3.3.4 Soil Liner Quality Control

3.3.4.1 Introduction – PLA-1

A. General

This plan delineates the methods and procedures to be followed during liner system construction to ensure the protection of surface and ground-water quality beyond the boundary of the landfill. Also contained in the plan are requirements for Quality Assurance/Quality Control testing, to include guidance for Engineers/Geologists who prepare and sign the Soils and Liner Evaluation Report (SLER) and the Flexible Membrane Liner Evaluation Report (FMLER). This Soil and Liner Quality Control Plan will be used in conjunction with the Texas Commission on Environmental Quality (TCEQs) Liner Construction and Testing Handbook. The two documents shall complement each other in that where one document does not address a concern the other does. The TCEQ shall have precedence in matters that are overlapping in nature, as it was published in accordance with 30 Texas Administrative Code, Chapter 330 the Municipal Solid Waste Regulations governing this site. The Liner Construction and Testing Handbook is located in Appendix IV.

B. Definitions

1. Geotechnical Quality Control Professional (GQCP)

A professional engineer, registered in Texas, who possesses professional experience in geo-technical engineering and testing or a graduate geologist, who has a minimum of four years experience in engineering geology and is experienced in geo-technical testing and its interpretations. For the purpose of this plan, the GQCP is the independent third party engineer who is responsible for Quality Assurance/Quality Control and the preparation of the SLER and FMLER.

2. Qualified Engineering Technician

An engineering technician, who is NICET-certified in Geo-technical Engineering Technology at level 2 or higher or an engineering technician with a minimum of four years of directly related experience or a graduate engineer or geologist with one year of directly related experience. For the purpose of this

plan, all qualified engineering technicians work at all times under the general supervision of the GQCP who signs the SLER and FMLER.

C. Liner System Description

1. Design

In situ soils at this facility do not meet Subtitle D ground-water protection requirements for an alternate liner. In lieu of a naturally occurring liner, a composite liner system shall be constructed. The constructed liner system shall consist of a two foot compacted clay layer, a 60 mil Flexible Membrane Liner (FML), a geo-synthetic layer (a composite of geo-textile fabric and geo-net-type drainage material), a Leachate Collection System (LCS), a one foot granular drainage layer, and a one foot protective cover layer (see liner system detail). An alternate layer design, if approved by the Executive Director, would consist of a Geo-synthetic Clay Liner material (GCL), a 60 mil FML, a geo-synthetic layer, a LCS, a one foot granular drainage layer, and a one foot protective cover layer. The GCL design will be submitted at a later date. For the purpose of this plan, the term "liner system" shall include the Leachate Collection System, with all associated piping, trenches, drainage media, sumps and other appurtenances.

2. Discussion

This facility is designed to be an area fill operation. Lateral expansions are constructed in the form of cells, which are typically 330 feet wide by 420 feet long. The width of expansions (cells), however, is not critical and may vary for a number of reasons, including rate of incoming waste, weather conditions, general geology, etc. The permanent side slopes of the excavation are designed on a 3 to 1 slope to ensure stability and constructability. For additional stability, a textured FML and a geo-textile fabric-drainage net composite is specified on the side slopes.

3.3.4.2 Materials Suitability

A. Clay Layer

1. Prior to clay layer construction, representative samples from each clay soil source to be used shall be tested in a geo-technical laboratory to ensure their suitability for lining purposes. The following set of tests shall be performed:

Test	Method	Suitability Criteria
Classification	ASTM D2487	Classified as CL or CH
Sieve Analysis (+40, +200, -200)	ASTM D422	30 + % (-200 sieve) 100% (1-1/2" screen)
Atterberg Limits Plasticity Index Liquid Limit	ASTM D4318	 No less than 15 No less than 30
Coefficient of Permeability	Appendix VII of Corps Of Engineers Manual EM 1110-2-1096 or ASTM D5084-90	No greater than 1.0×10^{-7} Cm/sec

2. Soils from each source to be used which meet the Atterberg Limits requirements shall be compacted to determine the moisture-density relationship, including maximum dry density and optimum moisture content using either the Standard Proctor (ASTM D698 – for Lightweight equipment) or the Modified Proctor (ASTM 1557 for heavy equipment). The selection of compaction test and permeability test shall be at the discretion of the GQCP, or their qualified engineering technician, based on their experience and knowledge of the actual compaction equipment and methods to be used.

B. FML LAYER

1. The Flexible Membrane Liner (FML) to be installed shall be High Density Polyethylene (HDPE) sheeting material manufactured from new, first quality products designed specifically for the purpose of leachate containment in landfills.
2. The manufacturer shall certify in writing that the FML material meets the physical property requirements for its intended application.
3. The FML material shall be extruded to produce a uniform sheet free of any defects that might affect its serviceability, such as holes, tears, nodules, blisters, undispersed raw materials, or foreign matter. Any such defect shall

be repaired by extrusion welding in accordance with the manufacturer's recommendations.

4. The sheeting material shall be packaged as prefabricated panels in rolls with labels identifying the thickness, length, width, product information, and manufacturer's information.
5. The FML material shall be stored in its original unopened crates on pallets and protected from direct sunlight under a light-colored, heat reflective, opaque cover in a manner that provides a free flowing air space between the crate and the cover.
6. The manufacturer or his designated representative shall furnish panel layouts as required for the installation.
7. All FML material to be used shall meet or exceed (unless otherwise noted) the following minimum specifications, which meet or exceed the NSF Standard 54 Specifications for High Density Polyethylene (HDPE):

SHEET

Test	**Method**	**Suitability Criteria**
Thickness	ASTM D374/D751	60 mils
Tensile Strength (yield)	ASTM D638	2200 psi
Tensile Strength (break)	ASTM D638	3800 psi
Elongation (Yield)	ASTM D638	13%
Elongation (break)	ASTM D638	700%
Tear Resistance	ASTM D1004C	45 lbs
Puncture Resistance	FTMS 101C Method 2065	69 lbs
Friction Angle (for textured only)	GRI-GS7	29°

BASE RESIN

Test	Method	Suitability Criteria
Density	ASTM D792/1505	0.94 g/cm^3
Carbon Black Content	ASTM D1603	2 – 3 %
Carbon Black Dispersion	ASTM D3015	A1 or A2

8. Whenever a different FML manufacturer is to be used, samples of the new material shall be welded to samples of the current HDPE material and "compatibility" testing shall be performed. The following shall comprise this "compatibility" testing and shall be the minimum acceptable values:

Test	**Method**	**Suitability Criteria**
Shear Strength	ASTM D4437	2000 psi
Peel Adhesion (Fusion Weld)	ASTM D4437	1500 psi
Peel Adhesion (Extrusion Weld)	ASTM D4437	1300 psi

C. GEOSYNTHETIC LAYER

The geo-synthetic layer to be installed directly on the textured FML on the side slopes shall be a composite of a layer of HDPE drainage net material heat bonded between two layers of continuous filament, needle punched, polypropylene geo-textile fabric. This composite is specifically designed to transmit fluids in the plane of the sheet. The composite shall be chemically resistant within a pH range of 2 to 13 and shall be stabilized to resist degradation caused by prolonged exposure to ultraviolet (U.V) light. The geo-synthetic material shall meet the following minimum specifications:

Test	**Method**	**Suitability Criteria**
Specific Gravity	ASTM D1505	0.94 g/cm3
U. V. Resistance	ASTM D4355	80% of strength retained
Permeability (of geo-textile)	ASTM D4491 (500 hours)	0.4 cm/sec
Transmissivity (of drainage net)	ASTM D4716 (@ 0.25 gradient)	10 gal/min/ft width
Ply Adhesion	ASTM DF904 (2" x 5" @ 2 ipm)	2.0 lbs/inch

1. The geo-synthetic material shall be uniformly rolled onto a cardboard core and wrapped in plastic to protect the material from moisture and damage. It shall be scored off the ground, out of weather, and in its original wrapping until installation. The rolls shall be tagged externally to indicate the manufacturer, product type, product grade, lot number, and physical dimensions. Each roll shall also be certified by the manufacturer that it contains no broken needles.

D. LEACHATE COLLECTION SYSTEM (LCS) COMPONENTS

1. General

The HELP model was used to aid in the design of this leachate collection system. The LCS design was developed based on the worst case scenario, in which the greatest amount of leachate was generated from several different simulated situations (see LCS typical details).

2. All components of the leachate collection system shall be manufactured of materials which are chemically resistant to the leachate expected to be generated; of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill; and designed and operated to function throughout the scheduled closure and post-closure care period of the landfill.
3. The following are considered components of the LCS: SDR-35 Perforated Drain Pipe and fittings (6” Dia.), SDR-35 Solid Wall Drain Pipe and fittings (8” Dia.), 1 ½” crushed aggregate (with less than 15% Calcium Carbonate), Clay Sump, and 16 oz. Geo-textile fabric “wrap” around the perforated pipe.
4. The SDR-35 pipe was selected for its excellent chemical resistance, strength, wall thickness, and drainage characteristics. The drainage laterals and headers shall employ perforated pipe, whereas, the clean-outs shall employ solid wall pipe.
5. The specification for the crushed aggregate was developed based on drainage characteristics, chemical resistance, and the size of the holes (1/2”) in the

perforated pipe. The specified aggregate size (1-1/2") will preclude any material from entering (and clogging) the drainage laterals and/or headers.

6. The sump shall be constructed as a single unit to prevent loss/leakage of leachate before it can be removed.

7. The geo-textile fabric used to "wrap" the LCS drainage laterals and headers shall act as a filter to prevent clogging of the LCS system and shall be chemically resistant within a pH range of 2 to 13 and shall be stabilized to resist degradation caused by prolonged exposure to ultraviolet (U.V.) light. The geo-textile shall have small enough openings to retain fine-grained soil particles and have large enough openings to retain fine-grained soil particles and have large enough openings to allow leachate to pass through without a significant reduction in flow. The geo-textile fabric shall meet the following minimum specifications:

Test	**Method**	**Suitability Criteria**
Fabric Weight	ASTM D3776	16 oz/SY
Mullen Burst	ASTM D3786	450 psi
U.V. Resistance	ASTM D4355 (500 hours)	80% of strength retained
Trapezoidal Tear	ASTM D4533	140 lbs
Grab Tensile Strength	ASTM D4632	320 lbs
Grab Elongation	ASTM D4632	90%

E. Drainage Layer

1. The material to be used for the drainage layer is a coarse sand. There are no soils of this type on site; therefore, this material must be purchased and tucked to the site.

2. The sand to be used shall have a coefficient of permeability of 1.0×10^{-2} cm/sec or greater.

F. Protective Cover Layer

1. The protective cover layer shall be constructed from on site soils, classified as CL or CH (ASTM D2487). The material/layer shall have no particles larger than 3 inches in any dimension.
2. This layer shall serve as filter to prevent the high permeability drainage layer from clogging.

3.3.4.3 CONSTRUCTION

A. General

Soil liner construction and testing shall be conducted systematically and shall not exceed 60 working days unless adverse weather prevents timely completion.

B. Excavation/Grading

1. Initial Preparation

Areas of the landfill to be excavated for lateral expansions shall be cleared and grubbed of all trees, stumps, roots, brush, debris, fences, and other items which would interfere with construction operations.

2. Depth Of Excavation

Each area shall then be excavated as shown on plans.

3. Grading

The bottom of the excavation shall be graded to a two percent minimum slope toward the leachate collection system laterals and sump.

4. Excavated Soils

Topsoil shall be carefully removed and stockpiled for final closure. All other excavated soil shall be stockpiled in a separate location for liner suitability testing or use as daily cover.

5. Protection Of Excavation

Surface water shall be directed away from the excavation and construction sites by diversion ditches, dikes, etc. Any surface or groundwater accumulating

in the excavation or construction site shall be pumped off the site as soon as possible.

6. Trenching For LCS

A rough trench for the leachate laterals and headers shall be constructed, as well as a rough sump. These rough excavations or the LCS shall be filled during clay layer construction to provide the extra thickness required to ensure a minimum of two foot of clay under the LCS trenches and sump.

7. Preparation For Clay Placement

The finished, graded bottom of the excavation shall be rolled with a flat wheel roller prior to placement of the first lift of clay.

C. Clay Layer

1. General

The clay layer shall be constructed monolithically with the side slopes in parallel lifts. Based on the 3 to 1 side slope, no key is required at the toe of the slope.

2. Clod Size Reduction

Prior to adding water, clod sizes shall be reduced by disking, pulverizing, or screening, as determined by the GQCP, or their qualified engineering technician. The GQCP, or their qualified engineering technician, shall determine which method best suits the soils present and when the clods have been sufficiently reduced for hydration. The maximum clod size of compacted clay layer shall be no greater than one inch in diameter. The clay shall also contain no rocks larger than one inch in diameter nor total more than 10 % by weight.

3. Hydrating Liner Soil

Clean, uncontaminated water shall be added and the soil mixed thoroughly, allowing sufficient time for the soil to hydrate completely.

4. Compaction Effort

The clay layer shall be compacted with a tamping-foot or prong-foot roller with minimum 6-inch pad or prong length. The lift thickness shall be controlled to achieve total penetration through the loose (8-to 9-inch) lift being compacted into the previously compacted lift, thereby ensuring adequate bonding between lifts. The top of the first three 6-inch lifts shall be roughened to a shallow depth and moistened prior to the placement of the next lift, to further ensure adequate bonding between lifts.

5. Markers

The limits of the constructed clay layer shall be clearly marked by discernible SLER markers, which shall be tied into the landfill grid system and maintained at all times until they are no longer required. The SLER markers shall not penetrate the constructed clay layer for any reason.

6. Lift Protection

The top surface of the completed clay layer shall be bladed or flat-wheel rolled smooth prior to final liner thickness verification and subsequent FML placement. Further, the top surface shall be proof rolled any time that construction is scheduled to be halted for more than 24 hours to help mitigate the effects of desiccation.

7. Liner Tie-In

The leading 10 to 20 feet of liner edge shall not receive waste in order to facilitate tie-in with the next lateral expansion (the exact width shall be dictated by the GQCP, or their qualified engineering technician). The top foot of previously compacted clay shall be removed across the 10 to 20-foot width to create a ledge (stair) on which to construct the new liner edge (see tie-in detail).

8. Hydrostatic Pressure

No waste disposal area shall be constructed below the seasonal high ground-water table, as defined in the initial soil boring logs. If and when ground-water is encountered during excavation and is determined to be under hydrostatic pressure, the GQCP, or their qualified engineering technician, shall dictate the type, amount

of, and procedures for ballasting. At a minimum, one foot of additional ballast shall be required for each two additional feet of hydrostatic head (the two foot clay layer will itself offset four feet of hydrostatic pressure). The clay layer shall not be constructed in standing water.

9. Ponded Water

No water shall be allowed to pond on the clay layer.

D. FML Layer

1. General

The FML layer shall be constructed directly atop the two foot clay layer as soon as possible after approval of the Soils and Liner Evaluation Report (SLER). Installation of the HDPE flexible membrane liner shall be performed in strict accordance with the manufacturer's recommendations, all applicable drawings, and this plan.

2. Certification Of Proficiency Of Installer

The installer shall have successfully installed at least ten million square feet of the same FML during the last five years. At least one of the installations shall have been a liner application at a municipal solid waste disposal site.

3. Certification Of Proficiency Of Installer's Personnel

Placement of the FML shall be performed by trained and experienced personnel, who are qualified and approved by the manufacturer to install this material, and under the supervision of a single field engineer, responsible for panel layout, seaming, repairing, and testing, who has supervised the installation of at least two million square feet of this FML.

4. Roll Inspection

The installer's quality control inspector shall inspect each roll, panel, or section of the FML to verify that it meets the required specifications and to check material thickness with a micrometer.

5. Panel Layout And Overlap

Only those panels that are to be placed and seamed in one day shall be unrolled. Panels shall be positioned with the overlap recommended by the manufacturer, but not less than two inches. The quality control inspector shall inspect and verify that the FML is placed with sufficient overlap.

6. Panel Deployment

The FML rolls/panels shall be deployed in a manner which minimizes rutting (less than 1 inch deep) in the clay layer surface.

7. Protection Of The FML

No support equipment shall be allowed on the FML. Personnel working on the FML shall not smoke, wear damaging shoes, or engage in any other activity likely to damage the FML.

8. Anchor Trenches

Anchor trenches shall be completed around the entire area to be lined (except for edges to be tied into on future expansions, which shall be anchored by sand bags). Excavated anchor trench soil shall be removed from the trenches. No loose soil shall underlie the FML in the anchor trenches. The anchor trenches shall be carefully backfilled and compacted to the specifications used for the clay layer, without damaging the FML (see anchor trench and termination details).

9. Preparation For Field Seaming

Prior to field seaming, all wrinkles shall be walked out removed as much as possible. All foreign matter shall be removed from the area to be bonded.

10. Field Seaming

Field seaming shall be performed by the methods approved by the manufacturer only (see fusion and extrusion weld details). As much as practical, field seaming shall start in the middle and work toward an open end in order to minimize cutting and patching of large wrinkles that become trapped. All completed seams shall be tightly bonded and sealed. Tack welds, if used, shall use heat only. No double-sided tape or glue shall be permitted. No folds, wrinkles, or fish-mouths shall be allowed within the seamed area. In general,

seams shall be oriented up and down, instead of across the slope. No horizontal seam shall be less than 5 feet from the toe of the slope. In corners, sumps, trenches, and other odd-shaped configurations, the number of field seams shall be minimized.

11. Seaming/Welding Equipment

Only welding systems which utilize the manufacture's recommended welding process shall be used for bonding the FML. The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the FML so as to ensure changes in environmental conditions shall not affect the integrity of the weld.

12. Repairs

Where wrinkles or folds occur, the FML shall be cut and overlapped, and an extrusion weld shall be applied. Where destructive samples are taken or seams fail, a patch shall be installed, which extends at least six inches beyond the edge of the defect, with all corners of patches rounded to a three inch radius. During wrinkle or fold repairs, the adjacent FML may not be required to meet the two inch minimum overlap if approved by the installer's quality control inspector.

13. Seaming Conditions

No seaming shall be attempted above 104 degrees Fahrenheit air temperature or in high wind. If seaming is to be performed below 41 degrees Fahrenheit ambient air temperature, preheating of the FML may be required.

14. Unseamed Edges

At the end of each day or installation segment, all be anchored with sand bags or other approved devices. Staples, U-shaped rods, or other penetrating anchors shall not be used to secure the FML.

15. Certification Of Installation

Upon completion of the FML installation, the installer shall certify in writing that the FML has been installed in accordance with the manufacturer's recommendations, all applicable drawings, and this plan.

16. Warranty

The manufacturer of the FML shall warrant, in writing, the material on a pro-rated (straight-line) basis against manufacturing defects and degradation of the material for a period of twenty (20) years from the date of final acceptance following installation. The manufacturer shall replace and reinstall any material which fails within the warranty period. In addition to the materials warranty, the installer shall warrant the installation of the FML against defects or failure for a period of one (1) year. The installation warranty shall commence from the date of final acceptance of the installed FML and shall include the services of qualified technicians and all materials required due to defects in installation and/or workmanship.

E. Leachate Collection System

1. General

The leachate collection system shall be constructed in accordance with all applicable permit drawings, details, etc. (see LCS details).

2. Trenches And Sumps

After approval of the SLER for the clay layer, the trench for the LCS laterals and headers, as well as the sump, shall be carefully excavated. The edges of the trench and sump shall be rounded to prevent sharp folds or bends in the FML material. The depth of the trench and sump may vary, but the thickness of clay liner below the trench and sump shall always be two feet or greater.

3. Geotextile “Wrap”

After placement, seaming, and testing of the FML, the geo-textile material shall be placed in the LCS trenches. The width of the geo-textile shall be sufficient to completely envelope the LCS laterals and headers after aggregate backfill.

4. Pipe And Sump Installation

The SDR-35 perforated pipe shall then be installed in the lateral and header trenches and connected together. The sump shall then be carefully excavated and leveled. All connections shall be in accordance with standard plumbing practice.

5. Trench Backfill

After pipe installation, the trenches shall be carefully backfilled with the 1-1/2" crushed aggregate around the drainage pipes. Upon completion of the backfill operation, the exposed edges (flaps) of the geo-textile fabric shall be "wrapped" each way over the pipes and backfill, enveloping the drainage piping system.

6. Cleanouts

After lateral and header pipe installation and backfill, the SDR-35 solid wall clean-out pipe shall be installed. See LCS Details for clean-out. The pipe shall be secured in place with sand bags or some other means until placement of the protective cover layer.

F. Geosynthetic Layer

1. General

Installation of the geo-synthetic composite layer on the side slopes shall be performed in strict accordance with the manufacture's recommendations, all applicable drawings, and this plan.

2. Certification Of Proficiency Of Installer's Personnel

Placement of the geo-synthetic composite shall be performed by trained and experienced personnel, including supervisors, foremen, and skilled laborers, who are qualified and approved by the manufacturer to install this material.

3. Seaming

The geo-synthetic composite shall be seamed by overlapping the panels at least six inches and tying them together with plastic ties every few feet along the seam. The plastic ties shall tie the drainage nets in both panels together, not just the geo-textile fabric. No wire ties shall be used. The layer of geo-synthetic

composite in place shall be free of holes, tears, wrinkles, creases, and other imperfections.

4. Repairs

Any required repairs on damaged composite shall be made in accordance with the manufacturer's recommendations.

5. Edges

All edges of the geo-synthetic composite shall be anchored as shown on the anchor trench detail, termination detail, or floor tie-in detail.

6. Certification Of Installation

Upon completion of the installation of the geo-synthetic composite, the installer shall certify in writing that the geo-synthetic layer has been installed in accordance with the manufacturer's recommendations, all applicable drawings, and this plan.

G. Drainage Layer

1. General

The installation of the granular drainage material (sand) shall be performed under the close supervision of the GQCP, or their qualified engineering technician.

2. Installation Procedure

Using a light-weight dozer, a "pad" shall be constructed approximately three feet thick initially. When the pad is stabilized, "fingers" shall be constructed across the floor to minimize wrinkles in the FML caused by pushing the sand outward. The dozer shall continue pushing the sand and increasing the pad and finger dimensions. As the pad and finger dimensions increase, the thickness gradually decreases. When the total required amount of sand has been brought in, the thickness shall be checked by survey methods and adjusted until it is uniform across the floor.

3. Additional Thickness

The area directly over the LCS trenches shall receive a two foot thick layer of sand. Also, the protective cover layer shall be constructed with "chimneys" to allow leachate to pass through the protective cover layer into the drainage layer and into the leachate collection system (see LCS details).

4. Termination And Tie-In

The sand drainage layer shall be terminated and tied-in as shown on the LCS details.

5. Sump Backfill

The space around the prefabricated concrete sump shall be backfilled with sand to the same elevation as the sand layer in the floor.

H. Protective Cover Layer

1. General

A layer of uniform native soil, free of rocks, vegetation, and debris that may damage the liner system, shall be installed directly on top of the sand drainage layer on the floor and on top of the geo-synthetic layer on the side slopes to act as a protective cover layer and filter to prevent clogging of the drainage media. All protective cover layers shall be installed as a single lift, regardless of thickness.

2. Floor

A one-foot, uncompacted protective cover layer shall be placed on the sand drainage layer immediately after verification of drainage layer thickness, upon approval of the GQCP, or their qualified engineering technician (see termination detail). Protective cover material shall not be placed over the additional thickness of the drainage layer over the LCS laterals and headers or over the chimneys through protective cover layer (see LCS details)

3. Side Slopes

A two-foot, uncompacted protective cover layer shall be placed on the geo-synthetic composite layer immediately after placement of the one-foot protective cover layer on the floor (see tie-in detail). Placement of the single two-foot lift

shall begin at the toe of the slope and progress up the slope to minimize loading on the FML.

3.3.4.4 QUALITY ASSURANCE/QUALITY CONTROL

A. General

1. Objective

The objective of Quality Assurance/Quality Control (QA/QC) during liner system construction is to ensure that each material component is structurally sound and that all construction procedures are correctly and properly followed so that the quality of the surface and ground-water is absolutely protected. This objective shall be met by using a GQCP whose credentials have already been submitted to and approved by the Commission, as well as requiring GQCP, or their qualified engineering technician, to be on site at all times during liner system construction.

2. Acceptable Criteria

The entire lateral expansion (cell construction) project shall be in accordance with all applicable drawings, plans, etc., and under the direct supervision of the GQCP, or their qualified engineering technician. The GQCP, or their qualified engineering technician, shall ensure that the QC/QA objective is met and shall have the authority and responsibility for making any required field decisions or judgments concerning liner system construction.

3. Testing And Reporting

The GQCP shall be responsible for all Quality Control/Quality Assurance testing (both field and lab) and reporting (both SLER and FMLER). Specific procedures and requirements for QC/QA testing and reporting follow.

B. Excavation/Grading

1. Excavation

The GQCP, or their qualified engineering technician, shall observe all excavation and trenching operations to ensure that areas are not over-excavated.

The GQCP shall certify that the depth of all excavations and trenches are in accordance with this plan and the Site Development Plan (SDP).

2. Grading

The GQCP, or their qualified engineering technician, shall be responsible for verifying all grades and lines using instrument survey methods and shall certify that the floor and LCS lateral trenches are on a two percent minimum slope toward the sump. The GQCP, or their qualified engineering technician, shall approve the graded excavation and the bladed/rolled surface for clay placement.

C. Clay Layer

1. General

The GQCP, or their qualified engineering technician, shall closely monitor the plasticity of the soils used for liner construction and may require additional soil suitability testing if he feels at any time that the initial soil suitability testing was inadequate for all the clay soils being used for lining.

2. Testing

The GQCP, or their qualified engineering technician, shall perform the following Quality Assurance tests:

Test	**Method**	**Frequency**	**Criteria**
Field Density	ASTM D2922	Per 8,000 SF per 6" Lift (at least 3 per 6" lift)	95 % of Max. Dry Density at Opt. Moisture or wetter
Sieve Analysis*	ASTM D422	Per 100,000 SF Per 6" Lift 100% (1 ½" Screen)	30 + % (-200 sieve)
Atterberg Limits* Plasticity Index Liquid Limit	ASTM D4318	Per 100,000 SF Per 6" Lift	 No less than 15 No less than 30
Coefficient of Permeability*	Appendix VII Corps of Engineers Manual EM1110-2-1906 or ASTM D5084-90	Per 100,000 SF/6" Lift	No greater than 1.0 X 10-7 cm/sec

* At least one test per 6" lift

3. Thickness Verification

Thickness shall be verified by instrument survey methods at a minimum of one verification point per 5,000 SF (at least two points).

4. Failed Tests

Sections of clay liner that fail the density/moisture criteria shall be reworked and retested until they pass. The procedure used to accurately define the failing section/area shall be determined by the GQCP.

5. Test Holes

All holes created for testing purposes shall be backfilled with bentonite.

D. FML Layer

1. Test Seams

Each day prior to commencing field seaming, test seams shall be made on fragment pieces of the FML to verify that seaming conditions are adequate. Such test seams shall be made at the beginning of each seaming period and at least once every four hours for each seaming apparatus used that day. Also, each seamer shall make at least one test seam each day. The GQCP, or their qualified engineering technician, shall observe and oversee all test seam procedures and field testing. The test seam shall be at least three feet long by one foot wide. Six adjoining one inch wide specimens shall be die-cut from the test seam sample. These specimens shall be tested in the field for shear and peel (three each), and must not fail in the seam. If additional test specimens fail at the seam, the seaming method used shall be investigated to determine the cause of the failures. Once the problem is identified and resolved, a new set of specimens shall be tested for verification.

2. Conformance Testing

Conformance testing samples shall be taken at the rate of one per resin lot and at least one per 100,000 SF. Sample size shall be three feet by the roll width. The GQCP shall perform conformance testing of the FML material as follows:

Test	Method	Suitability Criteria
Thickness	ASTM D751	60 mil
Tensile Strength (Yield)	ASTM D638	2200 psi
Tensile Strength (Break)	ASTM D638	3800 psi
Elongation (Yield)	ASTM D638	13 %
Elongation (Break)	ASTM D638	600 %

3. QA Testing Of Panels

The acceptance criteria for QA testing are the same as for its suitability and are delineated herein. The GQCP, or their qualified engineering technician, shall perform QA testing on the FML material as follows:

Test	Method	Frequency
Thickness	ASTM D374	5' increments along leading and trailing edges of each geomembrane panel
Tensile	ASTM D638	Per 100,000' & every resin lot
Density	ASTM D792/1505	Per 100,000' & every resin lot
C Black Content	ASTM D1603	Per 100,000' & every resin lot
C Black Dispersion	ASTM D3015	Per 100,000' & every resin lot
Puncture Resistance	FTMS 101C(2065)	Per 100,000' & every resin lot

4. QA Testing Of Seams – Nondestructive

Nondestructive seam testing shall be performed to verify the continuity of seams. The installer shall test the entire length of all double weld (fusion) seams using the manufacturer's recommended air pressure test procedure. The installer shall test all extrusion welds using the manufacturer's recommended vacuum box test procedure. The GQCP, or their qualified engineering technician, shall ensure that precautions are taken to prevent damage to the FML by the testing equipment. All testing information and results shall be reduced by the GQCP, or their qualified engineering technician, for reporting purposes.

5. QA Testing Of Seams – Destructive

Destructive seam testing shall be performed to evaluate the strength of seams. The location of destructive samples shall be determined by the GQCP, or their qualified engineering technician, and the installer's quality control inspector. The number and size of destructive samples to be taken shall also be determined by the GQCP, or their qualified engineering technician, and the installer's quality control inspector and may vary for field testing, lab testing, and archive storage. At each location, a minimum of one sample for field testing (peel), two samples for lab testing (peel and shear), and two samples for archive storage shall be taken. The GQCP shall order the following tests on the lab destructive samples:

Test	**Method**	**Frequency**	**Criteria**
Shear Strength	ASTM D4437	Per 500 LF of seam per welder	2000 psi
Peel Adhesion (Fusion Weld)	ASTM D4437	Per 500 LF of seam per welder	1500 psi
Peel Adhesion (extrusion weld)	ASTM D4437	Per 500 LF of seam per welder	1300 psi

6. Visual Inspection

The GQCP, or their qualified engineering technician, shall visually inspect 100 % of the FML surface and certify that it is free of visible defects.

E. Leachate Collection System

1. General

The GQCP, or their qualified engineering technician, shall observe all phases of the leachate collection system construction and shall verify that all LCS components being installed comply with the specifications.

2. Excavation And Trenching

Prior to installation of the SDR-35 pipe and the prefabricated concrete sump, the GQCP, or their qualified engineering technician, shall approve the trench and sump excavations by verifying minimum slopes and maximum depths.

3. LCS Layout And Installation

The GQCP, or their qualified engineering technician, shall ensure that spacing and installation of the LCS components is in accordance with all applicable details and drawings and that only standard plumbing practices are used for all pipe connections. The GQCP, or their qualified engineering technician, shall intensely monitor installation of all LCS components to ensure FML integrity is maintained.

4. Backfilling

The GQCP, or their qualified engineering technician, shall oversee the backfilling and "wrapping" of the LCS laterals, headers, and sumps, ensuring that care is taken to prevent damage to and minimize movement of the LCS components.

5. LCS Flushing

The GQCP, or their qualified engineering technician, shall as a functional check of the leachate collection system, flush out all laterals and headers with uncontaminated water, verifying that all piping drains properly into the sump. At the conclusion of the flush test, all water in the sump shall be pumped out.

F. Geosynthetic Layer

The GQCP, or their qualified engineering technician, shall observe all field seaming of the geo-synthetic composite material and shall verify that all seaming was performed in accordance with the manufacturer's recommended procedures and that no wire ties were used for the seams.

G. Drainage Layer

1. General

The GQCP, or their qualified engineering technician, shall closely monitor the placement of the sand drainage layer to ensure that the FML layer is not damaged.

2. Testing

The GQCP, or their qualified engineering technician, shall perform the following Quality Assurance tests:

Test	**Method**	**Frequency**	**Criteria**
Coefficient of Permeability*	Appendix VII Corps of Engineers Manual EM1110-2-1906 or ASTM D5084-90	Per 1000,000 SF	No less than 1.0 X 10 –2 cm/sec

*At least one test

3. Thickness Verification

Thickness shall be verified by instrument survey methods at a minimum of one verification point per 5,000 SF (at least two points). The sand drainage layer shall be at least one foot thick at all locations. The thickness above the LCS laterals and headers shall be two foot (see LCS details).

H. Protective Cover Layer

1. General

The GQCP, or their qualified engineering technician, shall closely monitor the placement of the protective cover layer to ensure that the sand drainage layer is not disturbed.

2. Chimneys

The GQCP, or their qualified engineering technician, shall inspect and verify that all chimneys have been constructed in accordance with all applicable drawings and that their dimensions and spacing are correct.

3. Thickness Verification

Thickness shall be verified by instrument survey methods at a minimum of one verification point per 5,000 SF (at least two points). The protective cover layer shall be at least one foot thick at all locations on the floor. The protective cover layer shall be at least two foot thick at all locations on the side slopes.

I. Reporting

1. SLER

All excavations and construction, as well as field and lab sampling and testing of components of the composite liner system shall be under the direct supervision of the GQCP, or their qualified engineering technician. The GQCP, or their qualified engineering technician, shall collect all test results from the excavation and construction of the clay layer and prepare a Soils and Liner Evaluation Report (SLER) for each new lateral expansion. Construction above the clay layer shall not commence until the SLER is accepted and approved by the Commission, unless conditions require more expedient progress, in which case, all construction above the clay layer shall be at the risk of the owner. The GQCP shall use TCEQ Form No. GWP-1 for SLER preparation. The GQCP shall include all maps, sketches, drawings, calculations, test results, and any other information required by the Commission in the SLER submission.

2. FMLER

The GQCP, or their qualified engineering technician, shall collect all test results for all construction above the clay layer and prepare a Flexible Membrane Liner Evaluation Report (FMLER) for each new lateral expansion. No waste shall be deposited in a new lateral expansion without approval of the Commission. The GQCP hall use TCEQ Form No. GWP-2 for FMLER preparation. The GQCP shall include all maps, sketches, drawings, calculations, test results, and any other information required by the omission in the FMLER submission. Each FMLER prepared by the GQCP shall include:

a Names of each seamer for start-up testing and afternoon break, including time and tip temperatures for each seaming apparatus used each day.

b Manufacturer's QC documents.

c Field micrometer measurements in one foot increments along the leading and trailing edges of geo-membrane panel. Nondestructive tests, including start and stop times, before and after pressure readings (for double track testing) for all seams.

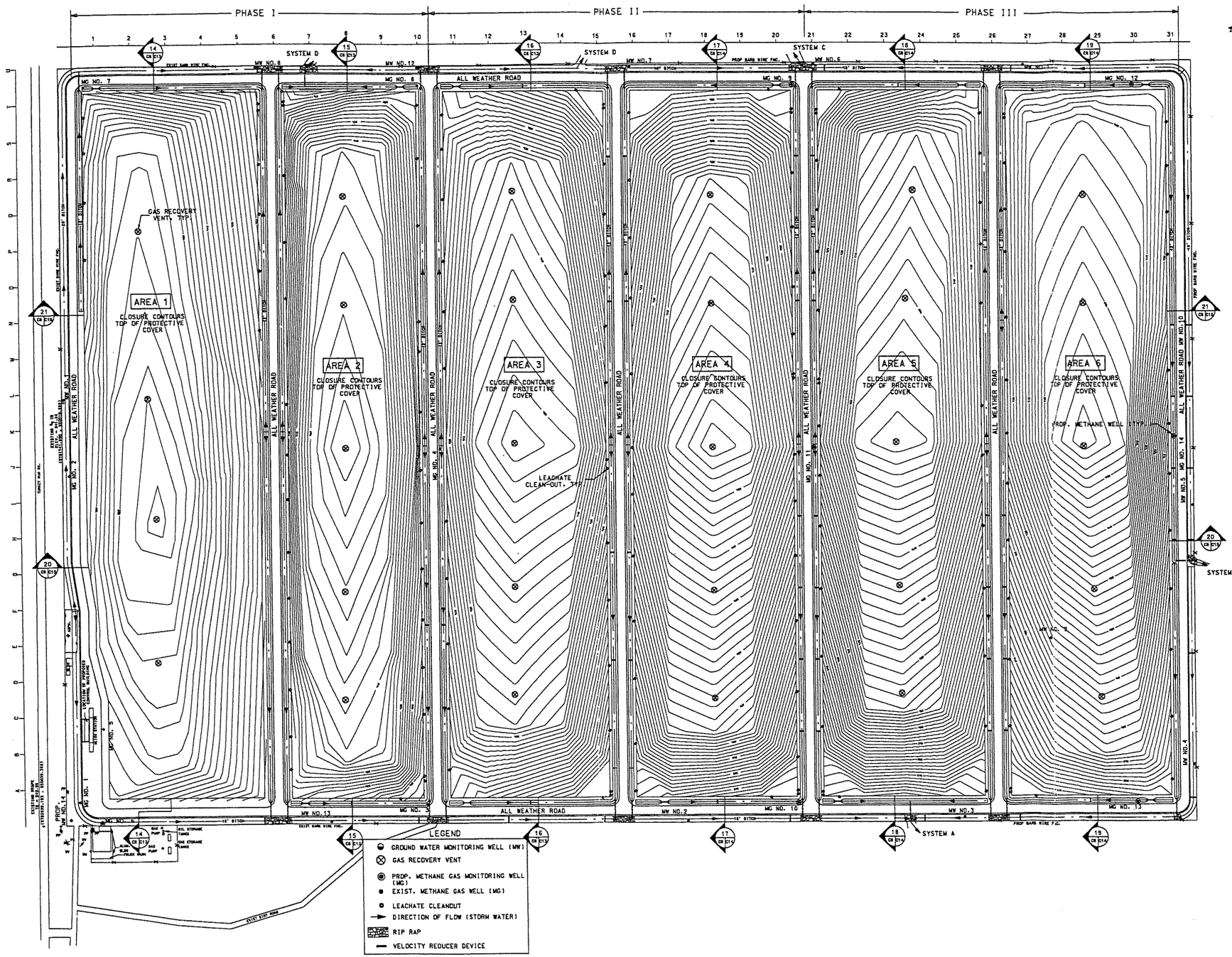
d Roll shipment/receipt and storage/handling information.

e All pertinent drawings, including the Sectorized Fill Layout Plan, the location of cell with SLER/FMLER markers, previous filled and active areas, panel placement including patches, repairs, caps, etc., and destructive tests and repairs.

f Verification of drainage layer and protective cover layer thickness.

g Report must include the qualitative results of Destructive tests for both field and laboratory values of Shear and Peel (both tracks when possible for double track and record location of failures).

h Report must discuss the full-time quality assurance by the GQCP, or their qualified engineering technician, nondestructive testing equipment, including testing procedures and methods of evaluation and passing criteria, subgrade acceptance, anchor trench preparation and backfilling, wrinkles/fishmouths, and normal manufacturing creases, deployment of panels, seam preparation/orientation, weather and air temperature/sheet temperature limits, continuous 100 % nondestructive seam testing; equipment placed on the geomembrane; repairs, including preparation and procedure, patch size and shape, failed test seams and testing either side of failed seam; placement of cover material up slope for sidewalls; thickness and sieve analysis requirements of drainage and protective cover material; field panel identification/placement; specification for air pressure testing/vacuum testing; 100 % visual inspection of geomembrane for defects, damage, etc.; handling and storage of geomembrane materials; quality control/assurance certificates from the manufacturer, including the testing required and frequency of testing; and daily start-up and additional testing for each seaming machine.



SCALE: 1" = 300'

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER
9/22/94

THOMPSON ENGINEERING
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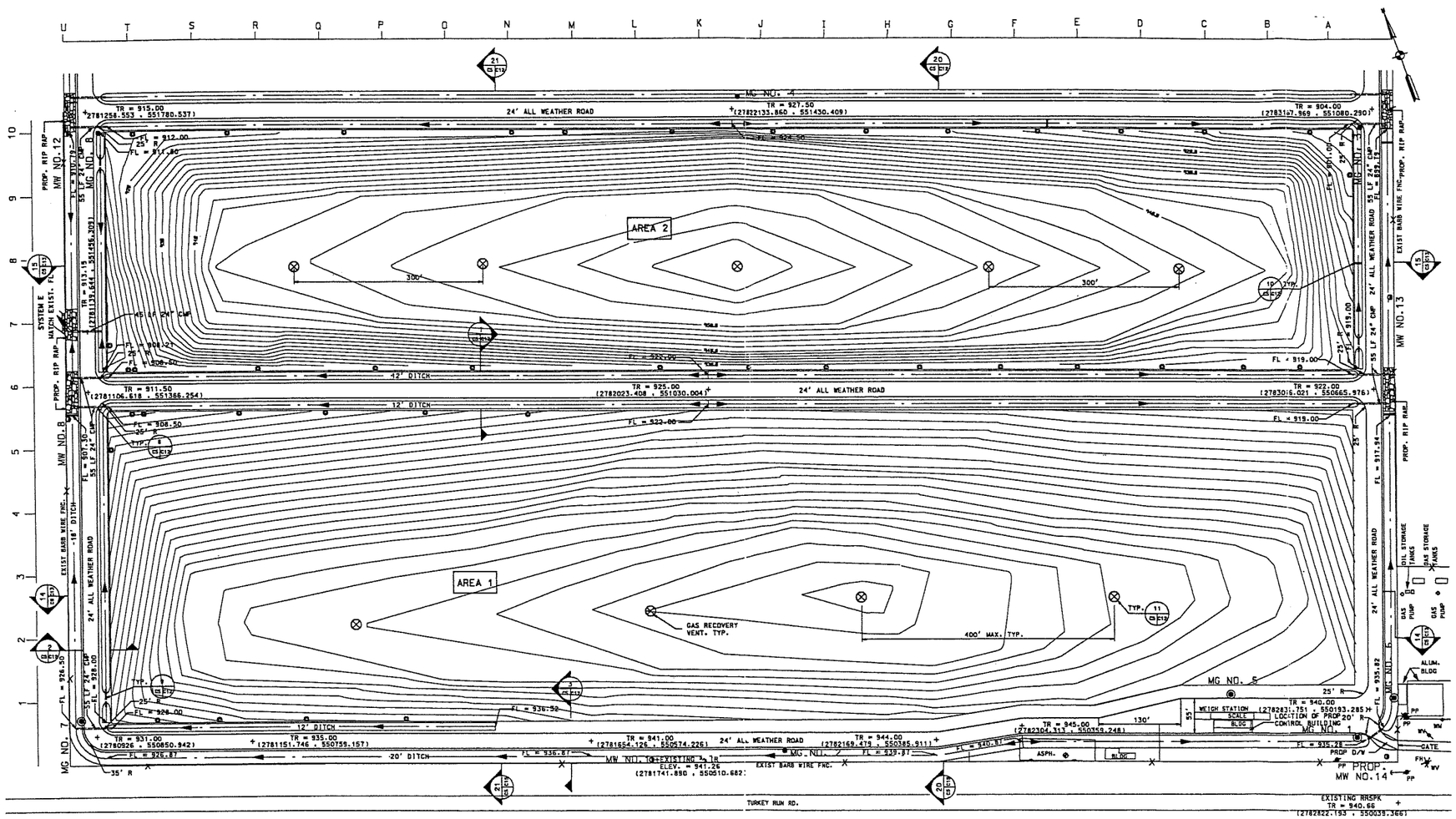
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

CLOSURE LAYOUT

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JFT
SUBMITTED BY:	FORT HOOD
SOL. NO.	
CONTR. NO.	
DRAWING NUMBER	
SHEET NO.	5 OF 16
DATED:	09-23-94
SEQUENCE NO.	C4

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION



LEGEND

- GROUND WATER MONITORING WELL
- GAS RECOVERY VENT
- PROP. METHANE GAS MONITORING WELL
- EXIST. METHANE GAS WELL (MG)
- LEACHATE CLEANOUT
- DIRECTION OF FLOW (STORM WATER)
- RIP RAP
- VELOCITY REDUCER DEVICE

60 0 60 120
SCALE: 1" = 200'

STATE OF TEXAS
JAMES F. THOMPSON
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U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

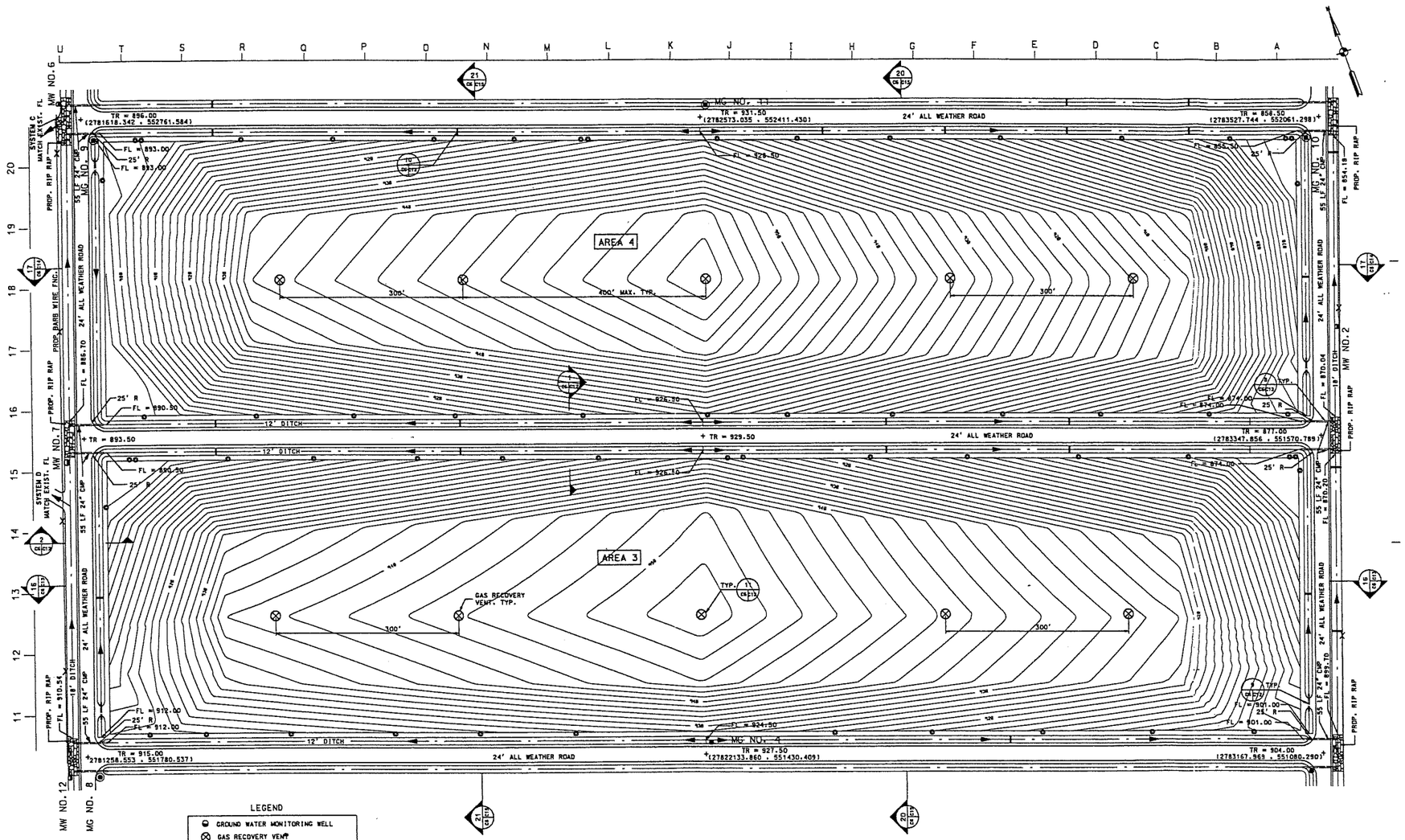
FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

PHASE 1
CLOSURE PLAN

DESIGNED BY: SSA
DRAWN BY: RLN/SSA
REVIEWED BY: JFT

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION

SUBMITTED BY: FORT HOOD
SOL. NO.
DATED: 09-23-9
CONTR. NO.
SEQUENC NO.
DRAWING NUMBER
SHEET NO.



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U.S. ARMY ENGINEER DISTRICT, FORT WORTH
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FORT WORTH, TEXAS

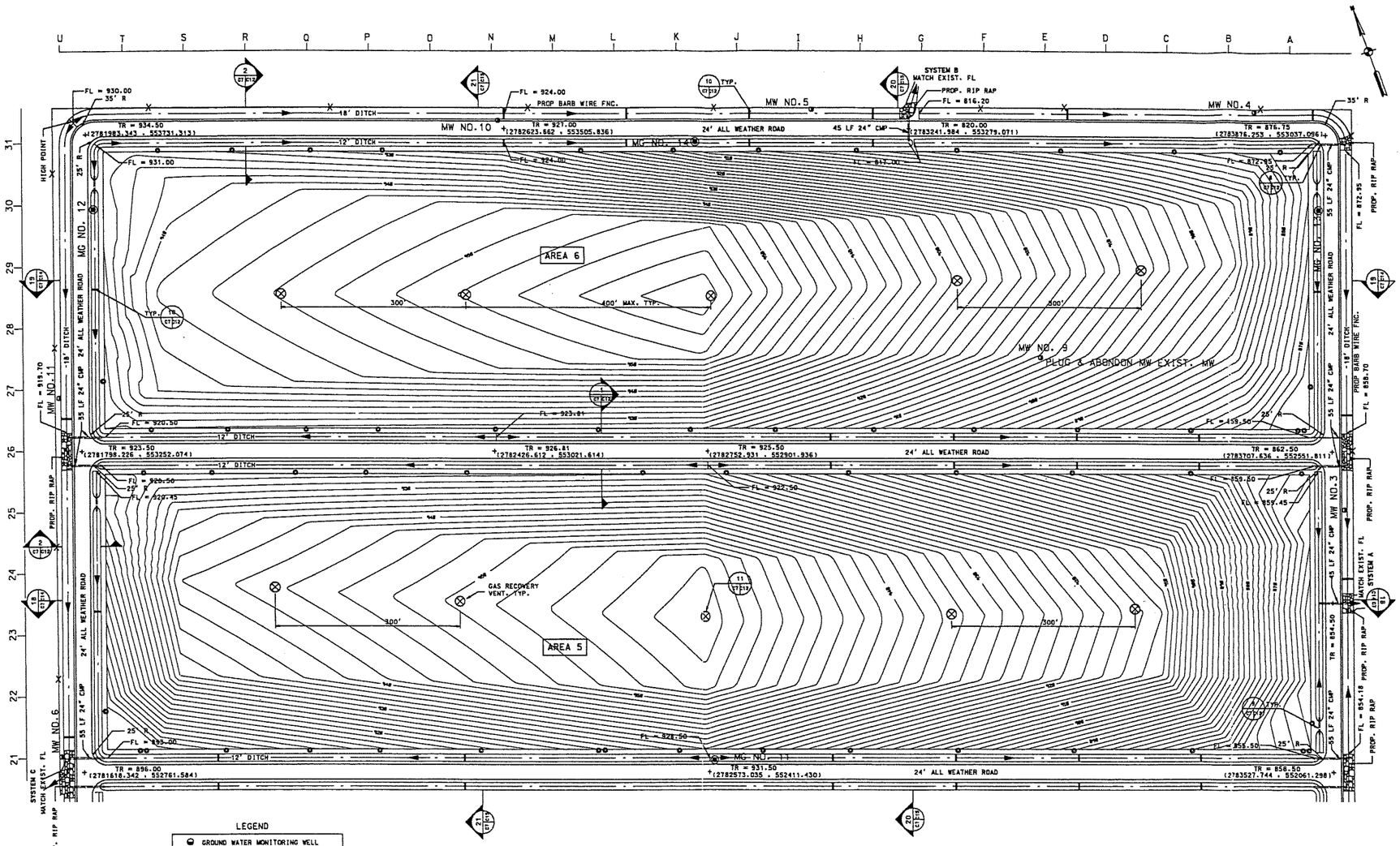
FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

PHASE 2
CLOSURE PLAN

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JFT
SUBMITTED BY:	FORT HOOD

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION

SOL. NO.	DATED: 09-23-94	
CONTR. NO.		SEQUENCE NO.
DRAWING NUMBER	SHEET NO.	



SCALE: 1" = 200'

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER
9/22/94

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U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

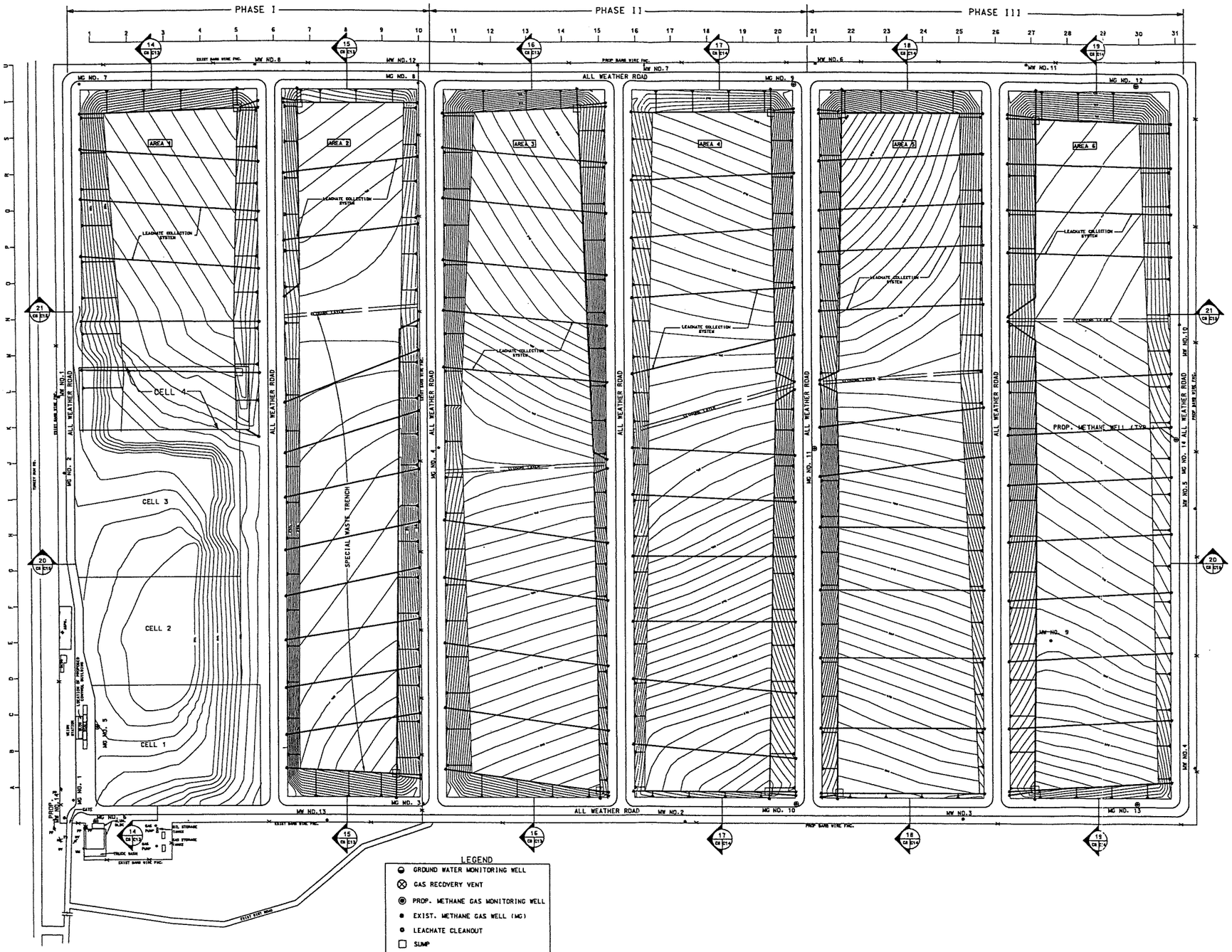
FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

PHASE 3
CLOSURE PLAN

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JFT
SUBMITTED BY:	FORT HOOD

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION

SOL. NO. — DATED: 09-23-94
CONTR. NO. — SEQUENCE NO.
DRAWING NUMBER — SHEET NO.



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U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

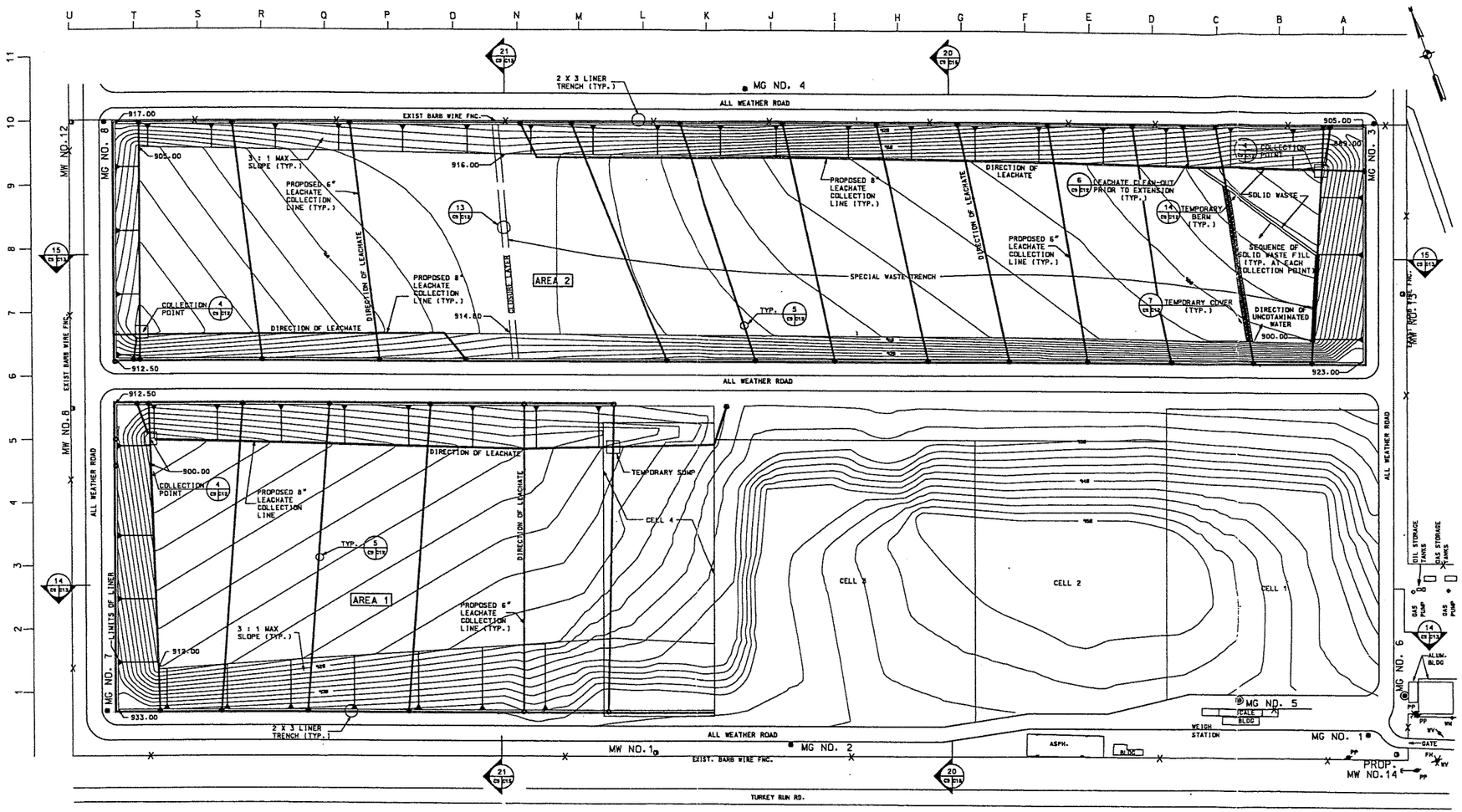
FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

LEACHATE COLLECTION SYSTEM LAYOUT PHASES 1, 2, & 3

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JFT
SUBMITTED BY:	FORT HOOD

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION

SOL. NO.	DATED: 09-23-94
CONTR. NO.	SEQUENCE NO.
DRAWING NUMBER	SHEET NO.



LEGEND

- GROUND WATER MONITORING WELL
- GAS RECOVERY VENT
- PROP. METHANE GAS MONITORING WELL
- EXIST. METHANE GAS WELL (MG)
- LEACHATE CLEANOUT
- SUMP
- LEACHATE COLLECTION SYSTEM

SCALE: 1" = 200'

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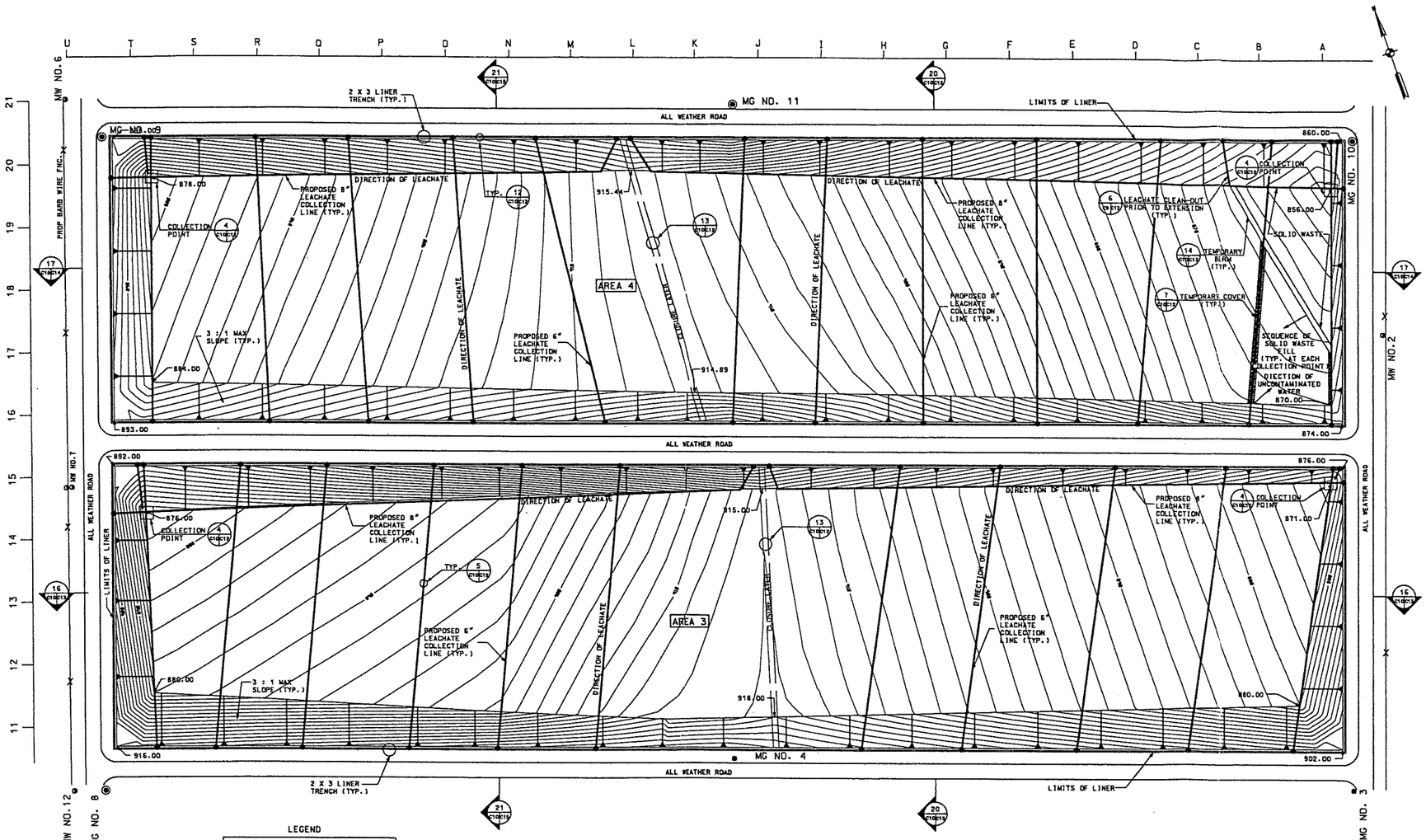
CORPS OF ENGINEERS
FORT WORTH, TEXAS

FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

PHASE 1 LEACHATE COLLECTION SYSTEM

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JET
SUBMITTED BY:	FORT HOOD
SOL. NO.	DATED: 09-23-94
CONTR. NO.	SEQUENCE NO.
DRAWING NUMBER	SHEET NO.

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION



LEGEND

- GROUND WATER MONITORING WELL
- GAS RECOVERY VENT
- PROP. METHANE GAS MONITORING WELL
- EXIST. METHANE GAS WELL (MG)
- LEACHATE CLEANOUT
- DIRECTION OF FLOW (STORM WATER)
- RIP RAP
- VELOCITY REDUCER DEVICE

SCALE: 1" = 200'

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9/24/94

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U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS

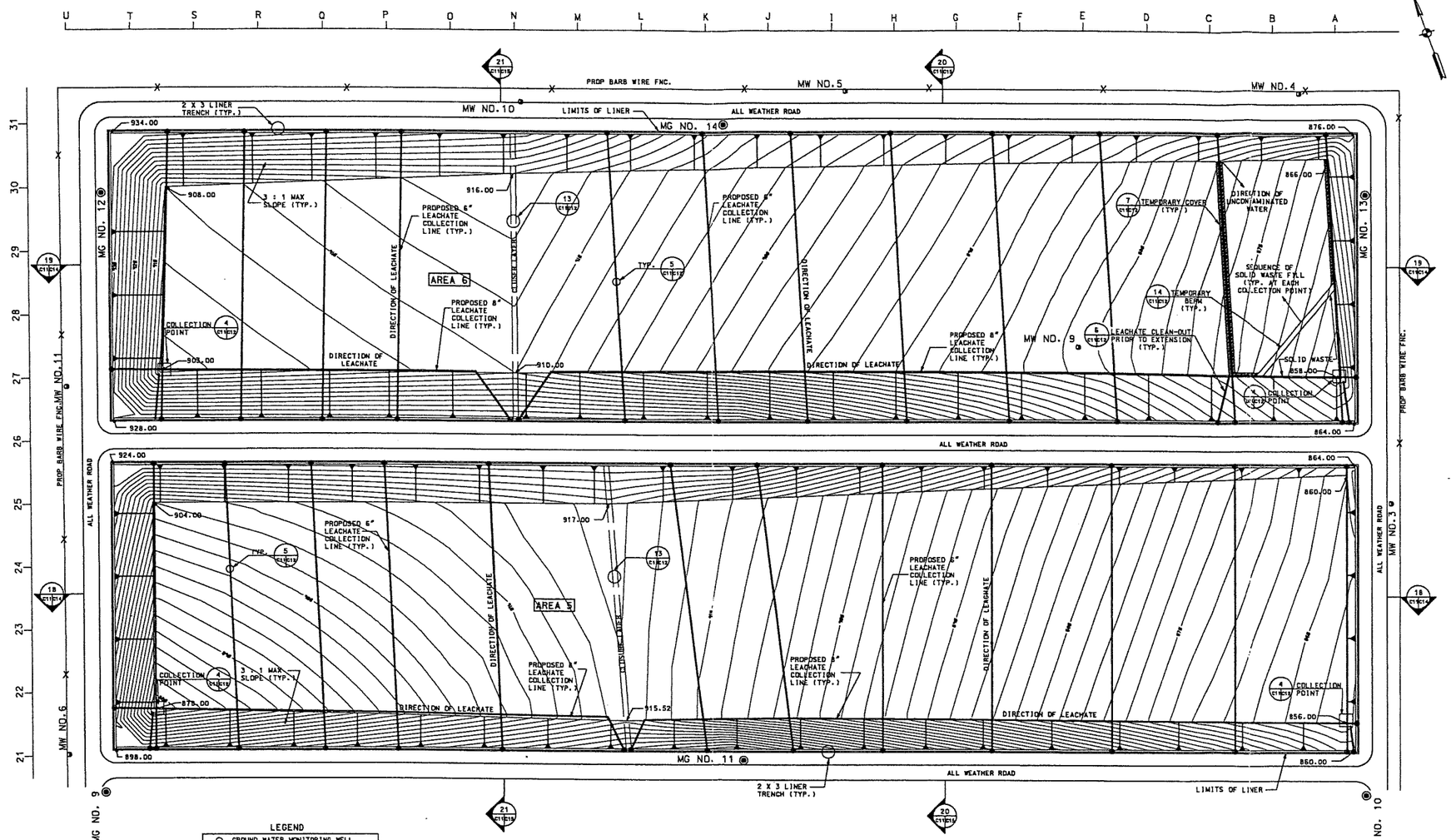
FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

PHASE 2
LEACHATE COLLECTION SYSTEM

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	
SUBMITTED BY:	FORT HOOD

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION

SOL. NO. | DATED: 09-23-94
CONTR. NO. | SEQUENCE NO.
DRAWING NUMBER | SHEET NO.



STATE OF TEXAS
JAMES F. THOMPSON
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9/22/94

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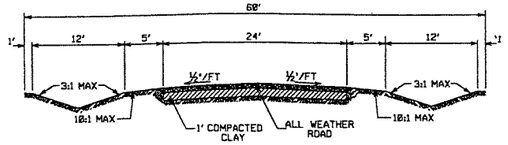
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

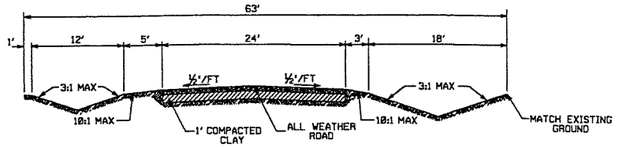
PHASE 3
LEACHATE COLLECTION SYSTEM

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JFT
SUBMITTED BY:	FORT HOOD
SOL. NO.	DATED: 09-23-94
CONTR. NO.	SEQUENCE NO.
DRAWING NUMBER	SHEET NO. 12 OF 16 — C11

SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION



1 SECTION
SCALE: ⅛"= 1'



2 SECTION
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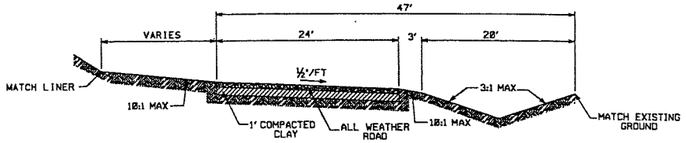
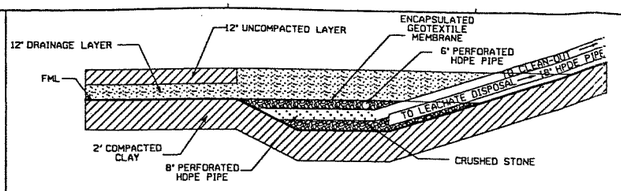
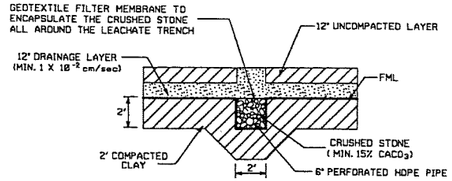


3 SECTION
SCALE: ⅛"= 1'

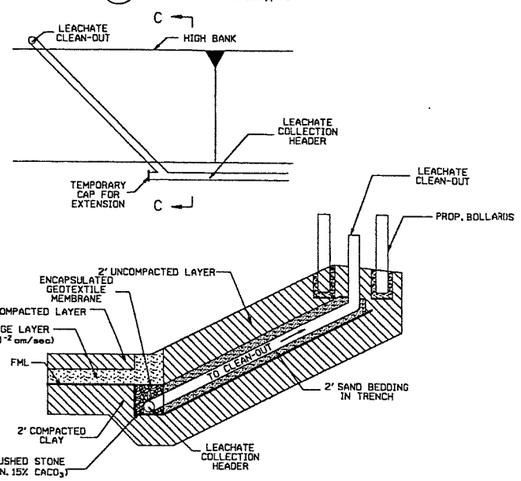
TYPICAL ROAD CROSS SECTIONS



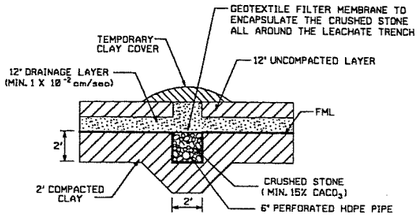
4 LEACHATE SUMP DETAIL
SCALE: ¼"= 1'



5 LEACHATE COLLECTION DETAIL
SCALE: ¼"= 1'

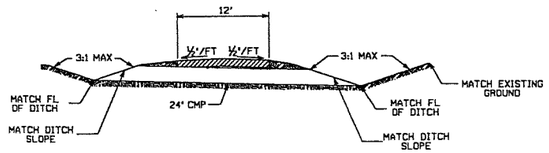


6 LEACHATE CLEAN-OUT DETAIL
SCALE: ¼"= 1'

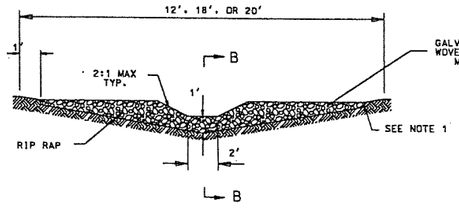


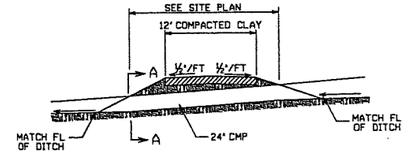
7 TEMPORARY COVER
SCALE: ¼"= 1'

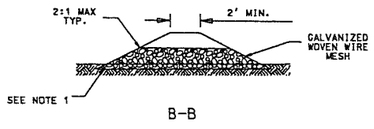
LEACHATE COLLECTION SYSTEM DETAILS



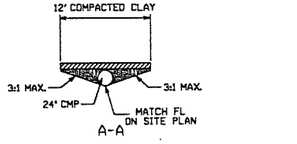
8 CULVERT DETAIL
SCALE: ⅛"= 1'







10 VELOCITY REDUCER DEVICE DETAIL
SCALE: ½"= 1'

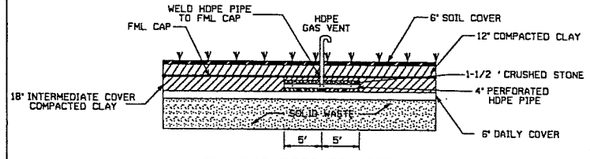


9 CROSSOVER DETAIL
SCALE: ⅛"= 1'

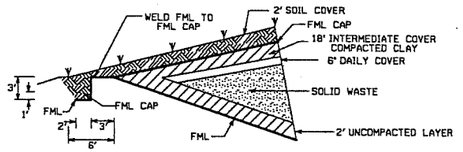
GENERAL NOTES:

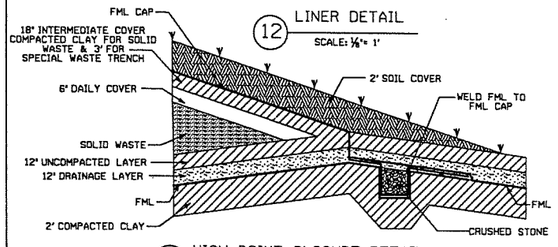
1. VELOCITY CONTROL DEVICE SHOULD BE EMBEDDED A MINIMUM OF 6" INTO EXISTING GROUND.
2. VELOCITY CONTROL DEVICE SHALL BE SECURED WITH 20 GAUGE GAL. WOVEN WIRE MESH WITH 1" DIA. HEX. OPENINGS. THE MESH SHALL BE FOLDED AT THE UPSTREAM SIDE OVER THE AGGREGATE AND TIGHTLY SECURED TO ITSELF ON THE DOWNSTREAM SIDE USING WIRE TIES OR HOG RINGS.

HYDRAULICS DETAILS



11 GAS RECOVERY DETAIL
SCALE: ⅛"= 1'

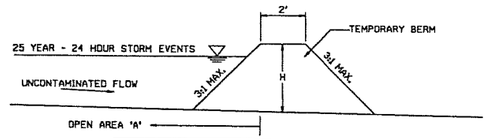




12 LINER DETAIL
SCALE: ⅛"= 1'

13 HIGH POINT CLOSURE DETAIL
SCALE: ¼"= 1'

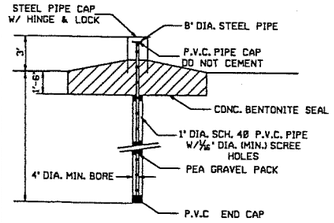
LINER SYSTEM DETAILS



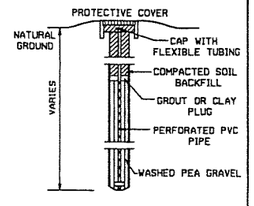
OPEN AREA 'A' (ACRES)	BERM HIEGHT 'H' (FT)
1 OR LESS	2
3 OR LESS	3
5 OR LESS	4
7 OR LESS	5

NOTE:
TEMPORARY BERMS ARE NOT TO BE USED TO CONTROL CONTAMINATED WATER, BUT ONLY UNCONTAMINATED WATER.

14 TEMPORARY BERM DETAIL
NOT TO SCALE



PROPOSED GAS MONITORING WELL



GAS MONITORING PROBE

THOMPSON ENGINEERING
H. Platt Thompson Engineering Company, Inc.
Consulting Engineers – Surveyors – Environmental Scientists
5445 Longfield Rd. – Houston, Texas 77026 – (713) 652-6250

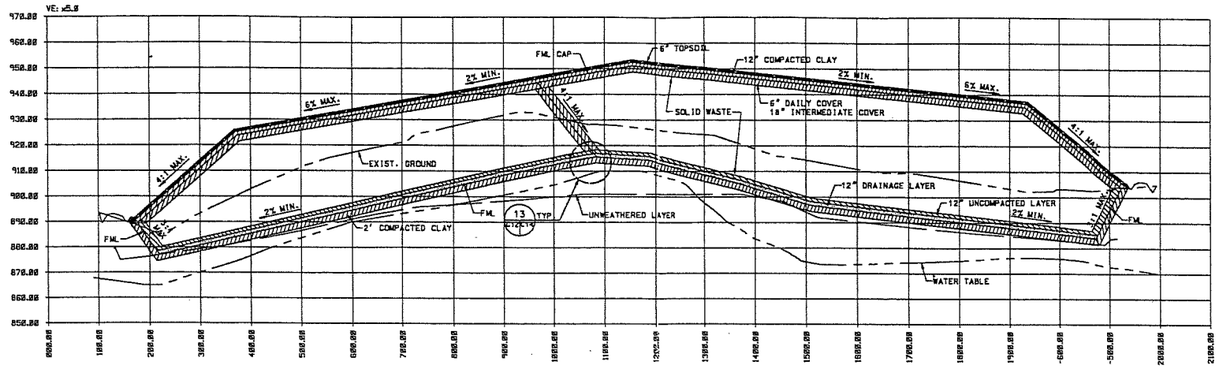
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS

FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

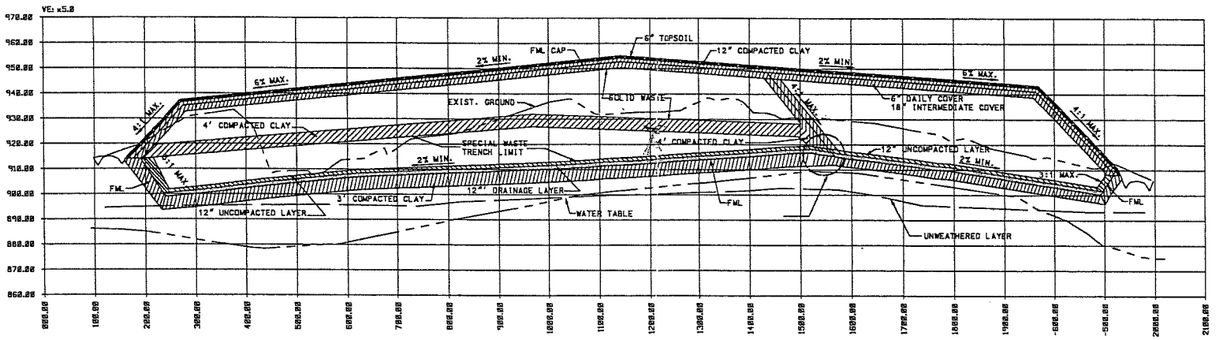
MISCELLANEOUS DETAILS

DESIGNED BY:	SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION
SSA					
DRAWN BY: RLN/SSA					
REVIEWED BY:	SUBMITTED BY: FORT HOOD				SOL. NO. DATED: 09-23-94
					CONTR. NO. SEQUENCE NO.

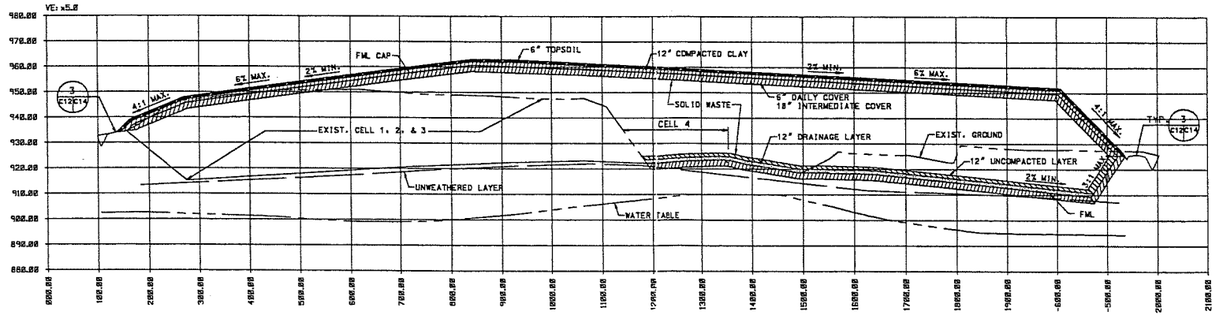
JAMES F. THOMPSON 64555 REGISTERED PROFESSIONAL ENGINEER STATE OF TEXAS
8/22/94



16 PHASE II CROSS SECTION
AREA 3



15 PHASE I CROSS SECTION
AREA 2



14 PHASE I CROSS SECTION
AREA 1

LEGEND

- FML FLEXIBLE MEMBRANE LINER
- TOPSOIL
- COMPACTED CLAY
- UNCOMPACTED LAYER
- SAND

SCALE: 1" = 300' H., 1" = 3' V.

THOMPSON ENGINEERING
N. Platt Thompson Engineering Company, Inc.
Consulting Engineers - Surveyors - Environmental Scientists
5245 Langfield Rd. - Houston, Texas 77040 - (713) 462-6556

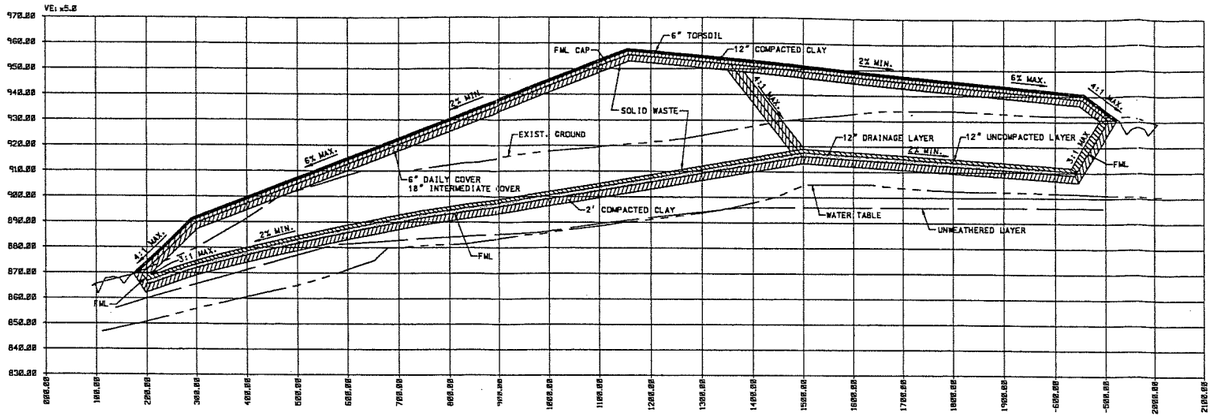
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

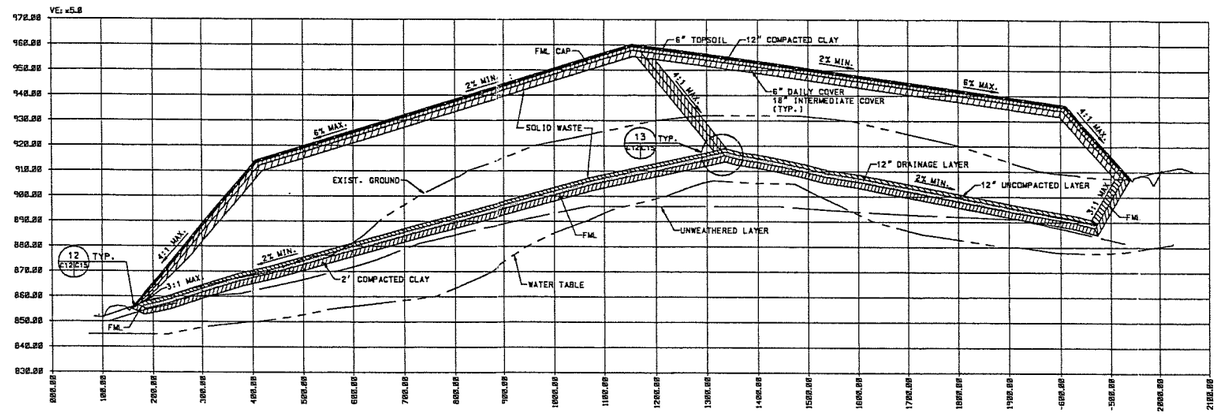
LANDFILL CROSS SECTIONS

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER
9/22/94

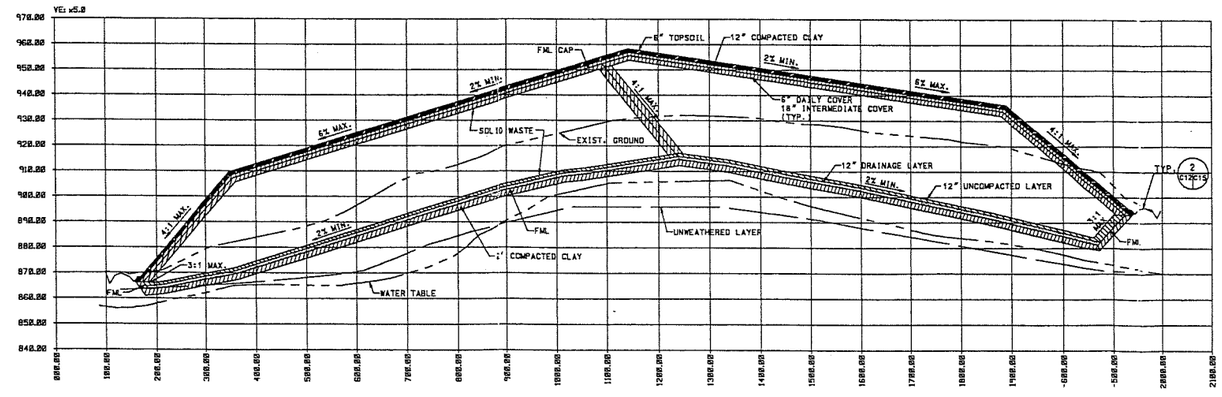
DESIGNED BY: SSA				
DRAWN BY: RLN/SSA	SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION
REVIEWED BY: JFT	SUBMITTED BY: FORT HOOD			SOL. NO.	DATED: 09-23-94
				CONTR. NO.	SEQUENCE NO.
				DRAWING NUMBER	SHEET NO. 14 OF 40



19 PHASE III CROSS SECTION
AREA 6



18 PHASE III CROSS SECTION
AREA 5



17 PHASE II CROSS SECTION
AREA 4

LEGEND

FML	FLEXIBLE MEMBRANE LINER
	TOPSOIL
	COMPACTED CLAY
	UNCOMPACTED LAYER
	SAND

SCALE: 1" = 300' H., 1" = 3' V.

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER
9/22/94

THOMPSON ENGINEERING
N. Platt Thompson Engineering Company, Inc.
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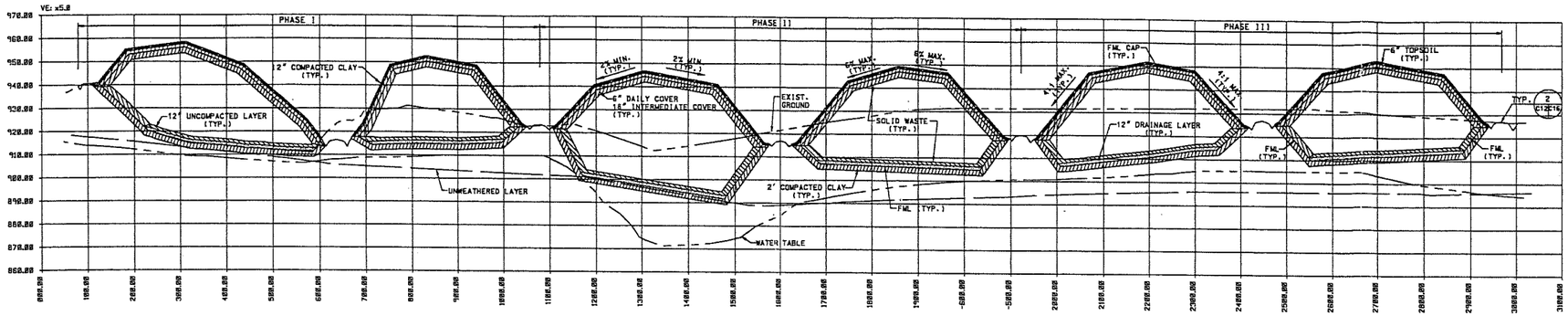
5849 Langfield Rd. – Houston, Texas 77092 – (713) 462-4256

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

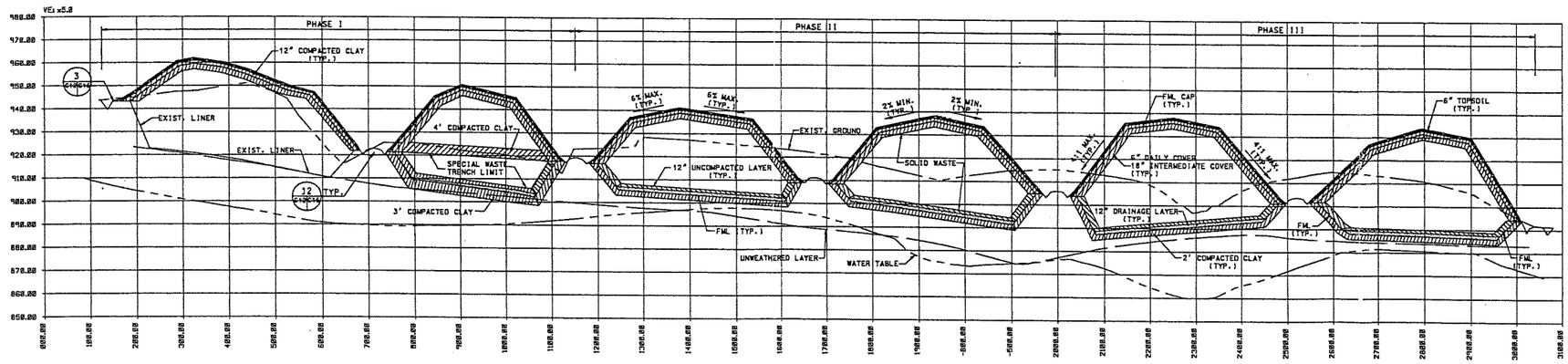
FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

LANDFILL CROSS SECTIONS

DESIGNED BY: SSA					
DRAWN BY: RLN/SSA	SYM	D.O. NO.	ACTION	DATE	DESCRIPTION OF REVISION
REVIEWED BY: JFT	SUBMITTED BY: FORT HOOD				
	SOL. NO.		DATED: 09-23-94		
	CONTR. NO.		SEQUENCE NO.		
	DRAWING NUMBER	SHEET NO. 15 OF 16	C14		



21 PHASE I, II, & III CROSS SECTIONS



20 PHASE I, II, & III CROSS SECTIONS

LEGEND

FML	FLEXIBLE MEMBRANE LINER
	TOPSOIL
	COMPACTED CLAY
	UNCOMPACTED LAYER
	SAND

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER
9/22/94

SCALE: 1" = 300' H., 1" = 3' V.

THOMPSON ENGINEERING
K. Platt Thompson Engineering Company, Inc.
Consulting Engineers - Surveyors - Environmental Scientists
5249 Longfield Rd. - Houston, Texas 77040 - (713) 462-4858

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

FORT HOOD
CORYELL COUNTY, TEXAS
PERMIT NO. 1866

LANDFILL CROSS SECTIONS

DESIGNED BY:	SSA
DRAWN BY:	RLN/SSA
REVIEWED BY:	JFT
SUBMITTED BY:	FORT HOOD
SYM	D.C. NO.	ACTION	DATE	DESCRIPTION OF REVISION
SOL. NO.	DATED: 09-23-94
CONTR. NO.	SEQUENCE NO.
DRAWING NUMBER	SHEET NO.

NAME: Fort Hood Landfill
PROJECT: Permit No. 1866
SUBJECT: Calculations

THOMPSON ENGINEERING
H. Platt Thompson Engineering Company, Inc.
Consulting Engineers • Surveyors • Environmental Scientists
5249 Langfield Rd. • Houston, TX 77040
(713) 462-6250 • Fax (713) 462-6550

CHECKED: SSA
DATE: 4/8/94
JOB NO.: 867-01.03
SHEET 1 OF 1 SHEETS

Solid Waste Placement:

Density = 700 lbs./cu.yd. = 0.35 tons/cu.yd.

Solid Waste Disposal Rates:

Present = 5,800.62 tons/month

Landfill Operations based on 305 days/yr.

Daily Landfill Area:

69,607.43 tons/yr. x 1 yr./305 days x

1 cu.yd/0.35 tons = 652 cu.yd./day

Total Volume available

4,548,616.60 cu.yds. x 4:1 Ratio Solid Waste to Daily Cover = 1,137,154.15 cu.yds. of Daily Cover

$$\frac{3,411,462.45 \text{ cu.yds. of solid waste}}{198,878 \text{ cu.yds./yr.}} = 17 \text{ yrs.}$$

Total Life of facility = 17 yrs.

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER

AUG 0 4 1994

HVJ ASSOCIATES, INC.

Project Fort Hood Landfill Project No. 94-1896

Subject Slope Stability Analyses Made by MOHAMAD KAYYAL Date 7/30/94

Slope stability analysis is made with the following Assumptions:

1. Clay shale will behave as a fractional material after weathering.
   The residual frictional angle is 16°
2. Seepage does not occur during life of waste site.
3. Maximum inclination angle for a sloped sidewall = 13.5 deg. (0.24 %).

Based on these assumptions; factor of safety (F.S.) is computed as.

$$F.S. = \frac{\tan(\text{residual friction angle})}{\tan(\text{slope angle})}$$

So based on maximum slope angle of 13.5° the minimum F.S. at this site is.

$$\text{Minimum F.S.} = \frac{\tan(16)}{\tan(13.5)} = \underline{1.2}$$

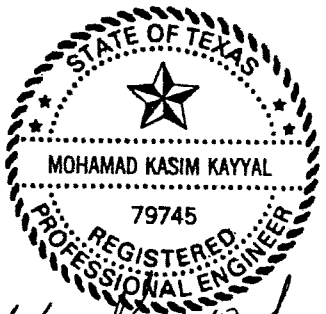
Any other slope angle with smaller inclination will have a larger factor of safety.

A factor of safety of 1.2 is considered satisfactory for the long term stability of a waste disposal site.

STATE OF TEXAS
MOHAMAD KASIM KAYYAL
79745
REGISTERED PROFESSIONAL ENGINEER
7/30/94

Sheet of

RESULTS OF SLOPE STABILITY COMPUTATIONS - FT. HOOD LANDFILL	
Slope Inclination (tanB)	Factor of Safety (F.S.)
0.06	4.8
0.14	2.0
0.17	1.7
0.13	2.2
0.17	1.7
0.16	1.8
0.08	3.6
0.13	2.2
0.19	1.5
0.16	1.8
0.17	1.7
0.14	2.0
0.24	1.2



7/30/94

NAME: James F. Thompson

PROJECT: Ft Hood Landfill

SUBJECT: Pipe Stress

THOMPSON ENGINEERING
H. Platt Thompson Engineering Company, Inc.
Consulting Engineers • Surveyors • Environmental Scientists
5249 Langfield Rd. • Houston, TX 77040
(713) 462-6250 • Fax (713) 462-6550

CHECKED: _____

DATE: 7/20/94

JOB NO.: 867-01.03

SHEET 1 OF 2 SHEETS

Strength Analysis of Leachate pipe

Wall Crushing:

$$\sigma_{ic} = \gamma_p D_p + C_s \frac{P (F_{ic})}{L_{ic} (B_c)}$$

8-inch & 6-inch.

$$\sigma_{ic} = 110 \frac{lb}{ft^3} (3 ft) + 0.079 \frac{16{,}000 lb (1.5)}{3 ft (0.76 ft)}$$

$$= 1{,}232.86 psf$$

$$= 8.56 psi$$

$\sigma_{ic\,allow}$ = hoop tensile stress, conservatively

= 4,000 psi

Note the difference in pipe size (6-8 inch) has little impact. Also, the depth of cover does not become relevant given the Allowable vs. actual stress.

Check of Overburden of final waste levels.

$$\sigma_{ic} = 125 \frac{lb}{ft^3} (50 ft.)$$

└ Conservatively assume saturated conditions

σ_{ic} = 6,250 psf

= 43.40 psi

∴ Failure Check due to Wall Crushing is OK.

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER

7/20/94

NAME: James F. Thompson

PROJECT: Ft. Hood Landfill

SUBJECT: Pipe Stress

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CHECKED: _____

DATE: 7/20/94

JOB NO.: 867-01.03

SHEET 2 OF 2 SHEETS

Pipe Buckling:

Critical stress occurs by post closure overburden.

$$FS_{WB} = \frac{1.2}{\sigma_{MAX}} \times \frac{E' E}{SDR^3}^{.5}$$

$$= \frac{1.2}{43.40 psi} \times \frac{3,000 psi \, (500,000 psi)^{.5}}{35^3}$$

$$= 1.37$$

∴ Failure Check due to Pipe Buckling is OK

Ring Deflection:

$$FS_{RD} = \frac{dr\, E'}{100\, \sigma_{MAX}}$$

$$= \frac{5\,(3,000 psi)}{100\,(43.40 psi)}$$

$$= 3.46$$

∴ Failure check due to Pipe Deflection is OK

STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER

7/20/94

NAME: James F Thompson

PROJECT: Ft Hood Landfill

SUBJECT: Pipe Stress

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CHECKED:

DATE: 7/20/94

JOB NO.: 867-01.03

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STATE OF TEXAS
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7/20/94

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DATE: 7/20/94

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STATE OF TEXAS
JAMES F. THOMPSON
64555
REGISTERED PROFESSIONAL ENGINEER

7/20/94

NAME: James F Thompson

PROJECT: Ft. Hood Landfill

SUBJECT: Pipe Stress

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5249 Langfield Rd. • Houston, TX 77040
(713) 462-6250 • Fax (713) 462-6550

CHECKED: _____

DATE: 7/20/94

JOB NO.: 867-01.03

SHEET 2 OF 2 SHEETS

Pipe Buckling:

Critical stress occurs by post closure overburden.

$$FS_{WB} = \frac{1.2}{\sigma_{MAX}} \times \frac{E' E^{.5}}{5DR^3}$$

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STATE OF TEXAS
JAMES F. THOMPSON
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7/20/94

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PROJECT: Ft Hood Landfill

SUBJECT: Pipe Stress

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DATE: 7/20/94

JOB NO.: 867-01.03

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STATE OF TEXAS
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64555
PROFESSIONAL REGISTERED ENGINEER

7/20/94

NAME: James F Thompson

PROJECT: Ft. Hood Landfill

SUBJECT: Pipe Stress

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H. Platt Thompson Engineering Company, Inc.
Consulting Engineers • Surveyors • Environmental Scientists
5249 Langfield Rd. • Houston, TX 77040
(713) 462-6250 • Fax (713) 462-6550

CHECKED: _____

DATE: 1/20/94

JOB NO.: 867-01.03

SHEET 2 OF 2 SHEETS

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STATE OF TEXAS
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1/20/94

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SUBJECT: Pipe Stress

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Consulting Engineers • Surveyors • Environmental Scientists
5249 Langfield Rd. • Houston, TX 77040
(713) 462-6250 • Fax (713) 462-6550

CHECKED: _____

DATE: 7/20/94

JOB NO.: 867-01.C3

SHEET 1 OF 2 SHEETS

Strength Analysis of Leachate pipe

Wall Crushing:

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STATE OF TEXAS
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64555
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7/20/94

NAME: James F. Thompson

PROJECT: Ft. Hood Landfill

SUBJECT: Pipe Stress

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CHECKED: _____

DATE: 7/20/94

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SHEET 2 OF 2 SHEETS

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STATE OF TEXAS
JAMES F. THOMPSON
64555
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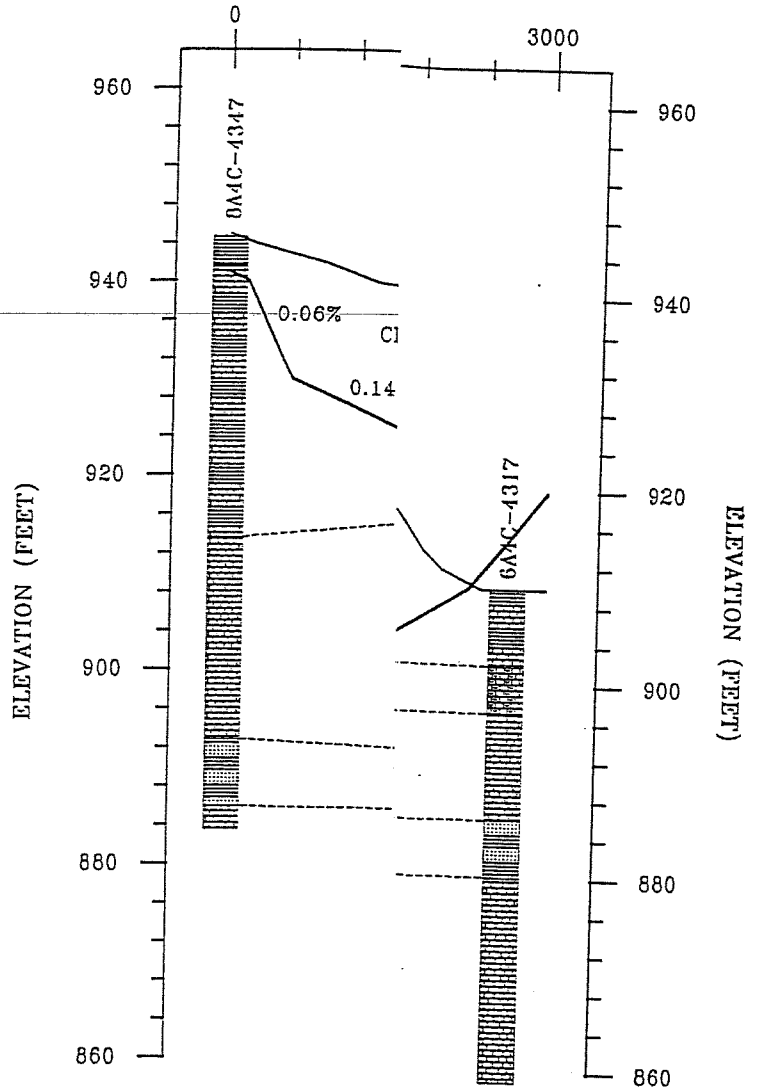
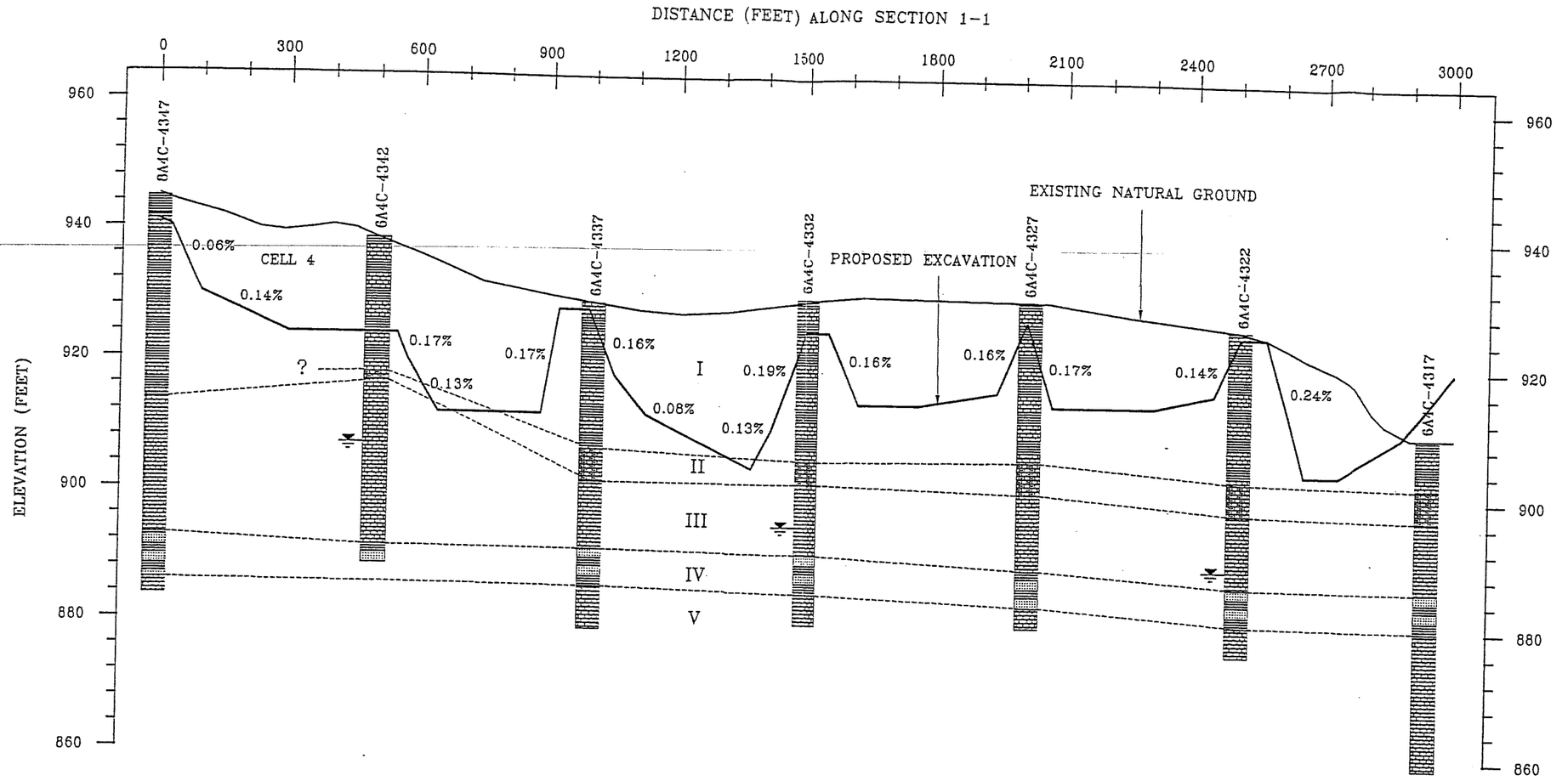
7/20/94



Stratum No. and Soil Description:

I Clay Shale/Limestone, badly to moderately weathered, hard, overlain by 0.5 to 1' thick medium to high plastic calcareous, sandy to silty clay, with limestone fragment
II Limestone, slightly weathered, soft to moderately hard
III Limestone, unweathered, fossiliferous
IV Clay Shale/Sand-Sand Stone, unweathered, slightly carb
V Limestone, unweathered

HVJ ASSOCIATES, INC. GEOTECHNICAL ENGINEERS		
HORIZONTAL SCALE: 1"=300'	APPROVED BY:	PREPARED BY:
VERTICAL SCALE 1"=20'	MH	JM
GENERALIZED SOIL PROFILE PROPOSED EXCAVATION FORT HOOD, TEXAS		
PROJECT NO. 94-189G	DRAWING NUMBER: PLATE 1	



Stratum No. and Soil Description:

I Clay Shale/Limestone, badly to moderately weathered, soft to hard, overlain by 0.5 to 1' thick medium to high plasticity calcareous, sandy to silty clay, with limestone fragments
II Limestone, slightly weathered, soft to moderately hard
III Limestone, unweathered, fossiliferrous
IV Clay Shale/Sand-Sand Stone, unweathered, slightly carbonaceous
V Limestone, unweathered

STATE OF TEXAS
MOHAMAD KASIM KAYYAL
79745
REGISTERED
PROFESSIONAL ENGINEER

7/30/94

HVJ ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS

HORIZONTAL SCALE: 1"=300'	APPROVED BY:	PREPARED BY:
VERTICAL SCALE 1"=20'	MH	JM

GENERALIZED SOIL PROFILE
PROPOSED EXCAVATION
FORT HOOD, TEXAS

PROJECT NO.	DRAWING NUMBER:
94-189G	PLATE 1