GEOTECHNICAL DESIGN MANUAL

CHAPTER 2

PROJECT GEOTECHNICAL PLANNING

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CHAPTER 2
Project Geotechnical Planning

2.1 OVERVIEW

This chapter addresses geotechnical planning for projects that involve significant grading or foundations for structures, from the project scoping/definition or conceptual phase through the project design phase to preparation for the PS&E development phase. Final design for the PS&E development will be covered in other chapters of this manual specific to each project element.

The design objectives of the different phases of a project and guidance on the general level of geotechnical investigation for each phase were discussed in NYSDOT GDM Chapter 1. It provides guidance concerning the roles and responsibilities of the Regional Geotechnical Sections and Main Office Geotechnical Engineering Bureau, as well as information on initiating geotechnical work, scheduling and site data and permits needed for each stage of a project. Geotechnical design for NYSDOT projects is generally provided by the Geotechnical Engineering Bureau and the Regional Geotechnical Sections or Geotechnical Consultants working either on behalf of these groups or as part of a Consultant Design Team.

This chapter includes general guidelines for geotechnical investigations conducted for project definition and design phases (see NYSDOT GDM Chapter 1), and preparation of the subsurface exploration plan for the PS&E phase. Specific information on the number and types of explorations for PS&E level design is provided in NYSDOT GDM Chapter 4.

To assure success of a project, it is important for the Departmental Geotechnical Engineer to become involved in the project at an early stage. The usual process starts with studying the preliminary project plans, gathering existing site data, determining the critical features of the project, and visiting the site, preferably with the Project and Structural Engineer. Good communication throughout the project between the Departmental Geotechnical Engineer, the Structural Designer, and the Regional Project Manager is essential.

See *Geotechnical Claim Avoidance* in NYSDOT GDM Chapter 1.

2.2 PRELIMINARY PROJECT PLANNING

2.2.1 Overview

The goal in the initial planning stages is to develop an efficient investigation plan and to identify any geotechnical issues (previously known or new) that could potentially impact the projects scope, design or construction as soon in the project's development as possible. Preliminary project planning and site reconnaissance are the initial steps in the risk handling process outlined in NYSDOT GDM Section 2.2.2 *Geotechnical Risk Assessment*. To effectively manage the geotechnical factors affecting a project, the process must go beyond the collection data on the geotechnical conditions at the site. For example, temporary or permanent easements (TE's or PE's) or FEE title acquisition of property is sometimes necessary for the construction and implementation of geotechnical design features of a project. If deemed necessary, these acquisitions typically take up to 18 months to obtain and should be identified early in planning.

An effort should be made to gather effective information during each phase of the investigation process and minimize the number of site visits required to obtain information. For many projects, it may be beneficial to conduct the field exploration in a phased sequence, consisting of a reconnaissance investigation and a preliminary subsurface investigation during the project definition phase and more detailed exploration conducted during the project design and PS&E development phases. In addition, if a project is not well defined and multiple alternatives are being considered, the reconnaissance investigation and preliminary subsurface investigation will need to explore the various alignments to examine costs and design implications of the subsurface conditions. In these instances, the design of a project needs to be a collaborative effort with input from the Departmental Geotechnical Engineer, the Structures Engineer, the Environmental staff, those who will be maintaining the completed facility and the Highway Designer. The preliminary office review and site reconnaissance for these types of projects are more expansive due to the breadth of the existing possibilities being investigated. However, a methodical examination of each alignment needs to be performed to develop a comparison, with the identification of any major impacts, for each alignment from a geotechnical standpoint.

If the subsurface exploration can be conducted in phases, it allows information obtained in the preliminary phase to be used in planning the exploration program for the detailed design phase. That is, the likely depths of additional test borings are known, the extent of the problem soil layers can be identified and studied in greater detail, the location of the proposed foundations, structures, and earthwork is better known, and the need for particular types of subsurface explorations or instrumentation can be identified.

The location of the site will play a part in the way the investigation is planned. For projects where mobilization costs for drilling equipment are high, the number of subsurface investigation phases should be minimized, even on fairly large projects.

The studies and activities performed during the planning stage should be documented in Conceptual or Preliminary Level Geotechnical Reports in accordance with NYSDOT GDM Chapter 26. A list of references should be developed, citing nearby explorations, notes from field visits and conversations with Design Engineers and Construction Engineers from nearby or previous projects. Any critical issues that are identified during the planning stages should be documented. At a minimum, sufficient information should be provided so that another Engineer picking up the project would not have to go through the same search for information.

2.2.2 Geotechnical Risk Assessment

The impact to a projects scope, design or construction by a geotechnical issue is a risk to the NYSDOT. If brought to fruition, the risk results in, among other things, increased costs. As defined by Carlsson (2005),

- Risk – the combined effect of the probability and the consequence of an event with negative consequences and can be calculated as the statistical expectation value of the event.

- Risk Handling – the process that identifies, evaluates, decides and implements actions in order to set risks at acceptable levels given project constraints and objectives.

A study by Flyvbjerg et al. (2003) of infrastructure project costs sampled 258 projects worldwide worth $90 billion. Some of the study's findings revealed:

- Costs are underestimated in 9 out of 10 transportation infrastructure projects.
- Actual costs are on average 34% higher than estimated costs for tunnels and bridges.
- Actual costs are on average 20% higher for road projects.
- Cost escalation has not decreased over the past 70 years (no learning seems to take place or, alternatively, Designers have used this to their advantage where underestimation is used tactically to get projects approved and built).

Numerous factors cause cost escalation including bias, delivery/procurement approach, project schedule changes, engineering and construction complexities, scope changes, estimation errors/omissions, inconsistent application of contingencies, faulty execution, ambiguous contract provisions, contract document conflicts, local government concerns and requirements, effects of inflation, market conditions, unforeseen events, and unforeseen conditions. To effectively manage the factors and thus handle the risk, the Department Geotechnical Engineers must focus on the factors within their purview – engineering and construction complexities and unforeseen conditions.

The Departmental Geotechnical Engineer must design project elements utilizing or retaining predetermined materials (created in nature and outside their control) with properties that are highly variable from location to location and with depth. In addition, these project elements are typically the initial building platform for the remaining construction project. Consequently, geotechnical risks often have disproportional effects on the cost and schedule of a project, since problems occurring in one phase affect the subsequent phases.

As outlined by Carlsson (2005 – adapted from Clayton (2001)), a successful management of geotechnical risks can be performed through the following steps:

i. creation of a team of geotechnical and geological experts,
ii. collection data on the geotechnical conditions at the site,
iii. identification of the likely range of forms of construction that might be used,
iv. identification of hazards and risks to different forms of construction,
v. ranking risk according to impact by group experience,
vi. establishment of a risk register,
vii. associate various risks to different stages of construction, and finally
viii. estimation of consequences and likelihood by group experience.

As stated earlier, the Departmental Geotechnical Engineer needs to become completely familiar with the proposed project elements in the preliminary office review. With an understanding of the project elements, the Departmental Geotechnical Engineer will prepare the subsurface exploration plan. The subsurface exploration program is a risk handling process, addressing the geotechnical parameters needed to design project elements and to fully explore the subsurface conditions within the project limits to minimize the potential for unforeseen conditions.

2.2.3 Preliminary Office Review of Project Site

The Departmental Geotechnical Engineer should become completely familiar with the proposed project elements by studying the preliminary plans provided by the Regional Designer. Location and size of structures, embankments and cuts should be determined. A discussion should be held with the Structural Engineer regarding the amount of flexibility in the location of structures and to determine the approximate magnitude of the loads to be transmitted.

Initial site review begins by identifying the geologic or human processes that have influenced the environment of the project site. Soils deposited by a particular process assume characteristic topographic features or landforms that can be readily identified by the Departmental Geotechnical Engineer. Early identification of landforms is used to optimize the subsurface exploration program.

The general geology of a project may also give indications of soil conditions that may or may not be encountered in test borings. For example, boulders and large cobbles in glacially deposited or glacial flood deposits, buried trees in debris flow deposits, or relatively fresh rock encountered in residual soils deposits in the coast range.

One of the goals of the office review is to plan site reconnaissance and prepare a conceptual plan for subsurface exploration.

2.2.3.1 Identifying Site Landforms, Geology, and Seismicity

Topographic Maps. Beginning in 1882, the United States Geological Survey (USGS) created a series of standard topographic maps covering the United States. Most USGS topographic maps use brown contours to show the shape and elevation of the terrain. Contour intervals vary, depending mainly on the type of terrain and the scale of the map, scale being the relationship between distance on the map and distance on the ground. The 15-minute map series at a scale of 1:62,500 (1 inch = approximately 1 mile) has been abandoned. However, the Geotechnical Engineering Bureau's HD&C Section has retained a copy of each 15-minute USGS Quad sheet for New York State.

The USGS 7.5-minute topographic quadrangle map series is the official replacement for the 1:62,500-scales series. The 7.5-minute, 1:24,000-scale quadrangle series portrays an area on each sheet ranging from 64 square miles at latitude 30 degrees north to 49 square miles at latitude 49 degrees north. A scale of 1:24,000 allows considerable detail to be shown in the quadrangle areas. It takes about 57,000 maps to cover the contiguous 48 States, Hawaii, and territories. The sheet size is about 22 x 27 in. north of latitude 31 degrees and 23 x 27 in. south of that latitude.

The features shown on topographic maps may be arranged in three groups:

1. Water – including seas, lakes, rivers, canals, wetlands, and other bodies of water,
2. Relief – including mountains, hills, valleys, and other features of the land surface, and,
3. Culture – works of man such as towns, cities, roads, railroads, and boundaries.

The symbols used to represent these features are shown in Figure 2-1.

The maps provide information on the overall topography of the site including drainage patterns, slope inclinations, wetlands and general accessibility for field exploration. Used in conjunction with geologic maps and aerial photos, easily recognized geologic features can sometimes be identified. The headscarps and hummocky terrain of landslides can often be identified from topographic maps.

In addition to having the resource of copies in the Geotechnical Engineering Bureau's Highway Design & Construction (HD&C) Section, information is also available from:

- The USGS website: http://egsc.usgs.gov/isb/pubs/booklets/usgsmaps/usgsmaps.html, and
- Through the University of New Hampshire Library, Government Information Department which posts historic USGS maps of New England and NY on the website: http://docs.unh.edu/nhtopos/nhtopos.htm

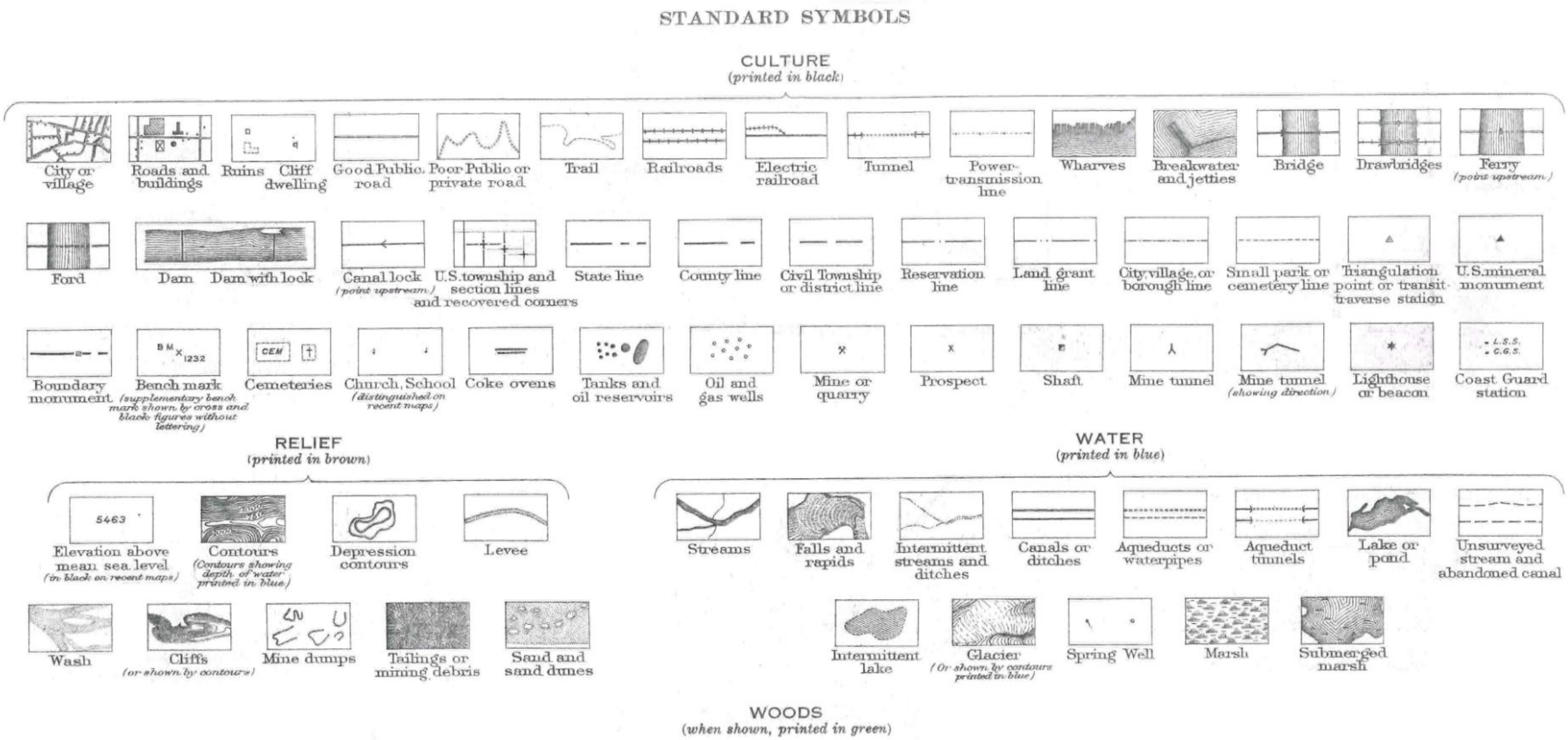

Figure 2-1 Topographic Map Standard Symbols

Geologic Maps. The New York State Geological Survey (NYSGS) conducts geologic research, evaluates mineral resources and geologic hazards of the State of New York, and makes the data and advice derived from that research available to State agencies, the educational community, and the public for the health, safety, and economic welfare of the citizens of the State. The NYSGS is a Bureau of the State Museum in the State Education Department.

The NYSGS maintains a comprehensive inventory of the geologic resources and conducts research into the characteristics of, and processes operating in, the earth's crust, and makes the resulting geologic knowledge readily available. Information is available on the NYSGS website: http://www.nysm.nysed.gov/nysgs/

Information available from the NYSGS includes:
- Tectonic Timeline,
- Earthquakes,
- Landslides,
- Mineralogy,
- Sand Dunes, and
- Sedimentology & Stratigraphy

Aerial Photos. The Geotechnical Engineering Bureau's HD&C Section provides a repository service for aerial photographs extending back to 1955. The Department's aerial photography is usually taken using black and white film in 9 in. x 9 in. (230 x 230 mm) format. Although black and white photography is the standard product, color aerial photography can be obtained if there are very special project requirements. Generally the scale of the film negative is 1:3000 for design scale mapping projects. For planning or wide corridor studies 1:6000 or 1:12000 scale aerial photography can be flown.

Photos are marked with the 6 digit project identification number (PIN), date of photography, approximate altitude above mean terrain, flight strip and exposure number. Photos are taken with 60% overlap between successive photos to permit stereo viewing. Block coverage for large areas also includes 35% side lap between parallel photo strips. All projects are flown with airborne GPS (Global Positioning System) which provides 3-D coordinates of the camera which reduces the amount of ground control survey required.

Aerial photography is best flown in the Spring (March/April), when the snow cover is gone and before tree foliage is present. Photography can also be flown in the Fall (November/December); however, Spring flying is much preferred because of better sun angle, better weather, longer days and longer flying season. The photography must be taken during a very short flying season and only on days with near optimal weather conditions.

These photos are not horizontally accurate. Scale variations exist since the photography has not been corrected for tip, tilt and changes in terrain elevations and flying height.

Aerial photos can be one of the most useful sources of information for planning the subsurface exploration program. When used with a general understanding of the geology of the site and limited subsurface information, the extent of geologic deposits on the site can often be determined.

The identification of a landform via a stereoscope as a dune, terrace deposit, alluvial fan, esker, moraine, or other type of deposit often permits the general subsurface conditions to be established within given limits and thus yields the initial appraisal of the situation. Drainage patterns can also aid in the identification of soil type and in the structural characteristics of the underlying rock. The maximum amount of information will be obtained when aerial photos are used in conjunction with field investigations that can verify and correct interpretations.

Landslides are often recognizable in aerial photos by slide formed features or conditions, including hillside scars; disturbed or disrupted soil and vegetation patterns; distinctive changes in slope or drainage patterns; irregular, hummocky surfaces; small undrained depressions; step-like terraces; and steep hillside scarps. Although one of the more difficult features to evaluate, vegetation is often indicative of subsurface conditions. The relationship between vegetation soil type, moisture content, topography and other pertinent factors may be important and any variations should be checked in the field.

Aerial photos from different years can give an indication of the history and previous use of the site. A complete set of air photos from the oldest available to the most recent can give an indication of the previous site use, as well as significant changes in topography or landforms due to the more rapid geologic processes such as stream channel migration, beach erosion, landslides, or rockfalls.

This and more information on aerial photography is available from the Department's Photogrammetry Section of the Design Services Bureau at website: https://www.dot.ny.gov/divisions/engineering/design/design-services/photogrammetry Additionally, The Food and Agriculture Organization (FAO) of the United Nations Corporate Document Repository includes Marine Resource Mapping: An Introductory Manual by MJA Butler, C. LeBlanc, JA Belbin, and JL MacNeill. Section 8 Aerial Photographs and Their Interpretation provides and outline of various aspect of aerial photography: http://www.fao.org/docrep/003/T0390E/T0390E08.htm. Also, The Spatial Information Clearinghouse for Humanitarian Mine Action is a website intended as an educational resource for members of the demining community on Spatial Data and Geographic Information Systems. This website provides a primer on visually interpreting aerial images: http://maic.jmu.edu/sic/rs/interpreting.htm

Soil Surveys. Agricultural soil surveys in the United States have been conducted by the Department of Agriculture (USDA) in conjunction with state agencies since the early 1900's. The results of the surveys are presented in the form of reports and maps which commonly cover a complete county. The reports, in general, contain a description of the aerial extent, physiographic relief, drainage patterns, climate, and vegetation, as well as the soil deposits of the area covered. The maps show the extent and derivation of the various deposits, typically to a depth as much as 8 ft. below the surface.

The surveys give some information on the slope inclination and erosion hazards that may be common. The reports also provide engineering classifications of the near surface soil and sometimes information on the suitability of the soils for various construction uses as well as an indication of the general drainage characteristics. The surveys are regional in aspect and only provide information on the top several feet of soil. They should not be used for more than providing some preliminary soil information.

This and more information on soil surveys is available from United States Department of Agriculture, Natural Resources Conservation Service (NRCS):
http://www.ny.nrcs.usda.gov/. Additionally, New York City Soil and Water Conservation District (NYCSWCD):
http://www.nycswcd.net/soil_survey.cfm

Other Sources. The Regional Geotechnical Section may have an inventory of unstable soil slopes. The Geotechnical Engineering Bureau maintains a database of historic problems of rock slope instability or rock fall problems.

2.2.3.2 Previous Site Exploration Data

Most highway transportation projects are on or near existing alignments, and previous subsurface information might be available. The Regional Geotechnical Sections maintain files of historic subsurface explorations progressed for past contracts. These Sections may also have on file past correspondence on problematic soil conditions found on previous contracts.

2.2.3.3 Previous Site Use

Screenings/assessments for contaminated materials/hazardous waste completed for a project may indicate recent land use of area and describe previous site use(s). Identification of potential subsurface contamination could affect the subsurface investigation approach for the geotechnical design. This issue may need to be considered in the planning for the geotechnical subsurface investigation. The geotechnical investigation approach will also need to be adjusted during the subsurface investigation if potentially hazardous materials are retrieved during the subsurface investigation, both for Drill Crew safety purposes and to comply with environmental regulations.

If potentially hazardous materials are discovered during a preliminary office review or subsequent subsurface investigation, or for sites where soil and/or groundwater contamination is expected, contact the Regional Environmental Unit. The Regional Environmental Unit will investigate the potential for contamination, defining its nature and extent, and how to address for the project. Environmental Science Bureau may be contacted for additional technical support.

Other site uses may also affect the site investigation approach and possibly the timing of the investigation. Especially important is whether or not the site is historically or archeologically significant, and whether or not there is potential for archaeological deposits to be encountered at the site. The investigation for this type of previous site use should be conducted prior to beginning the geotechnical site investigation. In general, the Regional Design Section is responsible for making sure that this investigation is carried out, in coordination with the Regional Cultural Resources Coordinator.

While the Departmental Geotechnical Engineer is not responsible to specifically carry out a detailed investigation regarding the potential to encounter hazardous subsurface materials or archeological deposits, the Departmental Geotechnical Engineer is responsible to know whether or not such investigations have taken place and to adjust the geotechnical site exploration program accordingly.

2.2.3.4 Construction Records

Many NYSDOT projects consist of improvement or replacement of existing alignments or facilities. Construction records are often available from Main Office or Regional Record Plans. The Regional Construction Section has the most complete collection of construction records for a period of 10 years after the projects completion. The Regional Structures Section often has construction records in their bridge identification number (BIN) folders for use on their bridge inspections.

Consultation with the Engineer-In-Charge who may have completed work on similar structures in the same general area should be utilized to gain general information on the soil, foundation, and groundwater conditions. Previous experience may also reveal acceptable foundation conditions for the problems at hand.

Many of the county and city agencies also maintain records of investigations and construction, and these are generally available through each agency.

2.2.4 Site Reconnaissance

2.2.4.1 General

Before the site reconnaissance is performed, the Departmental Geotechnical Engineer should have initially performed the preliminary office review as described in NYSDOT GDM Section 2.2.3 *Preliminary Office Review of Project Site*, as well as given some thought to the field exploration plan. The field reconnaissance should be done with the preliminary plans in hand. Cross sections provided with the preliminary plans should be field checked. The cross sections are often generated by Photogrammetry and may not accurately represent the existing ground surface, especially at areas with very steep changes in elevation or with dense vegetation. If available, the Project Design Engineer and/or Structural Engineer should also participate in the site visit.

Note the location, type and depth of any existing or abandoned structures or foundations and the location, size, and condition of any rock outcrops. Make note of any pavement cracks (alligator cracking, numerous concrete slab cracks, etc.) or isolated, but significant, pavement or guiderail depressions, and any signs of seepage. Inspect any nearby structures to determine their performance. If settlement or lateral movement is suspected, obtain the original structure plans and arrange to have the structure surveyed using the original benchmark, if possible. Inspect for adequate catchment area at the base of rock cuts.

For water crossings, inspect structure footings and the stream banks up and down stream for evidence of scour. Riprap present around the bridge foundation may indicate a past scour problem, could impact the location of test borings and will need to be dealt with during construction. Take note of the streambed material. Often large cobbles and boulders are exposed in the stream bed, but not encountered in the borings or noted on the boring logs. The boulders are an indication of unexpected subsurface obstructions to deep foundation installation.

Relate site conditions to proposed boring locations.

- Check access for exploration equipment and make an initial determination of what type of equipment might be best suited to the site conditions. If site preparation is necessary, note the type of equipment, such as a bulldozer, that may be needed for drilling equipment access.
- Note potential problems with utilities such as overhead and underground power, site access, private property or other obstructions. While utility clearances (see NYSDOT GDM Section 2.3.3.2 *Utility Clearance*) will need to be obtained before the subsurface exploration begins, the locations will influence where explorations can be located.
- Note any water sources that could be used during drilling.
- Also note work zone 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. If borings are to be located in a stream bed, the reconnaissance should note the size of the barge best suited for the job, details of anchoring, depth of water, locations for launching the barge, etc.
- Notes should be made as to which type of drilling is best suited to the site. Also note potential problems with borings such as shallow groundwater table, loose or heaving sands, cobbles and boulders, etc. Availability of water, if coring or mud rotary methods are anticipated, should be determined. Special sampling equipment needed, such as undisturbed sampling equipment, should be noted.

Right of Entry (see NYSDOT GDM Section 2.3.3.1 *Access Needs*) on NYSDOT projects is generally obtained through the Regional Geotechnical Section. However, note proximity of residences and buildings for possible difficulties due to noise and other disturbances during the subsurface exploration. Local residents can often provide some information on the history of the site.

Compare the topography of the site with that shown on maps and try to confirm the assumptions made during the office review concerning the site geology. Observe and note natural occurring exposures evident at river banks, natural escarpments, quarries, highway or railway cuts and rock outcrops. Measure the inclination of any existing steep slopes. Note and describe the type and amount of fill that has been placed on the site.

Note the extent of any existing unstable slopes or erosion features. For unstable slopes or landslides note the length and width of the area affected and look for possible causes of instability. Note any other indications of slope instability such as pistol butting of trees, stone fill armoring, long or numerous depressions, leaning electric poles, hummocky terrain or springs. Note types of vegetation present. For example, a pocket of phragmites may indicate an area that is continually saturated by seepage. Full investigation of these issues will require review of the site conditions well above and below the facility alignment, and may extend on to private property. Right of entry may be needed in such cases to complete the site reconnaissance. If steep slopes must be accessed to fully investigate the site, safety issues will need to be addressed before attempting to access the area, or alternative means of getting into the position to make the necessary observations should be considered (e.g., a man-lift, or use of a helicopter).

Note the presence of any wetland or other surface water and the likely source for its water supply.

Hand-dug holes, retractable plugs, or probes may be useful to obtain information on thicknesses of soft soils or organic layers.

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.

A record of the field visit should be kept and included in the project file. Measures should be taken to permanently archive any photographs taken. The record should list and describe significant site features as discussed above along with approximate stationing. An example field reconnaissance report form is included in the FHWA Soil and Foundations Workshop Manual (Cheney and Chassie, 2000).

Special site reconnaissance requirements for investigation of rock slopes are provided, by reference, in NYSDOT GDM Chapter 15.

2.3 DEVELOPMENT OF THE SUBSURFACE EXPLORATION PLAN

2.3.1 General Preparation of the Subsurface Exploration Plan

If the site reconnaissance is performed as part of the project’s Scoping Phase, the results will be used to develop the project’s scope by transmitting the findings to the Project Manager in the form of a Conceptual or Preliminary Level Geotechnical Report in accordance with NYSDOT GDM Chapter 26. Otherwise, the site reconnaissance and office review results are used to develop the geotechnical designs required in the Design Phase.

A cost-benefit analysis (CBA) is a systematic process for calculating and comparing benefits and costs of a project (or decision or policy), which has two purposes:

1. To determine if it is a sound investment/decision (justification/feasibility),
2. To provide a basis for comparing project elements. It involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

In terms of the Subsurface Exploration Plan, the CBA helps predict whether the benefits of obtaining *additional* subsurface explorations outweigh its costs, and by how much relative to *other alternatives*.

- Additional subsurface explorations: Requirements for boring spacing, depth, and sampling frequency are provided in NYSDOT GDM Chapter 4, which is the minimum level of exploration that should be carried out. The need for additional explorations will be based on engineering judgment applied by a Departmental Geotechnical Engineer in order to adapt the exploration program based upon the findings of the preliminary office review, site reconnaissance, and geotechnical needs of the project elements for risk management.

  As stated earlier, with an understanding of the project elements, the Departmental Geotechnical Engineer will prepare the subsurface exploration plan to handle risk. As defined by Carlsson (2005), *risk analysis* is the first phase of the risk management process and is the process of estimating the probability of hazards and the consequences of these. This process is a basis for the decision-making regarding the risks. The second phase in the risk management process, *risk evaluation*, comprises decisions regarding acceptable risk levels and the analysis of different options concerning how to deal with the risks. The third and last phase, *risk reduction and risk control*, includes decisions regarding how to deal with the risk, implementation of the risk management plan into the project plan and the monitoring of the risks during the project. In this phase, a decision regarding the extent of geotechnical investigations in relation to the degree of geotechnical risks involved is required.

  By following the steps and understanding the acceptable risk levels, the geotechnical risk management process provides an opportunity to produce an effective design by exposing the risks involved and creates information for decisions regarding design and execution. Cost-effective alternatives during the evaluation can be revealed, which otherwise may have never been explored.

- Other alternatives: The conventional means used to investigate those underlying features suggested by the office review and field reconnaissance, so as to confirm, modify, or deny the assumed conditions existing below the ground surface, is the Standard Penetration Test. However, other means for obtaining subsurface data can be considered in order to develop a more complete picture of the subsurface conditions. Generally, these additional subsurface exploration methods perform either in-situ material evaluation (directly or indirectly) or only obtain samples for laboratory testing. Field testing procedures for alternate methods for obtaining/supplementing subsurface information are described in NYSDOT GDM Chapter 4.

The sections that follow expand on the considerations required for the preparation of the subsurface exploration plan. Development of exploration plans for geotechnical baseline reports is covered in NYSDOT GDM Chapter 25.

2.3.2 General Criteria for Determining Subsurface Exploration Effort

The goal of the geotechnical investigation program is to obtain the engineering properties of the soil or rock and to define the lateral extent, elevation, and thickness of each identifiable soil/rock stratum, within a depth that could affect the design of the structure, fill, cut, landslide, or other project element. Typical properties and conditions to be evaluated include permeability, compressibility, shear strength, the depth of groundwater and the presence and magnitude of artesian pressures, if present. Regarding the determination of properties for design, the focus of the exploration and testing program should be on the geologic unit/stratum, and the number of measurements of each critical design property in each unit/stratum to have a reasonable degree of confidence in the property measured (see NYSDOT GDM Chapter 6). The geotechnical investigation completed by the final design phases should be adequate to fully define the subsurface conditions for design and construction purposes, and shall be consistent with the national standards of practice identified in this manual and as specifically augmented in this manual, subject to adjustment based on the experience of the Departmental Geotechnical Engineer.

The type, location, size and depth of the explorations and testing are dependent upon the nature and size of the project and on the degree of complexity and critical nature of the subsurface conditions. In general, it is justifiable to spend additional money on explorations and related testing and engineering beyond the standards as identified in this manual as long as sufficient savings can be realized in the project construction costs.

Consideration should be given to the small cost of a boring in relation to the foundation cost. A test boring will typically cost less than one driven pile. Yet the knowledge gained from the boring may permit a more efficient design that may allow elimination of one or more piles for that structure. Consideration should be given to how sensitive the structure or embankment is to variations in subsurface conditions when planning the geotechnical investigation. Embankments can generally tolerate several inches of settlement while a structure may be limited to less than 1 in. Embankment loads are spread over a wide area while structure loads are concentrated.

Some consideration should be given to the amount of risk that unknown soil conditions could bring to the project (e.g., what is the risk to the constructability and functioning of the facility if detailed subsurface information at a specific location is not obtained?). There are times when soil conditions may be understood fairly well for the geotechnical design, but that unknown soil conditions could affect the cost of the project. Generally if rock is encountered at the foundation grade in a boring at a pier location, the location and quality of the rock should be explored at the other side of the pier. If the rock surface dips, slopes, or is highly variable, make sure the borings explore the rock contact on all sides of the footing.

Requirements for boring spacing, depth, and sampling frequency are provided in NYSDOT GDM Chapter 4 organized in tables for various project elements. While engineering judgment will need to be applied by a Departmental Geotechnical Engineer to adapt the exploration program to the foundation types and depths needed and to the variability in the subsurface conditions observed, the intent of specific requirements provided in the chapter identified above regarding the minimum level of exploration needed should be carried out.

The specific exploration requirements identified in NYSDOT GDM Chapter 4 should be used only as a first step in estimating the number of borings for a particular design, as actual boring spacing will depend upon the project type and geologic environment. In areas underlain by heterogeneous soil deposits and/or rock formations, it will probably be necessary to drill more frequently and/or deeper than the minimum guidelines provided in the chapter to capture variations in soil and/or rock type and to assess consistency across the site area. Even the best and most detailed subsurface exploration programs may not identify every important subsurface problem if conditions are highly variable. The goal of the subsurface exploration program, however, is to reduce the risk of such problems to an acceptable minimum.

In a laterally homogeneous area, drilling or advancing a large number of borings may be redundant, since each sample tested would exhibit similar engineering properties. Furthermore, in areas where soil or rock conditions are known to be very favorable to the construction and performance of the foundation type likely to be used (e.g., footings on very dense soil and groundwater is deep enough to not be a factor), obtaining fewer borings than specified in the chapter identified above may be justified.

2.3.2.1 Planning for Subsurface Explorations

The types of subsurface explorations and the specific exploration requirements are identified in NYSDOT GDM Chapter 4. Subsurface explorations discussed in this section include those progressed for bridge foundations, retaining walls, embankments, cut excavations, culverts, noise barrier walls, and pavement structures. The planning for the drilling operation needs to address a variety of issues which include:

1. Work Zone Traffic Control (WZTC): Subsurface explorations progressed to develop designs for the types of structures identified above are typically progressed in or directly adjacent to the roadway. Planning these borings need to address the use and set up of Daily Work Zone Traffic Control pattern(s) based on the conditions at each work site. The use of signs, flaggers, arrow boards, and barrier/shadow vehicles, and all adjustments to the traffic control patterns are described in the National MUTCD provided by the Federal Highway Administration (modified by the 2009 version of the New York State Supplement to the NMUTCD). Diagrams of all WZTC patterns may be found on the NYSDOT's web page under the Work Zone Traffic Control, and/or additional guidance provided on Standard Sheets for Section 619 *Work Zone Traffic Control*.

   When work is performed in or adjacent to sidewalk areas, a safe pedestrian walkway (minimum width of 4 ft.) should be provided at all times.

   For reasons of safety, the WZTC shall not be established during periods of inclement weather, wet or icy pavement, reduced visibility, during a traffic accident or other emergency. Any previously established lane closures during such conditions shall be immediately removed.

Key corridors designated by the Region may be subject to additional restrictions regarding allowable work periods and lane/shoulder closures.

2. Storing Equipment: For sites which require multiple subsurface explorations that cannot be accomplished in one day, all equipment, supplies, vehicles and materials stored at the site should not be located in a manner that will inhibit access by the public to public areas. Equipment stored during non-working hours should be located behind a protective barrier or in an area where it will not impede traffic flow or be a hazard to the traveling public.

3. Drilling in or near Streams or other Bodies of Water: Drilling should be progressed in such a manner as to prevent any damage to any stream or water body from pollution by debris, sedimentation, or other foreign material resulting from the manipulation of equipment and/or materials. Planning these borings need to address aspects such as water used for wash purposes or other similar operations which may then cause contamination with sand, silt, cement, oil, or other impurities, should not be allowed to return directly to the stream or water body.

   If water is to be used from any stream or water body, an intake or temporary dam may need to be constructed.

   With the exception of any paved areas, temporary strawbale dikes should completely surround the subsurface exploration area (including the operating equipment and excavated materials).

   Planning should also address aspects such as the use of turbidity curtains, pumping wash water to vegetated upland locations, and utilizing drill wash tubs.

   During equipment removal operations, Drill Crews are not allowed to drop waste grout, rock or soil debris, and other materials into or near the water body. Platforms, nets, screens, or other protective devices may be used to catch the material.

   Non-petroleum products should be used for lubrication during the drilling operations in or near water bodies.

4. Soil Erosion and Sediment Control: The Drill Crews are to perform all drilling operations in a manner so as to minimize soil erosion and ensure sediment control. Erosion protection measures are items which minimize the movement of surface soils, and sediment control measures are items which keep loose soil from leaving the project site. The general requirements of both control measures are described NYSDOT Standard Specifications Section 209 *Soil Erosion and Sediment Control*.

   Effective soil erosion protection and sediment control can be more easily accomplished by limiting the area of exposed soil, and utilizing a drill wash tub to recirculate drilling fluids.

An erosion and sediment control plan should contemplate that during drilling operations, no wet or fresh grout, leachate, or drilling mud shall be allowed to escape directly or indirectly into any water bodies (including wetlands), nor shall washings from grout mixers, drill wash tubs, or other devices (if necessary) be allowed to escape directly or indirectly into any water bodies (including areas within wetland boundaries). Protection of nearby catch basins or other inlets by strawbales or berms may be required.

Planning should also consider a stabilized construction entrance provided at any point where vehicles will be entering or leaving a subsurface exploration site to or from a maintained roadway.

Additional soil erosion and sediment control measures may be found in the "New York Guidelines for Urban Erosion and Sediment Control".

5. Physical Obstacles: The Drill Crews may need to remove, store, clean, and reset railing and posts to allow access to a site. Planning should address appropriate equipment to perform this operation.

   For instances where it is necessary to cut or drill through bridge decks, or any structures, the Regional Structures Engineer should be involved in the planning phase to identify the maximum size and location of the hole to be cut. The Drill Crews should verify the clearance of any bridge support members. The Drill Crews will need to repair the cut hole upon completion of the work with a method approved by the Regional Structures Engineer.

6. Backfilling: Planning should extend beyond the progression of the borings and identify the need to backfill the hole. Upon satisfactory completion of each subsurface exploration, the Drill Crews should completely backfill all voids in the ground with compacted, suitable material. For subsurface explorations in pavements, sidewalks, and driveways, the upper 6 ft. of backfill should be continuously compacted with a rod or pole, and sealed with a suitable patch of bituminous or concrete material.

   In cases where it is necessary that the full depth of a subsurface exploration be sealed to prevent migration of water or hazardous fluids, the Drill Crew shall seal the hole in accordance with NYSDOT Standard Specifications Section 648 *Subsurface Explorations*.

Test boring methods which obtain samples, such as the Standard Penetration Test, are the conventional means used to obtain subsurface information and samples for laboratory evaluation. However, other means for obtaining subsurface data can be considered in order to develop a more complete picture of the subsurface conditions, and these may even help to reduce the cost of the Subsurface Explorations program. Generally, these additional subsurface exploration methods perform either in-situ material evaluation (directly or indirectly) or only obtain samples for laboratory testing. Planning the use of some of these other subsurface exploration methods is discussed in the following sections.

2.3.2.1.1 Planning for Probes

Subsurface explorations may include probes. This type of exploration consists of advancing (by driving or vibrating) a rod into the ground to a predetermined depth or until it is stopped by an obstruction, and is used primarily to determine if rock will be encountered during construction. However, samples are not acquired using this method, nor is it certain if refusal is actually caused by bedrock, a boulder, compact soil, or some other buried hard object. The probes are rarely advanced more than 15 ft. below the ground surface due to the difficulty of removing rods from the ground.

The use of probes can involve somewhat specialized equipment, such as narrow, smooth faced rod sections with threaded ends, a mechanical or manual means to advance the probe without damage to the threaded end of the rod, and a probe extractor jack for removal from the ground.

2.3.2.1.2 Planning for Retractable Plug Samples

Subsurface explorations may include retractable plug (RP) samples. This is a hand-driven tube fitted at its end with a pointed plug. When the tube (normally of 1 in. diameter) reaches the sampling depth, the plug is retracted and a thin-walled sampling tube is forced into the soil. The tube and entrapped sample are then removed. The device is highly portable, but severely limited and cannot be used in coarse soils or for deep explorations.

The planning for RP’s may include:

1. Equipment: RP’s shall be performed using appropriate equipment. As described above, the RP is a lightweight coring device ordinarily used for shallow exploration studies and usually hand driven using a small, slip hammer. In addition to the RP components, additional 5 ft. increments of both inner rods and outer tubes are needed to reach the intended sampling depth. Also, to retrieve the RP, an extractor jack is typically necessary.
2. Documentation: The materials encountered during this process shall be logged in a similar manner as are subsurface explorations.

2.3.2.1.3 Planning for Test Pits

Subsurface explorations may include test pits. These are simply manually or mechanically dug holes, often large enough for persons to work in, used to investigate subsurface strata, determine groundwater conditions, or sample granular material sources. They are particularly useful in examining characteristics of landfill deposits. Small test pits may be used as percolation test pits or holes.

The planning for test pits may include:

1. Equipment: Test pits shall be performed using appropriately sized backhoe equipment or other suitable excavation equipment and techniques.
2. Stability: Test pits typically do not extend to significant depths. However, if necessary, the stability of the pit should be addressed to ensure worker safety and support for the surrounding terrain.
3. Documentation: The materials encountered during this process shall be logged in a similar manner as are subsurface explorations. Photographs of test pits can also be very helpful to document findings.

2.3.2.2 Planning the General Sampling Requirements

Sampling requirements will depend on the type of soil or rock encountered and the nature of the project element to be designed and the properties necessary for the geotechnical design of that project element. Properties needed for design, and how those properties can best be obtained, should be identified as part of the geotechnical investigation planning process. For example, if soft to stiff cohesive soils are present, an adequate number of undisturbed samples will need to be obtained to perform the laboratory shear strength and consolidation testing to define the shear strength and compressibility properties needed for design.

The degree of sample disturbance acceptable should also be considered, as well as the ability of the specific sampling technique to retain the high quality undisturbed soils needed (see NYSDOT GDM Chapter 4 regarding sampling techniques). The disturbed sampling technique selected to obtain representative samples for classification and characterization will depend on the size and depth of the bigger particles anticipated. For example, if the gravelly soils of interest are close enough to the surface, it may be possible to obtain a more representative bag samples through test pit techniques. If detailed stratigraphy is needed, for example, to identify potential unstable zones or surfaces, Shelby tube samples or triple tube coring techniques can be used to get a continuous soil or rock sample for visual assessment.

2.3.2.3 Planning the Use of Undisturbed Sampling

Obtaining undisturbed soil samples from the project, usually through use of Shelby Tubes, can greatly enhance the designer's assumptions on a soft or compressible soil's performance during loading or disturbance. The progression and sampling with Shelby Tubes is described in NYSDOT GDM Chapter 4. An undisturbed sample attempts to preserve the in-situ condition of the soil to allow thorough testing of the structural and functional properties of the soil of interest.

The Subsurface Exploration Plan should include a thorough examination of the project limits to define the possible impacts from the depth and extent of any soft or compressible soils.

Planning of explorations utilizing undisturbed sampling should be influenced by the Terrain Reconnaissance studies and data from past construction activities in immediate project area. Some aspects that need to be considered in the planning of the depths and locations of undisturbed soil sampling include:

1. Reliability of the Terrain Reconnaissance information and historical subsurface explorations in regards to project's current conditions, and should also be checked as investigations proceed.
2. The possibility of waste or unsuitable material disposal sites from previous construction projects. This situation may require review of old project record data, if available, as well as the need for initial site investigations, such as test pits.
3. Adjacent test borings should be progressed to a depth sufficiently deep to verify that soft compressible materials do not underlie a more competent soil material.
4. The lateral limits of undisturbed sampling should cover the influence zone for all project elements (foundations, fills, cuts, etc.). Some undisturbed sample explorations can be located beyond these limits to address a possible alignment shift to areas with less problematic materials.

Considering that obtaining undisturbed samples is only the first step in the examination of a soft or compressible soil, planning should also identify the sample testing requirements. The complexity of testing required for a particular project may range from a simple moisture content determination to specialized strength and stiffness testing. Since testing can be expensive and time consuming, the Departmental Geotechnical Engineer should recognize the project's issues ahead of time so as to optimize the testing program.

As outlined by Mayne et al. (2002), the following minimal criteria should be considered while determining the scope of the laboratory testing program:

- Project type (bridge, embankment, rehabilitation, buildings, etc.)
- Size of the project
- Loads to be imposed on the foundation soils
- Types of loads (i.e., static, dynamic, etc.)
- Critical tolerances for the project (e.g., settlement limitations)
- Vertical and horizontal variations in the soil profile as determined from boring logs and visual identification of soil types in the laboratory
- Known or suspected peculiarities of soils at the project location (i.e., swelling soils, collapsible soils, organics, etc.)
- Presence of visually observed intrusions, slickensides, fissures, concretions, etc.

2.3.2.4 Planning for In-Situ Testing without Concurrent Sampling

The types and techniques of in-situ testing are identified in NYSDOT GDM Chapter 4. In-situ testing refers to material analysis done in a field setting as opposed to a laboratory setting. Considering that testing of the subsurface conditions will be performed in the field, the planning for the in-situ test needs to address those specialized and unique techniques related to the performance of the test. Some aspects that need to be considered in the planning for in-situ tests include:

1. Subsurface Exploration: Subsurface explorations are required for conducting the Standard Penetration Test (SPT) and normal versions of the Pressuremeter Test (PMT) and Field Vane Test (FVT). Planning of subsurface explorations is discussed in NYSDOT GDM Section 2.3.2.1 *Planning for Subsurface Explorations*. The in-situ testing devices such as the pressuremeter or vane shear are used to supplement the information obtained in the conventional subsurface exploration drilling operation (i.e. SPT). For example, the pressuremeter is useful for obtaining in-situ soil stiffness properties that can be used to more accurately assess settlement or lateral load response of foundations. Shear vane testing can be useful to obtain in-situ undrained shear strength of soft cohesive soils.

   In the case of the Cone Penetration Test (CPT), Piezocone Penetration Test (CPT_U), and Flat Dilatometer Test (DMT), subsurface explorations are not needed, thus termed "direct-push" technologies. These may be conducted using either standard drill rigs or mobile hydraulic systems (cone trucks) in order to directly push the probes to the required test depths.

2. Cone Penetrometer Test (CPT) probes can be an effective means to reduce the number of conventional borings, yet provide additional data that cannot be obtained from conventional test hole drilling and sampling. Cone data can be especially effective in locating and defining any thin layered stratigraphy of geologic units, to obtain pore pressure measurements and in-situ permeability and shear wave velocities, as well as obtain data that can be directly correlated to a variety of soil properties. However, the cone is not very useful in dense to very dense soils or soils with larger gravels and cobbles (due to inability to penetrate such soils). The cone can be especially useful in comparison to conventional borings when heaving sands are present. If cone probes are used to supplement a subsurface exploration program, some conventional test hole data are necessary to correlate readings from the probe to physical samples of the soil (since the cone is not capable of retrieving physical soil samples), as well as to obtain soil samples for laboratory measurement of soil properties.

3. The field vane test (FVT) is used to evaluate the in-place undrained shear strength (s_{uv}) of soft to stiff clays and silts at regular depth intervals. The FVT is slow and time consuming and can be affected by sand lenses and seams. However, it is a simple test. The test is best performed when the vane is pushed beneath the bottom of a pre-excavated subsurface exploration. Some other approaches include:
   a. In very soft clays, a special protective housing that encases the vane is also available where no borehole is required and the vane can be installed by pushing the encasement to the desired test depth to deploy the vane.
   b. Two side-by-side soundings (one with the vane, the other with rods only) may be pushed. Then, the latter rod friction results are subtracted from the former to obtain the vane readings. This alternate should be discouraged as the rod friction readings are variable, depend upon inclination and verticality of the rods, number of rotations, and thus produce unreliable and questionable data.

4. The flat dilatometer test (DMT) uses pressure readings from an inserted plate to obtain stratigraphy and estimates of at-rest lateral stresses, elastic modulus, and shear strength of

sands, silts, and clays. The test is simple, quick and economical. However, the plate is difficult to push in dense and hard materials and the test primarily relies on correlative relationships (need calibrations for local geologies).

5. The pressuremeter test (PMT) consists of a long cylindrical probe that is expanded radially into the surrounding ground. By tracking the amount of volume of fluid and pressure used in inflating the probe, the data can be interpreted to give a complete stress-strain-strength curve. The PMT tests larger zones of a soil mass as compared to other in-situ tests. However, due to complicated procedures, the tests are time consuming and the equipment is delicate and can be easily damaged.

See FHWA Geotechnical Engineering Circular 5 (Sabatini, et al., 2002) for additional information on these types of in-situ tests and their use.

2.3.2.5 Planning for Evaluation of Groundwater Conditions

Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations. The depth at which the soil pore spaces or fractures and voids in rock are completely saturated with water is the water table. Pore water pressure refers to the pressure of groundwater held within the gaps or pores between particles of soil or rock. Pore water pressure below the phreatic level (pressure head equal to zero) is measured by piezometers. NYSDOT GDM Chapter 23 addresses instrumentation used to measure the groundwater pressure at the point at which the piezometer is installed.

Managing groundwater in geotechnical designs may introduce a variety of aspects to address in planning. The concern regarding the erosive action of water is identified in NYSDOT GDM Chapter 22. In evaluating the groundwater conditions at a site, the following factors have to be considered:

- groundwater level observations vs. method of subsurface exploration,
- soil layering,
- topography,
- surface water (streams, lakes, wetlands, etc.),
- time of year.

1. Groundwater Level Observations and Soil Layering

   If the subsurface profile contains soil or rock layers of varying permeability's, it is common to have more than one water level in the profile, especially if two layers of pervious soils or rock are separated by a less pervious one. Therefore, a water level reading made after the completion of a single test hole can be misleading.

   Water level observations apply to the portion of the soil profile between the bottom of the casing and the bottom of the hole (or at the bottom of the casing if depth of hole equals depth of casing) and will be affected by water above the bottom of casing unless grout or a swelling clay is placed along the outside of the casing.

In the case of two or more layers of soil or rock exposed below the bottom of the casing, the observed water level will generally be that in the most pervious layer (which can be affected by water above the bottom of casing as noted above). This applies also to observation wells penetrating two or more soil or rock layers.

Groundwater level observations made in cased borings in soils of low permeability (clays, silty clays, clayey silts, organic silts), or in test holes progressed with drilling mud, are not indicative of the water level in the soil unless the casing is left in place for a very long time.

A water level observation made in a boring at the beginning of the next working day may be very close to the true groundwater level reading if the soil is sufficiently pervious.

If the water level in the boring is below the water level in the exposed soil, the time to equalization may be shorter than if the water level in the boring is above the water level in the exposed soil. The reason is clogging of the soil surface by soil particles suspended in the water. For the same reasoning, care should also be used in measuring the water level at the completion of the test hole if water has been used to clean out the casing during drilling operations.

2. Affects on Groundwater Depth by Topography and Surface Water

   The depth to groundwater is typically greater near the top of the natural slope than near its toe.

   Streams with a bed in soil are sometimes associated with artesian pressure conditions. Streams flowing in a bed of ledgerock are often associated with perched water conditions in the surrounding hillsides. In both cases, this is especially true if there are ponds or wetlands on the surrounding high ground.

   The level of water in adjacent streams, lakes and wetlands is generally a good indicator of the approximate groundwater level at the water source. Groundwater levels uphill of these locations may be close to the surface, thereby requiring subsurface explorations to confirm.

3. Time of Year

   Groundwater level generally drops from June until October or November, rises slightly during late fall and winter and rises sharply in the spring (reaching a maximum typically in May).

In addition to the above and to orchestrate an instrumentation program to evaluate the groundwater conditions, see NYSDOT GDM Section 2.3.2.10 *Planning for Field Instrumentation*.

2.3.2.6 Planning for Geophysical Techniques

Geophysical techniques should be considered to enhance subsurface interpretation between test holes, to obtain information in areas where access is difficult for conventional test hole equipment, and to potentially reduce the cost of the geotechnical subsurface investigation program. Geophysical techniques are especially useful for defining lateral geologic stratigraphy, and can be useful to identify buried erosion channels, detailed rock surface location, overall rock quality, buried obstructions or cavities, etc., and, most recently (with improved electronics), shear wave profiles.

Geophysical testing should be used in combination with information from direct methods of exploration, such as SPT, CPT, etc. to establish stratification of the subsurface materials, the profile of the top of bedrock and bedrock quality, depth to groundwater, limits of types of soil deposits, the presence of voids, anomalous deposits, buried pipes, and depths of existing foundations. Geophysical tests shall be selected and conducted in accordance with available ASTM standards. For those cases where ASTM standards are not available, other widely accepted detailed guidelines, such as Sabatini, et al. (2002), AASHTO Manual on Subsurface Investigations (1988), Arman, et al. (1997) and Campanella (1994), and Sirles (2006) should be used.

Geophysical testing offers some notable advantages and some disadvantages that should be considered before the technique is recommended for a specific application. The advantages are summarized as follows:

- Many geophysical tests are noninvasive and thus, offer significant benefits in cases where conventional drilling, testing and sampling are difficult (e.g. deposits of gravel, talus deposits) or where potentially contaminated subsurface soils may occur.
- In general, geophysical testing covers a relatively large area, thus providing the opportunity to generally characterize large areas in order to optimize the locations and types of in-situ testing and sampling. Geophysical methods are particularly well suited to projects that have large longitudinal extent compared to lateral extent (such as for new highway construction).
- Geophysical measurement assesses the characteristics of soil and rock at very small strains, typically on the order of 0.001%, thus providing information on truly elastic properties, which are used to evaluate service limit states.
- For the purpose of obtaining subsurface information, geophysical methods are relatively inexpensive when considering cost relative to the large areas over which information can be obtained.

Some of the disadvantages of geophysical methods include:

- Most methods work best for situations in which there is a large difference in stiffness or conductivity between adjacent subsurface units.
- It is difficult to develop good stratigraphic profiling if the general stratigraphy consists of hard material over soft material or resistive material over conductive material.

- Results are generally interpreted qualitatively and, therefore, only an experienced Departmental Geotechnical Engineer or Engineering Geologist familiar with the particular testing method can obtain useful results.
- Specialized equipment is required (compared to more conventional subsurface exploration tools).
- Since evaluation is performed at very low strains (or no strain at all), information regarding ultimate strength for evaluation of strength limit states is only obtained by correlation.

There are a number of different geophysical in-situ tests that can be used for stratigraphic information and determination of engineering properties. These methods can be combined with each other and/or combined with the in-situ tests presented in NYSDOT GDM Chapter 4 to provide additional resolution and accuracy. ASTM D 6429, "Standard Guide for Selecting Surface Geophysical Methods" provides additional guidance on selection of suitable methods.

2.3.2.6.1 Seismic Refraction Survey

Seismic refraction investigates the subsurface by generating arrival time and offset distance information to determine the path and velocity of the elastic disturbance in the ground. The disturbance is created by an energy source (shot, hammer, weight drop, or some other comparable method) for putting impulsive energy into the ground.

The basic premise of seismic refraction is that the earth strata are in distinct layers, each having a velocity greater than the overlying layer. In general, this is the case. However, if an uppermost layer has a velocity greater than the underlying layers, the method will not work. In addition to this aspect, some other features that need to be considered in the planning for a seismic refraction survey include:

1. Site Limitations:
   a. Dynamite is used as the energy source. This can be a problem if there are buried utilities in the vicinity of the seismic points, or in heavily populated areas. There is usually a small crater left behind.
   b. Frost in the ground creates a problem because the frozen ground is a high speed layer. The resulting velocity inversion masks underlying layers, and results in erroneous depth calculations.
   c. Manmade Fill doesn't transmit the seismic energy waves (even when a large amount of dynamite is utilized) so seismic lines cannot be shot in fill areas.
   d. Topography of the field layout is an important consideration. There has to be at least 200 ft. of flat or evenly sloping ground surface. If there are too many surface ridges or depressions (gullies, small hills, etc.), the geophone lateral spacing will be too variable and it may have to be moved to a less desirable location. This is often a problem at bridge locations, especially when an existing structure is in place. At bridges, designers generally want depth to rock at a specific location. However, the cables might not be able to be set up because of physical constraints.
   e. Noise from traffic or other sources can be a problem, because the geophones are

extremely sensitive to vibrations. Filters can be used to minimize environmental noise, but use of filters may require use of more explosives.

2. Operational Limitations:
   a. Speed of data delivery. Geologists can generally shoot 6 to 10 points a day, but field results may take several days to interpret.
   b. Boulders: Soils containing numerous shallow boulders may negatively impact the final results.
   c. Trend of Bedrock: Seismic surveys can give reliable depth to rock at a single location. The general incline of the bedrock surface between multiple shot points can be determined, but hidden ledges or pinnacles can be missed.
   d. Portability: The equipment can be carried in to any location.
   e. Water work: Generally, the Geologists can operate in slowly moving or still water. Fast moving water or rough flow may negatively affect results.

3. Stakeout:
   a. Two-Lane Highway
      i. Side-hill cut: Stakes on deep ditch line every 200 ft., with the following data on each stake: (a) Line, (b) Station, (c) Offset, (d) Elevation and, (e) Approximate cut depth.
      ii. Through cut: Stakes on both ditch lines carrying the same data as for side-hill cut. If geologic conditions appear to be reasonably uniform, it may be prearranged to stakeout only the centerline.
   b. Multiple-Lane Highway
      i. Side-hill cut: Stakes on deep ditch line of both roadways.
      ii. Through-cut: In cases where the dividing strip is narrow, say 36 ft. wide, it is necessary to stake out only the outside ditch line for each roadway. In cases where the dividing strip is wide, and especially where the two roadways are at different grades, it may be necessary to consider each roadway as a separate highway.

2.3.2.7 Planning Needed at Wetlands & Wetland Mitigation Sites

Wetland mitigation is defined as any activity that seeks to avoid or lessen negative impacts to wetlands from development and/or to compensate for negative impacts. Subsurface explorations in or near wetlands and open water bodies can require challenging subsurface investigations and long term monitoring of site conditions. Often, subsurface investigations in these areas require additional efforts to protect or minimize impacts to the wetland.

The following are some of the aspects that must be considered when planning subsurface explorations within or near a wetland:

1. The subsurface investigations, while in or near the vicinity (usually an offset of 100 ft.) of a wetland ecosystem, must protect plants, animals, air, and water adjacent to the operation. All necessary precautions shall be planned to prevent direct or indirect contamination of the wetland areas by silt, sediment, fuels, solvents, lubricants, leachate,

or any other pollutant associated with exploration operations. Common methods include straw bale or gravel dikes, turbidity curtains, and silt fence which completely surround the work area.

2. Planning of subsurface explorations must consider preliminary permits and access to the operations area and any possible impact on the wetland. Timber or gravel mats may be needed for equipment access and setup. The Drill Crews may be required to disinfect (off-site) the equipment and the inside any water storage tanks with a high temperature (160° F minimum) pressure washer prior to starting work. Access paths and work sites will be restored, as close as reasonably possible, to the area's original condition.

3. The Drill Crew should use a recirculation pan to capture the drill wash material and the wash water should be recirculated to progress the bore hole. The excavated material should periodically be removed from the pan and placed on an approved geotextile material. After completion of the drilling of the hole, the excavated material that has been deposited on the geotextile material should either be returned to the bore hole or removed from the site. The wash water may need to be removed from the site or placed into an excavated infiltration hole located outside the 100 ft. offset from the wetland.

4. The wetland itself may be prone to flooding and quick removal of equipment may be necessary. Wetland flooding can vary widely due to local and regional differences in topography, hydrology, vegetation and other factors (e.g. human involvement).

5. Explorations may be progressed to establish limits or sources of wetland soils that require removal and/or relocation for new wetland development. Subsurface explorations usually involve a minimum of one test boring per acre, installation of piezometers, and percolation tests performed to determine inflow rates and seasonal water levels. Probes or retractable plugs can be utilized in a grid pattern to establish a reliable estimate on the subsurface profile of any organic or soft soils.

In addition to the above, and to assess the conditions of the groundwater regime, see NYSDOT GDM Section 2.3.2.5 *Planning for Evaluation of Groundwater Conditions*.

2.3.2.8 Planning for Infiltration Facilities

Infiltration facility design includes the design of basins, ponds, trenches and other best management practices (BMP's) developed to encourage infiltration of stormwater back into the ground. The design of Infiltration Facilities is identified in NYSDOT GDM Chapter 20.

Geotechnical design of infiltration facilities includes an initial assessment of the groundwater regime, soil stratigraphy, and hydraulic conductivity of the soil, and the geotechnical stability of the facility. NYSDOT Chapter 20 provides additional test procedures to develop an understanding of the coefficient of permeability and/or infiltration rate at the site. Planning in the early stages is necessary for the following, as per the guidance in the New York State Stormwater Management Design Manual (NYS SMP manual) and NYSDOT GDM Chapter 20:

1. Initial Subsurface Investigations: For a proposed site to be suitable for an infiltration facility, soils underlying the bottom of a facility must have an infiltration rate of at least 0.5 in. per hour, and the bottom of the facility should be at least 3 ft. higher than the seasonally high water table or rock. Requirements for boring spacing, depth, and sampling frequency are provided in NYSDOT GDM Chapter 4.

   Grain size analysis and hydrometer tests can be used to accurately classify the soil and its texture. Lab testing should only be used as a last resort to establish the infiltration rates of the in-situ soils.

2. Initial Percolation Tests: Initial investigations will also involve an evaluation of the general infiltration rate of the proposed facility through a percolation test. Percolation is defined as the gravity flow of groundwater through the pore spaces in rock or soil. The percolation test involves digging a hole (generally 2 ft. square), or installing a cased bore hole (4 in. diameter, min.) to 24 in. below the proposed base of the facility. Do not utilize the same bore hole for both the subsurface investigations and a percolation test. The percolation test should then be progressed as per the procedure given in the NYS SMP manual or GDM Chapter 20.

3. Final Investigation and Testing: If the proposed site for the infiltration facility is acceptable, additional test borings/pits and percolation tests shall be progressed at each facility as per the table for Concept Design Testing shown in the NYS SMP manual.

In addition to the above, and to assess the conditions of the groundwater regime, see NYSDOT GDM Section 2.3.2.5 *Planning for Evaluation of Groundwater Conditions*.

2.3.2.9 Planning for Trenchless Installation of Casing

Trenchless technology is a type of subsurface construction work that requires few trenches or no continuous trenches. It is defined as a family of methods, materials, and equipment capable of being used for the installation of new or replacement or rehabilitation of existing underground infrastructure with minimal disruption to surface traffic, business, and other activities. NYSDOT GDM Chapter 21 addresses trenchless installation techniques.

There are many methods that allow installation of a casing in a manner that will not disrupt existing above ground structures or subsurface facilities. Commonly utilized trenchless installation techniques are:

- Auger Boring (AB),
- Slurry Boring (SB),
- Pipe Jacking (PJ),
- Microtunneling (MT),
- Horizontal Directional Drilling (HDD), and
- Utility Tunneling (UT).

The subsurface exploration program for this work should include test holes taken in sufficient numbers and at sufficient depths to investigate the feasibility of the design and construction of the trenchless installation proposed. Subsurface explorations and the specific exploration requirements for trenchless installations are identified in NYSDOT GDM Chapter 4. The complexity of the trenchless installation, the size and depth of the jacking and receiving pits, the design of dewatering system and construction methods vary between the different techniques. The subsurface exploration program should consider the list of available trenchless installation options to ensure that adequate subsurface information is available to advance with any method a Contractor chooses.

Two aspects commonly control a trenchless installation operation:

- Obstructions: The presence of obstructions, such as buried utilities, old pavement, boulders or numerous large cobbles, or shallow rock with an uneven surface have a significant impact on the outcome of the trenchless installation.
- Water Control: This requires the development of a soil profile of the pervious and impervious layers that will be encountered. The thickness and depth of these layers have a prominent influence upon construction difficulties.

To address the aspects that affect trenchless installation operations, various subsurface conditions need to be identified. Sufficient information is needed to determine:

1. Soil types - visual identification, linear extent, thickness and uniformity of strata
2. Soil consistency and/or density – needed to determine jacking resistance, ease of excavation and possible effect on adjacent structures.
3. Overburden gradation - needed for determining jacking and tunneling resistance, percentage and size of boulders or cobbles, location of flowable soils or tunneling overcut problem areas, and soil permeability for dewatering purposes.
4. Soil compressibility – determines settlement or misalignment of the pipe in soft soils, and affects from adjacent structures and possible future loading.
5. Relative compressive strength of boulders and rock – compressive strength will affect the size and type of tunneling equipment.
6. Groundwater elevation – presence of water and/or need to dewater to control operation.
7. Presence of utilities – actions required to avoid obstructions need to be identified.

In addition to subsurface conditions, other aspects that may need to be addressed during planning a trenchless installation operation include:

1. Above ground structures – likelihood of ground movement caused by the proposed trenchless installation should be evaluated to ensure stability of adjacent structures.
2. Surface drainage conditions – observe and address surface drainage conditions entering and exiting the project site.

2.3.2.10 Planning for Field Instrumentation

Specific requirements for field instrumentation are provided in NYSDOT GDM Chapter 23. Field instrumentation planning is also crucial to the development of a complete field exploration program. Ground water measurement in terms of its location, piezometric head, extent across the site, gradient, and connection to surface water features is typically important for most geotechnical designs, and its measurement should always be a part of any geotechnical investigation planning effort. Elimination of ground water measurement from the geotechnical investigation plan must be justified by strong evidence that there is no groundwater present within the depths of interest, or that the presence of ground water will have no effect on the geotechnical design of the project element or its construction. Note that measurement of the water level in the drilled hole at the time of drilling is generally not considered to be adequate for ground water measurement. In granular soil with medium to high permeability, reliable groundwater levels can sometimes be obtained in the drilled hole. At a minimum, groundwater levels should be obtained at completion of drilling after the water level has stabilized and 12 hours after drilling is completed. However, since the presence of drilling fluids and the time required for ground water levels to reach equilibrium after drilling can be significant, measurements of ground water at time of drilling can be misleading. It may be necessary to install some type of temporary piezometer to make such measurements in a timely manner.

The extent of the ground water measurement program shall be capable of evaluating both design and constructability needs (note that this does not mean that the piezometers need to be available for use during construction of the project element, but only means that constructability issues can be assessed). Seasonal or tidal variations in the ground water levels should also be assessed to the extent feasible given the project design schedule. Continuous monitoring of groundwater can be achieved by using electrical piezometers such as vibrating wire type in conjunction with digital data loggers.

See NYSDOT GDM Section 2.3.2.5 *Planning for Evaluation of Groundwater Conditions*. Additional information on ground water monitoring as part of the field investigation is provided in Mayne, et al. (2002).

Other field instrumentation may be needed as part of a geotechnical investigation for certain situations. For example, where instability is anticipated, slope inclinometers placed at strategic locations to define the potential failure surface should be installed. The inclinometer should be installed deep enough to ensure that it is firmly fixed in stable soil. For forensic analysis of existing structures, tilt meters and/or extensometers can be useful for determining the direction and location of structure movement. Setting up survey control of key points on the structure as part of the geotechnical investigation can also be of use in some cases.

2.3.3 Preparing the Subsurface Exploration Plan

It is important to be confident of the accuracy of the preliminary site data provided by the Designer requesting the geotechnical investigations, and to clearly understand the scope of services being requested. The Designer requesting the geotechnical investigations should also clearly understand what affect approximations in the site data could have on the geotechnical design, and the possibility of returning later to redo some of the geotechnical work if the impact of such approximations on the geotechnical design is significant. Any geotechnical concerns that are likely to develop, or the need for contingencies, should also be communicated at this time. Communication between the Departmental Geotechnical Engineer and the Project Designer is essential throughout the geotechnical investigation. The Departmental Geotechnical Engineer is defined as the Regional Geotechnical Engineer or Geotechnical Engineer from the Geotechnical Engineering Bureau who has been given responsibility to coordinate and complete the geotechnical design activities for the project. Early communication of potential complications due to geotechnical concerns will result in more cost effective and constructible designs. Any impact to project schedule resulting from the geotechnical investigation as it progresses should also be communicated to the Project Designer promptly. It is the Departmental Geotechnical Engineer’s responsibility to make sure that this communication takes place. As such, the Departmental Geotechnical Engineer should submit the Exploration Plan to the Project Designer before explorations begin and alert the Project Designer of any unforeseen developments or deviations from the Exploration Plan.

The proposed locations of the subsurface explorations should have been checked for accessibility during the site reconnaissance (normally, the drilling supervisor will check for this). It may be necessary to shift the locations of some explorations due to local conditions, such as utilities, encountering obstacles such as boulders during drilling, or changes in engineering plans. The revised locations of these holes should be carefully plotted on the layout and the reason for the shift should be noted on the field log. Some tolerance in location of the explorations should be expected and communicated to the Drill Crew. The amount of tolerance will depend on the topography at the site, the expected soil conditions, stage of exploration, and type of structure. For example, for explorations made during the project scoping/definition phase or for cut slope design, exact locations might not be critical. On the other hand, if the test boring is being made to define the rock contact beneath a spread footing, moving the boring 10 ft. might be too much. If the location of the exploration is critical, it may be justified to mobilize a different type of drill rig. Costs incurred during construction because of differing site conditions are generally much greater than the cost of an additional mobilization.

Communication between the Departmental Geotechnical Engineer and the Drilling Inspector during the field exploration is also crucial. The Drilling Inspector should be briefed as to what subsurface conditions to expect, any required methods of explorations, and the termination criteria for each subsurface exploration. They should contact the Departmental Geotechnical Engineer if any significant changes are encountered. It may be necessary to adjust the sampling intervals, the depth of explorations, or add explorations if the subsurface conditions are different than expected. If it becomes apparent that such changes will significantly impact the project budget or schedule, it is important to immediately contact the Project Designer to discuss the situation with them, and come to an agreement on the best course of action.

The information on the Boring Stake-Out and Progress Sheet shown in Figure 2-2 should be as complete as possible to make efficient use of the Drill Crew’s time. They need to know how to get to the site, where to drill, what equipment to take, and what difficulties to expect. The Drill Crew’s time should be spent in drilling and sampling and not in sending back for more equipment.

REGION		PIN:		BORING STAKEOUT AND PROGRESS SHEET		BIN:		SHEET	1	OF	
PROJECT						REQUESTED BY:					
						PREPARED BY:					
COUNTY		PSN:		TYPE OF WORK		CHECKED BY:			DATE:		

HOLE	COORDINATES		GR. ELEV.	DEPTH		LOGS, SAMPLES & CORE				REMARKS
	NORTH(ft.)	EAST(ft.)	FT	REQUIRED	OBTAINED	DATE	SAMPLE REC'D (*)	CORE RECEIVED (M)- XX/60"-RUN#'s	AX/NX	
										A-Starting at a Depth of 5', Terminate at 30B.P.F. for 20' or 20 B.P.F. for 30' or 10' Rock with 85% Recovery
										B-Starting at a depth of 10', Terminate at 30 B.P.F. for 20' or 20 B.P.F. for 30' or 10' Rock with 85% Recovery
										C-Starting at a depth of 15', Terminate at 30 B.P.F. for 20' or 20 B.P.F. for 30' or 10' Rock with 85% Recovery
										D-Starting at a Depth of 25', Terminate at 30 B.P.F. for 20' or 20 B.P.F. for 30' or 10' Rock with 85% Recovery
										E- Drill 25' or 10' Rock with 85% Recovery
										F- Drill 35' or 10' Rock with 85% Recovery
										G- Drill 50' or 10' Rock with 85% Recovery
										H- Drill 60' or 10' Rock with 85% Recovery
										I- To Rock - 10' Core with 85% Recovery
										J- Refusal or 2' Below Soft or Organic Layer
										Notes: 1. Drill required depth or 5' Rock Core. 2. Add 15' to hole after termination criteria are achieved in soil. 3. Driven casing. 4. Minimum 60' hole in soil. 5. Continuous Sampling First 15' 6. Install Piezometer, 20' well, 2' grout

Figure 2-2 Boring Stake-Out and Progress Sheet

In preparing the Subsurface Exploration Plan, the Departmental Geotechnical Engineer identifies appropriate information such as:

- Type or method of explorations required.
- Sequence of drilling to allow for adjustment in the plan. For example, explorations in areas where soil conditions are unknown or problem soils are expected to be present should be performed in the first stages of the program, to allow for adjustment in sampling intervals or additional explorations to be added.
- Expected soil conditions. Attach field logs from nearby explorations, if available.
- Sampling intervals and types of samples to be obtained.
- Instrumentation and procedures for installation.
- Criteria for terminating each exploration – such as depth, refusal, thickness of bearing layer, etc. If at all possible, the depth of all explorations should be estimated prior to doing the fieldwork. However, that is not always practical.
- Coordination of Drilling Inspector and Regional Geotechnical Engineer regarding when and at what stages of the field exploration communication should take place.
- Equipment required and access needs
- Known permits required and regulations, and locations of all adjacent property lines
- Known utilities with locations and depths
- Special work zone traffic control requirements

Coordination between the Regional Geotechnical Engineer and Drill Crews is necessary to implement the field investigation program, to make sure that there are no logistical problems with the plan implementation.

2.3.3.1 Access Needs

At times, it is necessary to progress subsurface explorations outside the right-of-way. The Department has the absolute, legal right to enter a property for the activities of survey and soil explorations necessary to plan and design a transportation project pursuant to the authority of Section 30, Paragraph 17 of the New York State Highway Law. Yet, the Department is always aware that work on or near private properties may be disconcerting to the owners. Therefore, Departmental personnel should heed to the sensitive nature of such actions.

To provide advance notification that the Department will be conducting preliminary surveys, explorations, or tests that require access to private property, a right-of-entry letter (shown in Figure 2-3 & 2-4) is presented to the homeowner.

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

- - Regional Address - -

www.DOT.NY.gov

- - Regional Director - -
REGIONAL DIRECTOR

- - Commissioner - -
COMMISSIONER

Dear Property Owner:

RE: PROJECT # *- - Project Identification Number - -*
COUNTY: *- - Project Description - -*
- - County - -

The New York State Department of Transportation is about to plan and design the abovementioned transportation improvement project.

For the purposes of surveys and soil explorations, it will be necessary for members of the Department or their representatives to enter property within the design area. We find that this project area contains property belonging to you. Therefore, we wish to inform you in advance that we will be conducting preliminary surveys, explorations, or tests that may require us to enter onto your property on *- - date - -*

We understand that our entry onto your property may be disconcerting to you, and we will make every effort to accommodate your concerns. Should any damage be done to your property as a result of such entry, you are entitled to compensation. The Department is authorized to pay claims directly for damages not in excess of $2500.00. For claims exceeding $2500.00, the procedure set forth in Section 10 of the Court of Claims Act for bringing an action against the State must be followed.

For information purposes, we are bound to inform you that the Department has the absolute, legal right to enter your property for the activities described above pursuant to the authority of Section 30, Paragraph 17 of the New York State Highway Law, a copy of which is attached.

We look forward to your cooperation in this matter. Please be assured that we will, to the best of our ability, work with you to prevent any disruption to your personal life. Should you have questions, please feel free to call *- - Regional Geotechnical Engineer - -* of the Regional Geotechnical Group at *- - phone number - -*

Very truly yours,

- - Regional Director - -
Regional Director

Figure 2-3 Right-of-Entry Letter

RIGHT OF ENTRY REQUEST

PIN: *- - Project Identification Number - -* COUNTY: *- - County - -*
- - Project Description - -

"Section 30"

Section 30, Paragraph 17 reads as follows:

"Notwithstanding the provisions of any general, special or local law, the Commissioner of Transportation, his officers, agents or contractor and the officers or agents of the United States when engaged on such highway projects, may, pursuant to Section Four Hundred Four of the Eminent Domain Procedure Law, enter upon property for the purpose of making surveys, test pits, test borings, or other investigations and also for temporary occupancy during construction. Claims for any damage caused by such entry, work or occupation not exceeding twenty-five hundred dollars may be adjusted by agreement by the Commissioner of Transportation with the owner of the property affected as determined by him by reasonable investigation without appropriating such property. Upon making any such adjustment and agreement, the Commissioner of Transportation shall deliver to the Comptroller such agreement and a certificate stating the amount due such owner and the amount so fixed shall be paid out of the State Treasury from monies appropriated for the acquisition of property for the project requiring such entry, work or occupation."

COPY FOR PROPERTY OWNER

Figure 2-4 Right-of-Entry Letter Attachment

2.3.3.2 Utility Clearance

The proposed locations of the subsurface explorations are physically marked in the field either by the use of spray paint (White - designating a proposed excavation) or wooden stake, including identification of the subsurface exploration as described in NYSDOT GDM Chapter 4. White is the industry standard for this purpose and is used to avoid confusion with the following other underground facility designations:

- Red - Electric
- Yellow - Gas/Oil
- Orange - Communications/Telephone/CATV
- Blue - Potable Water
- Green - Sewer/Drainage
- Purple - Reclaimed Water
- Pink - Temporary Survey Markings

Chalk based paint is advised since it will dissipate quicker with rain, etc. Take care that the white marks will not be confused with traffic or pedestrian control marks.

The purpose of staking-out proposed explorations is to communicate to the Drill Crews the location(s) for exploration and to identify the location(s) for an Underground Facilities Protection Organization (UFPO) clearance, e.g., Dig Safely New York (NYS Code Rule 753). The latter practice helps locators avoid marking where it is unnecessary, while assuring the excavation site does get marked properly. The purpose of these rules is to establish procedures for the protection of underground facilities in order to assure worker and public safety and to prevent damage to public and private property.

2.3.3.2.1 Public Service Law

Public Service Law Section §119-b. *Protection of Underground Facilities*, adopts rules and regulations to implement and carry out the requirements of Article 36 *Construction and Excavation near Underground Facilities* of the General Business Law, established for the protection of underground facilities. The rules and regulations include:

- Requirements for notice,
- One-call notification systems,
- Participation of operators in such systems,
- Designation and marking of the location of underground facilities, and the verification of the designated or marked location of underground facilities,
- Support for underground facilities and obligations of excavators to protect underground facilities under such article, including the use of hand-dug test holes at underground facilities furnishing gas or liquid petroleum products, and
- Such other matters as may be appropriate for the protection and security of property, life or public health, safety or welfare.

Excavations and demolition may be inspected to examine the methods used by any person within 15 ft. in any direction of any underground pipeline used for conveying natural gas, or of any underground telephone, electric, steam or water facility used for providing service, and to order compliance with the standards. Enforcement procedures include:

- Any violation of any of the provisions of the rules and regulations is a violation of the provisions of Article 36 of the General Business Law and the Attorney General may prosecute to recover penalties,
- Any penalties, fines and financial liability resulting from violations shall be those specified in §765 *Penalties and Liabilities* of the General Business Law. In the event a violation is subject to a civil penalty, the Commission shall determine the amount of the penalty under due consideration of the nature, circumstances and gravity of the violation, history of prior violations, effect on public health, safety or welfare, and such other matters.

Failure to comply with any provision of General Business Law Article 36 shall subject an excavator or a utility operator, under §765 *Penalties and Liabilities*, to a civil penalty of up to $1,000.00 for the first violation and up to an additional $7,500.00 for each succeeding violation which occurs in connection with the entire self-same excavation or demolition activity within a two month period.

Penalties shall not apply to an excavator who damages an underground facility due to the failure of the utility operator to comply with any of the provisions of the Article 36 and the excavator will not be liable for repairs.

In the event that, as a result of a violation by an excavator, it is necessary that a utility operator make any repair to or provide new support to an underground facility, the excavator shall be liable to the operator for reasonable costs incurred.

2.3.3.2.2 One Call Center

811 – The New "Call Before You Dig" Number
A nationwide "Call Before You Dig" number was implemented on April 13, 2007 by the Common Ground Alliance (CGA). The number is 811. Calling 811 before digging is a critical safety precaution. Before calling, information about the type of work and proposed locations should be identified in a Location Request Information sheet. Dig Safely New York's Location Request Information sheet is shown in Figure 2-5.

Dig Safely New York and DigNet of New York City & Long Island are part of the national 811 number.

- **Dig Safely New York**
  Dig Safely New York was established in 1968 as a message handling service for member facility owners and operators. Information about planned excavations is distributed to its membership to promote an easier, safer digging environment. Dig Safely New York serves the entire state of New York outside of Long Island and New York City, which is covered by New York City One-Call. Dig Safely New York's number is 1-800-962-7962. However, they may also be reached via 811. Dig Safely New York is now known as Dig

Safely New York 811.

- **DigNet of New York City & Long Island**
  DigNet of NYC & LI Inc. (formerly known as The New York City & Long Island One Call Center) was established in 1990 to act as a communications link between utility companies and individuals planning any digging activity in the five boroughs of New York City and Nassau and Suffolk Counties on Long Island. DigNet's number is 1-800-272-4480. However, they may also be reached via 811. DigNet of NYC & LI Inc. is now known as New York 811.

Dig Safely New York 811 and New York 811 are links between an excavator and the utility operators. Calling 811 reduces the likelihood of incidents. Reports indicate that when an excavator notifies a one call center before digging, damage occurs less than 1% of the time.

I-Notice
I-Notice is the Dig Safely New York 811 system's internet method of entering a location request. The i-notice program allows an excavator to directly enter location requests into the IRTH database system over the internet.

- Using the i-notice system satisfies all the requirements of a dig notification, as mandated in NYS Code Rule 753, without having to wait on the phone.
- The excavator has the freedom to create location requests on the internet 24 hours a day, 365 days a year.
- I-notice provides access to electronic maps which allows the excavator to represent the dig-site utilizing the polygon features of the system.
- I-notice allows the opportunity to print or manage location requests electronically by tracking locations or printing a listing of facility operators that have been notified, along with their telephone numbers.

ITIC
The ITIC service is the New York 811 system's internet method of entering a location request and provides the same benefits as described for the i-notice system for Dig Safely New York 811.

Dig Safely. New York
Call 811 before you dig

Location Request Information Sheet

Fill out this helpful information sheet before you call Dig Safely New York.

Company ID#: ____________ **Today's Date:** ____________
Company Name: ____________
Company Mailing Address: ____________
City: ____________ **State:** ____________ **Zip:** ____________
Phone: ____________ **Fax:** ____________
Email: ____________
Field Contact Name: ____________ **Phone:** ____________
Name or Company for whom you are doing the work? ____________

***NYS LAW REQUIRES AT LEAST 2 FULL WORKING DAYS ADVANCE NOTICE, NOT INCLUDING THE DAY YOU CALL.**

Start Date: ____________ **Start Time:** ____________
Duration of job: ____________ **Days / Hours / Months / Weeks / Years / Unknown**

Excavation Site State: New York **County** ____________
City / Town / Village ____________
Street Address: ____________
The TWO nearest cross streets the address is located between:
Near Street 1: ____________ **Near Street 2:** ____________
Where on the property are you excavating? ____________
Depth of Excavation: ____________ **Inches / Feet**
Length: ____________ **Feet / Miles / Meters**
Width: ____________ **Inches / Feet**
Type of Work: ____________
Means of Excavation: ____________
Will there be Blasting? ❍ Yes ❍ No
Will there be Boring or Directional Drilling? ❍ Yes ❍ No
Is the Dig Site within 25ft from the Edge of the road or in the road? ❍ Yes ❍ No
Is the Excavation marked in WHITE? ❍ Yes ❍ No

TICKET NUMBER
______ - ______ - ______

List of Members Notified
____

NOTES
____

To print more forms, please visit our website: www.digsafelynewyork.com/dsny/pdf/Format_pad.pdf

i-notice ONLINE LOCATION ENTRY

Place your tickets online 24 Hours a Day!
Send an email with your Company ID Number to:
register@digsafelynewyork.com

Figure 2-5 Location Request Information Sheet

2.3.3.2.3 Clearance Ticket

Once the proposed locations of the subsurface explorations are physically marked in the field, the following is a synopsis of the procedures for clearing a site:

1. Call the One-Call Center: Call 2 to 10 days in advance of start date, not counting date of call. Make a note of the ticket reference number and names of the operators to whom the notice will be transmitted.
2. Wait the Required Time: Do not start before the stated commencement date, unless notified by every operator that they have no facilities in the work area. Maintain all utility markings - it is the responsibility of the excavator to maintain all markings.
3. Confirm Utility Response: All operators of utilities located within 15 ft. of the proposed excavation are required to accurately mark their facilities. Check that each notified operator has either marked the work site or given an "all clear" response.
4. Verify Locations: Check the marked-out locations of utilities on-site to be sure they make sense. Errors sometimes do occur.
5. Resolve Conflicts: The One Call Center may need to be contacted again if utility conflicts require the proposed exploration to be relocated a significant distance.
6. Conform to the Start Date: Make note of the “must start by” date on the ticket. Failure to start by the date will require re-calling the One-Call Center (e.g. if the excavation start date is postponed by more than 10 working days, the one call center must be contacted again and a new ticket issued).

It should be noted that:

- No mechanical excavation is allowed within 2 ft. of a utility prior to verifying the exact location by hand or “soft dig” methods (i.e. vacuum truck).
- No mechanical excavation is allowed within 4 in. of any utility without the express written consent of the utility operator.

Figure 2-6 shows an example of a Utility Clearance Ticket.

IRTH One Call

```
Ticket: 09042-500-117-00 Type: Regular       Previous Ticket:
---------------------------------------------------------------------------
State: NY  County: ORANGE                Place: FLORIDA  /V
Addr:  From:          To:        Name: N  MAIN                          ST
Cross: From:          To:        Name:    BRIDGE                        ST
Offset:
---------------------------------------------------------------------------
Locate: ENTIRE INTERSECTION
NearSt: BRIDGE ST
Means of Excavation: SOIL BORINGS                          Blasting: N
Site marked with white: Y
Boring/Directional Drilling: Y
Within 25ft of Edge of Road: Y

Work Type: SOIL BORINGS
Duration:
Depth of excavation:
Site dimensions:
Start Date and Time: 09/07/2012 07:00
Must Start By: 09/21/2012
---------------------------------------------------------------------------
Contact Name: MICHAEL GREENMAN
Company: AQUIFER DRILLING
Addr1: 75 EAST 2ND ST                Addr2:
City: MINEOLLA                       State: NY    Zip: 11501
Phone: 516-616-6026                  Fax: 516-616-6194
Email: AMGREENMAN@MSN.COM
Field Contact: MIKE
Email: MGREENMAN@AQUIFERDRILLING.COM
Working for: NYS - DOT
---------------------------------------------------------------------------
Comments: MARK ENTIRE INTERSECTION AND 50 FEET IN ALL DIRECTIONS.  BRIDGE ST
        : BECOMES GLENMERE AVE ON EAST SIDE OF INTERSECTIONS
        : Lookup Type: MANUAL
---------------------------------------------------------------------------

Members:
  ORANGE & ROCKLAND UTILITIES INC. | ORANGE              845-577-2373
  VILLAGE OF FLORIDA                                     845-651-7815
  WARWICK VALLEY TELEPHONE                               845-986-2504
```

Service Area Code	Service Area Name	Contact	Day Phone	Emergency Phone	Alt Phone	Utility Type	Response
O&R UTILS / ORNG	ORANGE & ROCKLAND UTILITIES INC. | ORANGE	STEVE NOSTRO	(845) 577 - 2373		(845) 629 - 3275	ELECTRIC, GAS	30 MARKED, THE APPROXIMATE HORIZONTAL LOCATION OF UNDERGROUND FACILITIES WITHIN 15 FT OF THE EXCAVATOR DEFINED WORK AREA HAVE BEEN MARKED
VIL FLORIDA	VILLAGE OF FLORIDA	TIM BRUNSWICK	(845) 651 - 7815		(845) 741 - 1325	ROADS, SEWER, WATER	MARKED AS PER TIM
WARWICK VLY TEL	WARWICK VALLEY TELEPHONE	FRANK CORKUM	(845) 986 - 2504		(914) 755 - 1239	FIBER, TELEPHONE	10 CLEAR, NO FACILITIES WITHIN 15 FT OF THE EXCAVATOR DEFINED WORK AREA

Figure 2-6 Example of a Utility Clearance Ticket

2.4 CONSIDERATIONS FOR LARGE SCALE PROJECTS

As stated previously, the Departmental Geotechnical Engineer must design project elements utilizing or retaining predetermined materials (created in nature and outside their control) with properties that are highly variable from location to location and with depth. Numerous geotechnical design methodologies are based partly on theory and partly on empirical test results. Of particular concern to a Departmental Geotechnical Engineer designing a foundation is:

- Establishing whether or not the site conditions are such that piles should be used,
- Choosing an appropriate type of pile,
- Determining the number, length, and size of the piles required,
- Calculating the nominal pile resistance.

To address the geotechnical parameters needed to design project elements, and to fully explore the subsurface conditions within the project limits to minimize the potential for unforeseen conditions, the Subsurface Exploration Program is a valuable risk handling process. Furthermore, for large scale, expensive structures, another risk handling process is to award a separate contract during the design phase to performance test foundation elements in a Pile Load Test Program. This type of performance testing during the design phase of the project may also be necessary for project sites with unusual geologic materials or materials unlike those for which empirical design information is available. Performance testing within the design phase enables a more aggressive geotechnical design by verifying actual resistance. They are generally performed to either prove that piles are capable of sustaining the design load or to gain more detailed information that will enable a more efficient design. A more aggressive geotechnical design will typically result in a reduction of the cost of foundations.

The following projects are described in greater detail in Hannigan et al. (2006):

- Oregon Department of Transportation – Alsea River Bridge: A pile load test program was conducted as part of FHWA DP-66. As a result, the final foundation design utilized a 100% increase in the pile resistance (twice the design load) anticipated in preliminary design. This resulted in both the number of piles and the pile material quantity being reduced by approximately ½ and in a net foundation cost savings of $2.1M (considering a test program cost of approximately $0.35M, this achieved a cost-benefit ratio in excess of 6:1). The foundation cost savings did not consider other items such as smaller footing and cofferdam sizes or reduced construction time.
- Washington Department of Transportation – Third Lake Washington Bridge: A pile load test program was conducted as part of FHWA DP-66. As a result, the final foundation design utilized a 67% increase in the pile resistance anticipated in preliminary design. Test results also made possible a 40% reduction in the pile wall thickness. The project realized a net foundation cost savings of $5M (considering a test program cost of approximately $0.5M, this achieved a cost-benefit ratio of 10:1).

The additional investment required to procure more precise information often pays large dividends in material cost savings.

2.4.1 Planning a Pile Load Test Program

Performance testing foundation elements in a Pile Load Test Program awarded in a separate contract during the design phase of a project is warranted if a sufficient number of production piles are to be installed and if a higher resistance factor will result in a sufficient shortening of the piles thereby resulting in a potential net cost savings. Performance testing enables a more aggressive geotechnical design by verifying the actual geotechnical resistance whereas when a test pile is not used, a lower resistance factor is required. If a project's preliminary design indicates that very few piles are required, longer piles (as required by the lower resistance factor) may be less expensive than performing a Pile Load Test Program (utilizing a higher resistance factor and using shorter piles).

Pile load tests should also be performed if the structure will be subjected to very high loads, cyclic loads of an unusual nature, or where highly variable soil conditions exist. Special pile load tests should be performed to determine soil parameters used in design when the structure is subject to large dynamic loads (e.g. earthquakes).

The pile load test should be conducted as near to the construction installation environment as possible (i.e. the footing elevation of the substructure with the excavation as nearly complete as possible). If the pile load test cannot be performed with the excavation completed, it will be necessary to evaluate and compensate for the additional soil confining pressure that existed during the load test.

The pile load test is generally performed to either prove that piles are capable of achieving the required nominal resistance or to gain more detailed information that will enable a more efficient design. Therefore, a Pile Load Test Program should conduct a test to pile failure or soil/pile failure in lieu of testing to a specified load of termination. A Pile Load Test Program should incorporate the following:

- Analysis of the Pile Installation Operations: Piles are installed at selected locations with a primary intention of gaining installation information, concentrating their location in any suspect or highly variable areas of the foundation strata.
- Analysis of the Hammer for Driven Pile Installation: Piles are driven to allow hammer selection testing. In some cases different hammers will produce piles of different ultimate resistances. Evaluating the hammer will allow a correlation between hammer energy (blow count and stroke) and pile resistance. Therefore, a Pile Driving Analyzer (PDA) should be used to allow the results to be correlated with static tests with the intention that a greater reliance can be placed upon future results when using the PDA for verifying the driving system efficiency, pile resistance, and pile integrity for production piles.
- Analysis of the Test Piles: Piles are installed and tested to allow final selection of the pile length or determination of pile driving criteria. Upon completion of the testing program, test piles may be extracted and inspected to gain further information on the installed product.

The Departmental Geotechnical Engineer should begin with outlining the objectives of the Pile Load Test Program. Examples of objectives include:

- The Pile Load Test Program will investigate the effects of several factors on the compression and tension capacities of driven steel H and pipe piles. The main objectives of the program are to study:
    1. The effect of load test procedure on pile capacity (i.e. ASTM Standard vs. ASTM Quick Test),
    2. The effect of pile batter on pile capacity,
    3. H-Pile vs. pipe pile capacity, and
    4. Pile capacity variation across the site.

- Due to an aggressive project schedule, the Pile Load Test Program will focus on the risk of not meeting the project schedule, while maintaining the details necessary to provide relevant data. Therefore, the Pile Load Test Program will need to provide information that will reduce schedule uncertainties, such as time for pile setup, requirements for restrikes, or requirements for extra driving of piles beyond planned tip elevations. The information will be used to institute an effective set of driving criteria for each pier on the bridge. In order to aid in establishing the driving criteria, the specific objectives of the Pile Load Test Program are to:
    1. Verify that piles could be installed to minimum tip elevation with the hammers selected,
    2. Evaluate need for any driving aids to achieve the first objective,
    3. Define the driving resistance level below which reduced stroke is needed to avoid pile damage,
    4. Evaluate any changes required to cushions to avoid pile damage, and
    5. Verify or adjust the estimated tip elevations with an appropriate allowance for setup.

A Pile Load Test Program is not practical or economically feasible under certain circumstances, but they are always technically desirable. The advantages of awarding a separate contract to refine the design prior to construction are:

- The pile size, type, lengths, and preferred installation method can be determined before construction of the project, and
- Any problems with the pile test and potential problems with design revealed by the pile tests may be resolved prior to construction when they are more likely to be less costly.

The disadvantages of this approach are:

- The design schedule is extended to allow time for the separate operations,
- The test conditions may not closely simulate design assumptions since excavation, water conditions, fill, etc. may not necessarily match construction conditions, and
- Additional problems may develop if different Contractors and/or equipment are used during the Pile Load Test Program.

These advantages and disadvantages must be evaluated in relation to the site availability.

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