INSPECTION PROCEDURE 88131

GEOTECHNICAL/FOUNDATION ACTIVITIES

PROGRAM APPLICABILITY: 2630

88131-01 INSPECTION OBJECTIVES

01.01 To determine whether the technical requirements detailed or referenced in the Construction Authorization Request (CAR), the U.S. Nuclear Regulatory Commission, Safety Evaluation Report (SER), and the approved-Mixed-Oxide Project Quality Assurance Plan (MPQAP), associated with the baseline design criteria and geotechnical/foundation construction and quality control for Seismic Category I (SC-I) and SC-II structures, have been adequately addressed in the licensee and/or contractor construction specifications, drawings, and work procedures, and whether the established system of management controls is adequate.

01.02 To determine whether QA plans, instructions, and procedures for geotechnical/foundation activities have been established in the facility QA manual and QA implementing procedures.

01.03 To determine by direct observation and independent evaluation, whether work and inspection performance relative to geotechnical/foundation activities are being accomplished in accordance with the design specifications, drawings, and procedures.

01.04 To determine whether the licensee system for preparing, reviewing, and maintaining records relative to geotechnical/foundation activities is functioning properly, and to determine whether the records reflect work accomplishment consistent with specifications and procedures.

01.05 To determine, by direct observation of work activities and review of records, whether inadequacies in work activities associated with geotechnical/foundation activities indicate any potentially generic problems, management control inadequacies, or other weaknesses that could have safety significance.

88131-02 INSPECTION REQUIREMENTS

02.01 For each onsite organization with QA and/or Quality Control (QC) responsibilities relative to geotechnical/foundation activities, the inspector should refer to the appropriate Mixed Oxide Fuel Fabrication Facility QA inspection procedures. If there are multiple contractors with QA/QC responsibilities in this area, inspect a sample, using engineering judgment, concerning the safety significance and the complexity of each work activity.

02.02 Review the construction specifications related to geotechnical activities and ascertain whether the specified technical requirements conform to the commitments contained in the CAR. Determine whether appropriate and adequate procedures in the

following areas are compatible with the QA program and prescribe adequate methods to meet the construction specifications, where applicable.

a. Excavation and subgrade preparation.
b. Foundation verification.
c. Placement of engineered fill and backfilling.
d. Dewatering.
e. QC inspection and testing.
f. Instrumentation and settlement monitoring.
g. Surveying.
h. Engineering direction.
I. Soil compaction and testing

02.03 If applicable to the project, perform a review of the results of the test-fill program, before reviewing the implementing construction procedures, to verify that the fill procedures have been qualified. The implementing procedures should reflect the methods, equipment, materials, and conditions of the test-fill program.

02.04 Determine whether the licensee has an established audit program (including plans, procedures, and audit schedule) for assessing the adequacy of SC-I and SC-II work control functions, in the area of geotechnical/foundation activities, and for ensuring that examination, inspection, and test personnel associated with performing tests and inspections of geotechnical/foundation activities are qualified and/or certified to perform their assigned work.

02.05 By direct observation of work in progress on the material supporting SC-I and SC-II structures, ascertain whether the following applicable geotechnical/foundation activities are being controlled and accomplished in accordance with the requirements of the documents reviewed in 02.02, above:

a. Excavation and Subgrade Preparation. The following items should be verified when inspecting the excavation, and preparation of the foundation subgrade.

1. The excavation methods and sequence of operations should not be detrimental to the final foundation subgrade materials.

2. Unusual or changed conditions encountered during excavation of cavities, faults, pockets of unsuitable material, springs, seeps, boils, and protrusions, are noted, investigated, evaluated, and taken into consideration.

3. The foundation subgrade should be free of organic or soft unsuitable material. Depressions or holes left by grubbing and stripping or excavation should be backfilled with suitable materials compacted and tested to the specified density and moisture content. Soil classification at the depth excavated for foundations should be verified and compared with the soil profile determined during subgrade explorations (bore holes, exploratory excavations, etc.). The occurrence of extraneous detrimental or unexpected soil may necessitate further investigation or evaluation/redesign. The finished grade should be as specified, meet compaction and density requirements, be protected from the elements, and be tested and inspected.

4. Determine whether the stockpiling and segregation of excavated materials which are to be used as SC-I fill material are in accordance with specifications.

5. The foundation subgrade treatment such as compaction, installation of foundation drains, or other methods should be properly controlled.

6. Determine whether QC inspections are adequate with regard to scope, frequency, and inspector qualifications.

7. The record-keeping activities should reflect the actual conditions encountered in the field and provide adequate documentation of work and inspections. Determine whether records are being maintained, reviewed, and approved as specified.

b. Foundation Verification.

Verify that geotechnical engineering direction is available. Foundation subgrades should be approved by an experienced geotechnical engineer before placement of engineered fill, mudmats, or structural concrete. Determine whether records are maintained to document approval of the final foundation subgrade. Records should include elevation, actual conditions, methods to achieve acceptable conditions, and inspection and test acceptance criteria and final acceptance results.

c. Backfilling (Fill Materials and Compaction Control). At least quarterly while backfill, engineered fill, or compaction activities are in progress, ascertain that:

1. Specified lift thicknesses are adhered to and specified equipment is being used with the correct number of roller passes.

2. Source material being used is identified and is traceable to an approved borrow source. The approved source material should meet design and earthwork specification requirements and have been properly qualified by an approved soils laboratory.

3. Ensure that engineered fill or backfill is placed at the proper location and on approved foundation materials.

4. Verify that in-place density tests are being performed at the required frequency with properly calibrated instruments (including moisture content tests). If a nuclear density test is performed using a nuclear density gauge or Troxler, verify that the instrument has been calibrated and radioactive source leak checks have been performed.

5. Samples for laboratory tests are being taken at the required frequency, chain-of-custody established, and the samples are adequately identified. Review the results of the required tests and compare results to design specification requirements and applicable standards.

6. Inspection activities (QA and QC) are being performed as required by qualified and/or certified personnel. Review inspection documentation and verify that the records quantitatively define actual construction conditions and QC qualitative test results.

d. Dewatering Systems. The following items should be reviewed (permanent, important-to-safety dewatering systems will necessitate a more extensive review). Note that 1 and 2, below, represent good practice, but are not requirements unless specified in the site specifications.

1. Emergency power supply to ensure continuous dewatering system operation is being maintained and tested.

2. Open excavations are protected from flooding by an adequate sump pump system.

3. Piezometric surfaces are being defined by monitoring performed at the required frequency.

4. Inspection and testing of system discharge should assure that sediment material is not being removed from the foundation.

e. QCl Inspection and Onsite Testing Laboratory. The onsite laboratory should be inspected while tests are being performed on SC I material. The following items should be verified during the inspection:

1. The onsite laboratory has performed verification of laboratory personnel qualifications (education and experience) of testing and inspection personnel. Personnel qualification verifications must be supported by objective evidence documenting education and experience.

2. Test results are being evaluated at an appropriate level and evaluation includes trend analysis.

3. Observed testing standards conforms to the procedures specified in the American Society for Testing and Materials.

4. Testing apparatuses are calibrated at the required frequency and calibration traceable to a nationally recognized standard and calibration is in accordance with approved procedures.

5. Records reflect the results of inspections, the actual field conditions, testing frequency requirements, acceptance criteria, and data calculations are checked.

f. Instrumentation and Settlement-Monitoring Program. Review specific instrumentation or settlement-monitoring programs. The following items should be verified during the inspection:

1. Number, location, and type.

2. Instrumentation and settlement-monitoring systems installed before start of activity being monitored.

3. Instrumentation and settlement-monitoring systems are installed as specified, functioning properly, and protected against construction hazards.

4. Operation and monitoring: operations are monitored at specified frequency to assure that construction activities have not made installed instrumentation inoperable.

5. Calibration of measuring and testing equipment is maintained, logged and functionally checked.

6. Recordkeeping activities: records reflect specified frequency of monitoring, data checks (e.g., supervisory review, engineering review), data evaluated

and accepted. This is important in activities such as settlement monitoring. A comparison of the actual settlement data with those predicted can reveal problems at an early stage, enable the cause to be determined relatively early in the construction phase, or can cause design changes to be incorporated before the completion of extensive construction work.

g. Surveying. Surveying activities should be reviewed annually to assure that the instruments are properly calibrated, and calculations are checked to assure accurate results.

h. Engineering Direction. Verify that engineering direction is available onsite to monitor geotechnical/foundation construction activities. The onsite engineering staff should be supplemented by an experienced geotechnical engineer to approve final foundation subgrade materials, monitor and review QC inspection and test results, and identify changed field conditions. The onsite engineering staff should be involved in disposition of nonconformance reports, and prepare engineering field change requests for approval by the engineering design agent or organization.

i. Personnel Interviews. Informal interviews with field-craft and inspection personnel should be randomly conducted, to determine how well employees know the requirements of their work activity. Also, obtain a sense of the degree of adversarial or intimidating relationships that may exist with the construction forces. Perceived management support should be identified. Any adverse trend should be identified to regional management. Ascertain whether a sufficient number of adequately qualified QA and inspection (QC) personnel are at the construction site, commensurate with the work in progress, and adequately performing their assigned duties through the established organizational structure.

02.06 Review the documentation generated for the geotechnical/foundation activities. Determine whether the licensee/contractor system for documenting safety-related work is functioning properly. Records should be legible, complete, reviewed by QC and/or engineering personnel, and readily retrievable. Review a sample of the following records:

a. Receipt Inspection and Material Certification (if applicable). Applicable for materials purchased from offsite suppliers such as drainage materials, geosynthetic fabrics, select fill materials, sand and gravel, instrumentation, and dewatering system components. Records confirm that required material characteristics, performance tests, civil soil tests, nondestructive tests, and other earthwork specification requirements were met.

b. Installation Inspection. Records confirm that specified materials and components were installed as specified and that the required inspections were performed and acceptance criteria are defined.

c. Nonconformance/Deviation Record. Records include current status of these items. Nonconformance reports include the status of corrective action or resolution,(e.g., determine whether adequate corrective action is being taken when moisture density test results are not within tolerance or acceptance criteria.

d. Training/Qualification Records of Craft, QA, and Inspection (QC) Personnel. Records establish that QA/QC personnel are adequately qualified for their assigned duties and responsibilities and that craft personnel have been trained in their assigned tasks.

e. QA Audits. Records establish that the required audits were performed and that deficiencies identified during audits were corrected, and that corrective action was such that repetition of the deficiency, or similar deficiencies, would be precluded.

88131-03 INSPECTION GUIDANCE

General Guidance. Applicable portions of the CAR, the SER, and approved QA plan should be reviewed to determine licensee commitments relative to construction and inspection requirements, before performing this inspection. The inspector should then use these documents during the review of the construction specifications, drawings, work procedures, and QA implementing procedures. Geotechnical/foundation activities should also be reviewed in the light of being consistent with standard industry practice for the successful completion of that activity.

Because earth structures involve unique construction processes for each project, the number of geotechnical/foundation activities listed above, which should be reviewed, depends on the significance and applicability of that activity with respect to site conditions and the need for establishing a close relationship between the geotechnical design and the construction techniques and related monitoring. It is for this reason that this inspection module should be performed by someone who is able to discriminate between, and weigh those activities that will require the most attention, and which will have the most impact on safety. The inspector should use judgment in determining sample selection during inspection activities. Sample selection should reflect the importance of the activity to safety. Observations of work and independent verification of critical dimensions, locations, etc. should be performed at various stages of completion, especially for engineered fill and structural foundations. The inspector should be aware of the compaction and backfill materials problems identified at several sites and described in IE Circular 81-08.

The licensee is responsible to implement or have implemented the approved QA program and the commitments described in the CAR . The inspector must determine if this program is implemented in an adequate and timely manner for the important-to-safety work in progress.

QA/QC procedures must provide for effective inspections that will ensure that work is performed in accordance with specification requirements. QA audits should identify procedural inadequacies and the root cause of repetitive nonconforming conditions. Inspections should require verification of specified controls and should not be accomplished merely by surveillance. Laboratory and field testing procedures must provide for verification of correct material usage, correct selection of reference standards, and should prohibit discretionary selection of inspection and testing parameters by the contractor or QC personnel. Results of testing should be reviewed by qualified personnel and a determination of acceptability of the results made. Construction procedures must reference the required inspection hold points and must also address the QA/QC department stop-work authority.

Findings from this inspection activity should address each element as being satisfactory, being unresolved and requiring resolution, or being in violation and requiring correction. When significant inadequacies are identified, in the specifications or procedures, indicating weakness within the preparing organization, the inspector should inform cognizant regional management. The issue should be addressed at the appropriate level of licensee management.

03.01 Specific Guidance

Note: The numbering of the guidance below refers to specific subsections of 02, above.

02.01 The inspector should also review appropriate sections of American Society of Mechanical Engineers (ASME) NQA-1-1994 Edition with NQA-1a-1995 Addenda, as they relate to Structural Concrete, Structural Steel, Soils and Foundations for Nuclear Power Plants. Specific attention should also be given to the QA program needs that may result from the distribution of design and construction responsibilities. Examples of these needs may be: provisions for adequate onsite engineering direction, appropriate and adequate procedures related to procurement and use of materials, and adequate control of hold points.

02.02 The construction specifications must translate design requirements with sufficient detail to define the acceptance testing requirements and should specify the personnel and interface responsibilities required to define, control and resolve field or design geotechnical/foundation problems that are evidenced during construction. The specifications must also provide for qualifications of the equipment and techniques to be used to meet the specification requirements for compaction of soils. The specifications should provide for control of design changes and the issuance of design change notices.

02.02a Generally, procedures for the removal of material (excavation) are not required, but the condition of the underlying soil must be prepared/retained as specified.

02.02b Procedures should provide for approval of foundation elevation (soil subgrade material), by an experienced geotechnical engineer, before placement of engineered fill, mudmats, or structural concrete. The procedures should specify appropriate sampling and testing procedures to verify the foundation material in place is as specified in the design documents.

02.02c Selection and compaction of fill material is not always considered an important activity by some construction contractors. Attention should be given to the adequacy of compaction procedures and inspection (QC) procedures to ascertain whether fill placement meets applicable requirements. Continuous inspection by QC inspectors will be required during fill placement operations.

02.02e Procedures for settlement monitoring should provide for settlement survey accuracy, review of data, establishment of settlement points/monuments, and establishment of bench marks for vertical control, such that they are unaffected by groundwater levels and construction activities.

02.02f Site-surveying activities are one of the fundamental jobs done during construction, but do not receive much attention. Surveying activities include layout, settlement monitoring, and dimensional verification of structures, components, or equipment.

02.05b Determine whether a geotechnical engineer is available to inspect and monitor excavation and fill-placement activities. Final approval of foundation/soil subgrades, by a qualified geotechnical engineer, is required, before placement of engineered fill, mudmats, or structural concrete. Approval needs to be based on appropriate sampling and testing procedures to verify the foundation material in place is as specified in the design documents.

02.05c2 If select fill is used, the inspector should determine, before use, whether the materials satisfy the prescribed gradation specifications and tests.

02.05c4 By a selective review of test results, the inspector should determine whether adequate corrective action is being taken, when density, or moisture test results, are not within acceptance criteria.

02.05d The inspector should be aware that the design of the dewatering system may have to be modified when excavation or testing identify such a need, more pumping capacity may be required after evaluation of existing conditions.

02.05e.1 In determining the adequacy of QA/QC staffing, the effectiveness of their activities must be considered. Insufficient or unqualified personnel, or inadequate QA management, indicate inadequate staffing. Capabilities and effectiveness, rather than only the number of personnel, are the principal criteria to be used.

02.05e.5 A sample of data calculations should be reviewed for accuracy and conformance to design requirements.

02.05f Examples of typical instrumentation are monuments, for settlement monitoring, and piezometers or well points, for monitoring groundwater surface and pore pressure.

03.02 Prevalent Errors and Concerns. Prevalent errors and recent concerns are areas in which the inspector should be alert to potential generic issues. These areas include:

a. Insufficient compaction of foundation and backfill materials was identified at several sites, as described in IE Circular 81-08.

b. Placement of fill for control of compaction requires control of ground-water levels.

c. QC test results need to be reviewed and trended to assure that tests are performed in accordance with specification requirements, that the results are reasonable, that the results meet requirements, and that locations where samples/tests were obtained (location and elevation) can be accurately identified. Test deficiencies need to be entered into the corrective action program and evaluated by engineering personnel.

d. QA audits should identify procedural inadequacies or the cause of repetitive nonconforming conditions.

03.03 Background Information. This information is to be used as reference material; however, the site specifications govern. The information may be valuable in discussions about the adequacy of the specifications.

a. Foundation Subgrade

1. Excavation. Unexpected conditions are frequently encountered, ranging from unfavorable deposits of materials not found in the exploratory program, to problems not identified in previous site studies.

Where unfavorable conditions are encountered, further exploration by test pits, borings, or other means are necessary to define the extent and nature of conditions. The effect of the unexpected conditions must be evaluated in

relation to the original design. Examples of common unfavorable conditions frequently encountered are:

- Highly compressible and low-strength soils;
- Collapsible soils - low-density soils that collapse when saturated;
- Old river channels;
- Cavities and solution features;
- Overhangs and surface depressions;
- Springs or artesian conditions; and
- Unstable excavation slopes because of unanticipated conditions.

Excavation materials are frequently used as engineered fill or backfill around and under SC-I and SC-II structures. The inspector should determine whether these materials have been qualified through explorations and testing by a soils testing laboratory and whether they are stockpiled in designated areas. Excavated materials to be used as SC-I and SC-II structural fill, should be excavated in layers, so that widely varying soil classes are not mixed. Some of the more common tests used for qualifying soils materials, and their associated standards, are:

- Moisture/density relationships, ASTM D-698 or D-1557;
- Soil-classification tests, ASTM D-2487;
- Particle-size analysis, ASTM D-422;
- Test for plastic limit and plasticity index, ASTM D-424; and
- Other Codes and Standards, as listed in ASME NQA-1.

A geotechnical engineer should control acceptance and qualification of excavated materials.

b. Foundation Verification - Undisturbed Soil. A geotechnical engineer should approve soil subgrades before placement of engineered fill, mudmats, or structural concrete. Compaction is the usual method to treat or stabilize loose, disturbed, or unsuitable areas in soil subgrades. The inspector should determine whether appropriate sampling and testing procedures are included to verify the material in place is as specified. Common tests used to verify that foundation subgrades meet design specifications are listed in Appendix B, “Methods of Subsurface Exploration”, of Regulatory Guide 1.132, “Site Investigations for Foundations of Nuclear Power Plants.”

b. Backfilling. In some instances, preparation for foundations may consist merely of excavation and grading to appropriate dimensions. However, in many locations, the top layer of native site material may be too soft, or otherwise unsuitable, to properly support the structures. In this case, some special compactive effort may be required. Occasionally, adequate compaction may be achieved on the native material in place in conjunction with careful control of groundwater level. More typically, it will be necessary to remove the native material and fill the resultant

excavation under carefully controlled procedures, in relatively thin layers, sequentially compacted.

Before placing engineered fills, materials and compaction requirements should be qualified by laboratory tests and test fills. Required moisture/density relationships for each material should be determined in accordance with either ASTM D-698 or ASTM D-1557. The inspector should be assured that the specified method is being used. Where impervious materials are used, qualification tests should include determination of the Atterberg Limits ("Liquid Limit, Plastic Limit and Plasticity Index", ASTM D-4318). Particle-size analysis should also be made, as specified by test methods in ASTM D-422 and ASTM D-1140.

Test fills for each material type should be made to determine lift thickness, type of compaction equipment, and number of passes to be used in compacting fills to specified densities.

In-process testing used to control fill placement, for the most part, will be density tests and moisture tests. Acceptance will be in terms of some percentage of the maximum dry density (usually 95 percent) and a moisture content within some percentage of optimum (usually ±2 percent) as determined by ASTM D-698 or ASTM D-1557. Density tests may be made by test methods ASTM D-1556 (most common method used); ASTM D-2167; ASTM D-2922, or ASTM D-2937. Test-method ASTM D-2922, the nuclear method, must be calibrated against a reliable direct method.

Control of moisture content at time of compaction is extremely important, especially with materials having more than 12 percent passing a No. 200 sieve. Testing and research has demonstrated that variation of the moisture content of a material, at time of compaction, even though it has been compacted to the same dry density, has a wide-ranging effect on the shear strength, permeability, and consolidation characteristics of the material. Ultimate control of moisture should be by test-method ASTM D-2216, "Laboratory Determination of Moisture Content of Soil". Rapid methods, such as the "Speedie" and field stoves, are sometimes used to expedite operations, because of the time required for test-method ASTM D-2216. Where rapid methods are used, they should be calibrated against ASTM D-2216, and their variation taken into consideration in controlling moisture content of the fill. For example, if the specified moisture control is ±2 percent of optimum and calibration checks show that the rapid method varies by ±1 percent from ASTM D-2216, then field control using the rapid method should be held to ±1 percent of optimum. Field-stove methods should be limited to granular materials, with little or no fines, since experience shows results with impervious materials are erratic (probably because of driving off the water of hydration).

Minimum acceptable test frequencies and other recommended in-process testing controls are listed in Table 5.6 of ASME NQA-1 Subpart 2.5.

d. Dewatering Systems. Some degree of groundwater control will be required, at least during site preparation and foundation placement. Groundwater removal may be required to properly compact the soil-bearing area. The design may require that groundwater be permanently maintained below some specified elevation.

Excavations and placement of fill and foundations must be in the dry state. Discharge outlets of dewatering systems should be monitored for sediment content, to assure that subgrades are not being undermined. Dewatering systems, if not properly designed, installed, and operated, can have an adverse effect on foundations. Improper design and operation can and have resulted in undermining

of foundations through removal of sediment with the discharge water. The inspector should assure himself that careful consideration has been given to the impact that the installation, operation, shutting down, and decommissioning of the system will have on foundation design. Through observations, the inspector should satisfy himself that the system has been installed and is being monitored as specified. Piezometers or observation wells should be used in conjunction with the dewatering system, to monitor the groundwater surface and pore pressure beneath the subgrade and adjacent ground.

Acceptable methods for installation and maintenance of piezometers and observation wells are presented in the U.S. Army Corps of Engineers Manual, EM 1110-2-1908, 1972.

e. Testing Laboratory. Acceptance of all earthwork onsite, including verification of soil foundations, engineered fill and backfill, for the most part, will be based on testing done by the site-soil laboratory. The inspector should routinely check the soils laboratory during inspections. The inspector should ensure that work is being done in accordance with specified methods and with specified equipment that is periodically calibrated for accuracy. Testing personnel should check data calculations for accuracy and the inspector should spot check them.

Qualifications of testing personnel should be checked by personal interviews, examination of certification records, and licensee's procedures and records, to verify contractor's qualification records.

f. Instrumentation- and Settlement-Monitoring Programs. Instrumentation will, for the most part, consist of settlement monuments for monitoring settlement and piezometers, or well points for monitoring the groundwater surface and pore pressure. Specific guidance regarding their use, installation, and maintenance is presented in the U.S. Army Corps of Engineers Manual EM 1110-2-1908. The inspector should ensure that the instrumentation is installed as specified, is adequate for the intended use, and that accuracy of the data recorded is sufficient to provide needed information. The instruments should be monitored periodically, throughout construction, and, if needed, post-construction.

88131-04 RESOURCE ESTIMATE

This inspection procedure is expected to take, on the average, 24 to 32 hours for each review of licensee/contractor activities. The procedure should be run once during the early excavation and preparation for SC-1 structures, and additional inspections should be conducted during any back-fill operations that could significantly affect SC-I or SC-II structures. Regional Management should use inspector observations, concerning the relative complexity of required SC-I foundation work, and observed competency of licensee and contractor personnel, to schedule additional inspections as required.

88131-05 REFERENCES

Duke, Cogema, Stone and Webster, “Mixed-Oxide Fuel Fabrication Facility Construction Authorization Request”, Docket Number 070-03098, latest revision accepted by NRC.

Duke, Cogema, Stone and Webster, “Mixed-Oxide Fuel Fabrication Facility, MOX Project Quality Assurance Plan (MPQAP)”, Docket Number 070-03098, under US Department of Energy Contract DE-AC02-99-CH10888, latest revision accepted by NRC.

Office of Inspection and Enforcement, IE Circular No. 81-08, “Foundation Materials”, May 29, 1981.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.28, “Quality Assurance Program Requirements (Design and Construction)”. (Rev. 3)

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.132, “Site Investigation for Foundations of Nuclear Power Plants”.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.138, “Laboratory Investigation of Soils for Engineering Analysis and Design of Nuclear Power Plants”.

U.S. Army Corps of Engineers, “Instrumentation of Earth and Rock-Fill Dams (Groundwater and Pore Pressure Observations)”, Engineer Manual EM 1110-2-1908.

U.S. Army Corps of Engineers, “Soil Sampling”, Engineer Manual EM 1110-2-1907.

U.S. Department of the Army, “Dewatering and Groundwater Control for Deep Excavations”, Technical Manual TM 5-818-5.

U.S. Department of the Army, “Grouting Methods and Equipment”, Technical Manual TM 5-818-6.

American Society of Testing and Materials, ASTM D-422, “Particle Size Analysis of Soils”.

American Society of Testing and Materials, ASTM D-653, “Terms and Symbols Relating to Soil and Rock”

American Society of Testing and Materials, ASTM D-698, “Moisture-Density Relations of Soils”.

American Society of Testing and Materials, ASTM D-1140, “Test for Amount of Material in Soils Finer than No. 200 Sieve”.

American Society of Testing and Materials, ASTM D-1143, “Testing Piles Under Axial Compressive Load”.

American Society of Testing and Materials, ASTM D-1452, “Practice for Soil Investigations and Sampling by Auger Borings”.

American Society of Testing and Materials, ASTM D-1556, “Test for Density of Soil in Place by the Sand-Cone Method”.

American Society of Testing and Materials, ASTM D-1557, “Moisture-Density Relations of Soils”.

American Society of Testing and Materials, ASTM D-1586, “Penetration Test and Split-Barrel Sampling of Soils”.

American Society of Testing and Materials, ASTM D-2049, “Test for Relative Density of Cohesionless Soils”.

American Society of Testing and Materials, ASTM D-2167, “Test for Density of Soil Inplace by the Rubber-Balloon Method”.

American Society of Testing and Materials, ASTM D-2216, “Laboratory Moisture Content of Soil”.

American Society of Testing and Materials, ASTM D-2487, “Classification of Soils for Engineering Purposes”.

American Society of Testing and Materials, ASTM D-2488, “Practice for Description and Identification of Soils”.

American Society of Testing and Materials, ASTM D-2922, “Tests for Density of Soil and Soil-Aggregate Inplace by Nuclear Methods (Shallow Depth)”.

American Society of Testing and Materials, ASTM D-2937, “Test for Density of Soil Inplace by the Drive-Cylinder Method”.

American Society of Testing and Materials, ASTM D-3017, “Moisture Content of Soil and Aggregate in Place by Nuclear Methods”.

American Society of Testing and Materials, ASTM D-4253, “Test Methods for Maximum Index Density of Soils and Calculation of Relative Density”.

American Society of Testing and Materials, ASTM D-4318, “Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils”.

END

ATTACHMENT 1

Revision History for IP 88131

Commitment Tracking Number	Issue Date	Description of Change	Training Needed	Training Completion Date	Comment Resolution Accession Number
	10/25/06 CN 06-031 06-NMSS	IP 88131 is a newly issued procedure. Issued for MOX inspection program to improve effectiveness and efficiency by incorporating and consolidating inspection requirements involving geotechnical and civil soils inspection.	None	N/A	