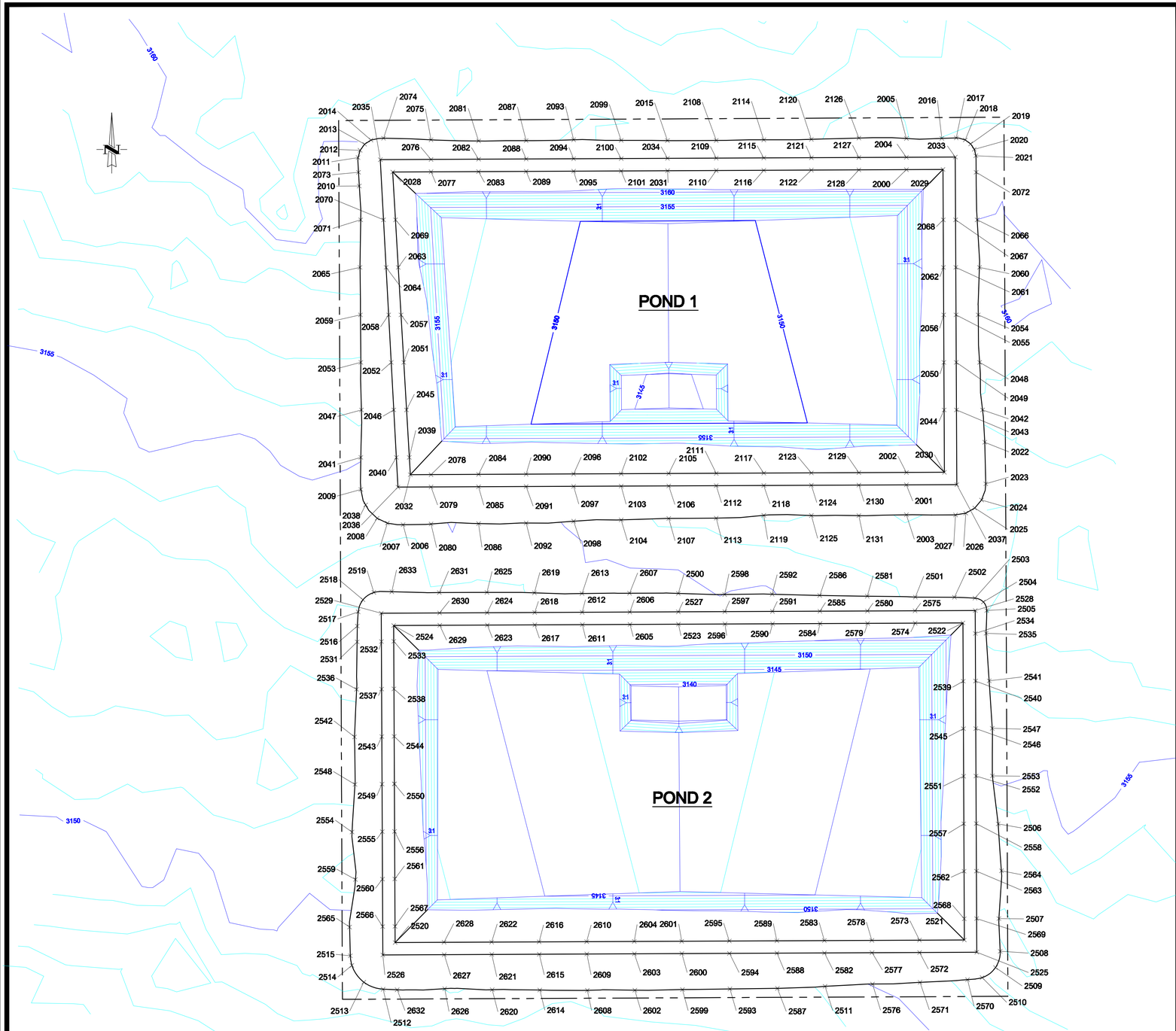


RECEIVED
By OCD Dr Oberding at 10:13 am, Dec 16, 2016

NOTES

1. POND 1 ABOVE GRADE STAKING POINTS ARE FROM 2000 THRU 2131 REFERENCE ASCII FILE - POND-1 ABOVE GRADE STAKING.TXT
2. POND 2 ABOVE GRADE STAKING POINTS ARE FROM 2500 THRU 2634 REFERENCE ASCII FILE - POND-2 ABOVE GRADE STAKING.TXT
3. STAKING POINT FILE IS A COMMA DELINEATED FILE WITH CORRESPONDING POINT NUMBER, NORTHING, EASTING, ELEVATION
4. FOR POND 1 AND POND 2 BELOW GRADE STAKING POINTS SEE SHEET C-15

LEGEND

- 3155 — EXISTING 5' CONTOUR INTERVAL (FEET, MSL)
- EXISTING 1' CONTOUR INTERVAL
- PERMIT BOUNDARY
- 2587 — STAKING POINT NUMBER AND LOCATION

JASON A. VICKERY — NEW MEXICO — 17697 — PROFESSIONAL ENGINEER

REVISIONS

NO.	DATE	DESCRIPTION

DESIGNED	NL
DRAWN	DKK
CHECKED	JV
DATE	10/18/16

Tetra Tech Inc.
Texas Registered Engineering Firm F-3924
4000 N. BIG SPRING, Suite 401
MIDLAND, TEXAS 79705
(432) 682-4559

CHEVRON N.A. E&P, MCBU
LEA COUNTY, NEW MEXICO
GPS (WGS84): 32.034518°N, -103.638474°W

VERIFY SCALE
BAR IS ONE (1) INCH ON ORIGINAL DRAWING.
0 — 1"
IF NOT ONE (1) INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

SCALES:
HORIZONTAL SCALE: 1" = 60'
VERTICAL SCALE: NA

POND 1 AND POND 2 ABOVE GRADE STAKING PLAN SALADO DRAW LEA COUNTY, NEW MEXICO

PROJECT NO. 212C-MD-00546
DRAWING NO. C-16
SHEET NO. 16 OF 16

Appendix 5 – Recycling Containment Construction Specifications

Technical Specifications
Salado Draw, Section 23
Water Recycling Ponds Construction

Chevron North America Exploration and Production
Mid-Continent Business Unit
Lea County, New Mexico

Prepared for:

Chevron North America Exploration and Production
Mid-Continent Business Unit

15 Smith Road

Midland, Texas 79705

Prepared by:

Tetra Tech, Inc.
4000 North Big Spring St., Suite 401
Midland, Texas 79705
Phone: 432-682-4559

Tetra Tech Project No. 212C-MD-00546

September 2016

SECTION 00 01 10 – TABLE OF CONTENTS

END OF SECTION 00 01 10

SECTION 31 11 00 – CLEARING, GRUBBING, AND STRIPPING

PART 1 - GENERAL

1.01 SUMMARY

A. Requirements of this Section shall consist of CONTRACTOR providing all required clearing, grubbing, and stripping related labor, materials, equipment, tools, and services for the WORK.

1.02 DEFINITIONS

A. Clearing: Clearing shall consist of removal of all vegetation and the satisfactory disposal of brush, rubbish, and any other vegetation.

B. Grubbing: Grubbing shall consist of the removal and disposal of roots, root mats, stumps, logs, peat, and other objectionable matter which could adversely affect the quality of the subgrade or borrow materials.

C. Topsoil: Topsoil is the upper soil horizon which is characterized by a significant organic content.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 AREAS TO BE CLEARED AND GRUBBED

A. Perform clearing and grubbing only in areas identified by the ENGINEER OR OWNER. Clear and grub all areas where WORK is to take place.

B. Clear and grub all borrow areas to the extent necessary to provide fill materials free of all objectionable matter described above.

C. Vegetation located outside the construction limits shall not be damaged.

3.02 DISPOSAL OF CLEARED AND GRUBBED MATERIALS

A. All brush, vegetation, rubbish, organic soils, and other debris from clearing and grubbing operations, including all debris remaining from previous clearing operations, shall be stockpiled separately at a location designated by the OWNER.

3.03 EXCAVATING, STOCKPILING, AND WASTING TOPSOIL

A. If present, excavate topsoil from areas designated for project grading or construction, as encountered. In addition, excavate topsoil from areas designated for use as waste locations for earth subsoil material.

B. Remove lumped soil, vegetative material, boulders, and rocks from the excavated topsoil to be stockpiled.

C. Stockpile, if available, sufficient topsoil material on-site for use as vegetative cover for future reclamation purposes. Protect stockpile from erosion and grade to prevent ponding of water. Organic soils shall be segregated from soil materials that may be suitable for other uses described in these SPECIFICATIONS and shown on the DRAWINGS.

D. Dispose of excess topsoil and waste topsoil not intended for reuse in a location selected by the OWNER. Disposal and handling of this material shall be performed following the requirements of the appropriate government agencies.

END OF SECTION 31 11 00

SECTION 31 23 00 - EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. The section describes the following:

1. All excavation required to reach planned grades and contours, install project components, and to construct temporary run-on and run-off conveyance systems.
2. Placement of various fill materials:
   a. Compacted embankment fill
   b. Drainage Aggregate (Drain Rock)
3. Material placement and compaction
4. Site grading
5. Foundation preparation
6. Construction of fills and backfills
7. Compaction requirements
8. Site grading

B. The WORK shall be done in accordance with the SPECIFICATIONS and as shown on the DRAWINGS.

C. The WORK includes furnishing all labor, tools, materials, equipment, and supervision necessary to construct the project as described in the contract documents.

1.02 TOLERANCES

A. All excavations shall be constructed within the tolerance as shown in these SPECIFICATIONS except where dimensions or grades are shown or specified as minimum or maximum in the DRAWINGS. All grading shall be performed to maintain slopes and drainages as shown in the DRAWINGS.

B. Excavate to within a horizontal and vertical tolerance of ± 0.1 -foot on all slopes flatter than 10% and within a vertical tolerance of ± 0.2 -foot on all slopes 10% or steeper unless otherwise approved by the ENGINEER or OWNER.

C. Place Drain Rock Aggregate within a vertical tolerance of ±0.1-ft, regardless of the steepness of the slope.

1.03 SUBSURFACE CONDITIONS

A. Subsurface investigations have been performed at the site by the ENGINEER. The results of the subsurface investigations can be provided to the CONTRACTOR at the CONTRACTOR'S request during the bidding interval.

B. The CONTRACTOR shall identify and locate utility lines, flow lines, wells, survey monuments, and other nearby structures prior to performing work. Utilities, flow lines, wells, survey monuments and other nearby structures shall be protected from damage during the WORK. Any damage to utility lines, flow lines, wells, survey monuments, and other nearby structures during the WORK shall be repaired by the CONTRACTOR at no additional cost to the OWNER. Costs associated with these repairs shall include the actual repair costs and all engineering costs required by the ENGINEER to coordinate and obtain regulatory approval of repairs, if required.

1.04 SUBMITTALS

A. Imported materials that may include Drain Rock Aggregate, Engineered Fill or others shall have material properties such as grain size distribution submitted to the OWNER or ENGINEER for material approval prior to delivery to the site.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM D698 – Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort
2. ASTM D2434 – Test Method for Permeability of Granular Soils
3. ASTM D6913 – Test Method for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
4. ASTM D6938 – Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. TXDOT ITEM 247 – Flexible Base

C. Tetra Tech, Inc. - Report of Geotechnical Study Salado Draw, Section 23, Water Recycling Pond.

1.06 DEFINITIONS

A. Liner – A completed system constructed as required by the DRAWINGS and SPECIFICATIONS, as specified in Section 33 47 13.

PART 2 - PRODUCTS

2.01 ENGINEERED FILL

A. Engineered Fill is defined as material obtained from excavations associated with the WORK or designated on-site borrow sources, approved by the ENGINEER, that meet the requirements of the SPECIFICATIONS.

B. Engineered Fill material shall be free of debris, organics, oversized material (clods or rocks greater than 1 inch in diameter), frozen material, ice, snow, deleterious, or other unsuitable materials.

C. The aggregate for the fill material should conform to the requirements as shown in TXDOT item 247, Table 1, Grade 1. Each source must meet Table 1 requirements for liquid limit, plasticity index, and wet ball mill for grade 1. Do not use additives such as, but not limited to lime, cement, or fly ash, to modify aggregate to meet requirement of Table 1. As per the geotechnical study, the on-site material meets these requirements and are suitable as Engineered Fill.

D. The CONTRACTOR will provide laboratory testing results to the OWNER for all fill material used in construction for verification of material compliance as required for the project.

E. Based on the results of the geotechnical investigation, native soils at the Salado Draw Section 23, Water Recycling Pond site are suitable for use as "Engineered Fill" as described in this Section and Section 2.02.

2.02 ENGINEERED FILL MATERIAL USED IN SUBGRADE PREPARATION

A. The upper six inches of the pond bottom, interior embankment slopes, and sump shall be regular, smooth, and compacted; and shall be free of sharp changes in elevation, rocks larger than 1.0 inch, clods, organic debris, and standing water, other unsuitable objects, deleterious materials, or soft unsuitable areas. One hundred percent of the prepared subgrade soil material gradation shall pass a U.S. standard #4 sieve.

B. Engineered Fill material used for the prepared pond bottom shall meet the liner manufacturer's specifications for material suitable for liner placement.

2.03 DRAINAGE AGGREGATE (DRAIN ROCK)

A. Drainage Aggregate (Drain Rock) is defined as engineered fill material consisting of selected or processed granular material that meets the requirements of the SPECIFICATIONS and is in accordance with this section. Drain Rock shall be obtained from on-site approved stockpiles or outside sources approved by the ENGINEER or OWNER.

B. The Drain Rock shall be clean washed sand and gravel with the following gradation:

Gradation	
Sieve Size	**Percent by Weight**
1 ½ inch	100
1 inch	95-100
½ inch	25-60

No. 4	0-10
No. 8	0-5

Particles shall be rounded and free of sharp, angular edges that may damage the liner.

C. Drain Rock Aggregate shall be free of organic material, frozen material, ice, snow, or excess moisture.

D. Drain Rock Aggregate material must be hard, durable, and not subject to grain crushing. Individual rock fragments shall be dense, sound, and resistant to abrasion and shall be free from cracks, seams, and other defects that would tend to increase their destruction from water and frost actions. Drain Rock Aggregate shall be less than 5 percent carbonate.

E. Material shall be poorly-graded within the SPECIFICATION limits with a uniform grading of coarse to fine particles. No gap-graded material, as determined by the ENGINEER, shall be acceptable.

F. Verify that all necessary pre-construction submittals such as conformance testing of the Drain Rock Aggregate have been performed prior to placement or importing.

PART 3 - EXECUTION

3.01 PREPARATION, EXAMINATION, AND PROTECTION OF EARTHWORK

A. Provide construction staking and grade control. Establish and set required lines, levels, grade, contours, and datum by construction staking.

B. Provide for dust control in accordance with site requirements and OWNER'S direction.

C. Provide for dewatering as necessary for finish excavation and fill placement.

D. Locate, identify, and protect all utilities and existing structures from damage (including overhead and suspended utilities).

E. Protect temporary or permanent bench marks, survey stakes, settlement monuments, existing structures, fences and existing WORK from damage or displacement by construction equipment and vehicular traffic.

F. Coordinate traffic control, operations, and haul routes with the OWNER and LINER CONTRACTOR.

G. Note that topography shown on DRAWINGS may differ from topography at time of construction.

H. Protect the exposed surfaces of compacted lifts from drying and cracking due to excessive heat, or softening due to excessive moisture, until overlying fill material is placed and compacted.

I. Any earthen surface upon which the liner is installed shall be prepared and compacted in accordance with the project SPECIFICATIONS. The surface shall be smooth, firm, and unyielding. The top six-inches of fill beneath the surface shall be free of:

1. Vegetation/Roots/Sticks
2. Construction debris
3. Sharp, angular rocks
4. Rocks larger than 1 inch in diameter
5. Void spaces
6. Abrupt elevation changes
7. Standing water
8. Cracks larger than six millimeters in width
9. Any other foreign matter that could contact the liner

J. Immediately prior to liner deployment, LINER CONTRACTOR shall arrange for the subgrade to be final-graded by the EARTHWORK CONTRACTOR to fill in all voids or cracks, then smooth-rolled to provide the best practicable surface for the liner. At completion of this activity, no wheel ruts, footprints or other irregularities in the subgrade are permissible. Furthermore, all protrusions extending more than 0.5-inches from the surface shall be removed, crushed, or pushed into the surface with a smooth-drum roller compactor.

K. On a continuing basis, the OWNER's REPRESENTATIVE shall examine the subgrade for suitability before liner placement.

L. It shall be the CONTRACTOR'S responsibility to indicate to the OWNER or ENGINEER any change in the condition of the subgrade that could cause the subgrade to be non-compliance with any SPECIFICATION requirement. If the CONTRACTOR has not notified the OWNER or ENGINEER of changes that cause the subgrade to be non-compliant and installs the liner, then the CONTRACTOR has determined and assumes responsibility that the subgrade is acceptable for liner installation.

M. At the crest of the embankments, an anchor trench for the liner shall be constructed by the EARTHWORK CONTRACTOR as detailed on the DRAWINGS. Any deviation from the anchor trench details shown on the DRAWINGS requires review and approval by the ENGINEER. No loose soil shall be allowed at the bottom of the trench, and no sharp corners or protrusions shall exist anywhere within the trench.

N. Verify as applicable that all underlying components such as geosynthetics and piping have been installed, tested, and accepted in accordance with the DRAWINGS and SPECIFICATIONS.

3.02 EXCAVATION

A. Excavate material shown on the DRAWINGS and as necessary to complete the WORK. Excavation carried below the grade lines shown on the drawings shall be repaired as specified by the OWNER unless previously approved by the OWNER. Correction of all over-excavated areas shall be at the CONTRACTOR's sole expense.

B. All necessary precautions shall be taken to preserve the material below and beyond the established lines of all excavation in the soundest possible condition. Any damage to the

WORK beyond the required excavation lines due to wetting, drying, or the CONTRACTOR'S operations shall be repaired at the CONTRACTOR'S sole expense.

C. Excavation, shaping, and any other work related to material removal, shall be carried out by the method(s) considered most suitable, provided it meets the design intent as determined by the ENGINEER.

D. Limits of excavation to accomplish the WORK safely shall be determined by the CONTRACTOR. Any minimum excavation limits shown on the DRAWINGS are for material identification only and do not necessarily represent safe limits. All excavations shall be free of overhangs, and the sidewalls shall be kept free of loose material. As a minimum, the CONTRACTOR shall slope, bench and shore all excavations as necessary to prevent any unsafe conditions as required by OSHA 29 CFR 1926.651 and 1926.652.

E. Accurate trimming of the slopes of excavations to be filled will not be required, but such excavations shall conform as closely as practical to the established lines and grades.

F. For pipe trench excavations, grade trench bottom to provide uniform bearing for the entire length of pipe to be installed. Fill in voids, gaps, low points ("dips" or "bellys") and bridging areas within trench bottom and along the entire length of pipe.

G. Subsoil not to be used in the construction of earth fills or reclamation shall be stockpiled in areas designated by OWNER and in accordance with applicable laws, rules, and regulations.

H. Permanently stockpiled earth material shall be graded to drain and blended seamlessly into the natural landscape.

I. Provide and operate equipment adequate to keep all excavations and trenches free of water.

J. Excavate unsuitable areas of the subgrade and replace with approved fill materials. Compact to density equal to requirements for subsequent fill material.

K. The subgrade of each pond shall be proof-rolled and compacted in place prior to fill placement or grading.

L. Grade top perimeter of excavation to prevent surface water from draining into excavation.

3.03 FILL PLACEMENT

A. General

1. Transport, process, place, spread, compact, and complete fill using the appropriate equipment to achieve lift thickness, design lines and grades and compaction specified in the DRAWINGS and SPECIFICATIONS.
2. To the extent practicable, fill shall be placed by routing the hauling and spreading units approximately parallel to the axis of the embankment.
3. Hauling equipment shall be routed in such a manner that they do not follow in the same paths but spread their traveled routes evenly over the surface of the fill.
4. Protect installed measurement instrumentation, structures, and utilities from damage.

5. Care shall be taken at all times to avoid segregation of material being placed, and all pockets of segregated or undesirable material shall be removed and replaced with material matching the surrounding material.
6. Each zone shall be constructed with materials meeting the specified requirements and shall be free from lenses, pockets, and layers of materials that are substantially different in gradation from surrounding material in the same zone.
7. No material shall be placed on material that is too soft, smooth, wet, or dry, or that has been damaged by drying, cracking, frost, runoff, or construction activities. Previously completed portions of the subgrade that are deemed unsuitable for construction shall be repaired until approved by the ENGINEER. **The top 8 inches of the foundation surface shall be scarified, moisture conditioned (as necessary), and compacted so fill material will bond firmly to surfaces of excavation.** Remove standing water prior to placement of all fill material.
8. To the extent practicable, fill materials shall be brought to the placement area at the recommended moisture content.
9. Moisture conditioning is the operation required to increase or decrease the moisture content of material to within the specified limits for proper material placement and compaction. If moisture conditioning is necessary, it may be carried out by whatever method CONTRACTOR deems suitable, provided it produces the moisture content specified in the SPECIFICATIONS.

3.04 MOISTURE CONTROL

A. Prior to and during all compacting operations, maintain moisture content within the limits recommended herein. Maintain uniform moisture content throughout the lift. To the extent practicable, add water to materials that are too dry at the site of excavation. Supplement, if necessary, by sprinkling and mixing water into the fill material prior to compaction. The moisture content shall be at or no more than 2 percent above the optimum moisture content in accordance with ASTM D 698[1].

B. Do not attempt to compact fill material containing excessive moisture. Aerate material by blading, disking, harrowing, or other methods, to dry the material to acceptable moisture content.

3.05 LIFT THICKNESS REQUIREMENTS

A. Berm Fill:

1. Placement lift thickness for Engineered Fill shall not exceed 6 inches prior to compaction with hand-operated compaction equipment and should not exceed 8 inches with heavy machine operated compaction equipment. It is the CONTACTOR's responsibility to ensure that the compaction achieved meets the specifications.
2. Fill placement for anchor trenches shall not exceed 6 inches in loose lift thickness for each lift.

B. Drain Rock Aggregate:

1. Drain Rock Aggregate shall be placed and spread in lifts not exceeding 8 inches in thickness.

3.06 COMPACTION AND MOISTURE CONTENT REQUIREMENTS

A. After material placement, spreading, and leveling to the appropriate lift thickness, all material shall be uniformly compacted in accordance with the requirements for each type of fill as indicated on the following table:

Table 2: Compaction and Moisture Content Requirements

Fill Material	Compaction Specifications	Moisture Content
Engineered Fill	95% of standard Proctor maximum dry density with vibratory compactor	±2% of Optimum
Drain Rock Aggregate	Place uniform thickness and tamp with dozer or loader bucket	No requirements

3.07 COMPACTION EQUIPMENT

A. Compaction equipment shall be maintained in good working condition at all times to ensure that the amount of compaction obtained is the maximum for the equipment.

B. Compactor:

1. The fill is required to be compacted with a heavy vibratory-optional roller and a maximum roller speed of approximately 2 mph.
2. The compactor shall be of self-propelled design to develop 10,000 pounds in weight per linear foot of width at rest on level ground or equivalent as approved by the ENGINEER.

C. Special Compactors:

1. Special compactors shall be used to compact materials that, in the opinion of the ENGINEER, cannot be compacted properly by the specified roller because of location or accessibility.
2. Special compaction measures shall be adopted, such as hand-held compactors, smooth drum rollers, or other methods approved by the ENGINEER, to compact fill material in trenches, around structures, around geosynthetics, and in other confined areas that are not accessible to the Compactor. The final surface on which the geosynthetics will be placed shall be compacted with a smooth drum roller.
3. Anchor trenches shall be compacted with a hand-operated compaction machine.

3.08 COMPACTION TESTING OF ENGINEERED FILL

A. Field compaction testing of each lift shall be performed a minimum of one test every 100 to 300 linear feet or 5000 square feet.

B. Compaction testing of anchor trenches shall be performed such that puncturing of the geosynthetic materials is avoided.

3.09 SITE GRADING

A. Perform all placement of fill to lines and grades as shown in the DRAWINGS and/or established by the ENGINEER, with proper allowance for surface treatments (topsoil placement, etc.) where specified or shown. Neatly blend all new grading into surrounding, existing terrain.

END OF SECTION 31 23 00

SECTION 33 47 13 - GEOSYNTHETICS

PART 1 - GENERAL

1.01 SUMMARY

A. The WORK described in this SPECIFICATION section includes specifications for manufacturing and installing HDPE geosynthetics.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit a letter to the OWNER prior to installation of the geosynthetics stating the subgrade is acceptable and does not void the warranty.

B. The CONTRACTOR shall submit the following product data to the ENGINEER:

1. Resin Data:

    a. Certification stating that the resin meets the SPECIFICATION requirements.

2. Geosynthetics Roll:

    a. Statement certifying no recycled polymer and no more than 10% rework of the same type of material is added to the resin.

C. Pre-Construction Submittals: Submit the following within 10 days of Notice to Proceed. Pre-Construction materials shall be submitted to the OWNER and ENGINEER.

1. The MANUFACTURER'S Information
    a. The MANUFACTURER'S name and address and primary contact.
    b. The manufacturing plant name and address where the geosynthetics for this project will be produced.
    c. The MANUFACTURER'S qualifications including:
        1) Evidence of production of at least 10 million square feet of geomembrane that meets the specifications.
        2) Certification that the MANUFACTURER has sufficient capacity to provide the required material in the given timeframe.
        3) A list of at least 10 projects for which geomembrane has been supplied by the MANUFACTURER, three of which shall have been for projects of similar size.
    d. Product name and the MANUFACTURER'S description of the proposed geosynthetics and five representative samples of the product proposed for use on this project.
    e. The MANUFACTURER'S material properties sheets (cut sheets) of proposed geosynthetic products meeting the requirements of the specification.
    f. The MANUFACTURER'S Quality Control (MQC) Plan, including examples of geosynthetics certification documents, name and address of the quality control

testing laboratory, quality control laboratory certification, examples of retesting notification, and documentation.

g. The MANUFACTURER'S written instructions for storing, handling, installing, seaming, protecting from hydration, and repairing the proposed geosynthetics, including recommendations for handling equipment (model number and load capacity).

h. Samples product warranty.

2. CONTRACTOR'S Information:

a. CONTRACTOR'S name and address and primary contact.

b. CONTRACTOR'S qualifications including a list of at least three previous projects of similar size to this project, including project name, location, size and date of installation, and evidence of installing at least 1 million square feet of geomembrane.

c. The Construction Quality Control (CQC) Plan, including examples of subgrade certification documents, daily record documents, methods for repairing geomembrane and subgrade and example documents to certify repairs, method for removing rejected materials, proposed staffing, and proposed equipment.

d. Description of welding equipment, techniques, and material, including a list of proposed equipment.

e. A complete set of forms to be used for record installation CQC data.

f. Résumés of key installation personnel. The Installation Supervisor, Master Seamers, and QC Representative must be clearly identified.

g. Workmanship warranty.

D. The CONTRACTOR shall furnish SHOP DRAWINGS to the OWNER and ENGINEER as follows:

1. Installation layout SHOP DRAWINGS.

a. Must show proposed panel layout including field seams and details.

b. Must show panel identification numbers.

c. Installed square footage of the geomembrane.

d. Must be approved prior to installing the geomembrane.

e. Approved SHOP DRAWINGS will be for concept only and actual panel placement will be determined by site conditions.

E. CONTRACTOR'S geosynthetics field installation quality assurance plan.

F. The CONTRACTOR will submit the following to the OWNER and ENGINEER upon completion of installation:

1. Certificate stating the geosynthetics have been installed in accordance with the contract documents.

2. Material and installation warranties:

a. Material shall be warranted against MANUFACTURER's defects for a period of five years from the date of geosynthetics installation.

b. Installation shall be warranted against defects in workmanship for a period of one year from the date of geosynthetics completion.

3. As-built drawings showing actual geosynthetics placement, seams, testing locations and results, and anchor trench details.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
2. ASTM D1004 – Test Method for Initial Tear Resistance of Plastic Film and Sheeting
3. ASTM D1238 – Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
4. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics
5. ASTM D3895 – Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
6. ASTM D4218 – Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
7. ASTM D4716 - Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
8. ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
9. ASTM D4833 – Test Method for Index Puncture Resistance of Geomembranes and Related Products
10. ASTM D5035 - Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
11. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
12. ASTM D5596 – Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
13. ASTM D5641 – Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
14. ASTM D5820 – Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
15. ASTM D5885 - Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry
16. ASTM D5994 – Test Method for Measuring Core Thickness of Textured Geomembrane
17. ASTM D6364 - Standard Test Method for Determining Short-Term Compression Behavior of Geosynthetics
18. ASTM D6392 – Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
19. ASTM D6693 – Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes
20. ASTM D7179 - Standard Test Method for Determining Geonet Breaking Force
21. ASTM D7406 - Standard Test Method for Time-Dependent (Creep) Deformation Under Constant Pressure for Geosynthetic Drainage Products
22. ASTM D7466 – Standard Test Method for Measuring the Asperity Height of Textured Geomembrane

B. Geosynthetic Research Institute (GRI)

1. GRI-GC8 Standard Guide for Determination of the Allowable Flow Rate of a Drainage Geocomposite

2. GRI GM14 - GM Sampling by Attributes

3. GRI GM10 – Specification for the Stress Crack Resistance of Geomembrane Sheet

4. GRI GM19 - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

C. GSE Environmental, LLC

1. Drainage Design Manual, 2nd Edition – June 2007.

1.04 DEFINITIONS

A. Lot – A quantity of resin (usually the capacity of one rail car) used in the manufacture of geosynthetics. Finished roll will be identified by a roll number traceable to the resin lot used.

B. ENGINEER – Party, independent from manufacturer and CONTRACTOR, that is responsible for observing and documenting activities related to quality assurance during the lining system construction.

C. Geosynthetics Manufacturer – The party responsible for manufacturing the geosynthetics rolls.

D. Geosynthetic Quality Assurance Laboratory (testing laboratory) – Party, independent from the OWNER, manufacturer, and CONTRACTOR, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing.

E. CONTRACTOR – Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.

F. Minimum Average Roll Value (MARV): Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed value reported.

G. Panel – Unit area of a geomembrane that will be seamed in the field that is 10 square yards or larger.

H. Patch – Unit area of a geomembrane that will be seamed in the field that is less than 10 square yards.

I. Subgrade Surface – Soil layer surface which immediately underlies the geosynthetic material(s).

1.05 QUALIFICATIONS

A. MANUFACTURER

1. MANUFACTURER shall have manufactured a minimum of 10 million square feet of HDPE geomembrane material during the last year.
2. MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of polyethylene geonet material during the last year.
3. MANUFACTURER shall have a GAI-LAP Accredited Laboratory at the manufacturing facility.
4. MANUFACTURER shall have ISO 9001; 2008 certification.

B. CONTRACTOR

1. CONTRACTOR shall have installed a minimum of 1,000,000 square feet of geosynthetics in the last 3 years.
2. CONTRACTOR shall have worked in a similar capacity on at least 3 projects similar in complexity to the project described in the contract documents, and within a total of at least 400,000 square feet of geomembrane installation on each project.
3. The Installation Supervisor shall have worked in a similar capacity on at least 3 projects similar in size and complexity to the project described in the Contract Documents in the last 5 years.

1.06 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Geosynthetics labeling, shipment, and storage shall follow ASTM D4873. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

B. Each geonet roll shall be wrapped with a material that will protect the geonet from damage due to shipment, water, sunlight, and contaminants.

C. The CONTRACTOR shall note any visible damage to roll materials on the Bill of Lading prior to unloading roll materials. Should any visible damage be noted, CONTRACTOR or ENGINEER shall notify the MANUFACTURER in writing immediately.

D. Labeling – Each roll of geosynthetics delivered to the site shall be labeled by the manufacturer. The label will identify:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Length
5. Width
6. Roll number
7. Date and time of production
8. Resin lot number

E. Delivery – Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

F. Storage – The on-site storage location for geosynthetics material, provided by the CONTRACTOR to protect the geosynthetics from punctures, abrasions and excessive dirt and moisture, should have the following characteristics:

1. Level (no wooden pallets)
2. Smooth
3. Dry
4. Protected from theft and vandalism
5. Adjacent to the area being lined
6. Geosynthetics shall not be stacked higher than three rolls

G. Handling – Materials are to be handled so as to prevent damage. The CONTRACTOR shall take any necessary precautions to prevent damage to underlying layers during placement of the geosynthetics.

1.07 WARRANTY

A. Material shall be warranted, against manufacturer's defects for a period of five years from the date of geosynthetics installation.

B. Installation shall be warranted against defects in workmanship for a period of one year from the date of geosynthetics completion.

PART 2 - PRODUCTS

2.01 HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE

A. Material shall be GSE Environmental (GSE) HD Smooth Geomembrane or equivalent HDPE geomembrane meeting the thickness, texture, and color requirements as shown on the DRAWINGS.

B. Geomembrane Rolls

1. Geomembrane rolls must not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
2. Geomembrane shall be free of holes, pinholes, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.
3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width, and manufacturer.
4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in Table 1, 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.

C. Geomembrane roll testing values for a 60-mil smooth and testing frequencies requirements are presented in Table 1 below.

TABLE 1: MINIMUM VALUES FOR 60-MIL SMOOTH HDPE GEOMEMBRANES

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE
Thickness, (minimum average) mil Lowest individual value	ASTM D5994 / D5199	Every roll	57 54
Asperity Height (mil)	ASTM D7466	Every second roll	18
Density, g/cm3	ASTM D792	200,000 lb	0.940
Tensile Properties (each direction) Strength at Break, lb/in-width Elongation at Break, %	ASTM D 6693, Type IV Dumbbell, 2 in/min G.L. = 2.0 in	20,000 lb	 228 700
Tear Resistance, lb	ASTM D1004	45,000 lb	42
Puncture Resistance, lb	ASTM D4833	45,000 lb	108
Carbon Black Content, %	ASTM D1603*/4218	20,000 lb	2.0 – 3.0
Carbon Black Dispersion	ASTM D5596	45,000 lb	+Note 1
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**
Oxidative Induction Time, min (Standard OIT)	ASTM D3895, 200° C; 02, 1 atm	200,000 lb	≥ 100
Melt Flow, g/10 min.	ASTM D1238, 190° C; 2.16kg	200,000 lb	≤ 1.0
Oven Aging With HP OIT, (% retained after 90 hours)	ASTM D5721 ASTM D5885, 150° C; 500 psi O_2	Per resin formulation	80
UV Resistance With HP OIT, (% retained after 1600 hours)	ASTM D5885, 150° C; 500 psi O_2	Per resin formulation	50 (+Note 2)

+NOTE 1: DISPERSION ONLY APPLIES TO NEAR SPHERICAL AGGLOMERATES. 9 OF 10 VIEWS SHALL BE CATEGORY 1 OR 2. NO MORE THAN 1 VIEW FROM CATEGORY 3.
+NOTE 2: 20-HOUR CYCLE AT 75° C/4 HR DARK CONDENSATION @ 60° C.
*MODIFIED.

2.02 RESIN

1. Resin shall be first quality, compounded polyethylene resin.

2. Resin testing values and testing frequencies requirements are presented in Table 2 below. Natural resin (without carbon black) shall meet the following additional minimum requirements:

TABLE 2: RAW MATERIAL VALUES

Property	Test Method [(1)]	Testing Frequencies	Value
Density (g/cm3)	ASTM D 1505	Once Per Resin Lot	>0.94
Melt Flow Index (g/10 min)	ASTM D 1238	Once Per Resin Lot	$\leq$ 1.0

[1]Manufacturer may utilize test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geosynthetics.

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Gauges showing temperatures in apparatus (extrusion welder) or wedge (wedge welder) shall be present.
2. An adequate number of welding apparatus shall be available to avoid delaying WORK.
3. Power source must be capable of providing constant voltage under combined line load.

B. Extrudate Rod or Bead

1. Extrudate material shall be made from the same type of resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Preparation of surfaces to be lined shall be completed by the EARTHWORKS CONTRACTOR but the LINER CONTRACTOR will be responsible for inspecting the prepared surfaces to verify that the surfaces are acceptable for liner placement and free from any rocks, clods, sticks, surface irregularities or debris which could damage the liner. Acceptance of the subgrade shall be provided in a written submittal.

B. All geosynthetics installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

3.02 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 WORK site.

B. Visually inspect the geosynthetics during deployment for imperfections and mark faulty or suspect areas.

C. The geosynthetics installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

D. Deployment of geosynthetics panels shall be performed in a manner that will comply with the following guidelines:

1. Unroll geosynthetics using methods that will not damage geosynthetics and will protect underlying surface from damage (spreader bar, protected equipment bucket).
2. The geosynthetics roll shall be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.
3. Use full length rolls or those with a significant length remaining at the top of the slope so that no roll end occurs on side slopes.
4. Place ballast (commonly sandbags) on geosynthetics, which will not damage geosynthetics, to prevent wind uplift.
5. Personnel walking on geosynthetics shall not engage in activities or wear shoes that could damage it. Smoking will not be permitted on the geosynthetics.
6. Do not allow heavy vehicular traffic directly on geosynthetics. Rubber-tired ATVs and trucks are acceptable if wheel contact is less than six pounds per square inch.

E. Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material. This practice will be used to prevent excessive tension (trampolines) from developing. This is particularly important in cold weather conditions.

F. Anchor trench compacting equipment shall not come into direct contact with the geosynthetics. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.

3.03 FIELD SEAMING

A. Seams shall meet the following requirements:

1. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.
2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
3. Slope seams (panels) shall extend a minimum of five feet beyond the grade break into the flat area.
4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the ENGINEER and CONTRACTOR.
5. All seam overlaps shall be aligned consistent with the requirements of the welding equipment being used. Seams shall be made by lapping the uphill material over the downhill material with sufficient overlap. Extrusion seaming shall have a minimum overlap of six inches. Wedge-welded seaming shall have a minimum overlap of six inches.
6. Seaming of the geomembrane at material temperatures below 32 degrees F and above 170 degrees F must be successfully demonstrated to the ENGINEER using prequalification test seams to demonstrate that the seams comply with these SPECIFICATIONS.

B. Geonet Components:

1. Adjacent edges along the length of the geonet roll shall be overlapped a minimum of 6 inches or as recommended by the ENGINEER.
2. The overlapped edges shall be joined by tying the geonet structure with cable ties.
3. These ties shall be spaced every 5 feet along the roll length.
4. Adjoining rolls across the roll width should be shingled down in the direction of the slope and joined together with cable ties spaced every foot along the roll width.

C. During Welding Operations

1. Provide at least one master seamer who shall provide direct supervision over other welders as necessary.

D. Extrusion Welding

1. Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.
2. Clean geomembrane surfaces by disc grinder or equivalent. Number 80-grit sandpaper shall be used.
3. Grinding shall not reduce the thickness of the geomembrane more than one mil.
4. Purge welding apparatus of heat-degraded extrudate before welding.
5. Extrusion welding shall be considered a secondary means of welding and shall be used for repairs unless otherwise approved by ENGINEER.

E. Hot Wedge Welding

1. Welding apparatus shall be a self-propelled device equipped with an electronic controller which displays applicable temperatures.
2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.
3. Protect against moisture build-up between sheets.
4. Hot wedge welding shall be considered the primary method of welding and shall be used for panel seaming unless otherwise approved by ENGINEER.

F. Trial Welds

1. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.
2. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
3. A minimum of two trial welds shall be required per day, per welding apparatus, one made prior to the start of work and one completed at mid-shift. Additional trial welds will be required after repairs are made to the apparatus.
4. Cut six one-inch wide by six-inch long test strips from the trial weld.
5. Quantitatively test three specimens for peel adhesion, and then three specimens for shear strength.
6. Trial weld specimens shall pass when the results shown in Table 3 are achieved in both peel and shear test.

TABLE 3: MINIMUM WELD VALUES FOR HDPE GEOMEMBRANES

Property	Test Method	Minimum Value
Peel Strength (fusion), ppi	ASTM D 6392	98
Peel Strength (extrusion), ppi	ASTM D 6392	78
Shear Strength (fusion & ext.), ppi	ASTM D 6392	121

7. The break, when peel testing, occurs in the liner material itself, not through peel separation (Film Tear Bond (FTB) break).
8. The break is ductile.
9. A test will be considered a failure if one specimen on either peel or shear testing does not meet the requirements on Table 3 or does not achieve an FTB break.
10. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
11. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed two additional trial welds.

G. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. The CONTRACTOR shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.

H. Defects and Repairs

1. 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.
2. 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.

3.04 FIELD QUALITY ASSURANCE

A. The manufacturer and CONTRACTOR shall participate in and conform to all terms and requirements of the OWNER'S quality assurance program. The CONTRACTOR shall be responsible for assuring this participation.

B. Quality assurance requirements are as specified in this section.

C. Field Testing

1. Non-destructive testing shall be carried out as the seaming progresses, not at completion of all field seaming. Each seam shall be non-destructive tested.

a. Vacuum Testing

1) Shall be performed in all extrusion welds performed during installation and in accordance with ASTM D 5641.
2) The vacuum box assembly shall consist of the following:

a) Rigid housing;
b) Transparent viewing window;
c) Soft rubber gasket attached to bottom of housing;

d) Porthole or valve assembly;
e) Vacuum gauge; and
f) A vacuum pump capable of delivering a minimum of a 27 psi vacuum.

3) When vacuum testing, the installer shall:

a) Carefully trim all overlapped material using an approved cutting instrument. The "pull-tear" method of overlap removal shall not be accepted;
b) Clean windows, gasket surfaces, and check for leaks;
c) Wet a strip of geomembrane approximately 1 foot by 2.5 feet (length of box) with soapy solution;
d) Place the vacuum box over the wetted area;
e) Ensure that a leak-tight seal is created;
f) Apply a minimum vacuum pressure of five psi;
g) For a period of not less than 15 seconds, examine the length of weld through the viewing window for the presence of soap bubbles;
h) If no bubbles appear after 15 seconds, move the box over the next adjoining area with a minimum three inches of overlap and repeat the process;
i) Areas where soap bubbles appear shall be marked, repaired, and re-tested;
j) All vacuum testing will be documented by the CONTRACTOR'S QC Technician and submitted to the ENGINEER at the end of each WORK shift. The liner shall be indelibly marked near the seam to indicate passing or failing test results accordingly.

b. Air Pressure Testing

1) Shall be performed in all hot wedge welds performed during installation and in accordance with ASTM D 5820
2) The equipment for pressure testing shall include the following:

a) Air pumps equipped with a pressure gauge capable of generating and sustaining a pressure of 30 pounds per square inch (psi); and
b) Sharp hollow needles or other pressure feed devices approved by the ENGINEER. The liner shall be indelibly marked near the tested area to indicate passing or failing test results accordingly.

3) To perform the air pressure test, the installer's QC Technician shall:

a) Pass air through the channel to guarantee a clear pathway;
b) Seal both ends of the seam to be tested;
c) Insert a needle or other approved pressure-feed device into the tunnel created by double hot wedge seaming;
d) Energize the air pump to 30 psi;
e) Close the valve while sustaining the air pressure and allow the air to reach ambient liner temperature;
f) Read the pressure gauge;
g) Sustain the test for a minimum of five minutes and re-read the pressure gauge;

h) If the loss of pressure exceeds three psi after a two-minute period or does not stabilize, faulty areas shall be located and repaired. After testing, pressure-feed devices shall be removed and insertion points sealed; and

i) All pressure testing shall be documented by the CONTRACTOR'S QC Technician and submitted to the ENGINEER by the end of each WORK shift. The liner shall be indelibly marked near the seam to indicate passing or failing test results accordingly.

c. Alternative testing methods other than vacuum or pressure testing may be proposed by the CONTRACTOR and will be subject to the approval of the ENGINEER prior to their use.

d. At locations where seams cannot be non-destructively tested, the CONTRACTOR shall:

1) Cap-strip seams with the same geomembrane when possible; and

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

e. Seaming and cap-stripping operations will be observed by the ENGINEER for uniformity and completeness.

2. Destructive Testing (performed by the CONTRACTOR with observation from the ENGINEER)

a. Location and frequency of testing

1) Collect destructive test samples at a frequency of one per every 500 lineal feet of seam length per machine used.

2) Test locations will be determined after seaming.

3) Exercise method of attributes as described by GRI GM-14 to minimize test samples taken.

b. Sampling Procedures are performed as follows:

1) The CONTRACTOR shall cut samples at locations designated by the ENGINEER as seaming progresses in order to obtain field laboratory test results before the geomembrane is covered.

2) The ENGINEER will number each sample, and the location will be noted on the installation as-built.

3) Samples shall be 12 inches wide by 36 inches long with the seam centered lengthwise (length may vary to minimize cutting of the liner).

4) Cut 10 two-inch wide by six-inch long test strips from each end of the samples for field testing.

5) The remaining sample shall be distributed as follows:

a) One portion for CONTRACTOR, 12 by 12 inches

b) One portion for the third party laboratory, 12 by 18 inches

c) Additional samples may be archived if required by OWNER

6) The CONTRACTOR shall repair all holes in the geomembrane resulting from destructive sampling.

7) Repair and test the continuity of the repair in accordance with these SPECIFICATIONS.

c. Destructive testing procedures

1) Destructive testing shall be performed in accordance with ASTM D6392.
2) Quantitatively test five specimens for peel adhesion, and then five specimens for shear strength.
3) Destructive testing specimens shall pass when the results shown in Table 3 are achieved in both peel and shear test.
4) The break, when peel testing, shall occur in the liner material itself, not through peel separation (FTB).
5) The break is to be ductile.
6) A test will be considered a failure if one specimen on either peel or shear testing does not meet the requirements on Table 3 or does not achieve an FTB break.

3. Failed Seam Procedures

a. If the seam fails, the CONTRACTOR shall follow one of two options:

1) Reconstruct the seam between any two passed test locations.
2) Trace the weld to intermediate locations at least 10 feet minimum or where the seam ends in both directions from the location of the failed test. If necessary the failed seam shall be traced to previous days of seaming for the particular machine.
3) All tracing events shall be recorded by the ENGINEER.

b. An additional sample is required for the next seam welded using the same welding device regardless of the length of the next seam.
c. If the new sample passes, then the failed seam shall be reconstructed or capped between the test sample locations.
d. If any sample fails, the process shall be repeated to establish the zone in which the seam is to be reconstructed.

3.05 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. Install additional liner anywhere excessive tension (trampolines) exists and to avoid excessive tension.

D. The CONTRACTOR shall be responsible for repair of defective areas.

E. Agreement upon the appropriate repair method shall be decided between the ENGINEER or OWNER and CONTRACTOR by using one of the following repair methods:

1. Patching – Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter. Patch materials shall be of the same material type and thickness as the material being repaired. A patch shall be a minimum of 12 inches larger in all directions than the area requiring repair. All patches shall have rounded corners;
2. Abrading and Re-welding – Used to repair short section of a seam;
3. Spot Welding – Used to repair pinholes or other minor, localized flaws, or where geomembrane thickness has been reduced;
4. Capping – Used to repair long lengths of failed seams;
5. Flap Welding – Used to extrusion-weld the flap (excess outer portion) of a fusion weld in lieu of a full cap; or
6. Remove the unacceptable seam and replace with new material.

F. The following procedures shall be observed when a repair method is used:

1. All geomembrane surfaces shall be clean and dry at the time of repair;
2. Surfaces of the geomembrane which are to be repaired by extrusion welds shall be lightly abraded to assure cleanliness; and
3. Extend patches or caps at least six inches for extrusion welds and six inches for wedge welds beyond the edge of the defect, and around all corners of patch material.

G. Repair Verification

1. Number and log each patch repair (performed by the ENGINEER)
2. Non-destructively test each repair using methods described in this SPECIFICATION
3. Any rips, tears or damaged areas on the deployed geonet 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, the two portions of the geonet shall be cut out, and the two portions of the geonet shall be joined in accordance with these SPECIFICATIONS.

3.06 DEPTH OR ELEVATION MARKINGS

A. Following completion of geomembrane installation paint depth or elevation markings as shown on the DRAWINGS.

B. Paint shall be non-corrosive and weather resistant.

SECTION 33 47 13.15 - GEOTEXTILES

PART 1 - GENERAL

1.01 SUMMARY

A. The WORK described in this SPECIFICATION section includes the manufacture and installation of geotextile fabrics as stand-alone items only and not included as part of a geocomposite.

1.02 SUBMITTALS

A. Product Data

1. The CONTRACTOR shall provide to the ENGINEER a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile. The certification shall state that the furnished geotextile meets Minimum Average Roll Value (MARV) requirements of the SPECIFICATION as evaluated under the manufacturer's quality control program. The certification shall be attested to by a person having legal authority to bind the manufacturer.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. ASTM D4354 – Practice for Sampling of Geosynthetics for Testing
2. ASTM D4355 – Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
3. ASTM D4533 – Test Method for Index Trapezoid Tearing Strength of Geotextiles
4. ASTM D4632 – Test Method for Grab Breaking Load and Elongation of Geotextiles
5. ASTM D4751 – Test Method for Determining Apparent Opening Size of a Geotextile
6. ASTM D4833 – Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
7. ASTM D4873 – Guide for Identification, Storage, and Handling of Geotextiles
8. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity
9. ASTM D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles

B. American Association for Laboratory Accreditation (A2LA)

C. Geosynthetic Accreditation Institute (GAI) – Laboratory Accreditation Program (LAP)

D. National Transportation Product Evaluation Program (NTPEP)

1.04 DEFINITIONS

A. Minimum Average Roll Value (MARV): Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed value reported.

1.05 QUALIFICATIONS

MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of geotextile material during the last year.

1.06 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Geotextiles labeling, shipment, and storage shall follow ASTM D4873. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

B. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants.

C. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames (including welding sparks), excess temperatures, and any other environmental conditions that may damage the physical properties of the geotextile.

PART 2 - PRODUCTS

2.01 GEOTEXTILE

A. The geotextile shall be GSE Environmental (GSE) Nonwoven Geotextile or equivalent. The geotextile shall be manufactured with fibers consisting of long-chain synthetic polymers composed of at least 95% by weight of polyfins or polyesters. They shall form a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

B. Woven slit film geotextiles (i.e., geotextiles made from yarns of a flat, tape-like character) shall not be allowed.

C. The geotextile shall meet the requirements of Table 1. All numeric values in Table 1 except Apparent Opening Size (AOS) represent MARV in the weakest principal direction. Values for AOS represent maximum average roll values.

TABLE 1: 8 OZ GEOTEXTILE REQUIREMENTS

Property	Test Method	Units	Value
Mass per unit Area	ASTM D5261	oz/yd^2	8
Grab Tensile Strength	ASTM D4632	lbs	220
Grab Tensile Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs	90
CBR Puncture Strength	ASTM D4833	lbs	575
Permittivity	ASTM D4491	sec^{-1}	1.3
Apparent Opening Size	ASTM D4751	U.S. Sieve	80
Water Flow Rate	ASTM D4491	gpm/ft^2	95
UV Resistance[1]	ASTM D4355	%	70

[1]After 500 hrs

2.02 QUALITY CONTROL

A. Manufacturing Quality Control: Testing shall be performed at a laboratory accredited by GAI-LAP and A2LA for tests required for the geotextile, at a frequency meeting or exceeding ASTM D4354.

B. Geotextile properties, other than sewn seam strength, burst strength, and ultraviolet stability shall be tested by NTPEP to verify conformance with this SPECIFICATION.

C. Sewn seam strength shall be verified based on testing of either conformance samples obtained using Procedure A of ASTM D4354, or based on manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D4354. A lot size for conformance or quality assurance sampling shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

D. Ultraviolet stability shall be verified by an independent laboratory on the geotextile or a geotextile of similar construction and yarn type.

PART 3 - EXECUTION

3.01 PREPARATION

A. Grading shall be done in such a way so as to prevent large voids from occurring along the geotextile contact. The graded surface shall be smooth and free of debris.

3.02 INSTALLATION

A. The geotextile installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

B. The geotextile shall be placed loosely with no wrinkles or folds, and with no void spaces between the geotextile and the ground surface. Successive sheets of geotextiles shall be overlapped a minimum of 12 inches, with the upstream sheet overlapping the downstream sheet.

C. Should the geotextile be damaged during installation or drainage aggregate placement, a geotextile patch shall be placed over the damaged area extending beyond the damaged area a distance of 12 inches, or the specified seam overlap, whichever is greater.

END OF SECTION 33 47 13.15

SECTION 33 47 13.16 – GEONET DRAINAGE LAYERS

PART 1 - GENERAL

1.01 SUMMARY

A. This section covers the technical requirements for the manufacturing and installation of the geonet drainage layers. All materials must meet or exceed the requirements of this SPECIFICATION, and all work will be performed in accordance with the procedures provided in these project SPECIFICATIONS unless approved by the ENGINEER.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)
   1. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique
   2. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics
   3. ASTM D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
   4. ASTM D4354 - Practice for Sampling of Geosynthetics for Testing
   5. ASTM D4716 - Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
   6. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
   7. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
   8. ASTM D7179 - Standard Test Method for Determining Geonet Breaking Force

B. Relevant publications from the Environmental Protection Agency (EPA):

   1. Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.03 DEFINITIONS

A. Geonet Manufacturer (MANUFACTURER) - The party responsible for manufacturing the geocomposite rolls.

B. Geosynthetic Quality Assurance Laboratory (TESTING LABORATORY) - Party, independent from the MANUFACTURER and CONTRACTOR, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.

C. Lot - A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geonet rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

1.04 QUALIFICATIONS

A. MANUFACTURER

MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of polyethylene geonet material during the last year.

B. CONTRACTOR

a. CONTRACTOR shall have installed a minimum of 3,000,000 square feet of geosynthetics in the last 3 years.
b. CONTRACTOR shall have worked in a similar capacity on at least 5 projects similar in complexity to the project described in the contract documents, and within a total of at least 3,000,000 square feet of geonet or geocomposite installation on each project.
c. The Installation Supervisor shall have worked in a similar capacity on at least 5 projects similar in size and complexity to the project described in the Contract Documents in the last 5 years.

1.05 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Labeling - Each roll delivered to the site shall be wrapped and labeled by the MANUFACTURER. The label will identify:

1. manufacturer's name
2. product identification
3. length
4. width
5. roll number

B. Delivery - Rolls 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 provided by the CONTRACTOR to protect the geonet from abrasions, excessive dirt and moisture shall have the following characteristics:

1. level (no wooden pallets)
2. smooth
3. dry
4. protected from theft and vandalism
5. adjacent to the area being lined

D. Handling

1. The CONTRACTOR shall handle all rolls in such a manner to ensure they are not damaged in any way.
2. The CONTRACTOR shall take any necessary precautions to prevent damage to underlying layers during placement of the drainage material.

1.06 WARRANTY

A. Geonet portion of the material shall be warranted against defects for a period of 5-years from the date of the installation.

B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geonet completion.

PART 2 - PRODUCTS

2.01 GEONET PROPERTIES

A. A geonet shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure.

B. The geonet shall be GSE Environmental (GSE) HyperNet Geonet or equal. Geonet materials shall be used as shown on the DRAWINGS. Each type of geonet specified shall have properties that meet or exceed the values listed in the following tables below.

TABLE 1: 200-MIL HYPERNET GEONET PROPERTIES

Property	Test Method	Frequency	Value
Geonet (prior to lamination)			
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft^2	200
Transmissivity[1], gal/min/ft	ASTM D 4716	1/540,000 ft^2	9.6
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94
Creep Reduction Factor	ASTM D 7406/7361	Per formulation	Maximum of 1.2 at 15,000 lb/ft^2
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft^2	45
Carbon Black Content, %	ASTM D 1603[2]/4218	1/50,000 ft^2	2.0

[1]Gradient of 0.1, normal load of 25,000 lb/ft^2, water at 70° F, between steel plates for 15 minutes.
[2]Modified.

C. Resin

1. Resin shall be new first quality, compounded polyethylene resin.

2. Resin testing values and testing frequencies requirements are presented in Table 2 below. Natural resin (without carbon black) shall meet the following additional minimum requirements:

TABLE 2: RAW MATERIAL PROPERTIES

Property	Test Method[(1)]	Value
Density (g/cm^3)	ASTM D 1505	>0.94
Melt Flow Index (g/10 min)	ASTM D 1238	$\leq$ 1.0

[1]Manufacturer may utilize test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geosynthetics.

2.02 MANUFACTURING QUALITY CONTROL

1. The geonet shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the ENGINEER.
2. The geonet shall be tested according to the test methods and frequencies listed on Tables 1 which has been prepared based on product data sheets.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

A. Inspection

1. Prior to implementing any of the work in the Section to be lined, the CONTRACTOR 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.

2. If the CONTRACTOR has any concerns regarding the installed work of other Sections, the CONTRACTOR shall notify the ENGINEER.

3.02 MATERIAL PLACEMENT AND INSTALLATION

A. The geonet installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

B. The geonet roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.

C. Use full length rolls or those with a significant length remaining at the top of the slope so that no roll end occurs on side slopes.

D. In the presence of wind, all geosynthetics, including the geonets, shall be weighted down with ballast (i.e. sandbags or approved equal)

E. Ballast shall be used during placement and remain until replaced with cover material or liquids.

F. The geonet shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geonet.

G. The drainage rock material shall be placed on the geosynthetics in a manner that does not permit vehicular traffic directly on the geosynthetics, and prevents damage to the geosynthetics and geonet. No equipment shall be driven upon the geonet layer or geosynthetics.

3.03 SEAMS AND OVERLAPS

A. Each component of the geonet will be secured or seamed to the like component at overlaps.

B. Geonet Components

1. Butt seams should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geonet a minimum of 24 inches across the roll width and as recommended by the manufacturer. The overlaps shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 12 inches along the roll width.

2. Adjacent edge seams across the roll length should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geonet a minimum of 6 inches across the roll length. The overlaps shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 5 feet minimum along the roll width.

3.04 REPAIR

A. Prior to covering the deployed geonet, each roll shall be inspected for damage resulting from construction.

B. Any rips, tears or damaged areas on the deployed geonet 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 3.03 of this part.

END OF SECTION 33 47 13.16

END OF SECTION 33 47 13

SECTION 40 23 00 - POLYETHYLENE PIPE

PART 1 - GENERAL

1.01 SUMMARY

A. The WORK of this SPECIFICATION section shall consist of furnishing and installing the leakage collection and conveyance piping and appurtenances associated with the sump and collection trench as shown on the DRAWINGS.

B. The CONTRACTOR shall furnish all labor, materials, tools, equipment, and services for construction of the polyethylene piping and appurtenances.

C. Although such WORK may not be specifically indicated, CONTRACTOR shall furnish and install all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a fully functional installation.

1.02 PIPEWORK AND APPURTENANCES

A. All drainage, collection and conveyance pipework shall be carefully fabricated and placed as shown on the DRAWINGS and approved by the OWNER.

B. All pipe invert elevations and gradients shall be accurately set. CONTRACTOR shall adequately anchor or ballast the pipe to prevent movement during construction.

1.03 REFERENCES

A. Provide IPS size HDPE pipe in accordance with the following standards and all other mandatory ASTM requirements detailed therein.

1. American Society for Testing and Materials (ASTM) most current versions and other applicable standards.
    a. ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
    b. ASTM F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

1.04 SUBMITTALS

A. The CONTRACTOR shall submit the following:

1. Shop drawings of HDPE pipe, fittings, and manner of securing; a list of materials to be furnished; and the name of the pipe manufacturer;
2. Product data sheets showing compliance with the product requirements of this Section
3. Certifications of welder’s qualifications for HDPE pipe fusion required for the project.

B. Submit manufacturer's installation instructions and maintain a copy on-site for reference during construction.

1.05 PIPE WELDERS QUALIFICATIONS

A. All operators conducting fusion welding activities must be certified by the manufacturer as technically qualified and properly experienced for fusion welding of HDPE pipe.

B. Submit names of certified operators in accordance with this Section.

PART 2 - PRODUCTS

2.01 HDPE PIPE

A. HDPE pipe and fittings shall be high-density, high molecular weight polyethylene pipe PE4710.

B. High density polyethylene (HDPE) resin: compounded and manufactured specifically for producing HDPE pipe.

C. Pipe: Manufactured in accordance with ASTM D3350 and ASTM F714.

D. Dimension Ratio (DR): As required by the DRAWINGS.

E. HDPE pipes shall be supplied in standard laying lengths not exceeding 40 feet.

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

G. Fitting at the toe of the slope for the leachate detection sump (LDS) pipe shall consist of a fabricated bend constructed of the same material as the pipe.

PART 3 - EXECUTION

3.01 GENERAL

A. Coordinate details of the prefabricated pipe penetration through the primary liner with the liner manufacturer and CONTRACTOR.

3.02 HANDLING AND PLACEMENT

A. HDPE pipe and fittings shall be installed as indicated on the DRAWINGS.

B. The CONTRACTOR shall exercise care when transporting, handling and placing pipe and fittings, such that they will not be cut, kinked, twisted, or otherwise damaged.

C. The CONTRACTOR shall comply with the pipe manufacturer's recommendations for handling, storage, and installation of all polyethylene pipe and fittings.

D. Ropes, fabric, or rubber-protected slings and/or straps shall be used when handling pipe. Chains, cables or hooks shall not be used as a means of handling pipe.

E. Pipe or fittings shall not be dropped or dragged over sharp objects.

F. The maximum allowable depth of cuts, gouges, or scratches on the exterior surface of pipe or fittings is 10% of the wall thickness. The interior of the pipe and fittings shall be free of cuts, gouges, and scratches. CONTRACTOR shall be required to remove and replace damaged pipe, at no additional cost to the OWNER.

G. Whenever pipe laying is not actively in progress, the open ends of pipes that have been placed shall be closed using watertight plugs.

3.03 INSTALLATION

A. Pipe shall be laid on geotextile within pond leak collection system as shown on the DRAWINGS.

B. All polyethylene pipe and fittings shall be installed in accordance with this SPECIFICATION and in conformance with the pipe manufacturer's written instructions.

C. The CONTRACTOR shall carefully examine all pipe and fittings for cracks, damage, or defects before installation.

D. The interiors of all pipes and fittings shall be inspected, and foreign materials shall be completely removed from the pipe and fitting interiors before they are moved into their final positions.

E. Do not damage underlying WORK, soil layers or geosynthetic installations during pipe installation operations. Repair all damaged WORK.

3.04 JOINTS AND CONNECTIONS

A. Fusion joining equipment shall be as supplied by, leased from, or approved by the pipe manufacturer.

B. Joining techniques and operating procedures shall carefully follow written instructions provided by the pipe manufacturer and the joint equipment supplier. A copy of such instructions, including heating time, cooling time, fusion temperature, and fusion pressure for each size of pipe shall be present at any location in which butt-fusion is being carried out.

3.05 PERFORATIONS

A. Perforations as shown on the DRAWINGS may be manufactured or field constructed with approval from the ENGINEER or OWNER.

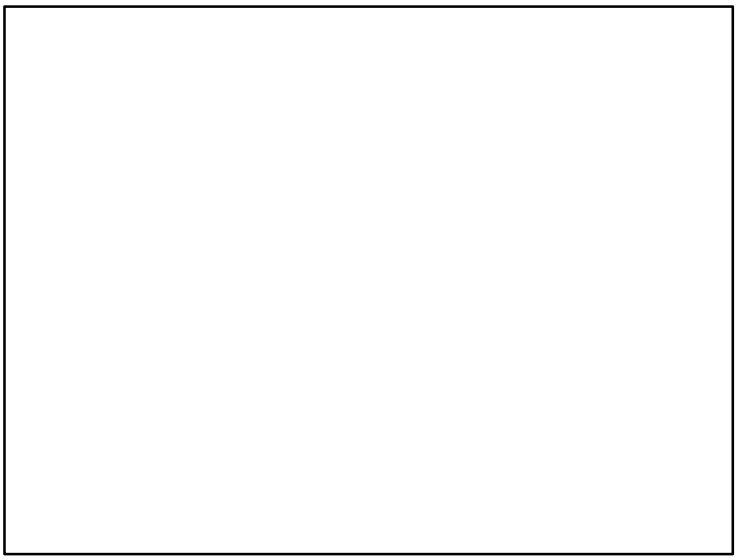
END OF SECTION 40 23 00

Appendix 6 – Recycling Containment Geotechnical Engineering Report

TETRA TECH

Report of Geotechnical Study
Salado Draw, Section 23 - Water Recycling Ponds

Lea County, New Mexico



September 15, 2015

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Report of Geotechnical Study
Proposed Salado Draw, Section 23 – Water Recycling Ponds

Lea County
Near Jal, New Mexico

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Tetra Tech Project No. 212C-DS-00546

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Senior Geotechnical Engineer

September 15, 2016

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EXECUTIVE SUMMARY

Chevron North America Exploration and Production Company has proposed water recycling ponds (frac pond) at the Salado Draw area located in Lea County, New Mexico. The frac ponds will have a combined storage capacity of approximately 700,000 barrels (bbls) and will service the well drilling operations. We understand the frac ponds are to be constructed with double liner and a leak detection system. The bottom of the pond will be sloped and equipped with a liner leak detection sump. The purposes of this study were to obtain information on subsurface conditions, perform laboratory testing and analysis, and to provide geotechnical design criteria for the excavation of the proposed pond and foundations to support proposed pump structures. The general site location is shown on the Site Location Map, Figure 1.

After the first two attempts by Tetra Tech (June 6, 2016 and July 19, 2016) to access the site with the truck mounted drilling rig, Chevron contracted an independent driller with a track mounted drilling rig contractor on July 26, 2016 to drill the borings.

Based on the boring logs provided by Chevron, on July 26, 2016, five (5) exploratory soil borings, B-1 through B-5, were drilled by others at the site to identify subsurface conditions. The boring locations had been marked in the field by Chevron personnel, and the locations were cleared for drilling by New Mexico Utility Locate. The borings, B-1, and B-3 through B-5, were terminated at a depth of approximately 35 feet below the existing ground surface. Boring B-2 was terminated at a depth of approximately 20 feet below the existing ground surface. Approximate locations of the borings are shown on the Soil Test Boring Location Plan, Figure 2.

The borings indicated the subsurface conditions consisted of loose to very dense sand with varying contents of silt and clay. This stratum was encountered from the ground surface and extended to the boring termination depths of 20 and 35 feet below existing ground surface. Standard Penetration Test (SPT) N-values within this stratum ranged from 8 blows per foot (bpf) to greater than 100 bpf. The borings were dry at time of drilling.

In general, the subsurface soils consist primarily of loose to dense sands within the depths of the proposed excavation. Excavation at this site can be achieved with nominal effort. When disturbed, this type of material has a tendency to cave-in, especially in a dry state. During excavation, the excavation slope and embankment interior and exterior slopes should be constructed with 3H:1V, with soil compacted to at least 95 percent of the maximum dry density as determined by ASTM D 698, standard Proctor to at least 2 percent above the optimum moisture content. Detailed discussions and recommendations are provided in the following sections of this report.

We have prepared this executive summary solely to provide a general overview, and it should not be used for any purpose except that for which it was intended. Carefully review the entire report in detail for information about our findings, recommendations and other concerns related to geotechnical conditions for the site.

1.0 PURPOSE AND SCOPE OF STUDY

The purpose of this investigation was to characterize the subsurface soils at the site for the proposed frac ponds and to provide excavation recommendations.

2.0 SITE CONDITIONS

The site for the proposed frac pond(s) is located near unnamed oil-field lease roads south of NM Highway 128 in Lea County, approximately 27 miles west of Jal, New Mexico.

Based on visual observations, the site was moderately wooded and appeared to be relatively flat. The upper two feet of the ground surface was covered with windblown cover sand and was very loose. This made access to site very difficult with standard truck mounted drilling rig. Active flow lines crossed the site that prevented vehicles from accessing the site.

3.0 PROPOSED DEVELOPMENT

Based on the information provided by Chevron, the proposed development will consist of water recycling ponds (frac ponds) to service the well drilling operations. The frac ponds will have a storage capacity of approximately 700,000 barrels (bbls) and will be mostly below ground. The ponds will be double lined and equipped with a leak detection system. The bottom of the pond will be sloped and a liquid leak detection sump will be installed.

4.0 GEOLOGIC CONDITIONS

The Hobbs Sheet of the Geologic Atlas of Texas locates the project site within sand, silt, and clay deposits (Windblown sand, alluvium, playa, and fluviatile terrace deposits, Qcs, Qp,) underlain by Blackwater Draw (Qbd) Formation consisting of caliche. The caliche and windblown deposits consist of sand and silt in sheets and may sometimes be associated with playa deposits that are generally associated with organics. The windblown cover sands are fine to medium grained, silty, calcareous, and include caliche nodules. Generally, these deposits are 20 to 50 feet thick. The caliche is a conglomerate of various materials such as clay, silt, sand, and gravel that included precipitated calcium carbonate. Often, the calcium carbonate cements the soil grains together. The level of cementation can vary and can be highly cemented to weakly cemented. These deposits can often be soft or loose, especially in the presence of groundwater. Our findings of the exploration are consistent with this within the depths explored.

5.0 FIELD EXPLORATION

5.1 Exploratory Soil Borings

Tetra Tech mobilized to the site on June 6, 2016 with a truck mounted drilling rig. Due to the presence of very loose sand, trees, and flow lines, the site was inaccessible. Chevron field personnel indicated the site will be cleared and be made accessible. Tetra Tech again mobilized to the site on July 19, 2017. Although the site was cleared of trees and other large vegetation, the site was still inaccessible to the truck mounted drilling rig because of the very loose sandy surface and flow lines.

On July 26, 2016, Chevron contracted an independent drilling company with a track-mounted drilling rig to drill five (5) exploratory soil borings, B-1 through B-5 within the footprint of the proposed pond to identify subsurface conditions. The drillers logged the borings and the field logs were provided to Tetra Tech by Chevron. We understand from Chevron that the boring locations had been marked in the field by Chevron personnel. Based on these logs, the borings, B-1, and B-3 through B-5, were terminated at a depth of approximately 35 feet below the existing ground surface. Boring B-2 was terminated at a depth of 20 feet below the existing ground surface. Approximate locations of the borings are shown on the Soil Test Boring Location Plan, Figure 2.

6.0 SUBSURFACE CONDITIONS

Based on the data from the borings, the subsurface conditions consisted of loose to dense sand with varying contents of silt and clay. This stratum was encountered from the ground surface and extended to the boring termination depths of 20 and 35 feet below existing ground surface. Standard Penetration Test (SPT) N-values within this stratum ranged from 8 blows per foot (bpf) to greater than 100 bpf. The blow counts generally increased with depth. The borings were dry 24 hours after drilling.

We understand that at the time of drilling, groundwater was not encountered in the borings and that the borings were backfilled with soil from auger cutting to the ground surface. It should be noted that a detailed groundwater study was beyond the scope of our current investigation. Our observations are only indicative of conditions at the time and boring locations indicated. Groundwater levels can vary due to many factors, including seasonal changes, site topography, surface runoff, post development conditions, the layering and permeability of subsurface strata, water levels in waterways, utilities, and other factors that may not have been evident at the time this study. Long-term observations would be necessary to more accurately evaluate the groundwater behavior and fluctuations.

7.0 ENGINEERING ANALYSES AND RECOMMENDATIONS

7.1 Primary Geotechnical Considerations

Based on the type of proposed development at this site, the primary concern that would preclude the proposed development is the presence of loose sand within the proposed depths of excavation. Excavation in sandy material, especially when dry and loose, will tend to cave in.

In our opinion, these constraints can be mitigated by proper engineering design and careful construction of the embankment in accordance with the recommendations below.

7.2 Site Preparation

The construction footprint should be stripped of vegetation, roots, organic material, existing construction materials, debris, and other unsuitable materials. Obstructions that could hinder preparation of the site should also be removed, with special attention given to unknown or un-documented below ground appurtenances and the existing below ground pipelines. A typical stripping depth is approximately 6 inches; however, the actual depth will vary and should be based on field observations. After stripping, the widely spaced borings indicate a moderately stable surface for support of construction equipment using tracks. Rubber-tired equipment will potentially get stuck. Unsuitable areas (such as those with loose, wet, soft, yielding, and/or pumping subgrade) should be corrected before construction proceeds. We recommend the stripping and site preparation extend to at least 5 feet beyond the planned construction footprint. Depending on finished subgrades, all cuts should be made at this time.

Care should be taken not to damage the existing buried utilities located within the footprint of the proposed construction. Buried utilities in conflict with the proposed development should be relocated appropriately. The resulting utility trenches/excavations should be backfilled as discussed in the Fill Placement and Compaction section of this report.

7.3 Excavation

Based on the data from the borings, loose to dense sands are present beneath the topsoil. These soils can be excavated with nominal effort using standard excavating equipment within the upper 20 feet. Beyond this depth, difficult to excavate material should be anticipated. The general contractor should review the subsurface conditions and appropriately select excavation equipment and initial slope of the excavation to minimize cave-in.

7.4 Liner Protection

The existing liner will be removed and replaced with new liner, double lined. Any rock protrusions will potentially damage the liner. The subsurface conditions at this site indicate fine to medium grained sand; thus the need for geotextile and a cushioning layer may be eliminated after inspection and approval by the geotechnical engineer.

7.5 Fill Placement and Compaction

The proposed frac ponds will be constructed to balance cut and fill depths. Significant fill placement and compaction is anticipated at this suite due to the presence of very loose sands. A loss of 20 percent in volume of the on-site soils should be anticipated.

The on-site soils, free of organics and debris, are suitable for use as structural fill or backfill. Fill and backfill should not be placed on organics or other deleterious materials, and should be moisture-conditioned to +2 percent of optimum moisture content. If additional fill is needed for the construction of the embankment, the imported fill should be a well-graded aggregate base course, or imported soils with engineering properties that are similar to on-site soils (depending on the intended use of the fill). For structural support, a uniform, granular material having 100 percent passing the 1 inch sieve, 30 to 70 percent passing the No. 4 sieve, and 3 to 15 percent passing the number 200 sieve is recommended. For on-site and imported fill and backfill, moisture should be adjusted and the soils thoroughly mixed prior to placement and compaction to provide uniform water content throughout the fill. Fill and backfill should be placed in uniform lifts of 8 inches loose thickness or less. Backfill should be compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698).

Prior to placement and compaction, the moisture content should be brought to at least 2 percent above the optimum moisture content. Fill should be compacted using heavy vibratory equipment. In areas with limited space for heavy equipment, appropriate compacting equipment such as a jumping jack or other hand tools should be used. Where smaller compacting equipment or hand tools are used, the fill lifts should be 6 to 8 inches loose thickness. The contractor should select the equipment type based upon the situation. Each lift should be tested by proof rolling using a loaded water truck or loaded dump truck to confirm it has the specified moisture and compaction. Each vertical foot of compacted fill placed should be tested for compaction. A minimum of one moisture/density verification test should be performed for every 5,000-square-feet of compacted area, or for every 150-lineal feet of utility trench backfill. For smaller areas, a minimum of 3 verification tests should be provided for every lift. Subsequent lifts should not be placed until the exposed lift has been tested to confirm the specified moisture and density. Lifts failing to meet the moisture and density requirements should be reworked to meet the required specifications.

The specified moisture content must be maintained until compaction of the overlying lift, or until the cushioning sand layer or geotextile fabric and liner are installed. Failure to maintain the specified moisture content could result in excessive soil movement resulting in embankment failure. The contractor must provide some means of controlling the moisture content (such as water hoses, water trucks, etc.). Maintaining subgrade moisture is always critical, but will require the most effort during warm, windy and/or sunny conditions. Density and moisture verification testing is recommended to provide some indication that adequate earthwork is being performed. However, the quality of the fill and compaction is the sole responsibility of the contractor. Satisfactory verification testing is not a guarantee of the quality of the contractor's earthwork operations.

7.6 Proof Rolling

Following fill placement, compaction, and testing, we recommend the embankments be proof rolled every two feet or for every four lifts of fill placed. Proof rolling should be used to detect areas of soft and/or pumping soil and should be based upon TxDOT Standard Specification Item 216. Proof rolling should be conducted using a heavy, rubber-tired vehicle weighing at least 25 tons, with the tires inflated to the manufacturer’s specified operating pressure. The entire area should be proof rolled, with each succeeding pass offset by not greater than one tire width. The geotechnical engineer should be present during proof rolling activities to assist with the identification of unsuitable soil. Unsuitable soil should be undercut and reworked, or otherwise improved in a manner that is suitable to the geotechnical engineer.

7.7 Excavation and Embankment Slopes

Using the limited data from the soil borings, we analyzed the soil types based on potential depth of excavation and embankment height. For soil design parameters, an angle of internal friction of 32 degrees is recommended with a compacted/improved subgrade soil unit weight of 110 psf.

According to the OSHA, the on-site soil type is classified as Type C with a recommended exterior and interior slope of 3H:1V. This should provide a factor of safety of 1.5.

Analysis of the embankment was conducted according to Natural Resources Conservation Service (NRCS) TR-60 (NRCS TR-60, 2005) criteria governing the design and construction of earth dams and reservoirs. This reference recommends the minimum factors of safety under given conditions as shown in Table 1. The most stringent (highest) minimum factor of safety was used as a design guideline. The horizontal acceleration used for the pseudo-static analysis was 0.20g, which corresponds to Peak Ground Acceleration (PGA) with a two percent probability of exceedance in 50 years for this site, according to the U.S. Geologic Survey (USGS) 2010 Earthquake Hazards Program Seismic Hazard Maps (USGS, 2010).

Table 1. Minimum Safety Factors for Slope Stability Analyses

Design Condition	Minimum Factor of Safety (NRCS TR-60, 2005)
End-of-construction	**1.4**
Rapid drawdown	**1.1**
Steady seepage, static loading	**1.5**
Steady seepage, pseudo-static loading	**1.1**

7.8 Freeboard

An important aspect of embankment stability and performance is maintaining the appropriate freeboard (the vertical distance from the water surface to the crest of the embankment). If the freeboard is insufficient, the embankment could overtop, leading to excessive erosion and possible failure. New Mexico (NMOCD) regulations require a minimum freeboard of three feet for the proposed ponds (or “permanent pits”). This minimum freeboard requirement must be maintained at all times.

7.9 Settlement of Embankment Materials

Settlement of embankment material is an important aspect of embankment stability and total fluid storage potential over time. The embankment will be constructed of fill consisting of on-site material and imported fill. The on-site soils are non-expansive soils, consisting primarily of sand with silt and clay. These soils have a low potential for settlement. Potential settlement of the embankment can be reduced by implementing good construction practices. Fill placement and compaction should be as discussed in Section 7.5: Fill Placement and Compaction.

7.10 Permitting and Closure

If applicable, a permit application should be filed with the NMOCD in accordance with NMOCD regulations prior to construction. Construction and installation in accordance with NMOCD

regulations and the design drawings and construction specifications is recommended. The NMOCD may require notification prior to construction and prior to operation of a water recycling pond (pit).

8.0 CONCLUSIONS

Geotechnical and civil engineering investigations indicate the proposed frac ponds can be constructed in accordance with NMOCD regulations, as described herein. The design and investigation were based on the five (5) soil borings.

Construction should be conducted in accordance with NMOCD regulations, the engineering drawings and specifications prepared by Tetra Tech, and this report. We believe this investigation was conducted in a manner consistent with generally accepted geotechnical and civil engineering principles and according to methods normally used in the vicinity of the project at this time. No warranty is made, express or implied. Should additional information become available that could alter the analyses, conclusions, or recommendations in this report, Tetra Tech should be contacted to review the design documents in the light of that information to determine if revisions are needed.

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10.0 LIMITATIONS

This report was prepared from data developed during our field exploration, laboratory testing, and engineering analysis. Calculations and design recommendations were based on subsurface data, laboratory testing, and our experience with similar projects. Our borings were spaced to obtain a reasonable interpretation of subsurface conditions. Variations in the subsoils not indicated in our borings are likely.

A qualified geotechnical engineer or their designated representative should observe the construction to look for evidence that would indicate differences in subsurface conditions from those described in this report. If any information becomes available that would alter our assumptions or our calculations, the opinions presented in this report should be considered invalid until we have been contacted to review our recommendations based on new information. The geotechnical engineer should review plans and specifications during the design. If applicable, placement and compaction of engineered fill, backfill, subgrade and other fills should be observed and tested by a representative of a Construction Materials Testing (CMT) firm during construction, and Tetra Tech should be retained to review these data.

We believe this study was conducted in a manner consistent with that level of skill and care ordinarily used by members of the profession currently practicing under similar conditions in the locality of this project. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the planned project from the geotechnical point of view, please contact us.

As mentioned previously, field observations, monitoring, and quality assurance testing during foundation installation are an extension of the geotechnical design. We recommend that you retain these services and that we be allowed to continue our involvement in the project through the phases of construction.

APPENDIX A
EXPLORATORY BORING LOGS

Tetra Tech Inc.
4000 N. Big Spring, Suite 401
Midland, TX, 79705
Telephone: 432-682-4559
Fax: 432-682-3946

BOREHOLE ID: B-1

CLIENT Chevron **PROJECT NAME** Salado Draw Frac Pit

PROJECT NUMBER 212C-MD-00546 **PROJECT LOCATION** Lea County, New Mexico

DATE(S) OF EXCAVATION: 07/26/2016 **GROUND ELEVATION: N/A** **METHOD: Mud Rotary**

CONSULTANT: Tetra Tech, Inc. **LATITUDE: 32.034833N** **LOGGED BY: Not Recorded**

DRILLING CONTRACTOR: Not Recorded **LONGITUDE: 103.639200W** **DRILLED BY: Not Recorded**

Notes: No Groundwater Encountered during Drilling.

DEPTH (ft)	SAMPLE TYPE	N Value	GRAPHIC LOG	MATERIAL DESCRIPTION
0	SS	5		Loose to Very Dense, Orange and White, Fine to Medium Grained **SAND** with some Silt and Clay, Calcareous, Rock Fragments, Dry
	SS	11		
5	SS	14		
	SS	50+		
10	SS	48		
15	SS	14		
20	SS	19		
25	SS	37		
30	SS	50+		
35	SS	50+		
35.0				Borehole terminated at 35.0 feet.

BOREHOLE/TP/WELL - VECTOR SALADO.GPJ LAB SUMMARY.GDT 9/19/16

Tetra Tech Inc.
4000 N. Big Spring, Suite 401
Midland, TX, 79705
Telephone: 432-682-4559
Fax: 432-682-3946

BOREHOLE ID: B-2

CLIENT Chevron **PROJECT NAME** Salado Draw Frac Pit

PROJECT NUMBER 212C-MD-00546 **PROJECT LOCATION** Lea County, New Mexico

DATE(S) OF EXCAVATION: 07/26/2016 **GROUND ELEVATION: N/A** **METHOD: Mud Rotary**

CONSULTANT: Tetra Tech, Inc. **LATITUDE: 32.000167N** **LOGGED BY: Not Recorded**

DRILLING CONTRACTOR: Not Recorded **LONGITUDE: 103.639017W** **DRILLED BY: Not Recorded**

Notes: No Groundwater Encountered during Drilling.

DEPTH (ft)	SAMPLE TYPE	N Value	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
	SS	8		Loose to Very Dense, Orange and White, Fine to Medium Grained **SAND** with some Silt and Clay, Calcareous, Rock Fragments, Dry
	SS	10		
5	SS	17		
	SS	35		
10	SS	40		
15	SS	50+		
20	SS	50+		
				20.0 Borehole terminated at 20.0 feet.

Tetra Tech Inc.
4000 N. Big Spring, Suite 401
Midland, TX, 79705
Telephone: 432-682-4559
Fax: 432-682-3946

BOREHOLE ID: B-3

CLIENT Chevron **PROJECT NAME** Salado Draw Frac Pit

PROJECT NUMBER 212C-MD-00546 **PROJECT LOCATION** Lea County, New Mexico

DATE(S) OF EXCAVATION: 07/26/2016 **GROUND ELEVATION: N/A** **METHOD: Mud Rotary**

CONSULTANT: Tetra Tech, Inc. **LATITUDE: 32.033966N** **LOGGED BY: Not Recorded**

DRILLING CONTRACTOR: Not Recorded **LONGITUDE: 103.638400W** **DRILLED BY: Not Recorded**

Notes: No Groundwater Encountered during Drilling.

DEPTH (ft)	SAMPLE TYPE	N Value	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
	SS	10		Medium Dense to Very Dense, Orange and White, Fine to Medium Grained **SAND** with some Silt and Clay, Calcareous, Rock Fragments, Dry
	SS	11		
5	SS	21		
	SS	27		
10	SS	50+		
15	SS	27		
20	SS	39		
25	SS	50+		
30	SS	45		
35	SS	50+		
				35.0
				Borehole terminated at 35.0 feet.

Tetra Tech Inc.
4000 N. Big Spring, Suite 401
Midland, TX, 79705
Telephone: 432-682-4559
Fax: 432-682-3946

BOREHOLE ID: B-4

CLIENT Chevron **PROJECT NAME** Salado Draw Frac Pit

PROJECT NUMBER 212C-MD-00546 **PROJECT LOCATION** Lea County, New Mexico

DATE(S) OF EXCAVATION: 07/26/2016 **GROUND ELEVATION: N/A** **METHOD: Mud Rotary**

CONSULTANT: Tetra Tech, Inc. **LATITUDE: 32.033417N** **LOGGED BY: Not Recorded**

DRILLING CONTRACTOR: Not Recorded **LONGITUDE: 103.637650W** **DRILLED BY: Not Recorded**

Notes: No Groundwater Encountered during Drilling.

DEPTH (ft)	SAMPLE TYPE	N Value	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
	SS	8		Medium Dense to Very Dense, Orange and White, Fine to Medium Grained **SAND** with some Silt and Clay, Calcareous, Rock Fragments, Dry
	SS	10		
5	SS	39		
	SS	33		
10	SS	50+		
15	SS	35		
20	SS	50+		
25	SS	50+		
30	SS	50+		
35	SS	50+		
				35.0
				Borehole terminated at 35.0 feet.

BOREHOLE/TP/WELL - VECTOR SALADO.GPJ LAB SUMMARY.GDT 9/19/16

Tetra Tech Inc.
4000 N. Big Spring, Suite 401
Midland, TX, 79705
Telephone: 432-682-4559
Fax: 432-682-3946

BOREHOLE ID: B-5

CLIENT Chevron **PROJECT NAME** Salado Draw Frac Pit

PROJECT NUMBER 212C-MD-00546 **PROJECT LOCATION** Lea County, New Mexico

DATE(S) OF EXCAVATION: 07/26/2016 **GROUND ELEVATION: N/A** **METHOD: Mud Rotary**

CONSULTANT: Tetra Tech, Inc. **LATITUDE: 32.034700N** **LOGGED BY: Not Recorded**

DRILLING CONTRACTOR: Not Recorded **LONGITUDE: 103.637633W** **DRILLED BY: Not Recorded**

Notes: No Groundwater Encountered during Drilling.

DEPTH (ft)	SAMPLE TYPE	N Value	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
	SS	13		Medium Dense to Dense, Orange and White, Fine to Medium Grained **SAND** with some Silt and Clay, Calcareous, Rock Fragments, Dry
	SS	15		
5	SS	26		
	SS	22		
10	SS	11		
15	SS	24		
20	SS	15		
25	SS	19		
30	SS	31		
35	SS	35		
				35.0 Borehole terminated at 35.0 feet.

Appendix 7 – HDPE Liner Specifications

19103 Gundle Road
Houston, TX 77073
800 435 2008 • 281 443 8564
281 230 8650 Fax
www.gseworld.com

October 27, 2016

Tony Banuelos
EC Applications-Texas
12002 E Highway 158
Gardendale, TX 79758

RE: GSE Geomembrane – Permeability for EDS-040NE and EDS-060NE

Certification of Compliance

The undersigned, being qualified and authorized to do so, hereby certifies that GSE 40 mil and 60 EDS Geomembrane will meet a permeability of $< 1 \times 10^{-12}$ cm/s when tested per ASTM E96.

Sincerely,

Miguel Garcia
GSE Technical Support

MG16-0214

PRODUCT DATA SHEET

GSE HD Smooth Geomembrane

GSE HD is a smooth high density polyethylene (HDPE) geomembrane manufactured with the highest quality resin specifically formulated for flexible geomembranes. This product is used in applications that require excellent chemical resistance and endurance properties.

AT THE CORE:

An HDPE geomembrane used in applications that require excellent chemical resistance and endurance properties.

Product Specifications

These product specifications meet GRI GM 13

Tested Property	Test Method	Frequency	Minimum Average Value				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5199	every roll	30 27	40 36	60 54	80 72	100 90
Density, g/cm³	ASTM D 1505	200,000 lb	0.940	0.940	0.940	0.940	0.94
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lb	 114 63 700 12	 152 84 700 12	 228 126 700 12	 304 168 700 12	 380 210 700 12
Tear Resistance, lb	ASTM D 1004	45,000 lb	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	45,000 lb	54	72	108	144	180
Carbon Black Content, % (Range)	ASTM D 1603*/4218	20,000 lb	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	500	500	500	500	500
Oxidative Induction Time, mins	ASTM D 3895, 200°C; O_2 1 atm	200,000 lb	>100	>100	>100	>100	>100
TYPICAL ROLL DIMENSIONS							
Roll Length(2), ft			1,120	870	560	430	340
Roll Width(2), ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft²			25,200	19,575	12,600	9,675	7,650

NOTES:
- (1)Dispersion only applies to mear spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)Roll lengths and widths have a tolerance of ±1%.
- GSE HD is available in rolls weighing approximately 3,900 lb.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77°C when tested according to ASTM D 746.
- *Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales ofice.