IGES®

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December 23, 2013

RECEIVED
DEC 23 2013
Utah Division of Water Quality

State of Utah – Department of Environmental Quality
Division of Water Quality
288 North 1466 West
P.O. Box 144870
Salt Lake City, Utah 84111-4870

Attention: Mr. Woodrow W. Campbell, P.E.

Subject: CS Mining, LLC
Lined Supernatant Clarification Ponds Permit
West of Milford, Utah

The attached design plans and construction specifications are submitted for your review and approval addressing the addition of a lined pond clarification system along the south side of the existing permitted tailings pond at the CS Mine near Milford, Utah. The additional ponds, exist in a fashion with embankments constructed previously, but have never been lined or placed in service as proposed herein. The attached design is an interim solution to be used for clarification of accumulating supernatant from the tailings facility until the permitted expansion can be completed. As you know, in your recent discussions with David McMullen, General Manager at CS Mining, the onset of abnormally harsh cold winter temperatures has necessitated this request in order to keep the mill operating effectively.

As the drawings show, we are proposing the use of an EPDM material for lining to facilitate the cold weather construction to line the ponds. Since the ponds have been partially developed previously, earthwork will be minimized and mostly be relegated to pond bottom leveling to prepare for liner installation and trimming the interior slopes for same. Only a limited amount of compacted fill placement is projected for developing final pond system geometry.

Because of the limited depth of the ponds, the fact that they are principally in cut, a limited amount of detailed engineering has been performed to develop the plans. We trust you will find this adequate considering the size of the ponds and urgency of the situation to get them constructed and in operation.

Should you have any questions, please do not hesitate to call me at (801)-270-9400 or my cell (801)-243-9603.

Respectfully submitted,
IGES, Inc.

PROFESSIONAL ENGINEER
157087
JOHN F. WALLACE
12/23/2013
ELECTRONIC SEAL
STATE OF UTAH

John F. Wallace, P.E., D.GE.
Principal

Attachments:
Drawings 1 -3
Specifications

CONSTRUCTION PERMIT ISSUED BY
Utah Department of Environmental Quality
Utah Division of Water Quality

Date: 16 Jan 2014

Review Engineer:

Director:

Document Date 12/23/2013

DWQ-2013-008699

TECHNICAL SPECIFICATIONS

For

LINED SUPERNATANT CLARIFICATION POND SYSTEM CONSTRUCTION CS MINING

Division 1 – General Requirements

SECTION	01011	Summary of Project
	01039	Project Coordination and Meetings
	01300	Submittals
	01500	Temporary Controls
	01600	Materials, Labor and Equipment
	01700	Contract Closeout

Division 2 – Site Work

SECTION	02200	Site Preparation
	02300	Earthwork
	02400	Subgrade Preparations
	02771	45-mil smooth EPDM

PROFESSIONAL ENGINEER
157987
JOHN F. WALLACE
12/23/2013
ELECTRONIC SEAL
STATE OF UTAH

DIVISION 1 - GENERAL REQUIREMENTS

SECTION 01011

SUMMARY OF PROJECT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Work included

B Summary of Work

1.2 RELATED SECTIONS

A. Section 01039 – Project Coordination and Meetings

B. Section 01300 – Submittals

C. Section 01500 – Temporary Controls

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 WORK INCLUDED

A. Construction of approximately 3.2 acres of lined temporary lined supernatant storage ponds. Work includes finish grading of existing two-pond system including bottom and excavation of side slopes, limited fill placement, anchor trench construction and placement of 45-mil smooth EPDM liner.

   Work includes excavation of 17,500 cubic yards and placement, compaction and grading of approximately 5,500 cubic yards of soil. Final subgrade preparation and certification of base soil for placement of EPDM liner.

   Furnish and install approximately 138,500 square feet of smooth 45-mil ethylene propylene diene monomer (EPDM) geomembrane.

B. Load, haul, place, compact and grade approximately 5.500 cubic yards of fill material from cut.

C. Excavate, load, haul and stockpile 12,000 cubic yards of excess cut and spoil material..

1.4 SUMMARY OF WORK

A. The construction of work will be performed in conjunction with the ongoing relocation of the existing tailings distribution pipes, the installation of new tailings discharge assemblies and initiation of raise construction. CONTRACTOR to perform the following work:

- Submit Health and Safety Plan to OWNER for review and approval
- Submit Construction Schedule to OWNER for review and approval
- Submit Quality Control Plan to OWNER for review and approval
- Submit Earthmoving Plan to OWNER for review and approval

B. Perform final subgrade preparation for placement of EPDM. Preparation of subgrade includes mass excavation and mass fill operations including compaction of fill soil where required. CONTRACTOR is required to certify, in writing (subgrade acceptance form), that the subgrade soil is adequate for the installation of liner materials prior to placement of EPDM.

D. Furnish and install 45-mil smooth EPDM as detailed on the construction drawings. Final locations and final details will be confirmed with the issue of construction drawings prior to work commencing. Quantities are not expected to change more than ten percent (10%) from bidding documents to construction documents.

E. All products are to be installed or placed in accordance with standards required by respective manufacturer(s).

F. Anchor geomembrane securely in place to prevent the movement of installed materials. Anchoring of all materials shall be performed with sandbags, anchor trenches or other ENGINEER approved methods.

G. Sequence installation to ensure that all operations are achieved in an orderly and expeditious manner.

H. Touch-up minor damaged surfaces caused during delivery, storage, handling and installation. Replace damaged components as necessary.

I. Installation will not be considered complete until the liner and other materials are completely accepted by the ENGINEER including any required quality control documentation.

PART 1 PRODUCTS

Not Used.

PART 2 EXECUTION

Not Used.

END OF SECTION

SECTION 01039

PROJECT COORDINATION AND MEETINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Prime CONTRACTOR Responsibilities

B. Preconstruction Meeting

C. Daily Meetings

D. Weekly Meetings

E. Work Deficiency Meetings

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01300 – Submittals

C. Section 01500 – Temporary Controls

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 PRIME CONTRACTOR RESPONSIBILITY

A. Coordination

1. The prime CONTRACTOR, herein referred to as "CONTRACTOR", shall properly coordinate all work, expediting the work of the various trades as necessary so that the different elements are built and installed in proper sequence and so that the parts fit together in a neat, tight, and professional manner and function properly and as intended at completion of the work without interruption of continued operation of the tailings impoundment operations.

2. The CONTRACTOR shall see to it that orders for manufactured items, which he is to furnish as called for under this contract and specifications and under his direction, are ordered by the various trades involved and are delivered to the site at the proper time.

3. The CONTRACTOR and the various trades working under his leadership and direction shall coordinate their work with adjacent work and with other trades so as to facilitate the general progress of the work. Each trade shall afford other trades every reasonable opportunity for the installation of their work and for the storage of their material.

4. The term "CONTRACTOR" shall be used to describe the various work activities of both the prime CONTRACTOR and all of the subcontractors for which the CONTRACTOR retains responsibility.

B. Conformity with Plans

1. The CONTRACTOR shall perform all work in conformity with the drawings, specifications, and instructions from the ENGINEER.

2. All minor details of the work, which are not specifically mentioned in the specifications, but are obviously incidental, shall be considered a part of the work for which prices are given in the proposal, and no extra compensation shall be allowed the CONTRACTOR for the performance thereof.

C. Errors and Omissions

1. If the CONTRACTOR, in the course of the work, finds any errors or omissions in plans or in the layout as given by survey points and instructions, or if he finds any discrepancy between the plans and the physical conditions of the locality, he shall promptly verify the same and notify the OWNER. Any work done after such discovery, until authorized, will be done at the CONTRACTOR's risk.

D. Notice to OWNER

1. The CONTRACTOR shall give forty-eight hours notice when he will need the services of the OWNER for staking out any portion of the work.

E. Lines and Grades

1. All work shall be done to the true line and grade, as indicated by the Drawings.

2. The OWNER will furnish initial survey control points and the CONTRACTOR must protect them and will be held responsible for any defective work caused by his negligence in this respect.

3. If the survey control points are destroyed or if additional points are needed, the OWNER will furnish them to the CONTRACTOR, and the CONTRACTOR shall reimburse the OWNER for the additional expense of reestablishing the survey control points.

F. Supervisory Personnel

1. It is the intent of these specifications to provide a completed project, which will in every way reflect the work of competent journeymen in the various trades represented.

2. The CONTRACTOR shall insure that each portion of the work is supervised by a qualified person, well versed in the operation of the various tools required for the trade, the method in which the work is to be done, and knowledge of the general requirements of the construction work.

3. All work is to be done in accordance with the latest methods devised for such work to insure a professional appearance of the completed project.

1.4 MEETINGS

A. A Preconstruction Meeting will be held with OWNER, ENGINEER, and all CONTRACTORS to facilitate project schedule and coordination. CONTRACTOR shall submit preliminary schedule at Preconstruction meeting and provide weekly updates as work progresses. The State of Utah Division of Water Quality (DWQ) personnel may attend the Preconstruction meeting at their option. The meeting will be documented by the ENGINEER on a Meeting Documentation form.

B. A Weekly Progress meeting will be held with attendance required by the CONTRACTOR and OWNER. The ENGINEER and State of Utah DWQ personnel may attend at their option. The meeting will be documented by the OWNER on a Meeting Documentation form. The purpose of the meeting will be to:

- Review minutes of previous meetings.
- Review of Work progress and updated schedule.
- Field observations, problems, and decisions.
- Identification of problems that impede planned progress.
- Review of submittals schedule and status of submittals.
- Review of off-site fabrication and delivery schedules.
- Maintenance of progress schedule.
- Corrective measures to regain projected schedules.
- Planned progress during succeeding work period.
- Coordination of projected progress.
- Maintenance of quality and work standards.
- Effect of proposed changes on progress schedule and coordination.
- Other business relating to Work.

C. A Work Deficiency Meeting will be held if or when any work items are identified to be deficient. Attendance will be required by the CONTRACTOR, ENGINEER, and OWNER. The meeting will be documented by the QC Inspector on a Meeting Documentation form. The State of Utah DWQ personnel may attend at their option. The purpose of the meeting will be

to:

- Review the Problem Identification/Corrective Measures Reports
- Review the Corrective Action Items
- Discuss any problems

PART 3 PRODUCTS

Not Used.

PART 4 EXECUTION

Not Used.

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Submittal Procedures

B. Proposed Products List

C. Product Data

D. Certificates

E. Manufacturer's Instructions

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01500 – Temporary Controls

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 SUBMITTAL PROCEDURES

A. Collect submittals from all manufacturers or suppliers and provide to ENGINEER for written approval of products.

B. Identify manufacturer or supplier and reference appropriate drawing and/or specification location.

C. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

D. Obtain written approval of materials from ENGINEER prior to ordering from vendor.

E. When revised for resubmission, identify all changes made since previous submission.

F. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

1.4 PROPOSED PRODUCTS LIST

A. Within 15 days after date of Notice to Proceed, submit list of major products proposed for use, with name of manufacturer, trade name and model number of each product.

B. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

1.5 PRODUCT DATA

A. Product Data For Review:

1. Submitted to ENGINEER for review for the limited purpose of checking for conformance with Plans and Specifications

B. Submit one copy to OWNER.

C. Mark copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this project.

1.6 CERTIFICATES

A. When specified in individual specification sections, submit certification by the manufacturer, installation/application subcontractor, to the ENGINEER.

B. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

C. Certificates may include recent or previous test results on material or Product, but must be acceptable to ENGINEER.

1.7 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification sections, submit printed instructions for delivery, storage, installation and maintenance to CONTRACTOR and ENGINEER. ENGINEER will forward instructions to QC personnel.

B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01500

TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Site Safety

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01300 – Submittals

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 SITE SAFETY

A. The CONTRACTOR shall ensure that proper care is exercised to make the work safe at all times.

1. Materials, equipment or other obstructions shall not be strung or placed on or in any traveled roadways in a manner that will be hazardous to vehicles or personnel and shall provide and maintain at all times, and as directed by the OWNER for the protection of all traffic operating in work areas.

2. If in the operation of equipment it becomes necessary to encroach upon the above mentioned traveled roadway or at any point that may be construed by the OWNER as dangerous to traffic or personnel, the CONTRACTOR shall place guards, at his expense, to direct and inform site persons of existing danger.

3. The CONTRACTOR shall be held responsible for any costs through mishaps or accidents caused by his neglect or the neglect of any of his employees or agents in the performance of the work involved in the handling of this project work. No additional costs will be allowed by the OWNER for this added protection.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01600

MATERIALS, LABOR AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. CONTRACTOR Provided Materials, Labor and Equipment

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01300 – Submittals

D. Section 01500 – Temporary Controls

E. Section 01700 – Contract Closeout

1.3 CONTRACTOR PROVIDED MATERIALS, LABOR AND EQUIPMENT

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, supervision, etc., and all costs involved, necessary to complete the work required under this contract as specified, including all power required to power all tools and equipment used, such as gasoline, fuel, oil, electricity, etc.

B. All equipment, tools, machinery, etc. used shall be in good repair and shall be maintained in a good workable and safe condition necessary to continuously carry on the work involved in this project in a professional, expeditious and safe manner, without serious or costly delays in the performance of all phases of the work involved.

C. Use of any and all equipment and machinery on this project shall be in accordance with all applicable MSHA standards.

D. No equipment or machinery shall be operated in or over paved streets or prepared roadway shoulders, in getting to, from or in working on this project that is equipped with treads or cleats that, in the opinion of the OWNER, may be injurious to pavement or shoulder surfaces.

E. Any damage done under these circumstances shall be immediately repaired by the CONTRACTOR at the CONTRACTOR's expense.

F. If requested by the OWNER or the ENGINEER, the CONTRACTOR shall furnish a list of all

equipment and machinery that he has of his own or that he has access to, which he proposes to use for this project. The CONTRACTOR shall state the present condition of equipment as to its fitness and safety on this type of work, together with a written statement as to the past experiences of those who will operate the various machines to be used, their qualifications and the previous experiences the CONTRACTOR has had in performing similar work as that required under this contract.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Closeout procedures.

B. Final cleaning.

C. Project record documents.

D. Warranties and bonds.

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01300 – Submittals

D. Section 01500 – Temporary Controls

E. Section 01600 – Materials, Labor and Equipment

1.3 CLOSOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for OWNER and ENGINEER's review.

B. Provide to OWNER all Project Record Documents.

C. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

1.4 FINAL CLEANING

A. Execute final cleaning prior to final project assessment.

B. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.5 PROJECT RECORD DOCUMENTS

A. Maintain on site one set of the following record documents; record actual revisions to the Work:

   1. Drawings.

   2. Specifications.

   3. Addendums.

   4. Change Orders and other modifications to the Contract.

   5. Product Data, and Samples.

   6. Manufacturer's instruction for installation, and repairing.

B. Ensure entries are complete and accurate, enabling future reference by OWNER.

C. Store record documents separate from documents used for construction.

D. Record information concurrent with construction progress.

E. Specifications: Legibly mark and record at each product section, a description of actual Products installed, including the following:

   1. Manufacturer's name and product model and number.

   2. Product substitutions or alternates utilized.

   3. Changes made by Addenda and modifications.

F. Record Drawings [and Shop Drawings]: Legibly mark each item to record actual construction including:

   1. Measured horizontal and vertical locations of underground installations, referenced to permanent surface improvements.

   2. Field changes of dimension and detail.

   3. Details not on original Contract drawings.

G. Submit documents to OWNER with claim for final Application for Payment

1.6 WARRANTIES AND BONDS

A. Provide notarized copies.

B. Execute and assemble transferable warranty documents from Subcontractors, suppliers, and manufacturers.

C. Provide Table of Contents and assemble in ring binder with durable cover.

D. Submit prior to final Application for Payment.

E. For items of Work delayed beyond date of Substantial Completion, provide updated submittal within 10 days after acceptance, listing date of acceptance as start of warranty period.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

Not Used.

END OF SECTION

DIVISION 2 – SITE WORK

SECTION 02200

SITE PREPARATION

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Clearing, grubbing, and stripping project site.

1.2 RELATED SECTIONS

A. Section 02300 – Earthwork

B. Section 02400 – Subgrade Preparation

C. Section 02771 – 45-mil EPDM

1.3 DEFINITIONS

A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.

B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.

C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the ENGINEER.

1.4 QUALITY ASSURANCE

A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Pre-construction meeting: Meet with ENGINEER to discuss order and method of work.

1.5 PROJECT CONDITIONS

A. Existing conditions:
   1. Verify character and amount of clay, sand, gravel, quicksand, water, rock, hardpan, and other material involved and work to be performed.

1.6 SEQUENCING AND SCHEDULING

A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verification of conditions: Examine site and verify existing conditions before beginning work.

3.2 PREPARATION

A. Protect existing improvements from damage by site preparation work.

3.3 INSTALLATION

A. Clearing:
   1. Clear areas where construction is to be performed, including borrow areas and other areas as indicated on the Drawings, or specified in this Section, of topsoil, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions. Borrow area topsoil shall be stockpiled in an area designated by the OWNER.
   2. It is the CONTRACTOR's responsibility to determine the effort needed to remove shrubs, brush, rocks, and objectionable materials required for construction activities.
   3. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
   4. CONTRACTOR's construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.

B. Grubbing:

1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

Height of Embankment over Stump	Depth of Clearing and Grubbing
0 feet to 2 feet	Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.
2 feet to 3 feet	Grub stumps 1 foot and over in diameter to 18 inches below original grade. Cut others flush with ground.
Over 3 feet	Leave no stumps higher than stump top diameter, and in no case more than 18 inches.

3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.

C. Stripping:

1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from both borrow areas and areas to receive fill.
2. Deposit stripped material in accordance at locations as directed by OWNER.

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for Embankment construction.
   2. Backfilling and compacting to support Embankment construction.

1.2 RELATED SECTIONS

A. Section 02200 – Site Preparation

B. Section 02400 – Subgrade Preparation

C. Section 02771 – 45-mil EPDM

1.3 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) Standards:
   1. D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
   2. D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN m/m^3)).
   3. D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
   4. D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.4 DEFINITIONS

A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

B. Embankments: Dikes, levees, berms, and similar facilities.

C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for

purposes of construction of structures, ditches, grading, berms, roads, and such other purposes as are indicated on the Drawings.

1.5 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Obtain acceptable import material from other sources if surplus obtained within Project site do not conform to specified requirements or are not sufficient in quantity.
   2. No extra compensation will be made for hauling of fill materials or for water required for compaction.

1.6 SUBMITTALS

A. Copy of Property OWNER's Agreement allowing placement of surplus soil material on their property.

B. Excavation plan.

C. Testing lab: Submit CONTRACTOR's proposed testing laboratory capabilities and equipment.

D. Test reports:
   1. Submit certified test reports of all tests specified to be performed by the CONTRACTOR.
   2. Sign and seal test reports by a registered PROFESSIONAL ENGINEER who practices geotechnical engineering and is registered in the State of Utah.

1.7 QUALITY CONTROL

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 100 linear feet of trench backfill.
      b. 100 cubic yards of embankment work.
      c. 100 cubic yards of fill.
      d. 50 cubic yards of roadway base material.
      e. 100 cubic yards of road fill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under the QUALITY CONTROL Plan.

1.8 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for

excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage away from critical work areas at all times.

PART 2 – PRODUCTS

1.1 MATERIALS

A. Water for compacting: Use water from source acceptable to ENGINEER as directed by OWNER.

B. Soil and rock materials:
   1. General:
      a. Provide native material and select material where specified or indicated on the Drawings.
      b. If suitable surplus materials are available, obtain native material and select material from cut sections or excavations or from borrow areas.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verification of conditions:
   1. Character and quantity of material:
      a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
      b. Determine gradation and shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
      c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations, or borrow areas. Include in cost of work to be performed.
      d. Include wasting of excess material, if required, in cost of work to be performed.

3.2 PREPARATION

A. Embankment additions:
   1. For downstream embankment areas, after clearing is completed, scarify entire areas which underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features which would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for embankments before

placing of embankment material.

3. If embankment areas have cemented rock, cobbles, or boulders, do not scarify the top 6 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.

3.3 INSTALLATION

A. General:
   1. Dispose of excavated materials, which are not required or are unsuitable for fill and backfill in lawful manner.
   2. Dispose of surplus material on private property only when written permission agreement is furnished by OWNER of property. Submit copies of such agreements.
   3. Obtain material required in excess of suitable material produced by cuts and excavation, from borrow areas subject to the material requirements specified.
   4. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to OWNER.
   5. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads which may be placed upon it by CONTRACTOR's equipment.

B. Borrow area: If there is insufficient borrow area on Project site, import material from off-site.
   1. Where material is required, import material from source located off Project site selected by the CONTRACTOR and subject to acceptance by the ENGINEER.
   2. There will be no additional cost to the Contract for use of imported material.

C. Compaction:
   1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
   2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
   3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D 1556, or with ASTM D 2922 and ASTM D 3017.
   4. Maximum density obtained in laboratory when tested in accordance with ASTM D 698.
   5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
   6. Compact to percentage of maximum density as follows:
      a. Utility trenches: 95 percent
      b. Embankments: 95 percent.

c. Intermediate dikes 90 percent.
d. Other areas: 85 percent.
e. Spoil areas 90 percent.
f. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
g. Upper 6 inches of cuts: 95 percent.
h. Fills: 95 percent.

D. Materials for backfills, embankments, fills, roadway fills:

1. General:
   a. Obtain import material from other sources if surplus materials from within Project site or borrow areas do not conform to specified requirements or are not sufficient in quantity for construction of Project.
2. Embankments:
   a. Native material, Select material, or imported material meeting the requirements of native material, select material, unless otherwise specified or indicated on the Drawings.
3. Fills:
   a. Native material, or imported material meeting the requirements of select material unless otherwise specified or indicated on the Drawings.

E. Placement:

1. General:
   a. Lines and grades:
      1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
      2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
2. Embankments:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction. A maximum initial loose lift thickness of 18 inches may be placed directly on the geotextile separation fabric and compacted prior to requiring the preceding 8 inch lift thickness requirement.
   b. Bring each layer to a moisture content between optimum moisture content and 2 percent above optimum moisture content before compacting.
   c. With the exception of the initial lift, all subsequent lifts of fill materials shall be compacted to 95% of the maximum dry unit weight determined using the ASTM D698 standard method of compaction. The initial lift of fill placed directly upon the separation geotextile in the upstream expansion area shall be compacted to a minimum of 85% of the maximum dry unit weight using the same standard.
   d. Defective compacted embankments: Remove/rework and recompact.
   d. In disposal areas: In disposal areas as indicated on the Drawings, bring fill up in an essentially level layer over entire spoil area indicated:
      1) Continue filling spoil area until disposal of surplus excavated material is completed.
      2) Slope edges of fill area at between 1 and 2 horizontal to 1 vertical to the intersection with existing grade.
      3) Provide slopes that are smooth and uniform.

4) Level finished surface of disposal area to within 4 inches of elevation indicated on the Drawings.

e. Clods or hard lumps of earth of 6 inches in greatest dimension: Break up before compacting material in embankments, except as provided as follows:

1) When fill material includes large rocky material or hard lumps, such as hardpan or cemented gravel which cannot be broken readily, distribute such material throughout fill.

2) Place sufficient earth or other fine material around larger material as it is deposited so as to fill interstices and produce dense, compact fill. Do not place such material within 2 feet of finish grade of fill.

3.4 FIELD QUALITY CONTROL

A. Tests:

1. Confirmation tests:

a. CONTRACTOR's responsibilities:

1) Accomplish specified compaction for backfills, fills, and other earthwork.

2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.

3) Cost of confirmation tests: Paid for by the CONTRACTOR.

4) Qualifications of CONTRACTOR's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the ENGINEER.

5) Copies of confirmation test reports: Submit promptly to the ENGINEER.

b. Frequency of confirmation testing:

1) Perform testing not less than the following:

a) Embankments: 1 test every 500 cy or every other lift, whichever is more frequent.

b) Pipe Trenches:

(1) 2 every 500 linear feet

(2) At each test location include tests for each type or class of backfill from bedding to finish grade.

2. Compliance tests:

a. Periodic compliance tests will be made by the ENGINEER to verify that compaction is meeting requirements previously specified.

b. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:

1) Remove and replace materials at proper density.

2) Bring density up to specified level by other means acceptable to the ENGINEER.

c. Retesting:

1) CONTRACTOR bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.

2) CONTRACTOR's confirmation tests during performance of remedial work: Double the normal rate specified.

B. Tolerances:
1. Finish grading of embankments, and fills:
   a. Perform fine grading such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
2. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
   a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
   b. Intent of proceeding is to avoid sandy or gravelly areas.
3. Finish grading of surfaces:
   a. Reasonably smooth, compacted, and free from irregular surface changes.
   b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
   c. Uniformly grade areas which are not under concrete.
   d. Finish ditches and gutters so that they drain readily.

3.5 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.6 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:

B. Protect newly graded areas from erosion and deterioration.

END OF SECTION

SECTION 02400

SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Final subgrade preparation.

B. Certification of subgrade soil.

1.2 RELATED SECTIONS

A. Section 02200 – Site Preparation

B. Section 02300 – Earthwork

C. Section 02714 – Geotextile Fabric

E. Section 02771 – 45-mil EPDM

1.3 PROJECT RECORD DOCUMENTS

A. Submit subgrade certification reports to ENGINEER to countersign prior to covering the area with geosynthetic liner. Liner installation work cannot proceed without written certification reports and approval from ENGINEER.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Only limited offsite soil material will be required for this portion of the project. Portions of the subgrade preparation may require excavation. Suitable excavated materials may be used as compacted fill with ENGINEERS prior approval.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing site conditions are in a condition suitable for initiating final grading procedures.

3.2 FINAL GRADING

A. Prepare subgrade soils to receive 45-mil EPDM liner by means of grading, rolling and/or track walking.

B. Subgrade will be free from rocks or other sharp objects, mounds, depressions, ridges or any anomaly that may cause concentrated stress or puncture to the EPDM.

3.3 SUBGRADE APPROVAL AND CERTIFICATION

A. CONTRACTOR will certify subgrade prior to material placement.

B. CONTRACTOR will provide ENGINEER with daily, written certification of subgrade approval for the ENGINEER'S countersignature prior to EPDM placement.

END OF SECTION

SECTION 02771

45-mil smooth EPDM

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Furnish and install a 45 mil, ethylene propylene diene monomer (EPDM) geomembrane liner (smooth).

1.2 RELATED SECTIONS

A. Section 02200 – Subgrade Preparation

B. Section 02300 – Earthwork

C. Section 02400 – Subgrade Preparation

1.3 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) Standards

B. Latest Version of the Geosynthetic Research Institute (GRI) Standards

C. Manufacturers Technical Specification Guidelines – Installation Guidelines as attached

1.4 DEFINITIONS

A. Batch: A quantity of resin, usually the capacity of one railcar, used in the fabrication of the geomembrane sheet. The finished sheet will be identified by a roll number corresponding to the particular quantity of resin used.

B. Bridging: The condition when geomembrane becomes suspended over its subgrade due to contraction of the material or poor installation.

C. Construction Quality Control (QC) Personnel: The party, secured by the CONTRACTOR, that is responsible for all of the CONTRACTOR's Construction Quality Control activities related to installation of the geosynthetic components of the lining system.

D. Construction Quality Assurance (QA) Personnel/ENGINEER: The site representative of the OWNER responsible for site Quality Assurance documentation.

E. Adhesives, tapes and primers: Compatible manufacture supplied products for developing overlap seams with EPDM liner product.

F. Fabricator: The party responsible for the fabrication of geomembrane panels constructed from rolls received from the manufacturer.

G. Geomembrane: An essentially impermeable membrane used as a solid or liquid barrier. In the context of this project it implies a 45-mil EPDM smooth product.

H. Geomembrane Manufacturer: The party responsible for the production of the geomembrane rolls from resin and for the quality of the resin.

I. Geomembrane: An essentially impermeable membrane used as a solid or liquid barrier. Synonymous term for geomembrane.

J. Subgrade: The soil or upon which the geomembrane lies.

K. Installer: The party responsible for field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installation of the geomembrane.

L. Panel: The unit area of geomembrane that will be seamed in the field. If the geomembrane is not fabricated into panels in a factory, a panel is identified as a roll or portion of a roll without any seams.

1.5 SUBMITTALS

A. Product Data: Submit the following to ENGINEER for written approval prior to ordering:

1. Geomembrane Base Material Data.

   a. Statement of production date or dates.
   b. Product Certifications.
   c. Copy of quality control certificates issued by manufacturer.
   d. Test reports from manufacturer.

2. Geomembrane Roll Data.

   a. Statement of production date or dates.
   b. Laboratory test results and certification stating that the geomembrane meets the product requirements (see Part 2 Products).
   c. Certification stating that all geomembrane rolls are furnished by one supplier, and that all rolls are manufactured from one resin type obtained from one resin supplier.
   d. Copy of quality control certificates issued by manufacturer.
   e. Test reports from the manufacturer.

f. Typical results of complete notched constant tensile load test (GRI-GM-5) for specified resin and sheet thickness.
g. Statement certifying that no reclaimed polymer is added to the resin.
h. Statement listing percentages/total of processing aids, antioxidants, and other additives other than carbon black added to or in the resin.
i. Geomembrane delivery, storage, and handling instructions.
j. Geomembrane installation instructions.
k. Sample warranties for review.

3. Geomembrane Seaming

a. Statement of production date or dates.
b. Laboratory certification stating that the seaming materials meets the product requirements.
c. Certification stating that all seaming materials are manufactured by one manufacturer and resin is supplied from one supplier.
d. Copy of quality control certificates issued by manufacturer.
e. Test reports from the manufacturer.

B. Schedules and Drawings (Installer)

1. Submit installation schedule to OWNER and ENGINEER. Include hours worked per day, week and per shift.

2. Installation layout drawings: Four weeks prior to installation of geomembrane, submit drawings to ENGINEER showing the panel layout indicating both fabricated (if applicable) and field seams, and details not conforming to the Drawings. Upon ENGINEER review, use these drawings for installation of geomembrane.

C. Qualifications (Installer).

1. Submit prior to installation, name of installer, and resume of installation supervisor/field ENGINEER to be assigned to the project. ENGINEER shall review and approve installers.

2. Submit, two weeks prior to installation, resume of master seamer.

3. Submit, prior to installation, resumes of installation seamers performing seaming operations.

D. Submit upon completion of the installation: (Installer).

1. Certificate stating the liner has been installed in accordance with the Drawings and Specifications.

2. The warranty obtained from the manufacturer/fabricator and the installation warranty.

3. As-built drawings showing location of panels, seams, repairs, patches, and destructive

samples, including measurements.

2. Copies of seam test results.

1.6 QUALIFICATIONS

A. Manufacturer/Fabricator/Installation Qualifications: The following are pre-qualified. Substitutions may be considered.

1. Firestone Specialty Products

2. Carlisle Syntec Geomembranes

B. Installer: Must have successfully installed a minimum of 1,000,000 square feet of installed liners with documented references.

C. Master Seamers Qualifications: Must have completed a minimum of 500,000 square feet of EPDM seaming work using the type of seaming methods proposed for use on this project.

D. Other Seamers Qualifications: Must have seamed a minimum of 500,000 square feet of EPDM geomembrane.

1.7 LABELING, DELIVERY, STORAGE, AND HANDLING (MANUFACTURER)

A. Labeling.

1. Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall clearly state the manufacturer's name, product identification, thickness, length, width and roll number.

2. The label shall be found on either of the end caps, an inside edge of the core, and outside the core.

B. Delivery.

1. Deliver materials to the site only after ENGINEER accepts required submittals.

2. Separate damaged rolls from undamaged rolls and store at locations designated by ENGINEER until ENGINEER determines proper disposition of the material.

3. ENGINEER will determine damage.

C. Storage on Site: (Installer).

1. Store geomembrane rolls in the space allocated by OWNER.

2. Store geomembrane to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

3. Store geomembrane rolls on CONTRACTOR prepared surface (not on wooden pallets).

4. Store adhesives, primers and taping materials in a dry heated environment at a temperature between 60 and 80 degrees F.

D. Handling on Site: (Installer).

1. Use appropriate handling equipment to load, move, or deploy geomembrane materials. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader, and roll bars for deployment. Dragging panels on ground surface will not be permitted.

2. Do not fold geomembrane material; folded material may be rejected.

3. CONTRACTOR is responsible for off-loading, storage, and transporting material from storage area to installation site.

1.8 QUALITY CONTROL

A. The CONTRACTOR will engage and pay for the services of a party responsible for the continuous testing and documentation of the geomembrane material being installed. Testing will be performed in accordance with both the Construction QC Plan and these Specifications.

2.0 WARRANTY

A. Provide manufacturer's warranty for geomembrane material in compliance with provisions of the Conditions of the Contract. Provide a minimum 20-year pro rata warranty for the material against deterioration due to exposure to the elements, either exposed or buried. The warranty for material must cover costs of material replacement and installation; assuming the area is rendered in a clean, dry unencumbered condition. In the event the area cannot be rendered as such, compensation for defective material will be provided to OWNER on a pro rata basis for the estimated cost to OWNER at that time of supplying and installing material to a clean, dry, and unencumbered condition by a third party installer.

B. Installation: Provide an installation warranty for geomembrane material in compliance with the conditions of the Contract. Provide a minimum of 2-year non-pro rata warranty for the installation against defects.

PART 2 – PRODUCTS

2.1 GEOMEMBRANE RESIN

A. Meet the following requirements unless otherwise approved:

Test	Test Designation	Requirements
Density (g/cc)[1]	ASTM D-792 Method A or ASTM D-1505	1.10 minimum
[1] Measure on pure resin without additives.		

2.2 GEOMEMBRANE

A. Manufacturing.

1. Geomembrane shall meet or exceed the minimum requirements set forth by ASTM D-7465 for Type 1 Non-reinforced EPDM Geomembrane.

2. Provide finished product free from blemishes, holes, pin holes, bubbles, blisters, excessive gels, undispersed resins, and/or carbon black, contamination by foreign matter and nicks or cuts on edges.

3. Roll manufactured sheets or panel for shipment.

2.3 ADHESIVES, PRIMER AND TAPE

A. Adhesives, primer and tape:

1. Meet the geomembrane manufacturer requirements.

2. Be free of contamination by moisture or foreign matter.

2.4 MANUFACTURER SOURCE QUALITY CONTROL

A. Provide Manufacturers Quality Control Documentation.

PART 3 – EXECUTION

3.1 EXAMINATION OF GEOMEMBRANE SUBSURFACE

A. Follow procedures set forth in the QC Plan. No geomembrane shall be deployed without written subgrade acceptance.

B. Grade changes rounded to min. 12-inch radius.

C. Subgrade will be free from rocks or other sharp objects, mounds, depressions, ridges or any anomaly that may cause concentrated stress or puncture the geomembrane.

3.2 PREPARATION

A. Repair damage caused to subgrade during deployment.

B. Prepare anchor trenches as shown in Drawings.

C. Perform trial seam as follows:

1. Perform trial on samples of geomembrane to verify the performance of seaming materials, methods, and conditions.

2. No seaming will be allowed until seamers have successfully completed trial seams.

3. Frequency of trial seams:

   a. Minimum of one trial seam per day prior to the start of work in the morning and one after lunch.
   b. When directed by the ENGINEER.

4. Make trial seams in the same surroundings and environmental conditions as the production seams, i.e., in contact with subgrade.

5. Make trial seam sample at least 2 feet long and 12 inches wide with the seam centered lengthwise.

3. Cut six, one-inch wide test strips from opposite ends of the trial seam.

4. Allow coupons (strips) to cure 24 hours before testing. Testing should be conducted at 70 degrees (plus or minus 4 degrees) Fahrenheit. Coupons temperatures greater than 70 degrees may result in lowered strengths.

7. Quantitatively test specimens for peel adhesion and bonded seam strength. Peel and shear values shall meet or exceed the 35 lb/in in shear at peak load and 8 lb/in in peel.

8. Repeat the trial seaming in its entirety when any of the trial weld samples fail in either peel or shear.

3.3 INSTALLATION

A. Protection

1. Do not use geomembrane surface as work area for preparing patches, storing tools and supplies, or other uses. Use protective cover as work surface, if necessary.

2. Instruct workers about requirements for protection of geomembrane such as handling geomembrane material in high winds, handling equipment, and walking on geomembrane surfaces. Shoes of personnel walking on geomembrane shall be such that they will not damage the liner. Smoking, eating, placing heated equipment directly on geomembrane or other activities that may damage geomembrane is prohibited.

3. Hold a daily meeting to discuss and coordinate work activities as detailed in the QC Plan.

4. Do not operate equipment without spark arresters in vicinity of geomembrane material, or place generators or containers of flammable liquid on geomembrane without the use of a splash pad.

5. Protect geomembrane from vehicular traffic and other hazards.

6. Keep geomembrane clean and free of debris during placement.

B. Geomembrane Deployment.

1. Give careful consideration to the timing and temperature during deployment. The QC Personnel will focus on verifying that (a) there is no bridging or stresses in the geomembrane and (b) there are no wrinkles in the geomembrane that will fold over when covering with soil material. Ideally, deployment, welding, and covering would all occur at the same temperature. In a practical sense, CONTRACTOR should strive to perform these activities within as narrow a temperature range as practical, and avoid these activities during peak hot or cold conditions. Do not deploy geomembrane during precipitation or moisture events (e.g. fog, drizzle, dew), or during excessive wind.

2. Panel Identification: Assign each panel an identifying code number of letter consistent with CONTRACTOR's submitted panel layout drawing. The coding should be coordinated with the ENGINEER.

3. Daily Panel Deployment: Deploy no more panels in one shift than can be welded during that same day.

4. Do not deploy in the presence of excessive moisture, precipitation, ponded water, or high winds.

5. Do not damage geomembrane by handling, trafficking, leakage of hydrocarbons or any other means.

6. Install miscellaneous products required to complete geomembrane installation according to manufacturer's recommendations.

7. Unroll geomembrane panels using methods that will not damage, stretch or crimp geomembrane. Protect underlying surface from damage. CONTRACTOR shall be solely responsible for protection of the subgrade. The ENGINEER will verify that the soils underlying the geomembrane are not damaged.

8. Use methods that minimize wrinkles and differential wrinkles between adjacent panels.

9. Temporarily weight geomembrane sheets with sandbags as necessary to anchor or hold them in position during installation. Use continuous hold-downs along edges to reduce wind flow under sheet.

    a. Sandbag fabric shall be sufficiently close knit to preclude fines from working through bags.
    b. Substitution of sandbags with tires or the use of paper bags even plastic lined paper bags is prohibited. Burlap bags may be used if lined with plastic.
    a. Immediately remove damaged or improperly sealed bags from the work area, and clean up the area affected.

10. Anchor edges of geomembrane as shown in Drawings.

11. Protect geomembrane in area of heavy traffic by placing protective cover that is compatible with and will not damage geomembrane.

12. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane.

13. Do not allow vehicular traffic directly on geomembrane, with the exception of a low psi, lightweight vehicle such as a 4-wheel ATV or similar equipment.

14. Remove wrinkled or folded material.

15. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.

16. Install material to account for shrinkage and contraction while avoiding wrinkles. Install material stress-free with no bridging before it is covered. Add material as needed to avoid bridging.

17. Before wrinkles fold over, attempt to push them out. For wrinkles that cannot be pushed

out, cut them out and repair cuts at the direction of the ENGINEER.

C. Geomembrane Seam Layout.

1. Orient seams parallel to line of a maximum slope, i.e., orient down not across slope.

2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.

3. Keep horizontal seams (seams running approximately parallel to slope contours) at least 6 feet away from toe or crest of slope.

4. Use seam numbering system compatible with panel number system.

5. Shingle panels on all slopes and grades as indicated in panel layout drawing.

D. Geomembrane Seam Personnel.

1. Provide at least one seamer (master seamer) who has experience seaming over 1 million square feet of geomembrane using the same type of adhesives and procedures used at site.

3. Master seamer will provide direct supervision over other seamers.

E Geomembrane Defects and Repairs.

1. Examine all welds and non-weld areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination.

2. Repair and non-destructively test each suspect location both in weld and non-weld areas. Do not cover geomembrane at locations which have been repaired until test results with passing values are available.

3.4 FIELD QUALITY CONTROL

A. General

1. Manufacturer, Fabricator, and Installer will participate in and conform to all terms and requirements of the Construction QC Plan, Drawings, and these Specifications. CONTRACTOR is responsible for assuring this participation. Quality control and requirements are as specified in this paragraph and as presented in the Construction QC Plan. If there is a discrepancy in the construction documents, the order of hierarchy shall be 1) Plans, 2) QC manual, and 3) Specifications.

B. Conformance Testing (Performed by QC with separated equipment).

1. Perform conformance testing on 100% of seams.

C. Field Testing (Performed by Installer).

1. General: Non-destructively test all field seams over their full length using air lance test (ASTM D4437), or other approved methods. Perform testing as the seaming progresses and not at the completion of all the field seaming. Complete all required repairs in accordance with this Specification and accepted Industry Standards.

2. Destructive Testing (performed by Installer).

a. Location and Frequency of Testing.

1) Collect destructive test samples at a minimum frequency of one test location per average **500** feet of seam length.
2) Determine test locations during seaming. Locations may be prompted by suspicion or contamination, offset seams, or suspected defect. QC and/or ENGINEER will be responsible for choosing the locations.
3) The QC Inspector may increase the test frequency based on marginal results.

b. Sampling Procedures.

1) Cut samples at locations designated by the QC Inspector as the seaming progresses. Verify that destructive test results have been obtained before the geomembrane is covered by another material.
2) QC Inspector will number each sample and mark sample number and location in compliance with the Construction QC Plan.

c. Immediately repair all holes in the geomembrane resulting from destructive test sampling. Repair in accordance with repair procedures described in this Section. Test the continuity of the repair in accordance with this Section.

d. Size of Sample: minimum 12 inches wide by 36 inches long with the seam centered lengthwise. Cut a one-inch wide strip from each end of the sample and test these for (shear and peel) in the field. Cut the remaining sample into three parts for distribution as follows:

1) One portion for Installer: 12 inches by 12 inches.
2) Two portions to ENGINEER for archive storage and testing: minimum 12 inches by 12 inches.

e. Field Testing (Performed by Installer)

1) Test the two, one-inch wide strips specified in paragraph d above by tensiometer

for peel and shear, respectively.

2) Both test strips must meet peel and shear requirements for welded seams specified in this Section.
3) If any field test sample fails, follow failed test procedures outlined in this Section.

D. Failed Weld Procedures.

1. Follow these procedures when there is a destructive test failure. Procedures apply when test failure is determined by the QC Inspector or ENGINEER, or by field tensiometer. Follow one of the following two options:

a. First Option.

1) Reconstruct the seam between any two passing test locations.

b. Second Option.

1) Trace the weld at least 10 feet minimum in both directions from the location of the failed test, or to the end of the weld.
2) Obtain a small sample at both locations for additional peal and shear tests.
3) Perform additional peal and shear tests.
4) If the additional peal and shear tests pass, then reconstruct the weld or cap between the two test sample locations that bracket the failed test location.
5) If any sample fails, then repeat the process to establish the zone in which the weld must be reconstructed.

E. Acceptable Welded Seams.

1. Bracketed by two locations from which samples have passed additional peal and shear tests.

2. For reconstructed seams exceeding 50 feet, a sample taken from within the reconstructed weld passes destructive testing.

F. Seams That Cannot Be Non-Destructively Tested: Perform the following:

1. If the seam is accessible to testing equipment prior to final installation, non-destructively test the seam prior to final installation.

3.5 REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

B. Repair, removal, and replacement is at CONTRACTOR's expense if the damage results from CONTRACTOR's or Installer's activities or material defects.

C. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. Do not commence welding on liner until trial weld test sample passes trial test. Repair procedures available include:

1. Patching: Used to repair large holes (over 3/8-inch diameter), tears, pinholes or other minor, localized flaws.

2. Spot seaming: Used to repair small tears (less than 2 inches long), pinholes or other minor, localized flaws.

3. Capping: Used to repair large lengths of failed seams.

4. Removing the seam and replacing with a strip of new material.

D. In addition, satisfy the following procedures:

1. Clean and dry all surfaces at the time of repair.

2. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches.

E. Verification of repair:

1. Number and log each patch repair.

2. Non-destructively test each repair using methods specified in this Section.

3. Additional destructive tests may be required at the discretion of the ENGINEER.

4. Reconstruct repairs until tests indicate passing results.

3.6 CLEANUP

A. Clean up work area as work proceeds. Take particular care to ensure that no trash, tools, or other unwanted materials are trapped beneath the geomembrane and that scraps of geomembrane material are removed from the work area prior to completion of the installation.

3.7 GEOMEMBRANE ACCEPTANCE

A. CONTRACTOR retains all ownership and responsibility for the geomembrane until acceptance by Owner.

B. Owner will accept geomembrane installation when:

1. All required documentation from the Manufacturer, Fabricator (if applicable), and Installer has been received and accepted.

2. The geomembrane installation is finished.

3. Test reports verifying completion of all field seams and repairs, including associated testing, is in accord with the Section.

4. Written certification documents and drawings have been received by OWNER.

END OF SECTION

Technical Specification Guidelines

SECTION II- INSTALLATION GUIDE

	PAGE
2.01 GENERAL	II.13
2.02 SUBMITTALS	II.13
2.03 JOB SITE CONSIDERATIONS (CAUTIONS AND WARNINGS)	II.13
2.04 SUBSTRATE PREPARATION	II.14
2.05 UNDERLAYMENT INSTALLATION	II.15
2.06 FIRESTONE EPDM GEOMEMBRANE INSTALLATION	II.16
2.07 FIRESTONE EPDM GEOMEMBRANE LAP SEAMING	II.16
2.08 FIRESTONE EPDM GEOMEMBRANE SEAMING PROCEDURES	II.17
2.09 GEOMEMBRANE TERMINATION	II.21
2.10 TERMINATIONS	II.23
2.11 FLASHING PENETRATIONS	II.23
2.12 FIRESTONE EPDM GEOMEMBRANE REPAIR & MAINTENANCE PROCEDURES	II.24
2.13 SEAM TEST PROCEDURES	II.24
2.14 PROTECTION OF THE FIRESTONE EPDM GEOMEMBRANE DURING SERVICE	II.25
2.15 WARRANTY	II.26

Firestone EPDM GEOMEMBRANE Lining in Action™

Technical Specification Guidelines

2.01 General

Furnish and completely install the Firestone EPDM Geomembrane System in accordance with Firestone's published specifications and details.

2.02 Submittals

A. Panel Layout
   1. The installation contractor shall provide a panel layout drawing or plan.
   2. This plan shall be made based on the specification and design details, and will indicate the position of the panel and field seams.
   3. The placement of the panels will proceed according to this plan unless changes must be made due to unforeseen site conditions.

B. Installation Details
   The installation contractor shall provide copies of any special detail terminations that may be required.

2.03 Job Site Considerations (Cautions and Warnings)

A. Ignition Sources
   Keep all adhesives, sealants and cleaning materials (e.g. gas, heptane, etc.) away from ALL ignition sources (i.e. torches, flames, fire, sparks, etc.).

B. Safety Instructions
   Consult container labels and Material Safety Data Sheets (MSDS) for specific sfety instructions.

C. Storage
   Store Firestone EPDM Geomembrane in the original undisturbed plastic wrap in such a manner as to protect it from becoming damaged.

D. Membrane Contamination
   Do not use oil-based or bituminous-based materials with Firestone EPDM Geomembrane.

E. Miscellaneous Contamination
   All bonding, splicing, and sealing surfaces must be free of dirt, moisture, and any other contaminates.

F. Temperature
   When the outside temperature is below 4.4° C (40° F), certain combinations of temperature and humidity may cause condensation on the surface of solvent-based adhesives and primers. If this condition occurs, discontinue the application. When the ambient air conditions no longer cause condensation on the adhesive surfaces, re-apply additional adhesive or primer and proceed.
   1. The consistency of sealants, adhesives and primers will begin to thicken as the temperature drops. To minimize this, the following is recommended:
      a. Start work with sealants, adhesives and primers that have been stored between 15.5° C and 26.7° C (60° F and 80° F). Insulated and/or heated boxes may be helpful.

b. Complete test areas to determine if conditions will cause problems such as condensation with the application of the material.
c. Stop the operation or change to another warm container when material becomes too thick to properly dry.

2. Do not use heat guns or open flames to dry adhesives and primers.

G. Cautions
Do not thin or modify any Firestone material

H. Deliver materials to job site in their original containers as labeled by the manufacturer.

I. Follow manufacturer's directions for protection of materials prior to and during installation. Do not use materials, which have been damaged to the point that they will not perform as specified.

J. Care should be taken not to damage the Firestone EPDM Geomembrane during transport, loading, and unloading. The rolls must be stacked on a flat, clean surface, free of sharp protrusions that could damage the geomembrane.

K. Firestone EPDM Geomembrane does not require any special protection against weather conditions. However, all accessories need to be stored in a dry and cool place between 10° C and 25° C (50° F and 77° F), protected against extreme weather conditions.

2.04 Substrate Preparation

A. Inspection of Support Surface

1. As part of Construction Quality Control (CQC) and before installing the Firestone EPDM Geomembrane, quality of the soil subgrade and the surface condition should be examined to determine the preparation steps required for installing the Firestone EPDM Geomembrane lining system.

B. Soil Preparation

1. The support soil layer in immediate contact with the Firestone EPDM Geomembrane shall be a clean, compacted, and regular surface free of aggressive angle changes, ruts, loose stones, stones in excess of 9.52 mm (0.375"), and small cavities. This layer should also be able to compensate for the differential settling of the soil and facilitate the installation of a drainage system, if required. Adequate support may be realized in the following ways:
   a. Excavate the unsuitable subgrade base, remove rock, vegetation, etc., followed by smoothing and compacting of the base.
   b. Backfill with layers of controlled particle size which are compacted (sand, select fill material) to the desired grade.

C. Vegetation
All plant growth should be removed from the base soil prior to compaction in order to avoid any gas generation and compressible areas. Depending on the conditions, the use of water-based herbicide is recommended. The herbicide must not contain any chemicals, known to affect the Firestone EPDM Geomembrane lining system.

D. Compaction
   1. All soils supporting the Firestone EPDM Geomembrane System must be compacted to between 90% and 95% of standard Proctor density. The density is achieved by either equipment travel or by mechanical methods. When mechanical methods are used, the soil material is deposited in layers of 152.4 mm to 304.8 mm (6" to 12") and compacted with a vibrating roller or other similar methods.
   2. The supporting surface should not contain any loose stones with a diameter exceeding 9.52 mm (0.375"). The final surface should be smooth and uniform with no abrupt changes in elevation.
   3. An additional layer of sand should be provided and/or a geotextile underlayment of at least 271.25 g/m^2 (8.0 oz/yd^2) should be installed. On embankments and on any type of rough substrate (concrete, masonry) a geotextile underlayment of at least 271.25 g/m^2 (8.0 oz/yd^2) should be installed.
   4. Soil around concrete structures
      The Firestone EPDM Geomembrane liner fixed to a concrete structure must be on firm soil subgrade. Compacting of the natural soil around such structures must be performed with particular care. Backfill material around the structure shall be compacted to 95% of standard Proctor density.

2.05 Underlayment Installation

A. Hard Substrates (concrete, treated soils, etc.)
   On hard substrates such as concrete, it is always necessary to install a protection layer, unless the Firestone EPDM Geomembrane is fully adhered. On a bituminous support (bituminous concrete, bitumen emulsion stabilized soil), a geotextile of at least 271.25 g/m^2 (8.0 oz/yd^2) or more should be used.
B. The Firestone EPDM Geomembrane liner fixed to a concrete structure must be on firm and solid base. Compacting of the backfill soil around such structures must be performed with particular care. Backfill material around the structure shall be compacted to 95% of standard Proctor density.
C. Installation of a geotextile between the support soil and the Firestone EPDM Geomembrane is generally recommended. It is an absolute necessity on slopes where deposition of an additional support layer is often difficult. Depending on the type of soil and roughness of the surface, the mass of the geotextile may vary between 203.43 and 508.59 g/m^2 (6 and 15 oz/yd^2). The typical geotextile is a non woven, needle punched fabric. When the geotextile also has a drainage function, it should be checked for sufficient flow under load. There are other types of geosynthetics, such as geonets, and geonet composites that provide higher planar flow rates. Consult Firestone or geotextile manufacturer for details.
D. If required, geotextiles are to be installed with an overlap of at least 304.8 mm (12".0). Alternatively, the overlaps may be thermally welded at an overlap of 101.6 mm (4.0"). To avoid any wind uplift, the geotextile should be temporarily ballasted.

2.06 Firestone EPDM Geomembrane Installation

A. The panels are unrolled and/or unfolded into the position indicated on the layout plan.
B. Generally, side slope panels are placed and temporarily ballasted (sand bags or tires) first, followed by the bottom panels.
C. The Firestone EPDM Geomembrane panels are unrolled from the anchor trench down the side slopes and the geomembrane is temporarily anchored to avoid movement down slope.
D. No rocks or sharp objects are allowed under the geomembrane during placement. Damage to the supporting soil or geotextile underlayment must be avoided and must be repaired.
E. The side slope panels should extend a minimum of 0.91 m (3.0') out onto the pond bottom for connecting with adjoining panels.
F. All Firestone EPDM Geomembrane panels must be allowed to relax at least 30-45 minutes before seaming or attachment to structures.
G. To avoid movement and wind uplift of the Firestone EPDM Geomembrane during installation, a temporary ballast (sand bags) is recommended. Such ballasting also facilitates the seaming operations.

2.07 Firestone EPDM Geomembrane Lap Seaming

A. The seaming of adjacent panels should be performed immediately after the relaxation of the Firestone EPDM Geomembrane.
B. All panels must be installed without tension and without wrinkles overlapping by at least 101.6 mm (4.0"). All seams on side slopes must be parallel with the slope (i.e., up and down the slope). Horizontal field seams on slopes are not allowed.
C. For soft or rough subsoils a board or piece of conveyor belt is used under the Firestone EPDM Geomembrane in the area of the seam. The seaming board is moved by means of a rope as the seaming process progresses.
D. Seams should not be made under the following conditions:
   1. Moisture
   2. Soft subgrade soil
   3. Condensation on the primer or on the geomembrane
   4. Rainfall
   5. Ponded water
   6. Excessive wind/dusty conditions
   7. Other contaminants
E. Moisture in the seam will cause failure of the seam.
F. Use only Firestone approved products. Non-Firestone products cannot be approved to make seams and will void any warranties.
G. Clean the seam area with water and dry before applying the QuickPrime™ Plus, if it is contaminated (mud, etc.).

H. Stop the application of the QuickSeam™ Tape and FormFlash™ when the atmospheric conditions are unfavorable (humidity, condensation on the QuickPrime Plus or rain).
I. Movement of the Firestone EPDM Geomembrane during application of the QuickSeam Splice Tape and during the first few minutes after application should be avoided.
J. Positioning of a large number of panels than can not be seamed together in one day is not allowed.

2.08 Firestone EPDM Geomembrane Seaming Procedures

A. 6.0 inch (150mm) wide cover strip tape seaming system:
   1. Position the Firestone EPDM Geomembranes
      a. Both adjacent panels are positioned with sufficient overlap 101.6 mm (4.0").
      b. The panels should lay flat and without any tension.
   2. Clean the Overlap
      If there is dirt in the overlap area, clean the overlap area using a broom, air blower or clean cotton cloth. Soil should not be allowed to contaminate the Firestone EPDM Geomembrane in the splicing area.
   3. Apply the QuickPrime
      a. Stir the QuickPrime Plus before and during use and transfer a small quantity 1.5 L (0.4 gal) to a bucket. The Primer is applied with a scrubbing pad.
      b. Immerse the scrubbing pad in the QuickPrime Plus, keeping the pad horizontal and let excess of QuickPrime Plus drip off the pad.
      c. Each pad immersed in QuickPrime Plus will cover an area of about 30.91 m (3.0') in length, over a width 101.6 mm (4.0") one side.
      d. Change scrubbing pads every 60.96 m (200.0') or when the primer has dried on the pad. Used pads are to be discarded at the end of the working day.
      e. Additional priming is required at factory seams, at the intersection of two seams and to areas covered with adhesive.
      f. Both sides to be seamed are treated simultaneously so as to obtain an identical drying time.
      g. Prime a minimum of 76.2 mm (3.0") on either side of the overlap edge.
   4. Test QuickPrime Plus for Readiness (use the touch-push method)
      Allow the primer to flash off. The primer needs to dry completely (approximately 5-10 minutes) before installing the tape. Check its dryness by touching the primed surface with a clean and dry finger to be certain that the primer does not string. When touching the primer, push forward on the primed surface at an angle to ensure that the primer is dry through out its thickness. If either motion exposes a stringy primer when the finger is lifted, then the splice is not ready for installing the tape. Flash-off time will vary depending on ambient air conditions (relative humidity, wind...).

5. Install the QuickSeam Cover Strip
   a. Place the roll of QuickSeam Cover Strip on the ground a few feet ahead of the overlap starting point, positioned so that it unrolls from the top of the roll (release paper will be on top).
   b. Starting a minimum of 76.2 mm (3.0") ahead of the edge of the panel, center the QuickSeam Cover Strip roll on the overlap edge and unroll onto the clean and primed surface.
   c. Advance the roll keeping the cover strip centered over the overlap edge. Peel the release paper as you apply the cover strip.
   d. When it is necessary to cover a longer overlap edge than the length of one roll of cover strip, it is required to overlap the next roll a minimum of 25.4 mm (1.0") onto the installed roll before continuing to unroll the second roll. When the end of the over lap is reached, extend the cover strip 76.2 mm (3.0") before cutting.
6. Roll the QuickSeam Cover Strip
   Apply pressure along the entire length of the cover strip by hand to completely mate the two surfaces. Using a 38.1 mm (1.5") wide silicone rubber roller, roll the QuickSeam Cover Strip with positive pressure towards the outside edge then along the entire length of the cover strip.
7. Install Cover Strip at the End of Seaming Runs or "T" Joints
   a. At the 25.4 mm (1.0") laps of the cover strip it is required to install a 304.8 mm (12.0") long section of cover strip parallel with the lap edge and centered over it. Before installing the cover strip, the area to be covered must be cleaned and primed in the normal fashion.
   b. When cover strips intersect at any point, a 304.8 mm (12.0") long section of cover strip shall be installed centered over each T-joint area.
   c. Round the corners on the 304.8 mm (12.0") section and then install it onto the dry primed area. Roll with the silicone rubber roller in the same manner as done to the cover strip.
8. Special Considerations- End Laps, "T" Joints, etc
   a. End Laps:
      When the splice is greater in length that the QuickSeam Cover Strip, the adjoining 152.4 mm (6.0") QuickSeam Cover strip must be overlapped a minimum of 25.4 mm (1.0")- See Detail PG 19.
   b. "T" Joints:
      Apply a section of Firestone QuickSeam Flashing or QuickSeam Joint Cover over the "T" joint area.

B. Overlapped Inseam Double Faced Tape System (alternative to 152.4 mm (6.0") wide cover strip tape seaming system)
   1. Position the Firestone EPDM Geomembrane
      a. Both adjacent panels are positioned with a minimum overlap of 101.6 mm (4.0").
      b. The panels should lay flat and without any tension.

   c. A marker is used to indicate on the lower sheet the exact location where the splice tape is to be installed.
   d. The mark shall be situated between 10.16 and 20.32 mm (0.4" and 0.8") from the edge of overlapping sheets, and is repeated every 0.91 m (3.0') of seam length.
2. Tack-back the Overlap
   a. The upper Firestone EPDM Geomembrane panel edge is folded back 254.0 mm (10.0") and the fold is tacked down every 0.91 m (3.0') with QuickPrime Plus.
   b. If there is dirt in the overlap area, clean the overlap area using a clean cotton cloth soaked in QuickPrime Plus. Soil should not be allowed to contaminate the Firestone EPDM Geomembrane in the splicing area.
3. Apply the QuickPrime
   a. Stir the QuickPrime Plus before and during use and transfer a small quantity 1.5 L (0.4 gal) to a bucket. The Primer is applied with a scrubbing pad.
   b. Immerse the scrubbing pad in the QuickPrime Plus, keeping the pad horizontal and let excess of QuickPrime Plus drip off the pad.
   c. Apply the QuickPrime Plus uniformly along the length of the overlap seam area, with long back and forth strokes, both to the lower face of the top sheet and the upper face of the lower sheet, until the surfaces become a dark gray in color. Avoid traces and wet spots. Each pad immersed in QuickPrime Plus will cover an area of about 0.91 m (3.0') in length, over a width of 101.6 mm (4.0") one side.
   d. Change scrubbing pads every 60.96 m (200.0') or when the primer has dried on the pad. Used pads are to be discarded at the end of the working day.
   e. Additional priming is required at factory seams and at the intersection of two seams.
   f. Both sides to be seamed are treated simultaneously so as to obtain a similar drying time.
   g. Test QuickPrime Plus for readiness. Allow the primer to flash off. The primer needs to dry completely (approximately 5-10 minutes) before installing the tape. Check its dryness by touching the primed surface with a clean dry finger to be certain that the primer does not string. When touching the primer, push forward on the primed surface at an angle to ensure that the primer is dry throughout its thickness. If either motion exposes a stringy primer when the finger is lifted, then the splice is not ready for installing the tape. Flash-off time will vary depending on ambient air conditions (relative humidity, wind...).
4. Install the QuickSeam Splice Tape
   a. Apply the QuickSeam Splice Tape (with release paper intact) on the bottom sheet, aligning the edge of the release paper with the markings.
   b. Immediately roll the splice with a 101.6 mm (4.0"), wide silicone sleeved hand roller or other methods to achieve 100% bond area.

c. When it is necessary to start a new roll of tape to continue seaming, it is required to overlap the installed tape by 25.4 mm (1.0") minimum before unrolling the second roll.

5. Check the QuickSeam Splice Tape Alignment
   a. The Firestone EPDM Geomembrane is released and the seam is closed by hand. To avoid wrinkling, close the splice gently with a movement perpendicular to the splice. The upper sheet must fall without wrinkling or tension onto the lower sheet. Allow the top sheet to rest on top of the tape's paper backing.
   b. Trim the top sheet as necessary to assure that 10.16 to 15.24 mm (0.4" to 0.6")of the QuickSeam Splice Tape will be exposed on the finished splice.
6. Remove the Paper Backing
   a. To remove the paper backing from the tape, first roll back the upper Firestone EPDM Geomembrane panel over the installed QuickSeam Splice Tape. Peel the paper backing off the QuickSeam Splice Tape by pulling against the weight of the bottom sheet at approximately a 45° angle to the tape.
   b. Allow the top sheet to fall freely onto the exposed QuickSeam Splice Tape. Mate the entire length of the seam as the release paper is being removed.
7. Roll the Overlap Seam
   a. Finally, roll the seam area by means of a 38.1 mm (1.5") silicone rubber roller, first across the splice and then along the entire length of the splice.
   b. For uneven or soft subgrades, a seaming board is required directly under the seam area. The seaming board is moved as the seam is completed.
8. Install QuickSeam Joint Covers or QuickSeam Cover Strip at the End of Seaming Runs and "T" Joints
   a. Install a 146.05 mm (5.75") QuickSeam Joint Cover over end laps or T-joints. Before installing the Joint Cover, the area to be covered must be cleaned and primed in the normal fashion. Roll the Joint Cover with the roller in the same manner as the overlap seam.
   b. At 25.4 mm (1.0") laps in the seam tape it is required to install a 152.4 mm x 152.4 mm (6.0" x 6.0") section of cover strip centered over the seam edge and over the lap. Before installing the cover strip, the area to be covered must be cleaned and primed in normal fashion.
   c. Trim seam so that the edge of seam tape and the edge of the geomembrane are flush beneath the T-joint area. Apply a 228.6 mm (9.0") long section of cover strip centered over the seam step-off.
   d. Round the corners of the cover strip section and then install it onto the dry-primed area. Be sure to center the cover strip so that it extends 76.2 mm (3.0") in each direction from the center of the overlap and the edge of the seam. Roll with the roller in the same manner as done with the overlap seam.

9. Special Considerations- End Laps, "T" Joints
   a. End Laps:
      When the splice is greater in length that the QuickSeam Cover Strip, the adjoining 152.4 mm (6.0") QuickSeam Cover strip must be overlapped a minimum of 25.4 mm (1.0")- See Detail PG 19.
   b. "T" Joints:
      1) Apply a section of Firestone QuickSeam Flashing or QuickSeam Joint Cover over the "T" joint area.
      2) After the primer has dried, apply a continuous bead of Lap Sealant .52 mm x 6.35 mm (0.375" x 0.25") around the cover strip section edge. Using the supplied Lap Sealant tool, feather the Lap Sealant immediately, taking care to leave a mound of sealant directly over the cover strip section edge.

2.09 Geomembrane Termination

The Firestone EPDM Geomembrane must be restrained in place to prevent movement down the slope and/or by wind. Depending on the situation, the Firestone EPDM Geomembrane may be anchored at various locations (i.e. top of embankment, toe of slope, or at an intermediate bench). If considerable settlement or movement is expected when the pond is filled, temporary ballasting should be provided at the top of embankment. The ballasting must allow for geomembrane movement with regard to the settlement but needs to be of an amount to prevent the geomembrane from sliding down the slope.

A. Top Anchoring the Firestone EPDM Geomembrane
   1. The top of the slope should be rounded to provide a smooth transition for the liner to reduce stress. An anchor trench must be excavated around the entire perimeter of the impoundment. The excavated soil material can be placed next to the trench for backfilling after Firestone EPDM Geomembrane placement. The anchor trench should be a minimum of 0.91 m (3.0') back from the top of slope. The edge of the trench should be rounded and free of protrusions to reduce stress on the Firestone EPDM Geomembrane.
   2. If considerable soil movements are expected during the filling of the pond, temporary anchoring should be provided at the crest so that the Firestone EPDM Geomembrane underlayment can move without being subjected to excessive tension. Partial ballasting in the anchor trench is immediately provided and final backfill is done at a later stage. To avoid movement and wind uplift of the Firestone EPDM Geomembrane during installation, temporary ballast (sand bags) is recommended. Such ballasting also facilitates the seaming operations.
   3. The Firestone EPDM Geomembrane must be kept in place to prevent down slope movement and/or wind uplift. Depending on the situation, the Firestone EPDM Geomembrane may be anchored in various ways, at the top of the embankment, at the bottom, or at an intermediate bench.

4. The top of slope anchors can be accomplished by burying the Firestone EPDM Geomembrane in a trench or by holding it in place through soil backfilling or ballasting. The dimensions of the trench depend on the expected stress. The minimum section should be 0.30 m (1.0') wide x 0.40 m (1.3') deep in cohesive soil, depending on the length (L) of the Firestone EPDM Geomembrane liner between two anchor points, the distance between the top anchor trench and the water level, the wind speed, etc. The top of the slope should be rounded to provide a smooth transition for the liner to reduce stress.
5. The Firestone EPDM Geomembrane should extend on the bottom of the trench over at least 304.8 mm (12.0") and up the back of the trench 152.4 mm (6.0").
6. The following table shows some approximate values for the trench section in compacted cohesive soil. However, it is recommended to calculate pullout requirements, especially for soil covered slopes, based on industry design standards.

Table 2.1

LENGTH OF SLOPE		SECTION OF TRENCH (M^2)			
		Low or medium wind		High wind speed	
M	F	< 100 km/h	< 62 mph	> 100 km/h	> 62mph
< 3	10	0.12	1.5	0.12	1.5
3-5	10-15	0.12	1.5	0.12	1.5
5-15	15-50	0.12	1.5	0.25	2.75
15-40	50-130	0.25	2.75	0.36	4.0
>40	> 130	0.36	4.0	0.49	5.25

7. As an alternative, using ballast at the top of the slope on a flat runout is possible if necessary measures are taken for the ballast not to erode over time.

B. Intermediate Anchors
1. If the embankment is high, it may be necessary to provide an intermediate anchor to accommodate the potential for Firestone EPDM Geomembrane movement. A bench may be added to the incline in order to provide slope stability of the embankment.
2. The Firestone EPDM Geomembrane should be held in place by ballast, anchor trench, or cover soil.

C. Toe of Slope / Bottom Ballast

In some cases, especially on large reservoirs, temporary and/or permanent ballast (soil cover) may be required due to operating conditions or wind conditions. Additionally and especially on embankments, or dam facings, toe of slope anchor trenches maybe required.

D. Inflow Terminations

In some cases, especially on reservoirs, and canals the point where the water enters the lined area must have proper termination. The area of inflow must be anchored

with a trenched of a depth designed by the project engineer. The membrane installed and then anchored with concrete prior to the covering with soil (see detail).

2.10 Terminations

A. Flashing Walls
   1. Connections of the Firestone EPDM Geomembrane to concrete/masonry structures shall comply with the following:
      a. Soil around the concrete/masonry shall be compacted to 95% standard Proctor density
      b. Connection surfaces shall be smooth, clean and free of any sharp protrusions
      c. Firestone EPDM Geomembrane shall be fully adhered to the walls using bonding adhesive or splice adhesive as required
      d. Corners are installed with QuickSeam Corner Flashings or by using QuickSeam FormFlash.
      e. The detail of the Firestone EPDM Geomembrane connection with the wall shall not permit any leakage
      f. Firestone EPDM Geomembrane is fastened at the ends or top using termination bars and fasteners adapted to concrete/masonry. Firestone Water-Block sealant is placed between the Firestone EPDM Geomembrane and the wall as shown in Firestone details.

2.11 Flashing Penetrations

A. In order to avoid any differential settling, the backfill around the structures should be placed in successive layers, each compacted to 95% standard Proctor density.

B. If possible, avoid cutting the Firestone EPDM Geomembrane at details. In some cases, however, as with corner details against concrete/masonry walls, pipe connections, etc., a cut in the Firestone EPDM Geomembrane liner will simplify the installation. In such cases, Quickseam FormFlash (unvulcanized EPDM sheet) will be used to provide a tight connection when properly installed according to the manufacturer's instructions.

C. For larger diameter pipes, connections to pipes shall be made by means of unvulcanized EPDM sheet, QuickSeam FormFlash, as follows:
   1. Pipe must be firmly anchored and the pipe wall temperature must not exceed 80° C (175° F) during service
   2. Make a circular cut-out in the Firestone EPDM Geomembrane, measuring approximately 80% of the pipe diameter
   3. Pull the Firestone EPDM Geomembrane over the pipe
   4. Pipe and Firestone EPDM Geomembrane are sealed by means of a piece of QuickSeam FormFlash.
   5. Mechanically secure the connection with a marine grade stainless steel clamping collar
   6. Firestone EPDM Geomembrane must be adhered to concrete/masonry thrust blocks with bonding adhesive.

D. Bottom Drains
   1. The Firestone EPDM Geomembrane shall be mechanically fastened at the location of water discharge.
   2. This detail requires the installation of a concrete base at the location of the drain.

2.12 Firestone EPDM Geomembrane Repair and Maintenance Procedures

A. A small tear or hole in the Firestone EPDM Geomembrane may be repaired by placing a piece of the 152.4 mm (6.0") cover strip over the area to be repaired with a of 76.2 mm (3.0") extending all directions beyond the repair. The patch must be round, oval, or contain rounded corners.

B. 152.4 mm (6.0)" Diameter QuickSeam Joint Cover patches may also be used.
   1. Small holes, < 6.35 mm (0.25 inch), may be repaired using the 6 inch diameter QuickSeam Cover Patch.
   2. Clean the damaged area by scrubbing with a cloth soaked in QuickPrime Plus. The surface should be dark gray in color with no streaking. Allow the area to dry.
   3. Repair the larger tears or holes by cutting a piece of Firestone EPDM Geomembrane that extends beyond the tear or hole by a minimum of 101.6 mm (4.0") extending all directions beyond the repair. Tape all edge seams as per Section 2.08- 152.4 mm (6.0") wide cover strip seaming tape system.

C. An annual inspection of the installation is recommended to detect any problems which may occur. This inspection process will limit costs if damage has occurred.
   1. Visual inspection of the Firestone EPDM Geomembrane, splice connections and the anchoring.
   2. Measurement of the leak flow rate and monitoring of water level.
   3. Check all gas drainage vents.
   4. Avoid any overflowing of the pond.
   5. Check the chemical composition and the temperature of the liquids coming into contact with the Firestone EPDM Geomembrane.
   6. Check the protection of the sheet, if any.

2.13 Seam Test Procedures

A. Test Seam or Trial Seam – Destructive Mechanical Testing
   1. At the start of a shift or at the beginning of each day, the seaming crew should complete a trial seam of approximately 3.05 m (10.0') in length.
   2. From the trial seam, 25.4 mm (1.0") wide strips are cut for testing on a field tensometer - 3 in peel and 3 in shear. Shear and peel tests are carried out in general accordance with ASTM D413 and D7272 with the strain rate of 500 mm/min (20 in/min) for both peel and shear due to the elastometric properties of Firestone EPDM Geomembranes. Trial seam test strips should be allowed 24 hours of cure time.
   3. The minimum requirements are as follows:
      a. Shear: 6.15 kN/m (35 lb/in) at peak load.

b. Peel: 1.41 kN/m (8 lb/in).

4. The same minimum requirements can be expected for specimens taken from a destructive field seam cut out when required.

B. Non-Destructive Test (NDT) Procedure

1. Air Lance Test (ASTM D4437)
   a. Inspect all field seams for unbonded areas using an air nozzle directed on the upper seam edge and surface to detect loose edges, riffles indicating unbonded areas within the seam, or other undesirable seam conditions.
   b. Check all bonded seams using a minimum 345 kPa (50 lb/in^2) air supply directed through a 4.8 mm (0.188") nozzle, held not more than 50.8 mm (2.0") from the seam edge and directed along the seam edge.

2.14 Protection of the Firestone EPDM Geomembrane During Service

A. Under all operating conditions, protection of the Firestone EPDM Geomembrane will be required. Table 2.2 below shows some recommendations for the protection against possible damage.

B. Protection of the geomembrane may be realized in the following ways:

1. Base
   a. Sand bed (minimum thickness: 304.8 mm (12.0"))- protection with geotextile not required
   b. Gravel (minimum thickness 304.8 mm (12.0"))- protection with geotextile required
   c. Prefabricated blocks - protection with geotextile required
2. Slopes
   a. Rock covering (riprap) - This solution is applicable for slopes less than 3:1. A transition layer (geotextile plus sand bed) with a minimum thickness of 304.8 mm (12.0") is required. Rock size depends on the level of the impacting forces, such as wave height.
   b. Prefabricated blocks - Stability investigations of prefabricated blocks and installation of a redundant layer of EPDM is required.
   c. Cast-in-place concrete - Stability investigations and installation of a redundant layer of EPDM are required.
   d. Shotcrete – installation of a geotextile may be required on steep slopes (>2H:1V). Additionally, wire reinforcement maybe required. (If wire reinforcement is used contact Firestone Specialty Products Department for additional protection requirements.)

Table 2.2

Protection Against	Recommendation
Wind	• Ballast at the bottom or on slopes • Correct section of anchor trench depending on pullout calculations
Waves	• Mechanical protection of the embankments depending on slope (rock covering, concrete pavement, cast-in-place-concrete)
Floating objects (dead wood, debris)	• Small ponds: cleaning • Large ponds: protection of side slopes
Ice	• Mechanical protection of embankments
Animals	• Ladders • Fence around reservoir • Geotextile under the Firestone EPDM Geomembrane on slopes
Vandalism	• Enclosure around reservoir • Mechanical protection of embankments
Operating vehicles	• Protection of the Firestone EPDM Geomembrane with soil or a sand bed (min. 18 in (450mm)) • Access ramp protection of embankments
Local turbulence with water velocity exceeding 4 ft/sec (1.2 m/sec) (internal agitator or canals)	• Protection with designed cover system or ballast

2.15 Warranty

A. Upon inspection and acceptance of the installed Firestone EPDM Geomembrane System, the requested warranty shall be issued. Only Firestone supplied components are covered by the Firestone warranty.

B. See Warranty Section for a listing of available Firestone warranties for Firestone EPDM Geomembrane installations.