AEC *AMERICAN ENVIRONMENTAL CONSULTING, LLC*

CONSTRUCTION QUALITY ASSURANCE AND SPECIFICATIONS PLAN

CONSERVATION SERVICES INC.
LINER, LEACHATE COLLECTION AND REMOVAL,
AND FINAL COVER SYSTEM

Prepared for:

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SECTION I - GENERAL

1.0 INTRODUCTION

The activities outlined in this Construction Quality Assurance (CQA) and Specifications Plan serve as the basis for certifying project compliant construction activities of all future (as of the date of this plan) disposal structures at the Conservation Services. Inc. disposal site, ultimately resulting in the preparation of a construction certification report documenting to the regulatory bodies that construction was completed in substantial compliance with approved plans. The plan is prepared to fulfill the Colorado Department of Public Health and Environment (CDPHE) and Adams County requirements including the Colorado Regulation Pertaining to Solid Waste Disposal Sites and Facilities 6 CCR 1007-2 dated September 1, 2000, hereinafter referred to as the "Regulations" or "State Regulations", and the CSI Revised Design and Operations (D&O) Plan dated February 5, 1996, and Adams County Certificate of Designation # 86-88-CD(A).

1.1 BACKGROUND

The Conservation Services Inc. (CSI) disposal site is located in Adams County, Colorado northeast of the town of Bennett. CSI was issued a Certificate of Designation (CD) from the Adams County Board of County Commissioners in August 1989. Subsequently, site improvements and cell construction commenced and the site opened for receipt of waste on December 22, 1989. The facility is permitted to accept non-hazardous liquid and solid waste including friable and non-friable asbestos and various other types of non-hazardous industrial wastes.

In August 1995, the Adams County Board of County Commissioners approved an amendment to the CD to expand the site acreage from approximately 238 acres to approximately 383 acres. Other components of this amendment included the construction and operation of a landfarming facility to bioremediate soils, sludges and other materials amenable to this type of prepared bed biotreatment (PBBT) and a revision to the current acceptable waste streams to allow the disposal of municipal solid waste (MSW) and construction and demolition waste in Cell #25 which has not been constructed.

CSI was purchased by USA Waste Services in 1997, which merged with Waste Management, Inc. in 1998. Each transaction was achieved through a stock acquisition and did not result in a change of ownership. CSI continues to own and operate the facility as a wholly owned subsidiary of WMI.

The completion and regulatory approval of this CQA Plan and Specifications document is required by the 1995 CD amendment, and formerly incorporates the design and construction procedures that were approved in the amendment. Individual construction level cell designs were completed following the 1995 CD amendment, and have received regulatory approval.

1.2 PURPOSE AND SCOPE

The purpose of this document is to define the activities required to ensure and document that the final cover, liner and leachate collection and removal portions of the facility disposal structures, or cells, are constructed in such a manner that meets the approved project requirements and design. Additional information on the facility design and operations may be found in the D&O Plan. The disposal areas of the facility may be constructed in a number of stages over a period of many years, and this CQA Plan is prepared to be applicable to all stages of construction related to these aspects of the disposal cells.

There are three types of disposal cells constructed at the facility, each for a specific waste stream as follows:

1. Industrial Solid Waste (ISW)
2. Municipal Solid Waste (MSW)
3. Asbestos Waste (AW)

The ISW and MSW waste disposal cell liners are designed with a minimum 2-foot thick compacted cohesive soil liner (maximum permeability of $1x10^{-7}$ cm/sec), overlain with a 60-mil High Density Polyethylene (HDPE) synthetic membrane. To facilitate transport and removal of leachate within the cell, a continuous 6-inch thick leachate drainage layer is constructed over the floor of the cell, which slopes to an over-excavated leachate sump. The sump is equipped with a piping system to allow removal of leachate from the cell.

The asbestos cell is designed with a similar system, except that the 2-foot thick cohesive soil liner is only placed in the base of the cell. HDPE is not used in the asbestos cell since asbestos is not generally considered a potential groundwater contaminant.

The final cover system constructed over the disposal cells incorporates a minimum 2.0-feet of cohesive soil liner as a barrier layer, overlain by a minimum 18.0-inches of miscellaneous protective soils and six inches of topsoil. An Alternative Final Cover (AFC) system using moisture storage and evapotranspiration (ET) as a method to minimize infiltration into the waste mass has been approved as an option to the low permeability barrier layer final cover.

This CQA Plan addresses the construction quality assurance of the soils, geosynthetics, and related liner and leachate removal system components for landfill liner and final cover system construction at the CSI facility and outlines the documentation activities necessary to verify that the construction of the liner, leachate collection and removal system, and final cover system was performed in accordance with the approved design plans. The following sections of the CQA Plan describe the specific construction documentation activities.

2.0 DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

2.1 Construction Quality Assurance and Construction Quality Control

The CQA Plan is a site-specific document which addresses the following: (i) CQA personnel responsibilities, authorities, and qualifications; (ii) inspection, monitoring, and testing activities necessary to ensure that the facility is constructed in substantial compliance with design criteria, plans, and specifications; and (iii) CQA documentation requirements.

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

In the context of this document Quality Assurance refers to means and actions employed by the CQA Firm to assure conformity of liner system preparation, production, and installation with this CQA Plan, the Specifications, and the Construction Drawings. CQA is provided by a party independent from the product Manufacturer and Contractor.

Construction Quality Control (CQC) -Those actions, which provide a means to measure and control the characteristics of an item or service to meet contractual and regulatory requirements.

Construction Quality Control (CQC) refers to those actions taken by Manufacturers, Suppliers, Contractors, or Owners, including their designated representatives, to ensure that manufactured materials and the workmanship meet the requirements of the Specifications, and the Construction Drawings. In the case of non-manufactured materials such as soils, and within this CQA Plan, CQC is typically made a part of the CQA requirements and is provided by the CQA Firm. In the case of geosynthetic and other non-soil components, the Manufacturers and installers of the various geosynthetics provide CQC.

3.0 PROJECT PERSONNEL AND CONTACTS

Disposal cell construction at the facility requires the participation and coordination of a number of personnel. This section provides a general description of the anticipated project personnel and their responsibilities. Since this CQA Plan is applicable to many construction events over a long period of time, it is recognized that titles, responsibilities, and names may change. Any change will be noted in the final cell construction certification report.

3.1 Project Personnel Description

3.1.1 Owner

In this CQA Plan, the term "Owner" refers specifically to Conservation Services, Inc., and may be represented by Waste Management of Colorado, Inc. personnel as the parent entity.

3.1.2 Design Engineer

The Design Engineer is the individual, firm or corporation having direct responsibility for the design of the landfill or the specified component. During construction or through the course of operations, designs may change and so the Design Engineer may also change. The Design Engineer, or other qualified engineer who then may become the Design Engineer, must approve any significant deviation from the original design requirements of the Contract Documents, including approved plans and drawings. The Design Engineer may or may not be an employee of the Owner, and can be found in the construction drawings or bid package developed for the specific construction event.

3.1.3 CQA Firm

The CQA Firm is an individual, firm, or corporation, independent from the Owner, Contractor, and Manufacturer, that observes, performs oversight on tests, and documents activities related to the CQA of the earthworks, geosynthethics, and piping and associated system components at the site. The CQA Firm will have ultimate responsibility to provide the necessary construction certification documents as required in Section VIII of this plan.

The CQA Firm will be required to provide for a Professional Engineer (P.E.) licensed in the State of Colorado, as well as other personnel responsible for CQA activities as may be required and listed below. The CQA Firm is generally represented on site during construction by the CQA Monitor, who is responsible for day-to-day construction oversight and testing. For purposes of this document, the terms CQA Firm, CQA Engineer, and CQA Monitor are generally used interchangeably, however, certain aspects of construction directly related to the ability of the P.E. to certify the construction must be approved by the P.E. in accordance with applicable rules and regulations governing the P.E. license.

3.1.4 Surveyor

The Site Surveyor (Surveyor) provides all point staking and field measurement for ensuring the excavation, slope, and grade requirements of the design are met. The Surveyor will also provide a certification to the CQA Firm that the facility is constructed to the lines and grades as approved. The Surveyor will be a Licensed Professional Surveyor in the State of Colorado, and may be contracted directly to the Owner, CQA Firm, or the Contractor. The Surveyor may be represented on site by a non-licensed surveyor of appropriate qualifications; however, it shall be the licensed surveyor responsibility to ensure all survey work is conducted in accordance with project requirements and within all rules and regulations governing the license.

3.1.5 Regulatory Authorities

The Colorado Department of Public Health and the Environment (CDPHE) is the state agency responsible for reviewing the technical and regulatory merits of the facility design and construction. Regulations require CDPHE approval of the construction before a disposal cell can be used.

Name: Hazardous Materials and Solid Waste Division
Address: 4300 Cherry Creek Drive South
Denver, CO 80246-1530

The Adams County Planning Department, as an entity of Adams County, Colorado, is the governmental entity with jurisdiction over the operations of CSI. The facility permit is issued by Adams County.

Name: Adams County Planning Department
Address: 4955 East 74th Avenue
Commerce City, Colorado 80222

The Tri-County Health Department (TCHD) is the local health department representing Adams County in the administration of their duties as the jurisdictional agency.

Name: Tri-County Health Department
Address: 4201 E 72nd Avenue
Suite D
Commerce City, Colorado 80022

3.1.6 Contractor

The Contractor is an individual, firm, or corporation undertaking the execution of the work under the terms of the Contract Documents. For purposes of this document, the term Contractor may reference a General Contractor responsible for all aspects of execution of the work, or specific components of the work such as earthworks, geosynthetic materials installation, piping installation, etc. The personnel referenced as Contractor is defined by the context in which it is used.

3.1.7 Soils Quality Assurance Laboratory

The Soils CQA Laboratory is independent from the Owner, Material Suppliers, or Contractor. The Soils CQA Laboratory is generally part of, or contracted to, the CQA Firm and conducts tests in the laboratory (which may be on site or off site) on samples of soil taken from the excavations, borrow pits, stockpiles, or the liner system.

3.1.8 Geosynthetics Construction Quality Assurance Laboratory

The Geosynthetics CQA Laboratory is independent from the Owner, Material Suppliers, or Contractor. The Geosynthetics CQA Laboratory is generally a part of, or contracted to, the CQA Firm and conducts tests on samples of geosynthetics taken from the site. The Geosynthetics CQA Laboratory may also conduct tests on pipes or other liner system components. The Geosynthetics CQA Laboratory service is independent of any party involved with the manufacture or installation of any of the geosynthetic components.

3.1.9 Supplier

The term supplier as used in this document, is a generic term for an individual, firm, or corporation that supplies components necessary to the design and/or installation of the work. The supplier may provide components to the contractor or manufacturer, but may also be a contractor if charged with execution of the work. Suppliers may provide such components and materials such as soil or aggregate materials for site earthworks, synthetic materials for site installation, or resin to the geosynthetics or piping manufacturer.

3.1.10 Manufacturer

The Manufacturer manufactures a specific component (e.g., geomembrane, geotextile, or pipe) of the proposed liner system. The manufacturer, a supplier, or the Contractor may accomplish delivery. In this plan, the term Manufacturer may refer to the geomembrane Manufacturer, geotextile Manufacturer, or pipe Manufacturer.

4.0 SCOPE OF CONSTRUCTION QUALITY ASSURANCE

The scope of this CQA Plan includes the CQA requirements of all construction components of the liner and leachate collection and removal systems, and final cover systems within the engineered disposal structures on site.

The CQA Firm may waive any informalities in this CQA Plan that do not affect the basic design and performance criteria, or regulatory or permit conditions, without violation of substantial conformance.

4.1 Units

In this CQA Plan, all properties and dimensions are expressed in units standard to the industry.

4.2 References

4.2.1 Applicable Organizations

Organizations whose standards may be referenced in the CQA Plan and the Specifications are as follows:

- ASTM - American Society for Testing and Materials;
- GRI - Geosynthetic Research Institute;
- OSHA - Occupational Safety and Health Administration; and,
- USEPA - United States Environmental Protection Agency.

4.2.2 Applicable Standards

Any reference to standards of any society, institute, association, or governmental agency will pertain to the edition in effect as of the date of this CQA Plan, unless stated otherwise.

5.0 CONSTRUCTION MEETINGS

5.1 Preconstruction Meeting

Prior to the start of construction a meeting shall be held involving the appropriate Owner, Contractor, CQA, and Survey personnel as applicable. A Pre-Construction Meeting Agenda, which identifies parties, documents, lines of communication and requirements, etc., and the minutes of such meeting, shall be recorded and maintained in the project files.

5.2 Project Progress Meetings

Generally, informal Project Progress Meetings will be conducted on a periodic basis as deemed necessary with the Contractor, CQA, Survey, and Owner personnel. These meetings will include updates to the activity schedule, a summary of work activities, testing results, discussion of any necessary decisions regarding construction activities and project requirements and schedules. If necessary, special meetings with the above-parties will be conducted to address any critical construction matters and determine an acceptable course of action. The CQA Firm shall maintain a file containing notes from such meetings.

SECTION II - SOILS CONSTRUCTION QUALITY ASSURANCE

1.0 INTRODUCTION

This section of the CQA Plan addresses the surveying and soils components of the liner system including the foundation subgrade, cohesive soil liner, leachate collection system drainage layer material, and sump gravel, as well as the soil components of the final cover system. It specifies the soils CQA program to be implemented with regard to material evaluation, laboratory test requirements, field test requirements, and issues related to non-conformance.

2.0 SURVEYING

Site survey requirements include performing periodic and record surveys to confirm that the disposal cells are constructed in accordance with approved design plans. Periodic surveys are conducted as necessary during construction to guide excavation and liner installation activities. Record surveys are considered final surveys of a specific constructed element demonstrating compliance with approved plans. Record surveys require Professional Land Surveyor certification and will be included in the CQA certification report.

Surveys will be required both within the portion of the landfill liner being constructed, and outside of the liner construction (generally for surface water drainage structures). Within the liner construction area, surveys shall be conducted on a grid system and appropriate breaklines in accordance with approved construction drawings on the following horizons:

- Excavation subgrade
- Top of cohesive soil liner
- Base of the cohesive soil cap
- Top of the cohesive soil cap in final cover
- Base and top of the moisture storage layer in the AFC system if used.

The record survey to be performed by the Surveyor within the liner construction area and immediately surrounding the area will include:

1. Subgrade record survey
    a) Subgrade on a grid within area of liner or final cover construction.
    b) Subgrade at designed limits of liner or final cover to be constructed and changes in orientation.
    c) Appropriate subgrade breaklines, including toes and crests of slopes.
    d) Bottom and top corners of the sump subgrade excavation.
    e) Anchor trench alignment.
    f) Any additional points as indicated on the drawings and as requested by the Owner or CQA Personnel to verify compliance with project plans.

2. Top of cohesive soil liner and cohesive soil cap
   a) On grid corresponding to subgrade grid in excavation, or base of final cover, as appropriate.
   b) Lateral limits of soil liner/cap construction and changes in orientation.
   c) Appropriate top of cohesive soil liner and cohesive soil cap breaklines, including toes and crests of slopes.
   d) Bottom and top of cohesive soil liner in corners of sump.
   e) Appropriate points to document tie-in with previous or future liner or final cover construction.
   f) Any additional points as indicated on the drawings.

3. Leachate Removal System
   a) Invert at end points of piping system.
   b) Inverts along piping alignments at spacing necessary to define alignment.
   c) Inverts at change of piping orientation.
   d) Appropriate points of leachate removal system appurtenant structures.

4. Top of moisture storage layer in AFC system if used in leui of the barrier layer system
   a) On grid corresponding to base of the moisture storage layer
   b) Lateral limits of moisture storage layer and changes in orientation
   c) Appropriate top of moisture storage layer breaklines, including toes and crests of slopes.
   d) Appropriate points to document tie-in with previous or future final cover construction.
   e) Any additional points as indicated on the drawings.

Thickness of the leachate drainage material will be verified by hand probing at approximate 50-foot spacing across the entire area of placement. The thickness of the miscellaneous protective soils and topsoil in either of the final cover systems will be verified by probing or controlling the construction in a method that the thickness can be verified by the CQA Personnel. The thickness of the moisture storage layer may also be verified by hand probing or controlling the construction in a method that the thickness can be visually verified by the CQA Personnel, such as visually verifying the top of the layer as marked on grade stakes.

All survey data will be reduced and given to the CQA Personnel in the form of a report. The surveyor will provide record grade tables in a final documentation report to the CQA Personnel to document compliance with design criteria, and shall be included in an appendix to the final construction certification report.

Survey/measured tolerances will be as follows unless otherwise previously approved by the CQA Firm:

TABLE II-1 SURVEY/MEASURED TOLERANCES	
Horizontal, All Points	plus or minus 0.20 feet of design coordinates (± 0.20 feet)
Vertical, Subgrade	plus 0.00 to minus 0.20 feet of design (+ 0.00 to – 0.20 feet)
Vertical, Top of Cohesive Soil Liner	plus 0.10 to minus 0.00 feet of design (+0.10 to – 0.00 feet)
Vertical, Top of Leachate Drainage Layer	Plus 0.20 to minus 0.00 feet of design (+0.20 to -0.00 feet), based on elevation at top of cohesive soil liner, must be minimum 0.5 feet thick
Vertical, Base of Cohesive Soil Cap	Plus 0.00 to minus 0.20 feet of design (+0.00 to –0.20 feet)
Vertical, Top of Cohesive Soil Cap	Plus 0.20 to minus 0.00 feet of design (+0.20 to –0.00 feet)
Vertical, Top of Miscellaneous Protective Final Cover Soils	Plus 0.20 to minus 0.00 feet of design (+0.20 to –0.00 feet); Based on Top of Cohesive Soil Cap, thickness must be between 1.5 and 1.7 feet thick.
Vertical, Base of Moisture Storage Layer in AFC Final Cover (if surveyed)	Plus 0.00 to minus 0.20 feet of design (+0.00 to -0.20 feet)
Vertical, Top of Moisture Storage Layer in AFC Final Cover (if surveyed)	Plus 0.20 to minus 0.00 feet of design (+0.20 to –0.00 feet); based on base of layer, must be minimum 20-inches thick on slopes ≥ 4H:1V and 18-inches thick on slopes < 4H:1V.
Vertical, Top of Topsoil	Plus 0.20 to minus 0.00 feet of design (+0.20 to –0.00 feet); Based on Top of Protective Final Cover Soils, thickness must be between 0.5 and 0.7 feet thick.
Slopes	Must maintain slopes at locations and within tolerances as shown on the drawings.

The allowable tolerances provided for in this plan shall not preclude the required minimum or maximum thicknesses of any components of the construction. All thickness measurements shall be made perpendicular to the slope, with the exception of thickness measurements on the cell floor which shall be measured in a vertical direction.

3.0 FOUNDATION SUBGRADE

Construction quality assurance for subgrade preparation involves monitoring grade control as stated in Section 2.0. In addition, the subgrade area (surface on which cohesive soil liner or cohesive soil cap is placed) is continually monitored for unstable areas that may develop under heavy traffic during cohesive soil liner construction. Unstable areas that are excavated and other over-excavated areas may require controlled fill.

3.1 Verification of Foundation Subgrade Continuity

When the excavation or final lift of refuse of the construction area of the landfill is completed, the CQA Personnel will:

- Inspect the subgrade on the side slopes, base, and over the refuse of the landfill and note areas of weak or excessively weathered subgrade material.
- Require as necessary, and observe proof rolling of the foundation subgrade and questionable areas of the sideslopes for excessive rutting, heaving, or soft soils
- Inspect the subgrade and sideslopes for the presence of moist materials that may indicate the presence of ephemeral, temporary, or permanent groundwater.

Proof rolling will be conducted with a scraper or similarly weighted heavy equipment. Any area exhibiting deflection of three inches or more during proof rolling will initially be compacted using appropriate equipment in an attempt to reduce the deflection. If compaction is unsuccessful, the area of unsuitable material will be delineated, removed, and replaced with compacted structural fill. Due to the nature of some refuse, particularly municipal solid waste, deflection of the subgrade over the final lift of refuse may be greater than three inches. The CQA Personnel will evaluate and must approve of the subgrade conditions in the final cover system before the cohesive soil cap is placed.

Should silt or sand lenses that produce groundwater seepage be encountered during excavation of a disposal cell, the amount and duration of seepage will be considered in selecting appropriate contingency measures to be implemented. For minor seeps that rapidly dry up (within a few days), no modifications to the liner or subgrade will be implemented. For minor seeps that remain damp or exhibit minor flows after a few days, the seep area will be over-excavated and backfilled with cohesive soil liner material. The depth of over-excavation will be determined at the time of construction. For large seeps that exhibit continuous flow after a few days, the seep area will be evaluated for remedial options. A plan of action may include design changes to be submitted to CDPHE and Adams County for approval prior to implementation.

Any required backfill material in the excavation area will be structural fill placed and compacted in accordance with this plan. Any backfill material over the refuse will be compacted to the most practical extent possible prior to construction of the cohesive soil cap. The CQA Personnel will observe any excavation and backfilling operations.

3.2 Conformance Evaluation

Material used for structural backfill shall be approved by the CQA Personnel prior to use and have a maximum particle size of 12 inches in the shortest direction, unless otherwise approved by the CQA Personnel

3.3 Construction Quality Assurance Evaluation

If backfilling of the foundation subgrade is required within lined areas of the excavation (excludes subgrade backfill on final cover), it shall be backfilled with soils meeting the requirements for structural fill, and the minimum frequency of soils testing for CQA purposes will conform to the minimum frequencies presented in Table II-2. Unless otherwise required by the CQA Personnel, the structural fill shall be placed in lifts not to exceed 12-inches compacted thickness, and compacted at a minimum dry unit weight of 95 percent of maximum dry unit weight within four percentage points ($\pm$4%) of the optimum moisture content as determined in the Standard Proctor Compaction test (ASTM D698).

Nuclear density meter test methods will be used for field testing the in-situ dry unit weight and moisture content of the in-place, compacted fill.

During structural fill placement the CQA Personnel will observe and document that:

- Individual fill lifts after compaction shall have an average thickness no greater than 12-inches.
- Compaction of structural fill material shall be performed using an appropriately heavy, properly ballasted piece of equipment subject to approval of the CQA Personnel.
- If frozen structural fill material is encountered, it is removed and replaced with unfrozen structural fill material.
- The Contractor shall not place structural fill material containing debris, branches, vegetation, mud, ice, or frozen material.

TABLE II-2: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF STRUCTURAL FILL		
Test	**Frequency**	**Standard Test Method**
Standard Proctor	1 per 5,000 cy placed (minimum 1 per material type per source)	ASTM D 698
IN PLACE		
Nuclear Density Meter (100 ft. grid)		
In-Situ Moisture Content	1 per 10,000 ft^2 per lift (minimum 1 per individual area)	ASTM D 3017
In-Situ Dry Unit Weight	1 per 10,000 ft^2 per lift (minimum 1 per individual area)	ASTM D 2922

Note: 1) Unless otherwise required by the CQA Personnel, structural fill shall be compacted at a moisture content between, and inclusive of, 4 percent dry to 4 percent wet of optimum and to a minimum dry unit weight of 95 percent of maximum dry unit weight determined in the Standard Proctor compaction test (ASTM D 698).

If an area in the fill is discovered that does not meet requirements, the CQA Personnel will determine the extent and nature of the area by additional tests, observations, a review of records, or other means that the CQA Personnel deems appropriate. After the extent of the area is determined, the CQA Personnel will observe and document that the Contractor corrects the deficiency before any additional work is performed in the area of the deficiency.

3.4 Surveying

A Professional Land Surveyor licensed in the State of Colorado will oversee the CQA survey. The Surveyor will survey the excavation to confirm that the grades and elevations in the field agree with those shown on the Construction Drawings or as otherwise approved by the CQA Personnel. CQA surveys will be conducted in accordance with the requirements described in Part 2.0 of Section II, only to the extent necessary to determine volumes of materials removed and replaced and verify compliance with project plans. The CQA Personnel will review and approve the survey results before the next phase of the lining system is constructed.

4.0 COHESIVE SOIL LINER AND COHESIVE SOIL CAP PLACEMENT

4.1 Design Construction Requirements

In accordance with design criteria of the Conservation Services Inc. D&O Plan, the following requirements shall be met for cohesive soil liner and cohesive soil cap (if used):

1. Base grades shall be consistent with approved design grades and as shown on the drawings.

2. The minimum thickness of the cohesive soil liner on the cell sidewalls, base, and the cohesive soil cap in the final cover shall be 2.0 feet measured perpendicular to the liner surface.

3. The minimum thickness of the cohesive soil liner in the sump areas shall be 3.0 feet.

4. Each lift of cohesive soil liner/cap shall be placed, processed, and compacted in a manner to result in compacted lifts no greater in thickness than the length of the feet on the compactor, and in no cases greater than six-inches after compaction.

5. The side slopes shall not exceed 3 horizontal to 1 vertical.

4.2 Conformance Evaluation

Samples of potential cohesive liner/cap soils will be collected and tested in the laboratory both prior to construction to verify suitable material properties, and during construction to verify continuity of material properties and compliance with cohesive soil liner and cohesive soil cap construction requirements per the requirements shown on Table II-3 in this Section.

To be considered acceptable for use as cohesive soil liner or cap, the material shall conform to the following requirements:

Classification.....CL, CH, or CL-CH (Unified Soil Classification System)
Permeability .....Less than or equal to 1x 10^{-7} cm/sec or less [(1)]
Liquid Limit .....Equal to or greater than 25 percent
Plasticity Index.....Equal to or greater than 10
Grain Size.....P200 content of 80% or greater by weight [(2)]

[(1)] After compaction to 95% or greater of maximum dry density at a moisture content of between 2 percent below optimum to 4 percent above optimum.
[(2)] Potential cohesive soils material with less than 80% passing the #200 sieve will require additional testing at the direction of the CQA Personnel to verify it suitability to meet project permeability requirements.

A soil sample inventory log will be maintained as samples are acquired. Prior to the preconstruction meeting, the CQA Personnel shall provide the Owner with a sample of this

inventory log for review and approval. All completed inventory logs shall be included in an Appendix to the certification report.

4.3 Cohesive Soil Liner and Cap Placement and Compaction

The CQA Personnel will verify and document that the cohesive soil liner and cap is constructed to the elevations, grades, and thicknesses shown on the Construction Drawings, with material meeting the requirements as determined by the test methods and frequencies specified within this CQA Plan. Regulatory and permit requirements specify that the cohesive soil liner and cap must be placed and compacted to result in a permeability of less than or equal to 1×10^{-7} cm/sec. The maximum particle size for cohesive soil liner or cap material following compaction is 2 inches.

Prior to the placement of the cohesive soil liner or cap, the CQA Personnel will observe and document that:

- All or an approved portion of the excavation or final lift of refuse is complete, and that a survey has been conducted to verify that the subgrade elevations conform to the Construction Drawings;

- The subgrade meets requirements as determined by the test requirements of this CQA Plan;

- The surface of the subgrade is free of debris, wet and soft areas, ponded water, vegetation, mud, ice or frozen material; and,

- If frozen subgrade material is encountered in the excavation or prior to final cover placement, it is removed and replaced with unfrozen structural fill material in accordance with Section II-3.0 of this plan.

During placement and compaction of the cohesive soil liner or cap, the CQA Personnel will observe and document that:

- CQA testing methods are conducted at the frequency listed in Table II-3. This includes pre-construction testing of cohesive soil liner or cap material prior to its use, and in-place testing during placement of the cohesive soil liner or cap during construction.

- Each lift is compacted to a minimum dry unit weight of 95% of maximum Standard Proctor Density (ASTM D698), at a moisture content of -2 to +4 percent of optimum.
  A minimum of 4 passes of the compactor shall be conducted uniformly over each lift.

- The CQA Personnel will fill perforations in the cohesive soil liner and cap resulting from CQA testing with granulated bentonite material. Such perforations may include, but are not limited to, the following:

  - Nuclear density test probe locations;
  - Shelby tube sample locations.

- If necessary to meet these requirements, a 24-inch (minimum) diameter disc will be used to break up the clay clods, expose stones in clay to allow for removal, and to assist in raising the moisture content to between (and inclusive) of -2 to +4 percent of optimum moisture content as determined by Standard Proctor Density test (ASTM-D698).

- Individual fill lifts after compaction shall have an average thickness no greater than the length of the pad foot and drum groove of the compaction equipment, and in no cases greater than 6 inches. Between lifts, the surface should be left rough or otherwise slightly scarified to promote bonding between lifts, but not to a depth to destroy the compaction of the underlying lift.

- Compaction of cohesive soil liner and cap material will be performed using a tamping foot compactor or equivalent heavy, penetrating foot compactor subject to approval of the CQA Personnel.

- The Contractor shall not place cohesive soil liner or cap material on a surface or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen material is encountered, it shall be removed and replaced in accordance with this Plan. Immediately prior to cohesive soil liner or cap placement, any wet or soft areas shall be proof-rolled as directed by the CQA Personnel. Any excessively wet or soft areas shall be excavated and replaced with properly compacted fill as per the requirements in Section II part 3.0.

- The finished surface of the cohesive soil liner and cap shall be relatively smooth and free of any protruding rocks and wheel ruts which could result in ponding water. In areas where geosynthetics are to be installed, the cohesive soil liner surface shall be smooth-drum rolled to prevent damage to overlying geosynthetics. The condition of the cohesive soil liner shall be maintained in accordance with this Section until covered with overlying materials.

- Test pits or other large excavations required for CQA purposes shall be backfilled by the contractor in accordance with this Plan.

- If any areas of completed cohesive soil liner remain exposed prior to covering with the overlying HDPE membrane for a period of two days or more, the upper lift of cohesive soil liner will be tested using nuclear methods at a minimum frequency of 1 test per approximately 40,000 square feet of exposed cohesive soil liner. The liner will be considered unaffected by desiccation if the moisture content is within, and inclusive of, 1.5 percentage points dry of specification. If the tested moisture content of the liner is less than 1.5 percentage points below specification, it will be reworked as necessary in an area ½ way the distance to the nearest acceptable test location to a density and moisture content within the original specifications and retested by nuclear methods.

The CQA Personnel will document the properties of the cohesive soil liner and cap as determined by the test methods and frequency prescribed by this CQA Plan and will report any nonconformance with the Plan to the CQA Personnel.

4.4 Construction Quality Assurance Evaluation

Construction quality assurance testing is required for the cohesive soil liner and cap, and the Contractor must take quality assurance testing into account when planning his construction schedule. Samples of cohesive material will be collected and submitted for laboratory analysis to verify suitable properties, and nuclear density meter test methods will be used for testing the in-situ compacted dry unit weight and moisture content of the materials. Nuclear density/moisture tests will be conducted on each individual lift on a pattern of approximately 100 feet by 100 feet to result in a test frequency of no less than one test every 10,000 square feet of liner. Test shall be offset on alternating lifts. The CQA Personnel will ensure laboratory suitability tests, and moisture and density tests are conducted as specified in Table II-3.

The testing frequency during cohesive soil liner and cap construction may be increased at the discretion of the CQA Personnel when visual observations of construction performance indicate potential problems such as inconsistent or non-uniform conditions. Additionally, the CQA Personnel may increase the frequency of testing during adverse weather conditions, if equipment breaks down, at the start and finish of grading, if the material fails to meet the requirements of this Plan, or the extent of the work area is reduced.

TABLE II-3: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF COHESIVE SOIL LINER AND COHESIVE SOIL CAP

Test	ASTM Designation	Construction Frequency	Preconstruction Frequency
Compacted Density-nuclear methods	D2922	Min 1 per 10,000 ft^2 per lift (approximate 100-foot centers)	
Compacted Moisture- nuclear methods	D3017	Min 1 per 10,000 ft^2 per lift (approximate 100-foot centers)	
Grain Size	D422/1140 (excluding hydrometer)	1 per 3,000 cy	1 per 20,000 cy
Atterberg Limits	D4318	1 per 3,000 cy	1 per 20,000 cy
Permeability	D5084 (5 psi confining pressure)	1 per 3,000 cy	1 per 20,000 cy
Standard Proctor	D698	1 per 3,000 cy or material changes	1 per 20,000 cy

If an area in the cohesive soil liner or cap is discovered that fails to meet requirements, the CQA Personnel will determine the extent of the area and reason for the failure. The CQA Personnel will define the extent of the defective area by additional tests, observations, a review of records, or other means that the CQA Personnel deems appropriate. After the extent of the area is determined, the area ½ the distance between the failing test locations and the nearest passing test locations will be reworked; moisture conditioned and recompacted as necessary. Retests will be performed following the rework activities. The CQA Personnel will observe and document that the deficiency is corrected by retesting repaired areas before the Contractor performs any additional work in the area of the deficiency.

Based on the specific project requirements (i.e., contractual agreements, etc.), the Contractor will be required to use all means necessary to protect all prior work, as well as all materials and completed work of other Sections. In the event of damage, the Contractor will be required to immediately make all repairs and replacements necessary. The CQA Personnel will observe and document that all damages are repaired.

All density and moisture tests will be reported on field moisture/density forms. Test locations will be identified in relationship to the pre-established survey grid coordinate or stake number locations. Completed field density forms shall be included in an appendix to the report.

Prior to the preconstruction meeting, the CQA Consultant shall provide the Owner with a sample of the field density form for review and approval.

4.5 Cohesive Soil Liner Tie-In

In situations where it is necessary to join, or tie-in, the cohesive soil liner or cap from different construction phases, the following procedures shall be used:

- The termination (edge) of the existing cohesive soil liner or cap shall be located by survey.

- The termination and surface of the existing cohesive soil liner or cap will be exposed for a minimum distance of four feet from the edge or as otherwise shown on the drawings. Care shall be taken to not damage components overlying the soil liner when exposing.

- The cohesive soil liner or cap will be either cut back at an approximate 45 degree angle, or stair-stepped at approximate six-inch vertical by minimum one-foot horizontal intervals, or as shown on the construction drawings. This procedure is intended to provide for blending individual six-inch lifts of the new soil liner with the corresponding six-inch thick lift of the existing liner and avoid the possibility of any vertical or continuous seams or permeability pathways where the two phases of soil liner or cap are joined.

- All requirements for acceptable soil characteristics, moisture conditioning, processing, and compaction at the cohesive soil liner or cap tie-in areas are the same as for the remainder of the cohesive soil liner or cap construction as provided for in Part 4.0 of this Section. Particular attention shall be given to compaction across the tie-in area.

- The geomembrane that was folded back to expose the surface of the existing cohesive soil liner will be visually inspected and may be unfolded back over the newly constructed tie-in area if CQA Personnel approves of the condition of the geomembrane.

- CQA Personnel shall document the methods used to tie-in the cohesive soil liner or cap, and document any adverse conditions not in compliance with this Plan or the construction requirements.

4.6 Surveying

A Professional Land Surveyor licensed in the State of Colorado will oversee the survey work used for certification purposes. The Surveyor will survey the elevations and grades of the cohesive soil liner and cap surfaces to confirm that the lines and elevations in the field agree with those shown on the Construction Drawings. Surveys will be conducted in accordance with the requirements described in Part 2.0 of Section II.

The CQA Personnel will review the results of the survey. The CQA Personnel will approve the survey results before the next phase of the liner system (geomembrane installation) or miscellaneous protective soils is constructed.

5.0 LEACHATE COLLECTION SYSTEM DRAINAGE MATERIAL

5.1 General

The leachate collection system drainage material will be placed a minimum of six-inches thick over the 60-mil HDPE liner on the base of the disposal cells (except directly over the cohesive soil liner in the asbestos cell). It will cover the entire base, up to and including the toe areas of the permanent side slopes.

Because the leachate collection drainage material is designed to work as a system with the cohesive soil liner, HDPE liner, and geotextile, the CQA Personnel shall approve of each of these components prior to their use on site.

The CQA Personnel will be provided with test results, or have tested, leachate collection system drainage material for compliance with project requirements. The CQA Personnel will examine the test results and is required to approve the material prior to it's being delivered to the site if off-site material is used.

5.2 Conformance Evaluation

Leachate drainage material shall consist of clean, hard, durable, non-carbonate, rounded, sub-rounded to sub-angular particles, which are free of metals, roots, trees, stumps, concrete, construction debris, other organic matter, and deleterious materials and coatings. Since the drainage material directly overlies an HDPE membrane, with the potential to damage the membrane, material used for leachate drainage material must be pre-approved by the CQA Personnel prior to use.

Drainage material shall have a hydraulic conductivity of at least $1x\ 10^{-1}$ cm/sec. Consolidation of the sample prior to testing shall be done by hand to the extent that crushing of sand/gravel particles does not occur. The test methods and frequency for CQA testing of the leachate drainage material are specified in Table II-4 of this Section.

5.3 Placement

Prior to the placement of the leachate drainage material, the CQA Personnel will observe and document that:

- The drainage material was stored in a manner so that it was not contaminated by dirt, mud, vegetation, or excessive dust,
- The underlying geosynthetic layers are free of holes, tears, excessive wrinkles, or foreign objects; and,
- All work on underlying layers is complete and accepted by the CQA Personnel.

During placement of the leachate drainage material, the CQA Personnel will observe and document that:

- Leachate drainage material shall not damage the underlying synthetic materials.
- The leachate drainage material is placed in a manner so that the maximum material drop height is no greater than 3 feet;

5.4 Construction Quality Assurance Evaluation

No density tests will be conducted on the leachate drainage material. If the CQA Personnel suspects damage to underlying geosynthetic, the contractor will be required to expose the potentially damaged materials and repair any observed damage. The CQA Personnel may require the contractor to remedy the situation so that further damage does not occur. Such remedies may include building a temporary roadway using a greater thickness or using different equipment.

TABLE II-4: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF LEACHATE DRAINAGE MATERIAL

Material Properties		
Sieve Analysis *	Maximum grain size 0.75 inches, app. 100% minus 3/8 inches	
Permeability	1.0×10^{-1} cm/sec or greater	
Test	**Frequency**	**Standard Test Method**
Sieve Analysis	1 per 3000 cy placed (minimum 1 per source)	ASTM D 422/C136/D 1140 as appropriate (excl. hydrometer)
Permeability	1 per 3000 cubic yards placed	ASTM D 2434

* Note: Because of the variety of drainage materials available, the CQA Personnel may waive the grain size requirements if the permeability requirement is met and would not result in damage to the underlying HDPE liner.

To effectively monitor the leachate drainage layer placement operations and ensure that the underlying layers are not damaged, there will be one CQA spotter for each piece of equipment placing or spreading the leachate drainage material.

5.5 Leachate Collection Drainage Layer Tie-In

When necessary to join, or tie-in, the leachate collection drainage layer of two separate construction events, the following procedure shall be followed:

- The edge of the existing cohesive soil liner will have been located per Section II, 4.0 of this Plan. The surface of the cohesive soil liner will be exposed back to a point where the edge of the existing leachate collection drainage layer is well exposed.

- After the cohesive soil liner tie-in has been completed, the geomembrane tie-in will be completed in accordance with Section III, 3.6 of this Plan.

- The new leachate collection drainage layer shall be extended to meet completely with the existing leachate collection drainage layer.

- CQA Personnel shall ensure that the tie-in area of the leachate collection drainage layer is relatively clean of fines and in a condition to avoid impedence of flow across the tie-in area. Any areas deemed not suitable by the CQA Personnel shall be removed or repaired at the direction of the CQA Personnel.

- CQA Personnel shall document any adverse conditions associated with tie-in operations of the leachate collection drainage layer.

5.6 Surveying

Surveying of the leachate drainage material is not required. The CQA Personnel will document that the leachate drainage material has been placed to the limits specified on the drawings (generally to lined limits on the floor of the disposal cell under construction). The CQA Personnel will document the required minimum thickness of leachate drainage material has been placed by hand probing and measuring the thickness on approximately 50-foot centers across the area of material placement.

The CQA Personnel must approve the results before any overlying materials are placed.

6.0 SUMP DRAINAGE MATERIAL

6.1 General

Sump drainage material is placed within the confines of the leachate sumps within each disposal cell.

Because the function of the sump drainage material and sump lateral and removal pipes works as a system with the cohesive soil and HDPE liners and geotextile, and is dependent upon the characteristics of each individual component, the CQA Personnel shall approve of each of these components prior to their use on site.

The CQA Personnel will be provided with quality control test results and will evaluate the results for compliance with project requirements. The CQA Personnel will examine the test results and is required to approve the material prior to being delivered to the site. If the sump drainage material supplier cannot provide test results required by this Plan, then the CQA Personnel may perform or arrange to perform the tests.

6.2 Conformance Evaluation

Drainage material for the work shall consist of clean, hard, durable, non-carbonate, rounded, sub-rounded to sub-angular particles which are free of metals, roots, trees, stumps, concrete, construction debris, other organic matter, and deleterious materials and coatings. Because unsuitable sump drainage material has the potential for damage to the underlying HDPE membrane, the sump drainage material must be pre-approved by the CQA Personnel prior to placement.

Drainage material shall have a hydraulic conductivity of at least $1x10^{-1}$ cm/sec. Consolidation of the sample prior to testing shall be done by hand to the extent that crushing of particles does not occur. The test methods and frequency for CQA conformance testing of the sump drainage material are specified in Table II-5 of this Section.

6.3 Placement

Prior to the placement of the sump drainage material, the CQA Personnel will observe and document that:

- The material was stored in a manner so that it was not contaminated by dirt, mud, vegetation, or excessive dust,
- The underlying geosynthetic layers are free of holes, tears, excessive wrinkles, or foreign objects; and,
- All work on underlying layers is complete and accepted by the CQA Personnel.

During placement of the sump drainage material, the CQA Personnel will observe and document that:

- The sump drainage material shall not damage the underlying synthetic materials.
- The sump drainage material is placed in a manner so that the maximum material drop height is no greater than 2 feet;

6.4 Construction Quality Assurance Evaluation

No density tests will be conducted on the sump drainage material. If the CQA Personnel suspects damage to pipes or underlying geosynthetics, the contractor will be required to expose the potentially damaged materials and repair any observed damage. The CQA Personnel may require the contractor to remedy the situation so that further damage does not occur. Such remedies may include building a temporary roadway using a greater thickness or using different equipment.

TABLE II-5: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF SUMP DRAINAGE MATERIAL

Material Properties		
Sieve Analysis *	Maximum grain size .75 inches, with less than one percent grain size smaller than the sump pipe openings.	
Permeability	1.0×10^{-1} cm/sec or greater	
Test	**Frequency**	**Standard Test Method**
Sieve Analysis	1 per sump	ASTM D 422/C 136 as appropriate
Permeability	1 per sump	ASTM D 2434

* Note: If the material meets the minimum permeability requirements, the CQA Personnel may waive the grain size requirements.

6.5 Surveying

Specific survey of the top of the sump drainage material is not required because of the smaller area of the gravel placement; however, it will be visually verified that the top of the sump drainage material is placed to an equivalent elevation to the surrounding leachate drainage material, or higher.

The CQA Personnel will document the proper completion of the sump drainage material, and may require surveying or other verification measures on the top of the sump drainage material if needed for verification. The CQA Personnel will approve the placement of the sump drainage material before placement of the overlying geotextile.

7.0 MISCELLANEOUS PROTECTIVE FINAL COVER SOILS PLACEMENT

7.1 Definitions of Miscellaneous Protective Soil Fill

The miscellaneous protective final cover fill soils are a minimum 18.0-inches thick and placed above the cohesive soil cap (if used) in the final cover system option to provide a rooting zone and protection of the cohesive soil cap from degradation due to the elements.

7.2 Conformance Evaluation

All miscellaneous protective soil fill, processing, compaction, and testing shall be conducted at the direction of the CQA Personnel. Unless otherwise specified, soil used for miscellaneous protective fill shall meet the following characteristics:

- Miscellaneous protective soils used in the final cover system shall be classified as CL, CH, ML, MH, SM, or SC.
- The maximum rock size for miscellaneous protective soils shall be six inches in the shortest axis; however, incidental occurrence of rock larger than six inches shall be allowed. By visual observation, the number of rock greater than six inches in the shortest axis shall not exceed approximately 1 per 10 square feet.
- The CQA Personnel must approve the soils used for the miscellaneous protective fill.

Samples of miscellaneous protective fill soils will be collected and tested in the laboratory both prior to construction to verify suitable material properties, and during construction to verify continuity of material properties and compliance with miscellaneous protective fill soil requirements as dictated by the CQA Personnel.

A soil sample inventory log will be maintained as samples are acquired. Prior to the preconstruction meeting, the CQA Personnel shall provide the Owner with a sample of this inventory log for review and approval.

All completed inventory logs shall be included in an Appendix to the certification report.

7.3 Miscellaneous Protective Fill Soil Placement and Compaction

The CQA Personnel will verify and document that any miscellaneous protective soil fills are constructed to the elevations, grades, and thicknesses shown on the Construction Drawings, with material meeting the requirements as determined by the test methods and frequencies specified in this document and approved by the CQA Personnel.

Prior to the placement of the miscellaneous protective fill soil, the CQA Personnel will observe and document that:

- All or an approved portion of the cohesive soil cap are complete, and that a survey has been conducted to verify that the subgrade grades and elevations conform to the Construction Drawings;

- The cohesive soil cap surface meets requirements as determined by the test requirements of this CQA Plan;

- The surface of the cohesive soil cap is free of debris, wet and soft areas, ponded water, vegetation, mud, ice or frozen material; and,

During placement and compaction of the miscellaneous protective fill soil, the CQA Personnel will observe and document that:

- Individual fill lifts after compaction shall be as directed by the CQA Personnel, but in no cases shall be greater than one foot.

- The miscellaneous protective fill soils will only be compacted to the extent that occurs due to incidental construction traffic; however, compaction must occur over the entire area of miscellaneous protective soil fill and may be best accomplished by tracking with a dozer. Compaction shall be conducted to the satisfaction of the CQA Personnel.

- The Contractor shall not place miscellaneous protective fill soil material on a surface or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen material is encountered, it shall be removed and replaced in accordance with this Plan. Immediately prior to miscellaneous protective fill soil placement, any wet or soft areas shall be proof-rolled as directed by the CQA Personnel. Any excessively wet or soft areas beneath the miscellaneous protective soils shall be excavated and replaced, as appropriate, with properly compacted cohesive soil cap material as per the requirements in Section II part 4.0.

- The finished surface of the miscellaneous protective fill soils shall be slightly roughened to promote bonding of the topsoil, and free of any protruding rocks and wheel ruts which could result in ponding water.

- Test pits or other large excavations required for CQA purposes shall be backfilled by the contractor in accordance with this Plan for the material excavated.

7.4 Construction Quality Assurance Evaluation

Construction quality assurance testing is required for the miscellaneous protective soils, and the Contractor must take quality assurance testing into account when planning his construction schedule. Construction Quality Assurance testing consists material observation during construction and of pre-construction and construction laboratory testing to verify proper soil characteristics. No in place moisture or density testing is required by this plan; however, the CQA Personnel may determine in place testing is necessary to verify proper construction.

The testing frequency during miscellaneous protective fill soil placement may be increased at the discretion of the CQA Personnel when visual observations of construction performance indicate potential problems such as inconsistent or non-uniform conditions. Additionally, the CQA Personnel may increase the frequency of testing during adverse weather conditions, if equipment breaks down, at the start and finish of grading, if the material fails to meet the requirements of this Plan, or the extent of the work area is reduced.

If an area in the miscellaneous protective fill soil is discovered that fails to meet requirements Table II-6, the CQA Personnel will determine the extent of the area and reason for the failure. The CQA Personnel will determine the extent of the defective area by additional tests, observations, a review of records, or other means that the CQA Personnel deems appropriate. After the extent of the area is determined, the area will be reworked, removed and replaced, or otherwise as necessary to comply with this plan. The CQA Personnel will observe and document that the deficiency is corrected before the Contractor performs any additional work in the area of the deficiency.

TABLE II-6: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF MISCELLANEOUS PROTECTIVE SOILS

Material Properties		
Unified Soils Classification System	CL, CH, ML, MH, SM, or SC	
Maximum Rock Size	Over 6” in shortest axis, no more than 1 per approximately 10 square feet	
Test	**Frequency**	**Standard Test Method**
Atterberg Limits with Unified Soils Classification System	1 per 10,000 cubic yards	ASTM D4318
Maximum Rock Size	Continual observation during construction	visual

Based on the specific project requirements (i.e., contractual agreements, etc.), the Contractor will be required to use all means necessary to protect all prior work, as well as all materials and completed work of other Sections. In the event of damage, the Contractor will be required to immediately make all repairs and replacements necessary. The CQA Personnel will observe and document that all damages are repaired.

7.5 Surveying

The miscellaneous protective soils placement does not require surveying. Proper placement and thickness will be visually verified during construction by any means acceptable to the CQA Personnel. Tolerances will be as specified in Part 2.0 of Section II.

8.0 AFC MOISTURE STORAGE LAYER SOILS PLACEMENT

8.1 Design Construction Requirements

In accordance with design criteria of the Conservation Services Inc. D&O Plan, the following requirements shall be met for the moisture storage layer in the AFC (if used):

1. Base grades shall be consistent with approved design grades and as those shown on the drawings.

2. The minimum thickness of the moisture storage layer shall be 20 inches on slopes greater than or equal to 4H:1V and 18 inches on slope less than 4H:1V.

3. Each lift of the moisture storage layer shall be placed and processed in a manner to avoid compaction and shall be placed in single lifts between roughly 12 and 20 inches, inclusive. If a thinner lift is necessary to reach design grades, it shall be placed to avoid compaction as much as possible.

4. The side slopes shall not exceed 3 horizontal to 1 vertical.

8.2 Conformance Evaluation

Samples of potential moisture storage layer soils will be collected and tested in the laboratory both prior to construction to verify suitable material properties, and during construction to verify continuity of material properties and compliance with moisture storage layer construction requirements per the requirements shown on Table II-7 in this Section.

A soil sample inventory log will be maintained as samples are acquired. Prior to the preconstruction meeting, the CQA Personnel shall provide the Owner with a sample of this inventory log for review and approval. All completed inventory logs shall be included in an Appendix to the certification report.

8.3 Moisture Storage Layer Placement

The CQA Personnel will verify and document that the moisture storage layer is constructed to the elevations, grades, and thicknesses shown on the Construction Drawings, with material meeting the requirements as determined by the test methods and frequencies specified within this CQA Plan. The moisture storage layer shall not have an abundance of material with particle size greater than 3-inches following placement.

Prior to the placement of the moisture storage layer, the CQA Personnel will observe and document that:

- All or an approved portion of the final lift of refuse is complete, and that a survey has been conducted to verify that the subgrade (may consist of waste) elevations conform to the Construction Drawings;

- The subgrade surface meets requirements as determined by the test requirements of this CQA Plan;

- The surface of the subgrade is free of debris, wet and soft areas, ponded water, vegetation, mud, ice or frozen material; and,

- If frozen subgrade material is encountered prior to final cover placement, it is removed and replaced with unfrozen structural fill material in accordance with Section II-3.0 of this plan.

During placement of the moisture storage layer, the CQA Personnel will observe and document that:

- CQA testing methods are conducted at the frequency listed in Table II-7. This includes pre-construction testing of soil material prior to its use, and in-place testing during placement of the moisture storage layer.

- Each lift is placed and spread using equipment and methods to result in minimal compaction.

- The CQA Personnel will fill perforations in the moisture storage layer resulting from CQA testing with granulated bentonite material. Such perforations may include, but are not limited to, the following:

    - Nuclear density test probe locations;
    - Shelby tube sample locations.

- If necessary to meet these requirements, a 24-inch (minimum) diameter disc will be used to break up clods, expose stones and oversize material to allow for removal, and to assist in reducing compaction.

- If possible, individual fill lifts during placement should be a minimum of 12-inches thick and a maximum of roughly 20-inches thick to avoid compaction of the material.

- The Contractor shall not place moisture storage layer soils on waste or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen material is encountered, it shall be removed and replaced in accordance with this Plan. Immediately prior to moisture storage layer placement, any wet or soft areas shall be proof-rolled as directed by the CQA Personnel. Any excessively wet or soft areas shall be excavated and replaced with properly compacted fill as per the requirements in Section II part 3.0.

- The finished surface of the moisture storage layer shall be relatively smooth and free of any protruding rocks and wheel ruts which could result in ponding water.

- Test pits or other large excavations required for CQA purposes shall be backfilled by the contractor in accordance with this Plan.

The CQA Personnel will document the properties of the moisture storage layer as determined by the test methods and frequency prescribed by this CQA Plan and will report any nonconformance with the Plan to the CQA Personnel.

8.4 Construction Quality Assurance Evaluation

Construction quality assurance testing is required for the moisture storage layer, and the Contractor must take quality assurance testing into account when planning his construction schedule. Samples of moisture storage layer material will be collected and submitted for laboratory analysis to verify suitable properties, and nuclear density meter test methods will be used for testing the in-situ compacted dry unit weight and moisture content of the materials. Nuclear density/moisture tests will be conducted on at the rate of one test per each 1,000 cubic yards placed to verify compliance with these specifications. The CQA Personnel will ensure laboratory suitability tests, and moisture and density tests are conducted as specified in Table II-7.

The testing frequency during construction of the moisture storage layer may be increased at the discretion of the CQA Personnel when visual observations of construction performance indicate potential problems such as inconsistent or non-uniform conditions. Additionally, the CQA Personnel may increase the frequency of testing during adverse weather conditions, if equipment breaks down, at the start and finish of grading, if the material fails to meet the requirements of this Plan, or the extent of the work area is reduced.

TABLE II-7: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF MOISTURE STORAGE LAYER SOILS

Test	ASTM Designation	Construction Frequency	Preconstruction Frequency	Requirement
Grain Size Analysis	ASTM D 422 (excluding hydrometer)	Min 1 per 5,000 cy constructed	1 per 20,000 cy	Min. 58% passing #200 sieve
Standard Proctor	ASTM D 698	Min 1 per 10,000 cy constructed	Min 1 per 20,000 cy	No requirement
Moisture Content	ASTM D 3017	Min. 1 per 1,000 cy	None	Dry of optimum
Density	ASTM D 2922	1 per 1,000 cy constructed	None	80%-90% inclusive of maximum Standard Proctor Density

If an area in the moisture storage layer is discovered that fails to meet requirements, the CQA Personnel will determine the extent of the area and reason for the failure. The CQA Personnel will define the extent of the defective area by additional tests, observations, a review of records, or other means that the CQA Personnel deems appropriate. After the extent of the area is determined, the area ½ the distance between the failing test locations and the nearest passing test locations will be reworked as necessary. Retests will be performed following the rework activities. The CQA Personnel will observe and document that the deficiency is corrected by retesting repaired areas before the Contractor performs any additional work in the area of the deficiency.

Based on the specific project requirements (i.e., contractual agreements, etc.), the Contractor will be required to use all means necessary to protect all prior work, as well as all materials and completed work of other Sections. In the event of damage, the Contractor will be required to immediately make all repairs and replacements necessary. The CQA Personnel will observe and document that all damages are repaired.

All density and moisture tests will be reported on field moisture/density forms. Test locations will be identified in relationship to the pre-established survey grid coordinate or stake number locations. Completed field density forms shall be included in an appendix to the report.

Prior to the preconstruction meeting, the CQA Consultant shall provide the Owner with a sample of the field density form for review and approval.

8.5 Moisture Storage Layer Tie-In

In situations where it is necessary to join, or tie-in, the moisture storage layer from different construction phases, the following procedures shall be used:

- The termination (edge) of the existing moisture storage layer shall be located by survey.

- The termination and surface of the existing moisture storage layer will be exposed for a minimum distance of four feet from the edge or as otherwise shown on the drawings.

- The moisture storage layer shall be cut back at an approximate 45 degree angle, or as otherwise shown on the construction drawings. This procedure is intended to provide for seamless joining of the new moisture storage layer with the existing moisture storage layer.

- All requirements for acceptable soil characteristics, moisture conditioning, processing, and minimal compaction at the moisture storage layer tie-in areas are the same as for the remainder of the moisture storage layer construction as provided for in Part 8.0 of this Section.

- CQA Personnel shall document the methods used to tie-in the moisture storage layers, and document any adverse conditions not in compliance with this Plan or the construction requirements.

8.6 Surveying

A Professional Land Surveyor licensed in the State of Colorado will oversee the survey work used for certification purposes if the thickness and grades are to be verified by survey. The Surveyor will survey the elevations and grades of the moisture storage layer surfaces to confirm that the lines and elevations in the field agree with those shown on the Construction Drawings. Surveys will be conducted in accordance with the requirements described in Part 2.0 of Section II. Alternatively, the thickness of the soil moisture storage layer may be verified by CQA Personnel by hand probing or verifying the proper grades and thickness by visually inspecting the completed surface to marked grade stakes.

The CQA Personnel will review the results of the thickness and grade checks. The CQA Personnel will approve the results before the next phase of the AFC system (topsoil) is constructed.

9.0 GENERAL SOIL FILL PLACEMENT

9.1 Definitions of General Soil Fill

General soil fill includes the placement, processing, and compaction of any soil materials necessary to meet project requirements that are not specified elsewhere in this document. General soil fill includes, but is not limited to, roadways, berms and dikes, and temporary anchor soils used to anchor construction materials such as HDPE membranes and geotextiles.

9.2 Construction and Material Requirements

All general soil fill, processing, compaction, and testing shall be conducted at the direction of the CQA Personnel.

Samples of general fill soils may be collected and tested in the laboratory both prior to construction to verify suitable material properties, and during construction to verify continuity of material properties and compliance with general fill soil requirements as dictated by the CQA Personnel.

A soil sample inventory log will be maintained as samples are acquired. Prior to the preconstruction meeting, the CQA Personnel shall provide the Owner with a sample of this inventory log for review and approval.

All completed inventory logs shall be included in an Appendix to the certification report.

9.3 General Fill Soil Placement and Compaction

The CQA Personnel will verify and document that any general soil fills are constructed to the elevations, grades, and thicknesses shown on the Construction Drawings, with material meeting the requirements as determined by the test methods and frequencies specified by the CQA Personnel.

Prior to the placement of the general fill soil, the CQA Personnel will observe and document that:

- All or an approved portion of the subgrade below the general fill are complete, and that a survey has been conducted, if necessary, to verify that the subgrade grades and elevations conform to the Construction Drawings;

- The subgrade meets requirements as determined by the test requirements of this CQA Plan;

- The surface of the subgrade is free of debris, wet and soft areas, ponded water, vegetation, mud, ice or frozen material; and,

During placement and compaction of the general fill soil, the CQA Personnel will observe and document that:

- CQA testing methods are sufficient to ensure the integrity of the general soil fill based on its intended purpose. This includes pre-construction testing of general fill soil material prior to its use, and in-place testing during placement of the general fill soil during construction.

- Compaction of general fill soil material will be performed using equipment appropriate for the soils and intended purpose of general fill structure. Compaction equipment and technique must be approved by the CQA Personnel.

- The Contractor shall not place general fill soil material on a surface or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen material is encountered, it shall be removed and replaced in accordance with this Plan. Immediately prior to general fill soil placement, any wet or soft areas shall be proof-rolled as directed by the CQA Personnel. Any excessively wet or soft areas shall be excavated and replaced, as appropriate, with properly compacted structural fill as per the requirements in Section II part 3.0.

- Each lift is compacted as directed by the CQA Personnel based on the intended purpose of the general fill.

- Test pits or other large excavations required for CQA purposes shall be backfilled by the contractor in accordance with this Plan for the material excavated.

The CQA Personnel will document the properties of the soils used in general fill as determined by the test methods and frequency prescribed by this CQA Plan.

9.4 Construction Quality Assurance Evaluation

Construction quality assurance testing may be required for the general fill soils, and the Contractor must take quality assurance testing into account when planning his construction schedule. On general fill soils that require compaction to specific density or moisture content, nuclear density meter test methods will be used for testing the in-situ compacted dry unit weight and moisture content of the materials. Tests will be conducted on each lift at a minimum frequency of at least 1 test per every 100 linear feet on linear placement areas, or a grid pattern no greater than approximately 100 feet by 100 feet on larger areas, unless otherwise directed by the CQA Personnel.

The testing frequency during general fill soil placement may be increased at the discretion of the CQA Personnel when visual observations of construction performance indicate potential problems such as inconsistent or non-uniform conditions. Additionally, the CQA Personnel may increase the frequency of testing during adverse weather conditions, if equipment breaks down, at the start and finish of grading, if the material fails to meet the requirements of this Plan, or the extent of the work area is reduced.

If an area in the general fill soil is discovered that fails to meet requirements, the CQA Personnel will determine the extent of the area and reason for the failure. The CQA Personnel will determine the extent of the defective area by additional tests, observations, a review of records, or other means that the CQA Personnel deems appropriate. After the extent of the area is determined, the area will be reworked; moisture conditioned and recompacted as necessary. Retests will be performed following the rework activities. The CQA Personnel will observe and document that the deficiency is corrected by retesting repaired areas before the Contractor performs any additional work in the area of the deficiency.

Based on the specific project requirements (i.e., contractual agreements, etc.), the Contractor will be required to use all means necessary to protect all prior work, as well as all materials and completed work of other Sections. In the event of damage, the Contractor will be required to immediately make all repairs and replacements necessary. The CQA Personnel will observe and document that all damages are repaired.

Any density and moisture tests will be reported on field moisture/density forms. Test locations will be identified in relationship to the pre-established survey grid coordinate or stake number locations. Completed field density forms shall be included in an appendix to the report.

9.5 Surveying

If required by the CQA Personnel, a Professional Land Surveyor licensed in the State of Colorado will oversee the CQA surveys. The Surveyor will survey the elevations and grades of the general fill soil construction if requested by the CQA Personnel and required by the project plans to confirm that the lines and elevations in the field agree with those shown on the Construction Drawings or as required by the CQA Personnel. Surveys will be conducted in accordance with the requirements described in Part 2.0 of Section II. General soil fills may be visually verified in some cases.

The CQA Personnel will review the results of the survey or observations. The CQA Personnel will approve the results prior to any general fill soil area being covered with subsequent phases of construction.

10.0 TOPSOIL PLACEMENT

10.1 Definition of Topsoil

Topsoil fill includes the top six inches of soil fill in the final cover system intended as a seedbed and germination profile for vegetation of the final cover. This section addresses placement and processing of topsoil materials necessary to meet project requirements. The topsoiling in this plan is in accordance with the approved D&O, and includes different provisions for the topsoil depending on whether the low permeability barrier layer or AFC final cover system is implemented.

10.2 Conformance Evaluation

A minimum of the upper nine inches of native ground that is excavated for site development is saved for later use as topsoil in revegetation of the final cover over the disposal cells. Prior to use as topsoil in revegetation, the Natural Resource Conservation Service (NRCS), or other competent resource will be contacted for input on revegetation requirements. For the AFC, a specific mix of warm and cool season grasses is required, and agronomic characterization of the topsoil used in the AFC system will be conducted after topsoil placement and prior to adding any amendments.

- Topsoil materials used for revegetation over the facility disposal cells shall have the qualities and nutrient requirements necessary for the viable germination and growth of the vegetation planted.
- Topsoil material excavated from the site will be used as much as possible, and amended as necessary to promote germination and growth.
- For the AFC system, a revegetation contractor will evaluate the results of the topsoil analysis and recommend treatments to remedy any soil deficiencies (i.e., pH, low nutrients, high carbonates, etc.) prior to seeding. A soil-testing plan will be developed specifically for CSI based on the results of the topsoil analyses.

Samples of topsoil may be collected and tested in the laboratory prior to construction to establish the quality of the topsoil and any amendments required only for the low permeability barrier layer final cover system. For the AFC system, topsoil requirements shall conform to the frequency and characteristics shown in Table II-8.

A soil sample inventory log will be maintained as samples are acquired. Prior to the preconstruction meeting, the CQA Personnel shall provide the Owner with a sample of this inventory log for review and approval.

All completed inventory logs shall be included in an Appendix to the certification report.

10.3 Topsoil Placement

The CQA Personnel will verify and document that topsoil fills are constructed to the elevations, grades, and thicknesses shown on the Construction Drawings, with material meeting the requirements as determined by the test methods and frequencies specified by the CQA Personnel and as recommended by the NRCS or similarly knowledgable resource in accordance with this CQA Plan.

Prior to the placement of the topsoil, the CQA Personnel will observe and document that:

- All or an approved portion of the miscellaneous protective soils (low permeability barrier layer system) or moisture storage layer (AFC system) are complete, and that a survey has been conducted, if necessary, to verify that the grades and elevations conform to the Construction Drawings;

- The top of the miscellaneous protective soils or moisture storage layer shall be slightly roughened to promote bonding of the topsoil materials;

- The surface of the miscellaneous protective soils or moisture storage layer is free of debris, wet and soft areas, ponded water, vegetation, mud, ice or frozen material; and,

During placement of the topsoil, the CQA Personnel will observe and document that:

- Topsoil placement shall not begin until the Contractor has verified that subgrade elevations and grades conform to the Construction Drawings and the CQA Personnel has accepted the existing subgrade condition.

- Topsoil should be placed and spread so it is well settled and firm, but not compacted.

- Topsoil shall be placed and spread in a single six-inch minimum thick lift so as to minimize the volume of traffic and compaction on the topsoil.

- The Contractor shall not place topsoil material on a surface or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen material is encountered, it shall be removed and replaced in accordance with this Plan. Immediately prior to topsoil placement, any wet or soft areas shall be proof-rolled if directed by the CQA Personnel. Any excessively wet or soft areas beneath the topsoil shall be excavated and replaced, as appropriate, with properly compacted miscellaneous protective fill or moisture storage layer soil as per the requirements in Section II part 7.0 or part 8.0, as appropriate.

- Test pits or other large excavations required for CQA purposes shall be backfilled by the contractor in accordance with this Plan for the material excavated.

The CQA Personnel will observe the continuity of topsoil materials as they are placed.

10.4 Construction Quality Assurance Evaluation

Construction quality assurance testing is not required for the topsoil during construction unless a change in materials is noted by the CQA Personnel. Any unapproved topsoil placement may require removal and replacement with approved topsoil.

For the AFC system, the topsoil material shall meet the following requirements:

TABLE II-8: MINIMUM FREQUENCY OF TESTING FOR CQA EVALUATION OF TOPSOIL FOR THE AFC SYSTEM

Test	ASTM Designation	Construction Frequency	Preconstruction Frequency	Requirement
Grain Size Analysis	ASTM D 422 (excluding hydrometer)	Min 1 per 5,000 cy constructed	1 per 20,000 cy	Min. 58% passing #200 sieve
Standard Proctor	ASTM D 698	Min 1 per 10,000 cy constructed	Min 1 per 20,000 cy	No requirement
Moisture Content	ASTM D 3017	Min. 1 per 1,000 cy	None	Dry of optimum
Density	ASTM D 2922	1 per 1,000 cy constructed	None	80%-90% inclusive of maximum Standard Proctor Density

For purposes of compliance with the above test requirements in the AFC system, the topsoil shall be considered a separate unit from the moisture storage layer (i.e., the volume of topsoil and the moisture storage unit shall not be combined).

Based on the specific project requirements (i.e., contractual agreements, etc.), the Contractor will be required to use all means necessary to protect all prior work, as well as all materials and completed work of other Sections. In the event of damage, the Contractor will be required to immediately make all repairs and replacements necessary. Following placement of acceptable topsoil, it will be revegetated in accordance with the D&O Plan.

10.5 Surveying

The topsoil layer does not require surveying. Proper placement and thickness will be visually verified during construction by any means acceptable to the CQA Personnel. Tolerances will be as specified in Part 2.0 of Section II.

SECTION III - GEOMEMBRANE CONSTRUCTION QUALITY ASSURANCE

1.0 GEOMEMBRANE CQA INTRODUCTION

The cohesive soil liner on the base and sidewalls of the ISW and MSW cells shall be overlain by 60-mil High Density Polyethylene (HDPE) material in accordance with the requirements of this document. The asbestos cell will not be constructed using an HDPE membrane. The Owner may use smooth or textured HDPE at their discretion. Minimum material requirements for both materials are provided in Tables III-1 and III-2 in this section.

2.0 GEOMEMBRANE MANUFACTURE AND DELIVERY

2.1 Resin

Prior to the installation of the HDPE geomembrane material, the Contractor will be required to provide the CQA Personnel and Owner with the following:

- A copy of the quality control certificates issued by the resin Supplier that includes the origin (resin Supplier's name and resin production plant), identification (brand name, number) the production date of the resin used in the manufacture of the geomembrane shipped to the site, and the results of tests conducted to verify that the quality of the resin used to manufacture the geomembrane rolls assigned to the project meets the Specifications; and

- Certification that recycled polymer does not exceed 2 percent by weight of the total polymer weight and that the HDPE resin has a specific gravity of between 0.932 to 0.960 gm/cc (ASTM D 4883-96).

The CQA Personnel will review these documents and report any discrepancies with the above requirements to the Owner.

2.2 Geomembrane Conformance Evaluation and Manufacturing Quality Control

Prior to the installation of the HDPE geomembrane, the Contractor will provide the CQA Personnel and Owner with a statement of conformance with the material and manufacturing requirements set forth in this plan, signed by a proper authority from the geomembrane Manufacturer. Any non-conformance with these requirements shall be documented by the Manufacturer and provided to the CQA Personnel and Owner:

The CQA Personnel will review the Manufacturer's certification information and document The following:

- The manufacturing quality control certificates for each shift's production of geomembrane, signed by a responsible party employed by the geomembrane Manufacturer (such as the production manager). The quality control certificates will include:
  - Roll numbers and identification; and,
  - Sampling procedures and results of quality control tests required by this plan.

- The material contains a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).

- The property values certified by the geomembrane Manufacturer meet all of the specified values listed in the Specifications and Table III-1 or Table III-2, as appropriate, below;

- The quality control certificates have been provided at the specified frequency for geomembrane rolls, and each certificate identifies the rolls or batch number related to that certificate.

TABLE III-1 HDPE GEOMEMBRANE PROPERTIES; 60-MIL SMOOTH			
Properties	**Test Method**	**Manufacturer QC Test Frequency**	**Required Test Values [11]**
Thickness (min.ave.) * Minimum Individual	ASTM D5199	1 per Roll	60 mil 54 mil
Sheet Density (min.ave.)	ASTM D792 or ASTM D 1505	1 per 50,000 sf	0.94 g/cc
Tensile Properties [1] (min.ave.) * Yield Strength * Break Strength * Yield Elongation * Break Elongation	ASTM D 638 Type IV	1 per 50,000 sf	 126 lb/in. 228 lb/in. 12 % 700 %
Tear Resistance (min.ave.)	ASTM D 1004 Die C	1 per 50,000 sf	42 lbs
Puncture Resistance (min.ave.)	ASTM D 4833	1 per 50,000 sf	108 lbs
Stress Crack Resistance [2]	ASTM D 5397 (App.)	(11)	200 hours
Carbon Black Content (range)	ASTM D 1603 [3]	1 per 50,000 sf	2-3 %
Carbon Black Dispersion [4]	ASTM D 2663 ASTM D 5596	1 per 50,000 sf	A1, A2, B1 Category 1,2, or 3 [4]
Oxidative Induction Time (OIT)(min.ave.) [5] * Std. OIT, or * High Pressure OIT	 ASTM D 3895 ASTM D 5885	 (10)	 100 min. 400 min.
Oven Aging at 85˚C [5][6] * Std. OIT (min.ave.), % retained after 90 days, or, * High Pressure OIT (min.ave.), % retained after 90 days	 ASTM D5721 ASTM D 3895 ASTM D 5885	(10)	 55% 80%
UV Resistance [7] * Std. OIT (min.ave.), or * High Pressure OIT (min.ave.) % retained after 1600 hours [9]	GM 11 ASTM D 3895 ASTM D 5885	 (10)	 (8) 50%

Notes for Table III-1:

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 1.3 inches. Break elongation is calculated using a gage length of 2.0 inches.

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value vis MQC testing

(3) Other methods such as D 4218 (muffle furnace or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2, 1 in Category 3.

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75˚ C followed by 4 hr. condensation at 60˚ C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(10) Manufacturer may provide certification letter.

(11) Based on GRI GMI 13,Rev. 4,12/13/00.

TABLE III-2 HDPE GEOMEMBRANE PROPERTIES; 60-MIL TEXTURED			
Properties	**Test Method**	**Manufacturer QC Test Frequency**	**Required Test Values [13]**
Thickness (min.ave.) * Lowest individual for 8 out of 10 values * Lowest individual for any of the 10 values	ASTM D5994	1 per Roll	57 mil 54 mil 51 mil
Asperity Height (min.ave.) [1][2]	GM 12	1 per 50,000 sf	10 mil
Sheet Density (min.ave.)	ASTM D792 or ASTM D 1505	1 per 50,000 sf	0.94 g/cc
Tensile Properties [3] (min.ave.) * Yield Strength * Break Strength * Yield Elongation * Break Elongation	ASTM D 638 Type IV	1 per 50,000 sf	 126 lb/in. 90 lb/in. 12 % 100 %
Tear Resistance (min.ave.)	ASTM D 1004 Die C	1 per 50,000 sf	42 lbs
Puncture Resistance (min.ave.)	ASTM D 4833	1 per 50,000 sf	90 lbs
Stress Crack Resistance [4]	ASTM D 5397 (App.)	(12)	200 hours
Carbon Black Content (range)	ASTM D 1603 [5]	1 per 50,000 sf	2-3 %
Carbon Black Dispersion [6]	ASTM D 2663 ASTM D 5596	1 per 50,000 sf	A1, A2, B1 Category 1,2, or 3 [6]
Oxidative Induction Time (OIT)(min.ave.) [7] * Std. OIT, or * High Pressure OIT	 ASTM D 3895 ASTM D 5885	 (12)	 100 min. 400 min.
Oven Aging at 85˚C [5][6] * Std. OIT (min.ave.), % retained after 90 days, or, * High Pressure OIT (min.ave.), % retained after 90 days	 ASTM D5721 ASTM D 3895 ASTM D 5885	(12)	 55% 80%
UV Resistance [9] * Std. OIT (min.ave.), or * High Pressure OIT (min.ave.) % retained after 1600 hours [11]	GM 11 ASTM D 3895 ASTM D 5885	(12)	 (10) 50%

Notes on Table III-2:

(1) Of 10 readings: 8 out of 10 must be $\geq$ 7 mils, and lowest individual reading must be $\geq$5 mils.

(2) Alternate the measurement side for double sided textured sheet.

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 1.3 inches. Break elongation is calculated using a gage length of 2.0 inches.

(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.

(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(6) Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2, and 1 in Category 3.

(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(9) The condition of the test should be 20 hr. UV cycle at 75˚ C followed by 4 hr condensation at 60˚ C.

(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the samples.

(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(12) Manufacturer may provide certification letter.

(13) Based on GRI GM13, Rev. 4, 12/13/00.

The CQA Personnel will report deviations from the above requirements to the Owner prior to installation of the geomembrane.

2.3 Labeling

The CQA Personnel will observe and document that the geomembrane Manufacturer has labeled each roll of geomembrane with sufficient information to correlate the Manufacturer's quality control testing to the material delivered to the site.

The CQA Personnel will examine geomembrane rolls upon delivery and record any deviation from the above requirements.

2.4 Transportation and Handling

Upon delivery at the site, the CQA Personnel will conduct a visual inspection of all rolls for defects and damage, and note the following:

- Any rolls that should be unrolled to allow for their inspection;
- Any rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and,
- Any rolls which include minor repairable flaws.

2.5 Storage

The CQA Personnel will observe and document that storage of the geomembrane is in accordance with this Plan and does not result in deleterious conditions that affect the integrity or constructibility of the material. The geomembrane shall also be placed on a smooth, well-drained surface, free of rocks or any other protrusions, which may damage the material. No special covering is required. Rolls of geomembrane shall not be stacked more than 3 rolls high.

3.0 GEOMEMBRANE INSTALLATION

3.1 Earthwork

3.1.1 Surface Preparation

The Contractor responsible for geomembrane installation will be required to certify in writing that the surface on which the geomembrane will be installed is acceptable, and shall be provided to the CQA Personnel and Owner prior to installing the geomembrane.

The CQA Personnel will observe and document that:

- Areas to receive geomembrane liner shall be smooth and even, and free of excessive moisture, ruts, voids, protrusions, or wrinkles. The Contractor who performs the earthworks shall remove any surface features, which could damage the geomembrane, as determined by the CQA Personnel, Owner, or Geosynthetics Contractor. For earth slopes of 3:1 (horizontal: vertical) or flatter, the final surface prior to receiving geomembrane shall be rolled smooth using a smooth drum roller. For slopes steeper than 3H:1V, dressing of the slopes shall be accomplished by gentle smoothing of the surface with a dozer blade, wheel rolling, or by other methods approved by the CQA Personnel (such as raking the surface by hand). No vehicles shall be allowed on the final dressed surface without the approval of the CQA Personnel.

- All required survey certifications have been provided and the surface has been constructed to the lines and grades required by the plans.

- Special care shall be taken to maintain the prepared surface on which the geomembrane will be installed.

- No geomembrane shall be placed in an area which has been softened by precipitation or which has excessively cracked due to desiccation. Desiccation potential shall be verified in accordance with the procedures specified in Section 4.3.

- The Contractor shall repair any damage to the surface caused by weather, installation activities, or other activities.

A certificate of acceptance from the installation contractor will be required to be given to the CQA Personnel, who will then verify that the subgrade is accepted immediately prior to commencement of geomembrane installation in the area under consideration.

3.1.2 Anchor Trenches

The CQA Personnel will observe and document that the anchor trench backfill meets the requirements of this Plan and that the backfill is placed in accordance with the requirements outlined in this Plan. The CQA Personnel will observe and document that:

- The anchor trench is excavated to the elevations, grades, and width shown on the Construction Drawings.

- No loose soil is present beneath the geomembrane in the anchor trench, which might damage the geomembrane.

- Care is taken when backfilling the anchor trench to prevent any damage to the geomembrane or other geosynthetics.

- The soil material used for backfilling trenches will be compacted using suitable hand-operated or other compaction equipment to the same moisture and density requirements established for the cohesive soil liner if within the lined area, or for the structural fill if outside of the lined area.

- Slightly rounded corners are provided at the top in-board side of the anchor trench to avoid sharp bends in the geomembrane.

3.2 Geomembrane Deployment

3.2.1 Layout Drawing

The Contractor will be required to produce layout drawings, which show the geomembrane panel configuration, dimensions, details, seam locations, etc. The CQA Personnel must approve the layout drawings prior to the installation of the geomembrane. The layout drawings, as modified and/or approved by the CQA Personnel will be part of the project plans, copies will be furnished to the Owner. The CQA Personnel will become familiar with the layout drawings.

3.2.2 Field Panel Identification

A field panel is the unit area of geomembrane, which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field.

The CQA Personnel will observe and document that each field panel is given an identification code (number or letter-number) consistent with the layout plan. This field panel identification code should be as simple and logical as possible. It will be the responsibility of the Contractor to ensure that each field panel placed is marked with the manufacturing plant roll number. The roll number will be marked in the center of the panel in a color to allow for easy inspection.

3.2.3 Field Panel Placement

3.2.3.1 Location

The CQA Personnel will observe and document that field panels are installed at the locations and positions indicated in the Contractor's layout plan, or otherwise as approved by the CQA Personnel.

3.2.3.2 Installation Schedule

The CQA Personnel will evaluate significant changes in the schedule proposed by the Contractor and advise the Owner on the acceptability of that change. The CQA Personnel will observe and document that the condition of the underlying layer has not changed detrimentally during installation. The Contractor will repair any damage to the surface of the underlying layer in accordance with this Plan.

The CQA Personnel will record the identification code, location, and date of installation of each field panel.

3.2.3.3 Weather Conditions

The CQA Personnel will observe and document that geomembrane is not placed during inclement weather conditions as specified within this Plan.

Geomembrane shall not be placed when the ambient temperature is below 40°F (when measured at the crest of the landfill) unless the Contractor has previously submitted a geomembrane cold weather placement and seaming plan and such plan has been approved by the CQA Personnel. Adjacent panels shall be placed under similar temperature conditions, preferably early in the day when temperatures are cooler, to minimize the potential for differential contraction.

Geomembranes shall not be placed during a precipitation event, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds. The CQA Personnel shall determine if the weather conditions are not satisfactory for placement and installation of the geomembrane.

Additionally, the CQA Personnel will observe and document that the underlying layer has not been damaged by weather conditions.

3.2.3.4 Damage

The CQA Personnel will visually observe each panel, after placement and prior to seaming, for damage (e.g., holes, blisters, creases). The CQA Personnel will document which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels that have been rejected by the CQA Personnel will be marked, and the CQA Personnel will document their removal from the work area. The CQA Personnel shall observe

and document that:

- No vehicular traffic is allowed on the geomembrane without sufficient protection.

- Equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.

- Personnel working on the geomembrane do not smoke, consume food or beverages (except for body fluid replenishment), wear damaging shoes, have cans, glass containers, or tools not required for liner placement on the geomembrane, or engage in other activities which could damage the geomembrane.

- The method used to unroll the panels does not scratch or crimp the geomembrane and shall not damage the supporting soil.

- The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels).

- Temporary loads and/or anchors (e.g., sand bags), not likely to damage the geomembrane, shall be placed on the geomembrane to prevent uplift by wind.

- Any field panel or portion thereof which becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material at no expense to the Owner. Less serious damage may be repaired with the approval of the CQA Personnel. Damaged panels or portions of damaged panels which have been rejected shall be removed from the work area at no expense to the Owner.

3.3 Field Seaming

3.3.1 Seam Layout

The CQA Personnel will observe and document that the seam layout shown on the Panel Layout Drawing is consistent with the Plans. No panels may be seamed in the field without the CQA Personnel's approval. In addition, seams not specifically shown on the seam layout drawing or as otherwise approved may not be made without the CQA Personnel's approval.

The Contractor and the CQA Personnel will agree upon a seam numbering system compatible with the panel numbering system. The CQA Personnel will observe and document that:

- In general, seams are be oriented parallel to the line of maximum slope, i.e., oriented down, not across, the slope. No horizontal seam shall be less than 10 feet from the toe of the slope, except where approved by the CQA Personnel.

- In general, the uppermost panels will be shingled over the lowermost panels.

- Seam overlaps shall be a minimum of 3 inches for extrusion welds and 4 inches for double fusion welds.

3.3.2 Seaming Equipment and Products

Methods approved for field seaming are: (i) extrusion seaming; and (ii) fusion seaming, with the preferred method being fusion. Proposed alternate methods will be required to be documented and submitted to the CQA Personnel for approval. Only seaming apparatus, which the CQA Personnel has specifically approved by make and model will be used. The Contractor will be required to use a seaming devices equipped with constant temperature readings to ensure that accurate temperatures of the extrudate and seamer nozzle are being achieved.

The Contractor will be required to provide to the CQA Personnel the Manufacturer's certification that the extrudate is compatible with this Plan and is comprised of the same resin as the geomembrane.

The CQA Personnel will log ambient temperatures, seaming apparatus temperatures, and extrudate temperatures or fusion seaming apparatus speeds. Ambient temperatures will be measured as specified in this Plan.

3.3.3 Seam Preparation

The CQA Personnel will observe and document that:

- Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and,

- If seam overlap grinding is required, the process shall be completed according to the geomembrane Manufacturer's instructions and in a manner that does not damage the geomembrane.

- Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths".

3.3.4 Seaming Requirements and Process

1. <u>General Seaming Requirements:</u>

   i. All geomembrane overlaps shall be continuously seamed using approved procedures.

   ii. Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

   iii. If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface, directly under the seam overlap to achieve proper support.

   iv. If seaming operations are carried out at night, adequate illumination shall be provided.

v. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

vi. At the end of each day or installation segment, all exposed geomembrane edges shall be anchored by sandbags or other approved means. Sandbags securing the geomembrane on side slopes should be connected by a rope fastened at the top of the slope by a temporary anchor. If high winds are expected, boards with weighted sand bags on top may be used to keep wind from getting under the exposed edge of the geomembrane.

2. Seaming Process:

i. Approved processes for field seaming are extrusion welding and fusion welding using equipment that the CQA Personnel has approved by make and model. Alternate processes shall not be used unless a plan for their use has been submitted by the Contractor and approved by the CQA Personnel. Seaming equipment shall not damage the geomembrane.

ii. Extrusion Equipment and Procedures:

a. The Contractor shall maintain at least one spare operable seaming apparatus on site.

b. The extrusion welding apparatus shall be equipped with gauges indicating the temperature in the apparatus and at the nozzle.

c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat-degraded extrudate.

d. The area for extrusion seaming shall be abraded according to manufacturers recommendations to promote bonding. No excessive abrading shall occur.

e. The Contractor shall provide documentation regarding the extrudate to the CQA Personnel and shall certify that the extrudate is compatible with this Plan, and consists of the same resin as the geomembrane.

f. The electric generator for the extrusion welders shall be placed either outside the area to be lined or on a smooth base or other such manner that no damage occurs to the geomembrane.

iii. Fusion Equipment and Procedures:

a. The Contractor shall maintain at least one spare operable seaming apparatus on site.

b. The fusion welding apparatus shall be an automated vehicular mounted device equipped with gauges indicating the applicable temperatures and pressures.

c. A movable protective layer shall be used directly below each geomembrane overlap to be seamed if deemed necessary by the CQA Personnel.

d. The electric generator for the fusion welders shall be placed either outside the area to be lined or on a smooth base or other such manner that no damage occurs to the geomembrane.

e. All fusion welded seam intersections shall be patched in accordance with this Section.

3.3.5 Weather Conditions for Seaming

The CQA Personnel will observe and document that seaming was not attempted at ambient temperatures below 40°F. A cold weather seaming plan will be submitted to the CQA Personnel for approval if seeming is to be attempted at temperatures below 40°F.

3.3.6 Trial Seams

The Contractor will be required to make trial seams on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. The CQA Personnel will observe and document that:

1. Trial seams are made on fragment pieces of geomembrane to verify that seaming conditions are adequate.
2. Such trial seams are made at the beginning of each seaming period (morning and afternoon).
3. Each seamer makes at least one trial seam each day.
4. Trial seams are also made in the event that the ambient temperature varies more than 20°F since the last passing trial seam.
5. The trial seam sample is at least 5 feet long by 1 foot wide (after seaming) with the seam centered lengthwise for fusion trial seams and at least 3 feet long by 1 foot wide for extrusion trial seams.
6. Seam overlap is a minimum of 3 inches for extrusion welding and 4 inches for fusion welding.

The CQA Personnel will observe trial seam testing procedures. Successful trial seam samples will be assigned a number and marked accordingly by the CQA Personnel, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. The sample itself will be retained only until the construction of the liner is complete, and the liner has been accepted by the Owner. The CQA Personnel will observe and document that:

1. Five specimens, each 1-inch wide, are cut from the trial seam sample by the Contractor.
2. Two specimens are tested for shear strength and three specimens are tested for peel. strength using a field tensiometer, or fail in Film Tear Bond (FTB) if a tensiometer is not used.
3. Both tracks of double fusion welds are tested for peel strength on each of the three specimens unless otherwise approved by the CQA Personnel.
4. The test specimens do not fail in the weld and meet or exceed the strength requirements in Table III-3. If a tensiometer is not used, the specimen must fail in FTB to be considered acceptable.

3.3.7 Nondestructive Seam Continuity Testing

3.3.7.1 Concept

Except as otherwise noted in the project requirements, the Contractor will nondestructively test all field seams over their full length in accordance with this Plan. The purpose of nondestructive tests is to check the continuity of seams. Continuity testing will be carried out as the seaming work progresses, not at the completion of all field seaming. Nondestructive testing will not be permitted before sunrise or after sunset unless the Contractor demonstrates to the Owner that the Contractor has the capabilities to perform continuity testing under reduced light conditions.

The CQA Personnel will observe and document:

- Location, date, test unit number, name of tester, and outcome of all testing;
- Document and inform the Contractor of any required repairs.
- If the seam cannot be nondestructively tested after final installation the seam shall be capped with the same type of geomembrane.
- If the seam is accessible to nondestructive testing prior to final installation but not after final installation, the seam shall be nondestructively tested prior to final installation.
- At the discretion of the CQA Personnel, vacuum testing of fusion welded seams may be allowed in lieu of capping fusion welded seams which cannot be air pressure tested.
- If none of the above techniques are practical the CQA Personnel will closely observe and document the seaming process.

3.3.7.2 Test Procedures

<u>Equipment and Procedures for Vacuum Testing</u>

- The equipment for vacuum box testing shall comprise the following:

i. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

ii. A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

iii. A rubber pressure/vacuum hose with fittings and connections.

iv. A bucket and applicator.

v. A soapy solution.

- The following procedures shall be followed:

i. Energize the vacuum pump and reduce the tank pressure to approximately 2 psi gauge.

ii. Wet a strip of geomembrane seam approximately 4 inches by one and one half times the length (minimum) of the vacuum box with the soapy solution.

iii. Place the box over the wetted area.

iv. Close the bleed valve and open the vacuum valve.

v. Ensure that a leak tight seal is created as evidenced by a negative box pressure of a minimum 2 psi gauge.

vi. Examine the geomembrane through the viewing window for a sufficient period of time as determined by the CQA Personnel to ensure no soap bubbles appear indicating a leak.

vii. If no bubbles appear, close the vacuum valve and open the bleed valve, move the box to the next adjoining area with a minimum 3 inches overlap, and repeat the process.

viii. All areas where soap bubbles appear shall be marked with a marker that will not damage the geomembrane and repaired in accordance with this Plan with no additional cost to the Owner.

<u>Equipment and Procedures for Air Pressure Testing (For Double-Fusion Seams Only)</u>

- The following procedures are applicable to those processes, which produce a double seam with an enclosed space.

- The equipment shall comprise the following:

i. An air pump (manual or motor driven), equipped with a pressure gauge, capable of generating and sustaining a pressure between 25 and 30 psi, and mounted on a cushion to protect the geomembrane.

ii. A rubber hose with fittings and connections.

iii. A sharp hollow needle, or other approved pressure feed device.

- The following procedures shall be followed:

i. Seal both ends of the seam to be tested.

ii. Insert needle, or other approved pressure feed device, into the tunnel created by the fusion weld.

iii. Insert a protective cushion between the air pump and the geomembrane if necessary to protect the geomembrane from damage.

iv. Energize the air pump to a gauge pressure between 25 and 30 psi, close valve, and sustain the pressure for not less than 5 minutes.

v. If the loss of pressure exceeds 2 psi, or does not stabilize, locate faulty area and repair in accordance with this Plan.

vi. At the end of the test, release the air channel at the end of the seam opposite the needle and verify air flow to ensure that the entire seam length was tested.

vii. Remove the needle, or other approved pressure feed device, and repair all test penetrations in accordance with this Plan unless needle penetration is outside of ultimate lined area (i.e. outbound of anchor trench).

The Contractor will be required to complete any required repairs in accordance with this Plan.

The CQA Personnel will observe and document the repair and re-testing of the repair.

The CQA Personnel will observe and document where seams cannot be nondestructively tested. The location, date of visual observation, will be recorded by the CQA Personnel.

3.3.8 Destructive Seam Testing

3.3.8.1 Concept

Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength and integrity. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming.

3.3.8.2 Location and Frequency

The CQA Personnel will select locations where seam samples will be cut out for laboratory testing. The test frequency and locations will be established as follows:

- Samples will be collected at a minimum frequency of one test location per 500 linear ft of seam length (this minimum frequency is to be determined as an average taken throughout the entire landfill); and,

- Test locations will be determined during seaming at the CQA Personnel's discretion; selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming.

The Contractor will not be informed in advance of the locations where the seam samples will be taken.

3.3.8.3 Sampling Procedure

The Contractor will be required to cut samples as directed by the CQA Personnel as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Personnel will:

- Observe sample cutting;
- Assign a number to each sample and mark it accordingly;
- Record the sample number and location on the panel layout drawing; and,
- Record the reason for taking the sample at this location (e.g., routine testing, suspicious feature of the geomembrane, etc.).

All holes in the geomembrane resulting from destructive seam sampling will be repaired by the Contractor following field destructive testing and approval of the seam by the CQA Personnel. The new seams in the repaired area will be nondestructively tested in accordance with the repair procedures described in this Plan.

3.3.8.4 Size of Samples

At a given destructive test sampling location, two types of samples will be required to be taken by the Contractor.

First, two specimens for field testing will be taken. Each of these specimens will be 1 inch wide by 6 to 12 inches long, with the seam centered parallel to the width. The distance between these two specimens will be a minimum of 42 inches. If both specimens pass the field test described in this Plan, a sample for laboratory destructive testing will be taken from between the specimens.

The destructive sample will be 12 inches wide by a minimum 42-inches long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- One portion to the Contractor, minimum 12 inches long;
- One portion to the Owner for archive storage, minimum12 inches long; and,
- One portion to the CQA Personnel for CQA Laboratory testing, minimum12 inches long.

3.3.8.5 Field Testing

The two 1-inch wide specimens specified above will be required to be tested in the field, by the Contractor, by tensiometer for peel and shear (see Table III-3 for required values) and should not fail in the weld. If a tensiometer is not used, each specimen must fail as FTB with no evidence of seam separation or distortion to be considered acceptable. If any field test sample fails to pass, then the procedures outlined in the Section 3.3.8.7 will be followed.

The CQA Personnel will observe field tests and observe that the contractor has marked all samples and portions with their number, date, and time.

3.3.8.6 Geosynthetic Construction Quality Assurance Laboratory Testing

Laboratory destructive test samples will be packaged and shipped to the CQA Laboratory by the CQA Personnel in a manner which will not damage the test sample.

The CQA Personnel will store the archive samples until the completion of the project. Laboratory destructive test samples will be tested by the Geosynthetics CQA Laboratory.

Testing will include Shear Strength, Peel Strength, Shear Elongation at Break, and Peel Separation (GRI-GM19, ASTM D 6392). The minimum acceptable values to be obtained in these tests are those indicated in Table III-3 below. At least 5 specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear). At least 4 out of 5 of the specimens must pass for the seam to be considered acceptable; the 5^{th} specimen can be as low as 80% of the listed values.

TABLE III-3 - REQUIRED GEOMEMBRANE SEAM PROPERTIES (smooth or textured)		
Property	**Test Method**	**60 Mil HDPE**
Wedge Seams		
Shear strength, lb/in	ASTM 6392, GRI-GM19	120
Shear elongation at break, %	ASTM 6392, GRI-GM19	50
Peel strength, lb/in	ASTM 6392, GRI-GM19	78
Peel separation, %	ASTM 6392, GRI-GM19	25
Extrusion Fillet Seams		
Shear strength, lb/in	ASTM 6392, GRI-GM19	120
Shear elongation, %	ASTM 6392, GRI-GM19	50
Peel strength, lb/in	ASTM 6392, GRI-GM19	78
Peel separation, %	ASTM 6392, GRI-GM19	25
Note: 1. Only the Peel and Shear strength measurements are required for field testing		

The Geosynthetics CQA Laboratory will provide test results verbally to the CQA Personnel in a timely manner after they receive the samples. The CQA Personnel will review laboratory test results as soon as they become available, and inform the CQA Personnel and Contractor of the test results.

3.3.8.7 Procedures for Destructive Test Failure

The procedures specified within this Plan will be required whenever a sample fails a destructive test, whether that test is conducted by the Geosynthetics CQA Laboratory, the Contractor's laboratory (if required), or by field tensiometer. The CQA Personnel will observe and document that one of the options specified within this Plan and listed below is followed. The Contractor shall have two options:

i. The Contractor can reconstruct the seam(s) (e.g., remove the old seam(s) and re-seam, or cap the seam(s)) between any two passed test locations.

ii. The Contractor can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take test specimens (a minimum 1-inch wide) for an additional field destructive test at each location. If these field destructive tests pass, then the seam(s) shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam shall be reconstructed. In cases exceeding 150 feet of reconstructed seam(s), a sample taken from within the reconstructed zone must pass destructive testing. Whenever a sample fails, the CQA Personnel may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift at no additional cost to the Owner.

Should three consecutive failing destructive tests be performed on a single welding apparatus, the apparatus shall not be permitted to weld until the machine has been repaired and successfully passed three consecutive trial seams.

The CQA Personnel will document all actions taken in conjunction with destructive test failures.

3.4 Defects and Repairs

3.4.1 Identification

All seams and non-seam areas of the geomembrane will be inspected by the CQA Personnel for evidence of defects, holes, blisters, un-dispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be required to be clean at the time of examination. The geomembrane surface will be required to be broomed or washed by the Contractor if the amount of dust or mud inhibits examination.

3.4.2 Evaluation

Each suspect location both in seam and non-seam areas will be required to be either non-destructively tested using the methods described in this Plan, or repaired as appropriate as determined by the CQA Personnel. Each location which fails the non-destructive testing will be marked by the CQA Personnel and will be required to be repaired by the Contractor. Materials should not be placed over geomembrane locations that have been repaired until the CQA Personnel has approved the repair.

3.4.3 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the CQA Personnel will visually inspect the geomembrane for wrinkles. The CQA Personnel will indicate to the Contractor which wrinkles, if any, should be cut and re-seamed. The seam thus produced will be tested like any other seam. As a general requirement, any wrinkle that can potentially fold over on itself shall be cut out and repaired, or otherwise removed to the satisfaction of the CQA Personnel.

3.4.4 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test will be repaired by the Contractor in accordance with the applicable method identified within this Plan.

The CQA Personnel shall observe and document that one or more of the following repair procedures are used:

- Patching, used to repair holes, tears, intersections of fusion-welded seams, and undispersed raw materials;

- Abrading and spot extrusion welding, used to repair small sections of extruded seams and air

pressure test needle holes within the lined area;

- Spot reinforcement using a bead of extrudite, to strengthen areas where the geomembrane has been scratched, the geomembrane thickness has been reduced, or other minor, localized flaws exist;

- Capping, used to repair failed seams; and,

- Removing failing seams and replacing them with strips of new material seamed into place (used with long lengths of fusion seams).

In addition, the following items will be satisfied:

- Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches; and,

- The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

- Surfaces of the geomembrane which are to be repaired by extrusion methods shall be abraded prior to the repair;

- All surfaces must be clean and dry at the time of repair;

- All seaming equipment used in repair procedures must be approved by the CQA Personnel;

- The repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the CQA Personnel;

3.4.5 Testing of Repairs

Each repair will be located and logged by the CQA Personnel. Each repair will be non-destructively tested using the methods described in this Plan as appropriate. Repairs which pass the non-destructive test will be considered as an adequate repair. Large caps may be of sufficient extent to require destructive testing, at the discretion of the CQA Personnel. Failed tests will require the repair to be redone and retested until passing test results are obtained. The CQA Personnel will observe the non-destructive testing of repairs and will document the date of the repair and test outcome.

3.5 Appurtenances

The CQA Personnel will observe and document that:

- Installation of the geomembrane around, and connection of geomembrane to appurtenances (if any) have been made according to this Plan;

- Extreme care is taken while seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and,

- The geomembrane has not been visibly damaged while being connected to appurtenances.

3.6 Geomembrane Tie-In

When necessary to join, or tie-in, geomembrane from two separate construction phases, the following procedures shall be followed:

- The edge or termination of the existing geomembrane will be located by previous survey information or visual identification. The surface of the geomembrane shall be carefully exposed a sufficient distance to allow for the proper tie-in of the cohesive soil liner and leachate collection drainage system as discussed previously in this document. In order to expose the geomembrane surface without damage, it may be necessary to carefully remove any overlying materials from the geomembrane.

- The existing geomembrane will be folded back sufficiently to allow for tie-in of the cohesive soil liner. Adequate space should be allowed to provide proper compaction of the underlying cohesive soil liner by construction equipment without damage to the geomembrane.

- The folded portion of geomembrane shall be adequately anchored (temporarily) in a manner to avoid damage to the liner and prevent movement by wind for the duration of the tie-in procedure.

- Once the phases of the cohesive soil liner are properly constructed and approved by CQA Personnel, the existing geomembrane will be unfolded back over the cohesive soil liner.

- CQA Personnel shall inspect the exposed portion of the geomembrane for any damage, and shall direct repairs in compliance with this Section III.

- The edge of the existing geomembrane shall be cleaned as necessary for seaming in compliance with this Section III.

- The new geomembrane shall be placed, overlapping the existing geomembrane a sufficient minimum distance for seaming in accordance with this Section III. The upgradient geomembrane shall overlap the top of the downgradient geomembrane.

- The two geomembranes shall be seamed using equipment and procedures specified for joining panels of geomembrane in compliance with this Section III.

- In compliance with this Section III, 100% of the seams used to tie-in geomembranes constructed in separate phases shall be tested either by vacuum box or air pressure methods as appropriate, and meet the same criteria for approval as other seams. CQA Personnel shall pay particular attention to the seaming, testing, and visual integrity of tie-in seams.

- All leaks or damaged areas shall be repaired in accordance with this Section III.

- Tie-in seams shall be included in the linear footage measurements for determining the appropriate number of destructive samples to be collected for laboratory strength testing.

- CQA Personnel shall document any adverse conditions noted with tie-in operations.

4.0 SURVEYING

The Contractor will be required to prepare an "as-built" Record Drawing for geomembrane installations. It will include the location of field panels, seams (factory and field), repairs, and test locations. It is not required that the field panels, seams, repair and test locations be surveyed; however the length of seams and locations of repairs, caps, destructive test locations, etc. shall be located by field measurements to a sufficient degree for accurate placement on the as-built drawing.

The CQA results (Record Drawing and certification of Contractor's work) must be submitted and approved by the CQA Personnel prior to proceeding with construction of any subsequent liner system components.

SECTION IV - GEOTEXTILE CONSTRUCTION QUALITY ASSURANCE

1.0 GEOTEXTILES

The geotextile material overlays the six-inch leachate drainage material on the base of the disposal cell as a filter media to minimize plugging of the drainage layer by fines. To minimize the potential for damage to the geotextile prior to being covered with waste, the Owner may place the geotextile in accordance with this plan after regulatory approval has been granted for filling in the cell and as filling progresses. Documentation of the geotextile placement will be placed in the facility operating record by the Owner.

1.1 Geotextile Conformance Evaluation and Manufacturing Quality Control

The geotextile material shall be a 10 oz per square yard material meeting the following basic criteria:

- Retain its structure during handling, placement, and long-term service,
- Meet any additional requirements listed on the Construction Drawings.

In addition, the material shall meet the minimum required properties as specified in Table IV-1 below.

TABLE IV-1 REQUIRED GEOTEXTILE PROPERTIES

Properties	Test Method	Manufacturer QC Test Frequency (2)	Required Test Values
Polymer Composition	NA	NA	95% polypropylene, polyester, or polyethylene, by weight
Manufacturing	NA	NA	Needle punched, non-woven from continuous filaments or stapled fibers
Mass/Unit Area (min.ave.)	ASTM D5261	1 per 100,000 sf	9.1 oz/sy
Apparent Opening Size (max) (1)	ASTM D4751	1 per 540,000 sf	0.25 mm
Grab Strength (min.ave.)	ASTM D4632	1 per 100,000 sf	230 lbs
Puncture Strength (min.ave.)	ASTM D4833	1 per 100,000 sf	120 lbs
U.V. Resistance	ASTM D4355	1 per resin formulation	70% (3)
Permittivity (min.)	ASTM D4491	1 per 540,000 sf	0.9(sec^{-1})

Notes: (1) Apparent Opening Size shall only be tested for geotextiles used in filter applications.
(2) Manufacturer may elect to provide certification of values for geotextiles.
(3) After 500 hours of exposure

If a geotextile sample fails to meet the quality control requirements, the material shall be rejected.

1.2 Labeling

The geotextile Manufacturer shall labeled all rolls of geotextile with sufficient information to correlate manufacturers quality control test results with the rolls of material delivered to the site.

If any special handling is required, it shall be so marked on the geotextile itself, e.g., "This Side Up" or "This Side Against Soil to be Retained".

1.3 Handling and Placement

The geotextile will be handled in such a manner as to ensure the geotextile is not damaged in any way. Handling and installation of the geotextile will be conducted in accordance with the following general specifications.

- Just prior to geotextile placement, the leachate drainage layer will be inspected for sharp stones, sticks, or any other deleterious materials that could potentially damage the geotextile.
- In the presence of excessive wind, the geotextile is weighted with sandbags or equivalent.
- Geotextile at the limits of the drainage layer shall extend past the drainage layer limits a sufficient distance to completely cover the drainage layer and allow for anchorage with soils, sandbags, or other non-damaging materials.
- Geotextile is kept under tension to minimize the presence of wrinkles in the geotextile. If necessary, the geotextile is positioned by hand after being unrolled to minimize wrinkles.
- If Geotextile is cut in place, special care is taken to protect other materials (such as underlying geosynthetics) from damage, which could be caused by the cutting.
- Necessary precautions are taken to prevent damage to the underlying layers during placement of the geotextile.
- During placement of geotextiles, care is taken not to entrap in the geotextile stones, excessive dust, or moisture that could damage the underlying layers, generate clogging of drains or filters, or hamper subsequent seaming.
- Geotextile is not left exposed for a period in excess of that recommended by the Manufacturer.

1.4 Seams and Overlaps

All geotextile seams shall be oriented, overlapped and seamed in accordance with this Plan:

- Geotextile overlaps are continuously heat lystered or sewn according to manufacturers recommendations, or alternatively overlapped a minimum of 12-inches.

- Geotextiles are overlapped a minimum 4 inches prior to lystering.

- No horizontal seams exist on slopes steeper than 5:1 (horizontal:vertical) (i.e., seams shall be oriented down, not across, the slopes), except as part of a patch.

1.5 Repair

Any holes or tears in the geotextile are repaired in accordance with the requirements of this Plan. Any holes or tears in the geotextile shall be repaired with a patch made from the same geotextile overlapped a minimum four inches and heat lystered or sewn into place, or 12 inches if not lystered. Care shall be taken to remove soil or other material which penetrates torn geotextile, seams, or overlaps.

1.6 Placement of Overlying Materials

Precautions taken when placing materials over the geotextile to prevent damage.

- Generally, soil like wastes that contain heavy, bulky, or sharp items that could damage the geotextile will not be placed directly on the geotextile. The geotextile shall be sufficiently anchored to prevent wind damage prior to the owner placing the wastes.

- All equipment operating on soil material overlying the geotextile shall have sufficiently low ground pressure to prevent damage to the geotextile.

1.7 Geotextile Tie-In

When necessary to join, or tie-in, geotextile constructed in different construction phases, the following procedures shall be used:

- The edge of the existing geotextile will be located either by previous survey information or by visual identification.

- The geotextile shall be exposed a sufficient distance back from the edge to allow the underlying components to be tied-in, and folded back with sufficient space provided to prevent damage to the geotextile during tie-in operations.

- The folded geotextile shall be temporarily anchored in a manner to avoid damage and hold it

in place through the duration of the tie-in construction.

- Once the underlying components have been tied-in to the satisfaction of CQA Personnel, the existing geotextile will be unfolded back over the tie-in zone.

- CQA Personnel shall closely inspect the existing geotextile to determine if any repairs are necessary.

- The new geotextile shall be overlapped with the existing geotextile, and continuously heat lystered, sewn, or alternatively overlapped a minimum of one foot in compliance with this Section IV.

- CQA Personnel shall document any adverse conditions noted with tie-in operations.

SECTION V – HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS CONSTRUCTION QUALITY ASSURANCE

1.0 HDPE PIPE MANUFACTURE AND DELIVERY

The sumps in disposal Cells 1, 2, 3, and 19/20 have been constructed with Polyvinyl Chloride leachate removal pipes in the sump. All future ISW and MSW sumps are to be constructed with a 12-inch diameter HDPE leachate riser pipe connected to a 24-inch diameter slotted HDPE lateral pipe in the base of the sump for removal of leachate.

Because the function of the leachate collection drainage material, sump drainage material, and sump lateral and removal pipes is dependent upon the characteristics of each individual component, the CQA Personnel shall approve of each of these components prior to their use on site.

1.1 Manufacturing

Prior to incorporating the HDPE pipe and fittings into the work, the Contractor will be required to provide the CQA Personnel with the Manufacturer's certification verifying the pipe meets project specifications and minimum requirements.

1.2 HDPE Pipe and Fittings Properties

A. The Contractor shall provide pipe having the nominal diameters shown on the Construction Drawings.

B. All piping shall be approved by the CQA Personnel for the intended use prior to delivery to the site.

C. All sump HDPE pipe and fittings shall have a minimum Standard Diameter Ratio (SDR) of 17 unless otherwise indicated on the Construction Drawings.

D. All HDPE pipe and fittings shall have a minimum hydrostatic design basis (HDB) of 1,600 pounds per square inch when determined in accordance with ASTM D 2837 unless otherwise indicated on the Construction Drawings.

E. All HDPE pipe and fittings shall comply with ASTM F 714.

F. HDPE pipe shall be supplied in standard laying lengths not exceeding 50 feet. Joints shall be joined by butt-fusion according to Manufacturer's instructions.

G. HDPE pipe shall be furnished non-slotted or slotted to meet the requirements of the

Construction Drawings.

H. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes (other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.

1.3 Labeling

The following shall be printed on the polyethylene pipe or accompanying shipping papers:

- Name and/or trademark of the pipe Manufacturer.
- Nominal pipe size.
- Standard dimension ratio (SDR).
- The letters PE followed by the polyethylene grade per ASTM D 1248, followed by the hydrostatic design stress in 100's of psi (i.e., PE 3408).
- Manufacturing Standard Reference (e.g., ASTM F 714-1).
- A production code from which the date and place of manufacture can be determined.

1.4 Shipment and Storage

Pipe and fittings shall be stored on clean, level ground, free of sharp objects, which could damage the pipe. Stacking shall be limited to a height that will not cause excessive deformation of the bottom layers of pipe under anticipated temperature conditions. Where necessary due to ground conditions, the pipe shall be stored on wooden sleepers that are spaced suitably and of such width as not to allow deformation of the pipe. The pipe shall be stored to minimize bowing.

The CQA Personnel will visually inspect the pipe upon delivery at the site for any deviations from the requirements of this Plan.

2.0 PIPE INSTALLATION

2.1 Handling and Laying

The CQA Personnel will observe and document that the pipe is installed at the specified locations and grades and that placement of backfill around and over the pipe is conducted in accordance with the requirements of this Plan, and in a manner intended to prevent damage to the pipe.

The CQA Personnel will observe and document that:

- Ropes, fabric, or rubber-protected slings and straps are used when handling pipe. Slings, straps, etc. are not be positioned at butt-fused joints. Chains, cables or hooks are not be inserted into the pipe ends as a means of handling pipe.

- Pipe or fittings are not dropped onto rocky or unprepared ground. The pipe and fittings are not dropped into trenches or dragged over sharp objects.

- The CQA Personnel will carefully examine the pipe and fittings before installation. The CQA Personnel will observe and document that cracks, damage or defects are not present in the pipe and fittings in excess of that allowed by the plans.

- The depth of cuts, gouges, or scratches on the exterior surface of pipe or fittings is less than 10 percent of the wall thickness. The interior of the pipe and fittings shall be free of cuts, gouges and scratches. Sections of pipe with excessive cuts, gouges, or scratches will be rejected and the Contractor will be required to remove and replace the rejected pipe, at no additional cost to the Owner.

- The CQA Personnel will also note the condition of the interior of pipes and fittings. Foreign material shall be removed from the pipe interior before it is moved into final position.

- Whenever pipe laying is not actively in progress, the open end of pipe that has been placed shall be closed, or otherwise by whatever means are effective, to prevent entry of water or foreign objects.

- Where pipes penetrate through geomembranes, an effective seal shall be established in accordance with this Plan as well as the details shown on the Construction Drawings.

The CQA Personnel will document any deviation from the above requirements.

2.2 Joints and Connections

Lengths of SDR 17 HDPE pipe will be required to be assembled into suitable installation lengths by the butt-fusion process. Butt-fusion refers to the butt-joining of the pipe by softening the aligned faces of the pipe ends in a suitable apparatus and pressing them together under controlled pressure. Other joining methods may be used if approved by the CQA Personnel.

Field cutting of pipe shall be carefully made, without damage to pipe or lining system components, so as to leave a smooth end at right angles to the axis of pipe. Manufacturer's recommended cutting devices shall be used. Sharp edges of cut ends shall be filed off smooth. Flame cutting will not be allowed.

The CQA Personnel will monitor butt fusion welding operations to ensure that the Contractor follows the project requirements and Manufacturer's recommendations.

The CQA Personnel will document any noncompliance with the above requirements.

2.3 Surveying

The Surveyor will survey the location and final elevation of the end points of all HDPE leachate pipe in accordance with the requirements of Section II-2.

The CQA Personnel will review the results of the survey. The CQA Personnel will approve the results before any subsequent construction that completely covers the pipe occurs.

SECTION VI - CONSTRUCTION QUALITY ASSURANCE DOCUMENTATION

1.0 DOCUMENTATION

1.1 Introduction

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored, and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of construction quality assurance activities. The CQA Personnel will document that all quality assurance requirements have been addressed and satisfied.

The CQA Personnel will provide the Owner with signed descriptive remarks, data sheets, and logs to verify and document that all monitoring activities have been carried out. The Owner will maintain at the site a complete file of Construction Drawings, the CQA Plan, project Specifications, and Construction Certification Report. The Construction Certification Report must be signed and stamped by a Colorado Registered Professional Engineer and approved by CDPHE, Tri-County Health Department, and Adams County before landfilling can begin. The report will be placed in the facility operating record.

1.2 Record Keeping

1.2.1 Overview

Records will be kept documenting CQA project administration, soils CQA, geosynthetics CQA, and other required CQA activities. Most information will be recorded on forms specific to the information as detailed below. The format of the information recorded for CQA purposes may vary; however the information listed below shall be required to be recorded in some fashion.

1.2.2 Daily Field Report Form

Most project administration records are completed daily by the CQA Personnel. A brief summary is presented below of these forms.

The Daily Field Report will be prepared by the CQA Personnel. At a minimum, the Daily Field Report will include the following information:

- The date, project name, location, and other identification;
- A narrative of the events and activities, including meetings and observation which occurred during a given day;
- The name of parties to any discussions;
- The weather conditions;

1.2.3 Soils CQA Records

Records kept for soils related activities will be completed by the CQA Personnel. The information will be recorded as testing is done in the field or as results are received from the laboratory. The records will be available for review on site, and copies will be issued as part of the Certification Report.

Sample Testing Tracking Log

This form will be used to track all soil samples obtained and submitted for lab testing, The sample identification numbers, the date the sample was collected, the analyses to be completed upon submittal, and the results of the analyses.

Field Moisture and Density Test Log

This form will provide a list of sample points for the moisture and density tests, field nuclear moisture and density test results, Proctor results, and drive tube cylinder density and moisture sample identification and test results.

1.2.4 Geosynthetics CQA Records

Records for the installation of geosynthetics will be completed by the Contractor's or installers QC representative and/or the CQA Personnel. The information will be recorded as the work progresses. The records will be available for review on site and copies will be issued as part of the Construction Certification Report.

Material Inventory

The identifying roll number and pertinent information of each roll of geosynthetic received at the site will be recorded as the materials arrive at the site. This information will be used to track manufacturer's quality control information, conformance test samples, and other CQA documentation.

Nondestructive Test Log

The time, date, equipment operator, and results of vacuum box or air pressure testing of production geomembrane seaming operations will be recorded.

Panel Placement Monitoring Log

Geomembrane panel numbers will be documented as they are placed in the field, and cross-referenced with roll numbers. The weather conditions, time, and temperature at placement will be recorded on the log. Measured dimensions used to calculate the area of the geomembrane will be

recorded on the log.

Repair Summary Log

Information on major repairs to geomembrane panels and seams will be recorded. The information recorded will include a code to describe the type of repair, the name of the operator making the repair, the location (i.e. seam or panel location) of the repair, nondestructive testing results of the repair, and initials of the responsible party on site for the Contractor.

Destructive Test Log

The location and results from testing performed on geomembrane seams at the CQA Laboratory (an independent testing laboratory) as well as those conducted in the field will be recorded. The test results for both peel and shear will be recorded. The log will be completed as data becomes available.

Trail Seam and Seaming Log

The results of trial geomembrane seam testing and to track production seaming activities will be documented. The time, temperature, type of seaming equipment used, name of seamer, and length of seam will be recorded. This form will be maintained by the geosynthetics contractor and reviewed by the CQA Personnel.

Certificate of Acceptance Subgrade Surface

The Certificate of Acceptance is required to be signed by the installation Contractor prior to the installation of the geomembrane. The area being accepted must be described on the certificate.

1.2.5 Pipe CQA Records

The documentation necessary to demonstrate compliance with these plans will be recorded, and may include manufacturer's specifications and labels from the piping delivered to the site.

1.2.6 Survey Records

The CQA Personnel will review record Drawings and Survey Certification Tables resulting from the surveying performed by the Surveyor. The Record Drawings and Tables will be available for review onsite, and will be included as part of the Construction Certification Report issued by the CQA Personnel. At a minimum, the Records Drawings and Tables will include as-built survey and CQA observation data for the following liner system components:

- Excavation Subgrade
- Cohesive soil liner
- Structural fill (if any)
- Leachate Collection Drainage Layer
- Polyethylene pipe
- Geosynthetic liner anchor trench
- Base and top of cohesive soil cap
- Top of miscellaneous protective soil
- Base and top of moisture storage layer
- Top of topsoil

1.3 Photographic Documentation

Photographic documentation will serve as a pictorial record of work progress, problems, and mitigation activities. All phases and components of the construction will be documented by photos. Selected photographs will be reproduced as part of the Construction Certification Report.

1.4 Design and/or Specification Changes

Design and/or specification changes may be required during construction. In such cases, the CQA Personnel will notify the Owner. If changes are of a substantial nature, the Owner will notify CDPHE and Adams County.

1.5 Signatures and Final Reports

Upon completion of the work, the CQA Personnel will submit a Construction Certification Report for submittal to CDPHE, TCHD, and Adams County for approval.

At a minimum, this report will include: (a) summaries of all construction activities; (b) observation logs and testing data sheets including sample location plans; (c) a discussion of any changes from design and material specifications; (d) CQA Record Drawings and Survey Certification Tables certified and sealed by the licensed surveyor; and (e) a summary statement sealed and signed by a Professional Engineer licensed in the State of Colorado that construction quality assurance was conducted in substantial compliance with the approved CQA Plan and, based on visual observations and data generated in accordance with the CQA Plan, the landfill was constructed in substantial conformance with the approved design, except as properly authorized and documented in the Construction Certification Report.

ATTACHMENT 1

ADDENDUMS AND REVISIONS
ERRATA FOR UPDATES AND REVISION

DATE	DESCRIPTION OF REVISION	BY
May 2003	Original Plan	AEC
May 2005	Updated to reflect approved elimination of leachate collection pipe	AEC
April 25, 2007	Updated to add option for alternative final cover system; includes new Section 8.0 for Moisture Storage Layer and additional requirements for Topsoil in AFC system	AEC
September 13, 2009	Added to the note on Table II-4 that the CQA Personnel's ability to waive the grain size would not result in damage to the underlying HDPE liner.	AEC