ISSUED

Effective Date: 04/12/17

WP 07-1
Revision 8

WIPP Geotechnical Engineering Program Plan

Cognizant Section: Geotechnical & Mine Engineering

Approved By: Reymundo Carrasco

Nuclear Waste Partnership LLC

An AECOM-led partnership with BWXT and AREVA

TABLE OF CONTENTS

CHANGE HISTORY SUMMARY

REVISION NUMBER	DATE ISSUED	DESCRIPTION OF CHANGES
7	11/19/12	• Editorial revision in accordance with MD 1.1.
8	04/12/17	• Minor editorial revision.

ABBREVIATIONS/ ACRONYMS

CE	Cognizant Engineer
CFR	*Code of Federal Regulations*
NWP	Nuclear Waste Partnership LLC
SIDL	Single Instrument Data Loggers
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This document defines the field programs and investigations to be carried out by the Nuclear Waste Partnership LLC (NWP) Geotechnical Engineering Section. The geotechnical engineering programs are designed to provide scientific information necessary to establish a high level of understanding of site characteristics and to assess the stability and performance of the underground facility. Programs currently consist of the following activities:

- Geosciences
- Geomechanical Monitoring
- Rock Mechanics
- Ground Control

These programs will be implemented and controlled by this program plan.

This document does not generate any quality-affecting records.

1.1 Background

The programs listed in Section 2.0, *Administration*, support the safe disposal of transuranic (TRU) waste, both in the short-term (during the operational life of the facility) and in the long-term (following decommissioning), that will satisfy the appropriate federal regulations governing isolation of the waste. The data increase confidence in the effectiveness and safety of the underground operations, validate the design, support site characterization and performance assessment activities, and support activities required for research and technological development.

Drivers for these programs include the Consultation and Cooperation Agreement with the State of New Mexico, which stipulates continuing studies of the site geology; the U.S. Environmental Protection Agency's standards for management of TRU waste; the Mine Safety and Health Administration; Title 30 *Code of Federal Regulations (*CFR) Part 57, Subpart B, "Ground Control"; 40 CFR §194.42, "Monitoring"; and the Hazardous Waste Facility Permit issued to the Waste Isolation Pilot Plant (WIPP), Identification No. NM4890139088-TSDF, by the New Mexico Environment Department. These programs implement the applicable portions of system AU00 System Design Description and the technical safety requirements to allow for waste handling and disposal activities. The programs also ensure that the facility operates safely and that data are available to make decisions for managing and performing engineering and operational activities.

Field activities will be organized into four programs that cover:

- Geosciences
- Data collection from geomechanical instrumentation
- Rock mechanics evaluation
- Ground control assessments and implementation of ground control measures

Each field program is controlled by a program plan, listed herein in section 3.0, describing the general scope of the investigation, its methods, and quality assurance requirements.

1.2 Geosciences Program

The Geosciences Program will continue confirmation of site suitability based on field activities such as geologic mapping of the facility horizon excavations and logging of cores. These activities are used to characterize, demonstrate the continuity of, and document the geology exposed in the underground excavations. The program also maintains a storage facility for site-generated geologic samples and a local seismic monitoring system.

1.3 Geomechanical Monitoring Program

The Geomechanical Monitoring Program provides data to validate design, track short-term and long-term geotechnical performance of underground openings, and support routine safety and stability evaluations of the excavations. Data on the stability and closure of underground excavations are used to identify areas of potential instability and allow remedial actions to be taken.

Monitoring of geotechnical parameters is performed using geomechanical instruments, including tape extensometers, convergence meters, borehole extensometers, piezometers, strain gauges, load cells, crack meters, and other instruments installed in the shafts and drifts of the WIPP facility.

1.4 Rock Mechanics Program

The Rock Mechanics Program assesses the performance of the underground facility. Data from geomechanical monitoring and geosciences observations are used to evaluate the current and future performance of the excavations. Numerical modeling and empirical methods are used to evaluate the effects of proposed design changes and the long-term behavior of the underground facility.

1.5 Ground Control Program

The Ground Control Program ensures that the underground is safe from any unexpected roof or rib falls. It provides the experience necessary to design ground control systems for the host rock, to monitor ground control system performance through data and observations, and to allow projections to be made regarding future ground support requirements.

2.0 ADMINISTRATION

2.1 Organization

The NWP organizational structure is described in *Nuclear Waste Partnership LLC Quality Assurance Program Description* (WP 13-1). Geotechnical Engineering reports to the Geotechnical & Mine Engineering Project Manager.

2.2 Responsibilities

The cognizant manager and staff are responsible for achieving and maintaining quality in the geotechnical engineering programs.

2.3 Training and Qualifications

Personnel who perform specific tasks associated with geological and geotechnical data collection, engineering assessments, and quality assurance/quality control measures are trained and/or qualified in the application of the specific requirements to complete their tasks. The minimum training requirements for engineering personnel are identified in the Engineering Technical Training Requirements Policy section of WP 09, *Engineering Conduct of Operations*.

3.0 TECHNICAL PROGRAM DESCRIPTION

3.1 Geosciences Program

The Geosciences Program contains activities that continue confirmation of site suitability through surface and underground field investigations. These activities generate data used in monitoring the repository and in rock mechanics studies. Information from the Geosciences Program is used to document the existing geologic conditions and characteristics and to monitor for changes resulting from the excavations. Activities associated with this program include geologic and fracture mapping, maintenance of a facility for the storage of geologic samples (the Core Library), seismic monitoring and evaluation, and other activities performed as needed. The program describes the general scope of investigations, the methods, and program requirements. The plan is updated periodically to reflect additions and changes to the program.

3.1.1 Background

The Los Medaños area has been studied since 1974 to assess site capability for isolation of radioactive waste. The present WIPP site was selected in 1976 and has been under continuous investigation since that time as a site for containment and isolation of TRU radioactive waste. Because geology is the principal factor in the isolation of the waste from the accessible environment, the Geosciences Program provided important data for site characterization and was integral to the decision on the design of the facility. Extensive geologic characterization of drifts and shafts was performed under the Site and Preliminary Design Validation Program for confirmation of site suitability. The program provided the basis for the decision to proceed with construction of the WIPP facility.

The Geosciences Program was developed to continue confirmation of site suitability based on field activities such as geologic mapping of the facility and near-surface stratigraphic horizons, core logging, and geophysical surveys. These activities characterize, demonstrate the continuity of, and document the geology at the site. The program maintains a library of site-generated geologic samples and quarterly reporting of the results of local seismic monitoring. The program is also responsible for the collection of geologic and structural data and other section activities as required.

3.1.2 Purpose

The purpose of the Geosciences Program is to confirm the suitability of the site based on continuing field activities.

3.1.3 Scope

Site investigations are performed as required, or as determined useful, for enhancement of the site geologic characterization knowledge base. Activities include reconnaissance geologic mapping of new excavations, detailed geologic mapping, investigations of regional exposures, and geologic support to projects conducted by other site participants. The activities associated with the Geosciences Program are designed to:

- Provide additional site geological characterization based on geologic mapping of excavations and core logging.
- Maintain a current database on mineralogy, chemistry, and textural feature characteristics of the local geology.
- Maintain a current level of knowledge on the geohydrology of the regional stratigraphic formations based on geologic, hydrologic, and geochemical data.
- Monitor the local seismicity using a series of surface-based seismographs. As part of this activity, analyses are performed to determine if any correlation of seismic events with mining or petroleum recovery operations can be established.

3.1.4 Methods

Routine tasks are carried out according to approved WIPP procedures. Activities in development, and those not expected to be performed routinely, are performed in accordance with industry standards or individual program plans that supplement this program plan.

Routine Activities

- Seismic Monitoring - Seismic monitoring and evaluation is carried out by the New Mexico Institute of Mining and Technology, through a subcontract.

- Geologic Mapping - Geologic mapping is performed in newly excavated areas and when the cognizant engineer (CE) or cognizant manager deems it necessary. The mapping results are documented in the annual geotechnical analysis reports and appropriate topical reports.

- All drifts and rooms in which geologic mapping was not conducted are visually inspected by the CE, or designee, within three months of excavation to verify that the exposed rock units are laterally continuous and similar to those exposed in the mapped areas of the facility. Any unusual features are reported in the annual geotechnical analysis reports.

- Fracture Mapping - Fracture mapping is performed and carried out by the CE, designee, or cognizant manager at locations selected in accordance with accepted industry practice. Observations from boreholes and excavated surfaces are used in performance assessments of the underground facility.

- Core Library Operations - Geotechnical Engineering maintains a repository for geologic samples that have been determined necessary for long-term storage. Approved WIPP procedures define the proper methods for maintaining the sample repository, the submittal of core to the Core Library, maintenance of the Core Storage Facility (inventory, handling, and distribution), authorization for access to view the core on-site, and authorization to remove samples from the library.

Other Activities of the Geosciences Program

Test plans are developed for geoscience activities that are in a developmental stage or are not routinely performed. They include, or reference, the appropriate procedures to ensure that all necessary steps for completion are carried out. The plans provide specific details that describe the activity, location, procedure, etc.

3.2 Geomechanical Monitoring Program

The Geomechanical Monitoring Program monitors the geomechanical response of the underground openings after mining. It also monitors geotechnical instruments installed in the shafts and drifts of the WIPP facility. Geotechnical instrumentation installed in the shafts and underground includes tape extensometer points, convergence meters, borehole extensometers, piezometers, strain gauges, load cells, and crack meters. The instrumentation is sensitive enough to detect small changes in rock displacements and rock stresses.

Information generated by this program is documented in annual geotechnical analysis reports. The data are documented more frequently as recommended by the CE or manager. An assessment of convergence measurements and geotechnical observations is made after each round of measurements. The results of this assessment are distributed to affected underground operations, engineering, and safety managers.

This plan describes the general scope of the investigation, methods, and program requirements, and is updated periodically to reflect additions and changes.

3.2.1 Background

The instrumentation system has provided data on the performance of the WIPP design for design validation for projecting the long-term behavior of the underground openings and routine evaluation of safety and excavation stability. From an operational standpoint, the geomechanical data allow the identification of areas of potential instability and remedial action to be taken. To determine the long-term behavior of the repository, assessments rely heavily on the extrapolation of in-situ data, taken over a period of years, to predict thousands of years of repository performance.

The engineering performance of the WIPP host rock is important in the assessment of the design of the operating facility and its long-term performance. Of significance are the time-dependent properties of the salt. Sandia National Laboratories has carried out extensive experimental work to establish an appropriate, constitutive relationship for salt that can predict its in-situ mechanical performance. To validate the adequacy of the facility design, field data from geomechanical instrumentation are used to determine actual mechanical performance of the shafts and excavations at the facility horizon.

3.2.2 Purpose

The purpose of the Geomechanical Monitoring Program is to determine the geomechanical performance of the underground excavations at WIPP. Data on stability and closure are needed for operational considerations and for performance assessment.

3.2.3 Scope

The activities associated with the Geotechnical Monitoring Program are designed to:

- Maintain and augment the geotechnical instrumentation system in the WIPP underground and upgrade the automatic data acquisition system as necessary.
- Monitor geotechnical instrumentation on a regular basis and maintain a current database of instrument readings.
- Evaluate the geotechnical instrumentation data and prepare regular reports that document the data and analyses describing the stability and performance of underground openings.
- Recommend corrective or preventive measures to ensure excavation stability and safe operation of the facility.

3.2.4 Methods

The process by which geomechanical monitoring of an area is initiated may vary as part of operational excavation monitoring or research testing. Proper documentation and analysis is common to all. Installation and monitoring of the instruments is governed by approved WIPP procedures. Instrumentation is monitored remotely using data loggers or read manually. Routine tasks are carried out according to approved WIPP procedures. Activities which are in development, or which are not expected to be performed routinely, are performed in accordance with industry standards and individual activity plans that supplement this program plan.

Data Acquisition

Remotely polled instruments are connected to a surface computer through a system of cables, termination boxes, and data loggers. Manually read instruments are monitored using electronic read-out boxes and mechanical measuring devices. The data are collected on a quarterly basis at a minimum, but more frequent readings may be collected as determined by the CE or cognizant manager.

Geomechanical Data Logging System

The system consists of surface computers, modems, data loggers, and associated interconnecting cabling. The instrumentation is routed to local termination cabinets or accessor boxes at various locations in the underground. These contain the electronic hardware needed for multiplexing, signal conditioning, data conversion, and communicating with the surface computers, which are connected by a dedicated communications data link cable. The surface computers communicate through modems using a series of communication and data management software programs. The data from the instruments are maintained in individual databases for each instrument type.

Instrumentation

The instrumentation used at WIPP is widely accepted in the geotechnical and mining industry. Geomechanical instrumentation installed in the shafts and underground includes tape extensometer points, convergence meters, borehole extensometers, rockbolt load cells, pressure cells, crack meters, strain gauges, and piezometers. The instrumentation is sensitive to small changes in rock displacement and stress. Geomechanical instruments are installed and monitored in accordance with approved procedures or written instructions. Instrument types, monitoring usage, and typical installation locations are listed in Table 1, *Geomechanical Monitoring Instrumentation*.

TABLE 1 - GEOMECHANICAL MONITORING INSTRUMENTATION

INSTRUMENT TYPE	MONITORING USAGE	TYPICAL LOCATION
Tape Extensometer	Manual monitoring of roof-to-floor closure and rib-to-rib closure	Shaft stations, access drifts, and disposal panels
Convergence Meter	Manual or remote monitoring of roof-to-floor closure and rib-to-rib closure	Areas of restricted access or with limited vehicular traffic
Multiple Point Borehole Extensometers	Fracture separation in the rock strata and deformation of the rock mass into the excavation	Shafts, shaft stations, access drifts, and disposal panels
Rockbolt Load Cells	Tensile loads in rockbolts	Selected roof support systems
Earth Pressure Cells	Pressure of the rock creep on the concrete shaft key and on selected roof support systems	Salt Handling Shaft, Waste Shaft, Exhaust Shaft and selected roof support components
Crack Meters	Displacement of a fracture or separation in the rock or between two anchorage points	Shaft brows and selected cable roof support components
Strain Gauges	Deformation of engineered materials (the shaft concrete liner and key and installed rock bolts) due to rock creep	Salt Handling Shaft, Waste Shaft, Exhaust Shaft, and selected roof support components
Piezometers	Groundwater (hydrostatic) pressure behind the shaft liners and keys	Salt Handling Shaft, Waste Shaft and Exhaust Shaft

Data Analysis and Dissemination of Data

The frequency of analyses of geomechanical data is based on the requirements established in design documents and regulatory requirements, and as determined by the geomechanical instrumentation CE. A comprehensive analysis of the data is performed annually. Results of the analyses are published in geotechnical analysis reports. Data may be released to external sources more frequently with consent from the U.S. Department of Energy.

Assessments of the convergence measurements and other geotechnical observations are performed after each round of complete measurements. Results are distributed to affected underground operations, engineering, and safety groups. Data analyses may be performed on a more frequent basis, as recommended by the CE or cognizant manager.

Calibration

Measurement and data collection equipment used to read the geotechnical instruments are calibrated in accordance with approved WIPP procedures. Frequency of calibration is based on manufacturer recommendations upon receipt of the measuring device at the WIPP site, or as determined by the CE. Calibration records are kept on file in Geotechnical Engineering.

Single instrument data loggers (SIDLs) incorporate an internal self-check using check standards. The check standards are two off-the-shelf precision resistors soldered to the SIDL circuit board. The use of check standards in lieu of periodic calibration is permitted under WP 13-1, when applicable. SIDLs perform both a check standard verification and an internal analog-to-digital converter check prior to each measurement cycle. This is performed as an alternative to periodic calibration. The measurement process has been documented in Self-Check of Single Instrument Data Loggers Using Check Standards. NWP Quality Assurance has approved this alternative to periodic calibration.

Routine Activities

Maintenance is performed as needed. When an instrument is damaged or erroneous readings are suspected, the instrument is inspected physically and evaluated for repairs or replacement. If repair efforts are unsuccessful, that instrument is documented as malfunctioning and monitoring is discontinued until the instrument has been replaced or abandoned.

Inspections of the instrumentation and data logging components are performed during monitoring activities. These inspections check the physical condition of the instrumentation, junction boxes, and cabling for damage, corrosion, and loose parts. Any unusual observations or deterioration are documented on the Geotechnical Instrumentation System field data sheets, and the CE is notified of existing conditions.

The inspection results and performance of the instrumentation and data logging components are evaluated by comparing the monitoring results against previous readings. These evaluations are used to determine whether the geomechanical instrumentation and data acquisition system are performing as anticipated.

Other Activities of the Geomechanical Monitoring Program

Test plans are developed for geomechanical monitoring activities that are either in a developmental stage or not routinely performed. These plans include or reference the appropriate procedures to ensure that all necessary steps to complete the activity are carried out and detail specific plans that describe instrument characteristics, locations, procedures, etc. These activities may include the installation and monitoring of new instrument types to evaluate their adequacy for use in salt. Changes to the remote monitoring equipment and software routines are documented in accordance with approved WIPP procedures.

3.3 Rock Mechanics Program

This program assesses the current and future performance of the underground facility. Its statistical and empirical data methods and numerical modeling codes, modified for use in salt rock, provide the process for analyzing data collected from geotechnical instruments and visual observations. The results follow approved WIPP procedures and are published in annual geotechnical analysis reports, or more frequently as recommended by the CE or manager.

This program plan describes the general scope, methods, and program requirements of investigations, which are updated periodically to reflect additions and changes.

3.3.1 Background

The Geomechanical Program provides data to validate design, track short-term and long-term geotechnical performance of underground openings, and support routine safety and stability evaluations of the excavations. From an operational standpoint, these assessments allow for the identification of areas of potential instability and the application of remedial actions, if necessary. To validate the adequacy of the facility design, field data from geomechanical instrumentation is used to determine actual mechanical performance of the shafts and excavations at the facility horizon.

Analytical methods, such as numerical modeling, are used to determine the potential effects of mining new excavations, excavation sequence, and long-term behavior of the repository. The engineering performance of the WIPP host rock is important to assess the design of the operating facility and its long-term performance. Of significance are the time-dependent properties of the salt. Extensive experimental work and observations have been used to establish an appropriate, constitutive relationship for salt that is used to predict its in-situ mechanical performance. These assessments rely heavily on the extrapolation of in-situ instrumentation data and field observations.

3.3.2 Purpose

The Rock Mechanics Program provides the capability to assess the geomechanical response of the surface and underground facility due to mining of the underground.

3.3.3 Scope

The activities associated with the Rock Mechanics Program are designed to:

- Assess the geotechnical performance of the underground excavations.
- Assess the effectiveness of support systems installed to control areas of potentially unstable ground.

- Assess the appropriateness of the current mine design and periodically evaluate the criteria.

- Provide geotechnical recommendations for the development of mine design criteria based on analytical assessment of the performance of the existing excavations and from modeling of proposed design changes.

- Project excavation performance based on new mining, ground control activities, and facility aging.

- Predict the performance of underground excavations based on instrumentation data and supplemented by analytical studies.

- Maintain a library of numerical modeling codes that include the state-of-the-art understanding of salt rock mechanics.

- Provide recommendations or corrective/preventive measures to underground operations personnel based on the performance and expected usage of the underground facility.

3.3.4 Methods

The processes by which rock mechanics activities are completed may vary. Numerical analysis techniques commonly used in the mining and civil engineering industries are used to evaluate of the geomechanical performance of the underground openings. The use of these techniques is governed by WIPP approved procedures for engineering calculations and computer software control.

Routine Activities

The following are routine activities of the Rock Mechanics Program:

- Geomechanical Data Assessment - Assessments of the instrument data and geologic observations are performed periodically and reported in the annual geotechnical analysis reports and other more frequent topical reports. Complete data analyses are performed at least once a year. The frequency of data analyses is based on the geotechnical performance of the excavations and their operational use. The geotechnical data are evaluated to determine whether conditions exist which warrant closer or, possibly, immediate attention from a ground control standpoint. Geotechnical assessments measure the stability of the openings with respect to operational safety and long-term performance.

- Support System Performance Evaluation - New support system technologies are evaluated as they become available and are used as they are proven. Several test sections of support systems have been installed and are being monitored. These systems are instrumented to monitor the performance of the system components. This instrumentation, in conjunction with nearby geomechanical instrumentation, allows assessments of the effectiveness of the support system to be performed.

- Numerical Modeling - Material modeling codes estimate the performance of the salt rock material based on the material properties and loading conditions provided to the model. These models can be used to determine the potential effects of mining new excavations on the facility or the long-term effect of an excavation on nearby openings. The accuracy of the models can be improved by modifying the code to more accurately represent the actual physical conditions. These modifications may include mesh refinement and the use of input data that more accurately describe the physical properties of the host rock.

Other Activities of the Rock Mechanics Program

Test plans are developed for rock mechanics activities that are in a developmental stage or are not routinely performed. These plans include or reference the appropriate procedures to ensure that all necessary steps to complete the activity are carried out, and detail specific plans that describe the activity, location, procedure, etc.

These activities may include investigations of the geomechanical effect of new mining and mine design changes on the performance of the underground facility and subsidence effects. These investigations may require numerical modeling, materials laboratory testing, and field observations. The results are used to incorporate the latest understanding of the host rock properties into the modeling codes and analytical techniques.

3.4 Ground Control Program

The Ground Control Program provides comprehensive evaluation of the ground conditions and effectiveness of installed support systems throughout the facility. The evaluations are based on visual observations, analyses of geomechanical instrumentation data, fracture data acquired from observation boreholes, and rockbolt failure data. The designs of new support systems are based on the results of these evaluations.

Ground control issues have been addressed since excavation began at WIPP. Initially, only minor spalls were observed. However, as the excavations aged and issues associated with the roof beam began to develop, most of the facility was pattern-bolted with mechanical anchor rockbolts. Because these bolts provide a basically rigid support system, they have a finite life, and supplemental systems are required in areas scheduled for decades of use. The support systems must maintain many areas of the underground accessible for the projected life of the facility.
The information generated by this program is documented in annual assessment reports. Assessments of the performance of the installed ground support systems are performed as recommended by the CE or cognizant manager. The results of these assessments are distributed to affected underground operations, engineering, and safety organizations.

This program plan describes the general scope of the ground control activities, methods, and program requirements, and is updated periodically to reflect additions and changes to the program.

3.4.1 Background

The operating life of sections of the underground facility may extend to approximately fifty years from the date of excavation. Over time, the strains associated with stress conditions around the excavation result in degradation of the surrounding rock. Safety concerns associated with deterioration of the roof necessitate monitoring, maintenance, and ground control mechanisms to ensure safe working conditions. Roof support systems are currently in place throughout the facility; however, because of creep closure, they may undergo severe stress, have a limited service life, and require periodic replacement.

Many options are currently available for ground control in the mining industry. Technologies used in potash and salt mines are the most applicable to WIPP because of the similar behavior of the rock. A comprehensive testing and evaluation program has been used to determine which ground support components and/or systems are most applicable to specific project requirements. This program consists of many aspects that include continuous visual inspections of the underground opening, extensive geomechanical monitoring, numerical modeling, analysis of rockbolt failures, implementation of ground control procedures, comprehensive in-situ and laboratory testing, and evaluation of ground support components and systems.

The excavations vary in geometry, geology, age, and operational use. These differences affect the selection of ground control measures, but the ability of the salt to creep or flow with time has the greatest impact on selection of support systems. Salt creep exerts strong forces, both vertical and horizontal, on any control mechanism. During the time that the underground has been active, a variety of ground control issues have been encountered ranging from minor spalling to roof falls.

3.4.2 Purpose

The Ground Control Program provides the strategies for development and selection of the most applicable and efficient means of maintaining and monitoring the ground conditions of the WIPP underground to ensure safe and operational conditions. The selection of ground control fixtures is in accordance with 30 CFR Part 57, Subpart B.

3.4.3 Scope

The program is continually evolving. Current associated activities include:

- Addressing ground control concerns and design and implementation of ground support systems on a case-by-case basis.
- Installing and monitoring of small-scale and full-scale in-situ support systems for evaluation.
- Identifying and/or developing new ground control technologies that have application to WIPP conditions.Documenting and evaluating ground support system component failure.
- Evaluating the effects of new mining and mine design changes on the effectiveness of installed ground support systems, proposed installations, and the stability of the excavation.

3.4.4 Methods

Thorough evaluations of the ground conditions and support system performance throughout the facility are performed annually. Some areas may be evaluated more frequently as conditions warrant. These evaluations provide information necessary to address the near-term ground control needs and for long-term ground control planning.

Three basic options are available to address unstable ground conditions: (1) support the ground, (2) remove the ground, or (3) discontinue access. The first two options are engineering alternatives while the third option is an administrative decision. The ground control design criteria are based on long-term objectives, experience, performance of existing systems, laboratory and in-situ tests of selected ground control components and/or systems, numerical analysis, and site-specific geotechnical data. These criteria may be modified to accommodate technological advances, geologic conditions, or operational requirements.

Routine Activities

Ground support systems are installed in accordance with approved written instructions. Monitoring of the geotechnical instruments that monitor the performance of the support systems is performed routinely and carried out according to approved WIPP procedures.

Other Activities of the Ground Control Program

Activities which are in development, or which are not expected to be performed routinely, are performed in accordance with industry standards or individual activity plans that supplement this program plan.

4.0 QUALITY ASSURANCE

The WIPP Geotechnical Engineering programs are governed by WP 13-1. Steps to ensure quality are incorporated, as needed, in the technical procedures used for geotechnical engineering activities. The Geotechnical Engineering manager, or assigned designee, is responsible for developing and maintaining this program plan and associated procedures.

4.1 Design Control

Items and processes are designed using sound engineering/scientific principles and appropriate standards. Design work, including changes, incorporates appropriate requirements such as general design criteria and design bases. Design interfaces are identified and controlled. The adequacy of products is verified by individuals or groups other than those who performed the work. Verification work is completed before approval and implementation of the design.

4.2 Procurement

Procurement is carried out in accordance with the appropriate policies and procedures. Technical requirements and services are developed and specified in procurement documents. If deemed necessary, these documents require suppliers to have an adequate quality assurance program to ensure that required characteristics are attained.

4.3 Instructions, Procedures and Drawings

Quality-affecting activities performed by, or on behalf of, the geotechnical engineering programs are performed in accordance with written plans or approved procedures. WIPP general procedures are used for procurement, document control, and quality assurance.

Technical procedures are developed for routine quality-affecting functions. The procedures include in-process and final quality controls and documentation requirements. The procedures are as detailed as required and include, when applicable, quantitative or qualitative acceptance criteria to determine that activities have been satisfactorily accomplished. Procedures are developed in accordance with applicable WIPP procedures.

4.4 Document Control

Documents that prescribe processes, specify requirements, or establish design are prepared, approved, issued, and controlled. Controls ensure that the latest approved versions of procedures are used in performing geotechnical functions, and that obsolete and outdated documents are removed from work areas. The Geotechnical Engineering manager identifies the individuals responsible for the preparation, review, and approval of geotechnical engineering controlled documents.

4.5 Control of Purchased Material, Equipment, and Services

Measures are taken, in accordance with current WIPP procurement policies and procedures, to ensure that procured items and services conform to specified requirements. These measures generally include one or more of the following:

- Evaluation of the supplier's capability to provide items or services, in accordance with requirements, including their historical performance in providing similar products or services satisfactorily
- Evaluation of objective evidence of conformance, such as supplier submittals
- Examination and testing of items or services upon delivery

If it is determined that additional measures are required to ensure quality in a specific procurement, additional steps may be included in procurement documents and implemented by Geotechnical Engineering personnel and/or the Quality Assurance Department. These additional assurances may include source inspection and audits or surveillance at the suppliers' facilities.

4.6 Identification and Control of Items

Measures are used to ensure that only correct and accepted items are used at WIPP. All items that potentially affect the quality of the geotechnical engineering programs are identified and controlled to ensure traceability and prevent the use of incorrect or defective items.

4.7 Test Control

Testing or experimental/monitoring activities are in accordance with written plans or procedures that contain the following provisions, as applicable:

- Purpose, scope and/or definition
- Prerequisites such as calibrated instrumentation and supporting data; adequate test equipment and instrumentation, including accuracy requirements; completeness of item to be tested; suitable and controlled environmental conditions; and provisions for data collection and storage
- Instructions for performing the test
- Any mandatory inspection and/or hold points to be witnessed
- Acceptance and rejection criteria
- Methods of documenting or recording test data
- Requirements for qualified personnel
- Evaluation of test results by authorized personnel

Test or experimental/monitoring procedures prepared by other project participants (e.g., Sandia National Laboratories) used as procurement documents are reviewed to ensure that the documents are complete and the tests described by the documents are adequate to determine that the involved equipment, systems, or structures are operationally acceptable.

4.8 Software Requirements

Computer program procurement, design, and testing activities that affect quality-related activities performed by NWP or its suppliers are accomplished in accordance with WP 16-2, *Software Screening and Control*.

Test requirements and acceptance criteria are specified, documented, and reviewed and are based upon applicable software requirement, design, or other pertinent technical documents. Required tests, including verification, hardware integration, and in-use tests, are controlled.

Testing of software, at a minimum, verifies the capability of the computer program to produce valid results for test problems encompassing the range of permitted usage defined by the program documentation. Testing is also designed to identify and eliminate any serious operational defect.

Depending on the complexity of the computer program being tested, requirements may range from a single test of the completed computer program to a series of tests performed at various stages of computer program development to verify correct translation between stages and proper working of individual modules. This is followed by an overall computer program test.

Regardless of the number of stages of testing performed, verification testing and validation are of sufficient scope and depth to establish that software functional test requirements are satisfied and that the software produces a valid result for its intended function.

4.9 Control of Monitoring and Data Collection Equipment

Monitoring and data collection equipment is controlled and calibrated in accordance with applicable WIPP controlled procedures. Results of calibrations, maintenance, and repair are documented. Calibration records identify the reference standard and the relationship to national standards or nationally accepted measurement systems.

Calibration reports and operability test data are maintained by Geotechnical Engineering. Any out-of-tolerance condition is evaluated for potential impact on the validity of data. Impact evaluation and corrective actions are initiated per specific Geotechnical Engineering instructions.

4.10 Handling, Storage, and Shipping

Handling, storage, and shipping of items are coordinated in accordance with established procedures or other specific documents. Geotechnical Engineering is responsible for storing, handling, and shipping rock core and other geologic samples.

4.11 Control of Nonconforming Conditions/Items

Conditions adverse to quality are documented and classified in regard to their significance. Corrective action is taken accordingly.

Equipment that does not conform to specified requirements is controlled to prevent its use. Faulty items are tagged and segregated. Repaired equipment is subject to the original acceptance inspections and tests prior to use.

4.12 Corrective Actions

Conditions adverse to acceptable quality are documented and reported in accordance with corrective action procedures and corrected as soon as practical. Immediate action is taken to control work, and the results of that work, performed under conditions adverse to acceptable quality to prevent degradation in quality.

The Geotechnical Engineering manager, or designee, investigates any deficiencies in activities in accordance with approved procedures.

4.13 Records Management

Identification, preparation, collection, storage, maintenance, disposition, and permanent storage of records are in accordance with approved WIPP procedures.

Generation of records accurately reflects completed work and facility conditions and comply with statutory or contractual requirements. The Geotechnical Engineering Records and Inventory and Disposition Schedule describes the classification and disposition for all records generated by the group. While in their custody, the records are protected from loss and damage in accordance with approved WIPP procedures and they coordinate with Project Records Services (PRS) for transfer of quality records to PRS. They are also responsible for records that are maintained of all Core Library activities, including additions, removal of any material, any tests performed on the core, a record of people who examine the core on-site, and any other alterations made to the core.

4.14 Audits and Independent Assessments

Planned periodic assessments are conducted to measure management and item quality and process effectiveness, and to promote improvement. The organization performing independent assessments has sufficient authority and freedom to carry out its responsibilities. Persons conducting assessments are technically qualified and knowledgeable of the items and processes to be assessed.

4.15 Data Reduction and Verification

Computer programs, commercial data processing applications, and manual calculations that collect or manipulate/reduce data are verified. Verification must be performed before the presentation of final results or their use in subsequent activities. If it becomes necessary to present or use unchecked results, transmittals and subsequent calculations are marked "preliminary" until such time that the results are verified and determined to be correct.

REFERENCES	
DOCUMENT NUMBER AND TITLE	KEY STEP
Title 30 CFR Part 57, Subpart B, "Ground Control"	
Title 40 CFR §194.42, "Monitoring"	
ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition "Quality Assurance Requirements for Nuclear Facility Applications;" "Quality Assurance Program Requirements of Computer Software for Nuclear Facilities Applications"	
New Mexico Environment Department, Waste Isolation Pilot Plant Hazardous Waste Facility Permit, NM4890139088-TSDF	
WP 09, *Engineering Conduct of Operations*	
WP 13-1, *Nuclear Waste Partnership LLC Quality Assurance Program Description*	
WP 16-2, *Software Screening and Control*	
NWP Geotechnical Engineering (11/3/04) Self-Check of Single Instrument Data Logger Using Check Standards (Geotechnical Engineering file number IS.B.65)	