Maps. If deemed appropriate, include geological, seismic or highway maps and indicate the applicable geotechnical features on the maps.
 - b. Boring Logs. If [Activity 455](#) has been completed prior to [Activity 460](#), include a copy of the preliminary boring logs. If boring logs are available from previous projects in the area and they are applicable to the project, include copies of these logs.
 - c. Photographs. If photographs were taken during the site investigation, include applicable photographs showing only the major geotechnical features. On the photograph, indicate the reason for the photograph (e.g., steep rock cuts, landslides), the location (e.g., reference post, stationing) and direction the picture was taken.

5.2.2 Exploration Findings (Activity 462)

The subsurface exploration for a project is performed under [Activity 462](#). This work includes borings, soundings, test pits and geophysical explorations. An Activity 462 Report, is only prepared for relatively large or critical projects. For these projects, the project geotechnical specialist will prepare and submit to the design teams, a memorandum outlining the exploration findings and any potential issues affecting the project. For smaller or non-critical projects, this information is included in the [Activity 464](#) or [466](#) reports.

Where an Activity 462 Report is prepared, include the topic areas: Introduction, Project Information and Area Geology as discussed in [Section 5.2.1](#) and the Subsurface Investigation as discussed in [Section 5.1.2](#). The level of detail should be consistent with the degree of complexity of the site conditions. As the site becomes more complex, provide extra details of the field explorations. Highlight any field observations that could be critical to design and construction.

5.2.3 **Consultant Reports (Activity 106)**

The Consultant's Preliminary Geotechnical and Materials Report should include the information discussed in [Section 5.2.1](#) and the following, if applicable:

- Preliminary Soil Survey Investigation Report;
- Borrow and Surfacing Pit Reports, including the Prospected Area Report;
- Preliminary Geotechnical Evaluation Report, including:
 - + results from field investigations;
 - + geologic surveying and mapping, geophysical surveys or other surficial investigations;
 - + results from laboratory testing of samples;
 - + boring logs (these may be submitted in an electronic format); and
 - + concept-level foundation design recommendations; and
- Preliminary Surfacing Typical Sections.

5.3 GEOTECHNICAL ENGINEERING REPORTS

5.3.1 General

The project geotechnical specialist is responsible for preparing a detailed geotechnical engineering report ([Activities 464](#) and [466](#) Reports) outlining the findings of the field and laboratory investigations, results from the geotechnical engineering analyses, designs for geotechnical features, and recommendations and alternatives for potential issues affecting the project alignment or construction.

Not all of the subject areas listed in the following Sections will be required for every Geotechnical Report, and adjustments may be required as deemed necessary. The level of coverage for each item will also vary from project-to-project. Although in-depth coverage of the individual details is usually not provided in the Report, provide sufficient detail to allow the reader to fully understand the problem and any proposed recommendations. Detailed analyses may be added as appendices to the Report.

[Section 5.1](#) provides the general transmittal requirements that should be followed when preparing the Geotechnical Engineering Report. Prepare the [Activities 464](#) and [466](#) Reports using the following format and layout:

- Introduction, see [Section 5.2.1](#) for content requirements;
- Project Information, see [Section 5.2.1](#) for content requirements;
- Area Geology, see [Section 5.2.1](#) for content requirements;
- Subsurface Investigation Results, see [Section 5.1.2](#) for content requirements;
- Laboratory Results, see [Section 5.1.2](#) for content requirements;
- Design and Construction Recommendations, see [Sections 5.3.2](#) and [5.3.3](#) for content requirements;
- Contact Person, see [Section 5.2.1](#) for contact recommendations;
- Report Limitations, content varies project-to-project; and
- Attachments/Appendices (e.g., data obtained from testing and analyses, Boring Summary Sheet, map of boring locations, boring logs, sketches and drawings, special provisions).

5.3.2 Geotechnical Engineering Roadway Alignment Report (Activity 464)

This Report is generally prepared for the Road Design Section in Headquarters or to the District, if the design is performed by the District, and covers roadway embankments, side slopes, rock cuts, pavement subgrade, etc. For each item discussed in the Report, clearly indicate:

- the applicable station-to-station distance, width and depth of the area of concern;
- any recommendations and/or alternatives;
- detailed drawings or sketches, these may be included in the appendices; and
- where necessary, include applicable special provisions.

In addition to information discussed in [Section 5.3.1](#), the Geotechnical Engineering Roadway Alignment Report should include, but is not limited to, the following topics:

1. Alignment Recommendations. Identify recommended revisions to the horizontal and vertical alignment from the preliminary plans. These recommendations may have been included in the Preliminary Geotechnical Evaluation Report ([Activity 460](#)). Include a discussion on why alignment revisions are recommended.
2. Right-of-Way Considerations. Note where additional right-of-way, not identified in Preliminary Geotechnical Evaluation Report, is required to accommodate landslide areas, cut and embankment slopes, rock containment, etc.
3. Specific Findings and Design Recommendations. The Alignment Report may include discussions and recommendations on the following:
 - landslides — movement history, past maintenance records, identification of failure planes, excavation/buttressing limits, recommended slopes, instrumentation requirements, results from the slope stability analysis, drainage requirements, construction requirements, etc.;
 - rockfalls — slope, ditch and retaining design;
 - retaining walls — types, alternatives, basic stability analysis and wall pressures;
 - subgrades — digouts, special borrow, constructability, etc.;
 - pavements and slab on grade, if applicable — coordinate with the Pavement Design Section;
 - roadway grading — shrink and swell factors, material types for the subgrade or embankment, removal of topsoil, etc.;
 - drainage — excavation concerns, erosion protection, culvert bedding materials, geotextile fabrics, water table levels, dewatering recommendations, settlement considerations, etc.;
 - stability analysis — methods used (e.g., computer programs), assumptions made for soil strength parameters (e.g., strength) and groundwater conditions, selected factors of safety or resistance factors, conclusions from analyses (slope angles and heights), and recommended methods of mitigation (e.g., regrading, reaction berms, ground improvement);
 - settlement analysis — methods used, assumptions for soil parameters (e.g., preconsolidation pressure, compression index, recompression index, coefficient of consolidation), groundwater conditions, conclusions from analyses,

recommended mitigation (e.g., dig outs and subexcavation, use of light-weight fills, wick drains and preloading, staged construction);

- seismic — ground acceleration, site amplification/deamplification, potential for liquefaction, slope instability, failure mitigation, etc.;
- rock cuts — strength parameters that characterize the discontinuity and rock mass, excavation, slopes, blasting requirements, containment areas, etc.;
- computer programs — summary of the analyses and list of software programs used;
- results — discussion on the uncertainties of the analyses and results; and
- special issues to consider during construction, including construction staging, scheduling of preloads, special field testing and instrumentation.

5.3.3 **Geotechnical Engineering Structures Report (Activity 466)**

This Report is generally prepared for the Bridge Bureau and covers bridges, retaining walls, noise walls, etc. For each item, clearly indicate:

- the applicable station-to-station distance, width and depth of the area of concern;
- any recommendations and/or alternatives;
- detailed drawings or sketches, these may be included in the appendices; and
- where necessary, applicable special provisions.

In addition to information discussed in [Section 5.3.1](#), the Geotechnical Engineering Structures Report should include, but is not limited to, the following topics:

1. **Roadway Recommendations.** If a Geotechnical Engineering Alignment Report ([Activity 464](#)) has not been prepared, include the applicable items identified in [Section 5.3.2](#) (e.g., alignment recommendations, right-of-way considerations, embankment heights and slopes, roadway grading requirements) in this Report.
2. **Deep Foundation Recommendations.** Based on load values provided by the Bridge Bureau or consultant, subsurface investigation and geotechnical engineering analyses, include in the Report:
 - a summary of the foundation analyses performed and a summary of the results including any computer software used;
 - a recommended pile type or drilled shaft design;
 - a design table indicating the pile/drill shaft size, tip elevation, lengths, ultimate pile capacity during driving, scour assumptions, negative skin friction, etc., at each bent and/or foundation;

- estimated total pile/drilled shaft tip settlement and lateral deflections;
 - LPILE files containing the soils and foundation information;
 - assessment of liquefaction potential of foundation soil during the design earthquake and the implications as related to deep foundation performance;
 - construction considerations for pile driving including wave equation analyses, potential for boulder or obstructions, need for test piles, use of cutting shoes, etc.;
 - construction consideration for drilled shaft construction, including need for temporary casing for the full length of the drilled shaft, groundwater location, potential for encountering boulders or other obstructions; requirements for crosshole sonic logging (CSL), other field inspection requirements.
3. Scour Predications. Where applicable, provide recommended geotechnical modifications to initial scour values provided by the Hydraulics Section based upon results of the subsurface investigation.
4. Spread Footing Recommendations. Indicate the recommended bottom elevation for the footing and minimum width. Provide a reason for the recommendation (e.g., frost depth, scour depth, depth to competent bearing materials). Also, indicate:
- the nominal (ultimate) soil or rock bearing capacity,
 - estimated settlement and time, including the potential for differential settlement,
 - special compaction requirements. Include a note that the Geotechnical Section will need to inspect site, and
 - special construction requirements (e.g., potential for dewatering).
5. Select Backfill or Bridge End Backfill. Where necessary, indicate where select backfill and/or bridge end backfill should be used and provide any necessary special provisions.
6. Retaining Structures. In addition to the above, include discussions and data results for the following:
- design soil strength parameters,
 - pullout resistance (soil nails),
 - ultimate anchor capacity,
 - expected wall design lateral earth pressures,
 - allowable bearing pressure,
 - interface shear sliding stability analysis,
 - wall and external slope stability analysis results,
 - estimated settlement on compressible foundation soils,
 - wall drainage requirements,
 - backfill requirements,

- testing and instrumentation requirements, and
- alternative wall designs.

When documenting the design studies listed above for deep foundations, spread footings, retaining walls and scour protection, include a discussion of the design method used to determine the design information (e.g., earth pressures, nominal pile capacity, settlement); appropriate load and resistance factors for service, strength and extreme limit states; key assumptions regarding soil parameters and groundwater conditions; computer programs that may have been used to conduct the evaluation; any uncertainties in the results; and recommended range in properties for use by the Bridge Bureau, as appropriate.

5.3.4 Supplemental Geotechnical Report (Activity 468)

Occasionally, the project design team may request the Geotechnical Section to conduct additional geotechnical reviews or studies. Based on these reviews or studies, the project geotechnical specialist will prepare a Supplemental Report to the Geotechnical Report complete in [Activities 464](#) and/or [466](#). The Supplemental Report should only address the analysis and alternatives for those elements requested for additional geotechnical review or study. See [Sections 5.3.1](#), [5.3.2](#) and [5.3.3](#) for guidance on the content of this Report.

5.3.5 Special Reports

Occasionally, the Geotechnical Section may be required to prepare a special geotechnical report not related to a particular project (e.g., landslides, rock falls). Typically, these reports are prepared under emergency conditions and, as a result, only may include the recommendations to mitigate the immediate problem. If practical, the Special Report should include the methods of analysis, design assumptions, computer programs used and other information as applicable from [Sections 5.3.1](#), [5.3.2](#) and [5.3.3](#).

5.3.6 Consultant Reports (Activity 130)

The Final Geotechnical and Materials Report should contain all the geotechnical and surfacing design recommendations required to complete the project. In addition to the information provided in [Sections 5.3.2](#) and [5.3.3](#), the Final Geotechnical and Materials Report should include the following, where applicable:

- design computations as required by the consultant's agreement,
- quality assurance/quality control certifications, and
- alternate designs, if considered.

The consultant is required to conduct a quality assurance/quality control review of the Report before it is submitted to MDT. The quality assurance/quality control review should include checking all calculations, as well as a review by a senior engineer or geologists of the approach, assumptions, results and conclusions/recommendations of any work carried out for the project. The Report should also be edited to be free of grammatical and spelling errors, and graphics

should be legible and easy to interpret. All consultant Geotechnical and Material Reports must be signed by a Professional Engineer licensed in the State of Montana.