GCS

Golder Construction Services, Inc.

R. Scott Callaway

Education

B.S.C.E., Georgia Institute of Technology, 1990.
Hazardous Waste Site Investigation and Safety Training Course.
Certified in Radiation Safety and use of Nuclear Densometers.
Trained in the Assembly and Installation of the Boutwell Two-Stage Field Permeability Test.
Padgett Thompson Seminar on Innovative Management Techniques.

Affiliations

American Society of Civil Engineers.

Experience

1994 to Date **Golder Construction Services, Inc.** **Atlanta, Georgia**

Project Engineer.
Responsibilities include project management for all aspects of various construction projects including: preparation of project cost estimates, management of on-site monitoring activities, management of project budgets, review of all field and laboratory test data, report writing, and interfacing with clients, contractors, and regulatory agencies involved.

1992 to 1994 **Golder Construction Services, Inc.** **Atlanta, Georgia**

Assistant Project Manager.
Responsibilities included assisting project managers with all aspects of various construction projects including: on-site project management and training of site personnel, preparation of cost estimates, management of project budgets, review collected field and laboratory data, report writing and interfacing with clients, contractors, and regulatory agencies involved. On-site and office duties included the management of over 250 thousand cubic yards of low permeability clays and structural fill, 105 thousand cubic yards of granular fill, and 2.0 million square feet of HDPE liner.

1990 to 1992 **Golder Construction Services, Inc.** **Atlanta, Georgia**

Staff Engineer.
Provided resident on-site quality assurance/quality control engineering services for construction activities at various landfills throughout the Eastern United States. Responsibilities included observation, documentation, and testing of over 730 thousand cubic yards of low permeability clays and structural fill, 300 thousand cubic yards of granular fill, 30,000 linear feet of high density polyethylene pipe, 2.2 million square feet of HDPE liner, 2.1 million square feet of geotextile, 2.2 million square feet of geonet, and 650 thousand square feet of bentonite mats. Also responsible for the daily observation of all site construction activities, site soil and geosynthetic laboratory testing, as-built documentation, and review of all soils testing results and collected geosynthetic data to insure compliance with the established project guidelines. Additional duties included extensive interfacing and coordination with clients, contractors, CQA personnel, and regulatory agencies; and assisting project managers in the preparation of proposals and final certification reports. Responsibilities progressed to the level of assistant project manager.

Trained by Soils Testing Engineers Inc. in the assembly and installation of the Boutwell Two Stage Field Permeability Test. Multiple test pad construction and Boutwell testing have been performed in Ohio, Tennessee and Virginia.

R. Scott Callaway

PROJECT RELATED EXPERIENCE - SOLID WASTE MANAGEMENT

Emelle Facility — Emelle, Alabama

Resident Site Manager for a 15-acre hazardous landfill cell constructed at the Emelle facility. Construction activities included the placement of the leachate pressure relief layer, structural fill, and compacted chalk layer. Additional activities include the on-site monitoring and testing of the active borrow source and the construction of a portion of an above grade berm at an adjacent active hazardous waste cell.

Salem Waste Disposal Center — Salem, Alabama

Project Manager responsible for sample tracking and laboratory testing of borrow source samples collected during a borrow source investigation in central Alabama. Responsible for coordination of all laboratory tests, compilation of data, and generation of borrow source report.

Bechtel Corporation — Kingsport, Tennessee

Assistant Project Manager for a 2.5 acre double lined hazardous waste disposal unit constructed at the Tennessee Eastman facility located in Kingsport, Tennessee. Responsibilities included project start-up, sample tracking, and technical guidance to site personnel. Also, assembled and installed the Boutwell Two Stage Field Permeability Test as required for borrow source approval Additionally, trained the resident site manager in the installation and monitoring procedures of the Boutwell test.

Plant Daniel Facility — Pascagoula, Mississippi

Project Manager for a 21-acre, 60-mil high density polyethylene liner installation located in Sedimentation Pond B of the facility. The construction involved mechanical connections to concrete and steel structures throughout the pond. Responsibilities included personnel management, sample tracking, review of all data and writing the final certification report.

King and Queen Landfill — Little Plymouth, Virginia

Boutwell installation specialist for a single composite sanitary landfill cell in eastern Virginia. Responsibilities included the assembly and installation of the Boutwell Two Stage Field Permeability Test within a constructed area of the landfill cell. Additionally, trained the resident site manager on the procedures required to advance the test to Stage 2 and collect readings throughout the running of the test.

Calhoun County Landfill — Anniston, Alabama

Project Manager for a closure cap being placed at a sanitary landfill in northeast Alabama. Responsibilities included testing and sampling of the placed closure cap material, data review, and production of a final report.

Fairfield Sanitary Landfill — Amanda, Ohio

Project Manager for a 4.5-acre single composite sanitary landfill cell and a 14-acre composite cap at a facility located in central Ohio. Responsibilities included project start-up and management, sample tracking, data review and production of a final certification report. Also assembled and installed the Boutwell Two Stage Field Permeability Test as required and trained the resident site manager in the installation and monitoring procedures of the test.

Pecan Row Landfill — Valdosta, Georgia

Assistant Project Manager for a 5-acre single composite sanitary landfill cell in southern Georgia. Responsibilities included project set-up, sample tracking, data review and technical guidance to site personnel. Additionally, served as the lead geosynthetics monitor for the installation of the high density polyethylene liner.

Fairfield Sanitary Landfill — Amanda, Ohio

On-site Assistant Project Manager for the construction of 6.3-acre sanitary landfill expansion, a clay lined sedimentation basin, a double containment leachate storage tank, and a leachate transfer system for a landfill in central Ohio. Responsibilities included project set-up and management of double shifts, obtaining and tracking samples, in-situ soils testing, over-view of geosynthetics installation, data review, and production of a final certification report. Also assembled and installed the Boutwell Two Stage Field Permeability Test as required for borrow source approval. Additionally, trained the lead soils monitor in the installation and monitoring procedures of the Boutwell test.

Bolton Road Landfill — Atlanta, Georgia

Resident Site Manager for the construction of two single composite, sanitary landfill cells, totaling 14-acres in size. Also, monitored the construction of haul roads, facility entrance area, leachate collection tanks and process areas, two sedimentation basins, a maintenance building, an office building, and a leachate transfer pipeline. Responsibilities included project start-up and management of site personnel, obtaining and tracking samples, in-situ soils testing, overview of geosynthetics installation, data review, and assisted in the production of the final certification report.

Countywide Landfill — Stark County, Ohio

Boutwell installation specialist for a single composite sanitary landfill in northeast Ohio. Responsibilities included the assembly and installation of a Boutwell Two Stage Field Permeability Test as required for borrow source approval. Additionally, trained the resident site manager in the installation and monitoring procedures of the Boutwell test.

Statewide Landfill — Stark County, Ohio

Boutwell installation specialist for a 3-acre closure cap in northeast Ohio. Responsibilities included the assembly and installation of two Boutwell Two Stage Field Permeability Tests as required for borrow source approval. Additionally, trained the resident site manager in the installation and monitoring procedures of the Boutwell test.

Springhill Regional Sanitary Landfill — Graceville, Florida

Lead Geosynthetics Monitor for the installation of a 60-mil high density polyethylene liner for an 8.2-acre single composite sanitary landfill cell and a 1.3-acre leachate collection pond. Responsibilities included the project set-up and management of site personnel, data collection and review, obtaining and tracking samples, and assisting in the production of a final certification report.

PCFA Warren County — Warren County, New Jersey

Lead Soils and Lead Geosynthetics monitor for the construction of two double composite sanitary landfill cells totaling 11-acres in size. Also monitored the construction of gabion baskets, water diversion channels, a sedimentation basin, a double containment leachate storage tank, and leachate transfer pipe lines. Responsibilities included management of site personnel monitoring both soils and geosynthetics materials, obtaining and tracking samples, in-situ soils testing, overview of geosynthetics installation, and data review.

Golder Construction Services, Inc.

John W. Carruth

Education B.S., Geology, University of Southwestern Louisiana, 1986

Certifications Radiation Safety and Use of Nuclear Soil Gauges - July 1989
Hazardous Waste Site Investigation Health and Safety Training Course - November 1989
(29 CFR 1910.120 8 Hour Refresher Courses, April 1994 & July 1992)
Mine Safety and Health Admin. (MSHA) 8 Hour Course - January 1994

Experience

1990 - 1994 **Golder Construction Services, Inc.** **Houston, Texas**

Staff Geologist/Lead Soils and Geosynthetics Technician

Served as lead technician for GCS on a variety of projects primarily related to liner systems CQA for municipal and hazardous waste containment and cover systems. Responsibilities as CQA soils technician included: supervision of CQA monitors and coordination between the owner's engineer and the GCS project engineer; general soils and clay liner CQA duties such as field compaction testing, field laboratory testing for soils index tests, monitoring sealed single ring infiltrometers (permeability) and test pad construction.

Responsibilities as lead geosynthetics technician included: review of all site specific documents, design drawings and specifications; supervision of CQA geosynthetic personnel; preparation of project summary reports; preparation of as-built drawing(s); review of laboratory conformance test results; coordination of survey activities and review survey data.Data management experience includes presenting summary tables, graphs and spreadsheets with daily/weekly reports using Lotus 1-2-3, Wordperfect, and Quattro Pro.

1989 - 1990 **Golder Construction Services, Inc.** **Houston, Texas**

Geosynthetics Monitoring Technician

Started with GCS as geosynthetics laboratory technician testing conformance samples of geomembrane, geonet and geotextile on landfill liner projects. Responsibilities included: logging, photographing and documenting all geosynthetic installation operations; sampling for conformance testing; monitoring geosynthetic deployment, seaming and repair operations; monitoring seam preparation, trial seams, seaming, nondestructive testing, and field tensiometer testing; and sampling for destructive tests.

1987 - 1989 **Mudlogger, Exlog USA, Inc.** **Houston, Texas**

Monitored all facets of drilling operations on offshore drilling rigs, including rate of penetration, identification of hydrocarbon gasses, sample identification and description. Drafted information onto logs for geological interpretation.

John W. Carruth

PROJECT RELATED EXPERIENCE - LINER SYSTEMS

LAC, Bullfrog Mine — **Beatty, Nevada**

Field Tech/CQA Monitor - Provided observation and soils testing for tailings impoundment expansion utilizing 60 mil VLDPE liner.

WMI, Westside Landfill — **Ft. Worth, Texas**

Lead CQA Monitor responsible for observation of protective cover placement as well as coordination of survey and general earthworks activities.

CWMI, Kettleman Hills Facility — **Kettleman City, California**

Soils Lab Manager/Lead Geosynthetics CQA Monitor. Conducted all CQA soils testing for 57 acre double lined system consisting of (secondary and primary) compacted clay and geosynthetic liners. Acted as Lead CQA Monitor for portion of geosynthetics installation. Provided CQA for approximately 1,564,870 sq. ft. HDPE geomembrane, 1,787,054 sq. ft. geotextile and 130,513 sq. ft. geonet.

Laidlaw, Southeast Sanitary Landfill — **Kansas City, Missouri**

Lead CQA Monitor for single composite lined solid waste landfill expansion. Provided CQA for clay liner and approximately 130,680 sq. ft. HDPE geomembrane.

CWMI — **Lake Charles, Louisiana**

CQA Monitor/Soils Technician. Assisted with CQA services for double lined geosynthetics system consisting of (secondary and primary) compacted clay and geosynthetic liners. Provided CQA for approximately 130,000 sq. ft. HDPE geomembrane and associated geotextile and geonets and 400 cubic yards of clay liner.

BFI — **Port Arthur, Texas**

Resident Manager/Lead Soils CQA Monitor responsible for QC/QA soils testing and construction management for 3 feet compacted clay cap at hazardous waste site and 7,500 cubic yards of clay liner.

Laidlaw, Jacksonville Sanitary Landfill — **Jacksonville, Texas**

Resident Manager/Lead Soils CQA Monitor responsible for QC/QA, soils testing and construction management for 3 ft. compacted clay liner for municipal landfill cell.

USPCI, Waynoka Cells 12 and 13 — **Waynoka, Oklahoma**

Lead Soils Tech/Lead Geosynthetics CQA Monitor responsible for QC/QA for triple lined geosynthetic system consisting of secondary, primary and tertiary geosynthetic and compacted clay liners. Also responsible for observation and documentation of placement of erosion protection materials, placement of runoff channel culverts, concrete sampling, test pad equipment and procedures. Provided CQA services for approximately 1,950,000 sq. ft. HDPE geomembrane, 975,000 sq. ft. geotextile, 1,706,250 sq. ft geonet and 335,510 cubic yards of clay liner.

BFI, Oaks Landfill — **Laytonsville, Maryland**

Lead CQA Monitor providing QC/QA for single lined 60 mil cap of existing solid waste landfill cell. Provided CQA for approximately 1,310,000 sq. ft. HDPE geomembrane, 435,600 sq. ft. geotextile and 152,460 sq. ft. geonet.

John W. Carruth

Teco — **Robstown, Texas**

Lead Soils/Lead Geosynthetics CQA Monitor providing soils testing and CQA for a double liner geocomposite system of compacted clay and geosynthetic lining. Provided CQA for approximately 200,000 sq. ft. HDPE geomembrane and 20,000 cubic yards clay liner.

WMI, Community Refuse Ltd. — **Greencastle, Pennsylvania**

Lead CQA Monitor/Soils Technician responsible for overseeing subgrade preparation, clay liner testing and providing CQA for overall composite liner installation. Provided CQA for approximately 522,729 sq. ft. HDPE geomembrane, geotextile and geonet each.

Modern Landfill — **York, Pennsylvania**

Lead CQA Monitor providing QA for approximately 87,120 sq. ft. geotextile repair at capped landfill cell.

York County Landfill — **York, Pennsylvania**

CQA Monitor, assisted with CQA services for approximately 70,000 sq. ft. HDPE geomembrane and 35,000 sq. ft. geonet at an incinerator ash monofill.

Modern Landfill — **York, Pennsylvania**

CQA Monitor, assisted with CQA services for approximately 360,000 sq. ft. HDPE geomembrane, 750,000 sq. ft. geotextile, 360,000 sq. ft. geonet at single lined HDPE cap of municipal landfill cell.

Solid Waste Landfill — **Montrose, Michigan**

CQA Monitor, assisted with CQA services for single composite liner of municipal landfill cell. Provided CQA for clay liner and approximately 125,000 sq. ft. 60 mil HDPE.

WMI, Plantation Oaks Landfill — **Nachez, Mississippi**

CQA Monitor, assisted with CQA services for composite liner for municipal landfill cell. Provided CQA for clay liner and approximately 133,000 sq. ft. HDPE geomembrane and 14,520 sq. ft. geonet.

Golder Construction Services, Inc.

Brian P. Perino

Education B.S., Civil Engineering, Rutgers, The State University, 1990.

Experience

1991 to date **Golder Construction Services, Inc.** **Mt. Laurel, New Jersey**

Resident Engineer.

Responsible for management of geosynthetic and soils quality assurance monitoring activities during construction of solid and hazardous waste landfills in New Jersey, Ohio, Pennsylvania, Louisiana, and Vermont. Responsibilities included management of CQA staff, review of data generated during geosynthetic installation and preparation of record documentation reports for state regulatory agencies. Other responsibilities included training of in-house staff and testing of soils and HDPE geomembrane. More than 5,000,000 ft^2 of geosynthetics and more than 100,000 yd^3 of soils were installed for these projects.

1990 to 1991 **Golder Construction Services, Inc.** **Mt. Laurel, New Jersey**

Staff Engineer.

Responsible for construction quality assurance monitoring of solid waste landfills in New Jersey, Ohio, Pennsylvania, Maryland, and Mississippi. Responsibilities included on-site construction quality assurance monitoring of liner and final cover at solid waste landfills. Monitoring included more than 3,000,000 ft^2 of geosynthetics. Work involved detailed observation and documentation, Troxler testing, and HDPE destructive testing to approved plans and specifications.

1989 - 1990 **Golder Associates Inc.** **Mt. Laurel, New Jersey**

Field Technician.

On-site inspector during municipal solid waste landfill construction. Responsibilities included monitoring the installation and seaming of geosynthetic materials, development of record drawings of installed HDPE geomembrane liner and destructive testing.

Golder Construction Services, Inc.

Robert R. Turton

Education B.Sc. Civil Engineering, Queen's University, Kingston, Ontario, 1967.
M.Sc. (Eng.) Civil Engineering, Queen's University, Kingston, Ontario, 1969.

Affiliations Registered Professional Engineer, Alabama, Georgia, Kentucky, Mississippi, North Carolina, and South Carolina.

Experience

1991 to date **Golder Construction Services, Inc.** **Atlanta, Georgia**

Principal.

Office Manager of the GCS Duluth, Georgia office. Project Manager/Certifying Engineer for new landfill construction, expansions, and closure projects throughout the southeastern United States.

1987 to 1991 **Golder Associates** **Atlanta, Georgia**

Associate then Principal.

Project Manager for hydrogeological investigations for solid waste landfills in Mobile, AL., Natchez, MS., Baton Rouge LA., Autauga County, AL., and Talladega County, AL. Project Manager for municipal solid waste landfill design projects in Baton Rouge, LA., Kernersville, N.C., and Nashville, TN. Advisor responsible for geotechnical aspects and report preparation, site characterization and remediation, for a former automotive casting plant in Muscle Shoals, AL.

1985 - 1987 **Town of Lunenburg** **Lunenburg, Nova Scotia**

Town Engineer.

Responsible for maintenance of, and design of town infrastructure.

1979 - 1985 **Golder Associates.** **Halifax, Nova Scotia**

Associate then Principal.

Manager of the Halifax office operations, responsible for all geotechnical investigations and studies undertaken by the Halifax office within the Maritime Provinces. Project Manager for multi-discipline project team, preparing tender packages for two 3 km long mine access tunnels for Donkin-Morien Development Project, Cape Breton County, Nova Scotia. Project Engineer for review of geotechnical aspects of design, Annapolis Tidal Power Project, Annapolis Royal, Nova Scotia.

1973 - 1979 **Golder Associates.** **Toronto, Ontario**

Senior Engineer then Associate.

In charge of local projects. Responsible for geotechnical laboratory and coordination of investigation, inspection, and testing services. Project Manager for the planning and development of two large uranium tailings management areas in Elliot Lake, Ontario. The scope of services for the larger area (600 acres) entailed the design of two impervious dams to be constructed using the upstream method. The project for the smaller area (100 acres) involved characterizing two existing sand dams and planning for the reactivation of the area. Gave extensive evidence to a public hearing in 1978 on the expansion of the uranium mine in Elliot Lake.

Robert R. Turton

1971 - 1973 **Golder Associates.** **Toronto, Ontario**
Project Engineer.
Project Engineer for two million cu. yd. stage construction tailings dam at Elliot Lake, Ontario. Supervised site investigation for the dam and remained on site supervising construction for the 1971 construction season. Prepared three geotechnical reports and supervised preparation of a complete set of construction drawings for the project.

1970 - 1971 **Golder Associates.** **Toronto, Ontario**
Engineer.
Involved with design of approach embankments for large bridge across Saskatchewan River near Nipawin, Saskatchewan.

1969 - 1970 **H.G. Acres Limited.** **Toronto, Ontario**
Field Engineer.
Responsible for site geotechnical laboratory and compaction control for 17 million cu. yd. earth dam at Lower Notch Generating Station, Cobalt, Ontario.

1967 - 1969 **Queen's University** **Kingston, Ontario**
Post-Graduate Studies.
Franki Fellowship, in soil mechanics and foundation engineering.

1967 **Department of Highways.** **Toronto, Ontario**
Engineer.
Supervised subsurface investigations for highway embankments in soft clays.

TRAIL RIDGE LANDFILL PROJECT-SPECIFIC ADDENDA TO QUALITY ASSURANCE MANUAL

This plan specifically addresses the quality assurance and quality control (QA/QC) for Trail Ridge Landfill, Phases IIIA, IIIB, IVA and IVB. This program delineates the quality procedures and standards for the construction.

In the context of this plan, quality assurance, quality control and the plan participants are defined as follows:

Quality Assurance - A planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Quality Control - Those actions which provide a means to measure and regulate the characteristics of an item or service to contract and regulatory requirements.

Permittee - Trail Ridge Landfill, Inc.

Owner - The City of Jacksonville

Design Engineer - England, Thims & Miller, Inc.

Contractor - J. B. Coxwell Contracting

The QA/QC Program for this project includes General QA/QC, Soils QA/QC, and Synthetic Liner System QA/QC. These QA/QC activities (including monitoring, sampling and testing) shall be directed and conducted by the following third parties whom are independent of the Contractor.

General Quality Assurance/Quality Control - England, Thims & Miller, Inc.

Soils Quality Assurance/Quality Control - Law Engineering

Synthetic Liner System Quality Assurance/Quality Control - Golder Associates

The General QA/QC includes full-time services to periodically observe the contractor's work to verify substantial compliance with permits, plans, specifications and design concepts.

General Quality Control Monitor - shall monitor the construction for compliance with the permits, plans, specifications and design including construction to proper lines and grades, maintain daily logs and weekly progress reports of the construction (including observation data sheets, problem identification and correction logs), make note of construction deviations, coordinate qualifying and testing of materials, and monitor filling. This individual shall be experienced in civil site construction and solid waste regulations.

General Quality Assurance Engineer - shall supervise the construction monitoring to verify compliance with permits, plans, specification and design concepts. This individual shall be experienced in civil site construction and solid waste regulations and shall be a registered Professional Engineer.

The General QA/QC Program includes monitoring the following activities:

1. General Earthwork
2. Storm Drainage Installation
3. Perimeter Roadway Construction
4. Concrete Structure Installations
5. Leachate Pump System Installation
6. Leachate Forcemain Installation
7. Overall Liner System Installation
8. General Construction Quality Control

The Soils QA/QC for this project includes soil material qualifying, sampling and testing to verify substantial compliance with the material standards.

Soils Quality Control Monitor - shall pre-qualify soil materials, monitor the installation of soil materials, determine where in-place soil materials shall be tested, and test the in-place soil materials. This individual shall be responsible for assuring that all soil materials have been pre-qualified and have a chain-of-custody from the pre-qualified source to the project site, prior to installation. This individual shall be experienced in civil site construction and soil testing standards and procedures.

Soils Quality Assurance Engineer - shall supervise the soil material pre-qualifying and testing of in-place soil materials to assure compliance with the test standards and testing frequency requirements, and verify compliance with the plans, specification and design. This individual shall be experienced in civil site construction and soil testing procedures and shall be a registered Professional Engineer.

The QA/QC Plan shall include monitoring and testing of the following:

A. SUBGRADE

Prior to construction of the liner system including the clay subbase, a subgrade shall be prepared. The subgrade shall be placed and compacted in 12" lifts.

1. Subgrade

a. Location - The Soils Quality Control Monitor shall visually inspect the fill material and test the material in-place.

b. Standard - Soil shall be free of brush, weeds, and other litter; and free of roots 3/8" diameter or greater, stumps, stones 1" diameter or greater and any other extraneous or toxic matter.

The soil shall be cohesionless soil with a fines content of 15% or less.

Compacted to 96%* of Modified Proctor maximum dry density (ASTM D 1557) and a firm unyielding surface. Testing by Drive Cylinder (ASTM D2937), Nuclear (ASTM D2922) or Sand Cone (ASTM D1556) Methods

* If the required densities are achieved at a moisture content exceeding 2% of optimum moisture content, the soil will be proof rolled and visually inspected by the Soils Quality Control Monitor to determine if it is unyielding and not pumping. Clay subbase shall not be placed on a yielding subgrade.

c. Frequency - Density tests shall be conducted at the frequency of four tests per acre of finished subgrade including the same frequency for each 12-inch lift of fill.

B. CLAY SUBBASE

Prior to placement of the synthetic liner system, a clay subbase shall be prepared. The subbase shall be a minimum of 6" in thickness.

1. Clay Subbase

   a. Borrow Source - Prior to clay subbase installation, an appropriate borrow source shall be located. Suitability of the subbase construction materials from that source shall be determined in accordance with the following:

      (1) If demonstrated field experience is available from at least three prior successful projects of five or more acres each to document that a given borrow source can meet the requirements of the project specifications, then extensive laboratory testing of the borrow source will not be required. However, the source of material shall be geologically similar to and the methods of excavating and stockpiling the material shall be consistent with those used on the prior projects. Furthermore, a minimum of three representative samples from the appropriate thickness of the in-situ stratum or from stockpiles of the borrow material proposed for subbase construction shall be submitted to the Soils Quality Assurance Engineer to document through index testing that the proposed material is consistent with the material used on prior successful projects. At a minimum, index testing shall consist of percent fines, Atterberg limits and moisture content determinations.

      (2) If demonstrated field experience as defined above is not available or cannot be documented, then the following requirements shall be met.

         (a) A field exploration and laboratory testing program shall be conducted by the Soils Quality Assurance Engineer to document the horizontal and vertical extent and the homogeneity of the soil strata proposed for use as subbase material. A sufficient number of index tests from each potential borrow stratum shall be performed to quantify the variability of the borrow materials and to document that the proposed borrow material complies with specifications. At a minimum, the index tests shall consist of percent fines (ASTM D1140), Atterberg limits (ASTM D4318) and moisture content (ASTM D2216) determinations.

         (b) Sufficient laboratory hydraulic conductivity tests shall be conducted on samples representative of the range invariability of the proposed borrow source (ASTM D5084). At a minimum, the tests shall be taken once per 20,000 cubic yards of soil. For each such sample, test specimens shall be prepared and tested to cover the range of molding conditions (moisture content and dry density) required by project specifications. The hydraulic conductivity tests shall be conducted in triaxial type permeameters. The test specimens shall be consolidated under an isotropic consolidation stress no greater than 10 pounds per square inch and permeated with water under an adequate backpressure to achieve saturation of the test specimens. The inflow to and outflow from the specimens shall be monitored with time and the hydraulic conductivity calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of hydraulic conductivity are measured (ASTM D5084). The borrow source will only be considered suitable if the hydraulic conductivity of the material, as documented on laboratory test specimens, can be shown to meet the requirements of the project specifications at the 98 percent confidence level.

(3) The Soils Quality Assurance Engineer shall review the pre-qualification data and shall approve or reject the material for use.

b. Test Strip - Prior to full-scale clay subbase installation, a field test section or test strip shall be constructed at the site above a prepared subgrade. The test strip shall be considered acceptable if the measured hydraulic conductivities of undisturbed samples from the test strip meet the requirements of the project specifications at the 98 percent confidence level. If the test section fails to achieve the desired results, additional test sections shall be constructed in accordance with the following requirements:

(1) The test section shall be of sufficient size (20' x 50' minimum) such that full-scale clay subbase installation procedures can be duplicated within the test section;

(2) The test section shall be constructed using the same equipment for spreading, kneading and compaction and the same construction procedures (e.g., number of passes, moisture addition and homogenization, if needed) that are anticipated for use during full-scale clay subbase installation;

(3) At a minimum, the clay subbase test section shall be subject to the following field and laboratory testing requirements by the Soils Quality Control Monitor:

(a) A minimum of five random samples of the clay subbase construction material delivered to the site during test section installation shall be tested for moisture content (ASTM D2216), percent fines (ASTM D1140) and Atterberg limits (ASTM D4318);

(b) At least five field density and moisture determinations shall be performed on the compacted clay subbase test section;

(c) Upon completion of the test section, the thickness of the section shall be measured at a minimum of five random locations to check for thickness adequacy; and

(d) A minimum of five Shelby tube or drive cylinder (ASTM D2937) samples shall be obtained from each test section for laboratory hydraulic conductivity testing. Laboratory hydraulic conductivity testing shall be conducted in triaxial type permeameters (ASTM D5084). The test specimens shall be consolidated under an isotropic consolidation stress no greater than 10 pounds per square inch and permeated with water under an adequate backpressure to achieve saturation of the test specimens. The inflow to and outflow from the specimens shall be monitored with time and the hydraulic conductivity calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of hydraulic conductivity are measured (ASTM D5084).

(e) The test strip shall meet or exceed the standards established below except the field density which shall be established by the Soils Quality Assurance Engineer based upon the test strip results. If the test strip fails to meet these standards, the construction methods and/or material will be rejected and the test strip shall be performed again.

c. Clay Subbase Installation - Full scale clay subbase installation may begin only after completion of a successful test section. During clay subbase construction, quality control testing shall be provided to document that the installed clay subbase conforms to project specifications. The testing frequency for quality control testing are specified below. <u>However, during construction of the first five acres of the clay subbase, the frequencies shall be doubled.</u> The clay subbase shall be installed in one 6" lift.

(1) Location - The clay subbase shall be tested in-place at random locations. These locations of tests shall be determined by the Soils Quality Control

Monitor. If there are indications of a change in product quality or construction procedures during clay subbase construction, additional tests shall be performed to determine compliance.

(2) Standard

(a) Subgrade - Compacted to 96% of Modified Proctor maximum dry density (ASTM D1557) (See Subgrade).

(b) Field Density - The field density shall be established by the Soils Quality Assurance Engineer based upon the test strip results and shall be determined by Standard Proctor Density (ASTM D698). In no case shall the field density be less than 80% of Standard Proctor Density (ASTM D698).

(c) Thickness - The clay subbase shall have a minimum in-place thickness of 6"

(d) Hydraulic Conductivity - The compacted clay subbase shall have an in-place hydraulic conductivity no greater than 1×10^{-7} cm/sec (ASTM D5084).

(3) Field Testing Frequency

(a) Prior to the laying of the clay subbase materials, the subgrade shall be compacted to the specified density. Density tests shall be conducted at a minimum rate of four tests per acre of finished subgrade.

(b) A minimum of two moisture content and field density determinations shall be conducted per acre of compacted clay subbase. The degree of compaction shall be checked using the one-point field Proctor test or other appropriate test procedures; and

(c) A minimum of four thickness measures shall be conducted per acre of the compacted clay subbase.

(4) Laboratory Testing Frequency

(a) Percent fines (ASTM D1140) of the subbase construction material shall be determined at a minimum frequency of two tests per acre of installed clay subbase;

(b) Atterberg limits determinations shall be performed on one sample per acre of installed clay subbase; and

(c) Hydraulic conductivity testing of Shelby tube or drive cylinder (ASTM D-2937) samples of the compacted clay subbase shall be performed at a minimum frequency of one test per acre. Laboratory hydraulic conductivity tests shall be conducted in triaxial type permeameters (ASTM D-5084). The test specimens shall be consolidated under an isotropic consolidation stress no greater than 10 pounds per square inch and permeated with water under an adequate backpressure to achieve saturation of the test specimens. The inflow to and outflow from the specimens shall be monitored with time and the hydraulic conductivity calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of hydraulic conductivity are measured.

(5) Deficiency - If the test data from a clay subbase section does not meet the requirements of the project specifications, additional random samples shall be tested from that clay subbase section. If such additional testing demonstrates that the thickness and hydraulic conductivity meet the requirements of the project specifications at the 95 percent confidence level, that clay subbase section will be considered acceptable. If not, that clay subbase section shall be reworked or reconstructed so that it does meet these requirements.

C. BENTONITE MAT (Geosynthetic Clay Liner)

A bentonite mat shall be installed as part of the synthetic liner system. In addition to the requirements of the "Quality Assurance Manual For the Installation of Lining Systems", the bentonite mat shall be monitored and tested as follows:

1. Bentonite Mat

a. Location - Upon delivery of the bentonite mat rolls to the site (prior to installation) samples shall be obtained.

b. Standard

(1) Hydraulic Conductivity - The hydraulic conductivity (GRI GCL-2) shall be no greater than $1x10^{-9}$ cm/sec at a confining stress of 30 psi.

(2) Moisture Content - The moisture content (ASTM D4643) shall be no greater than 10 percent.

(3) Mass - The mass per unit area (ASTM D3776) shall be no greater than 1.10 lb/ft^2 (5390 g/m^2).

c. Frequency - The bentonite mat shall be tested for moisture content, hydraulic conductivity and mass per unit area at least once per 40,000 square feet or once per lot, whichever is more frequent.

D. PROTECTIVE SAND BLANKET

After the synthetic liner system has been installed, it shall be covered with a protective sand blanket. The protective sand blanket shall be a minimum of 24" in thickness.

1. Protective Sand Blanket

a. Location - Material shall be pre-qualified by hydraulic conductivity, particle size, and calcium carbonate content testing at the borrow location.

Truck tickets shall be utilized for chain of custody to site.

Thickness shall be verified by as-built survey.

b. Standard - Sand shall be reasonably free of brush, weeds, and other litter; and relatively free of roots, stumps, stones and any other extraneous or toxic matter. The Soils Quality Control Monitor shall visually inspect the sand during placement.

Hydraulic Conductivity shall be greater than 1x10^{-3} cm/sec at a density of 96 percent Modified Proctor maximum dry density (ASTM D1557). Hydraulic Conductivity testing by Constant Head Method (ASTM D2434).

Thickness shall be no less than 24 inches at each location.

The sand shall be non-calcareous (ASTM D3042).

Compatibility of protective sand cover grain size with geotextile to be determined, prior to initial placement.

c. Frequency - Hydraulic Conductivity testing shall be on-going as necessary to support fill borrow operations with minimum of one test per 500 cubic yards.

Prior to placement, the sand shall be tested for particle size and calcium carbonate content. The test shall be taken at least once per 5,000 cubic yards and for each change in material source.

d. Miscellaneous - The material shall be placed loose and spread on top of the liner system to a minimum depth of 24 inches. No equipment shall come in direct contact with liner. Low ground pressure equipment shall be used for the placement and spreading of the sand cover. Temporary haul roads and access roads over the liner for the delivery of material shall include a minimum of 36 inches of sand cover depth. These temporary facilities shall be removed during the finish grading of the protective sand blanket.

The leading edge of sand placement over the synthetic liner system shall be by vertical placement versus pushing sand horizontally.

E. CLAY ANCHOR BERM

A clay anchor berm shall be constructed in accordance with the Contract Drawings.

1. Clay Anchor Berm

a. Location - The clay anchor berm shall be sampled in place. Hydraulic conductivity testing shall be conducted in the laboratory.

b. Standard - Hydraulic conductivity shall be less than $1x10^{-7}$ cm/sec. Hydraulic conductivity testing by Falling Head Method (ASTM D5084).

c. Frequency - One testing location per 100 linear feet of anchor trench.

F. LEACHATE COLLECTION TRENCH AND SUMP AGGREGATE

Aggregate shall be placed in leachate collection trenches and sumps.

1. Aggregate

   a. Location - The aggregate shall be sampled on site, prior to placement.

   b. Standard - Gradient shall meet AASHTO No. 3 coarse aggregate (ASTM D448). Testing by Sieve Analysis (ASTM C136).

      The aggregate shall be non-calcareous (ASTM D3042).

   c. Frequency - Prior to placement, one gradation test per sump plus one testing location per trench with a minimum of one test per 500 cubic yards of aggregate.

      Prior to placement, the aggregate shall be tested for calcium carbonate content. The test shall be taken once for 2,600 LF of trench or once per change in material source.