

THE CAPRA COMPANY
2460 SAGE CANYON ROAD

SPECIFICATIONS FOR
EAST MONEY HOLE RESERVOIR

March 2025

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

March 10, 2025

THE CAPRA COMPANY
2460 SAGE CANYON ROAD
EAST MONEY HOLE RESERVOIR

TECHNICAL SPECIFICATIONS



SPECIAL CONDITIONS

SUMMARY OF WORK

1. Work Covered by Contract Documents:

The Contractor shall furnish, in accordance with the Specifications and Drawings, all plant, labor, equipment and materials required for construction of the Harney-Marino Reservoir Project.

2. Project Access:

For purposes of mobilization and demobilization of heavy earthmoving equipment, access to the project site will be allowed from 2460 Sage Canyon Road, St Helena, as shown on the Drawings. All vehicles and heavy equipment making such access shall have been cleaned prior to entering The Capra Company property and will be subject to inspection for such cleaning by the Owner.

3. Owner-furnished Products:

The Contractor shall provide his own construction water supply and shall obtain whatever approvals and permits may be required by local, State or Federal regulations to access, divert and transport such supply

4. Control of Water:

The Contractor shall be responsible for dewatering and control of water as may be required to achieve acceptable embankment and structure foundation and to safely and satisfactorily construct the improvements.

5. Contractor Use of Premises:

Do not unreasonably encumber site with materials or equipment.

Assume full responsibility for protection and safekeeping of products stored on premises.

Move any stored products which interfere with operations of Owner or other contractors. Obtain and pay for use of additional storage or work areas needed for operations.

During the progress of the work the Contractor shall keep the entire job site in a clean and orderly condition. Spillage resulting from hauling operations along or across existing streets or roads shall be removed immediately by the Contractor. Contractor shall govern Contractor's operations and methods at all times to minimize dust problems within the area of the work or along adjacent properties. Water or dust palliative shall be applied as required to provide adequate control of dust to the complete satisfaction of the Engineer. Additionally, the Contractor's operations shall not cause silting or other pollution of lakes and watercourses downstream of the project.

6. Protection of Workers in Trench Excavation and Excavation Safety:

As required by Section 6705 of the California Labor Code and in addition thereto, whenever work involves trench excavation 5 feet or more in depth, the Contractor shall submit for acceptance by a registered civil or structural engineer representing the Owner, in advance of excavation, a detailed plan showing the design of shoring, bracing, sloping, or other provisions to be made for worker protection from the hazard of caving ground during the excavation. If such plan varies from the shoring system standards established by the Construction Safety Orders of the Division of Industrial Safety, the plan shall be prepared by a registered civil or structural engineer. Nothing in this section shall be deemed to allow the use of a shoring, sloping or other protective system less effective than that required by the Construction Safety Orders. Nothing in this section shall be construed to impose tort liability on the Owner, Engineer, or any of their officers, agents or employees.

At all times, temporary construction excavations should conform to the regulations of the State of California, Department of Industrial Relations, Division of Industrial Safety or other stricter governing regulations. The stability of temporary cut slopes, such as those constructed during the installation of underground utilities, should be the responsibility of the contractor. Temporary cut slopes may need to be excavated to 1½:1, or flatter. The tops of the temporary cut slopes shall be rounded back to 2:1 in weak soil zones.

7. Erosion Control:

To minimize potential erosion impacts from construction activities, Best Management Practices (BMPs) for any disturbed areas should be included in any plan to control erosion for the proposed project. At a minimum, BMPs should include, but not be limited to the following measures:

- a. Vegetation removal shall be limited to the minimum amount necessary to accommodate the proposed project. As the permanent vegetation cover is maturing,

temporary vegetation or other erosion control measures sufficient to stabilize the soil shall be established on all disturbed areas. New plantings shall be protected by using such measures as jute netting, straw mulching, and fertilizing;

b. Temporary erosion control measures, such as silt fences, staked straw bales, and temporary revegetation, shall be installed in disturbed areas;

c. No disturbed surfaces shall be left without erosion control measures in place during the winter and spring months; and

d. Sediment shall be retained onsite by a system of sediment basins, traps, or other appropriate measures.

Construction activities within 100 feet of any drainage shall only occur between April 1 and September 15 to minimize the potential for rainfall events to mobilize and transport sediment to aquatic resources.

Right holder shall prevent any debris, soil, silt, cement that has not set, oil, or other such foreign substance from entering into or being placed where it may be washed by rainfall runoff into the waters of the State.

8. Biological Protection Terms:

A. Initial ground disturbance should occur from August 16 to January 31, outside of the general bird nesting season. If work during this time is not feasible, a preconstruction nesting bird survey should be performed by a qualified biologist no more than 14 days prior to the initiation of tree removal or ground disturbance is recommended. The survey should cover the Project Area (including tree removal areas) and surrounding areas within 500 feet. If active bird nests are found during the survey, an appropriate no-disturbance buffer should be established by the qualified biologist. Once it is determined that the young have fledged (left the nest) or the nest otherwise becomes inactive (e.g., due to predation), the buffer may be removed, and work may be initiated within the buffer.

CLEARING, GRUBBING AND STRIPPING

1. Definitions:

Clearing means cutting, removing and disposing of trees, brush, and shrubs. Clearing further means removing and disposing of fences, rubbish piles, structures and other material unsuitable for use in an earth fill embankment.

Grubbing means removing and disposing of wood and other vegetable matter remaining after clearing and includes stumps, roots and limbs larger than one inch diameter or longer than one foot.

Stripping means the removal and disposal of grass, grass roots, vegetable matter, unsuitable top soil and miscellaneous debris. Soil containing more than two percent by weight of organic matter should be considered organic. Actual stripping depth is anticipated to be about 2 to 3 inches, however actual depth shall be determined by a representative of the geotechnical engineer in the field at the time of stripping.

2. General:

Clear and grub to 5 feet measured horizontally from top of excavated slopes and toe of embankments. Strip embankment foundations and reservoir area to five feet beyond excavation limits.

3. Disposal:

Strippings shall be placed as directed on areas in the immediate vicinity of the work and thence distributed at the toe of the embankment, as directed by Engineer.

EXCAVATION

1. General:

Excavate to lines, grades and dimensions shown on the Drawings and as directed by the Engineer. Perform excavation at times and by methods which will facilitate the timely scheduling of subsequent construction activities.

Vary slopes or dimensions, as directed, if found to be necessary or desirable.

2. Utilization of Excavated Materials:

Suitable materials from required excavations will be used to construct compacted embankment as described in subsequent Sections of these Specifications.

3. Borrow Excavation:

Selectively excavate as necessary to obtain suitable construction materials, and as directed. Conduct excavation to facilitate selection of suitable materials and identification of unsuitable materials. Segregate suitable and unsuitable materials prior to loading and hauling.

Dispose of unsuitable material in the immediate vicinity as shown or as directed. Grade borrow areas and waste fills to drain and to a reasonably smooth appearance.

4. Embankment Excavation:

Embankment foundations shall be excavated to remove the underlying loose soil to an expected minimum depth of three (3) feet below original grade as shown on the Drawings, or as directed by Geotechnical Engineer. Foundation shall be excavated in benches to provide for fill placement in appropriately level lifts.

Along the toe or downstream edge of the embankment, a keyway, at least 12 feet minimum wide, shall be excavated at least 3 feet into compacted engineered fill as shown on the Drawings, or as directed by the Engineer.

5. Landslide Deposit Excavation:

Remaining landslide deposit within reservoir area shall be removed to its full depth as directed by the Geotechnical Engineer. Excavate landslide deposit to expose undisturbed bedrock. Excavate a level keyway at least 10 feet wide, extended at least 2 feet below the landslide plane as identified by Geotechnical Engineer. Keyway shall be graded to drain towards the cut slope. Additional level keyways may be excavated up the slope as shown on the Drawings, or as directed by the Geotechnical Engineer.

COMPACTED EMBANKMENT

1. General:

Construct compacted fills to lines, grades and dimensions shown on the Drawings and as directed by the Engineer.

Remove, dispose of and replace, at no cost to the Owner, any material placed which fails to meet the requirements of these Specifications; or which may have been placed or compacted at times or in a manner not acceptable to the Engineer.

Construct compacted fill from suitable earth and rock materials obtained from the required excavations and as provided by Owner. To the extent possible, use the most suitable materials obtainable from these sources without special processing.

Perform selective excavation, as directed, when necessary to obtain the type of material required. Mixing of materials during the excavation process may be required.

Unsuitable materials include those containing brush, roots, sod or other organic matter.

2. Foundation Preparation:

Prepare the areas to receive compacted fill as follows: General preparation shall include stripping of vegetation/root layer and subexcavating the underlying loose soil as shown on the Drawings, or as directed by Geotechnical Engineer.

Prior to placing fill material, the undisturbed surfaces exposed by stripping or excavation shall be reviewed and approved the Geotechnical Engineer. Following approval by Engineer, foundation surface shall be scarified to a depth of at least 8 inches, moisture conditioned to at least optimum moisture content and compacted in accordance with the Specifications and Drawings.

Breakdown the sides of holes, test pits and similar cavities, as directed.

Scarify the bottom and sides of cavities.

Fill cavities with compacted material to approximately the plane of the adjacent foundation. Moisture condition, place and compact cavity fill as specified herein for embankment.

Fill cavities which are too small or of a configuration which prevents adequate compaction with roller equipment as follows: Spread fill in 4 inch uncompacted layers. Compact with power tampers.

1. Materials:

Materials obtained from onsite excavations are anticipated to be suitable for use as embankment fill. Mixing of materials during excavation and/or loading may be required.

Suitable embankment materials are those consisting of a mixture of sand, silt and clay with rock fragments, soil and very weathered rock. It is the intent of these specifications that the embankment materials be excavated, processed, and placed so as to provide a homogeneous zone of embankment material with a maximum particle size of six inches.

If additional import fill is required, import fill shall be free of organic matter, have a low expansion potential, and conform in general to the following requirements:

Sieve Size	Percent Passing (by dry weight)
6 inch	100
4 inch	90-100
No. 200	10-60

Liquid Limit – 40 Percent Maximum
Plasticity Index – 15 Percent Maximum

2. Placement:

Obtain Engineer's approval of the portion of the foundation or embankment surfaces to be covered before placing fill thereon. Clods shall be broken up and the surface of the ground shall be moisture conditioned, uniformly pulverized and graded to a smooth surface. Material shall be placed on level surfaces. Embankment fill shall be placed in layers of 8 inches or less in loose thickness, moisture-conditioned and compacted. Remove from the embankment and dispose of, as directed, oversize stones and rock fragment. A rock rake may be required. Remove and dispose of, as directed, all roots, limbs, sticks, boards and other organic matter. Material shall be placed in lifts orientated generally parallel with the dam crest. Fill slopes shall be constructed fat and trimmed back to expose well-compacted fill.

3. Moisture Control:

The application of water to the fill material shall be done at the site of the excavation.

All fill materials shall be compacted with a moisture content within one percent below to four percent above optimum moisture content. The moisture content of existing soil or fill shall be maintained by sprinkling or other approved means, until covered by a lift of fill, or aggregate base.

Material from borrow areas may require moisture conditioning (increase or decrease the

moisture content) prior to placement and compaction. The Contractor shall disk, aerate or add water and work soil to achieve the recommended moisture content.

Approved compacted embankment shall be maintained with adequate moisture throughout embankment construction operations to prevent material from drying out. This may require periodic sprinkling or covering with an impermeable barrier. Embankment materials not maintained with adequate moisture shall be removed and replaced, as directed by Engineer or Geotechnical Engineer, at no cost to the Owner.

4. Compaction:

Compaction shall be performed using compacting rollers, pneumatic or vibratory rollers or other suitable equipment as specified herein. Compaction and recompaction requirements for both native and imported fill shall be as follows:

- a) Minimum for embankment: 92 percent
- b) Minimum for crest subgrade (upper 6 inches of crest fill) and aggregate base: 95 percent
- c) Minimum for subgrade below reservoir liner (upper 6 inches): 95 percent

ASTM D-1557 shall be used to determine reference value for optimum moisture content and relative compaction.

Compact each embankment layer after moisture content has been brought to the specified condition and oversized and unsuitable material have been removed.

Compact with tamping rollers to the specified maximum dry density. Self-propelled sheepsfoot type rollers may be used upon prior approval by the Engineer.

Moisture condition and compact top surface of reservoir liner subgrade with vibratory smooth drum roller to at least 95 percent of maximum dry density, as determined by ASTM D-1557.

5. Structure Backfill:

Place backfill or embankment within 24-inches horizontally and 18-inches above pipes and other structures in four-inch uncompacted layers.

Remove material larger than three inches. Remove unsuitable material as specified above.

Moisture control is to comply with the above paragraph 5 "Moisture Control":

Compact with approved hand held or guided tampers to 95 percent maximum dry density, as determined by ASTM D-1557

6. Finishing:

Dress and grade exposed slopes and roads to provide a uniform surface and slope. Slope embankment crest to drain as shown on Drawings. Grade area at downstream toe to conform with surrounding undisturbed ground.

All ground surfaces shall be finished to uniform grades and slopes as per the drawings and in such a manner as to drain properly and be free from depressions, which may cause areas of standing water. Embankment transitions shall form a uniform surface and to drain.

All embankment crest surfaces shall be graded to a tolerance of one-tenth (0.10) foot above the elevation and/or grades shown on the drawings. Slopes shall be in accordance with the lines and grades shown on the drawings. All slope surfaces shall be graded to a tolerance of three-tenths (0.30) foot above the elevation and/or grades shown on the drawings.

The exterior slope of the finished embankment shall be track-walked perpendicular to the slope face with tractor fitted with apex tracks or an approved equivalent.

Reservoir slopes and surfaces in contact with the reservoir liner shall be thoroughly visually inspected to remove any potentially sharp or deleterious rocks or other materials from the liner subgrade surface and rolled with a vibratory smooth drum roller to develop an obstruction-free, smooth subgrade surface suitable for installation of the reservoir liner.

7. Field Quality Control And Materials Testing:

General construction shall be performed under the observation and testing of the Engineer or Geotechnical Engineer to assist in determining if the work conforms with these Specifications. The observation and testing will be as frequent as the Engineer or Geotechnical Engineer considers necessary. The Contractor shall cooperate with the Engineer and Geotechnical Engineer in all aspects of the observation and testing. The Contractor shall remove surface material and render such assistance as necessary to facilitate sampling and testing. The Contractor shall take such precautions as necessary to protect the Engineer and Geotechnical Engineer from injury due to the Contractor's operations during the observation and testing operations.

The Engineer shall be notified at least 24 hours prior to required observation and testing. Any materials placed or improvements constructed in the absence of the Engineer's approval to proceed shall be presumed to be defective and, at the discretion of the Engineer, shall be removed and replaced at no cost to the Owner.

Field and laboratory observation and testing performed by the Engineer and Geotechnical Engineer shall be at no cost to the Contractor. When observation and testing are required as a result of initially failing test results, improper moisture content, inadequate compaction, unsuitable material, or for other causes necessitating re-observation and retesting, the re-observation and retesting shall be at the expense of the Contractor.

KEYWAY, SUBSURFACE, AND LINER SUB-DRAINS

1. General:

The embankment keyway drain, landslide excavation subsurface drain, and liner sub-drains shall be installed as shown on the drawings, or as directed by the Engineer. Drains consist of perforated SDR-35 perforated pipe in a drainage rock envelope. Sub-drains should be installed at a minimum slope of one (1) percent and should have cleanouts located at their ends and at turning points. "Sweep" type elbows and wyes should be used at all turning points and cleanouts, respectively. Subdrain outlets and riser cleanouts should be fabricated of the same material as the subdrain pipe as specified herein. Outlet and riser pipe fittings should not be perforated.

2. Materials:

Perforated pipe size shall be as shown on the drawings. Pipe shall have 2 rows of holes, 120-degrees apart, parallel to the axis of the pipe. Maximum perforation diameter shall be 0.5 inch, at 5 inch spacing.

Drain outfall pipe through embankment shall be PVC SCH 80 pipe and with solvent weld connections and fittings, size as shown on the Drawings or as direct by Engineer. Drain outfall pipes shall be backfilled with Controlled Low Strength Fill (CLSM) and/or Structural Backfill as described in these Specifications and as shown on the Drawings.

Drain rock shall comply with the minimum requirements in Caltrans Standard Specifications, for Class 2 Permeable Material. No geotextile fabric is required.

Discharge manhole structure shall be a segmented precast structure with integral base unit as manufactured by Jensen Precast or an approved alternative manufacturer, as shown on the Drawings.

Pipe penetrations shall be sealed with non-shrink grout or cement mortar inside and out or else manhole structures shall be cast with pre-cast boot installed to match pipe. Penetrations shall be watertight when finished structure is filled with water.

Controlled Low Strength Material (CLSM) shall be a fluid workable mixture of aggregate, cement, and water.

Cement must be one of the following:

- a. Cement complying with ASTM C150
- b. Blended hydraulic cement complying with either of the following:
 - i. ASTM C595
 - ii. Physical requirements in ASTM C1157

When tested under ASTM D4832, the controlled low-strength material must have a 28-

day compressive strength:

- a. From 50 to 100 psi for pipes with 20 feet or less in height of cover
- b. Of at least 100 psi for pipes with over 20 feet in height of cover

Water must be free of oil, salts, and other impurities that adversely affect the backfill.

Aggregate must be one of the following:

- a. Commercial-quality concrete sand
- b. Excavated or imported material in any combination, free of organic material and other deleterious substances and complying with the gradation requirements shown in the following table:

<u>Sieve size</u>	<u>Percentage passing</u>
1-1/2"	100
1"	80-100
3/4"	60-100
3/8"	50-100
No. 4	40-80
No. 100	10-40

Mix materials thoroughly by machine. A pugmill rotary drum or other authorized mixer must be used. Mix until cement and water are thoroughly dispersed.

Wherever controlled low-strength material is placed within the travelled way or covered by paving or embankment materials, the controlled low-strength material must achieve a maximum indentation diameter of 3 inches when tested under ASTM D6024 before covering and opening to traffic.

3. Installation:

Prior to installation of pipe, gravel, CSLM and structural backfill, thoroughly clean trench of loose soil, loose rock and other deleterious materials.

Place drainage material in trenches as required to provide pipe clearance. Drainage material shall be placed in lifts and compacted as Structural Backfill as described in these specifications.

SEEDING

1. General:

The finished downstream slope of the completed embankment, and any other areas as directed, shall be seeded to establish a permanent cover crop.

2. Seed:

Seed species and rate of application:

<u>Common Name (Botanical Name)</u>	<u>Rate Per Acre</u>
Blando Brome (Bromes Mollis L.)	8 pounds
Hykon Rose (Trifolium Hirtium)	9 pounds
Zorro Annual Fescue (Vulpia myuros)	<u>4 pounds</u>
Total	21 pounds

3. Seedbed Preparation:

Prior to seeding, seedbed pockets shall be created by “track-walking” tractors up and down the slope or by other similar mechanical means where horizontally oriented depressions are required. Seedbed pockets shall be 1 to 2 inches deep and capable to capturing seed and water runoff and shall extend the length and width of the area to be seeded.

4. Schedule:

Seeding shall be completed by September 15, unless prior authorization is obtained from the Engineer for a later application date.

METAL FABRICATIONS

1. Anchors:

Stud anchors with wedge bolts, sizes as shown. Bolts: 303 stainless steel. Nuts and washers: Type 18-8 stainless steel. Wedges: Double plated spring steel. Phillips "Red Head" Wedge Anchors, Hilti "Kwik-Bolt" or approved equal

2. Materials:

Steel bars, plates, and shapes: ASTM A 36.

Steel pipe: Commercial quality welded

Bolts and nuts: ASTM A 307. Galvanized bolts and nuts in accordance with ASTM A 153.

Washers and other parts: Commercial quality.

Welding: Electrode (E 70)

3. Fabrication:

Fabricate metalwork in accordance with good commercial quality and neat workmanship. Remove burrs, rough and sharp edges and other flaws. Straighten warped pieces after fabrication and before galvanizing.

Perform welding with electrodes and procedures, including visual inspection, conforming to AWS D1.1.

Holes for anchor bolts to be bolt size plus 1/8 inch. Bolt lengths to be sufficient to avoid bearing on threads.

Hot dip galvanize metalwork, except stainless steel, after fabrication in accordance with ASTM A 123. Galvanize components of bolted assemblies separately before assembly

4. Installation:

Install metalwork accurately to lines and elevations shown. Align and adjust as necessary to produce a neat appearance.

Clean embedded metalwork to remove all dirt, grease, mortar, grout, loose scale, loose rust or other foreign matter.

Perform field cutting and fitting accurately and neatly. Remove burrs, rough and sharp edges.

Repair damaged galvanized surfaces as follows: Remove all loose or cracked zinc coating. Thoroughly wire brush the damaged area. Paint with two coats alkyd-type zinc-dust zinc oxide priming paint, conforming to Federal Spec. TT-P-641, Type II.

OVERFLOW CONDUIT

1. Materials:

Overflow conduit piping pipe shall be welded steel pipe, 1/4 inch minimum, commercial quality of "structural" grade or better. No loose rust on pipe exteriors. Field joints to be welded around entire circumference of pipe, either bell and spigot lap or single-V butt. Pipe size shall be as shown on the Drawings.

Steel piping, fittings and flanges shall be sandblasted and coated with one coat of primer and two coats of enamel paint, color to be specified by the Owner. Buried piping and fittings shall be similarly coated, then wrapped with Scotchrap Tape 51 by 3M, 20 mil thickness or approved equal, to 6 inches above finish grade. Tape wrap shall be half-lapped and applied with pipe primer in accordance with manufactures recommendations.

Prefabricated steel fittings shall be standard weight steel conforming to ASTM A234 grade WPB. Steel flanges shall be AWWA C207 Class D with full face gaskets. Bolts shall be galvanized carbon steel conforming to ASTM A307.

2. Trench Excavation:

The overflow conduit shall be installed in a trench excavated into compacted embankment or firm existing ground. Excavate trenches for pipe to the minimum dimensions recommended by pipe manufacturer. Form bottom of trench at joints to conform to pipe bells and to provide firm uniform support of the entire pipe length.

3. Conduit Assembly:

Assemble pipe and associated fittings in accordance with manufacturers instructions.

Remove all dirt, mud, and other foreign substances from within the pipe prior to assembly.

4. Trench Backfill:

Conduit trench excavation shall be backfilled with Controlled Low Strength Material (CLSM) 4" beneath pipe to ensure adequate bedding to 6 inches over the pipe, and/or structural embankment to finish grade.

RIPRAP

1. General

Place or replace riprap in locations and to minimum dimensions as shown on the Plans or as directed.

2. Imported Materials:

Riprap shall be clean angular rock free from seams, cracks, and other defects tending to destroy its resistance to weather. Riprap shall conform to the following quality requirements:

- | | |
|-------------------------------|----------------|
| A. Degradation Factor | = 15 % minimum |
| B. Los Angeles Wear, 500 Rev. | = 50 % maximum |
| C. Specific Gravity | = 2.55 minimum |

HIGH DENSITY POLYETHYLENE GEOMEMBRANE LINER

1. Definitions

- a) Lot – A quantity of resin (usually the capacity of one rail car) used in the manufacture of polyethylene geomembrane rolls. The finished roll will be identified by a roll number traceable to the resin lot used.
- b) Construction Quality Assurance Consultant (CONSULTANT) – Party, independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the lining system construction.
- c) ENGINEER – The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.
- d) Geomembrane Manufacturer (MANUFACTURER) – The party responsible for manufacturing the geomembrane rolls.
- e) Geosynthetic Quality Assurance Laboratory (TESTING LABORATORY) – Party, independent from the OWNER, MANUFACTURER AND INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.
- f) INSTALLER – Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.
- g) Panel – Unit area of a geomembrane that will be seamed in the field that is larger than 100 square feet.
- h) Patch - Unit area of a geomembrane that will be seamed in the field that is less than 100 square feet.
- i) Subgrade Surface – Soil layer surface which immediately underlies the geosynthetic material(s).

2. Submittals Post-Award

- a) Furnish the following product data, in writing, to ENGINEER prior to installation of the geomembrane material:
 - i. Resin Data shall include the following:
 - a. Certification stating that the resin meets the specification.
 - ii. Geomembrane Roll
 - a. Statement certifying no reclaimed polymer is added to the resin (product run may be recycled).

- b) The INSTALLER shall furnish the following information to the ENGINEER and OWNER prior to installation:
 - i. Installation layout drawings:
 - a. Must show proposed panel layout including field seams and details
 - b. Must be approved prior to installing the geomembrane
 - c. Approved drawings will be for concept only and actual panel placement will be determined by site conditions.
 - ii. Installer's Geosynthetic Field Installation Quality Assurance Plan
- c) The INSTALLER shall submit the following to the ENGINEER upon completion of installation:
 - i. Certificate stating the geomembrane has been installed in accordance with the Contract Documents
 - ii. Material and installation warranties
 - iii. As-built drawings showing actual geomembrane placement and seams including typical anchor trench detail

3. Quality Assurance

- a) The OWNER may engage and pay for the services of a Geosynthetic Quality Assurance Consultant and Laboratory to monitor geomembrane installation.

4. Qualifications

- a) MANUFACTURER
 - i. Geomembrane MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane during the last year.
- b) INSTALLER
 - i. INSTALLER shall have worked in a similar capacity on at least 3 projects similar in complexity to the project described in the contract documents.
 - ii. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
 - iii. The INSTALLER shall provide a minimum of one Master Seamer for work on the project.
 - a. Must have completed a minimum of 1,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for the use on this Project.

5. Material Labeling, Deliver, Storage and Handling

- a) Labeling – Each roll of geomembrane delivered to the site shall be labeled by the MANUFACTURER. The label will identify:

- i. manufacturer's name
 - ii. product identification
 - iii. thickness
 - iv. length
 - v. width
 - vi. roll number
- b) Delivery – Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.
- c) Storage – The on-site storage location for geomembrane material, provided by the CONTRACTOR to protect the geomembrane from punctures, abrasions and excessive dirt and moisture, shall have the following characteristics:
- i. level (no wooden pallets)
 - ii. smooth
 - iii. dry
 - iv. protected from theft and vandalism
 - v. adjacent to the area being lined
- d) Handling – Materials shall be handled so as to prevent damage.

6. Warranty

- a) Material shall be warranted, on a pro-rata basis against MANUFACTURER'S defects for a period of 5 years from the date of geomembrane installation.
- b) Installation shall be warranted against defects in workmanship for a period of 1 year from the date of geomembrane completion.

7. Geomembrane

- a) Material shall be smooth polyethylene geomembrane as shown on the drawings.
- b) Resin
 - i. Resin shall be new, first quality, compounded and manufactured specifically for producing geomembrane.
 - ii. Natural resin (without carbon black) shall meet the following additional minimum requirements:

Property	Test Method	HDPE
Density [g/cm ³]	ASTM D 792	0.932
Melt Flow Index [g/10 min.]	ASTM D 1238 (190/2.16)	≤ 1.0
OIT [minutes]	ASTM D 3895 (1 atm/200°C)	100

c) Geomembrane Rolls

- i. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
- ii. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.
- iii. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating number, thickness, length, width and MANUFACTURER.
- iv. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in Section H, 4, and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

d) Smooth surfaced geomembrane shall meet the requirements shown in the following table(s) for the following material(s):

Minimum Values for Smooth Black-Surfaced HDPE Geomembranes

Property	Test Method	
Thickness, mil	ASTM D 5199	
Minimum Average		60
Lowest Individual Reading		54
Density, g/cm ³	ASTM D 792	0.94
Carbon Black Content, %	ASTM D 1603, Modified	2.0
Carbon Black Dispersion	ASTM D 5596	Cat 1 or 2
<i>Tensile Properties:</i> (each direction)	ASTM D 6693 Type IV, 2 ipm	
Strength at Yield, lb/in		126
Strength at Break, lb/in		228
Elongation at Yield, %	(1.3" gauge length)	12
Elongation at Break, %	(2.0" gauge length)	700
Tear Resistance, lb	ASTM D 1004	42
Puncture Resistance, lb	ASTM D 4833	108
Notched Constant Tensile Load, hrs.	ASTM D 5397, Appendix	300
Oxidative Induction Time, min.	ASTM D 3895	100

8. Equipment

- a) Welding equipment and accessories shall meet the following requirements:
 - i. Gauges showing temperatures in apparatus (extrusion welder) or wedge (wedge welder) shall be present.
 - ii. An adequate number of welding apparatus shall be available to avoid delaying work.
 - iii. Power source capable of providing constant voltage under combined line load shall be used.

9. Deployment

- a) Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the job site.
- b) Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.
- c) Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:
 - i. Unroll geomembrane panels using methods that will not damage geomembrane and will protect underlying surface from damage (i.e., spreader bar, protected equipment bucket).
 - ii. Place ballast (commonly sandbags) on geomembrane which will not damage geomembrane to prevent wind uplift.
 - iii. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage the geomembrane. Smoking will not be permitted on the geomembrane.
 - iv. Do not allow vehicular traffic directly on geomembrane. Rubber-tired ATV's and trucks are acceptable if wheel contact is less than 6 psi.
 - v. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.
- d) Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material.

10. Field Seaming

- a) Seams shall meet the following requirements:
 - i. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.
 - ii. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
 - iii. Slope seams (panels) shall extend a minimum of five-feet beyond the grade break into the flat area.

- iv. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the CONSULTANT and INSTALLER.
 - v. Align seam overlaps consistent with the requirements of the welding equipment being used. A 6-inch overlap is commonly suggested.
- b) During Welding Operations
- i. Provide at least one Master Seamer who shall provide direct supervision over other welders as necessary.
- c) Extrusion Welding
- i. Hot-air tack adjacent pieces together using procedures that do not damage geomembrane.
 - ii. Clean geomembrane surfaces by disc grinder or equivalent.
 - iii. Purge welding apparatus of heat-degraded extrudate before welding.
- d) Hot Wedge Welding
- i. Welding apparatus shall be a self-propelled device equipped with an electronic controller, which displays applicable temperatures.
 - ii. Clean seam area of dust, mud, moisture and debris immediately ahead of the hot wedge welder.
 - iii. Protect against moisture build-up between sheets.
- e) Trial Welds
- i. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.
 - ii. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
 - iii. Minimum of two trial welds per day, per welding apparatus, one made prior to the start of work and one completed at mid shift.
 - iv. Cut four, one-inch wide by six-inch long test strips from the trial weld.
 - v. Quantitatively test specimens for peel adhesion, and then for bonded seam strength (shear).
 - vi. Trial weld specimens shall pass when the results shown in the following table are achieved in both peel and shear test.
 - a. The break, when peel testing, occurs in the liner material itself, not through peel separation (FTB).
 - b. The break is ductile.

Minimum Weld Values for HDPE Geomembranes

Property	Test Method	60
Peel Strength (fusion), lb/in	ASTM D 6392	98
Peel Strength (extrusion), lb/in	ASTM D 6392	78
Shear Strength (fusion & ext.), lb/in	ASTM D 6392	121

- vii. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
 - viii. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed trial weld.
- f) Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. INSTALLER shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.
- g) Defects and Repairs
- i. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
 - ii. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

11. Field Quality Assurance

- a) MANUFACTURER and INSTALLER shall participate in and conform to all terms and requirements of the Owner's quality assurance program. CONTRACTOR shall be responsible for assuring this participation.
- b) Field Testing
- i. Non-destructive testing may be carried out as the seaming progresses or at completion of all field seaming.
 - a. Vacuum Testing
 - 1) Shall be performed in accordance with ASTM D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
 - b. Air Pressure Testing
 - 1) Shall be performed in accordance with ASTM D 5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
 - c. Other approved methods.
 - ii. Destructive Testing (performed by CONSULTANT with assistance from INSTALLER)

- a. Destructive testing shall be performed in accordance with ASTM D 6392, Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
- b. INSTALLER shall repair all holes in the geomembrane resulting from destructive sampling.
- c. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.
- d. Additional tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds.
- e. Sample Size:
 - 1) The sample should be twelve inches wide with a seam fourteen inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent lab testing by the owner or by specific project specifications.
 - 2) A one inch sample shall be cut from each end of the test seam for field testing on a calibrated field tensiometer.
- f. The one inch wide samples shall be tested in the field for peel. If any field sample fails to pass FTB, it will be assumed the sample fails destructive testing. The procedures outlined in Subsection 2. shall be followed to locate passing samples to send to the laboratory.
 - 1) If the sample passes the field test, the CONSULTANT shall test the remaining portion of the sample test strip to evaluate seam strength and confirm field testing. This test may be performed in the field on a calibrated tensiometer.
 - 2) Procedure in the event of Destructive Test Failure:
 - a. Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten feet in each direction from the location of the failed sample. Perform a field test with the tensiometer for peel strength, and confirm field testing.
 - b. If the laboratory samples pass, then reconstruct the seam up to the two passing sample locations.
 - i. Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld.
 - ii. Vacuum test the extrusion weld.
 - c. If either of the samples fail, then additional samples are taken in accordance with the above procedure until two passing samples are found to establish the zone in which the seam should be reconstructed.
 - d. All passing seams must be bounded by two locations from which samples passing destructive test have been taken.
 - e. In the case of reconstructed seams exceeding 150 feet, a sample must be taken and pass destructive testing.
 - f. All destructive seam samples sent to Third Party laboratory shall be numbered and recorded on a destructive seam test form.
 - g. Third Party Quality Assurance Laboratory Testing:
 - h. The remaining destructive sample will be sent to a qualified laboratory

or done on site and will be tested in "Seam Strength" and "Peel Adhesion" (ASTM D 3083 and ASTM D413) as modified in NSF Standard No. 54. Five specimens shall be tested for each test method with data recorded. Four out of the five specimens must pass for each test in order for the seam to pass the destructive test.

12. Repair Procedures

- a) Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.
- b) Repair any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test.
- c) INSTALLER shall be responsible for repair of defective areas using one of the following repair methods:
 - i. Patching – Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter.
 - ii. Abrading and Re-welding – Used to repair short section of a seam.
 - iii. Spot Welding – Used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.
 - iv. Capping – Used to repair long lengths of failed seams.
 - v. Flap Welding – Used to extrusion weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.
 - vi. Remove the unacceptable seam and replace with new material.
- d) The following procedures shall be observed when a repair method is used:
 - i. All geomembrane surfaces shall be clean and dry at the time of repair.
 - ii. Surfaces of the polyethylene, which are to be repaired by extrusion welds, shall be lightly abraded to assure cleanliness.
 - iii. Extend patches or caps at least 6-inches for extrusion welds and 4-inches for wedge welds beyond the edge of the defect, and around all corners of patch material.
 - iv. Repair Verification
 - v. Number and log each patch repair.
 - vi. Non-destructively test each repair using methods specified in this Specification.

GEOCOMPOSITE DRAINAGE LAYER

1. Materials

- a) Geocomposite shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure with a non-woven geotextile bonded to both sides.
- b) The geocomposite specified shall have properties that meet or exceed the values listed in Table 1 below.

Table 1: Geocomposite Properties

Property	Test Method	Test Frequency	Value
Geocomposite			
Transmissivity, gal/min/ft	ASTM D 4716	1/540,000 ft ²	7.2
Single-Sided Composite			2.4
Double-Sided Composite			
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft ²	1.0
Geonet Core			
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft ²	250
Transmissivity(2), gal/min/ft	ASTM D 4716		14.5
Density, g/cm ³	ASTM D 792	1/50,000 ft ²	0.94
Tensile Strength (MD), lb/in	ASTM D 7179	1/50,000 ft ²	55
Carbon Black Content, %	ASTM D 4218	1/50,000 ft ²	2.0
Geotextile			
Mass per Unit Area, oz/yd ²	ASTM D 5261	1/90,000 ft ²	8
Grab Tensile Strength, lb	ASTM D 4632	1/90,000 ft ²	220
Grab Elongation	ASTM D 4632	1/90,000 ft ²	50
CBR Puncture Strength, lb	ASTM D 6241	1/540,000 ft ²	575
Trapezoidal Tear Strength, lb	ASTM D 4533	1/90,000 ft ²	90
AOS, US sieve(1) (mm)	ASTM D 4751	1/540,000 ft ²	80
Permittivity, sec-1	ASTM D 4491	1/540,000 ft ²	1.3
Water Flow Rate, gpm/ft ²	ASTM D 4491	1/540,000 ft ²	95
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	Per formulation	70

Table 2: Raw Material Properties

Property	Test Method	Test Frequency	Value
Density (g/cm ³)	ASTM D 792	Once Per Resin Lot	>0.94
Melt Flow Index (g/10 min)	ASTM D 1238	Once Per Resin Lot	≤ 1.0

2. Manufacturing Quality Control

- a) The geocomposite shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the ENGINEER.
- b) The geocomposite shall be tested according to the test methods and frequencies listed in Table 1.

3. Execution

a) Inspection

- i. Prior to implementing any of the work in the Section to be lined, the INSTALLER shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the Section may properly commence without adverse impact.
- ii. If the INSTALLER has any concerns regarding the installed work of other Sections, he shall notify the Project ENGINEER.

4. Material Placement

- a) The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.
- b) If the project contains long, steep slopes, special care should be taken so that only full-length rolls are used at the top of the slope.
- c) In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until covered by geomembrane.
- d) The geocomposite shall be properly anchored within the anchor trench to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.
- e) No equipment shall drive directly across the geocomposite.
- f) The cover soil within the anchor trench shall be placed in a manner that prevents damage to the geocomposite. Placement of the cover soil shall proceed immediately following the placement and inspection of the geocomposite.

5. Seams And Overlaps

- a) Each component of the geocomposite will be secured to the like component at overlaps.
- b) Geocomposite Components
 - i. Adjacent edges of the geonet along the length of the geocomposite roll shall be placed with the edges of each geonet butted against each other.
 - ii. The overlapped edges shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 5 feet along the roll length.

- iii. Adjoining geocomposite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width.
- iv. The geonet portion should be tied every 6 inches in the anchor trench or as specified by the ENGINEER.

6. Repair

- a) Prior to covering the deployed geocomposite, each roll shall be inspected for damage resulting from construction.
- b) Any rips, tears or damaged areas on the deployed geocomposite shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geonet shall be cut out and the two portions of the geonet shall be joined in accordance with Subsection E.

GEOTEXTILE FABRIC

1. Scope

Contractor shall furnish all geotextile, labor, incidental materials, tools, supervision, transportation, and installation equipment necessary for the installation of geotextile, as specified herein, and as shown on the drawings.

2. Submittals

- a) Prior to material delivery to project site, the contractor shall provide the engineer with a written certification or manufacturers quality control data which displays that the geotextile meets or exceeds the requirements of these specifications.

The contractor shall submit, if required by the engineer, manufacturer's quality control manual for the geotextile to be delivered to the site.

3. Materials

The geotextile shall be manufactured from polyester, nylon or polypropylene material, or any combination thereof. The fabric shall be nonwoven, shall not act as a wicking agent, and shall be permeable.

The fabric shall be Mirafi S800, or equal and shall conform to the following:

Equivalent Opening Size (EOS)	70 to 100
Weight	8 oz/sq yard minimum
Grab Tensile Strength	200 lbs minimum
Elongation	50% minimum

4. Manufacture

All rolls of the geotextile shall be identified with permanent marking on the roll or packaging, with the manufacturers name, product identification, roll number and roll dimensions.

5. Transport & Storage

Transportation of the geotextile shall be the responsibility of the contractor. During shipment, the individually wrapped geotextile rolls shall be protected from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, or other damaging or deleterious conditions.

Upon delivery at the job site, the contractor shall ensure that the geotextile rolls are handled and stored in accordance with the manufacturer's instructions as to prevent damage.

6. Installation

The geotextile shall be handled in such a manner as to ensure that it is not damaged in any way. Should the contractor damage the geotextile to the extent that it is no longer usable as determined by these specifications or by the Engineer, the contractor shall replace the geotextile at his own cost.

The geotextile shall be installed to the lines and grades as shown on the contract drawings and as described herein.

The geotextile shall be deployed down the slope in such a manner as to continuously keep the geotextile in tension. The geotextile shall be securely anchored in an anchor trench where applicable, or by other approved or specified methods.

In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.

The contractor shall take necessary precautions to prevent damage to adjacent or underlying materials during placement of the geotextile. Should damage to such material occur due to the fault of the contractor, the latter shall repair the damaged materials at his own cost and to the satisfaction of the Engineer.

During placement of the geotextile, care shall be taken not to entrap soil, stones or excessive moisture that could hamper subsequent seaming of the geotextile as judged by the engineer.

The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct sun light for more than 15 days after installation.

The geotextile shall be seamed using heat seaming or stitching methods as recommended by the manufacturer and approved by the Engineer. Sewn seams shall be made using polymeric thread with chemical resistance equal to or exceeding that of the geotextile. All sewn seams shall be continuous. Seams shall be oriented down slopes perpendicular to grading contours unless otherwise specified. For heat seaming, fusion welding techniques recommended by the manufacturer shall be used.

The contractor shall not use heavy equipment to traffic above the geotextile without approved protection.

The geotextile shall be covered as soon as possible after installation and approval. Installed geotextile shall not be left exposed for more than 15 days.

Material overlying the geotextile shall be carefully placed to avoid wrinkling or damage to the geotextile.

