Prepared for

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Lower Colorado River Authority (LCRA)
P.O. Box 220
Austin, Texas 78767

RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN FOR COMBUSTION BYPRODUCT LANDFILL REGISTRATION NO. 31575

LCRA FAYETTE POWER PROJECT
FAYETTE COUNTY, TEXAS

Beth Ann Gross

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

8/11/2021

GEOSYNTEC CONSULTANTS, INC.
TX ENG FIRM REGISTRATION NO. F-1182

Prepared by

Geosyntec consultants
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July 2021

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Beth Ann Gross

8/11/2021

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1. INTRODUCTION

1.1 Purpose

This document presents the Run-on and Run-off Control System Plan (Plan) for the Combustion Byproduct Landfill (CBL) at LCRA's Fayette Power Project (FPP). In April 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR). The Texas Commission on Environmental Quality (TCEQ) has published their final CCR rule on May 22, 2020 and the final approval by EPA of the Texas CCR Permit Program is effective July 28, 2021. The initial Plan was prepared by Geosyntec Consultants (Geosyntec) in August 2016 and has been reviewed and revised under the direction of Dr. Beth A. Gross, P.E., a qualified professional engineer, to comply with the USEPA's requirements for run-on and run-off control systems plans (40 CFR §257.81(c)) for CCR landfills, the Texas Commission on Environmental Quality's new run-off and run-on requirements for CCR waste management (30 TAC §352.821), and TCEQ guidance (TCEQ, 2020). The owner/operator of a CCR landfill must update the Plan every five years.

1.2 Background

The FPP is a coal-fired power plant located east of La Grange in Fayette County, Texas. CCR generated at the facility are disposed in the CBL, a CCR landfill located south of the power plant and north of the railroad that borders the FPP site (Drawing 1). At final buildout, the CBL will consist of up to three cells, Cells 1 to 3 (Drawing 2). Depending on the rates of CCR production and beneficial use, all cells may not be needed for CCR disposal and the final CBL footprint would be smaller (e.g., Cells 1 and 2, Drawing 3).

Cell 1 was constructed in 1988 with a recompacted clay liner installed over natural clay subgrade. This liner is equivalent to the liner recommended at that time in Texas Water Commission (TWC) Guideline No. 3 for Class II industrial waste landfills: a 2-foot thick (minimum) recompacted clay-rich liner or 3 feet of in-place soil exhibiting a permeability less than 1×10^{-7} cm/s (TWC, 1988). The northern slope of Cell 1 was closed with a final cover system in 1992 (Drawing 2).

From October 2014 to May 2015, Subcell 2D was constructed with a 3-foot thick compacted clay liner with a hydraulic conductivity less than 1×10^{-7} cm/s, which meets the recommendations of TCEQ Technical Guideline No. 3 (2015) for Class 2 monofills of consistent, well characterized waste. This subcell currently includes a contact water retention pond (herein referred to as the Subcell 2D Contact Water Retention Pond) lined with a geomembrane/compacted clay composite liner (Drawing 2). Subcell 2D is being used as a waste storage/product preparation area during CCR operations in Cell 1 and future Subcells 2A, 2B and 2C. Cell 1 and Subcell 2D are existing CCR landfill areas under 40 CFR §257.53. The remainder of Cells 2 and 3 will be constructed with a liner system that meets the requirements of 40 CFR §257.70(b) and (d), which includes a leachate collection system and underlying geomembrane/compacted clay composite liner.

Runoff from active areas in Cell 1 of the CBL currently drains to the Runoff Retention Pond via the runoff channel (Drawing 2). Contact water from the Subcell 2D Contact Water Retention Pond is managed through a permanent pumping system which routes flow to the runoff channel. The Runoff Retention Pond is permitted under LCRA's Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0002105000 and is designated as the "CBL Pond" in the permit. The permit allows water in the pond to be managed by conveying it to the FPP Reclaim Pond or, if effluent limitations are met, by discharging via Outfall 004. The Runoff Retention Pond will be used for management of contact water from the active area until the Leachate Evaporation Pond (Drawing 4) is constructed, which will occur prior to disposal of CCR in Subcell 2A (Drawing 4).

Stormwater run-off from the final cover system of the CBL flows into drainage channels along the perimeter of the CBL that primarily discharge south of the CBL but also discharge to a drainage ditch north of the CBL. When CCR disposal operations are initiated in Cell 2, the majority of stormwater run-off from the final cover system will flow into a stormwater pond prior to being discharged from the site (Drawing 4).

1.3 Organization of Plan

The remainder of this Plan is organized as follows:

- Section 2 summarizes the regulatory requirements for the run-on and run-off controls systems and the Plan (40 CFR §257.81 and 30 TAC §352.821);
- Section 3 describes how the run-on control system for the CBL has been designed and constructed to prevent flow onto the active portion of the CBL;
- Section 4 describes how the run-off control system for the CBL has been designed and constructed to collect and control flow from the active portion of the CBL;
- Section 5 presents a certification by a qualified professional engineer that this initial Run-on and Run-off Control System Plan meets the requirements of 40 CFR §257.81(a) and (b) and 30 TAC §352.821; and
- Section 6 provides a list of references cited in the Plan.

2. REGULATORY REQUIREMENTS

2.1 Run-on and Run-off Controls

In accordance with 40 CFR §257.81(a) and 30 TAC §352.821, the run-on and run-off control systems for the CBL must be designed, constructed, operated, and maintained to prevent flow onto the active portion of the CBL and collect and control flow from the active portion of the CBL during the peak discharge from a 25-year, 24-hour storm event. As discussed in Section 4.3 and demonstrated in the calculations presented in Appendix A, the run-on and run-off features for the CBL were designed to convey a 100-year, 24-hour storm event. Therefore, the design of these features meets and exceeds the design requirements of 40 CFR §257.81(a) and 30 TAC §352.821.

As described in the rule preamble, the purpose of the run-on controls is to prevent erosion, prevent the surface discharge of CCR in solution or suspension, and minimize the percolation of run-on through wastes. The purpose of the run-off controls is to collect and control the water volume falling on the active portion of the landfill. Run-off from the active portion must be handled in manner that complies with the National Pollutant Discharge Elimination System (40 CFR §257.81(b)). Although the term "active portion" has often been used to refer to a portion of a landfill that is actively receiving waste, under USEPA's CCR regulations "active portion" is that part of a CCR unit that has received or is receiving waste and has not completed closure (40 CFR §257.53). Thus, the active portion includes areas where waste is being disposed and inactive areas, including areas overlain with intermediate cover.

2.2 Preparation of Plan

In accordance with 40 CFR §257.81(c), a Run-on and Run-off Control System Plan that documents how the run-on and run-off control systems have been designed and constructed to meet the requirements of 40 CFR §257.81(a) and (b) must be prepared and placed in the facility's Operating Record. The Plan must be supported by engineering calculations, and a certification from a qualified professional engineer must be obtained to document that the Plan meets the requirements of 40 CFR §257.81(a) and (b).

As described in the rule preamble, submittal of the Plan documents that run-on and run-off control systems have been designed and operated to meet 40 CFR §257.81(a) and (b), and the requirement of 40 CFR §257.81(c)(4) that the Plan be revised every five years is consistent with the requirement that run-on and run-off control systems also be operated and maintained to meet 40 CFR §257.81(a) and (b).

2.3 Amendment of Plan

In accordance with 40 CFR §257.81(c)(2), this Plan may be amended at any time provided the revised Plan is placed in the facility's Operating Record. This Plan must be revised whenever there is a change in conditions that would substantially affect the Plan in effect. Any amendment of the

Plan requires a certification by a qualified professional engineer that the revised Plan meets the requirements of 40 CFR §257.81(a) and (b).

3. RUN-ON CONTROL SYSTEM

3.1 Overview

This section describes the run-on control system for the CBL as it currently exists (i.e., active conditions) and at final grades (i.e., final conditions). In general, run-on to active areas of the CBL is controlled by topography and by the landfill perimeter berm. The north side of the CBL is on a topographic high, and the ground surface around the CBL primarily slopes to the south, and south of the CBL also towards two the central stormwater channels (Drawing 2). In addition, the perimeter berm for the CBL deflects stormwater run-on, and this potential run-on is collected in a stormwater channel at the toe of the outboard side slope of the berm (Drawings 2 and 6).

3.2 Initial Run-On Control System Plan

Cell 1 is the current active cell for the CBL, and the northern portion of this cell has been covered with final cover. The final cover slopes towards the perimeter; thus, based on topography, stormwater from the final cover of the CBL will not run-on to active areas of Cell 1 (Drawing 2). Furthermore, potential run-on from outside of Cell 1 will not overtop the existing perimeter berm and enter Cell 1 along the east and west sides of the cell or overtop the interim berm on the south side of Cell 1. Subcell 2D is also protected from run-on by topography and a perimeter berm (Drawing 2).

As new subcells are developed, run-on will continue to be controlled by perimeter and interim berms and adjacent stormwater channels located at the outboard toe of the berms. Stormwater collected in these channels will be conveyed to the two central stormwater channels located south of the CBL or to a stormwater pond (Drawing 4). In addition, run-on from inactive waste slopes that have received soil intermediate cover will be directed from subcells actively receiving CCR by temporary tack-on berms (Drawing 5).

3.3 Final Run-On Control System Plan

At final conditions, the CBL will be closed with final cover and will no longer be active. Run-on to the closed CBL will continue to be controlled by topography and the landfill perimeter berm and adjacent stormwater channel.

3.4 Compliance Assessment

Based on review of the topography of the ground surface around the CBL perimeter and the engineering controls designed for the CBL (e.g., perimeter berm and stormwater channel, temporary tack-on berms), the CBL will continue to be designed, constructed, operated, and maintained to prevent flow onto the active portion of the CBL. Therefore, the CBL is in compliance with the run-on control requirement of 40 CFR §257.81(a) and 30 TAC §352.821.

4. RUN-OFF CONTROL SYSTEM

4.1 Overview

This section describes the run-off control system for the CBL active conditions and final conditions. In general, run-off from the CBL is controlled by topography, the landfill perimeter berm and stormwater channel, and the stormwater management system components that will be constructed on the CBL as it is developed (Drawings 2, 5, and 6).

4.2 Initial Run-Off Control System Plan

Run-off from areas of Cell 1 that have not been covered with intermediate cover or final cover could have potentially come in contact with CCR and is, therefore, managed as contact water. Contact water collected in the cell is conveyed in the runoff channel to the Runoff Retention Pond (Drawing 2), as authorized under an individual TPDES permit (WQ0002105000). The perimeter and interim berms of Cell 1, as well as the underlying recompacted clay liner, keep run-off that has contacted CCR within the CBL. In addition, CCR is placed in Cell 1 in a manner that directs this runoff to the runoff channel. As Cell 1 is filled, the side slopes of the cell will be covered with intermediate or final cover (Drawing 5). Until a soil cover is placed, run-off from the CCR slopes will be collected and directed to the runoff channel. Run-off from areas of the CBL with intermediate or final cover has not contacted CCR and can be directed into a stormwater channel and conveyed away from the CBL rather than being conveyed to the Runoff Retention Pond.

Contact water from the Subcell 2D Contact Water Retention Pond is managed through a permanent pumping system which routes water collected in the pond to the runoff channel.

The Runoff Retention Pond is used for management of contact water from the active area. Water levels are currently managed at the Runoff Retention Pond by conveying flow through an underground HDPE pipe to the concrete storm drainage system leading to the FPP Reclaim Pond as appropriate or, if effluent limitations are met, by discharging via Outfall 004. Facility personnel monitor the Subcell 2D Contact Water Retention Pond, Runoff Retention Pond, and the FPP Reclaim Pond to maintain the surface water balance of the overall facility. The weather forecast is monitored to track anticipated storm events and manage the pumping schedules accordingly. Current operational procedures regarding the CBL pumping management system are described in further detail in Appendix C.

As new subcells are developed, run-off of contact water will continue to be controlled by perimeter and interim berms and the internal topography of the CBL, and the existing Runoff Retention Pond will be converted into a Leachate Evaporation Pond (Drawing 4). Areas will implement final cover and the permanent stormwater management system as they reach final grade (Drawing 5).

4.3 Final Run-Off Control System Plan

After the final cover has been constructed on the CBL, storm water run-off from the surface of the landfill will be conveyed off the landfill through a series of components, including drainage benches orientated approximately parallel to the final cover system side slopes and drainage downchutes that intersect the drainage benches and are designed to convey runoff to a perimeter drainage channel and then to one or two Stormwater Ponds (Drawings 4 and 6). As previously discussed in Section 2.1, the stormwater management system components are designed to route stormwater run-off resulting from a 100-year, 24-hour design storm event. The design of the stormwater management system components and associated calculations are presented in Appendix A, and details of these components are shown on Drawings 7 and 8.

The stormwater management features are also designed to control runoff velocities and limit soil loss to permissible values. The soil loss on the final cover system top deck and side slope is calculated in Appendix B using the Revised Universal Soil Loss Equation (RUSLE) and compared to a permissible maximum soil loss of 3 tons/acre/year (0.015 inches/year). Based on this calculation, the maximum spacing between drainage benches was limited to 170 feet. To control erosion in the drainage downchutes, the downchutes will be lined with articulated concrete block (ACB) or an alternative lining material that provides sufficient erosion resistance.

4.4 Compliance Assessment

Based on review of the topography of the ground surface around the CBL perimeter, the engineering controls designed for the CBL (e.g., perimeter berm and stormwater channel, temporary tack-on berms), the operational procedures for the CBL, and the fact that the CBL is operated under a TPDES permit, the CBL will continue to be designed, constructed, operated, and maintained to collect and control flow from the active portion of the CBL and handle run-off in a manner that complies with the National Pollutant Discharge Elimination System. Therefore, the CBL is in compliance with the run-off control requirement of 40 CFR §257.81(a) and the run-off management requirement of 40 CFR §257.81(b).

5. PROFESSIONAL ENGINEER CERTIFICATION

Based on the demonstrations and evaluations presented in this Run-on and Run-off Control System Plan for the Combustion Byproduct Landfill at LCRA's Fayette Power Project, it is my professional opinion that the Plan meets the requirements of 40 CFR §257.81(a) and (b) and 30 TAC §352.811.

GEOSYNTEC CONSULTANTS, INC
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Beth Ann Gross, Ph.D., P.E., D.GE

8/11/2021

Date

6. REFERENCES

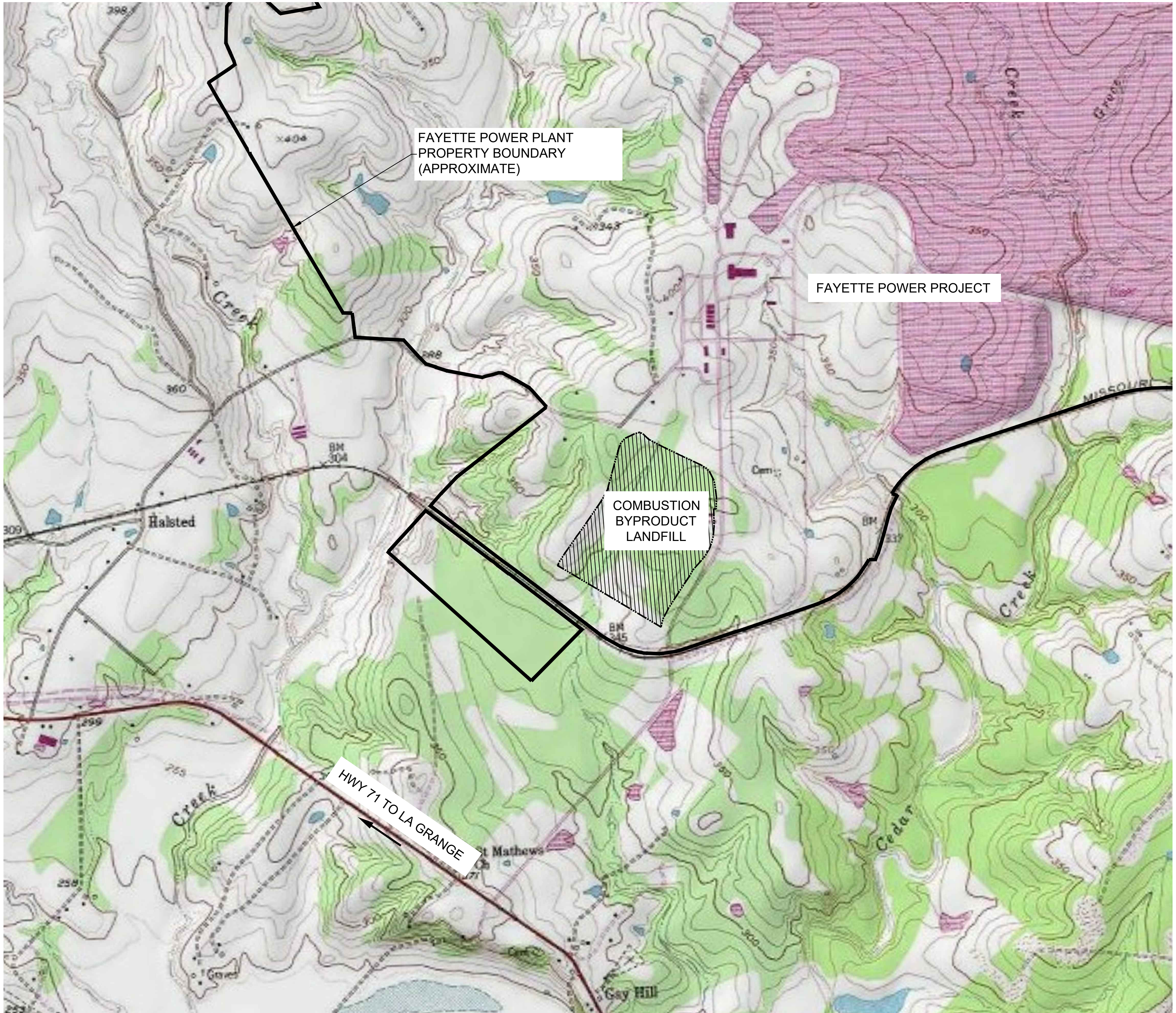
Geosyntec (2016). *Run-on and Run-off Control System Plan for Combustion Byproduct Landfill*. Registration No. 31575. October 2016.

Texas Commission on Environmental Quality (2015). "Nonhazardous Industrial Solid Waste Landfills" Industrial Solid Waste Management, Draft Technical Guideline No. 3.

Texas Commission on Environmental Quality (2020). "Coal Combustion Residuals Landfill" Waste Permits Division, Draft Technical Guideline No. 30. May 2020.

Texas Water Commission (1988). Letter from Minor Brooks Hibbs, Permits Section Chief, Hazardous and Solid Waste Division of TWC to Tom Remaley, Director of Environmental Quality, LCRA, indicating that the design of Cell 1 substantially conforms to the TWC Industrial Solid Waste Technical Guidelines, Jan 18.

DRAWINGS



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NOTE:

BASE MAP SOURCE: UNITED STATES GEOLOGIC SURVEY (USGS), 7.5 MINUTE SERIES QUADRANGLE (TOPOGRAPHIC) MAP OF LA GRANGE EAST, TEXAS 1957, REVISED 1981 AND FAYETTEVILLE, TEXAS 1958, REVISED 1981

0 800 1600
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

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TITLE:
OVERALL SITE PLAN

PROJECT:
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE:
FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

Beth Gross
SIGNATURE
10/13/2016
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

DESIGN BY:	BG	DATE:	OCTOBER 2016
DRAWN BY:	JJV	PROJECT NO.:	TXL0225.04
CHECKED BY:	BG	FILE:	TXL0225CCRR1
REVIEWED BY:	BG	DRAWING NO.:	1 OF 8
APPROVED BY:	BG		

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LEGEND

- 350 — EXISTING GROUND ELEVATION (FT,MSL) (NOTES 1,2)
- (350) — EXISTING TOP OF CLAY LINER ELEVATION (FT,MSL) (NOTE 2)
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING RAILROAD
- EXISTING VEGETATION / TREE
- N 9949000 / E 3428000 — COORDINATE GRID (NOTE 2)
- EXISTING FENCE
- EXISTING LIMIT OF LANDFILL
- EXISTING LIMIT OF FINAL COVER
- P — P — EXISTING POWER POLE AND OVERHEAD POWER LINE
- EXISTING COMBUSTION WASTE FORCE MAIN
- PROPOSED PHASE BOUNDARY
- PROPOSED LIMIT OF WASTE

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 NOVEMBER 2020 BY SKYVEYOR.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.
3. EXISTING COMBUSTION WASTE FORCE MAIN CONVEYS WATER FROM EXISTING RUNOFF RETENTION POND TO RECLAIM POND.

0 140 280
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

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TITLE: EXISTING SITE CONDITIONS

PROJECT: RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE: FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

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Beth Ann Gross
SIGNATURE

8/11/2021
DATE

STATE OF TEXAS
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PROFESSIONAL ENGINEER

DESIGN BY:	BG	DATE:	JULY 2021
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CHECKED BY:	BG	FILE:	TXL0225CCRR2
REVIEWED BY:	BG	DRAWING NO.:	
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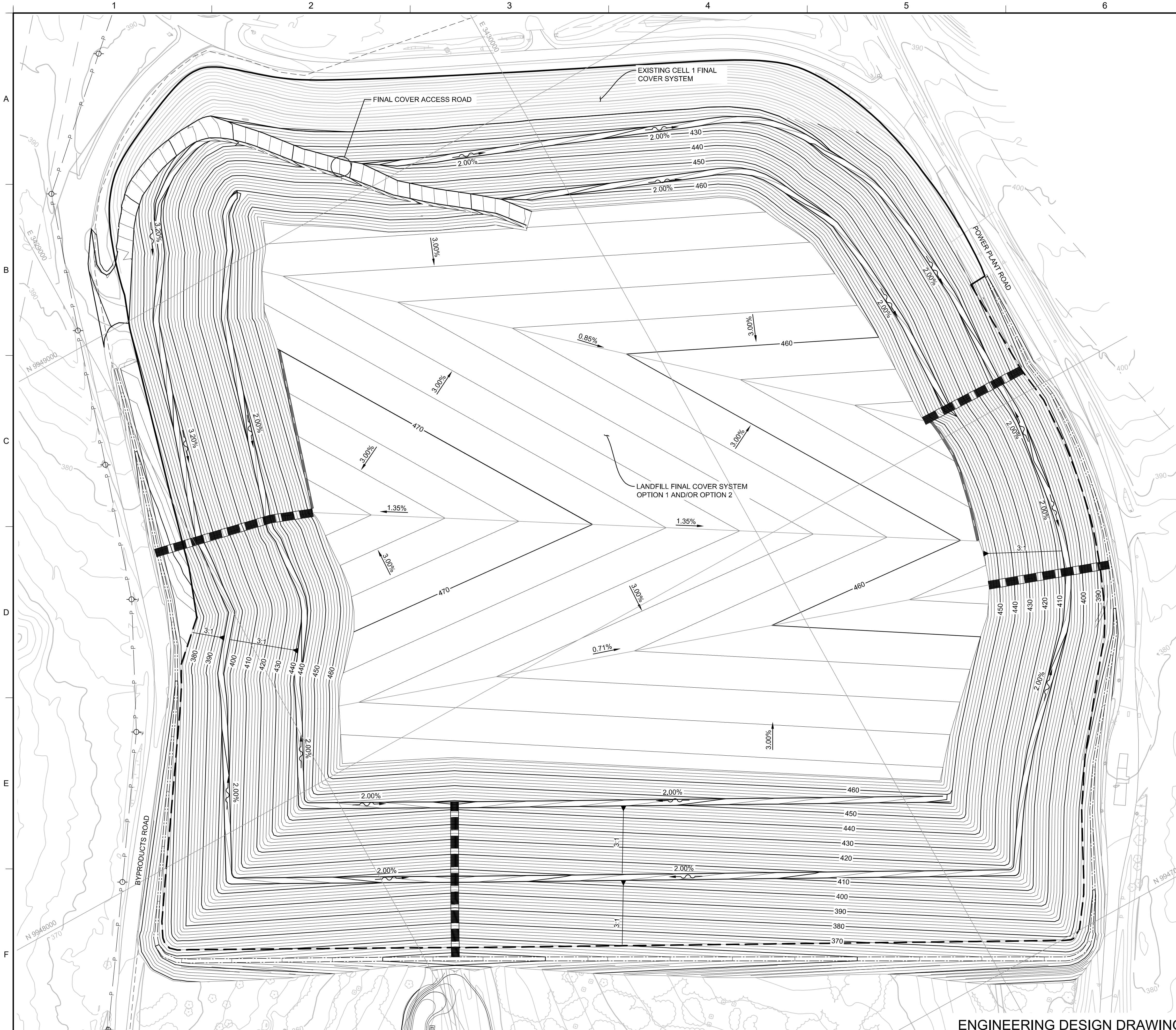
ENGINEERING DESIGN DRAWING



LEGEND

350	EXISTING GROUND ELEVATION (FT,MSL) (NOTES 1,2)
	EXISTING ROAD
	EXISTING VEGETATION / TREE
N 9949000 E 3428000	COORDINATE GRID (NOTE 2)
	EXISTING FENCE
	EXISTING UNDERGROUND RUNOFF DISCHARGE PIPE
	EXISTING LIMIT OF LANDFILL
	PROPOSED LIMIT OF LANDFILL
420	PROPOSED TOP OF FINAL COVER ELEVATION (FT,MSL)
	PROPOSED DRAINAGE DOWNCHUTE
	PROPOSED DRAINAGE TERRACE
	PROPOSED DRAINAGE BENCH
	PROPOSED PERIMETER DRAINAGE CHANNEL

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 OCTOBER 2013 BY SURDEX CORPORATION AND LIDAR DATA PUBLISHED DECEMBER 2008 AND PROVIDED BY LCRA SURVEYING, MAPPING, AND GIS.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.

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SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

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TITLE:
FINAL COVER GRADING PLAN

PROJECT:
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE:
FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

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Beth Gross
SIGNATURE

10.13.2016
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED PROFESSIONAL ENGINEER

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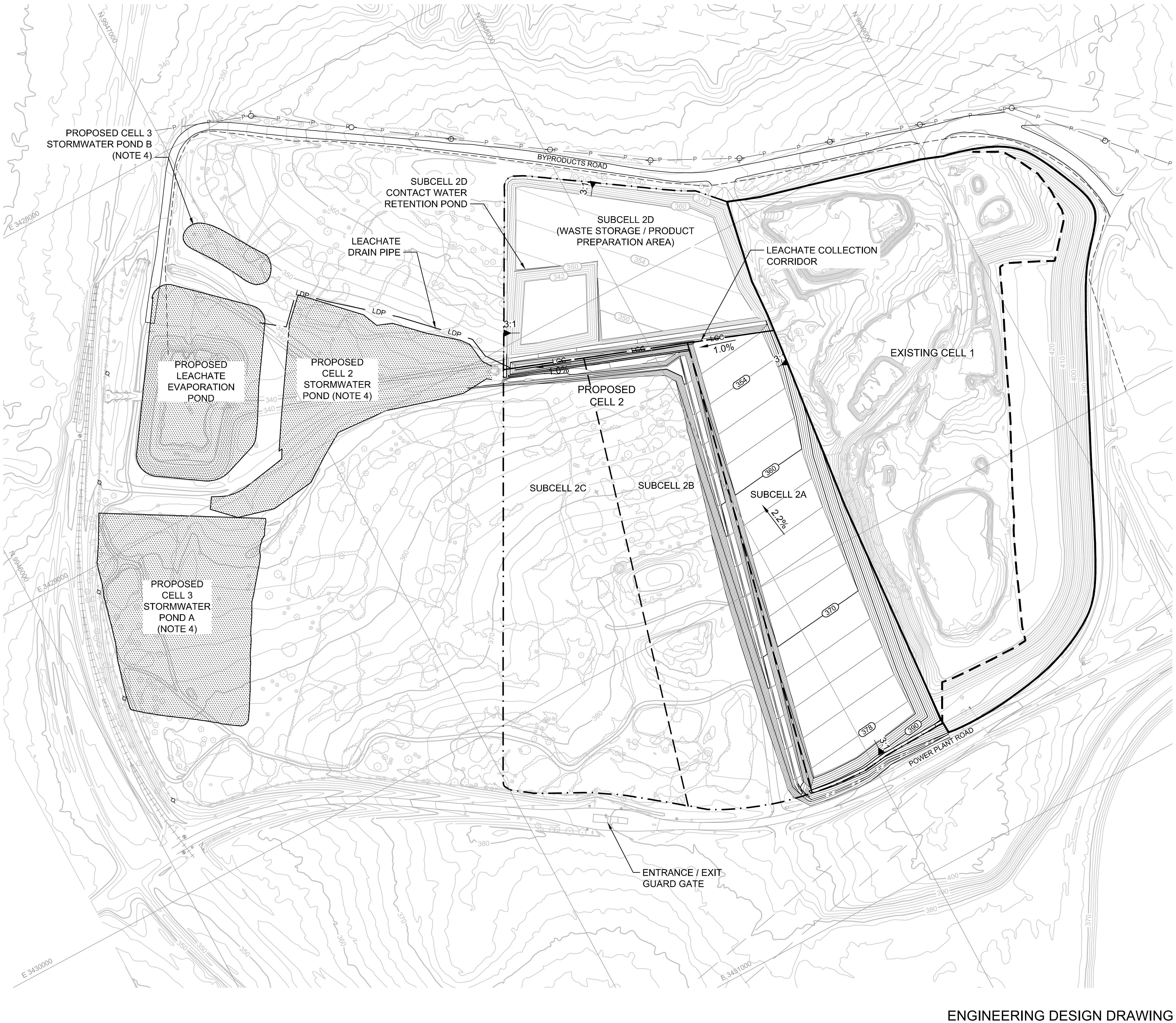
DRAWN BY:	JJV	PROJECT NO.:	TXL0225.04
CHECKED BY:	BG	FILE:	TXL0225CCRR3
REVIEWED BY:	BG	DRAWING NO.:	
APPROVED BY:	BG	3 OF 8	

ENGINEERING DESIGN DRAWING



LEGEND

350	EXISTING GROUND ELEVATION (FT,MSL) (NOTES 1,2)
(350)	EXISTING TOP OF LINER ELEVATION (FT,MSL)
	EXISTING ROAD
	EXISTING RAILROAD
	EXISTING COMBUSTION WASTE FORCE MAIN
P P	EXISTING POWER POLE AND OVERHEAD POWER LINE
	EXISTING VEGETATION / TREE
N 9949000 E 3428000	COORDINATE GRID (NOTE 2)
	EXISTING LIMIT OF LANDFILL
	EXISTING LIMIT OF FINAL COVER
	PROPOSED LIMIT OF WASTE
	PROPOSED PHASE BOUNDARY
(330)	PROPOSED TOP OF LINER ELEVATION (FEET) (NOTE 3)
LCC	PROPOSED LEACHATE COLLECTION CORRIDOR
LDP	PROPOSED LEACHATE DRAIN PIPE

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 OCTOBER 2013 BY SURDEX CORPORATION AND LIDAR DATA PUBLISHED DECEMBER 2008 AND PROVIDED BY LCRA SURVEYING, MAPPING, AND GIS.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.
3. LANDFILL BASE GRADES MAY BE ADJUSTED BASED ON SUBSURFACE CONDITIONS.
4. STORMWATER PONDS TO BE CONSTRUCTED IN SEQUENCE WITH LANDFILL OPERATIONS. CELL 2 STORMWATER POND TO BE DECOMMISSIONED PRIOR TO CELL 3 LANDFILL CONSTRUCTION. CELL 3 STORMWATER POND MAY BE CONSTRUCTED IN LIEU OF CELL 2 STORMWATER POND.

0 150 300
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

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TITLE:
SUBCELLS 2A – 2D BASE GRADING PLAN

PROJECT:
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE:
FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

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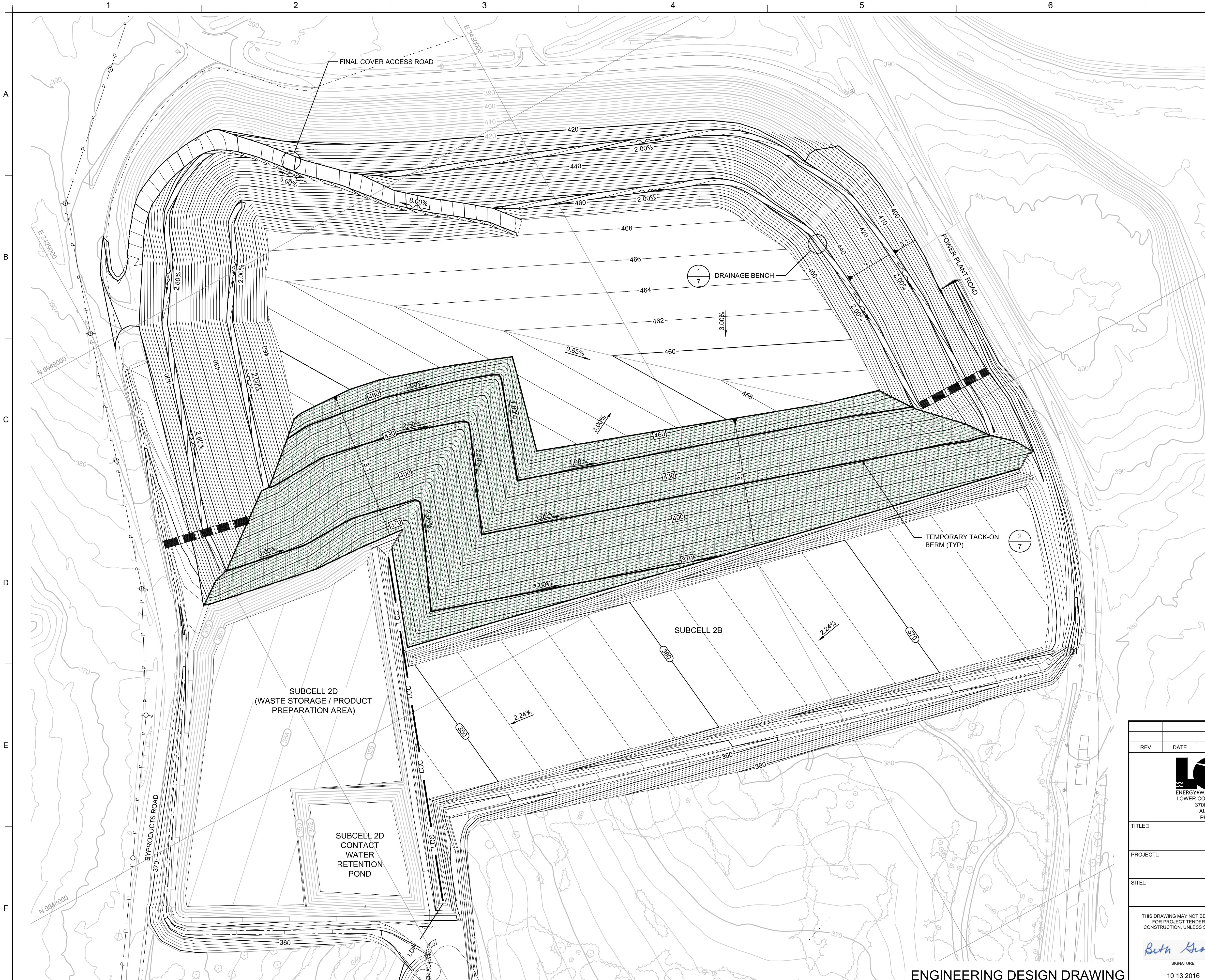
ENGINEERING DESIGN DRAWING

P:\CADD PROJECTS\FAYETTE POWER PLANT\ENG DESIGN\CCR RULE COMPLIANCE (TXL0225.08)\RUN-OFF CONTROL PLANS\DRAWINGS\TXL0225CCRR4



LEGEND

350	EXISTING GROUND ELEVATION (FT,MSL) (NOTES 1,2)
(350)	EXISTING TOP OF LINER ELEVATION (FT,MSL))
	EXISTING ROAD
	EXISTING VEGETATION / TREE
N 9949000 E 3428000	COORDINATE GRID
330	PROPOSED FINISHED GROUND ELEVATION (FT, MSL)
(350)	PROPOSED TOP OF CLAY ELEVATION (FT, MSL)
[460]	PROPOSED INTERIM WASTE ELEVATION (FT, MSL)
LCC	LEACHATE COLLECTION CORRIDOR
LDP	LEACHATE COLLECTION DRAIN PIPE
	PROPOSED DOWNCHUTE
	PROPOSED DRAINAGE BENCH
	PROPOSED TEMPORARY TACK-ON BERM
	PROPOSED DRAINAGE TERRACE
	AREA WITH INTERMEDIATE COVER

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 OCTOBER 2013 BY SURDEX CORPORATION AND LIDAR DATA PUBLISHED DECEMBER 2008 AND PROVIDED BY LCRA SURVEYING, MAPPING, AND GIS.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.

0 100 200
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

LCRA
ENERGY • WATER • COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512.473.3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD, SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: LANDFILL FILLING PLAN - SUBCELL 2A

PROJECT: RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE: FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

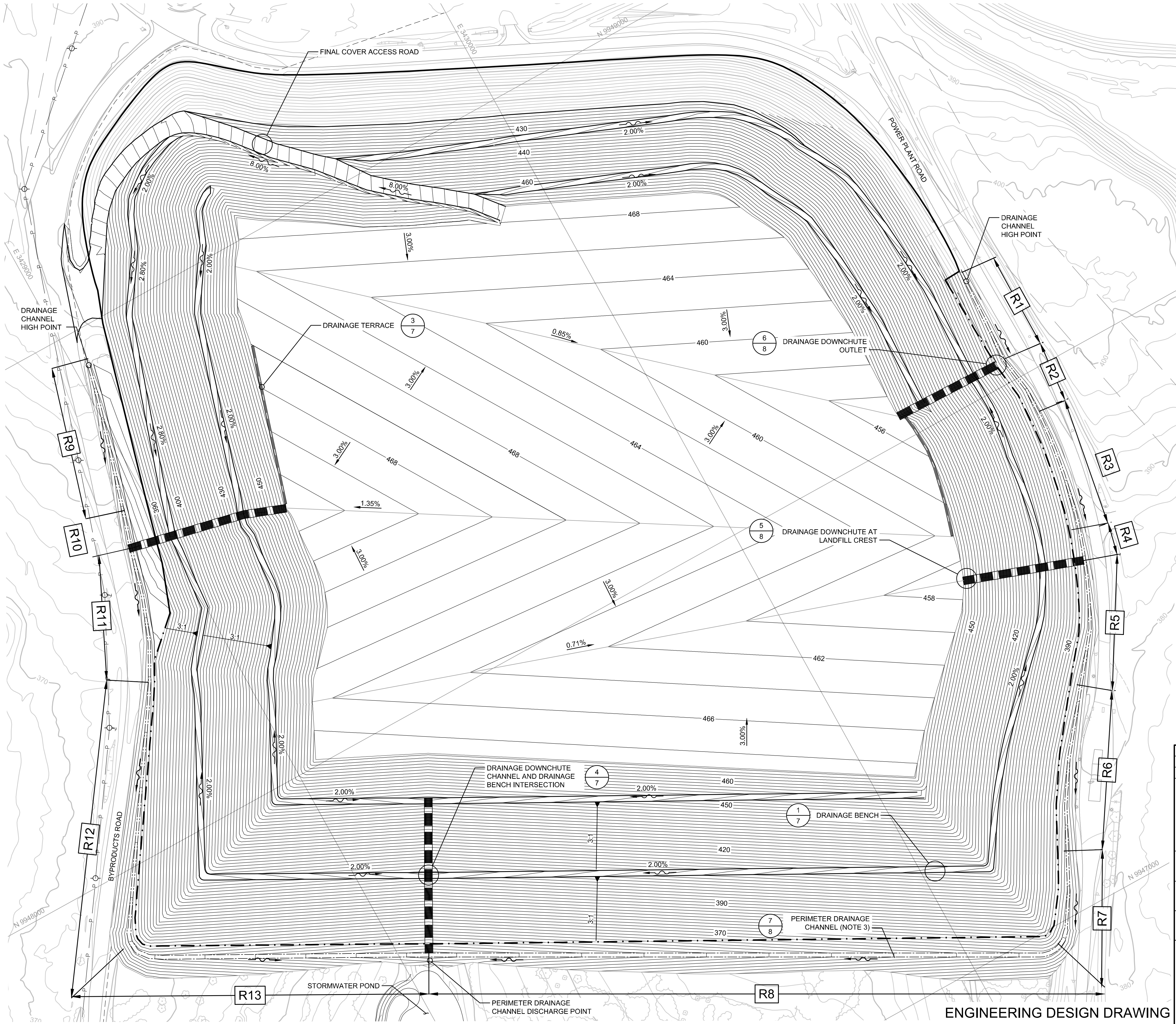
Beth Gross
SIGNATURE
10.13.2016
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

DESIGN BY:	BG	DATE:	OCTOBER 2016
DRAWN BY:	JJV	PROJECT NO:	TXL0225.04
CHECKED BY:	BG	FILE:	TXL0225CCRR5
REVIEWED BY:	BG	DRAWING NO:	
APPROVED BY:	BG	5 OF 8	

ENGINEERING DESIGN DRAWING

P:\CADD\PROJECTS\F\FAYETTE POWER PLANT\ENG DESIGN\CCR RULE COMPLIANCE (TXL0225.08)\RUN-ON RUN-OFF CONTROL PLANS\DRAWINGS\TXL0225CCRR5



LEGEND

- 350 — EXISTING GROUND ELEVATION (FT,MSL) (NOTES 1,2)
- EXISTING ROAD
- EXISTING VEGETATION / TREE
- N 9949000 / E 3428000 — COORDINATE GRID
- EXISTING FENCE
- EXISTING LIMIT OF LANDFILL
- PROPOSED LIMIT OF LANDFILL
- 400 — PROPOSED TOP OF FINAL COVER ELEVATION (FT,MSL)
- PROPOSED DOWNCHUTE
- PROPOSED DRAINAGE TERRACE
- PROPOSED DRAINAGE BENCH
- PROPOSED PERIMTER DRAINAGE CHANNEL
- R2 — PERIMETER DRAINAGE CHANNEL REACH (NOTE 3)
- DRAINAGE FLOW ARROW

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 OCTOBER 2013 BY SURDEX CORPORATION AND LIDAR DATA PUBLISHED DECEMBER 2008 AND PROVIDED BY LCRA SURVEYING, MAPPING, AND GIS.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.
3. SEE DRAWING 8 FOR TABLE OF PERIMETER DRAINAGE CHANNEL DESIGNATIONS (REACHES) AND DIMENSIONS (WIDTH, DEPTH).

REV	DATE	DESCRIPTION	DRN	APP

LCRA — ENERGY • WATER • COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512-473-3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD, SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512-451-4003

TITLE: STORMWATER MANAGEMENT PLAN

PROJECT: RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE: FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

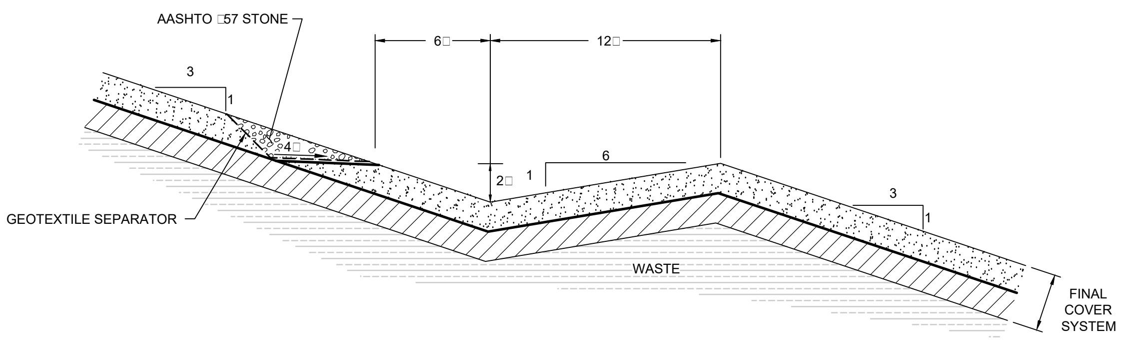
Beth Gross
SIGNATURE
10-13-2016
DATE

STATE OF TEXAS — BETH ANN GROSS — 79864 — LICENSED PROFESSIONAL ENGINEER

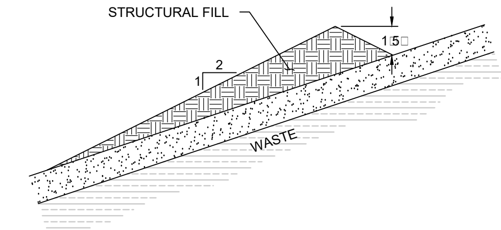
DESIGN BY:	BG	DATE:	OCTOBER 2016
DRAWN BY:		PROJECT NO.:	TXL0225-04
CHECKED BY:	BG	FILE:	TXL0225CCRR6
REVIEWED BY:	BG	DRAWING NO.:	
APPROVED BY:	BG	6 OF 8	

ENGINEERING DESIGN DRAWING

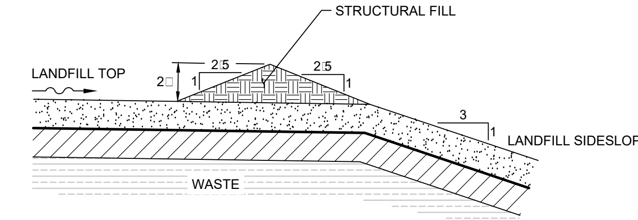
P:\CADD PROJECTS\F\FAYETTE POWER PLANT ENG DESIGN\CCR RULE COMPLIANCE (TXL0225-06)\RUN-OFF CONTROL PLANS\DRAWINGS\TXL0225CCRR6



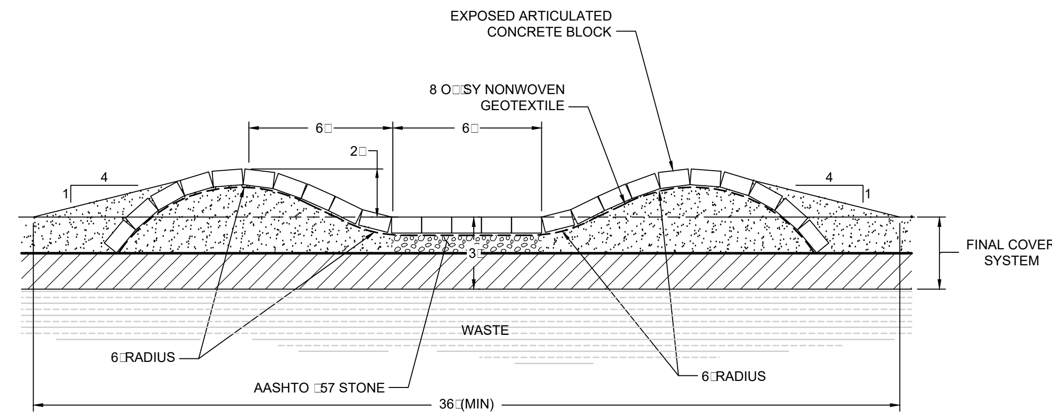
1/5 DETAIL
DRAINAGE BENCH
SCALE: 1" = 5'
0 5' 10'
SCALE IN FEET



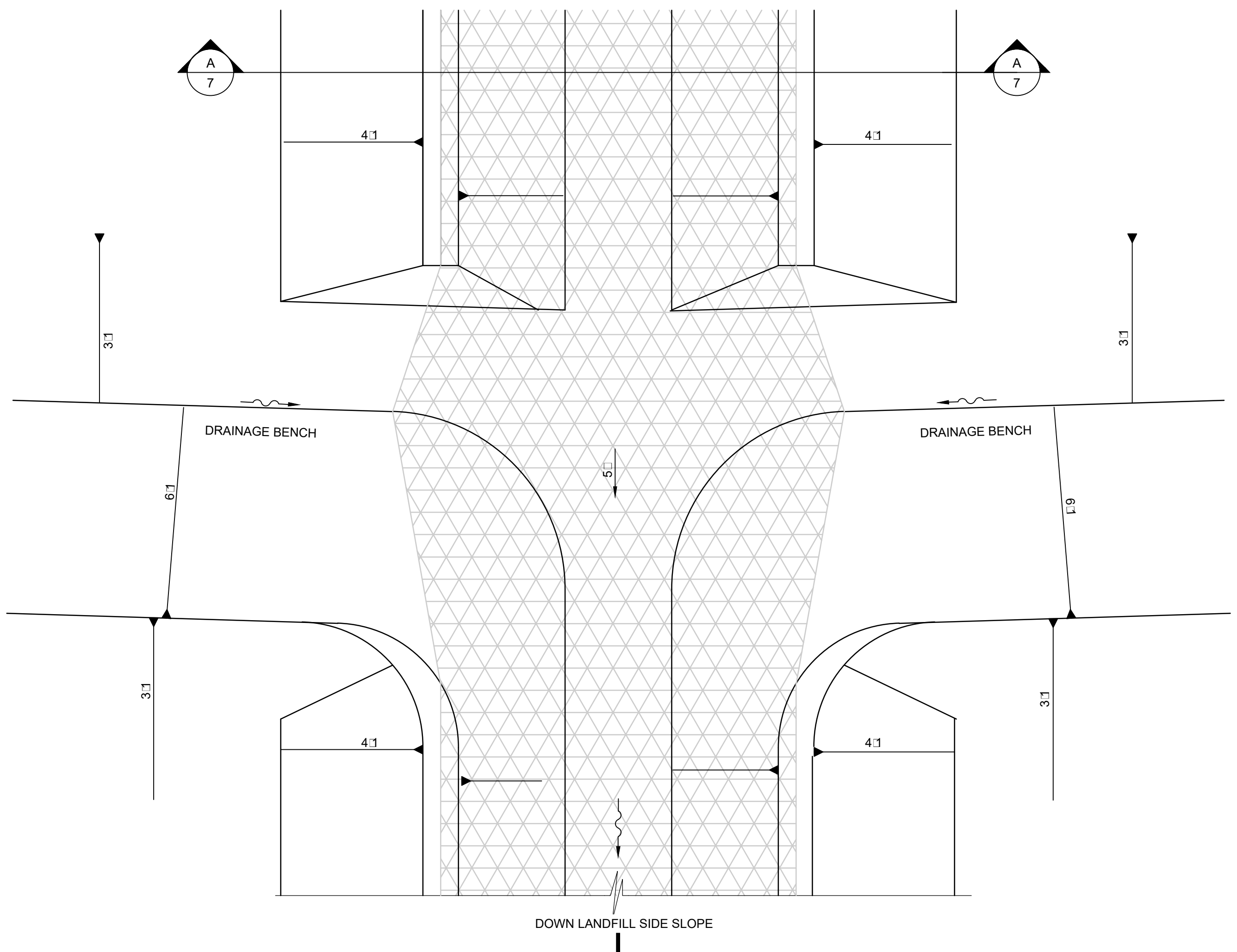
2/5 DETAIL
TEMPORARY TACK-ON BERM
SCALE: 1" = 5'
0 5' 10'
SCALE IN FEET



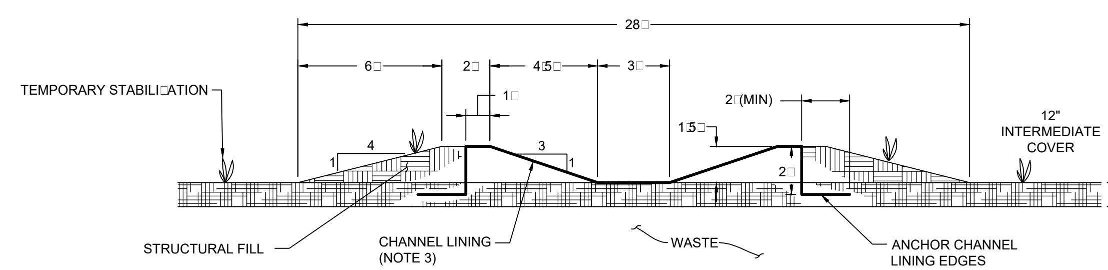
3/6 DETAIL
DRAINAGE TERRACE
SCALE: 1" = 5'
0 5' 10'
SCALE IN FEET



A/7 SECTION
DRAINAGE DOWNCHUTE CHANNEL
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET



4/6 DETAIL
DRAINAGE DOWNCHUTE CHANNEL AND DRAINAGE BENCH INTERSECTION
SCALE: 1" = 5'
0 5' 10'
SCALE IN FEET



A/7 DETAIL
TEMPORARY DRAINAGE DOWNCHUTE CHANNEL
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET

NOTES:

1. DETAILS ARE DRAWN TO SCALE AS NOTED EXCEPT FOR GEOSYNTHETICS WHICH MAY BE SHOWN AT AN EXAGGERATED SCALE FOR CLARITY.
2. DETAILS SHOW FINAL COVER SYSTEM OPTION WITH COMPOSITE CAP.
3. TEMPORARY DRAINAGE DOWNCHUTE CHANNEL TO BE LINED WITH PLASTIC SHEETING, TURF REINFORCEMENT MAT, OR OTHER ALTERNATIVE LINING MATERIAL WITH PERMISSIBLE VELOCITY OF 25:1 FPS AND PERMISSIBLE TRACTIVE STRESS OF 6:1 PSF.

ENGINEERING DESIGN DRAWING

REV	DATE	DESCRIPTION	DRN	APP

LCRA ENERGY•WATER•COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512-473-3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD, SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512-451-4003

TITLE: STORMWATER MANAGEMENT DETAILS I

PROJECT: RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE: FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

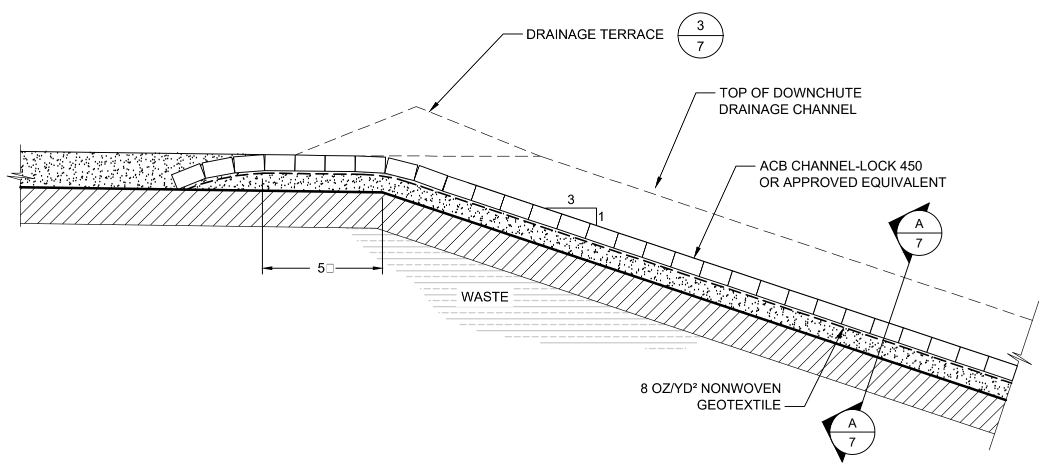
Beth Gross
SIGNATURE
10/13/2016
DATE

STATE OF TEXAS — BETH ANN GROSS — 79864 — LICENSED PROFESSIONAL ENGINEER

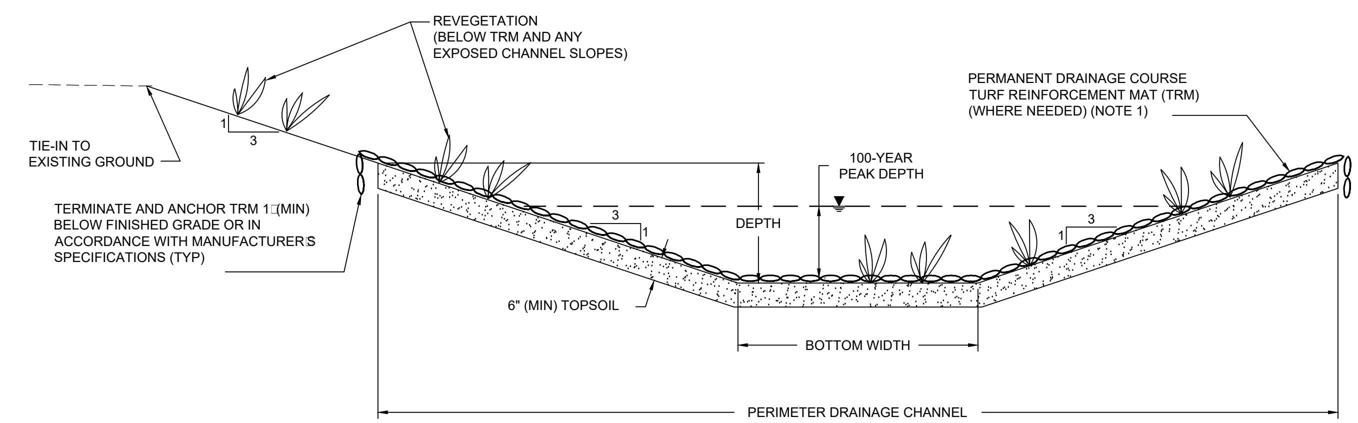
DESIGN BY:	BG	DATE:	OCTOBER 2016
DRAWN BY:	JJV	PROJECT NO:	TXL0225.04
CHECKED BY:	BG	FILE:	TXL0225CCRR7
REVIEWED BY:	BG	DRAWING NO:	
APPROVED BY:	BG	7 OF 8	

P:\CADD\PROJECTS\FAYETTE POWER PLANT ENG DESIGN\CCR RULE COMPLIANCE (TXL0225.08)\RUN-OFF CONTROL PLANS\DRAWINGS\TXL0225CCRR7

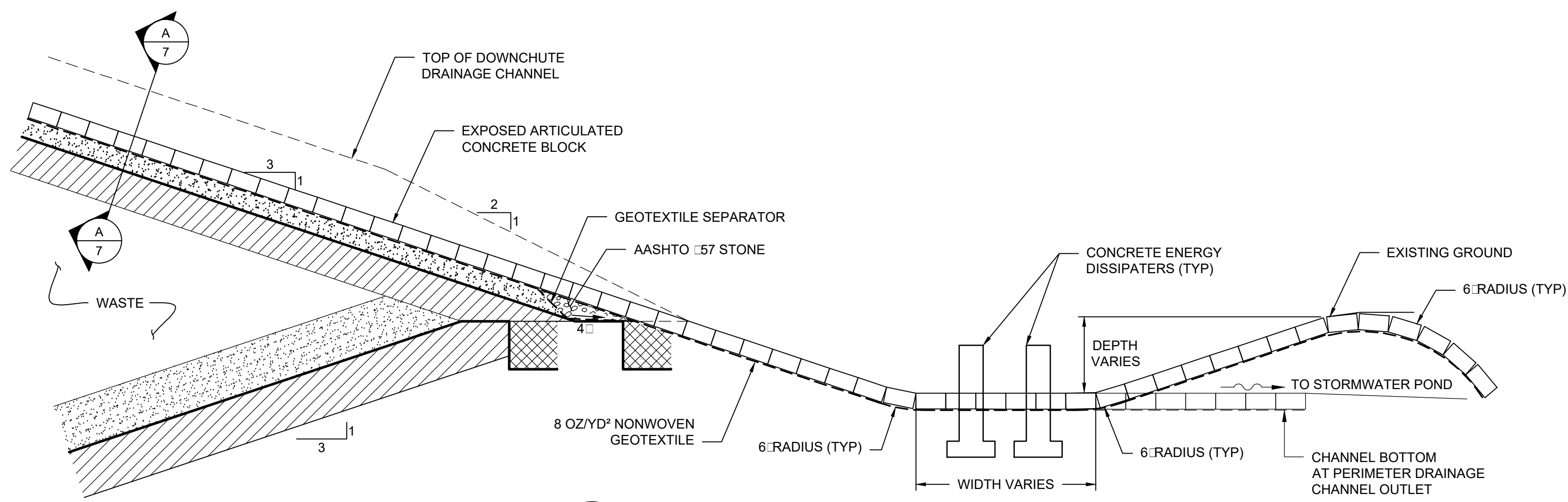
PERIMETER CHANNEL SEGMENT	Channel Slope (ft/ft)	CHANNEL DIMENSIONS (MINIMUM)					25-YEAR				100-YEAR				Channel Lining
		Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slopes (H:V)	Top Width (ft)	Peak Flow (cfs)	Peak Depth (ft)	Peak Velocity (ft/s)	Tractive Stress (psf)	Peak Flow (cfs)	Peak Depth (ft)	Peak Velocity (ft/s)	Tractive Stress (psf)	
Reach 1	0.015	196	5.0	3.0	3:1	23	1.87	0.20	1.72	0.16	2.80	0.25	1.98	0.20	Grass
Reach 2	0.015	127	5.0	3.0	3:1	23	79.13	1.52	5.47	0.92	115.98	1.83	6.05	1.07	Grass
Reach 3	0.009	249	5.0	3.0	3:1	23	81.97	1.76	4.54	0.61	120.22	2.11	5.03	0.71	Grass
Reach 4	0.020	66	5.0	3.0	3:1	23	82.67	1.37	6.63	1.15	121.26	1.66	7.35	1.34	TRM
Reach 5	0.021	252	5.0	3.0	3:1	23	140.62	1.76	7.78	1.48	206.21	2.11	8.61	1.72	TRM
Reach 6	0.016	335	5.0	3.0	3:1	23	146.77	1.92	7.11	1.20	215.41	2.30	7.87	1.40	TRM
Reach 7	0.017	218	5.0	3.0	3:1	23	149.61	1.92	7.23	1.24	219.65	2.31	8.00	1.44	TRM
Reach 8	0.016	1250	8.0	3.0	3:1	26	178.98	1.82	7.29	1.25	263.57	2.22	8.12	1.46	TRM
Reach 9	0.033	301	5.0	2.5	3:1	20	9.31	0.39	3.85	0.66	13.92	0.49	4.38	0.80	Grass
Reach 10	0.017	77	5.0	2.5	3:1	20	10.17	0.50	3.16	0.42	15.21	0.62	3.57	0.50	Grass
Reach 11	0.017	273	5.0	2.5	3:1	20	74.30	1.42	5.63	0.99	110.98	1.73	6.27	1.16	Grass
Reach 12	0.018	496	5.0	2.5	3:1	20	82.81	1.41	6.37	1.05	123.70	1.72	7.10	1.23	TRM
Reach 13	0.020	641	8.0	3.0	3:1	26	95.22	1.24	6.57	1.13	142.26	1.53	7.38	1.34	TRM
Outfall Ditch	0.010	550	10.0	4.0	3:1	34	306.60	2.49	7.05	1.05	554.80	3.35	8.28	1.34	TRM



5/6 DETAIL
DRAINAGE DOWNCHUTE AT LANDFILL CREST
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET



7/6 DETAIL
PERIMETER DRAINAGE CHANNEL
SCALE: 1" = 2'
0 2' 4'
SCALE IN FEET



6/6 DETAIL
DRAINAGE DOWNCHUTE OUTLET
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET

NOTES:

1. PERMANENT TURF REINFORCEMENT MAT TO BE INSTALLED ON PERIMETER CHANNEL REACHES 4 THROUGH 8 AND 12 AND 13.
2. TURF REINFORCEMENT MAT (TRM) SHALL BE PERMANENT (I.E., LONG-TERM) SYNTHETIC MATERIALS THAT ALLOW GRASS VEGETATION TO BECOME ESTABLISHED AND ENHANCE THE ABILITY OF GRASS VEGETATION TO STABILIZE SOILS. THE TRM SHOULD HAVE A MINIMUM RESISTANCE TO TRACTIVE STRESS OF 6 [illegible]
3. DETAILS SHOW FINAL COVER SYSTEM OPTION WITH COMPOSITE CAP.

ENGINEERING DESIGN DRAWING

REV	DATE	DESCRIPTION	DRN	APP

LCRA
ENERGY • WATER • COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512.473.3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD, SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: STORMWATER MANAGEMENT DETAILS II

PROJECT: RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

SITE: FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

Beth Gross
SIGNATURE

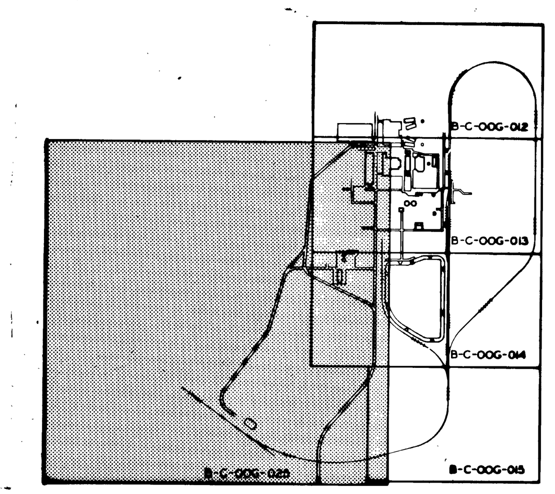
10.13.2016
DATE

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED PROFESSIONAL ENGINEER

DESIGN BY:	BG	DATE:	OCTOBER 2016
DRAWN BY:	JJV	PROJECT NO:	TXL0225.04
CHECKED BY:	BG	FILE:	TXL0225CCRR8
REVIEWED BY:	BG	DRAWING NO:	
APPROVED BY:	BG		8 OF 8

P:\CADD\PROJECTS\F\FAYETTE POWER PLANT\ENG DESIGN\CCR RULE COMPLIANCE (TXL0225.08)\RUN-ON-RUN-OFF CONTROL PLANS\DRAWINGS\TXL0225CCRR8

SELECT HISTORICAL DRAWINGS



KEY PLAN

GENERAL NOTES

1. ALL DISTURBED EARTHED AREAS ON THIS DRAWING, WITH THE EXCEPTION OF THAT LOCATED WITHIN THE COMBUSTION WASTE AREA BOUNDRY, SHALL BE SEEDED UNLESS INDICATED OTHERWISE.
2. ALL EARTHEN EMBANKMENTS AND DITCH SLOPES SHALL BE 3:1 MAXIMUM UNLESS OTHERWISE INDICATED.

STATE OF TEXAS — LEROY E. KASHKA — 52900 — REGISTERED PROFESSIONAL ENGINEER

P-1400-C -16

NO.	DATE	REVISIONS AND RECORD OF ISSUE	BY	CHK	APP	FLM
5	5-1-89	CONFORMED TO CONSTRUCTION RECORDS				
4	9-7-84	REVISED AS NOTED				
3	6-14-84	REVISED AS NOTED	SRW			
2	4-27-84	REVISED AS NOTED	SRW			
1	4-2-84	APPROVED FOR CONSTRUCTION	SRW			
0	10-7-83	INITIAL ISSUE	SRW			

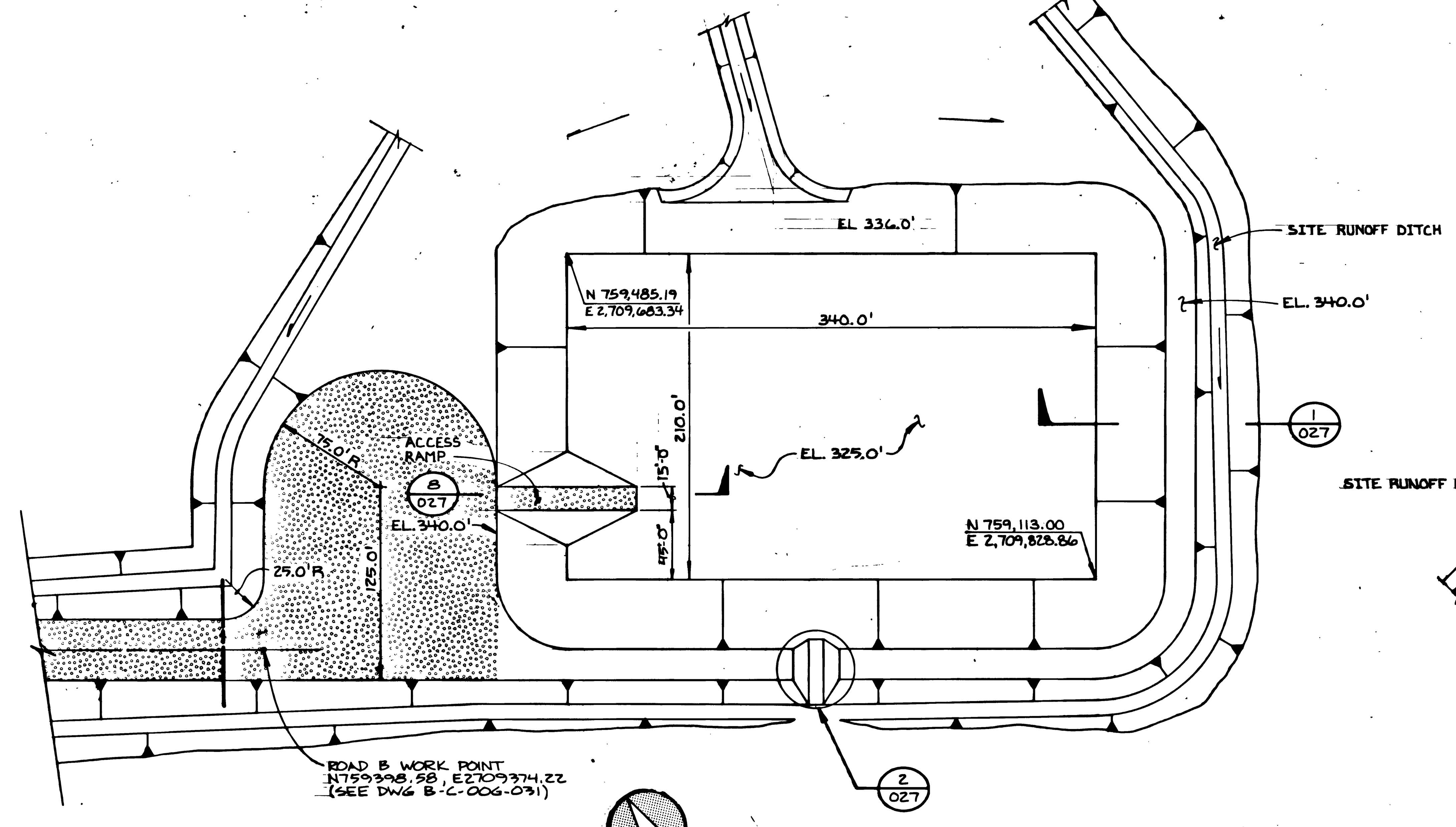
200' 100' 0 200' 400'
SCALE: 1" = 200'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF TEXAS
SIGNED Leroy E. Kashka
DATE 4/2/84 REG NO. 52900

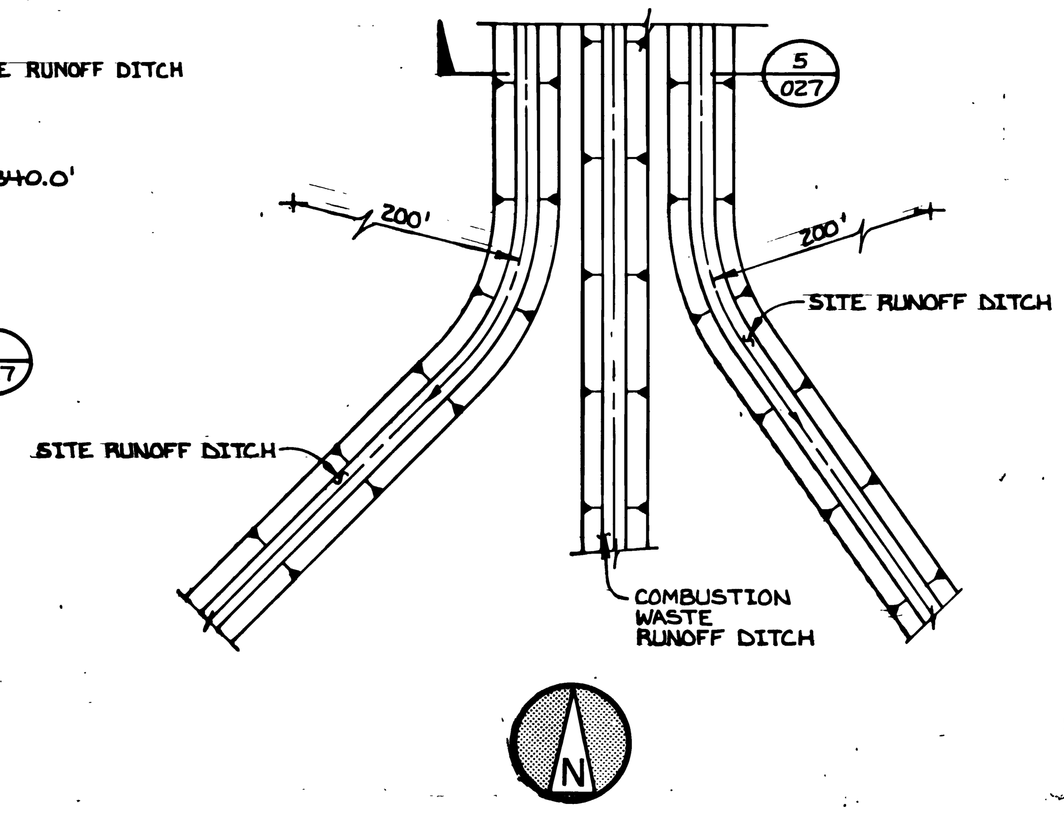
BLACK & VEATCH CONSULTING ENGINEERS
ENGINEER SRW DRAWN MJJ
CHECKED FHF DATE 4-2-84

LOWER COLORADO RIVER AUTHORITY
AUSTIN, TEXAS
FAYETTE POWER PROJECT - UNIT NUMBER THREE
SITE
COMBUSTION WASTE AREA
SITE PLAN

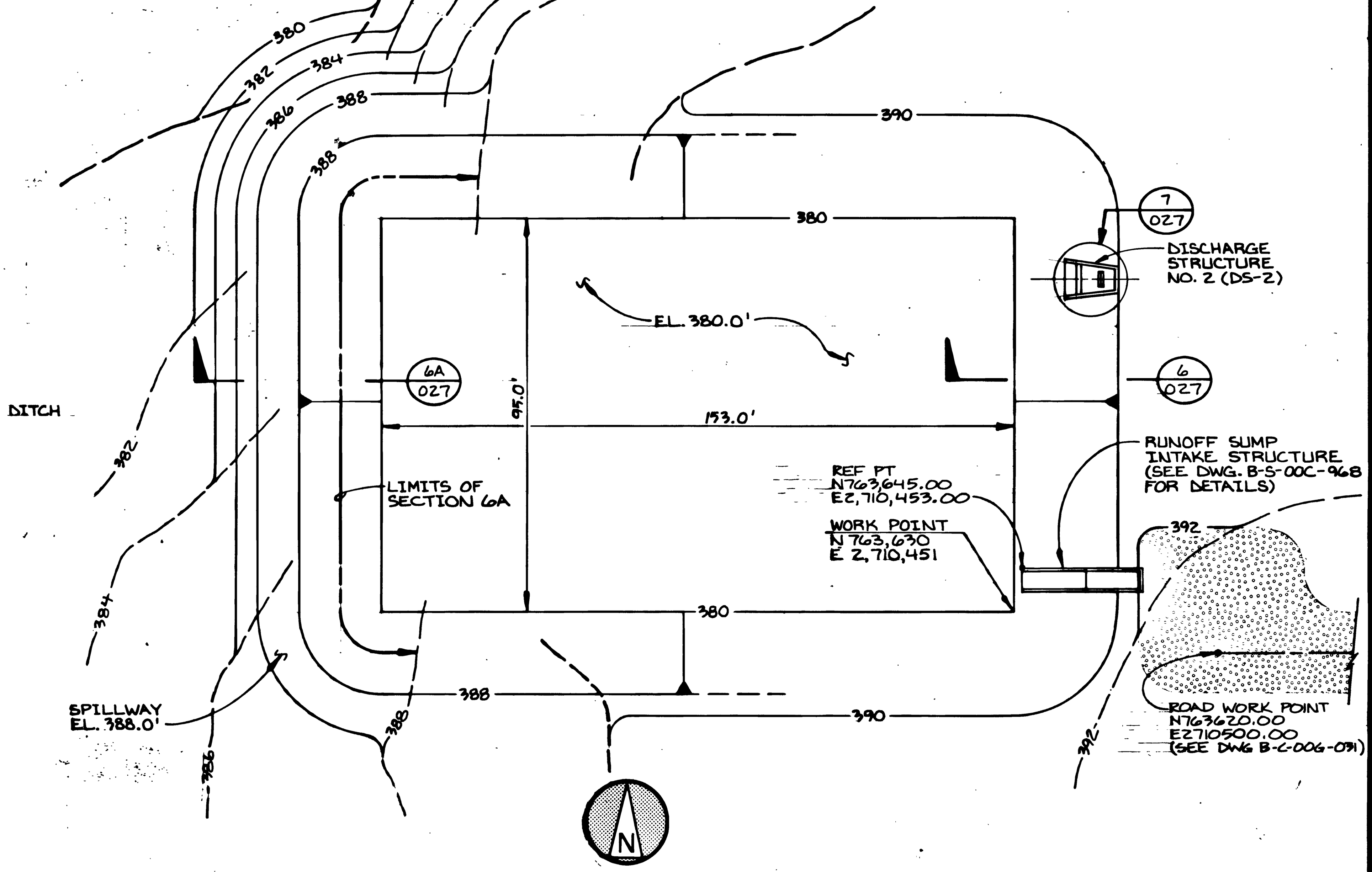
PROJECT 10439
DRAWING NUMBER B-C-00G-025
REV 5
CODE —
AREA —



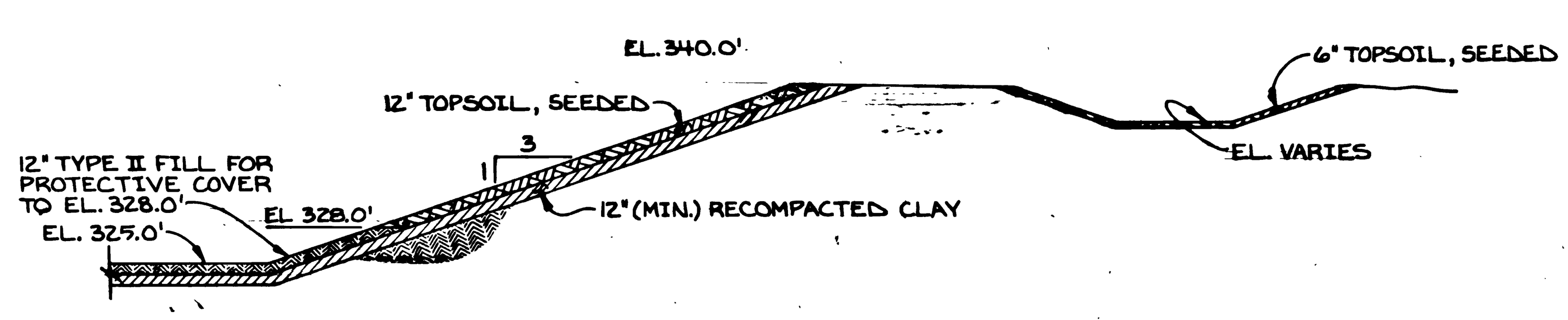
PARTIAL PLAN A
COMBUSTION WASTE AREA RUNOFF POND
SCALE : 1" = 50'
SEE DWG. B-C-00G-025



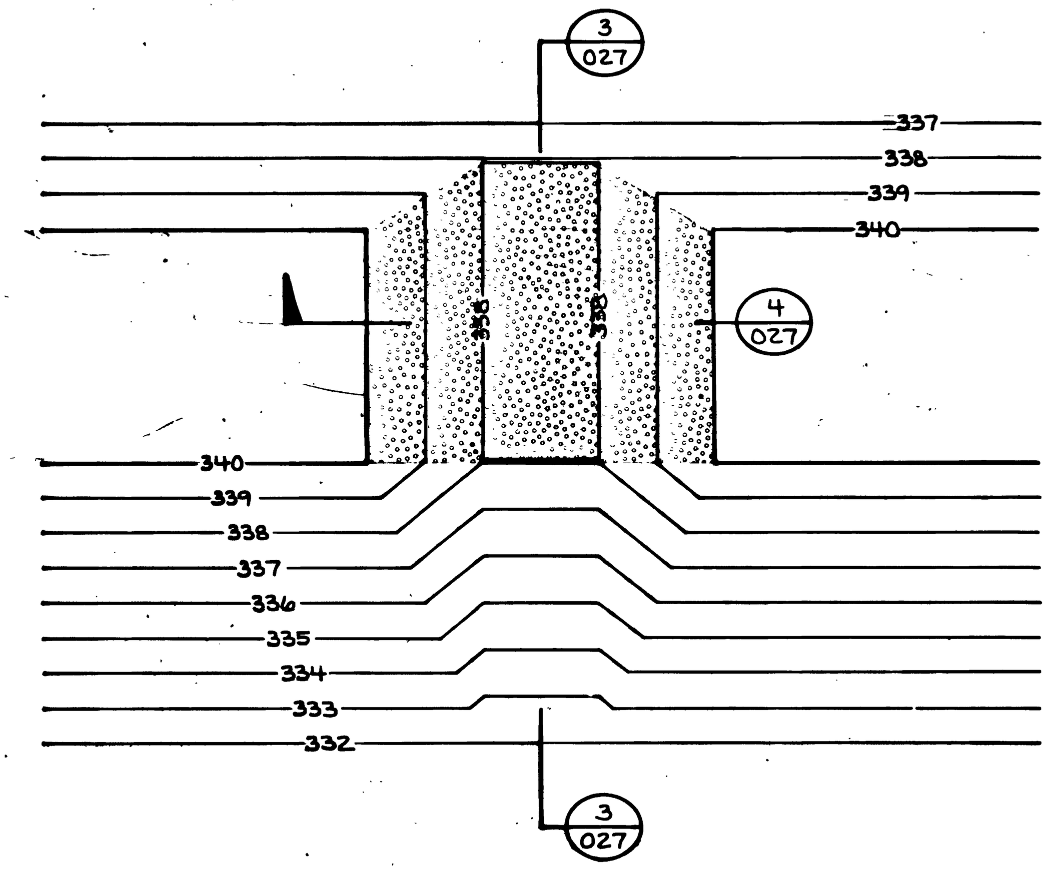
PARTIAL PLAN B
COMBUSTION WASTE AREA RUNOFF DITCHES
SCALE: 1" = 50'-0"
SEE DWG. B-C-00G-025



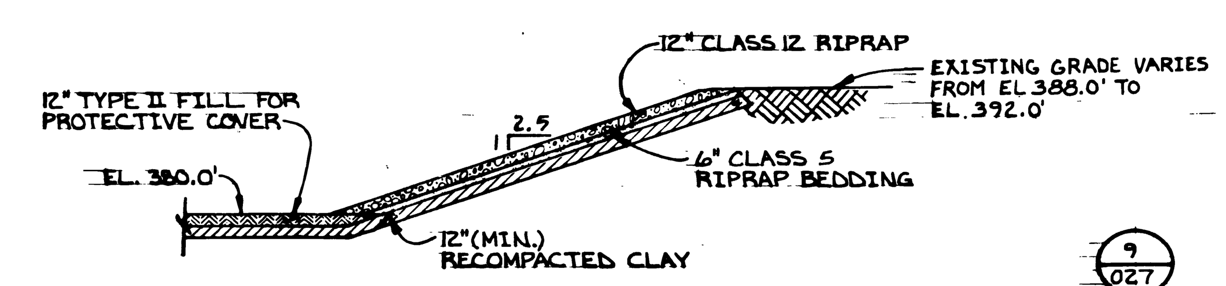
PARTIAL PLAN C
UNIT 3 BOTTOM ASH / UNITS 1 & 2 FLY ASH AREA RUNOFF SUMP
SCALE: 1" = 20'
SEE DWG. B-C-00G-025



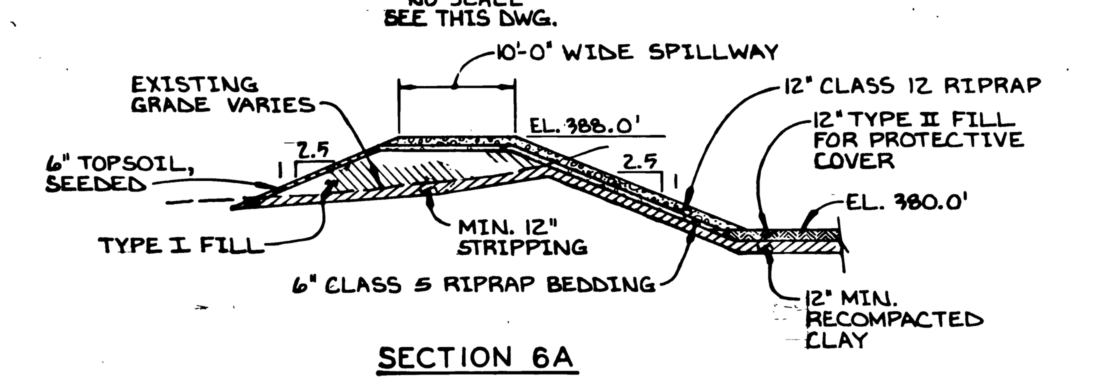
SECTION 1
SCALE: 1" = 10'-0"
SEE THIS DWG.



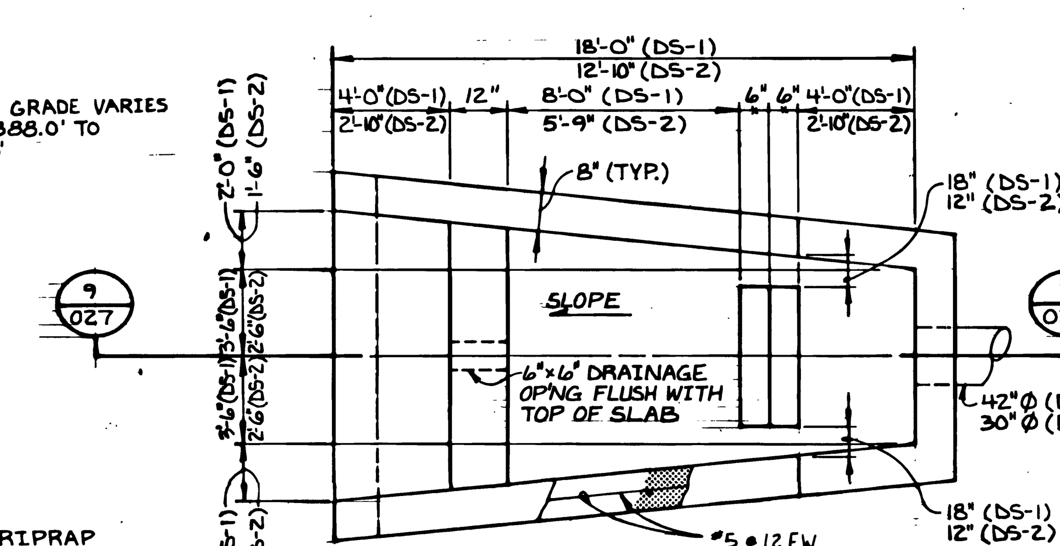
DETAIL 2
SPILLWAY PLAN
SCALE: 1" = 10'-0"
SEE THIS DWG.



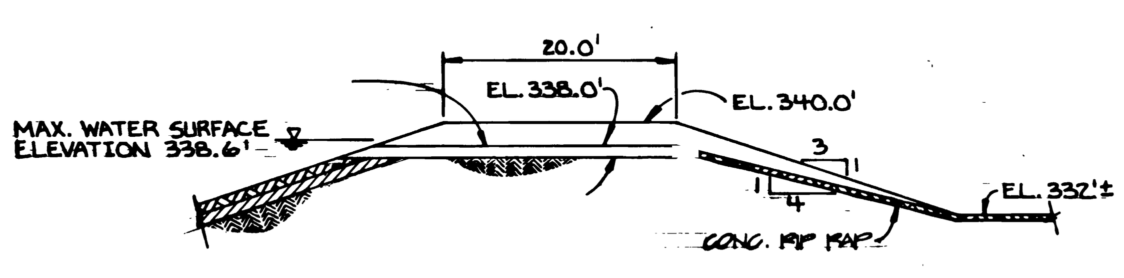
SECTION 6
NO SCALE
SEE THIS DWG.



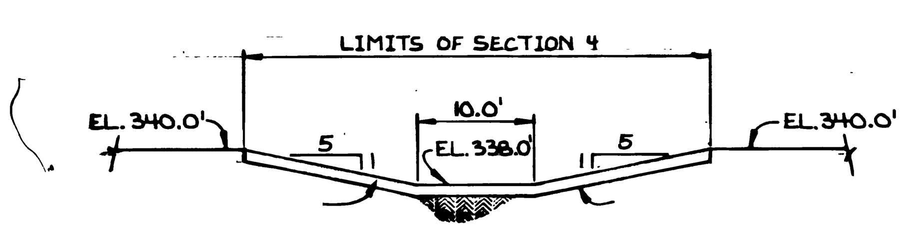
SECTION 6A
NO SCALE
SEE THIS DWG.



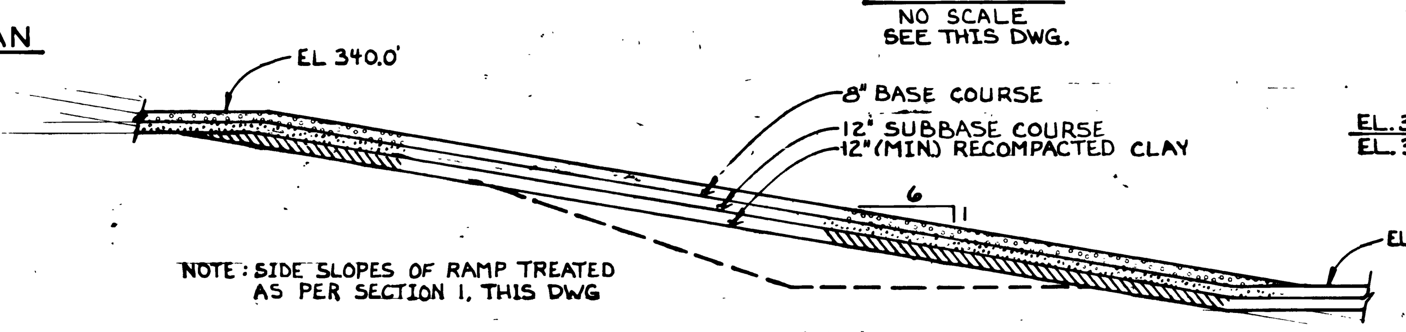
DETAIL 7
NO SCALE
SEE THIS DWG.
& DWG B-C-00G-047



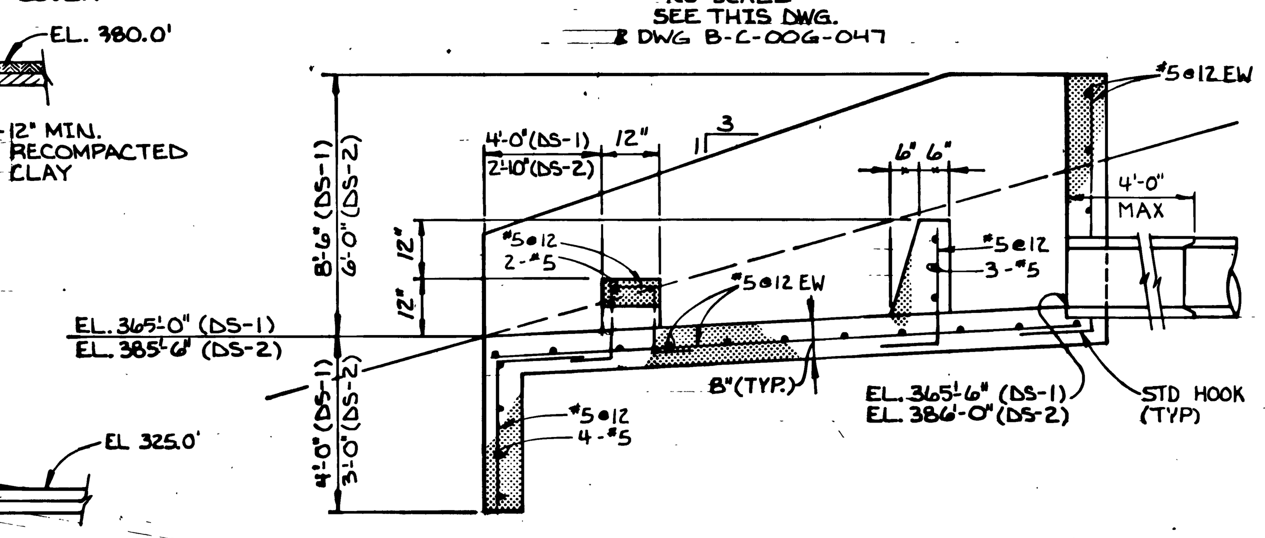
SECTION 3
SCALE: 1" = 10'-0"
SEE THIS DWG.



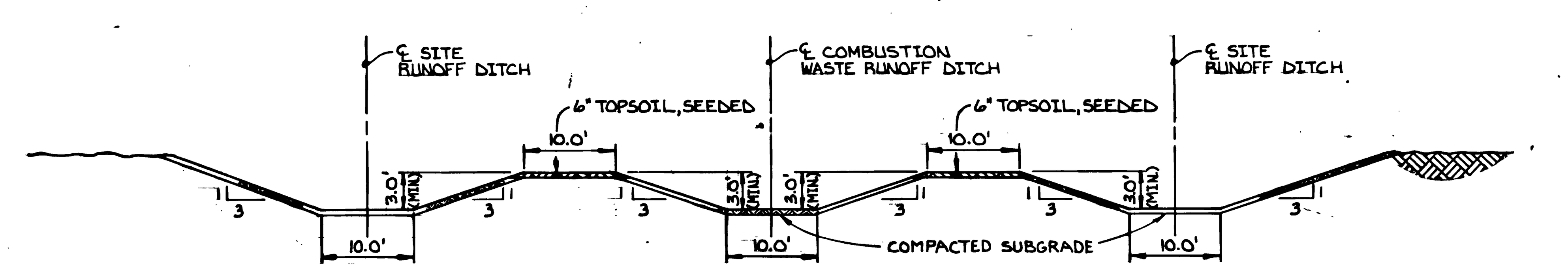
SECTION 4
SCALE: 1" = 10'-0"
SEE THIS DWG.



SECTION 8
SCALE: 1" = 10'-0"
SEE THIS DWG



SECTION 9
NO SCALE
SEE THIS DWG.



SECTION 5
SCALE: 1" = 10'-0"
SEE THIS DWG. & B-C-00G-025

NOTES

DWG. NO	REFERENCE DWGS.
B-S-00C-011	STANDARD CONCRETE DETAILS
B-S-00C-012	STANDARD CONCRETE DETAILS
B-C-00G-025	GRADING PLAN

P-1400-C -17

NO.	DATE	REVISIONS AND RECORD OF ISSUE	BY	CHK	APP	FLN
5	5-1-89	CONFORMED TO CONSTRUCTION RECORDS				
4	12-12-84	REVISED AS NOTED				
3	9-7-84	REVISED AS NOTED				
2	4-27-84	REVISED AS NOTED	SRW			
1	4-2-84	APPROVED FOR CONSTRUCTION	SRW			
0	10-7-83	INITIAL ISSUE	SRW			

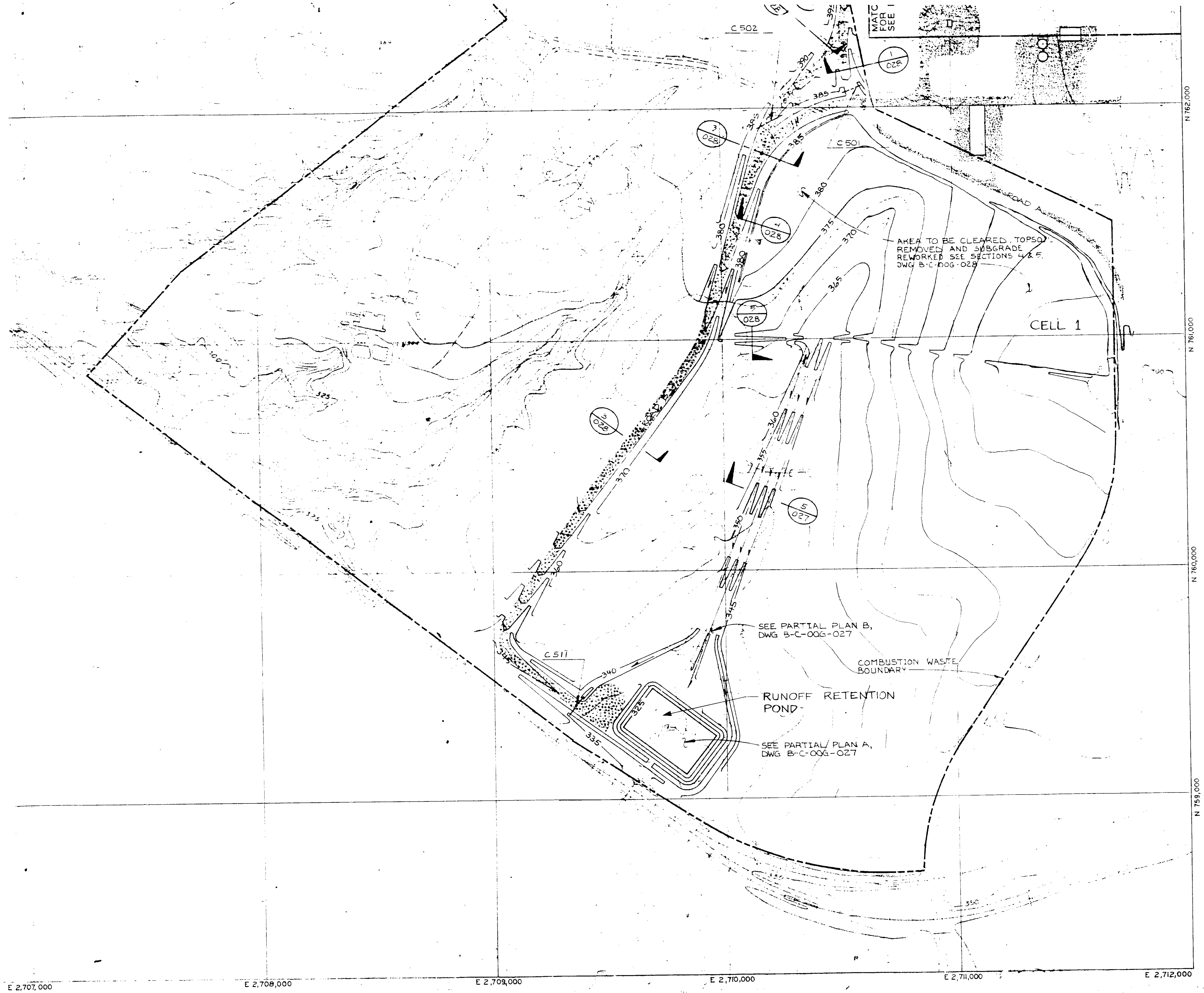
1" = 50' — 1" = 20' — SCALE: 1" = 10'

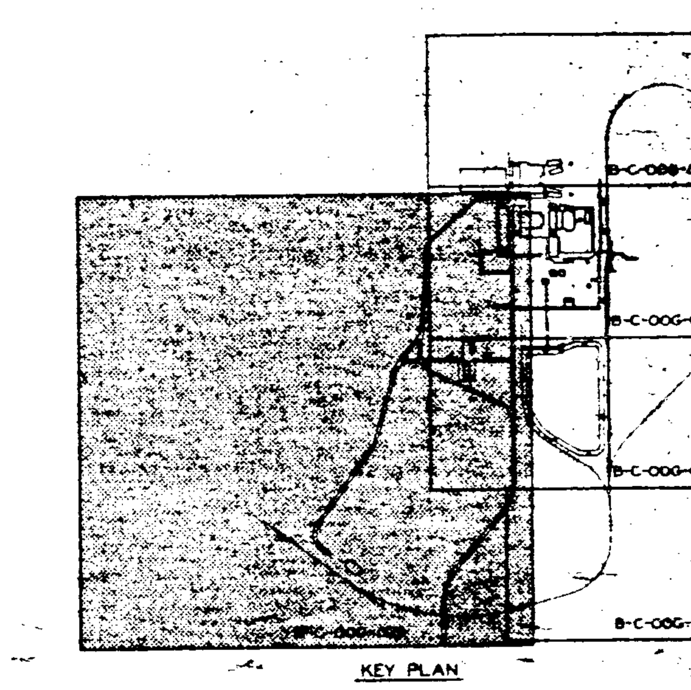
I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF TEXAS
SIGNED
DATE 4/2/84 REG NO. 32900

BLACK & VEATCH CONSULTING ENGINEERS
ENGINEER SRW — DRAWN WJM — CHECKED FHF — DATE 4-2-84

LOWER COLORADO RIVER AUTHORITY
AUSTIN, TEXAS
FAYETTE POWER PROJECT - UNIT NUMBER THREE
SITE
COMBUSTION WASTE AREA
PLANS, SECTIONS, AND DETAILS

PROJECT 10439 — DRAWING NUMBER B-C-00G-027





GENERAL NOTES

1. ALL DISTURBED EARTHED AREAS ON THIS DRAWING, WITH THE EXCEPTION OF THAT LOCATED WITHIN THE COMBUSTION WASTE AREA BOUNDRY, SHALL BE SEEDED UNLESS INDICATED OTHERWISE.
2. ALL EARTHEN EMBANKMENTS AND DITCH SLOPES SHALL BE 3:1 MAXIMUM UNLESS OTHERWISE INDICATED.

NO.	DATE	REVISIONS AND RECORD OF ISSUE	BY	CHK	APP
3	6-14-84	REVISED AS NOTED			
2	4-27-84	REVISED AS NOTED			
1	4-2-84	APPROVED FOR CONSTRUCTION			
0	10-7-83	INITIAL ISSUE			

SCALE: 200' 100' 0 200' 400'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF TEXAS

SIGNED ____
DATE ____ REG NO. ____

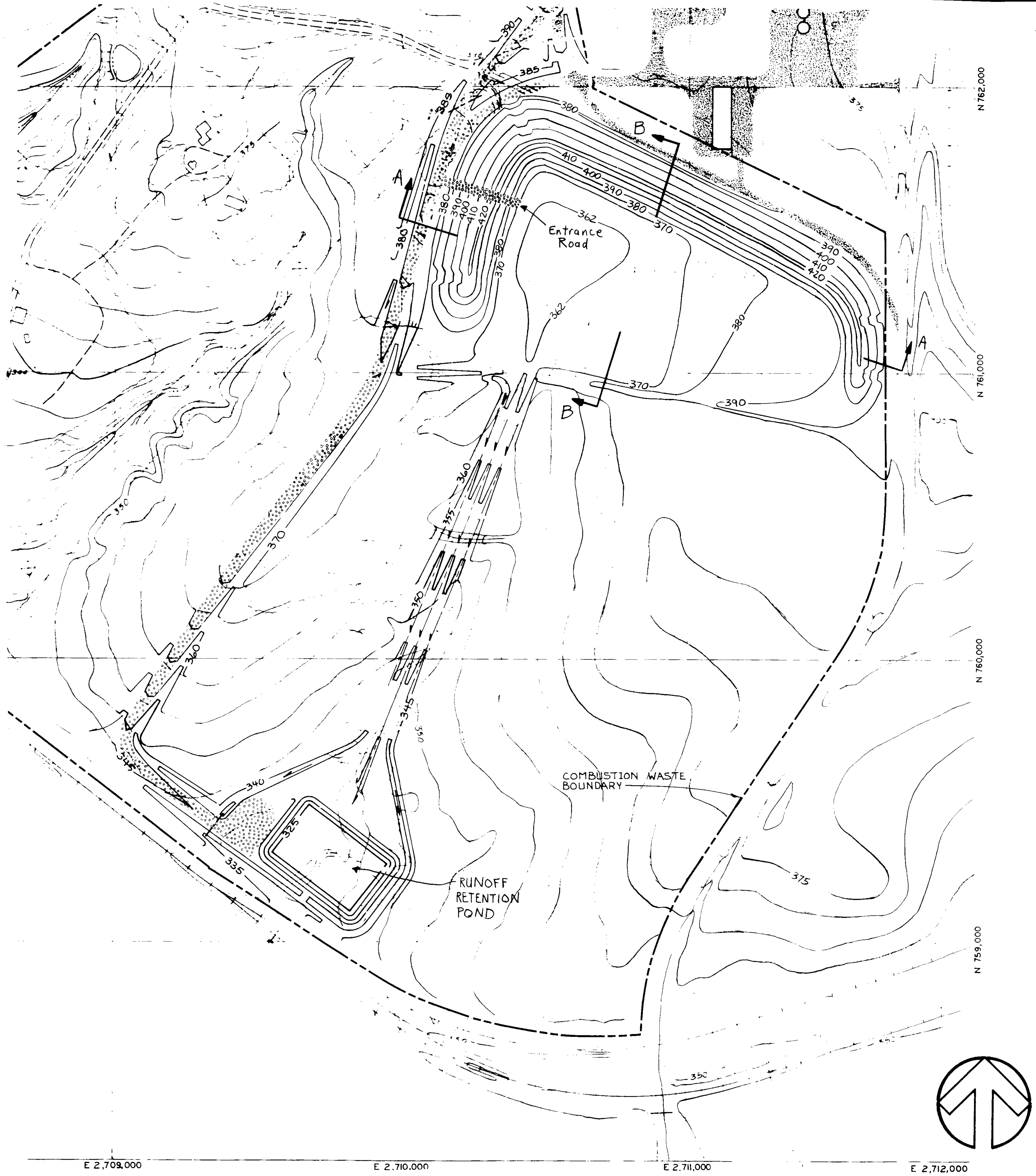
BLACK & VEATCH
CONSULTING ENGINEERS

ENGINEER SRW DRAWN MJJ
CHECKED FHF DATE 4-2-84

LOWER COLORADO RIVER AUTHORITY
AUSTIN, TEXAS
FAYETTE POWER PROJECT - UNIT NUMBER THREE

SITE
COMBUSTION WASTE AREA
SITE PLAN - EXISTING

PROJECT 10439
DRAWING NUMBER SK-00G-032



Notes For Channel To Retention Pond

1. Rainfall runoff will be collected for the active landfill cell and stored in a runoff retention pond. No rainfall runoff from the active cell will be discharged from the pond to the river unless an event equaling or exceeding the 50-year 24-hour rainfall occurs.

General Notes

1. Fly Ash, Bottom Ash & Scrubber Solids shall be delivered to the Combustion Waste Disposal Area at approximately 20% moisture.

2. The road into the disposal area shall be 35 feet wide. This road shall consist of a stabilized subgrade and at least 6 inches of base material.

Ltr.	Date	Revision	By	Chkd.	Appd.	Appd.
C						
B						
A						

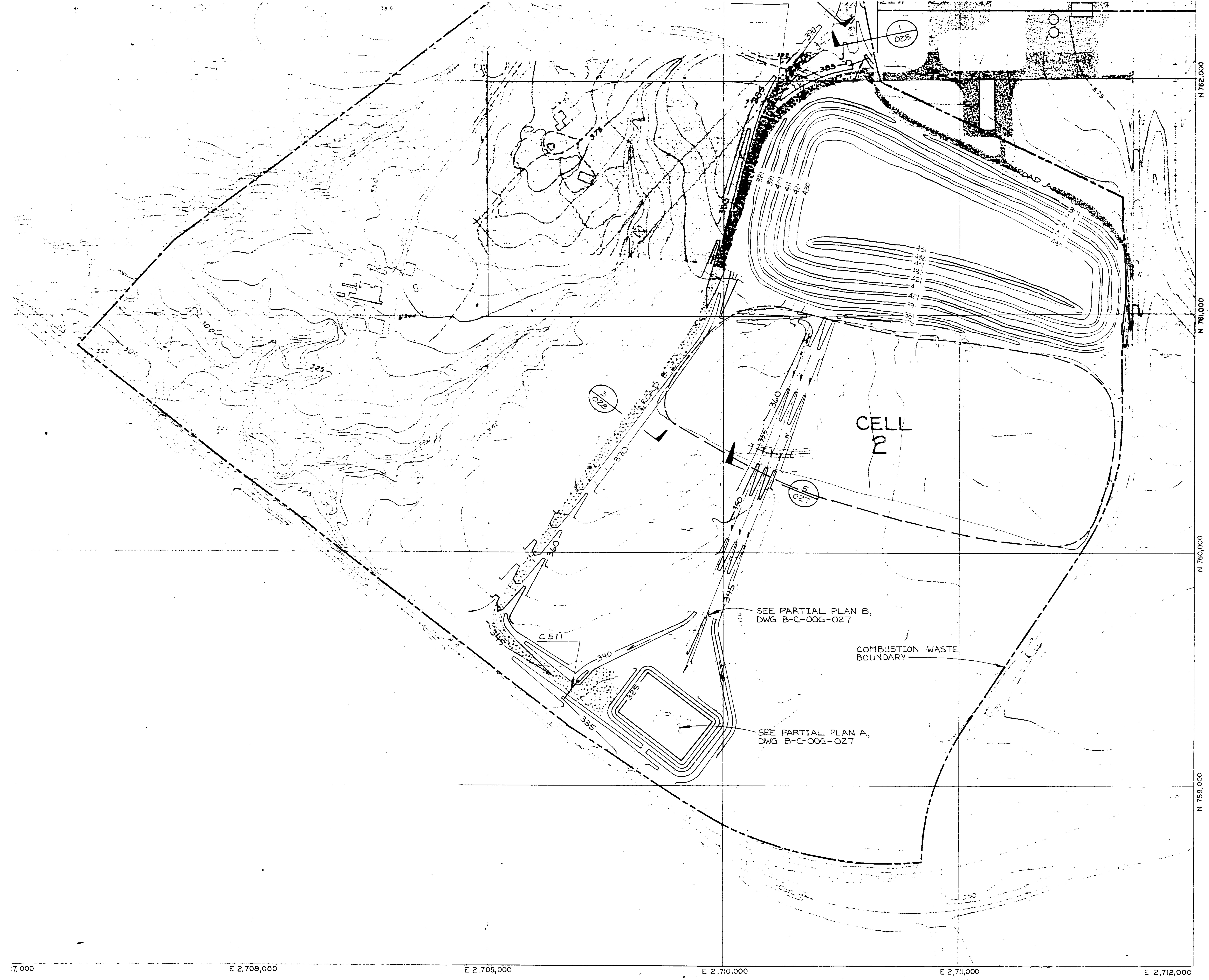
Ltr.	Date	Revision	By	Chkd.	Appd.	Appd.
F						
E						
D						

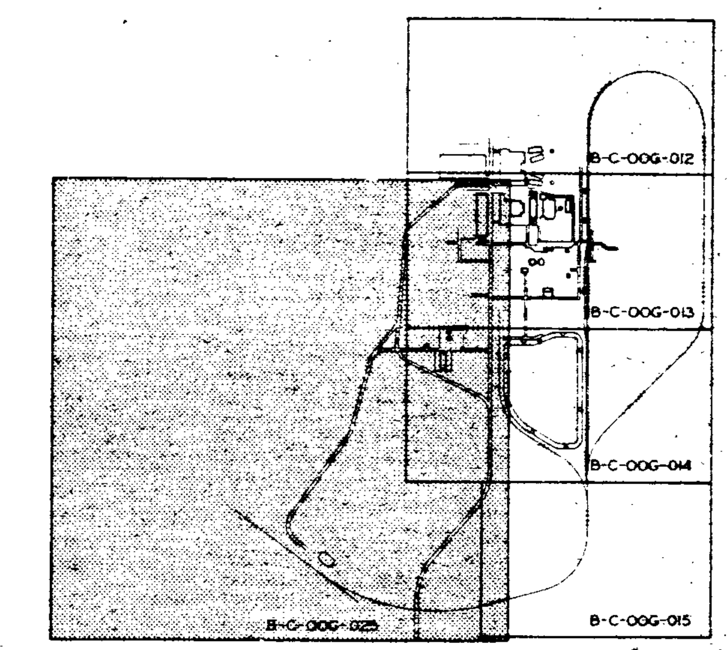
DRAWN M MOUSAVI — W.A. NO.
CHECKED
ENGR. DEPT.
APPROVED

LOWER COLORADO RIVER AUTHORITY
AUSTIN TEXAS
LOCATION
FAYETTE POWER PROJECT

SITE EXISTING
COMBUSTION WASTE AREA
SITE PLAN CELL I

DATE AUG. 11, 87
SCALE 1"= 200'
DWG. NO. SK-00G-033





KEY PLAN

GENERAL NOTES

1. ALL DISTURBED EARTHED AREAS ON THIS DRAWING, WITH THE EXCEPTION OF THAT LOCATED WITHIN THE COMBUSTION WASTE AREA BOUNDRY, SHALL BE SEEDED UNLESS INDICATED OTHERWISE.
2. ALL EARTHEN EMBANKMENTS AND DITCH SLOPES SHALL BE 3:1 MAXIMUM UNLESS OTHERWISE INDICATED.

NO.	DATE	REVISIONS AND RECORD OF ISSUE	BY	CHK	APP
4	9-7-84	REVISED AS NOTED			
3	6-14-84	REVISED AS NOTED	SRW		
2	4-27-84	REVISED AS NOTED	SRW		
1	4-2-84	APPROVED FOR CONSTRUCTION	SRW		
0	10-7-83	INITIAL ISSUE	SRW		

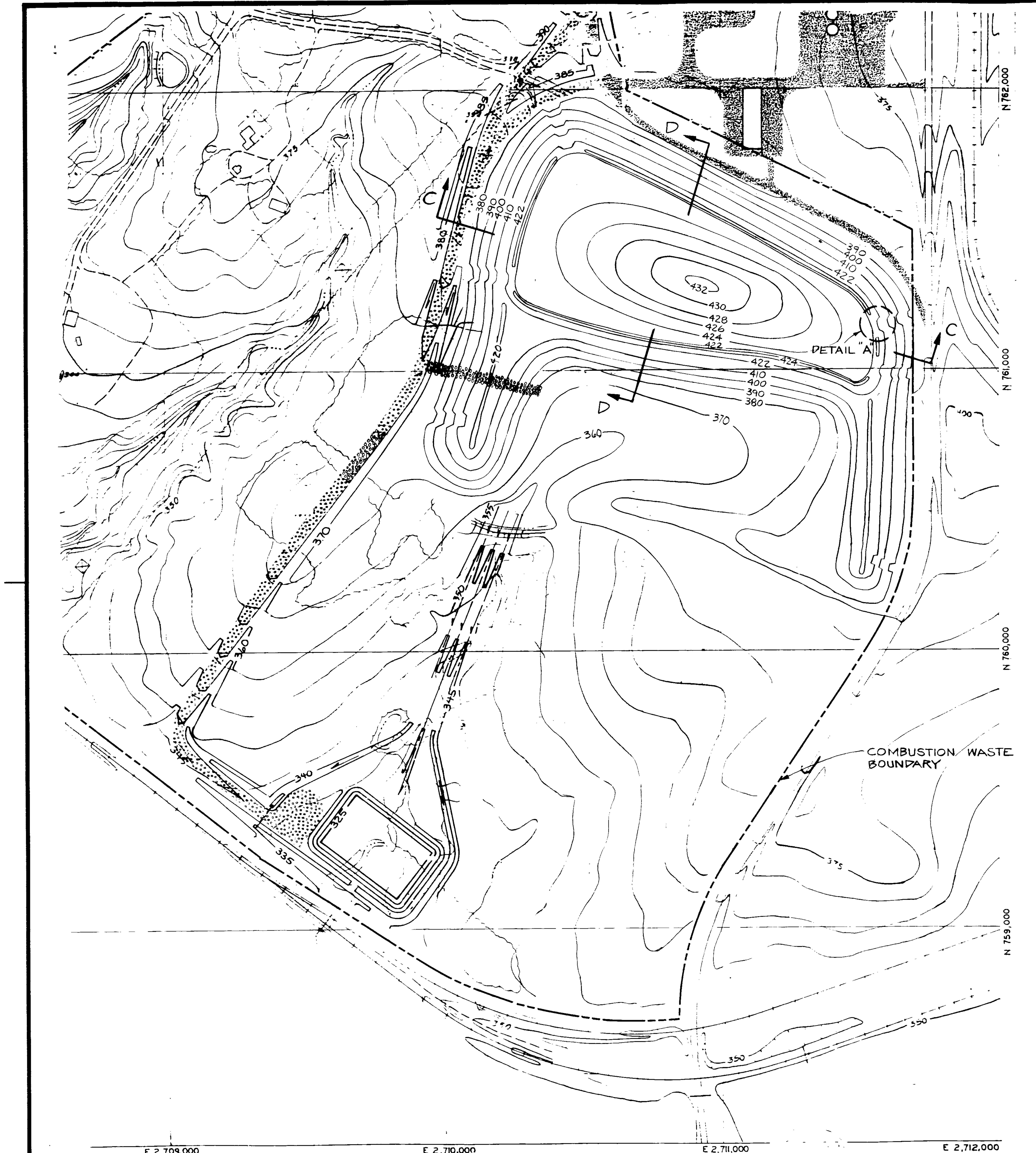
SCALE: 1" = 200'

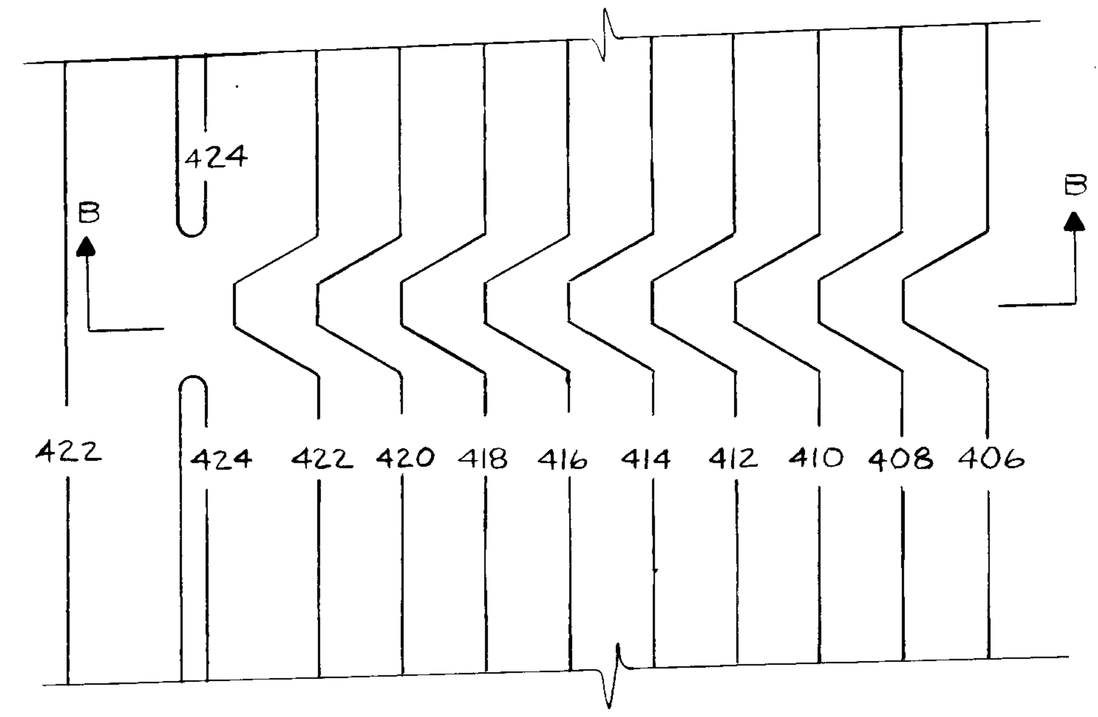
I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF TEXAS
SIGNED
DATE REG NO.

BLACK & VEATCH CONSULTING ENGINEERS
ENGINEER SRW DRAWN MJJ
CHECKED FHF DATE 4-2-84

LOWER COLORADO RIVER AUTHORITY
AUSTIN, TEXAS
FAYETTE POWER PROJECT - UNIT NUMBER THREE
SITE
COMBUSTION WASTE AREA
SITE PLAN-AT CLOSURE

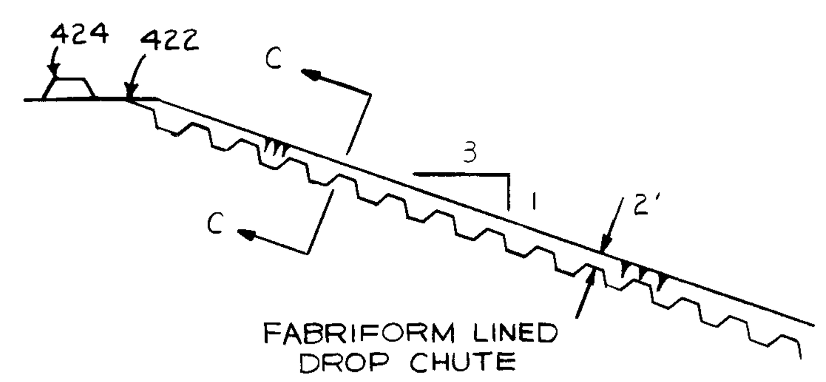
PROJECT 10439
DRAWING NUMBER SK-00G-033



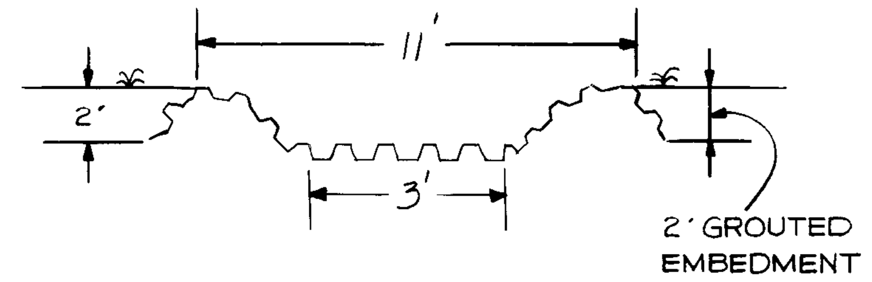


DETAIL A

SCALE: 3/32" = 10'-0"



SECTION B-B



SECTION C-C

Notes For Cap Runoff Control Berms

1. The cap runoff control berms shall consist of clay material. This material shall meet the same requirements as described in the embankment material.
2. The cap runoff control berms shall be constructed when the cell is closed out. The berm shall be a minimum of 2 feet in height.
3. The cap runoff control berms shall be constructed in such a manner as to direct water out the runoff drop chutes.

Notes For Runoff Drop Chutes

1. The runoff drop chutes shall be a minimum of 11 feet in width. Each drop chute shall have a flat bottom with a width of at least 3 feet.
2. The runoff drop chutes shall slope down at a 2:1 to the flat bottom.
3. The runoff drop chutes shall be fabriform lined. The runoff drop chutes shall extend from the top of the embankment to the bottom of each embankment. The water from these chutes shall be directed to the runoff diversion structures.

Notes For Runoff Diversion Structures

1. The runoff diversion structures shall be flat bottom ditches designed for a 100 year, 1 hour storm event. Rainfall runoff from non-active areas will be diverted through these diversion structures to follow natural drainage patterns.
2. The runoff diversion structures shall be at the toe of the outside embankment slope. The runoff diversion structures shall run parallel to the embankments.
3. Rainfall runoff from cells which have not been developed shall follow the natural site drainage pattern.

Ltr.	Date	Revision	By	Chkd.	Appd.	Appd.	Ltr.	Date	Revision	By	Chkd.	Appd.	Appd.
C							F						
B							E						
A							D						

DRAWN	M. MOUSAVI
W.A. NO.	
CHECKED	
ENGR. DEPT.	
APPROVED	

LOWER COLORADO RIVER AUTHORITY
AUSTIN TEXAS

LOCATION
FPP 3

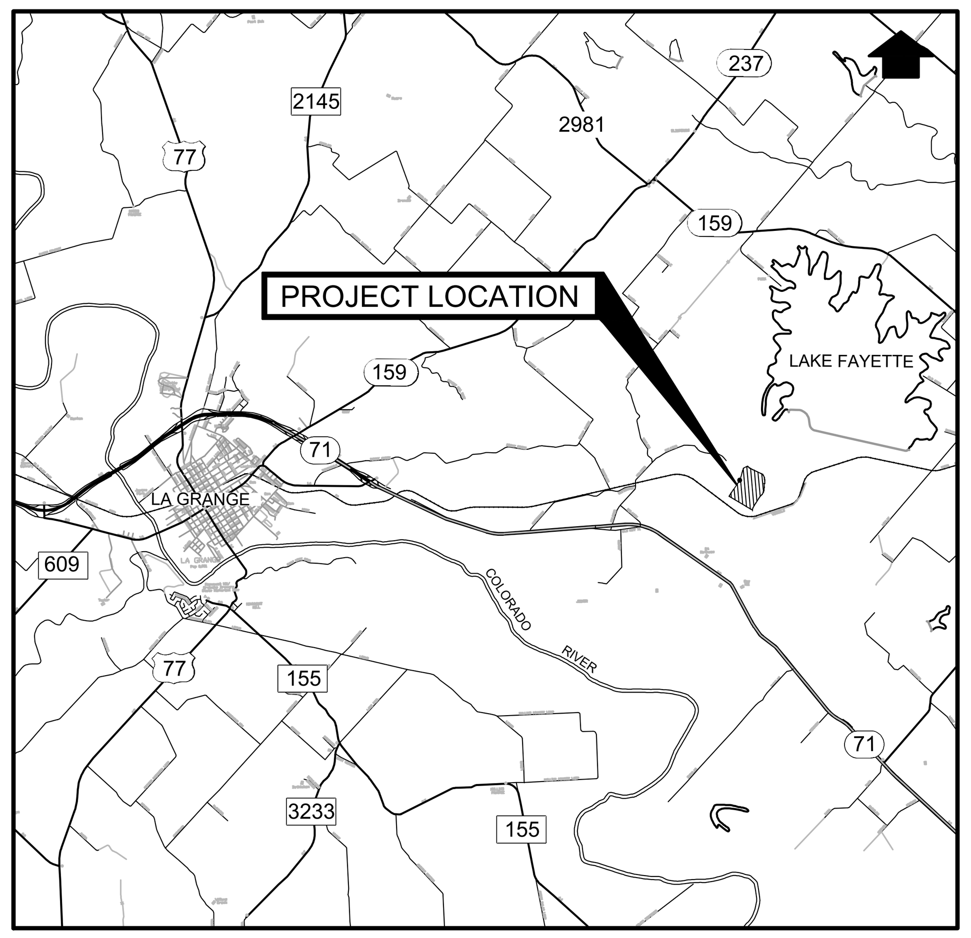
SITE
COMBUSTION WASTE AREA
SITE PLAN-AT CLOSURE (CELL 1)

DATE: AUG 7, 87
SCALE: 1" = 200'-0"
DWG. NO. SK-00G-034

SUBCELL 2D STORAGE AREA RECORD DRAWINGS

RECORD DRAWINGS
COMBUSTION BYPRODUCT LANDFILL
SUBCELL 2D STORAGE AREA
FAYETTE POWER PROJECT
FAYETTE COUNTY, TEXAS

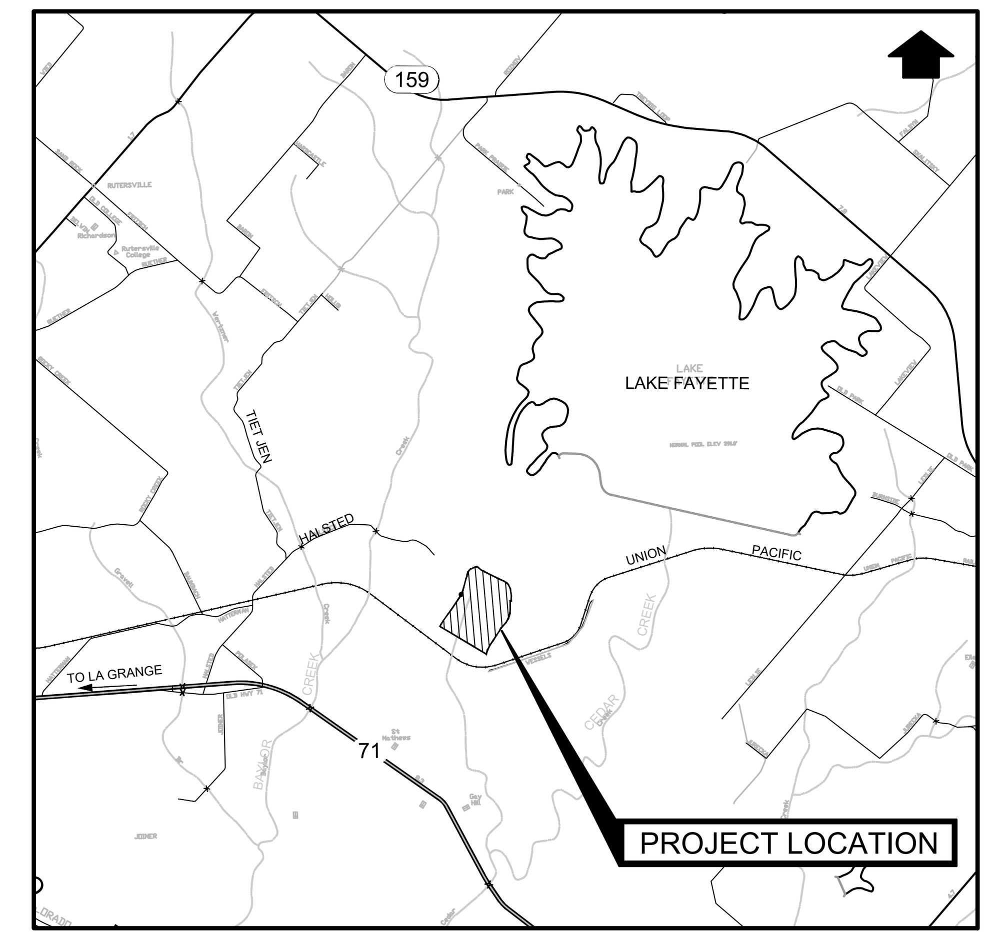
MARCH 2014



MAP SOURCE: TXDOT URBAN COUNTY MAP

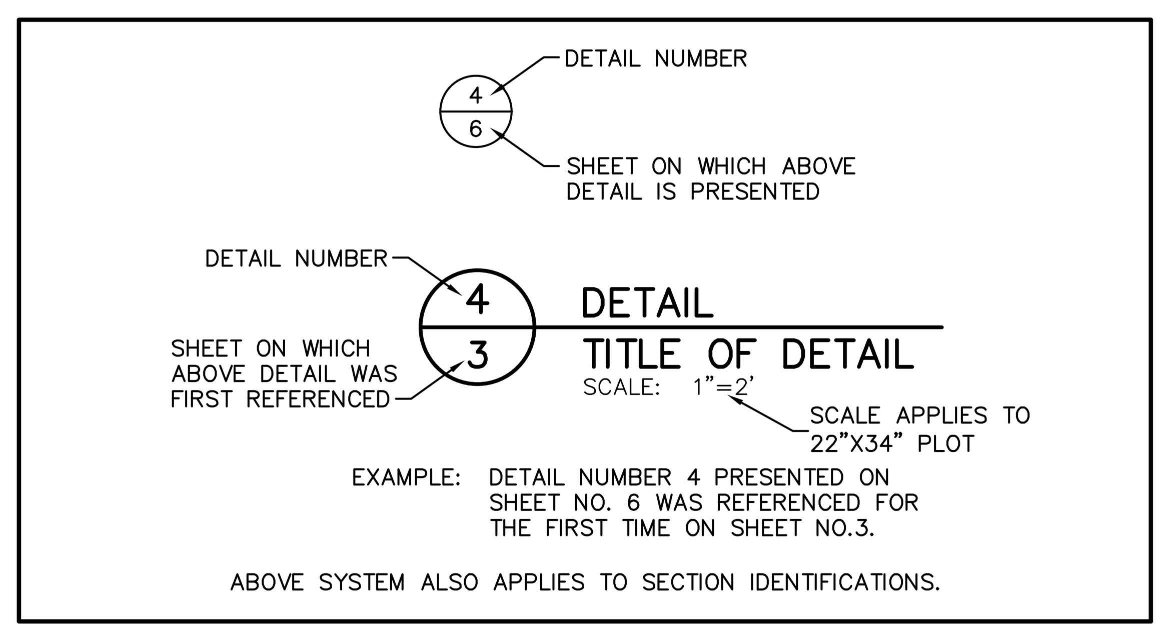
LOCATION MAP
0 2 MILES
APPROXIMATE SCALE

DRAWING INDEX (REV 3)			
DRAWING NUMBER	DRAWING TITLE	LATEST REVISION	DATE
B-C-00G-191	TITLE SHEET	3	NOV 2016
B-C-00G-192	EXISTING SITE CONDITIONS	1	NOV 2016
B-C-00G-193	SITE DEVELOPMENT PLAN	2	NOV 2016
B-C-00G-194	TOP OF SUBGRADE GRADING PLAN	3	NOV 2016
B-C-00G-195	TOP OF CLAY GRADING PLAN	3	NOV 2016
B-C-00G-196	STORMWATER MANAGEMENT AND OPERATIONS PLAN	3	NOV 2016
B-C-00G-197	LINER SYSTEM DETAILS I	2	NOV 2016
B-C-00G-198	LINER SYSTEM DETAILS II	2	NOV 2016
B-C-00G-199	STORMWATER MANAGEMENT AND OPERATION DETAILS I	1	NOV 2016
B-C-00G-200	STORMWATER MANAGEMENT AND OPERATION DETAILS II	2	NOV 2016
B-C-00G-201	CONSTRUCTION CONTROL POINTS	2	NOV 2016



MAP SOURCE: TXDOT URBAN COUNTY MAP

VICINITY MAP
0 1 MILE
APPROXIMATE SCALE



DETAIL IDENTIFICATION LEGEND

PREPARED FOR:

LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
TELEPHONE: 512.473.3200

PREPARED BY:

Geosyntec consultants
8217 SHOAL CREEK BLVD., SUITE 200
TEXAS ENG. FIRM REGISTRATION NO. 1182
AUSTIN, TEXAS 78757
TELEPHONE: 512.451.4003

(3) RECORD DRAWING

REV	DATE	DESCRIPTION	DRN	APP
3	11/01/2016	ISSUE FOR RECORD	JJV	MZI
2	11/14/2014	REVISIONS TO DRAWINGS B-C-00G-191,-194,-195,-196,-197,-198,-200,-201	JJV	MZI
1	04/04/2014	REVISIONS TO DRAWINGS B-C-00G-191,-193,-194,-195,-196	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

ENERGY•WATER•COMMUNITY SERVICES
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TEXAS ENG. FIRM REGISTRATION NO. 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: TITLE SHEET

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT
COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

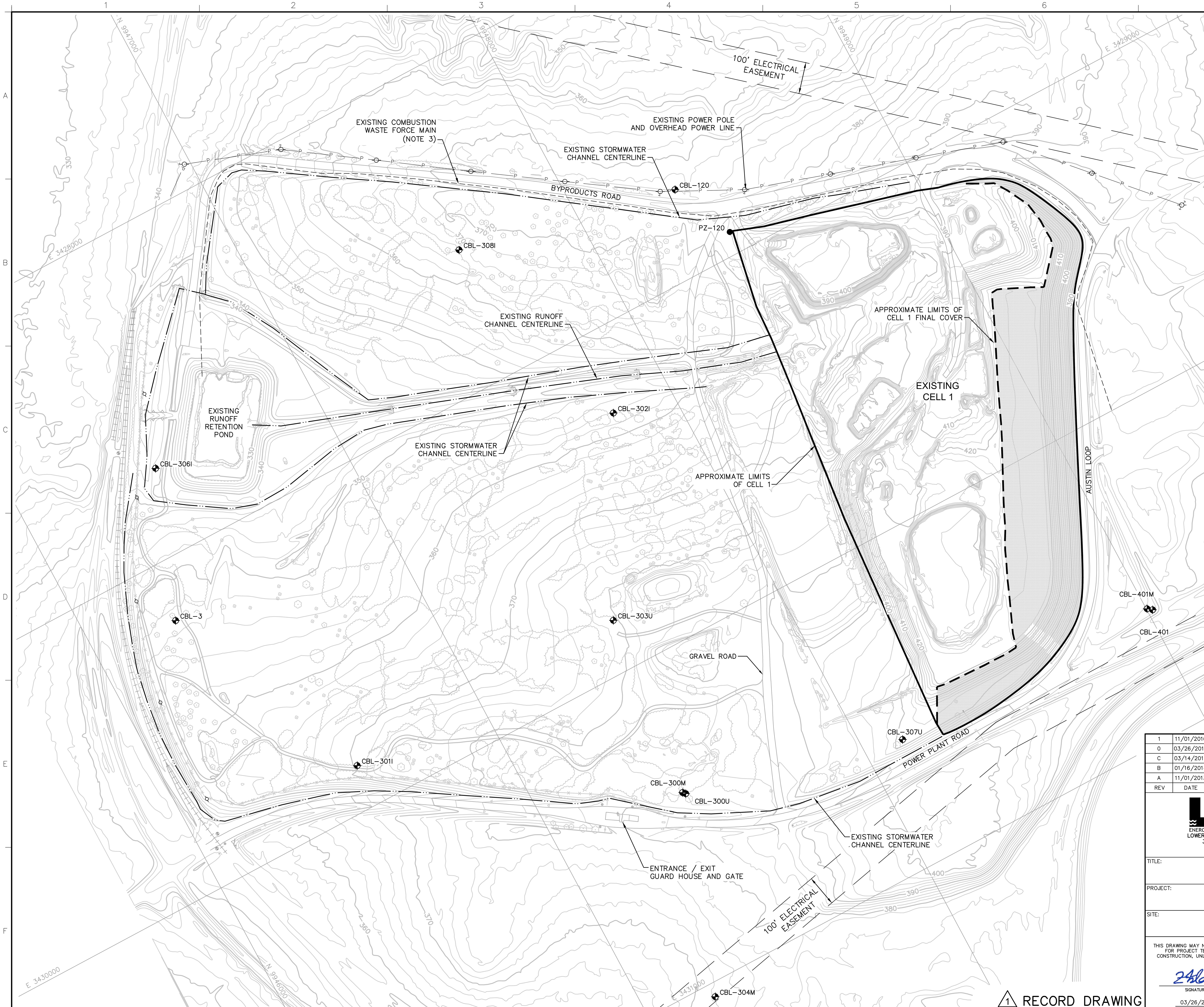
SIGNATURE

03/26/2014
DATE

STATE OF TEXAS
M. ZAHIRUL ISLAM
109989
LICENSED
PROFESSIONAL ENGINEER

DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-191
REVIEWED BY:	BG / TL	DRAWING NO.:	B-C-00G-191
APPROVED BY:	MZI		

DRAWING: P:\CADD\Projects\F\fayette power plant\construction\subcell 2d temp op (txl0225)\DRAWINGS\B-C-00G-191.dwg PLOTTED: Nov 01, 2016 - 11:30am



LEGEND

- 350 — EXISTING GROUND ELEVATION (FEET) (NOTE 2)
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING RAILROAD
- EXISTING VEGETATION / TREE
- N 9949000 / E 3428000 — COORDINATE GRID (NOTE 2)
- EXISTING FENCE
- EXISTING WATERLINE / POND
- EXISTING LIMIT OF LANDFILL
- EXISTING LIMIT OF FINAL COVER
- EXISTING POWER POLE AND OVERHEAD POWER LINE
- EXISTING COMBUSTION WASTE FORCE MAIN
- CBL — EXISTING GROUNDWATER MONITORING WELL
- PZ-120 — EXISTING PIEZOMETER (NOTE 4)

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 OCTOBER 2013 BY SURDEX CORPORATION AND LIDAR DATA PUBLISHED DECEMBER 2008 AND PROVIDED BY LCRA SURVEYING, MAPPING, AND GIS.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.
3. EXISTING COMBUSTION WASTE FORCE MAIN CONVEYS WATER FROM EXISTING RUNOFF RETENTION POND TO RECLAIM POND.
4. PIEZOMETER PZ-120 (CONVERTED BORING B-120) WILL BE PLUGGED AND ABANDONED PRIOR TO CONSTRUCTION OF THE SUBCELL 2D STORAGE AREA.

0 140' 280'
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
1	11/01/2016	ISSUE FOR RECORD	JJV	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

LCRA
ENERGY•WATER•COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512.473.3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NO. 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: EXISTING SITE CONDITIONS

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

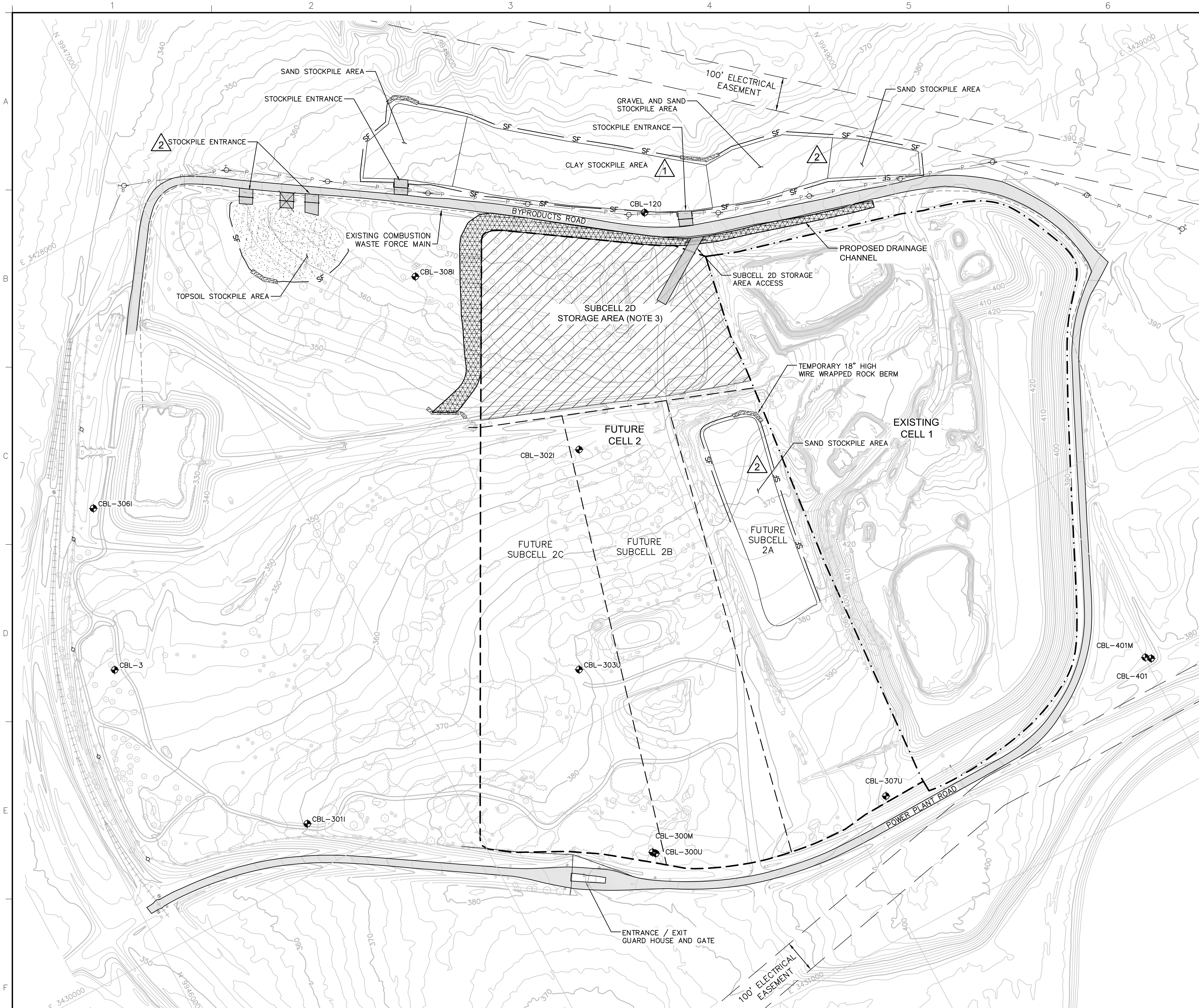
03/26/2014
DATE

STATE OF TEXAS — M. ZAHIRUL ISLAM — 109989 — LICENSED PROFESSIONAL ENGINEER

DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-192
REVIEWED BY:	BG / TL	DRAWING NO.:	
APPROVED BY:	MZI		B-C-00G-192

1 RECORD DRAWING

DRAWING: P:\CADD\Projects\F\fayette power plant\construction\subcell 2d temp op (txl0225)\DRAWINGS\B-C-00G-192.dwg PLOTTED: Nov 01, 2016 – 12:42pm



LEGEND

350	EXISTING GROUND ELEVATION (FEET) (NOTE 2)
	EXISTING ROAD
	EXISTING RAILROAD
	EXISTING VEGETATION / TREE
N 9949000 / E 3428000	COORDINATE GRID (NOTE 2)
	EXISTING FENCE
	EXISTING WATERLINE / POND
	EXISTING LIMIT OF LANDFILL
	EXISTING COMBUSTION WASTE FORCE MAIN
CBL	EXISTING MONITORING WELL
P	EXISTING POWER POLE AND OVERHEAD POWER LINE
	ACCESS ROAD
	FUTURE SUBCELL BOUNDARY
	PROPOSED DRAINAGE CHANNEL CONSTRUCTION AREA
	PROPOSED SUBCELL 2D STORAGE AREA CONSTRUCTION
SF	TEMPORARY SILT FENCE (NOTE 7)

NOTES:

1. THE EXISTING CONTOUR BASE MAP SHOWN ON THIS DRAWING WAS COMPILED USING AN AERIAL SURVEY BASED ON PHOTOGRAPHY PERFORMED ON 23 OCTOBER 2013 BY SURDEX CORPORATION AND LIDAR DATA PUBLISHED DECEMBER 2008 AND PROVIDED BY LCRA SURVEYING, MAPPING, AND GIS.
2. ELEVATIONS ARE IN FEET (FT) AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. STATE PLANE COORDINATE GRID CORRESPONDS TO TEXAS STATE PLANE COORDINATE SYSTEM, TEXAS CENTRAL ZONE (4203), NORTH AMERICAN DATUM 83 (NAD-83) 1983.
3. SUBCELL 2D STORAGE AREA WILL BE CONVERTED TO SUBCELL 2D LANDFILL BEFORE WASTE PLACEMENT TRANSITION FROM SUBCELL 2C TO SUBCELL 2D.

CONSTRUCTION NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR VERIFICATION OF EXISTING CONDITIONS SHOWN ON THIS DRAWING AND FOR LOCATING UNDERGROUND UTILITIES PRIOR TO INITIATING CONSTRUCTION.
2. CONTRACTOR SHALL NOT OBSTRUCT, INTERFERE, OR HINDER SITE OPERATIONS. CONSTRUCTION TRAFFIC SHALL BE RESTRICTED TO ROADS APPROVED BY THE OWNER. CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION, MAINTENANCE, AND RESTORATION OF ROADS AS SET FORTH IN THE CONTRACT DOCUMENTS.
3. ANY EXISTING FACILITY (E.G., GROUNDWATER MONITORING WELLS, PIPELINES, ETC.) DAMAGED BY THE CONTRACTOR SHALL BE RESTORED OR REPLACED TO THE SATISFACTION OF THE OWNER. THE CONTRACTOR SHALL BEAR THE ENTIRE COST OF RESTORATION AND/OR REPLACEMENT.
4. CONTRACTOR'S FACILITIES, MATERIAL STOCKPILES, STAGING AREAS, AND STORAGE AREAS SHALL BE LOCATED ONLY IN AREAS APPROVED BY THE OWNER. CONTRACTOR IS RESPONSIBLE FOR MAINTAINING ALL SUCH AREAS DURING CONSTRUCTION AND FOR CLEANUP/RESTORATION OF ALL SUCH AREAS TO THE ORIGINAL CONDITION.
5. STORMWATER MANAGEMENT AND EROSION AND SEDIMENT CONTROL FEATURES SHALL BE ESTABLISHED BY THE CONTRACTOR IN ACCORDANCE WITH APPLICABLE STATE AND LOCAL REQUIREMENTS AND AS SET FORTH IN CONTRACT DOCUMENTS. THE FEATURES SHALL BE INSTALLED BY THE CONTRACTOR AROUND AND DOWNGRADIENT OF AREAS TO BE DISTURBED PRIOR TO ANY CONSTRUCTION AND SHALL BE MAINTAINED BY THE CONTRACTOR AS NEEDED DURING AND AFTER CONSTRUCTION. THE LOCATION AND CONDITION OF EROSION AND SEDIMENT CONTROL FEATURES SHALL BE SUBJECT TO APPROVAL IN THE FIELD BY THE OWNER.
6. CONTRACTOR SHALL INSTALL AND MAINTAIN DIVERSION BERMS, DITCHES, ETC., AS NEEDED TO PROTECT WORK AREAS.
7. CONTRACTOR TO MAINTAIN SILT FENCES AS NEEDED DURING AND AFTER CONSTRUCTION..

0 140' 280'
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
2	11/01/2016	ISSUE FOR RECORD	JJV	MZI
1	04/04/2014	REVISION TO CLAY STOCKPILE AREA, SILT FENCE LOCATION, AND ADD ROCK BERM	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

ENERGY•WATER•COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512.473.3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NO. 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE:
SITE DEVELOPMENT PLAN

PROJECT:
SUBCELL 2D STORAGE AREA

SITE:
FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

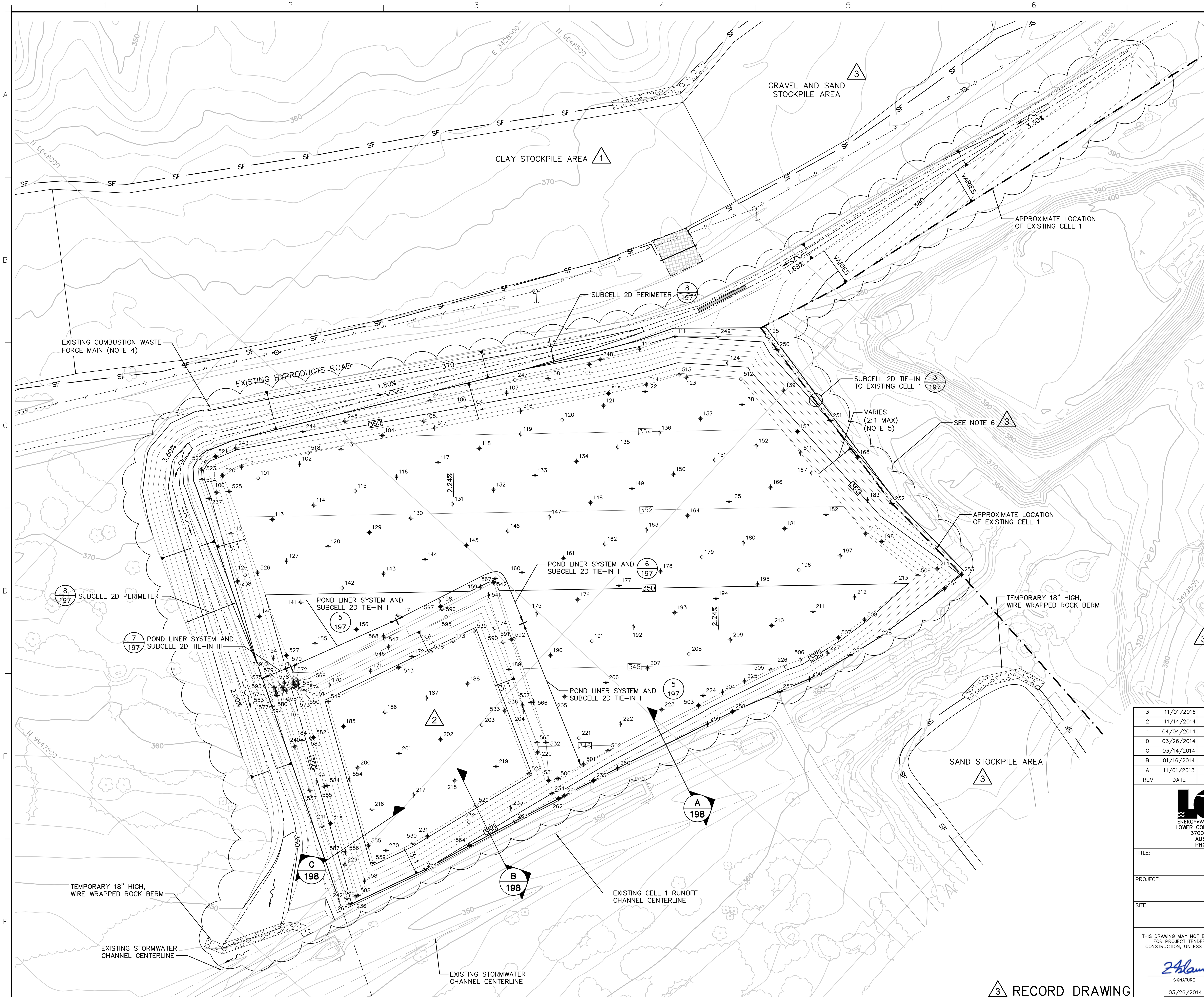
03/26/2014
DATE

STATE OF TEXAS
M. ZAHIRUL ISLAM
109989
LICENSED PROFESSIONAL ENGINEER

DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-193
REVIEWED BY:	BG / TL	DRAWING NO.:	B-C-00G-193
APPROVED BY:	MZI		

2 RECORD DRAWING

DRAWING: P:\CADD\Projects\F\Fayette Power Plant\CONSTRUCTION\SUBCELL 2D TEMP OP (TXL0225)\DRAWINGS\B-C-00G-193.dwg PLOTTED: Nov 01, 2016 - 3:40pm



LEGEND

Symbol	Description
390	EXISTING GROUND ELEVATION CONTOUR (FT, MSL)
	EXISTING ROAD
	EXISTING VEGETATION / TREE
N 9948500 / E 3429000	COORDINATE GRID
	EXISTING LIMIT OF LANDFILL
	EXISTING COMBUSTION WASTE FORCE MAIN
P	EXISTING POWER POLE AND OVERHEAD POWER LINE
650	PROPOSED TOP OF SUBGRADE ELEVATION CONTOUR (FT, MSL)(NOTES 2,3)
650	PROPOSED FINISHED GRADE ELEVATION CONTOUR OUTSIDE OF LINED AREA (FT, MSL)(NOTES 2,3)
	DRAINAGE CHANNEL
123	CONSTRUCTION CONTROL POINT

NOTES:

1. EXISTING CONDITIONS TAKEN FROM DRAWING B-C-00G-192.
2. CONTRACTOR TO FOLLOW CONSTRUCTION NOTES ON DRAWING B-C-00G-193.
3. PROPOSED GROUND CONTOURS CORRESPOND TO TOP OF SUBGRADE (BOTTOM OF CLAY LINER) ELEVATION. CONTOURS ARE SHOWN FOR ILLUSTRATIVE PURPOSES, CONTRACTOR SHALL USE CONTROL POINTS FOR CONSTRUCTION.
4. EXISTING COMBUSTION WASTE FORCE MAIN TO BE LOCATED AND MAINTAINED BY CONTRACTOR DURING CONSTRUCTION. THE FORCEMAIN TO BE FUNCTIONAL DURING CONSTRUCTION.
5. CONTRACTOR TO FIELD LOCATE AND TIE INTO THE EXISTING LINER, KEEPING THE TOE OF THE SUBCELL 2D STORAGE AREA SLOPE FIXED.
6. (3) CONSTRUCTION WAS CONDUCTED WITHIN THE CONSTRUCTION TOLERANCE NOTED ON DRAWINGS B-C-00G-196 AND B-C-00G-201.

SCALE IN FEET: 0 50' 100'

REV	DATE	DESCRIPTION	DRN	APP
3	11/01/2016	ISSUE FOR RECORD	JJV	MZI
2	11/14/2014	REVISION TO POND SUBGRADE GRADING	JJV	MZI
1	04/04/2014	REVISION TO CLAY STOCKPILE AREA, SILT FENCE LOCATION, AND ADD ROCK BERM	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

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PHONE: 512.451.4003

TITLE: TOP OF SUBGRADE GRADING PLAN

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

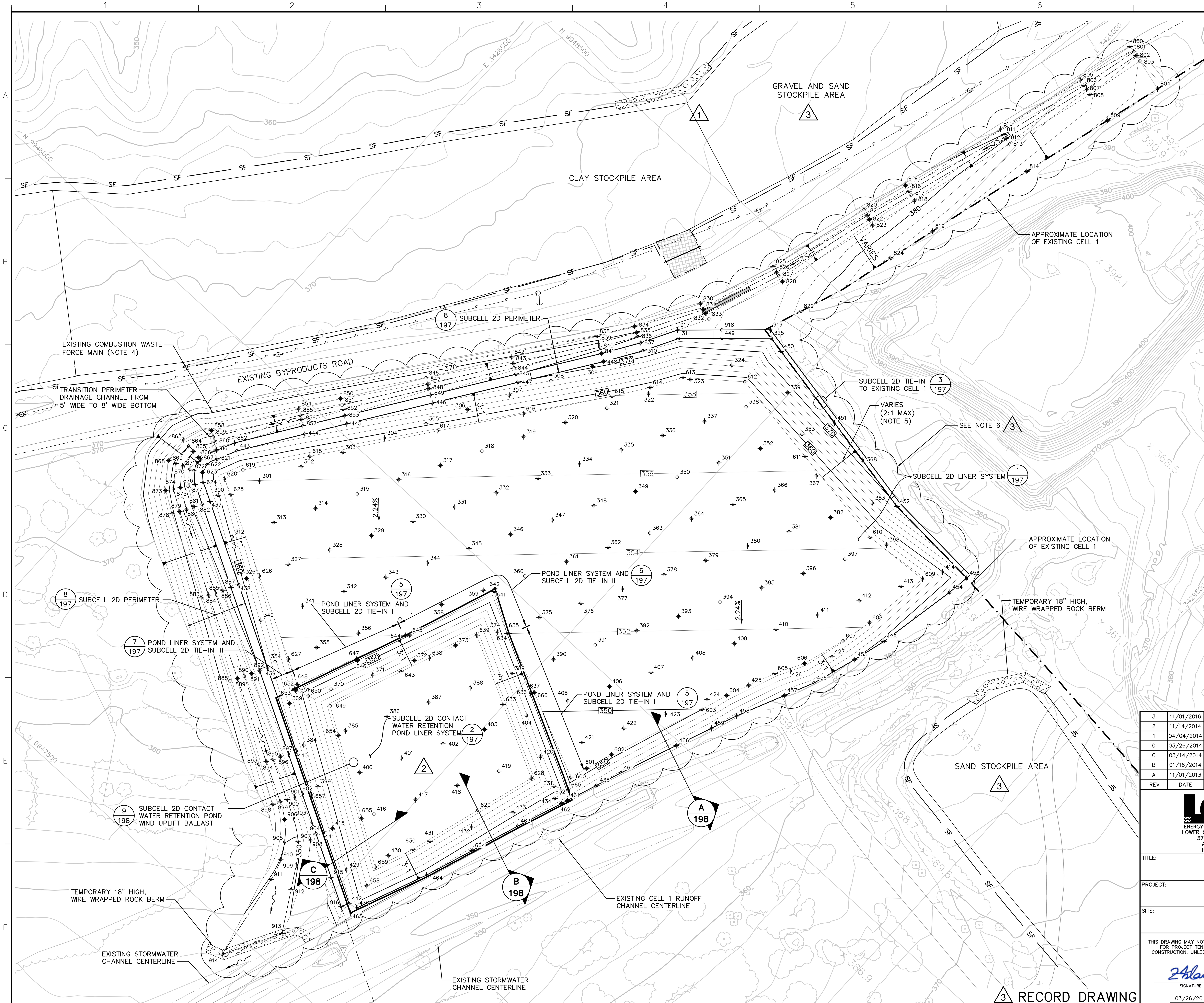
SIGNATURE

03/26/2014
DATE

STATE OF TEXAS — M. ZAHIRUL ISLAM — 109989 — LICENSED PROFESSIONAL ENGINEER

DESIGN BY: MZI		DATE:	MARCH 2014
DRAWN BY: JJV / KH		PROJECT NO.:	TXL0225.04
CHECKED BY: MZI / TL		FILE:	B-C-00G-194
REVIEWED BY: BG / TL		DRAWING NO.:	
APPROVED BY: MZI			B-C-00G-194

(3) RECORD DRAWING



LEGEND

390	EXISTING GROUND ELEVATION CONTOUR (FT, MSL)(NOTE 1)
	EXISTING ROAD
	EXISTING VEGETATION / TREE
N 9948500 E 3429000	COORDINATE GRID (NOTE 2)
P	EXISTING POWER POLE AND OVERHEAD POWER LINE
	EXISTING LIMIT OF LANDFILL
	EXISTING COMBUSTION WASTE FORCE MAIN
650	PROPOSED TOP OF CLAY ELEVATION CONTOUR (FT, MSL)(NOTES 2,3)
650	PROPOSED FINISHED GRADE ELEVATION CONTOUR OUTSIDE OF LINED AREA (FT, MSL)(NOTES 2,3)
	LIMIT OF GEOMEMBRANE LINER
	DRAINAGE CHANNEL
364	CONSTRUCTION CONTROL POINT

NOTES:

1. EXISTING CONDITIONS TAKEN FROM DRAWING B-C-00G-192.
2. CONTRACTOR TO FOLLOW CONSTRUCTION NOTES ON DRAWING B-C-00G-193.
3. PROPOSED GROUND CONTOURS CORRESPOND TO TOP OF OF CLAY LINER ELEVATION. CONTOURS ARE SHOWN FOR ILLUSTRATIVE PURPOSES, CONTRACTOR SHALL USE CONTROL POINTS FOR CONSTRUCTION.
4. EXISTING COMBUSTION WASTE FORCE MAIN TO BE LOCATED AND MAINTAINED BY CONTRACTOR DURING CONSTRUCTION. THE FORCE MAIN TO BE FUNCTIONAL DURING CONSTRUCTION.
5. CONTRACTOR TO FIELD LOCATE AND TIE INTO THE EXISTING LINER, KEEPING THE TOE OF THE SUBCELL 2D STORAGE AREA SLOPE FIXED.
6. (3) CONSTRUCTION WAS CONDUCTED WITHIN THE CONSTRUCTION TOLERANCE NOTED ON DRAWINGS B-C-00G-196 AND B-C-00G-201.

0 50' 100'
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
3	11/01/2016	ISSUE FOR RECORD	JJV	MZI
2	11/14/2014	REVISION TO TOP OF CLAY POND GRADING	JJV	MZI
1	04/04/2014	REVISION TO CLAY STOCKPILE AREA, SILT FENCE LOCATION, AND ADD ROCK BERM	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

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TITLE: TOP OF CLAY GRADING PLAN

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

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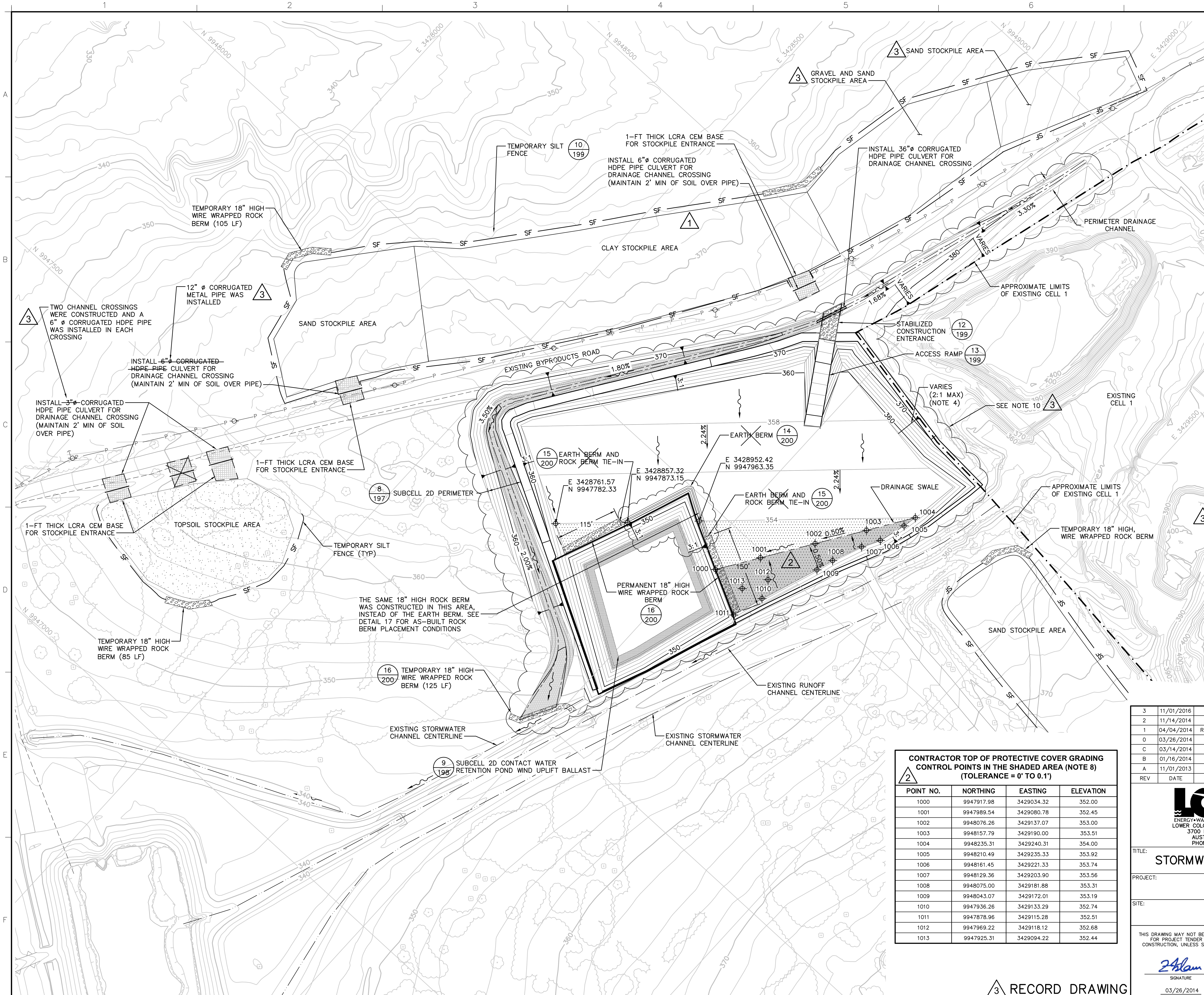
03/26/2014
DATE

STATE OF TEXAS — M. ZAHIRUL ISLAM — 109989 — LICENSED PROFESSIONAL ENGINEER

DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-195
REVIEWED BY:	BG / TL	DRAWING NO.:	B-C-00G-195
APPROVED BY:	MZI		

(3) RECORD DRAWING

DRAWING: P:\CADD\Projects\F\Fayette power plant\construction\subcell 2d temp op (tx0225)\DRAWINGS\B-C-00G-195.dwg PLOTTED: Nov 01, 2016 - 11:33am



NOTES:

1. EXISTING CONDITIONS TAKEN FROM DRAWING B-C-OOG-192.
2. CONTRACTOR TO FOLLOW CONSTRUCTION NOTES ON DRAWING B-C-OOG-193.
3. LANDFILL OPERATOR TO CLEAN SEDIMENT AND DEBRIS (IF ACCUMULATED) FROM THE UPSTREAM SIDE OF THE ROCK BERMS.
4. CONTRACTOR TO FIELD LOCATE AND TIE INTO THE EXISTING LINER, KEEPING THE TOE OF THE SUBCELL 2D STORAGE AREA SLOPE FIXED.
5. CONTRACTOR TO MAINTAIN SILT FENCES AS NEEDED DURING AND AFTER CONSTRUCTION.
6. CONTRACTOR TO CONSTRUCT TEMPORARY ACCESS ROADS TO AND ON STOCKPILES AS NEEDED.
7. DURING CONSTRUCTION, DISCHARGE OF PONDED WATER SHALL NOT OCCUR DURING OR IMMEDIATELY AFTER PRECIPITATION EVENTS, TO PROVIDE TIME FOR SEDIMENT TO SETTLE. CONTRACTOR TO PLACE DISCHARGE PUMP INTAKE HOSES ON A FLOTATION OR SIMILAR DEVICE IN A MANNER TO AVOID DISTURBING SEDIMENT THAT HAS SETTLED ON THE BOTTOM OF THE EXCAVATION. DISCHARGE FROM DEWATERING OPERATIONS MUST BE DIRECTED THROUGH AN APPROPRIATE SEDIMENT CONTROL MEASURE SUCH AS FILTER BAG OR SEDIMENT TRAP, AS NEEDED.
8. REFER TO DRAWING B-C-00G-201 FOR PROTECTIVE COVER GRADING CONTROL POINTS OVER THE REMAINING AREA.
9. USE SOIL (e.g., CLAY OR SAND) AS PROTECTIVE COVER IN THE REMAINING AREA.
10. (3) CONSTRUCTION WAS CONDUCTED WITHIN THE CONSTRUCTION TOLERANCE NOTED ON DRAWINGS B-C-00G-196 AND B-C-00G-201.

CONSTRUCTION SEQUENCE:

1. INSTALL ROCK BERMS AND SILT FENCES FOR STOCKPILE AREAS AND INSTALL ROCK BERM AT END OF PERIMETER DRAINAGE CHANNEL. CONSTRUCT AND INSTALL STABILIZED CONSTRUCTION ENTRANCE AND PIPE CULVERT FOR DRAINAGE CROSSING.
2. STRIP TOPSOIL FROM SAND AND CLAY STOCKPILE AREAS.
3. CONSTRUCT PERIMETER DRAINAGE CHANNEL TO FINAL GRADE.
4. SEED PERIMETER DRAINAGE CHANNEL PER REVEGETATION SPECIFICATION AND INSTALL TURF REINFORCEMENT MAT (TRM) PER MANUFACTURER'S SPECIFICATIONS.
5. CLEAR AND GRUB SUBCELL 2D AREA. IMMEDIATELY BEGIN EXCAVATION OF SUBCELL 2D.
6. STABILIZE ALL STOCKPILES WITH TEMPORARY SEEDING AND MULCHING.

CONTRACTOR TOP OF PROTECTIVE COVER GRADING CONTROL POINTS IN THE SHADED AREA (NOTE 8) (TOLERANCE = 0' TO 0.1') (2)

POINT NO.	NORTHING	EASTING	ELEVATION
1000	9947917.98	3429034.32	352.00
1001	9947989.54	3429080.78	352.45
1002	9948076.26	3429137.07	353.00
1003	9948157.79	3429190.00	353.51
1004	9948235.31	3429240.31	354.00
1005	9948210.49	3429235.33	353.92
1006	9948161.45	3429221.33	353.74
1007	9948129.36	3429203.90	353.56
1008	9948075.00	3429181.88	353.31
1009	9948043.07	3429172.01	353.19
1010	9947936.26	3429133.29	352.74
1011	9947878.96	3429115.28	352.51
1012	9947969.22	3429118.12	352.68
1013	9947925.31	3429094.22	352.44

(3) RECORD DRAWING

REV	DATE	DESCRIPTION	DRN	APP
3	11/01/2016	ISSUE FOR RECORD	JJV	MZI
2	11/14/2014	REVISION TO POND, PROTECTIVE COVER GRADING, AND BERMS	JJV	MZI
1	04/04/2014	REVISION TO CLAY STOCKPILE AREA, SILT FENCE LOCATION, AND ADD ROCK BERM	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

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TITLE: STORMWATER MANAGEMENT AND OPERATIONS PLAN

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

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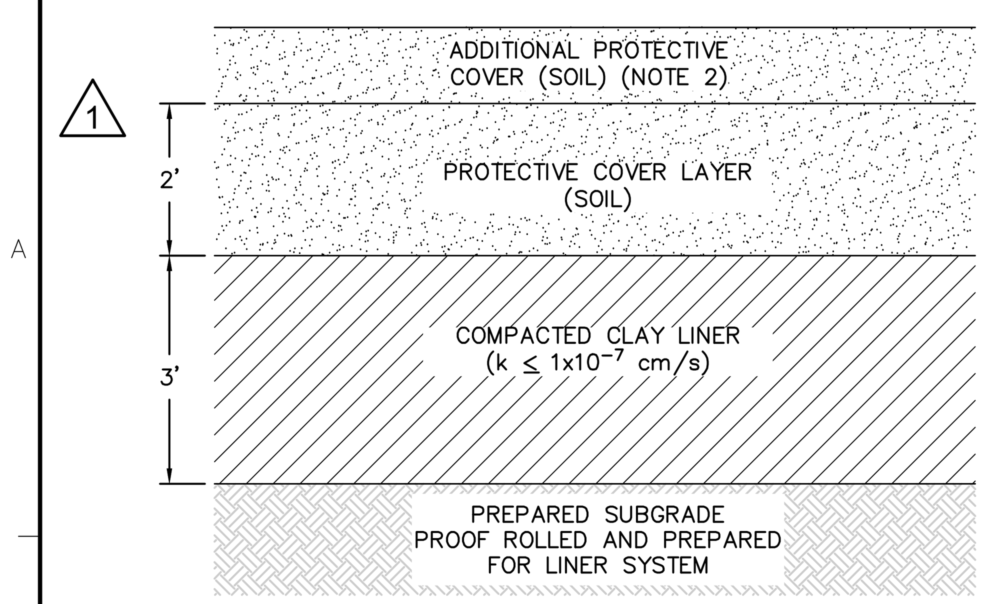
SIGNATURE

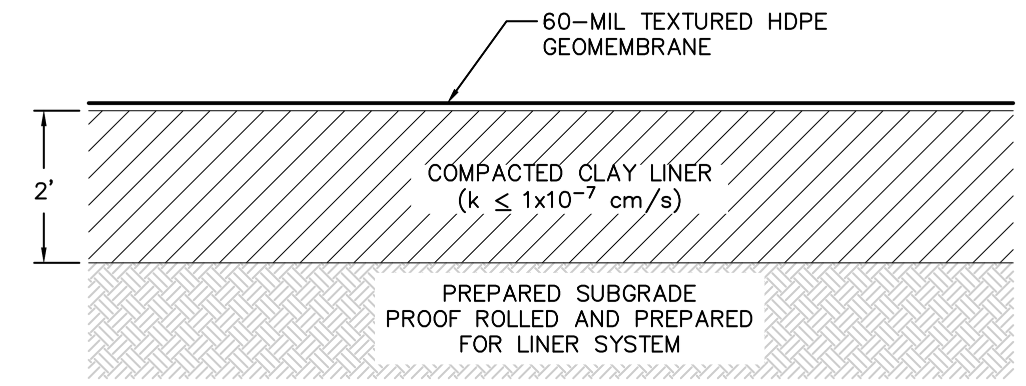
03/26/2014
DATE

STATE OF TEXAS — M. ZAHIRUL ISLAM — 109989 — LICENSED PROFESSIONAL ENGINEER

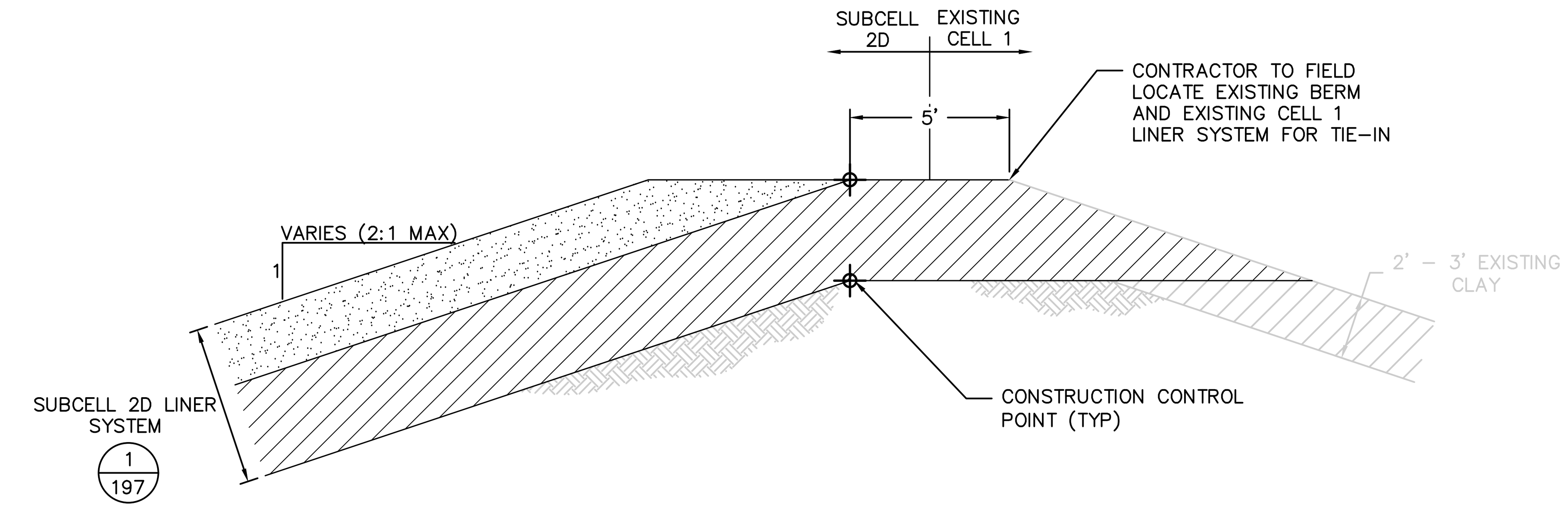
DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-196
REVIEWED BY:	BG / TL	DRAWING NO.:	B-C-00G-196
APPROVED BY:	MZI		



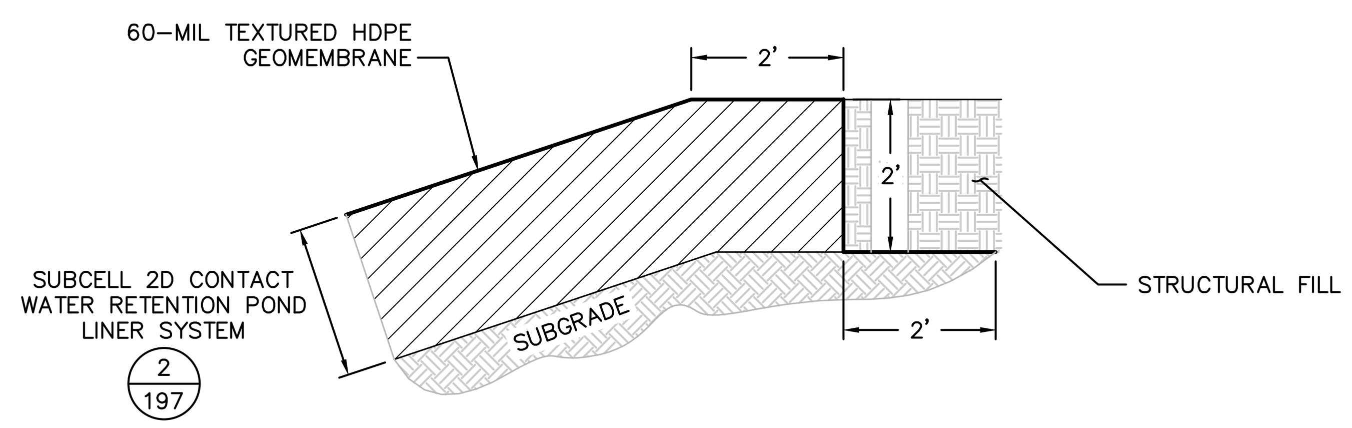
1 / 195 DETAIL
SUBCELL 2D LINER SYSTEM
SCALE: 1" = 2'
0 2' 4' SCALE IN FEET



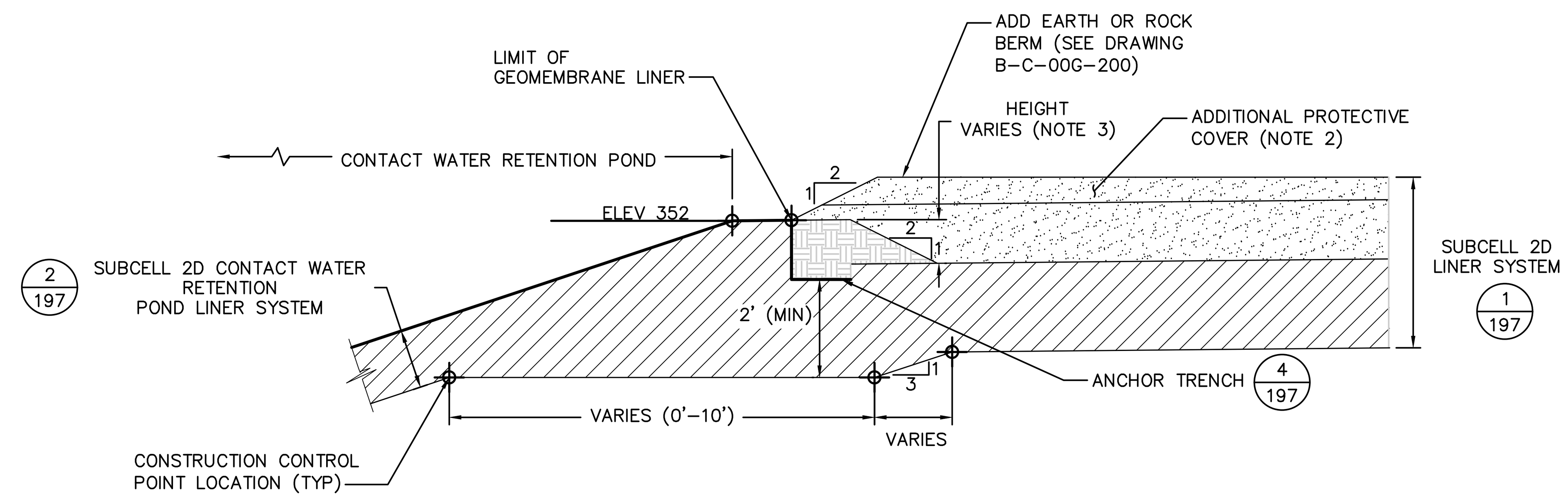
2 / 195 DETAIL
SUBCELL 2D CONTACT WATER RETENTION POND LINER SYSTEM
SCALE: 1" = 2'
0 2' 4' SCALE IN FEET



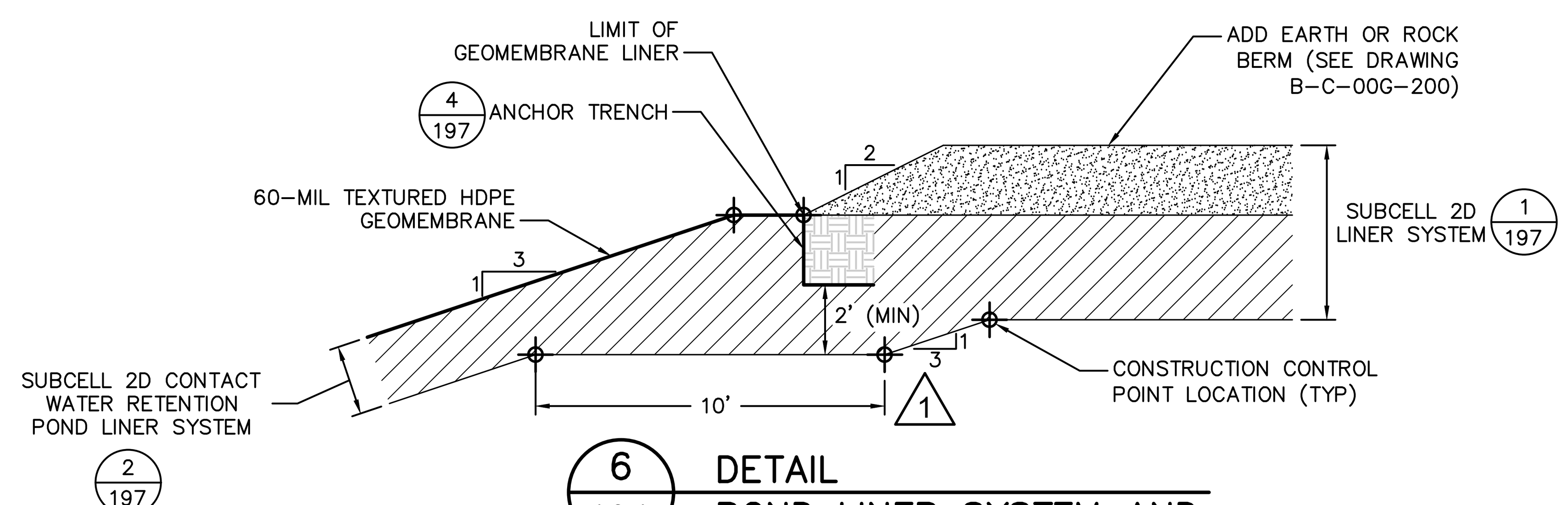
3 / 194 DETAIL
SUBCELL 2D TIE-IN TO EXISTING CELL 1
SCALE: 1" = 4'
0 4' 8' SCALE IN FEET



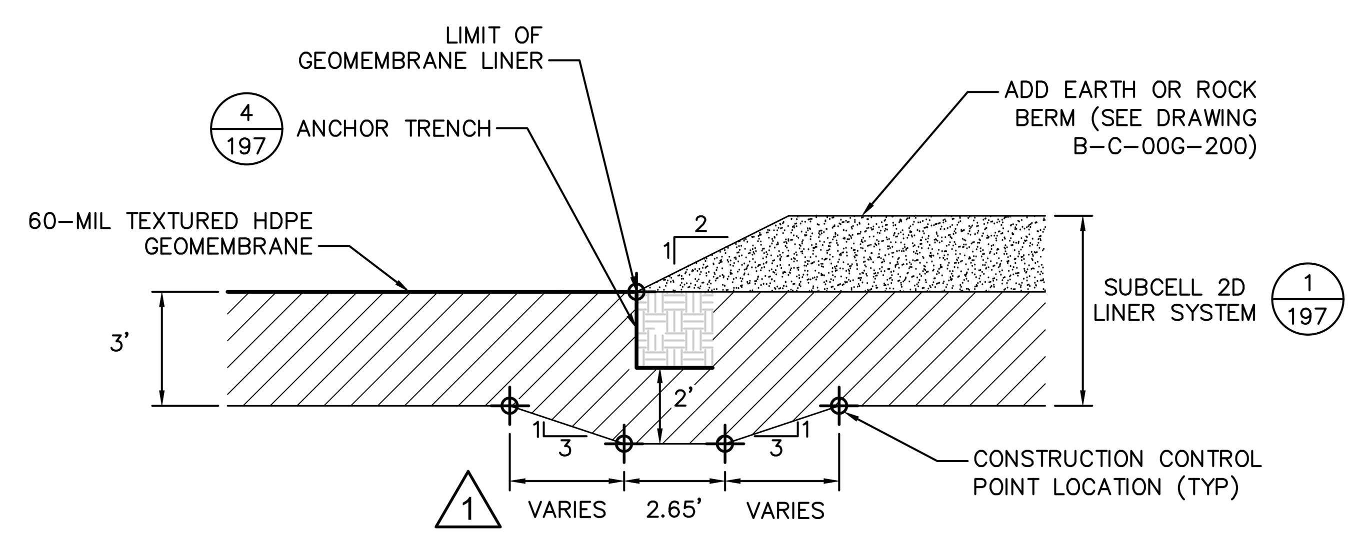
4 / 197 DETAIL
ANCHOR TRENCH
SCALE: 1" = 2'
0 2' 4' SCALE IN FEET



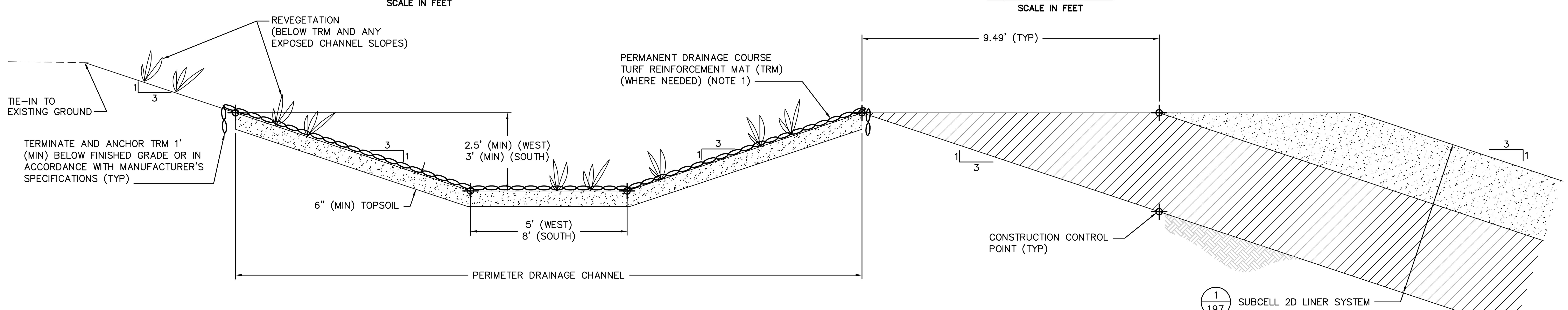
1 5 / 194 DETAIL
POND LINER SYSTEM AND SUBCELL 2D TIE-IN I
SCALE: 1" = 4'
0 4' 8' SCALE IN FEET



6 / 194 DETAIL
POND LINER SYSTEM AND SUBCELL 2D TIE-IN II
SCALE: 1" = 4'
0 4' 8' SCALE IN FEET



7 / 194 DETAIL
POND LINER SYSTEM AND SUBCELL 2D TIE-IN III
SCALE: 1" = 4'
0 4' 8' SCALE IN FEET



8 / 194 DETAIL
SUBCELL 2D PERIMETER
SCALE: 1" = 2'
0 2' 4' SCALE IN FEET

1 NOTES:

1. TURF REINFORCEMENT MAT (TRM) SHALL BE PERMANENT (I.E., LONG-TERM) SYNTHETIC MATERIALS THAT ALLOW GRASS VEGETATION TO BECOME ESTABLISHED AND ENHANCE THE ABILITY OF GRASS VEGETATION TO STABILIZE SOILS. THE TRM SHOULD HAVE A MINIMUM RESISTANCE TO TRACTIVE STRESS OF 1.16 psf.
2. ADDITIONAL PROTECTIVE COVER TO BE PLACED BY THE LANDFILL OPERATOR WHERE SHOWN ON DRAWING B-C-006-196 TO CONVEY CONTACT WATER TOWARD AND INTO THE CONTACT WATER RETENTION POND.
3. HEIGHT VARIES TO ACHIEVE 11' DEPTH IN CONTACT WATER RETENTION POND (POND ELEVATIONS: TOP=352 FT, MSL AND BOTTOM=341 FT, MSL).

REV	DATE	DESCRIPTION	DRN	APP
2	11/01/2016	ISSUE FOR RECORD	JJV	MZI
1	11/14/2014	REVISION TO DETAILS 1, 5, 6, & 7	JJV	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

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PHONE: 512.451.4003

TITLE: LINER SYSTEM DETAILS I

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

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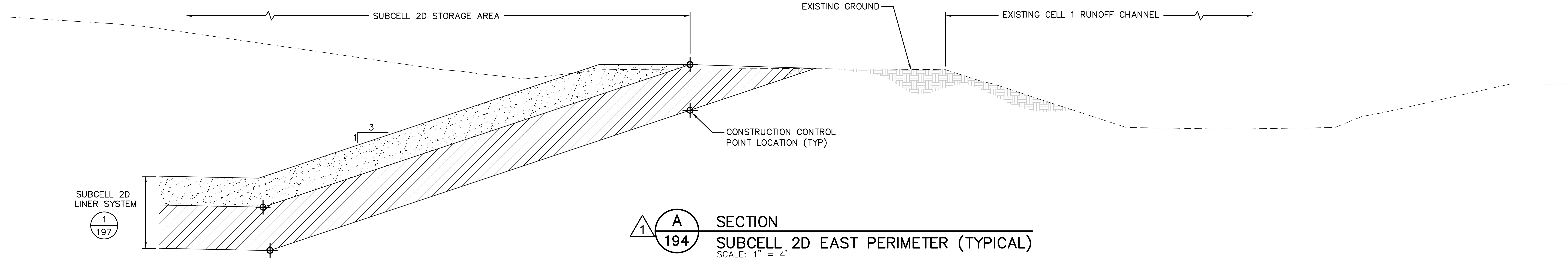
[signature]
SIGNATURE
03/26/2014
DATE

STATE OF TEXAS
M. ZAHIRUL ISLAM
109989
LICENSED PROFESSIONAL ENGINEER

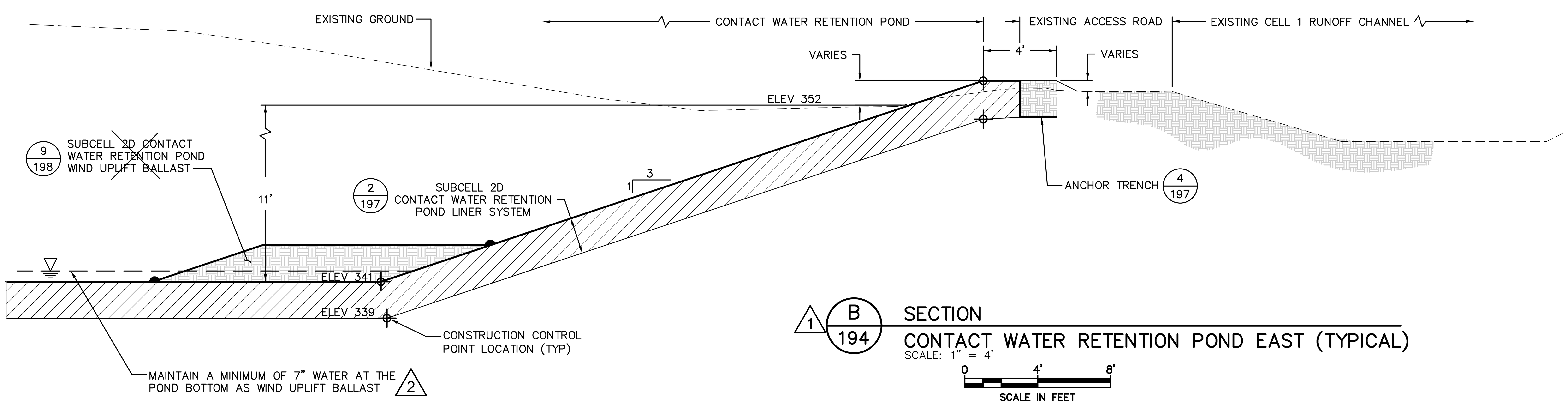
DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-197
REVIEWED BY:	BG / TL	DRAWING NO.:	B-C-00G-197
APPROVED BY:	MZI		

2 RECORD DRAWING

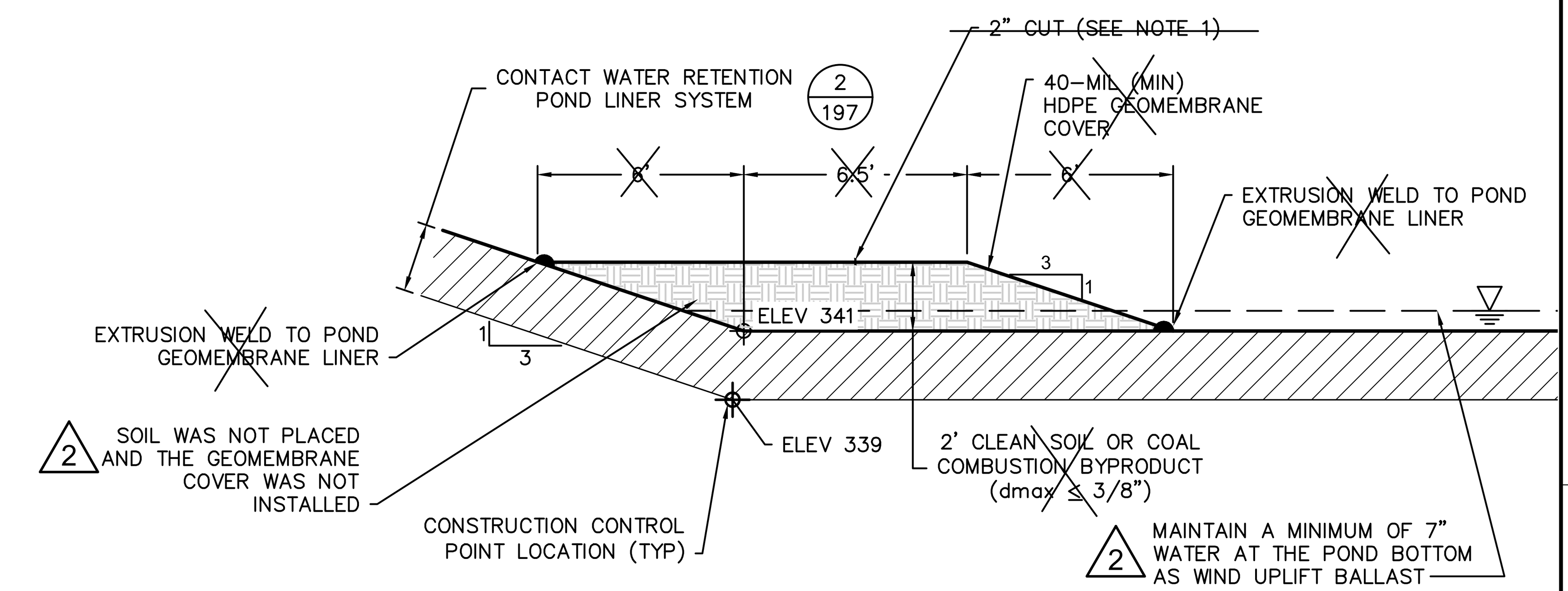
DRAWING: P:\CADD\Projects\F\fayette power plant\construction\subcell 2d temp op (tx0225)\DRAWINGS\B-C-00G-197.dwg PLOTTED: Nov 01, 2016 – 11:35am



1 A/194 SECTION
SUBCELL 2D EAST PERIMETER (TYPICAL)
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET



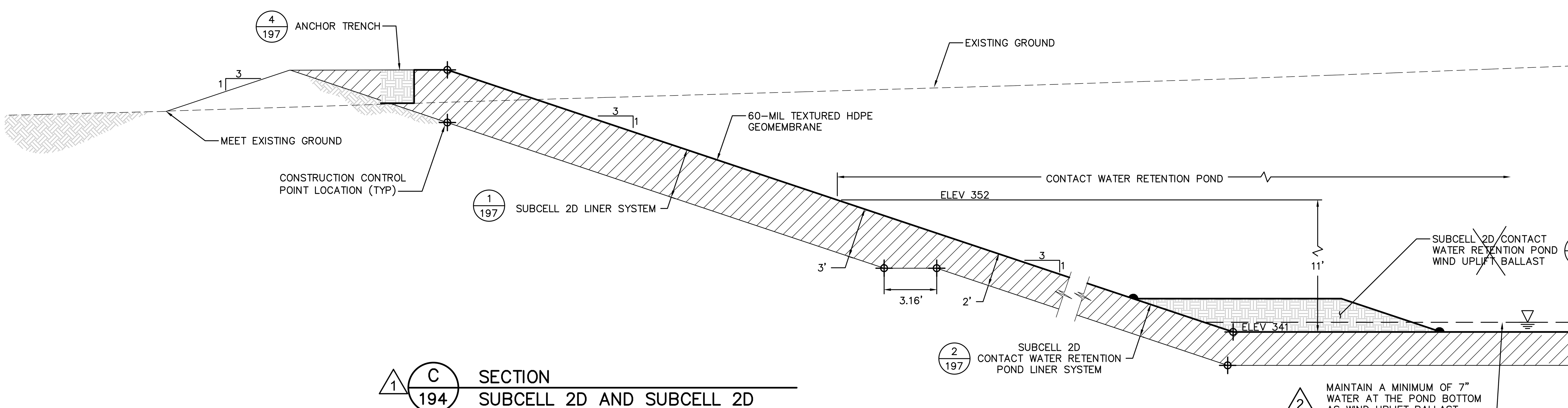
1 B/194 SECTION
CONTACT WATER RETENTION POND EAST (TYPICAL)
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET



1 9/196 DETAIL
SUBCELL 2D CONTACT WATER RETENTION POND WIND UPLIFT BALLAST
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET

NOTE:

1. CUT APPROXIMATELY 2" AT EVERY 10' IN THE MIDDLE OF THE GEOMEMBRANE COVER FOR RELEASING ENTRAPPED AIR WHEN UNDER WATER.



1 C/194 SECTION
SUBCELL 2D AND SUBCELL 2D CONTACT WATER RETENTION POND LINER TIE-IN SOUTH (TYPICAL)
SCALE: 1" = 4'
0 4' 8'
SCALE IN FEET

2 RECORD DRAWING

REV	DATE	DESCRIPTION	DRN	APP
2	11/01/2016	ISSUE FOR RECORD	JJV/KH	MZI
1	11/14/2014	REVISIONS TO DETAILS	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
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A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

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AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: LINER SYSTEM DETAILS II

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

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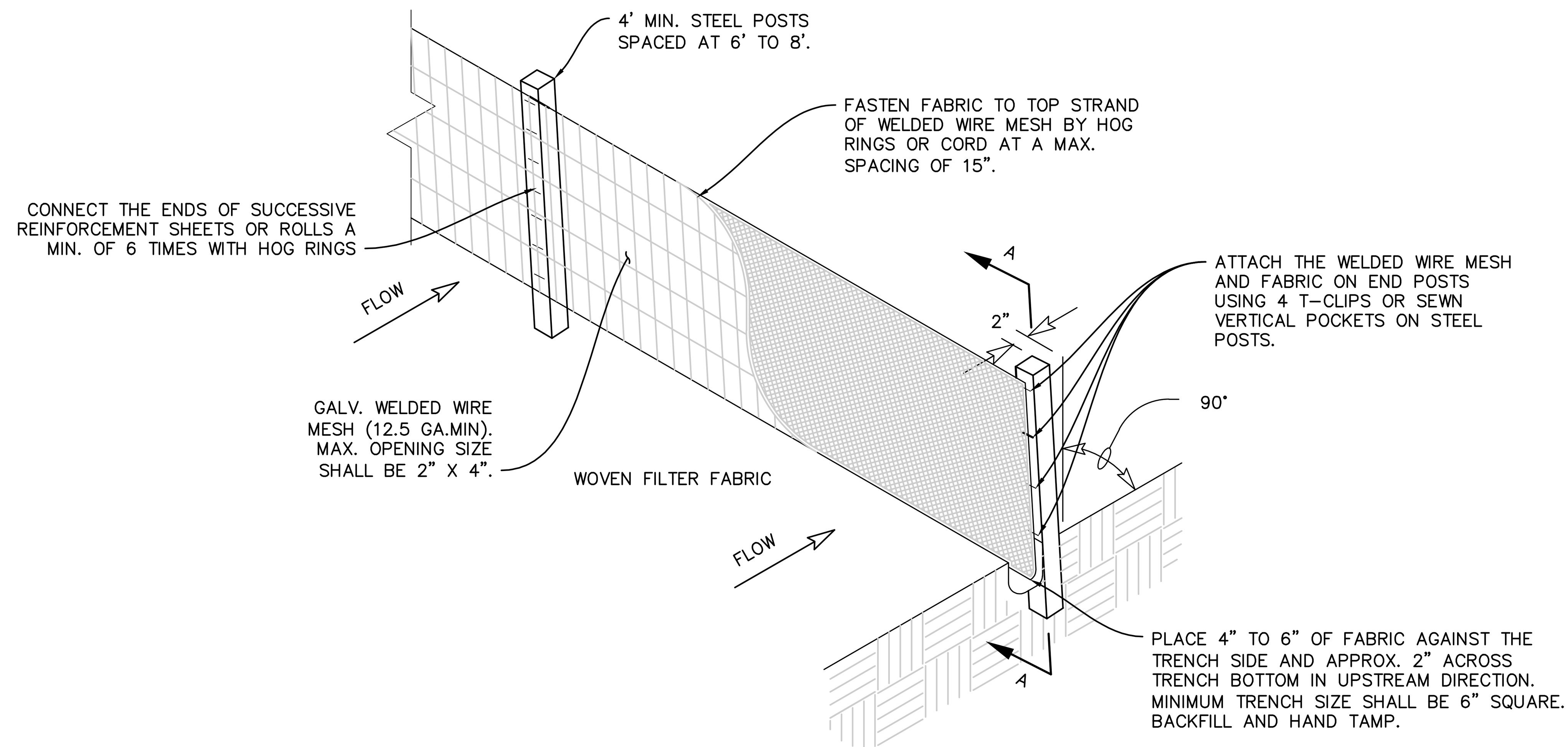
SIGNATURE

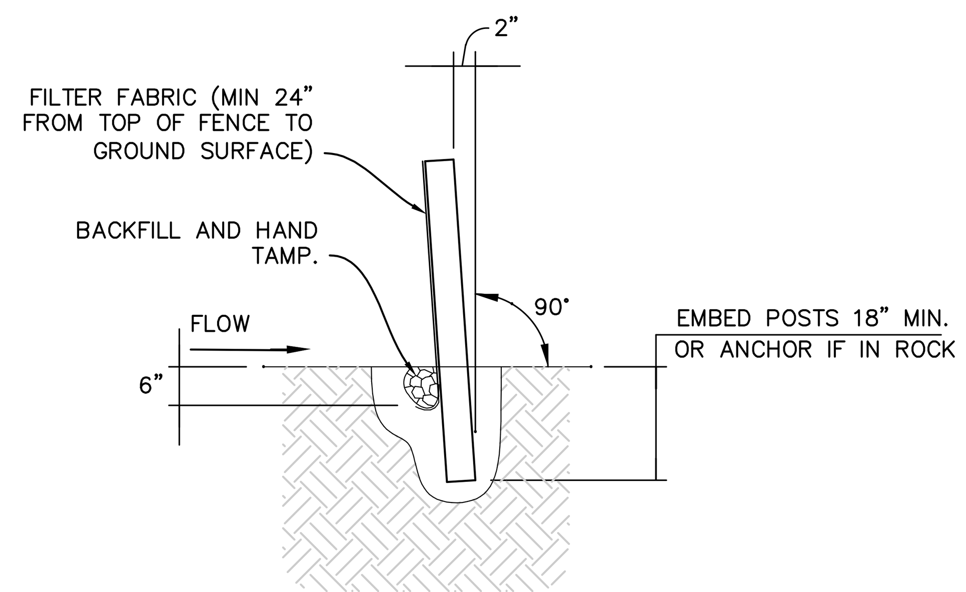
03/26/2014
DATE

STATE OF TEXAS
M. ZAHIRUL ISLAM
109989
LICENSED PROFESSIONAL ENGINEER

DESIGN BY: MZI		DATE:	MARCH 2014
DRAWN BY: JJV / KH		PROJECT NO.:	TXL0225.04
CHECKED BY: MZI / TL		FILE:	B-C-00G-198
REVIEWED BY: BG / TL		DRAWING NO.:	
APPROVED BY: MZI			B-C-00G-198

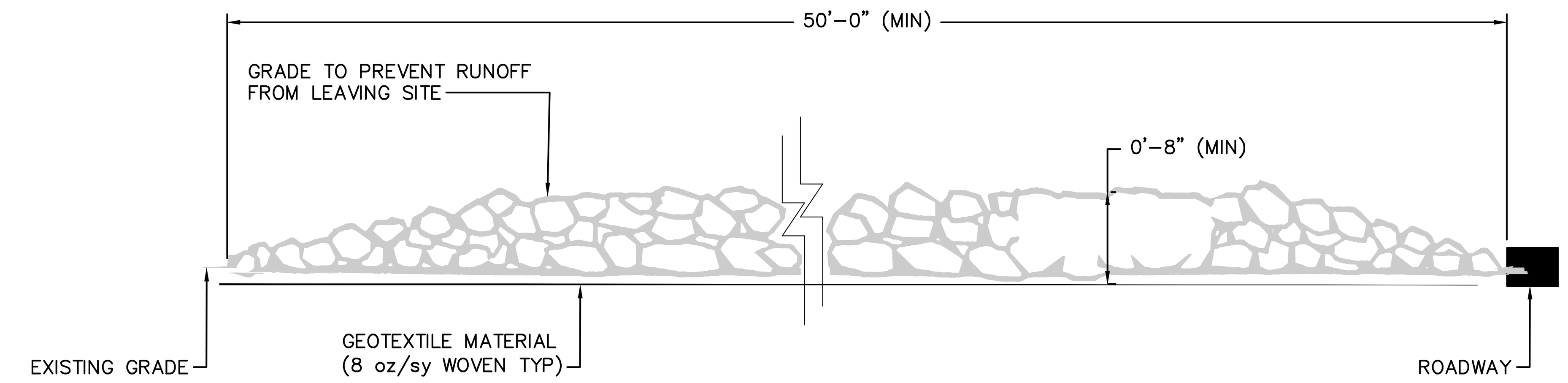
DRAWING: P:\CADD\Projects\F\fayette power plant\construction\subcell 2d temp op (tx0225)\DRAWINGS\B-C-00G-198.dwg PLOTTED: Nov 01, 2016 - 1:05pm



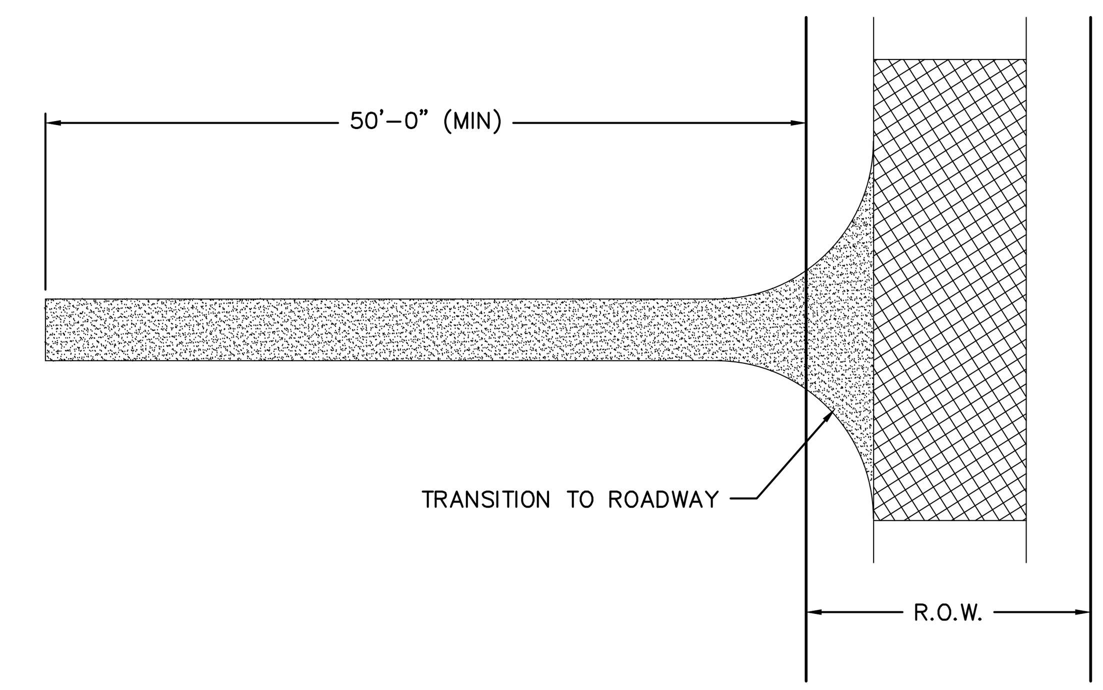


SECTION A–A

10 / 196 DETAIL
TEMPORARY SILT FENCE
SCALE: N.T.S.

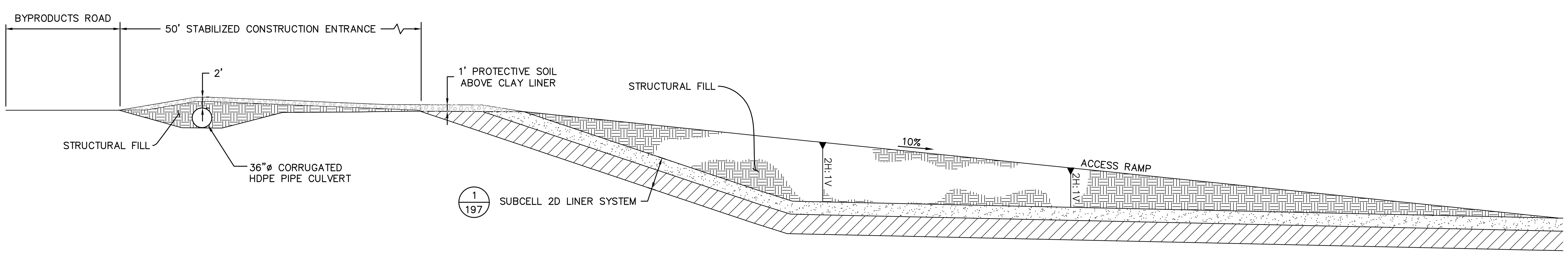


PROFILE



PLAN VIEW

12 / 199 DETAIL
STABILIZED CONSTRUCTION ENTERANCE
SCALE: N.T.S.
XREF: B-C-00G-199.DWG



13 / 196 DETAIL
ACCESS ROAD
SCALE: 1" = 10'
XREF: B-C-00G-199.DWG

1 RECORD DRAWING

REV	DATE	DESCRIPTION	DRN	APP
1	11/01/2016	ISSUE FOR RECORD	JJV	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

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TEXAS ENG. FIRM REGISTRATION NO. 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: STORMWATER MANAGEMENT AND OPERATION DETAILS I

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

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SIGNATURE
03/26/2014
DATE

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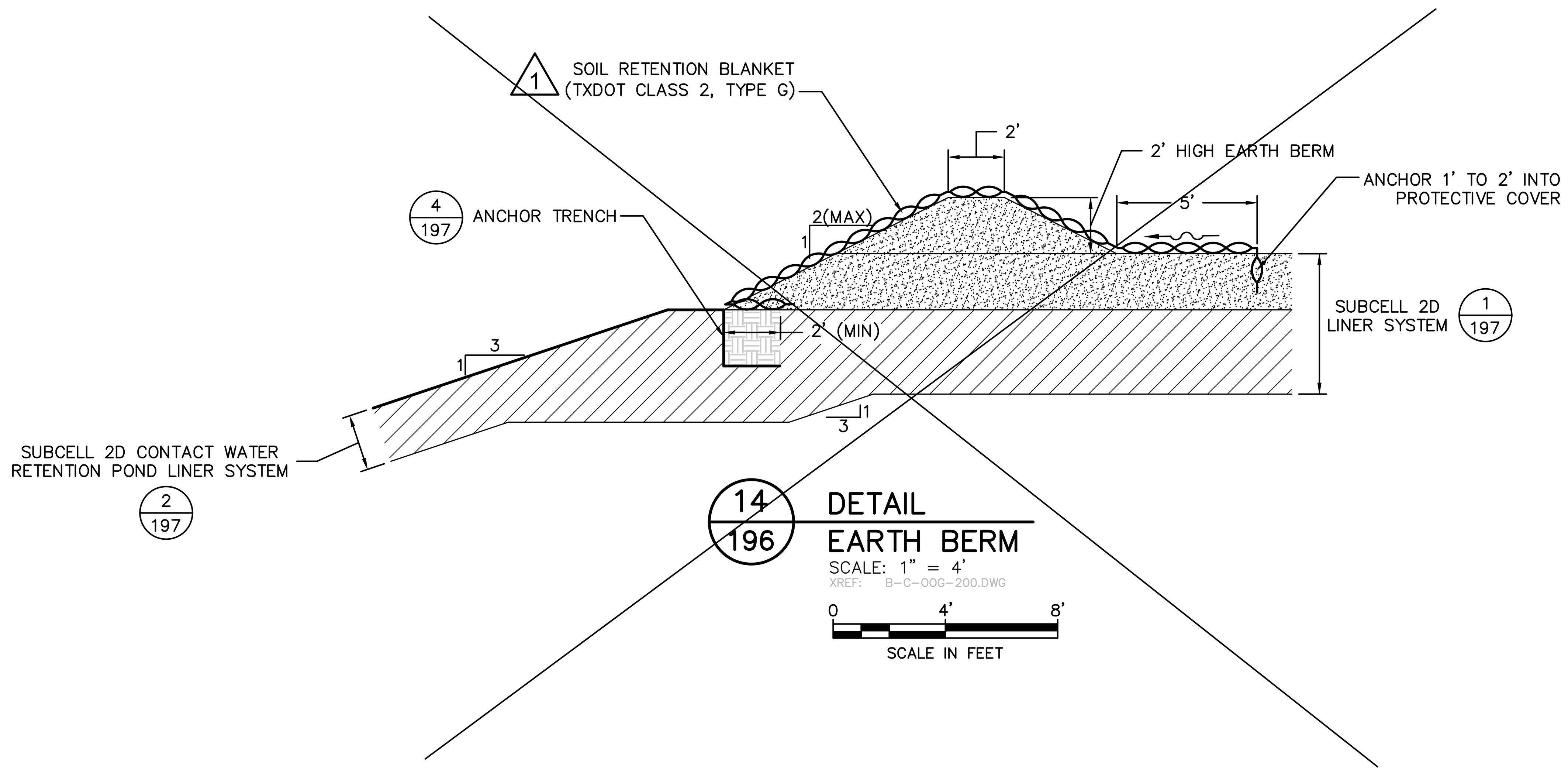
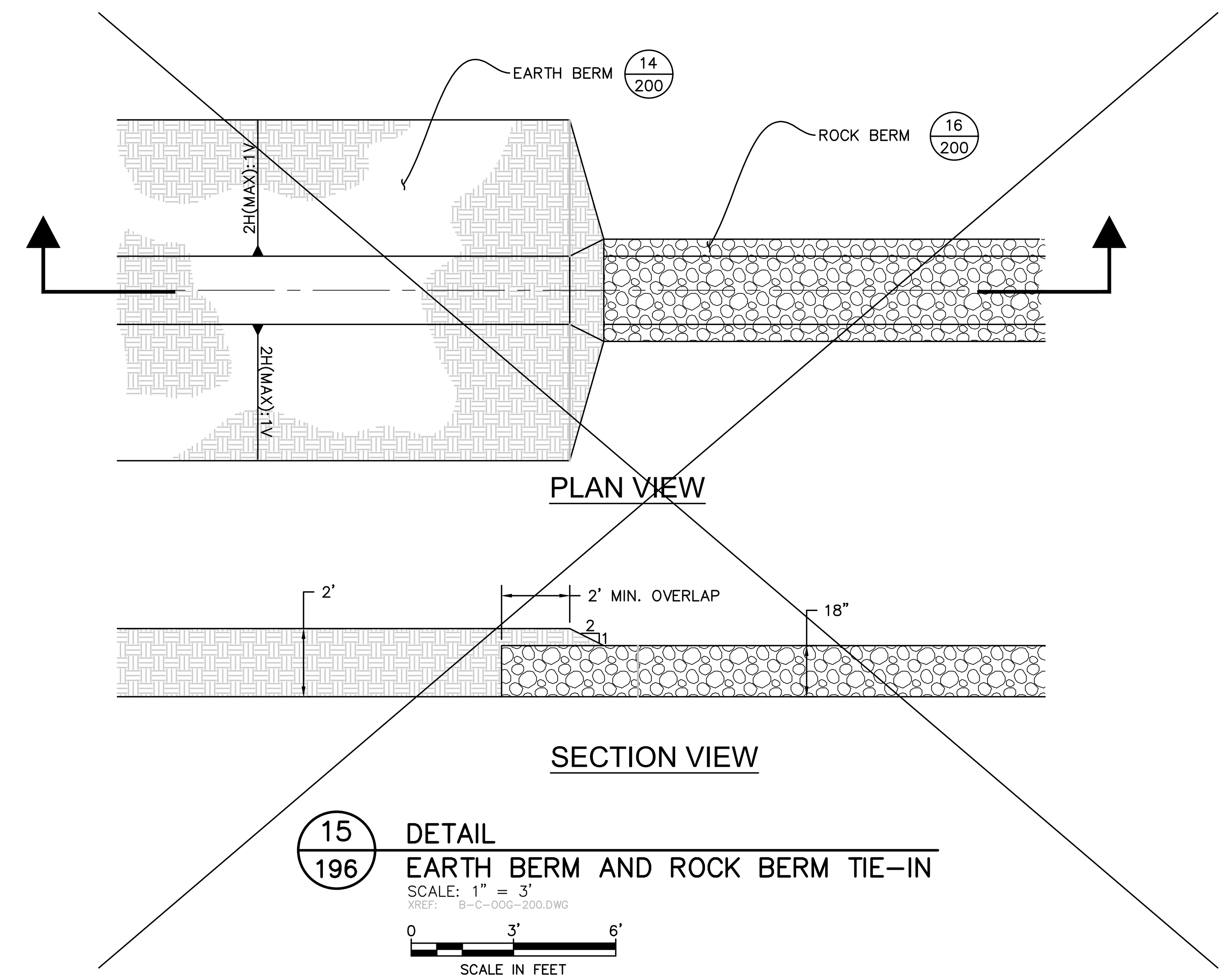
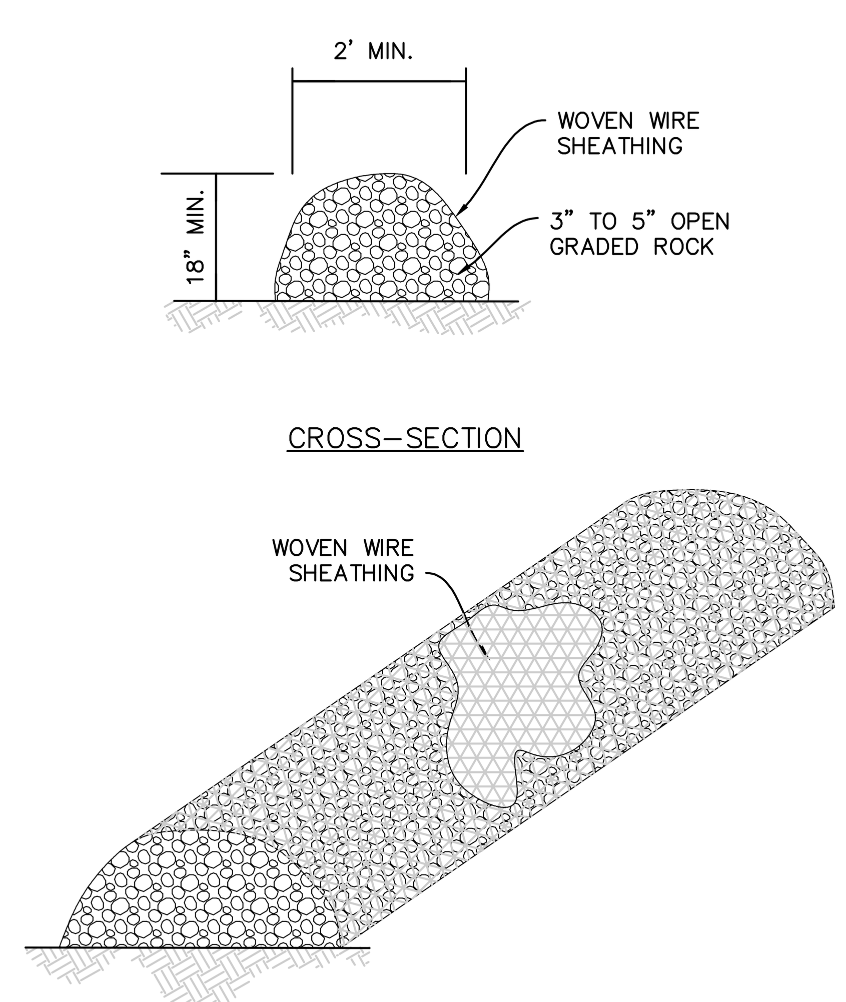
DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-199
REVIEWED BY:	BG / TL	DRAWING NO.:	
APPROVED BY:	MZI		B-C-00G-199



14 / 196 DETAIL
EARTH BERM
SCALE: 1" = 4'
XREF: B-C-00G-200.DWG
0 4' 8'
SCALE IN FEET



15 / 196 DETAIL
EARTH BERM AND ROCK BERM TIE–IN
SCALE: 1" = 3'
XREF: B-C-00G-200.DWG
0 3' 6'
SCALE IN FEET



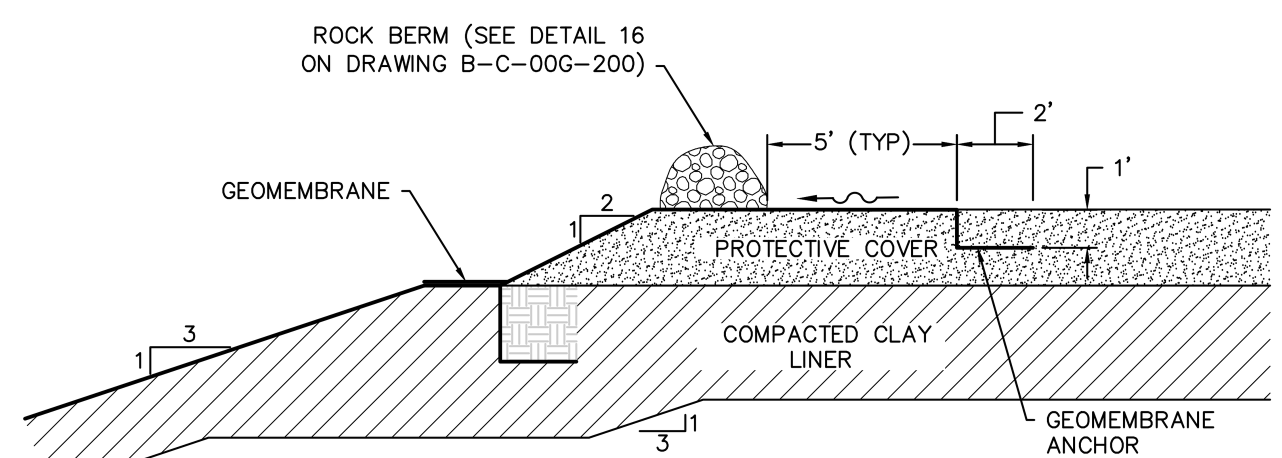
16 / 196 DETAIL
ROCK BERM
SCALE: N.T.S.
(SEE DETAIL 17 FOR AS–BUILT ROCK BERM PLACEMENT CONDITIONS) 2

MATERIAL SPECIFICATIONS

THE ROCK BERM SHALL BE CONSTRUCTED OF CLEAN OPEN GRADED 3 – 5 INCH DIAMETER ROCK. THE WIRE SHEATHING SHALL BE MINIMUM 20 GAUGE WOVEN WIRE MESH WITH 1 INCH OPENINGS.

BERM LOCATION

–SEE GRADING LAYOUT FOR BERM LOCATION
–RELOCATE THE ROCK BERM AS NECESSARY TO AVOID UNNECESSARY CLEARING OF VEGETATION.
–CLEAR THE MINIMUM AREA OF DEBRIS, ROCKS OR PLANTS THAT WILL INTERFERE WITH INSTALLATION.
–PLACE WOVEN WIRE FABRIC ON THE GROUND ALONG THE PROPOSED INSTALLATION WITH ENOUGH OVERLAP TO COMPLETELY ENCIRCLE THE FINISHED SIZE OF THE BERM.



2 17 / 196 AS–BUILT ROCK BERM DETAIL
ROCK BERM PLACEMENT AT NORTH AND WEST POND PERIMETER
SCALE: N.T.S.

REV	DATE	DESCRIPTION	DRN	APP
2	11/01/2016	ISSUE FOR RECORD	JJV	MZI
1	11/14/2014	REVISION TO DETAIL 14	JJV/KH	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

LCRA
ENERGY•WATER•COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512.473.3200

Geosyntec consultants
GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM REGISTRATION NO. 1182
8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: STORMWATER MANAGEMENT AND OPERATION DETAILS I

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

03/26/2014
DATE

STATE OF TEXAS
M. ZAHIRUL ISLAM
109989
LICENSED
PROFESSIONAL ENGINEER

DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B–C–00G–200
REVIEWED BY:	BG / TL	DRAWING NO.:	B–C–00G–200
APPROVED BY:	MZI		

2 RECORD DRAWING

DRAWING: P:\CADD\Projects\F\Fayette Power Plant\CONSTRUCTION\SUBCELL 2D TEMP OP (TXL0225)\DRAWINGS\B–C–00G–200.dwg PLOTTED: Nov 01, 2016 – 3:48pm

△1 REQUIRED CQA SURVEYOR CERTIFICATION POINTS

SUBGRADE (TOLERANCE = 0' TO -0.2')				TOP OF CLAY LINER (TOLERANCE = 0' TO 0.1')	
POINT NO.	NORTHING	EASTING	ELEVATION	POINT NO.	ELEVATION
100	9947853.00	3428599.50	357.26	300	360.42
101	9947896.92	3428623.40	352.99	301	355.99
102	9947940.84	3428647.30	353.33	302	356.33
103	9947984.76	3428671.20	353.68	303	356.68
104	9948028.68	3428695.10	355.03	304	358.19
105	9948072.59	3428719.00	357.47	305	360.63
106	9948116.51	3428742.90	359.92	306	363.08
107	9948160.43	3428766.80	362.36	307	365.52
108	9948204.35	3428790.70	364.81	308	367.97
109	9948248.27	3428814.60	367.26	309	370.42
110	9948300.02	3428844.73	369.16	310	372.32
111	9948338.04	3428865.35	369.94	311	373.10
112	9947829.10	3428643.42	356.31	312	359.47
113	9947873.02	3428667.32	351.92	313	354.92
114	9947916.94	3428691.22	352.27	314	355.27
115	9947960.86	3428715.12	352.61	315	355.61
116	9948004.78	3428739.02	352.96	316	355.96
117	9948048.69	3428762.92	353.30	317	356.30
118	9948092.61	3428786.82	353.65	318	356.65
119	9948136.53	3428810.72	353.99	319	356.99
120	9948180.45	3428834.62	354.34	320	357.34
121	9948224.37	3428858.52	354.68	321	357.68
122	9948268.29	3428882.42	355.03	322	358.03
123	9948312.20	3428906.32	355.37	323	358.37
124	9948356.12	3428930.22	361.08	324	364.24
125	9948409.05	3428942.41	372.32	325	375.48
126	9947805.20	3428687.34	355.34	326	358.50
127	9947849.12	3428711.24	350.86	327	353.86
128	9947893.04	3428735.14	351.20	328	354.20
129	9947936.96	3428759.04	351.55	329	354.55
130	9947980.88	3428782.94	351.89	330	354.89
131	9948024.79	3428806.84	352.24	331	355.24
132	9948068.71	3428830.74	352.58	332	355.58
133	9948112.63	3428854.64	352.93	333	355.93
134	9948156.55	3428878.54	353.27	334	356.27
135	9948200.47	3428902.44	353.62	335	356.62
136	9948244.39	3428926.34	353.96	336	356.96
137	9948288.30	3428950.23	354.31	337	357.31
138	9948332.22	3428974.13	354.65	338	357.65
139	9948376.14	3428998.03	364.52	339	367.68
140	9947781.30	3428731.26	354.37	340	357.53
141	9947825.22	3428755.16	349.79	341	352.79
142	9947869.14	3428779.06	350.14	342	353.14
143	9947913.06	3428802.96	350.48	343	353.48
144	9947956.98	3428826.86	350.83	344	353.83
145	9948000.89	3428850.76	351.17	345	354.17
146	9948044.81	3428874.66	351.52	346	354.52
147	9948088.73	3428898.55	351.86	347	354.86
148	9948132.65	3428922.45	352.21	348	355.21
149	9948176.57	3428946.35	352.55	349	355.55
150	9948220.49	3428970.25	352.90	350	355.90
151	9948264.40	3428994.15	353.24	351	356.24
152	9948308.32	3429018.05	353.59	352	356.59
153	9948352.24	3429041.95	358.00	353	361.16
154	9947757.40	3428775.18	353.40	354	356.56
155	9947801.32	3428799.08	348.73	355	351.73
156	9947845.24	3428822.97	349.08	356	352.08
157	9947889.16	3428846.87	349.42	357	352.42
158	9947933.08	3428870.77	349.77	358	352.77
159	9947977.00	3428894.67	349.85	359	353.11
160	9948020.91	3428918.57	350.45	360	353.45
161	9948064.83	3428942.47	350.80	361	353.80
162	9948108.75	3428966.37	351.14	362	354.14
163	9948152.67	3428990.27	351.49	363	354.49
164	9948196.59	3429014.17	351.83	364	354.83
165	9948240.50	3429038.07	352.18	365	355.18
166	9948284.42	3429061.97	352.52	366	355.52
167	9948328.34	3429085.87	352.87	367	355.87
168	9948376.79	3429112.22	368.48	368	371.64
169	9947733.50	3428819.09	352.43	369	355.59
170	9947777.42	3428842.99	344.46	370	346.57
171	9947821.34	3428866.89	342.49	371	344.59
172	9947865.26	3428890.79	340.51	372	342.62
173	9947909.85	3428913.46	339.00	373	341.00
174	9947953.10	3428938.59	346.76	374	348.86
175	9947997.01	3428962.49	349.39	375	352.39
176	9948040.93	3428986.39	349.74	376	352.74
177	9948084.85	3429010.29	350.08	377	353.08
178	9948128.77	3429034.19	350.43	378	353.43
179	9948172.69	3429058.09	350.77	379	353.77
180	9948216.60	3429081.99	351.12	380	354.12
181	9948260.52	3429105.89	351.46	381	354.46
182	9948304.44	3429129.79	351.80	382	354.80
183	9948348.36	3429153.69	360.37	383	363.53

△1 REQUIRED CQA SURVEYOR CERTIFICATION POINTS

SUBGRADE (TOLERANCE = 0' TO -0.2')				TOP OF CLAY LINER (TOLERANCE = 0' TO 0.1')	
POINT NO.	NORTHING	EASTING	ELEVATION	POINT NO.	ELEVATION
184	9947729.60	3428863.01	351.46	384	354.62
185	9947753.52	3428886.91	339.00	385	341.00
186	9947797.44	3428910.81	339.00	386	341.00
187	9947841.36	3428934.71	339.00	387	341.00
188	9947885.28	3428958.61	339.00	388	341.00
189	9947929.20	3428982.51	346.18	389	348.29
190	9947973.11	3429006.41	348.33	390	351.33
191	9948017.03	3429030.31	348.67	391	351.67
192	9948060.95	3429054.21	349.02	392	352.02
193	9948104.87	3429078.11	349.36	393	352.36
194	9948148.79	3429102.01	349.71	394	352.71
195	9948192.71	3429125.91	350.05	395	353.05
196	9948236.62	3429149.81	350.40	396	353.40
197	9948280.54	3429173.71	350.74	397	353.74
198	9948324.46	3429197.61	352.49	398	355.65
199	9947685.71	3428906.93	350.49	399	353.65
200	9947729.62	3428930.83	339.00	400	341.00
201	9947773.54	3428954.73	339.00	401	341.00
202	9947817.46	3428978.63	339.00	402	341.00
203	9947861.38	3429002.53	339.00	403	341.00
204	9947905.30	3429026.43	345.61	404	347.71
205	9947949.21	3429050.33	347.26	405	350.26
206	9947993.13	3429074.23	347.61	406	350.61
207	9948037.05	3429098.13	347.95	407	350.95
208	9948080.97	3429122.03	348.30	408	351.30
209	9948124.89	3429145.93	348.64	409	351.64
210	9948168.81	3429169.83	348.99	410	351.99
211	9948212.72	3429193.73	349.33	411	352.33
212	9948256.64	3429217.63	349.68	412	352.68
213	9948300.56	3429241.52	350.02	413	353.02
214	9948344.48	3429265.42	356.69	414	359.85
215	9947661.81	3428950.85	349.52	415	352.68
216	9947705.72	3428974.75	339.00	416	341.00
217	9947749.64	3428998.65	339.00	417	341.00
218	9947793.56	3429022.55	339.00	418	341.00
219	9947837.48	3429046.45	339.00	419	341.00
220	9947881.40	3429070.35	345.03	420	347.14
221	9947925.32	3429094.25	346.20	421	349.20
222	9947969.23	3429118.15	346.54	422	349.54
223	9948013.15	3429142.05	346.89	423	349.89
224	9948057.07	3429165.94	347.23	424	350.23
225	9948100.99	3429189.84	347.58	425	350.58
226	9948144.91	3429213.74	348.80	426	351.98
227	9948188.82	3429237.64	351.30	427	354.47
228	9948241.25	3429269.55	357.93	428	361.09
229	9947637.91	3428994.77	348.55	429	351.71
230	9947681.82	3429018.67	339.00	430	341.00
231	9947725.74	3429042.57	339.63	431	341.32
232	9947769.66	3429066.47	343.15	432	345.26
233	9947813.58	3429090.36	346.63	433	348.76
234	9947857.50	3429114.26	350.03	434	352.16
235	9947900.75	3429139.35	352.83	435	355.99
236	9947610.49	3429031.01	349.89	436	352.00
237	9947841.80	3428597.59	360.84	437	364.00
238	9947794.05	3428685.62	358.81	438	361.97
239	9947746.41	3428773.55	356.81	439	359.97
240	9947698.77	3428861.47	354.80	440	357.96
241	9947652.96	3428946.02	352.88	441	356.04
242	9947611.41	3429022.57	351.16	442	354.30
243	9947904.78	3428581.43	360.63	443	363.79
244	9947971.00	3428625.27	362.07	444	365.23
245	9948011.62	3428652.95	362.95	445	366.11
246	9948094.64	3428708.31	364.75	446	367.91
247	9948177.65	3428764.07	366.55	447	369.71
248	9948260.93	3428820.01	368.35	448	371.51
249	9948371.16	3428901.29	371.05	449	374.21
250	9948405.53	3428960.90	373.10	450	376.26
251	9948386.59	3429060.63	370.05	451	373.21
252	9948364.50	3429176.89	366.51	452	369.67
253	9948358.14	3429290.30	360.32	453	363.48
254	9948333.24	3429286.89	360.65	454	363.81
255	9948203.76	3429258.97	356.85	455	360.01
256	9948153.09	3429242.79	356.12	456	359.28
257	9948119.82	3429227.66	356.84	457	360.00
258	9948066.12	3429203.24	355.76	458	358.92
259	9948036.48	3429191.67	354.84	459	358.00
260	9947929.71	3429150.00	353.45	460	356.61
261	9947865.52	3429126.40	352.10	461	355.26
262	9947858.55	3429123.83	353.01	462	355.12
263	9947805.89	3429104.47	351.92	463	354.03
264	9947694.87	3429065.56	349.89	464	352.00
265	9947607.68	3429029.33	350.98	465	352.00
266	9947994.96	3429175.47	354.30	466	357.46

△1 CONTRACTOR SUBGRADE GRADING CONTROL POINTS (TOLERANCE = 0' TO -0.2')

POINT NO.	NORTHING	EASTING	ELEVATION
500	9947874.88	3429107.69	345.17
501	9947906.85	3429118.41	345.53
502	9947937.27	3429128.61	345.87
503	9948045.05	3429169.76	346.98
504	9948074.90	3429179.56	347.31
505	9948130.94	3429203.18	347.86
506	9948161.86	3429220.32	348.10
507	9948210.16	3429235.28	348.65
508	9948245.27	3429243.47	349.10
509	9948323.69	3429254.57	350.20
510	9948318.71	3429178.08	351.28
511	9948336.49	3429061.07	353.37
512	9948352.81	3428953.72	355.29
513	9948308.85	3428898.32	355.43
514	9948275.36	3428878.54	355.19
515	9948238.51	3428853.22	354.98
516	9948155.86	3428792.52	354.57
517	9948075.39	3428733.42	354.17
518	9947956.68	3428646.21	353.59
519	9947893.73	3428600.64	353.27
520	9947871.57	3428591.54	353.05
521	9947882.34	3428570.85	360.84
522	9947870.27	3428566.85	360.84
523	9947860.25	3428569.10	360.84
524	9947852.39	3428577.36	360.84
525	9947863.31	3428609.41	352.66
526	9947816.68	3428695.96	350.57
527	9947769.36	3428784.06	348.44
528	9947856.59	3429079.49	339.00
529	9947789.42	3429059.29	339.00
530	9947706.03	3429034.83	339.00
531	9947866.09	3429101.57	345.13
532	9947896.27	3429070.12	346.10
533	9947891.05	3429010.60	339.00
~~534~~	~~9947877.44~~	~~3428995.68~~	~~335.10~~
~~535~~	~~9947883.83~~	~~3428998.88~~	~~335.10~~
536	9947909.47	3429021.38	346.10
537	9947918.16	3429026.38	346.10
538	9947883.97	3428903.14	339.00
539	9947934.69	3428923.37	339.00
~~540~~	~~9947918.53~~	~~3428929.52~~	~~335.10~~
541	9947976.06	3428907.54	348.97
542	9947990.73	3428902.25	349.23
543	9947845.74	3428887.89	339.00
~~544~~	~~9947838.76~~	~~3428905.40~~	~~335.10~~
~~545~~	~~9947841.40~~	~~3428898.76~~	~~335.10~~
546	9947855.44	3428863.56	347.73
547	9947859.15	3428854.27	347.73
~~548~~	~~9947772.62~~	~~3428885.47~~	~~337.10~~
549	9947762.50	3428854.69	339.00
550	9947751.52	3428821.26	347.99
551	9947753.17	3428826.27	346.64
552	9947754.68	3428816.18	346.62
553	9947729.70	3428804.62	354.96
554	9947713.86	3428932.88	339.00
555	9947672.12	3428999.97	339.00
~~556~~	~~9947723.80~~	~~3428939.06~~	~~335.10~~
557	9947673.64	3428907.86	353.75
558	9947639.61	3429023.84	344.00
559	9947661.72	3429016.69	339.00
~~560~~	~~9947677.08~~	~~3429014.14~~	~~335.10~~
~~561~~	~~9947770.61~~	~~3429027.88~~	~~337.10~~
~~562~~	~~9947768.63~~	~~3429033.55~~	~~335.10~~
~~563~~	~~9947766.26~~	~~3429040.30~~	~~335.10~~
564	9947750.58	3429085.08	350.91
565	9947888.95	3429062.41	346.10
566	9947920.84	3429028.03	347.15
567	9947995.22	3428900.55	350.32
568	9947860.44	3428851.05	348.89
569	9947756.56	3428813.17	347.79
570	9947756.07	3428807.96	348.00
571	9947752.16	3428810.72	347.52
572	9947750.94	3428813.09	347.44
573	9947748.16	3428815.00	349.00
574	9947751.55	3428815.23	347.99
575	9947732.79	3428798.68	356.23
576	9947730.95	3428802.26	355.02
577	9947728.30	3428807.08	355.75
578	9947744.76	3428803.45	352.00
579	9947739.50	3428805.67	352.00
580	9947738.07	3428807.96	352.00
581	9947739.68	3428811.62	352.00
582	9947721.10	3428870.16	347.99
583	9947718.42	3428868.49	347.99
584	9947690.95	3428918.62	347.99
585	9947688.27	3428916.96	347.99
586	9947649.21	3428985.72	347.99
587	9947646.53	3428984.05	347.99

△1 CONTRACTOR SUBGRADE GRADING CONTROL POINTS (TOLERANCE = 0' TO -0.2')

POINT NO.	NORTHING	EASTING	ELEVATION
588	9947621.95	3429029.54	347.99
589	9947618.99	3429028.33	347.99
590	9947947.49	3428956.26	347.72
591	9947956.09	3428961.35	347.72
592	9947958.79	3428962.95	348.76
593	9947726.96	3428789.52	359.50
594	9947715.05	3428811.51	359.00
595	9947924.85	3428888.87	348.47
596	9947928.28	3428879.48	348.47
597	9947929.46	3428876.22	349.62

△1 CONTRACTOR TOP OF CLAY GRADING CONTROL POINTS (TOLERANCE = 0' TO 0.1')

POINT NO.	NORTHING	EASTING	ELEVATION
600	9947887.57	3429111.37	348.32
601	9947907.02	3429117.94	348.54
602	9947937.71	3429128.23	348.88
603	9948045.22	3429169.29	349.99
604	9948075.50	3429179.23	350.33
605	9948131.15	3429202.73	350.87
606	9948162.06	3429219.86	351.11
607	9948210.55	3429234.88	351.67
608	9948246.22	3429243.18	352.15
609	9948323.17	3429254.02	353.20
610	9948318.22	3429177.96	354.29
611	9948335.92	3429061.54	356.37
612	9948352.28	3428953.88	358.29
613	9948308.50	3428898.71	358.43
614	9948274.98	3428878.90	358.19
615	9948238.22	3428853.65	357.98
616	9948155.51	3428792.91	357.57
617	9948075.07	3428733.82	357.18
618	9947956.18	3428646.48	356.59
619	9947893.47	3428601.09	356.27
620	9947871.78	3428592.21	356.06
621	9947882.34	3428570.85	364.00
622	9947870.27	3428566.85	364.00
623	9947860.25	3428569.10	364.00
624	9947852.39	3428577.36	364.00
625	9947863.72	3428609.64	355.66
626	9947817.09	3428696.19	353.57
627	9947769.78	3428784.29	351.45
628	9947856.42	3429079.10	341.00
629	9947788.69	3429058.74	341.00
630	9947706.23	3429034.55	341.00
631	9947867.16	3429104.27	348.00
632	9947873.16	3429118.51	352.00
633	9947896.54	3428998.91	341.00
634	9947959.00	3428947.83	352.00
635	9947960.46	3428949.37	352.00
636	9947926.06	3429013.67	352.00
637	9947927.84	3429014.57	352.00
638	9947878.95	3428901.48	341.00
639	9947934.25	3428923.54	341.00
~~640~~	~~9947918.09~~	~~3428929.69~~	~~337.10~~
641	9947984.29	3428904.50	353.08
642	9947987.23	3428903.44	353.14
643	9947845.62	3428888.19	341.00
644	9947879.51	3428864.02	352.00
645	9947882.79	3428867.49	352.00
646	9947821.65	3428843.10	352.00
647	9947822.39	3428841.24	352.00
648	9947755.28	3428811.27	350.80
649	9947762.63	3428855.08	341.00
650	9947754.09	3428829.06	348.00
651	9947749.21	3428814.20	352.00
652	9947750.29	3428812.47	352.00
653	9947729.18	3428805.35	359.24
654	9947744.28	3428884.58	341.00
655	9947692.60	3428967.66	341.00
~~656~~	~~9947724.07~~	~~3428939.23~~	~~337.10~~
657	9947673.64	3428907.86	356.91
658	9947640.09	3429023.68	346.00
659	9947662.20	3429016.53	341.00
~~660~~	~~9947678.00~~	~~3429013.27~~	~~337.10~~
~~661~~	~~9947770.50~~	~~3429028.19~~	~~339.10~~
~~662~~	~~9947768.52~~	~~3429033.86~~	~~337.10~~
~~663~~	~~9947766.37~~	~~3429040.00~~	~~337.10~~
664	9947750.58	3429085.08	353.02
665	9947875.11	3429119.10	352.00
666	9947930.55	3429015.92	350.49

SHADING REPRESENTS REVISED POINTS (TYP) △1

STRIKE–THROUGH REPRESENTS OMITTED POINTS (TYP) △1

CONTRACTOR PERIMETER GRADING CONTROL POINTS (TOLERANCE = 0' TO 0.2')

POINT NO.	NORTHING	EASTING	ELEVATION
800	9948928.86	3429019.32	388.07
801	9948927.09	3429026.61	385.57
802	9948925.92	3429031.47	385.57
803	9948924.15	3429038.76	388.07
804	9948914.31	3429074.85	389.14
805	9948862.60	3429003.27	385.83
806	9948860.84	3429010.56	383.33
807	9948859.66	3429015.42	383.33
808	9948857.90	3429022.71	385.83
809	9948849.55	3429057.18	388.36
810	9948760.24	3428974.10	382.33
811	9948758.19	3428981.32	379.83
812	9948756.82	3428986.13	379.83
813	9948754.78	3428993.34	382.33
814	9948744.76	3429028.60	387.09
815	9948639.89	3428937.91	378.19
816	9948637.71	3428945.09	375.69
817	9948636.26	3428949.88	375.69
818	9948634.08	3428957.05	378.19
819	9948622.39	3428995.57	385.42
820	9948587.79	3428921.84	377.27
821	9948585.41	3428928.95	374.77
822	9948583.82	3428933.69	374.77
823	9948581.43	3428940.80	377.27
824	9948567.84	3428981.29	384.41
825	9948470.41	3428889.18	375.24
826	9948468.42	3428896.41	372.74
827	9948467.09	3428901.23	372.74
828	9948465.09	3428908.46	375.24
829	9948454.52	3428946.71	378.74
830	9948383.63	3428856.65	373.66
831	9948381.00	3428863.67	371.16
832	9948379.25	3428868.36	371.16
833	9948377.38	3428875.66	373.68
834	9948314.08	3428818.81	372.31
835	9948310.50	3428825.40	369.81
836	9948308.12	3428829.79	369.81
837	9948304.54	3428836.39	372.31
838	9948276.71	3428795.10	371.51
839	9948272.70	3428801.44	369.01
840	9948270.02	3428805.66	369.01
841	9948266.01	3428812.00	371.51
842	9948194.09	3428739.59	369.71
843	9948189.91	3428745.81	367.21
844	9948187.02	3428749.89	367.21
845	9948182.94	3428756.19	369.71
846	9948111.08	3428683.83	367.91
847	9948106.90	3428690.05	365.41
848	9948104.11	3428694.20	365.41
849	9948099.93	3428700.43	367.91
850	9948028.06	3428628.07	366.11
851	9948023.88	3428634.30	363.61
852	9948021.10	3428638.45	363.61
853	9948016.91	3428644.67	366.11
854	9947987.42	3428600.77	365.23
855	9947983.24	3428607.00	362.73
856	9947980.45	3428611.15	362.73
857	9947976.27	3428617.37	365.23
858	9947902.42	3428544.49	363.39
859	9947898.27	3428550.74	360.89

CONTRACTOR PERIMETER GRADING CONTROL POINTS (TOLERANCE = 0' TO 0.2')

POINT NO.	NORTHING	EASTING	ELEVATION
860	9947895.51	3428554.91	360.89
861	9947889.64	3428563.80	363.97
862	9947909.45	3428573.13	363.78
863	9947873.16	3428528.39	362.98
864	9947871.95	3428537.31	359.98
865	9947870.88	3428545.24	359.98
866	9947869.67	3428554.15	362.98
867	9947869.83	3428557.22	364.00
868	9947844.35	3428531.61	362.24
869	9947847.46	3428540.04	359.24
870	9947850.23	3428547.54	359.24
871	9947853.34	3428555.98	362.24
872	9947855.19	3428560.70	364.00
873	9947817.03	3428551.92	361.37
874	9947824.24	3428557.31	358.37
875	9947830.65	3428562.10	358.37
876	9947837.86	3428567.49	361.37
877	9947844.41	3428571.95	364.00
878	9947802.40	3428575.17	360.70
879	9947810.02	3428579.97	357.70
880	9947816.79	3428584.23	357.70
881	9947825.17	3428587.81	360.73
882	9947833.48	3428593.03	364.00
883	9947754.27	3428664.11	358.72
884	9947762.19	3428668.39	355.72
885	9947769.23	3428672.20	355.72
886	9947777.14	3428676.48	358.72
887	9947785.71	3428681.11	361.97
888	9947706.71	3428752.07	356.75
889	9947714.62	3428756.36	353.75
890	9947721.66	3428760.16	353.75
891	9947729.58	3428764.44	356.75
892	9947738.07	3428769.03	359.96
893	9947659.14	3428840.04	354.77
894	9947667.06	3428844.32	351.77
895	9947674.09	3428848.12	351.77
896	9947682.01	3428852.40	354.77
897	9947690.43	3428856.96	357.96
898	9947636.17	3428882.51	353.82
899	9947644.09	3428886.80	350.82
900	9947651.12	3428890.60	350.82
901	9947659.04	3428894.88	353.82
902	9947667.41	3428899.43	357.00
903	9947640.51	3428910.22	350.38
904	9947644.63	3428941.48	0.00
905	9947613.70	3428921.51	350.02
906	9947632.51	3428904.06	350.46
907	9947624.63	3428931.97	349.88
908	9947635.19	3428941.74	354.67
909	9947603.51	3428948.70	349.36
910	9947595.88	3428931.62	349.67
911	9947571.90	3428938.74	349.24
912	9947578.75	3428963.36	348.87
913	9947534.86	3428989.35	348.00
914	9947471.92	3428955.17	348.00
915	9947619.77	3428987.35	355.00
916	9947603.10	3429017.99	354.30
917	9948343.95	3428857.76	373.07
918	9948378.13	3428894.86	374.21
919	9948415.47	3428935.38	375.45

NOTE:
1. PROTECTIVE COVER SHALL BE PLACED A MINIMUM OF 2–FOOT THICK OVER SUBCELL 2D STORAGE AREA CLAY LINER. PROTECTIVE COVER IS NOT NEEDED OVER THE SUBCELL 2D CONTACT WATER RETENTION POND GEOMEMBRANE LINER. CONTRACTOR TOP OF PROTECTIVE COVER GRADING CONTROL POINTS SHALL BE AT THE SAME LOCATIONS AS THE SUBGRADE AND TOP OF CLAY LINER CQA CERTIFICATION POINTS PROVIDED ON THIS SHEET EXCEPT FOR POINTS 421–426, AND 600–607 WHICH FALL UNDER THE ADDITIONAL PROTECTIVE COVER AREA SHOWN IN DRAWING B–C–00G–196. TO PROVIDE A PROTECTIVE COVER THICKNESS OF 2' ON 3:1 SIDESLOPES, THE VERTICAL DISTANCE BETWEEN THE TOP OF CLAY ELEVATION AND THE TOP OF PROTECTIVE COVER ELEVATION SHALL BE 2.11' (MIN).

△2 RECORD DRAWING

REV	DATE	DESCRIPTION	DRN	APP
2	11/01/2016	ISSUE FOR RECORD	JJV	MZI
1	11/14/2014	REVISION TO SURVEY CONTROL POINTS	JJV	MZI
0	03/26/2014	ISSUE FOR CONSTRUCTION	JJV/KH	MZI
C	03/14/2014	DRAFT FINAL SUBMITTAL	JJV/KH	MZI
B	01/16/2014	FINAL DRAFT SUBMITTAL	JJV/KH	MZI
A	11/01/2013	DRAFT SUBMITTAL	JJV/KH	MZI

LCRA
ENERGY•WATER•COMMUNITY SERVICES
LOWER COLORADO RIVER AUTHORITY
3700 LAKE AUSTIN BLVD.
AUSTIN, TEXAS 78703
PHONE: 512.473.3200

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8217 SHOAL CREEK BLVD., SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE: CONSTRUCTION CONTROL POINTS

PROJECT: SUBCELL 2D STORAGE AREA

SITE: FAYETTE POWER PROJECT COMBUSTION BYPRODUCT LANDFILL

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE 03/26/2014 DATE

STATE OF TEXAS M. ZAHIRUL ISLAM 109989 LICENSED PROFESSIONAL ENGINEER

DESIGN BY:	MZI	DATE:	MARCH 2014
DRAWN BY:	JJV / KH	PROJECT NO.:	TXL0225.04
CHECKED BY:	MZI / TL	FILE:	B-C-00G-201
REVIEWED BY:	BG / TL	DRAWING NO.:	B-C-00G-201
APPROVED BY:	MZI		

APPENDICES

APPENDIX A

Stormwater Management System Design – Final Conditions

Written by:	**O. Bramlet**	Date:	**6/10/2021**	Reviewed & Revised by:	**B. Gross**	Date:	**6/30/2021**
Client:	**LCRA**	Project:	**FPP Run-on Run-off Plan Update**	Project No.:	**TXW8067**	Phase No.:	**03**

ADDENDUM

SURFACE WATER MANAGEMENT SYSTEM DESIGN – FINAL CONDITIONS

STATE OF TEXAS
BETH ANN GROSS
79864
LICENSED
PROFESSIONAL ENGINEER

Beth Ann Gross
8/11/2021

GEOSYNTEC CONSULTANTS, INC.
TX ENG FIRM REGISTRATION NO. F-1182

PURPOSE

The purpose of this addendum is to summarize the updates to the Run-on and Run-off Control System Plan (Plan) final conditions surface water management system for the Combustion Byproduct Landfill (CBL) at LCRA's Fayette Power Project (FPP). The initial Plan was prepared by Geosyntec in August 2016 (Geosyntec, 2016) and has been reviewed and revised as necessary to comply with the 40 CFR 257 and 30 TAC 352 regulations and TCEQ guidance. As discussed in Section 4.3 of the initial Plan and as demonstrated in the initial calculations presented in Appendix A, a copy of which follows this addendum, the surface water management features for the CBL were designed to convey a 100-year, 24-hour storm event in the initial Plan.

Precipitation frequency estimates published by the United States Geological Survey (USGS) have increased since the submittal of the initial Plan. However, the stormwater components for the final cover system were designed in the initial Plan for a 100-year, 24-hour storm event per TCEQ guidance for industrial waste landfills (TCEQ, 2015) and the new Texas Commission on Environmental Quality (TCEQ) rule for Coal Combustion Residuals (CCR) waste management (30 TAC 352) and TCEQ guidance (TCEQ, 2000) only requires that components be able to convey flows from a 25-year, 24-hour storm The latest 25-year, 24-hour storm event is of lower intensity than the previously used 100-year, 24-hour storm. The precipitation estimates used in the initial design and the latest available precipitation estimates are described and compared in detail below.

DISCUSSION

Rainfall depths used in the initial design of the final conditions stormwater management system were collected from the USGS's *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*. Published rainfall depths for the CBL area in that atlas were 7.80 inches and 10.50 inches for the 25-year, 24-hour and 100-year, 24-hour storm events, respectively (USGS, 2004). Since that time, precipitation frequency estimates for Texas have been updated. The latest available estimates can be obtained from the National Oceanic Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS). Current rainfall depths for the CBL are 9.36 inches and 13.60 inches for the 25-year, 24-hour and 100-year, 24-hour storm events, respectively, as shown in Table 1 (NOAA, 2018). The previous and current rainfall depth estimates are summarized in Table 2. The previous 100-year, 24-hour rainfall depth estimate of 10.50 inches used in the initial design of the final condition storm water management system is larger than the current 25-year, 24-hour rainfall depth estimate of 9.36 inches.

Previous rainfall intensity estimates used in the initial design were calculated based on guidance from TxDOT (2011) using the depth of rainfall specified for the 100-year design storm event from USGS (2004) and the storm duration from the design time of concentration (Tc) for each subcatchment at the CBL. As shown in the attached initial calculations, the highest rainfall intensities (calculated as depth of rainfall for design storm of duration Tc divided by Tc) were generated for the lowest Tc values. The minimum design Tc was estimated as 10 minutes, which yielded calculated rainfall intensities of 7.60 in./hr and 10.00 in./hr for the 25-year and 100-year storm events, respectively. From Table 3, current rainfall intensities for the CBL corresponding to the initial design's minimum Tc duration of 10 minutes are 8.61 in./hr and 10.60 in./hr for the 25-year and 100-year storm events, respectively.

The previous and current rainfall intensity estimates are summarized in Table 4. The maximum 100-year storm event intensity of 10.00 in./hr previously used in the initial design is larger than the current 25-year storm event intensity of 8.61 in./hr.

Written by:	**O. Bramlet**	Date:	**6/10/2021**	Reviewed & Revised by:	**B. Gross**	Date:	**6/30/2021**
Client:	**LCRA**	Project:	**FPP Run-on Run-off Plan Update**	Project No.:	**TXW8067**	Phase No.:	**03**

CONCLUSIONS

As described, the stormwater components for the final cover system detailed in Appendix A were previously designed for the 100-year, 24-hour storm event per TCEQ guidance (TCEQ, 2015), and the new TCEQ CCR rule and guidance (TCEQ, 2000) specify that components be able to convey flows from a 25-year, 24-hour storm, which is of lower intensity than the previously used 100-year, 24-hour storm. Under this case, modifications to the engineering calculations and drawings presented for the final conditions surface water management system in the initial Plan are not required to be updated as the design meets and exceeds the requirements of 40 CFR 257.81(c)(4), 30 TAC 352.811, and current TCEQ guidance.

REFERENCES

Geosyntec (2016). *Run-on and Run-off Control System Plan for Combustion Byproduct Landfill*. Registration No. 31575. October 2016.

NOAA (2018). *Precipitation-Frequency Atlas of the United States,* National Oceanic and Atmospheric Administration, Volume 9, Version 2.0. Available online: https://hdsc.nws.noaa.gov/hdsc/pfds/, accessed May 2021. La Grange, Texas Latitude: 29.9075º, longitude: -96.7565º.

Texas Commission on Environmental Quality (2015). “Nonhazardous Industrial Solid Waste Landfills” Industrial Solid Waste Management, Draft Technical Guideline No. 3.

Texas Commission on Environmental Quality (2020). “Coal Combustion Residuals Landfill” Waste Permits Division, Draft Technical Guideline No. 30. May 2020.

TxDOT (2011). Hydraulic Design Manual, Texas Department of Transportation, Austin, Texas, revised October 2011.

USGS (2004). Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas, Scientific Investigations Report 2004-5041, United States Geological Survey, authors William H. Asquith and Meghan C. Roussel.

TABLES

- Table 1 – NOAA Precipitation Depth Estimates for the CBL (from NOAA, 2018)
- Table 2 – Precipitation Depth Comparison
- Table 3 – NOAA Precipitation Intensity Estimates for the CBL (from NOAA, 2018)
- Table 4 – Precipitation Intensity Comparison

Written by:	**O. Bramlet**	Date:	**6/10/2021**	Reviewed & Revised by:	**B. Gross**	Date:	**6/30/2021**
Client:	**LCRA**	Project:	**FPP Run-on Run-off Plan Update**	Project No.:	**TXW8067**	Phase No.:	**03**

Table 1 – NOAA Precipitation Depth Estimates for the CBL (from NOAA, 2018)

NOAA Atlas 14, Volume 11, Version 2
Location name: La Grange, Texas, USA*
Latitude: 29.9075°, Longitude: -96.7565°
Elevation: 381.96 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.470 (0.356-0.621)	0.543 (0.416-0.713)	0.665 (0.507-0.874)	0.764 (0.573-1.02)	0.898 (0.652-1.23)	1.00 (0.707-1.41)	1.10 (0.759-1.60)	1.21 (0.810-1.79)	1.35 (0.874-2.07)	1.45 (0.920-2.30)
10-min	0.746 (0.565-0.986)	0.864 (0.661-1.13)	1.06 (0.807-1.39)	1.22 (0.914-1.62)	1.44 (1.04-1.97)	1.60 (1.13-2.26)	1.76 (1.22-2.56)	1.92 (1.29-2.86)	2.13 (1.38-3.27)	2.28 (1.44-3.60)
15-min	0.946 (0.716-1.25)	1.09 (0.835-1.43)	1.33 (1.01-1.75)	1.53 (1.15-2.03)	1.79 (1.30-2.46)	1.99 (1.41-2.81)	2.19 (1.51-3.17)	2.39 (1.61-3.56)	2.66 (1.73-4.10)	2.87 (1.82-4.54)
30-min	1.35 (1.02-1.78)	1.55 (1.18-2.03)	1.88 (1.43-2.47)	2.15 (1.61-2.86)	2.51 (1.82-3.43)	2.78 (1.96-3.91)	3.05 (2.10-4.42)	3.34 (2.24-4.97)	3.73 (2.43-5.76)	4.05 (2.56-6.39)
60-min	1.76 (1.33-2.32)	2.03 (1.56-2.67)	2.49 (1.90-3.27)	2.86 (2.15-3.81)	3.36 (2.43-4.60)	3.73 (2.64-5.26)	4.12 (2.84-5.97)	4.55 (3.06-6.77)	5.15 (3.35-7.94)	5.64 (3.57-8.91)
2-hr	2.13 (1.62-2.79)	2.52 (1.94-3.26)	3.15 (2.42-4.11)	3.69 (2.79-4.88)	4.43 (3.23-6.02)	5.01 (3.55-7.00)	5.62 (3.90-8.09)	6.33 (4.28-9.37)	7.38 (4.81-11.3)	8.25 (5.24-13.0)
3-hr	2.33 (1.79-3.04)	2.81 (2.16-3.60)	3.57 (2.74-4.62)	4.22 (3.20-5.56)	5.16 (3.78-6.98)	5.89 (4.20-8.21)	6.69 (4.66-9.60)	7.64 (5.18-11.3)	9.06 (5.92-13.8)	10.3 (6.53-16.1)
6-hr	2.67 (2.06-3.46)	3.32 (2.54-4.17)	4.29 (3.32-5.50)	5.17 (3.95-6.76)	6.46 (4.77-8.71)	7.52 (5.40-10.4)	8.71 (6.09-12.4)	10.1 (6.88-14.8)	12.2 (8.03-18.6)	14.0 (8.97-21.8)
12-hr	2.99 (2.32-3.85)	3.82 (2.91-4.69)	5.00 (3.89-6.35)	6.13 (4.72-7.96)	7.85 (5.86-10.5)	9.32 (6.76-12.9)	11.0 (7.75-15.6)	13.0 (8.88-18.9)	16.0 (10.5-24.2)	18.6 (11.9-28.7)
24-hr	3.33 (2.61-4.25)	4.36 (3.31-5.24)	5.77 (4.52-7.26)	7.18 (5.57-9.25)	9.36 (7.06-12.5)	11.3 (8.28-15.6)	13.6 (9.59-19.1)	16.1 (11.0-23.2)	19.9 (13.2-29.8)	23.1 (14.9-35.5)
2-day	3.73 (2.94-4.73)	4.98 (3.79-5.88)	6.66 (5.25-8.31)	8.38 (6.55-10.7)	11.1 (8.48-14.8)	13.6 (10.1-18.7)	16.4 (11.7-22.9)	19.4 (13.3-27.7)	23.6 (15.6-34.9)	26.9 (17.4-41.0)
3-day	4.05 (3.21-5.11)	5.41 (4.14-6.38)	7.26 (5.75-9.01)	9.12 (7.16-11.6)	12.0 (9.24-16.0)	14.7 (10.9-20.2)	17.7 (12.6-24.6)	20.8 (14.4-29.6)	25.1 (16.7-37.1)	28.5 (18.4-43.3)
4-day	4.34 (3.45-5.46)	5.74 (4.44-6.80)	7.69 (6.12-9.53)	9.61 (7.57-12.2)	12.6 (9.66-16.7)	15.3 (11.3-20.8)	18.3 (13.0-25.3)	21.4 (14.8-30.4)	25.8 (17.1-38.0)	29.2 (19.0-44.3)
7-day	5.04 (4.04-6.30)	6.49 (5.10-7.74)	8.57 (6.87-10.6)	10.5 (8.35-13.3)	13.5 (10.4-17.7)	16.1 (12.0-21.7)	19.0 (13.6-26.2)	22.1 (15.4-31.3)	26.6 (17.8-39.1)	30.3 (19.7-45.7)
10-day	5.62 (4.52-7.00)	7.11 (5.65-8.52)	9.29 (7.49-11.4)	11.3 (8.99-14.2)	14.3 (11.0-18.6)	16.8 (12.5-22.6)	19.6 (14.1-27.0)	22.8 (15.9-32.1)	27.3 (18.3-40.0)	31.1 (20.2-46.7)
20-day	7.31 (5.92-9.04)	8.93 (7.25-10.8)	11.4 (9.32-14.0)	13.6 (10.9-17.0)	16.8 (12.9-21.6)	19.3 (14.4-25.6)	22.0 (15.9-30.0)	24.9 (17.5-35.0)	29.2 (19.7-42.5)	32.7 (21.4-48.7)
30-day	8.71 (7.09-10.7)	10.4 (8.57-12.7)	13.2 (10.8-16.2)	15.6 (12.5-19.3)	18.8 (14.6-24.1)	21.4 (16.0-28.2)	24.0 (17.4-32.6)	26.8 (18.9-37.4)	30.8 (20.8-44.6)	33.9 (22.2-50.5)
45-day	10.7 (8.78-13.2)	12.6 (10.5-15.4)	15.8 (13.0-19.3)	18.4 (14.8-22.7)	21.8 (16.9-27.8)	24.4 (18.3-32.1)	27.0 (19.7-36.5)	29.7 (21.0-41.3)	33.4 (22.6-48.1)	36.2 (23.8-53.6)
60-day	12.6 (10.3-15.3)	14.6 (12.2-17.8)	18.1 (15.0-22.0)	20.9 (16.9-25.7)	24.5 (19.1-31.2)	27.2 (20.5-35.6)	29.8 (21.8-40.2)	32.4 (22.9-44.9)	35.8 (24.3-51.5)	38.3 (25.2-56.6)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Table 2 – Precipitation Depth Comparison

Storm Event	Previous Rainfall Depth Estimate (in.)	Current Rainfall Depth Estimate (in.)
25-year, 24-hour	7.80	9.36
100-year, 24-hour	10.50	13.60

Written by:	**O. Bramlet**	Date:	**6/10/2021**	Reviewed & Revised by:	**B. Gross**	Date:	**6/30/2021**
Client:	**LCRA**	Project:	**FPP Run-on Run-off Plan Update**	Project No.:	**TXW8067**	Phase No.:	**03**

Table 3 – NOAA Precipitation Intensity Estimates for the CBL (from NOAA, 2018)

NOAA Atlas 14, Volume 11, Version 2
Location name: La Grange, Texas, USA*
Latitude: 29.9075°, Longitude: -96.7565°
Elevation: 381.96 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	5.64 (4.27-7.45)	6.52 (4.99-8.56)	7.98 (6.08-10.5)	9.17 (6.88-12.2)	10.8 (7.82-14.8)	12.0 (8.48-16.9)	13.2 (9.11-19.2)	14.5 (9.72-21.5)	16.2 (10.5-24.9)	17.4 (11.0-27.6)
10-min	4.48 (3.39-5.92)	5.18 (3.97-6.80)	6.35 (4.84-8.35)	7.31 (5.48-9.74)	8.61 (6.26-11.8)	9.61 (6.80-13.6)	10.6 (7.29-15.3)	11.5 (7.75-17.1)	12.8 (8.29-19.6)	13.7 (8.64-21.6)
15-min	3.78 (2.86-5.00)	4.36 (3.34-5.72)	5.32 (4.06-7.00)	6.10 (4.58-8.13)	7.16 (5.20-9.82)	7.96 (5.63-11.2)	8.75 (6.03-12.7)	9.56 (6.43-14.2)	10.7 (6.92-16.4)	11.5 (7.27-18.1)
30-min	2.69 (2.04-3.56)	3.09 (2.37-4.06)	3.75 (2.86-4.94)	4.29 (3.22-5.72)	5.02 (3.64-6.87)	5.55 (3.92-7.82)	6.09 (4.20-8.83)	6.67 (4.49-9.94)	7.47 (4.85-11.5)	8.09 (5.12-12.8)
60-min	1.76 (1.33-2.32)	2.03 (1.56-2.67)	2.49 (1.90-3.27)	2.86 (2.15-3.81)	3.36 (2.43-4.60)	3.73 (2.64-5.26)	4.12 (2.84-5.97)	4.55 (3.06-6.77)	5.15 (3.35-7.94)	5.64 (3.57-8.91)
2-hr	1.06 (0.812-1.40)	1.26 (0.968-1.63)	1.58 (1.21-2.05)	1.84 (1.39-2.44)	2.22 (1.62-3.01)	2.50 (1.78-3.50)	2.81 (1.95-4.05)	3.17 (2.14-4.68)	3.69 (2.41-5.66)	4.13 (2.62-6.48)
3-hr	0.776 (0.594-1.01)	0.937 (0.719-1.20)	1.19 (0.914-1.54)	1.41 (1.07-1.85)	1.72 (1.26-2.32)	1.96 (1.40-2.73)	2.23 (1.55-3.20)	2.54 (1.72-3.75)	3.02 (1.97-4.61)	3.42 (2.17-5.35)
6-hr	0.446 (0.344-0.578)	0.554 (0.425-0.696)	0.717 (0.554-0.919)	0.863 (0.660-1.13)	1.08 (0.797-1.45)	1.26 (0.902-1.74)	1.45 (1.02-2.07)	1.69 (1.15-2.47)	2.04 (1.34-3.10)	2.35 (1.50-3.65)
12-hr	0.248 (0.193-0.319)	0.317 (0.242-0.389)	0.415 (0.323-0.527)	0.509 (0.392-0.661)	0.651 (0.486-0.875)	0.774 (0.561-1.07)	0.915 (0.643-1.30)	1.08 (0.737-1.57)	1.33 (0.875-2.01)	1.54 (0.989-2.38)
24-hr	0.139 (0.109-0.177)	0.182 (0.138-0.218)	0.241 (0.188-0.302)	0.299 (0.232-0.385)	0.390 (0.294-0.522)	0.471 (0.345-0.650)	0.565 (0.400-0.795)	0.672 (0.460-0.968)	0.831 (0.549-1.24)	0.964 (0.620-1.48)
2-day	0.078 (0.061-0.098)	0.104 (0.079-0.122)	0.139 (0.109-0.173)	0.174 (0.136-0.223)	0.231 (0.177-0.309)	0.283 (0.209-0.389)	0.342 (0.243-0.478)	0.404 (0.278-0.577)	0.491 (0.325-0.728)	0.560 (0.362-0.854)
3-day	0.056 (0.045-0.071)	0.075 (0.058-0.089)	0.101 (0.080-0.125)	0.127 (0.099-0.161)	0.167 (0.128-0.223)	0.204 (0.152-0.280)	0.246 (0.176-0.342)	0.289 (0.199-0.412)	0.349 (0.232-0.515)	0.396 (0.256-0.602)
4-day	0.045 (0.036-0.057)	0.060 (0.046-0.071)	0.080 (0.064-0.099)	0.100 (0.079-0.127)	0.131 (0.101-0.174)	0.159 (0.118-0.217)	0.190 (0.136-0.264)	0.223 (0.154-0.316)	0.268 (0.179-0.396)	0.305 (0.197-0.462)
7-day	0.030 (0.024-0.038)	0.039 (0.030-0.046)	0.051 (0.041-0.063)	0.063 (0.050-0.079)	0.080 (0.062-0.106)	0.096 (0.071-0.129)	0.113 (0.081-0.156)	0.132 (0.092-0.186)	0.159 (0.106-0.233)	0.180 (0.117-0.272)
10-day	0.023 (0.019-0.029)	0.030 (0.024-0.035)	0.039 (0.031-0.048)	0.047 (0.037-0.059)	0.060 (0.046-0.078)	0.070 (0.052-0.094)	0.082 (0.059-0.112)	0.095 (0.066-0.134)	0.114 (0.076-0.167)	0.129 (0.084-0.194)
20-day	0.015 (0.012-0.019)	0.019 (0.015-0.022)	0.024 (0.019-0.029)	0.028 (0.023-0.035)	0.035 (0.027-0.045)	0.040 (0.030-0.053)	0.046 (0.033-0.062)	0.052 (0.036-0.073)	0.061 (0.041-0.088)	0.068 (0.044-0.102)
30-day	0.012 (0.010-0.015)	0.014 (0.012-0.018)	0.018 (0.015-0.022)	0.022 (0.017-0.027)	0.026 (0.020-0.033)	0.030 (0.022-0.039)	0.033 (0.024-0.045)	0.037 (0.026-0.052)	0.043 (0.029-0.062)	0.047 (0.031-0.070)
45-day	0.010 (0.008-0.012)	0.012 (0.010-0.014)	0.015 (0.012-0.018)	0.017 (0.014-0.021)	0.020 (0.016-0.026)	0.023 (0.017-0.030)	0.025 (0.018-0.034)	0.028 (0.019-0.038)	0.031 (0.021-0.045)	0.033 (0.022-0.050)
60-day	0.009 (0.007-0.011)	0.010 (0.008-0.012)	0.013 (0.010-0.015)	0.014 (0.012-0.018)	0.017 (0.013-0.022)	0.019 (0.014-0.025)	0.021 (0.015-0.028)	0.022 (0.016-0.031)	0.025 (0.017-0.036)	0.027 (0.017-0.039)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Written by:	O. Bramlet	Date:	6/10/2021	Reviewed & Revised by:	B. Gross	Date:	6/30/2021
Client:	LCRA	Project:	FPP Run-on Run-off Plan Update	Project No.:	TXW8067	Phase No.:	03

Table 4 – Precipitation Intensity Comparison

Storm Event	Previous Rainfall Intensity Estimate (in/hr)	Current Rainfall Intensity Estimate (in/hr)
25-year, 10-min	7.60	8.61
100-year, 10-min	10.00	10.60

Geosyntec consultants

Written by:	H. Douglas & J. McNash	Date:	7/14/2015	Reviewed & Revised by:	B. Klenzendorf & Z. Islam	Date:	10/6/2016
Client:	LCRA	Project:	FPP CBL Expansion	Project No.:	TXL0225	Phase No.:	08

SURFACE WATER MANAGEMENT SYSTEM DESIGN – FINAL CONDITIONS

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PURPOSE

The purpose of this calculation package is to present the analysis and design of the surface water management system for the final cover system of the Combustion Byproduct Landfill (CBL) at LCRA's Fayette Power Project (FPP) in La Grange, Texas. This package assumes Cells 1 and 2 of the CBL will be constructed and provides calculations of peak design discharges (i.e., hydrology) and design of surface water management system components (i.e., hydraulic design), which include:

- drainage downchutes;
- mid-slope drainage benches;
- top deck drainage terraces;
- a perimeter drainage channel;
- an access road channel; and
- a chambered sediment/stormwater detention pond.

CALCULATION METHODOLOGY

Surface Water Management System Components

The final cover system of the CBL consists of a shallowly sloped (3% minimum) top deck and exterior 3 horizontal to 1 vertical (3H:1V) side slopes. Storm water runoff from the final cover will be conveyed off the landfill through a series of components, including drainage benches and terraces orientated approximately parallel to the final cover system side slopes, and drainage downchutes that intersect the drainage benches and are designed to convey runoff to a perimeter drainage channel and then to a chambered sediment/stormwater detention pond. The downchutes will be lined with articulated concrete block (ACB), drainage benches and terraces will be grass-lined, the access road channel will be lined with long-term turf reinforcement mat (TRM), and the perimeter drainage will be lined with grass or long-term TRM.

The pond is designed with an upstream sediment chamber to capture the "first flush" of runoff and allow sediment to settle out. The sediment chamber discharges to a downstream detention chamber through a controlled skimmer outlet structure. Flows greater than the volume of the sediment chamber are designed to bypass the chamber and enter the detention pond. The stormwater detention pond is comprised of a lower retention storage volume and an upper detention storage volume. The permanent pond within the retention volume can be used on-site for dust suppression and other beneficial uses. Flows from the chambered sediment/stormwater detention pond will be discharged through two culverts with an outlet riser structure and/or an overflow spillway and to a permanent drainage channel located adjacent to the east perimeter of the leachate evaporation pond. Discharge will leave the site at the southern site perimeter and through the existing culvert beneath the existing off-site railroad.

Design Storm Return Period

The United States Environmental Protection Agency (USEPA) coal combustion residuals (CCR) rule (40 CFR 257.81(a)) requires that runoff control systems be designed to collect and control flow from a 24-hour, 25-year storm. Texas Commission on Environmental Quality (TCEQ) Technical Guideline No. 3 (2015) recommends that runoff control systems for industrial landfills be designed for a 100-year, 24-hour rainfall event, a storm that would result in greater peak discharge and require larger drainage features than a 24-hour, 25-year storm. TCEQ Technical Guideline No. 3 does not address the design of detention ponds. However, TCEQ's 2006 guideline for municipal solid waste landfills recommends the 25-year, 24-hour design storm event for peak flow and volume sizing of stormwater ponds. In designing the stormwater management system for the CBL, Geosyntec followed the TCEQ (2006, 2015) guidelines.

Rainfall Information

The design rainfall distribution of the site is selected from the rainfall distribution map of the United States in Figure 1 (USDA, 1986). The site is located in an area categorized by Soil Conservation Service (SCS) Type III Rainfall Distribution. This rainfall distribution is used as input to the hydrologic model and is converted into a runoff hydrograph.

The 2-year, 25-year, and 100-year rainfall depths for a 24-hour storm event utilized for analyses were obtained from the USGS *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas* (USGS, 2004) as specified in the Texas Department of Transportation (TxDOT) Hydraulic Design Manual (TxDOT, 2011). A 2-year, 24-hour rainfall depth of 3.7 inches is used in the hydrologic model to estimate travel times for sheet flow conditions for the times of concentration for each subarea (Figure 2). Similarly, rainfall depths of 7.8 inches and 10.5 inches were selected for 25-year, 24-hour and 100-year, 24-hour rainfall events, respectively (Figure 3 and Figure 4).

Hydrology

Intensity of rainfall for design is based on calculations for times of concentration and intensity-duration-frequency relationships using the procedures outlined by the TxDOT *Hydraulic Design Manual* (TxDOT, 2011). Peak design discharges are calculated based on the Rational Method recommended for small basins for either undeveloped or developed lands. The Rational Method is appropriate for estimating peak discharges for drainage areas less than 200 acres (TxDOT, 2011).

The Rational Method is useful for estimating peak flow rates but does not estimate runoff volumes. Therefore, the SCS Curve Number method outlined in TR-55 (USDA, 1986) is used to estimate runoff volumes as recommended by TCEQ (2006) and to check the design of the stormwater detention pond.

Hydraulic Design

Hydraulic design of the mid-slope drainage benches, drainage downchutes, and perimeter drainage channels are performed using Manning's equation (Chow, 1959). HydroCAD version 8.5 (HydroCAD, 2006) was used to develop an outflow curve for the detention pond riser structure, culverts, and overflow spillway. HydroCAD allows for complex outlet structures and models the structure using orifice and weir equations. The outlet structure outflow curve was used as input to the pond structure in the hydrologic model, HEC-HMS version 3.5 (USACE, 2000). Average tractive shear stresses are calculated for each hydraulic feature. The channel lining was selected such that the calculated tractive stress for a 25-year design storm event is less than the permissible tractive stress for the lining material. In addition, the depth of the hydraulic feature is selected to convey the calculated 100-year design storm depth.

COMPUTATIONS

Rational Method for Hydrologic Design

The Rational Method was applied to design the stormwater drainage features (downchutes, mid-slope berms, and perimeter channels). The Rational Method is expressed as follows:

$$Q = C \times I \times A$$

where:
Q = flow rate (cfs);
C = runoff coefficient;
I = rainfall intensity (in./hr); and
A = contributing drainage area (acres).

Estimation of Contributing Drainage Areas

Figure 5 delineates the contributing drainage areas for each of the surface water management system components. Table 1 provides the calculated area, in acres, for each of the drainage areas (subcatchments) labeled on Figure 5. The area of each subcatchment was calculated from the design drawings using computer-aided design (CAD) software. The proposed final cover system drainage areas are divided based on the surface water management component. Additional areas draining to the detention pond and the down gradient discharge channel were estimated based on existing contours provided by LCRA.

Estimation of Runoff Coefficient for Rational Method

The runoff coefficient is estimated from the TxDOT *Hydraulic Design Manual* (TxDOT, 2011) for rural watersheds as presented in Table 2. The total runoff coefficient is estimated based on the following equation:

$$C = C_r + C_i + C_v + C_s$$

where: C = total runoff coefficient;
C_r = relief runoff coefficient;
C_i = soil infiltration runoff coefficient;
C_v = vegetal cover runoff coefficient; and
C_s = surface runoff coefficient.

The total runoff coefficient equation above applies to design storm events of less than or equal to a 10-year frequency. For higher frequency events, the runoff coefficient is modified due to infiltration and other abstractions having a proportionally smaller effect on runoff. Adjustment factors for the Rational Method, C_f, are given by TxDOT (2011) as 1.10, 1.20, and 1.25 for 25-year, 50-year, and 100-year recurrence intervals, respectively.

Estimation of Time of Concentration for Rational Method

The time of concentration is defined as the time for runoff to flow from the most hydraulically remote point of the drainage area to the point under investigation. The time of concentration (T_c) is a summation of sheet flow travel time, shallow concentrated flow travel time, and open channel flow travel time.

The method to estimate the sheet flow travel time was obtained from the U.S. Department of Agriculture (USDA) document *Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55)* (USDA, 1986). Manning's kinematic solution is used for estimating travel time for sheet flow for flow distances less than 300 ft (USDA, 1986):

$$T_t = \frac{0.007(nL)^{0.8}}{P_{2-24}{}^{0.5} S^{0.4}}$$

where: T_t = travel time for overland sheet flow (hr);
n = Manning's roughness coefficient;
L = flow length (ft);
$P_{2\text{-}24}$ = 2-year, 24-hour rainfall (in.); and
S = slope of hydraulic grade line (land slope, ft/ft).

To estimate sheet flow travel time (T_t), a Manning's roughness coefficient (n) of 0.15 was selected for short grass prairie surfaces as shown in Table 3 (USDA, 1986). Maximum flow lengths (L) were measured for each subcatchment area of the final cover system. The rainfall depth for the 2-year, 24-hour frequency (P_{2-24}) is provided as 3.7 inches (USGS, 2004). The slope of the hydraulic grade line, or land slope (S), for all subcatchment areas of the final cover system is shown in Table 1.

Based on the designed conveyance system, runoff will be converted from sheet flow to open channel flow quickly, and shallow concentrated flow is negligible. Surface water runoff within each subcatchment area will sheet flow along the top deck or side slopes of the final cover system until the water reaches either a drainage bench or the perimeter drainage channel, at which point the flow will be classified as open channel flow. For the undeveloped areas to the south of the landfill which drain directly to the detention pond or drainage channel, shallow concentrated flow will not be negligible. The Upland Method (USDA, 1986) is used to estimate the shallow concentrated flow velocities using Table 4 and the equation below.

$$V = K_v \sqrt{S}$$

where: V = average velocity (ft/sec),
K_v = shallow concentrated flow velocity factor (ft/sec) based on surface type (see Table 4), and
S = land slope (ft/ft).

A velocity factor of K_v = 7.0 ft/sec was selected for the undeveloped areas based on a short grass pasture surface description. The land slopes were estimated from the existing conditions topographic maps.

The method selected to estimate the shallow concentrated flow and open channel flow travel time is based on guidance provided in TR-55 (USDA, 1986). Travel time for shallow concentrated flow and open channel flow is estimated by dividing the longest drainage path by the velocity of runoff:

$$T_t = \frac{L}{V}\left(\frac{1}{60}\right)$$

where: T_t = travel time (min);
L = flow length (ft); and

V = average velocity (ft/sec).

The shallow concentrated flow velocities are defined above. The open channel flow velocities were estimated using Manning's equation based on guidance provided in TR-55 (USDA, 1986). The average flow velocities were determined for bank-full elevation as:

$$V = \frac{1.49}{n} R_h^{2/3} S^{1/2}$$

where:

V = average velocity (ft/sec);
n = Manning's roughness coefficient;
R_h = hydraulic radius (ft) = A/P;
A = cross sectional area (ft^2);
P = wetted perimeter (ft); and
S = slope of hydraulic grade line (channel slope, ft/ft).

To estimate open channel flow travel time (T_t), a Manning's roughness coefficient (n) was selected for clean and straight earthen open channels as shown in Table 5 (Chow, 1959). A Manning's roughness coefficient value of 0.027 was selected for the mid-slope drainage benches and some perimeter channel reaches which are proposed to be grass-lined, and a value of 0.030 was selected (see Table 6 from FHWA, 2005) for the remaining perimeter channel reaches and the access road channel which are proposed to be lined with TRM. The mid-slope drainage benches are designed with a minimum of 2% slope, the access road channel is designed with a slope of 8%, and the perimeter drainage channels are designed with slopes ranging from 0.9% to 3.3%.

The velocities and times of concentration used in the design are presented in Table 1. A minimum time of concentration of 10 minutes was used to calculate the rainfall intensity as recommended by the TxDOT Hydraulic Design Manual (TxDOT, 2011) and TCEQ RG-417 (TCEQ, 2006) because small areas with exceedingly short times of concentration could result in design rainfall intensities that are unrealistically high.

Estimation of Peak Rainfall Intensity for Rational Method

Rainfall intensity was estimated based on guidance provided in the TxDOT Hydraulic Design Manual (TxDOT, 2011). The design rainfall intensity was calculated from the following equation:

$$I = \frac{P_d}{T_c}$$

where: I = design rainfall intensity (in/hr);
T_c = computed time of concentration (hr); and
P_d = depth of rainfall (inches) for design storm of duration T_c.

The values of P_d for each design storm event were obtained from the USGS (2004) for both the 25-year and the 100-year rainfall events for various storm durations. The storm durations represented are 15 and 30 minutes for both the 25-year and 100-year storm events as shown in Figure 6 through Figure 9, respectively. The depth for the desired duration is calculated by performing an interpolation between depth-duration pairs provided in the figures. For times of concentration less than 15 minutes, the depth of rainfall is taken as a fraction of the 15 minute rainfall depth.

Estimation of Peak Design Discharges for Rational Method

The Rational Method was used to estimate peak discharge rates for each drainage area as described above. The runoff coefficients for each drainage area on the final cover system and the calculated peak discharges for the 25-year, 24-hour and 100-year, 24-hour rainfall events for each drainage area are shown in Table 1.

To obtain the design discharge for a specific point in the surface water management system, the peak discharges for each drainage area upstream of the point were added at the point of interest. This technique slightly overestimates peak discharge because peak flows from upstream drainage areas will likely combine downstream at different times. However, this technique is conservative and appropriate for design given the small drainage areas and short times of concentration. The drainage areas upstream of each surface water management system component area are shown in Table 7. The calculated design discharges for the downstream end of each surface water management system component are provided in Table 8.

SCS Curve Number Method for Hydrologic Design

The TCEQ RG-417 (TCEQ, 2006) indicates that the Rational Method is insufficient in modeling the volume of stormwater runoff and hydrograph development. Therefore, it is recommended (TCEQ, 2006) to use TR-55 SCS Curve Number Method to compute runoff volumes for detention pond sizing. Stormwater discharges for the landfill expansion are estimated using the computer program HEC-HMS (USACE, 2000). HEC-HMS applies hydrology design methods, such as the SCS Curve Number Method, as presented in TR-55 (USDA, 1986). Hydrographs generated within the computer program are routed through a user-specified network of reaches and ponds using documented hydraulic routing techniques.

HEC-HMS simulations were conducted to calculate surface water runoff volumes, peak flow rates, and flow characteristics for the surface water management features. Modeling performed using HEC-HMS included the following procedures built-in within the program.

- Runoff volumes were calculated within HEC-HMS using the SCS Curve Number Method as required by TR-55.
- Time-response of runoff (i.e., the process of converting a volume of runoff into a runoff hydrograph) was calculated within HEC-HMS using time of concentration, lag time, and unit hydrograph methods as required by TR-55 using a Type III rainfall distribution (see Figure 1).
- Runoff hydrographs generated within HEC-HMS were routed through a user specified network of reaches using industry standard hydraulic routing techniques such as: Kinematic Wave method for reach routing and an Outflow Curve method for routing through ponds. The Outflow Curve method was used for the detention pond since the outlet structure has a complex design with a combination of orifices, weirs, and culverts. The Outflow Curve was calculated using HydroCAD software that allows for a combination of multiple outflow structures as previously mentioned (HydroCAD, 2006).

The design storm event for peak flow and volume sizing of stormwater ponds is the 25-year, 24-hour storm (TCEQ, 2006). In addition, the pond outflow structure is designed to convey the peak flow rate of a 100-year, 24-hour event without overtopping the pond berm. Analyses of the post-development conditions for both a 25-year and 100-year design storm event are presented below.

For post-development conditions, the contributing drainage area to the detention pond outfall is approximately 84.8 acres as shown in Figure 5 based on the design contours developed by Geosyntec. The landfill area draining to the detention pond is approximately 71.6 acres and is classified as pasture, grassland, or range under fair condition with 50% to 75% ground cover which corresponds to a curve number 84 for hydrologic soil group (HSG) D used for analysis as shown in Table 9 (USDA, 1986). The remaining undeveloped area south of the landfill which drains directly to the detention pond consists of 13.2 acres. This undeveloped area was based on the USGS topography map for brush under good condition with greater than 75% ground cover which corresponds to a curve number of 73 for HSG D used for analysis as shown in Table 9. This additional area is accounted for in the detention pond design. Additional undeveloped areas to the south of the detention pond drain directly to the down gradient drainage channel and site outfall and consist of an additional 30.9 acres. The same undeveloped curve number of 73 is applied to this area which is accounted for in the drainage channel design.

Estimation of Time of Concentration for SCS Curve Number Method

The equations used to estimate the time of concentration described above for the Rational Method apply to the SCS Curve Number Method. The lag times calculated for each drainage area are presented in Table 10 for use in the SCS Curve Number Method and HEC-HMS software. The lag time is estimated as 0.6 times the time of concentration (USDA, 2010).

For the undeveloped contributing areas, shallow concentrated flow will occur after the allowable 300 ft of sheet flow but prior to open channel flow. The travel time for shallow concentrated flow is estimated using the Upland Method (USDA, 1986) as described above.

Surface Water Management System Components Hydraulic Design

Manning's equation was used to estimate the average velocity for the mid-slope drainage benches, downchutes, and perimeter channels. Manning's equation for velocity (Chow, 1959) is presented earlier. Manning's roughness coefficient was selected from Table 5 for a grass-lined channel. Average discharge is equal to the average velocity times the area of cross-section of flow (i.e., $Q = VA$). The mid-slope drainage benches, downchutes, and perimeter channels were designed to accommodate the peak discharge from the 100-year, 24-hour design storm without overtopping consistent with TCEQ TG-3 (TCEQ, 2009).

The tractive stresses in the mid-slope drainage benches, downchutes, and drainage channel outlets for various depths of flow are estimated using the following equation (Chow, 1959):

$$\tau_0 = \gamma_w R_h S$$

where:
- τ_o = average tractive stress (lb/ft^2);
- γ_w = unit weight of water (lb/ft^3);
- R_h = hydraulic radius of flow (ft); and
- S = channel slope (ft/ft).

The tractive stress at the 25-year design discharge for the mid-slope drainage benches, downchutes, and perimeter drainage channel outlets was calculated using the tractive stress equation. Permissible tractive stresses for grass-lined channels range from 0.35 psf to 3.70 psf depending on the retardation class of vegetation. Retardation Class C (which includes Bermuda and Crab grasses among others) is selected for the design of grass-lined channels (Table 11) and has a maximum permissible tractive stress of 1.0 psf (Table 12) according to TxDOT (2011). Where the calculated tractive stress was greater than 1.0 psf, TRM was used. In the TxDOT (2011) reference (see Table 12), the maximum permissible tractive stress of synthetic mat is 2.00 psf. However, there are TRMs available that provide resistance against higher tractive stresses. TxDOT Class 2, Type G TRMs have maximum permissible stresses up to 6 psf, and Type H TRMs have maximum permissible stresses up to 8 psf (TxDOT, 2015).

The allowable tractive stress for the ACB-lined downchutes is documented in published research data (e.g., Ayres, 2001) and selected for design. The ACB-lined downchute is designed to accommodate the design storm event without shifting of the blocks or any loss of embankment soil beneath the ACB system. The maximum allowable tractive stress, or shear stress, for the ACB-lined downchutes ranges from approximately 9.1 to 10.7 psf (Ayres, 2001), as shown in Table 13 with an average value of 9.9 psf which is recommended as the maximum allowable tractive stress.

RESULTS

Hydraulic design calculations for mid-slope benches, downchutes, and perimeter channels were performed using the spreadsheets presented in Appendix A-1 of this calculation package for the hydraulic elements with the largest design flow rates. HEC-HMS output results are provided in Appendix A-2. The design parameters and results of the hydraulic design of each component of the surface water management system are summarized below. Additionally, the mid-slope drainage benches and the perimeter channel dimensions are summarized in Table 14 and Table 15 at the end of this document. The Reach ID corresponds with the drainage area contributing to the adjacent surface water management component.

Summary of Mid-Slope Drainage Benches (Table 14)

- 100-year Rainfall Design Discharge = 4.72 to 32.56 cfs
- Top Width = 18 ft
- Channel Slope = 2.0 to 2.8%
- Manning's *n* = 0.027 (Table 5)
- Side Slopes = 6H:1V and 3H:1V[a]
- Bottom Width = 0 ft
- Available Depth of Flow = 2.0 ft
- **100-year Calculated Depth of Flow** = 0.56 to 1.12 ft
- ***Calculated Depth of Flow < Available Depth of Flow***
- Allowable Tractive Stress = 1.0 psf (Table 12)
- **25-year Calculated Average Tractive Stress** = 0.29 to 0.80 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

[a]Note: The mid-slope drainage benches are graded channels. A 2.0 ft deep (minimum) channel with 6H:1V slopes provides the outer slope of the channel. The 3H:1V slope of the landfill provides the inner slope of the channel.

Summary of Access Road Channel (Table 14)

- 100-year Rainfall Design Discharge = 13.04 cfs
- Top Width = 12 ft
- Channel Slope = 8.0%
- Manning's *n* = 0.030 (Table 5)
- Side Slopes = 3H:1V
- Bottom Width = 0 ft
- Available Depth of Flow = 2.0 ft
- **100-year Calculated Depth of Flow** = 0.78 ft
- ***Calculated Depth of Flow < Available Depth of Flow***
- Allowable Tractive Stress = 2.0 psf (Table 12) or 6 to 8 psf for TxDOT Class 2, Type G or H TRM (TxDOT, 2015)

- **25-year Calculated Average Tractive Stress** = 1.58 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

Summary of Drainage Downchutes[a] (Table 14)

- 100-year Rainfall Design Discharge = 57.84 to 111.34 cfs
- Top Width = 18 ft[b]
- Channel Slope = 33.3%
- Manning's n = 0.036 (Table 13)
- Side Slopes = 6 ft radius
- Bottom Width = 6.0 ft[b]
- Available Depth of Flow = 2.0 ft
- **100-year Calculated Depth of Flow** = 0.55 to 0.73 ft
- ***Calculated Depth of Flow < Available Depth of Flow***
- Allowable Tractive Stress = 9.9 psf (Table 13)
- **25-year Calculated Average Tractive Stress** = 7.55 to 9.62 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

[a]Note: Downchutes will be lined with ACB and constructed with a 6 ft radius of curvature. The downchutes were conservatively designed as trapezoidal channels with a 6 ft bottom width (except Downchute 1 as noted below) and 3H:1V side slopes.
[b]Note: Downchute 1 will be constructed with a bottom width of 8.0 ft and a resulting top width of 20 ft.

Eastern Perimeter Drainage Channel (Reach 1 to Reach 7)

- 100-year Rainfall Design Discharge = 2.80 to 219.65 cfs
- Top Width = 23 ft
- Channel Slope = 0.9 to 2.1% (Table 15)
- Manning's n = 0.030 to 0.033 (Table 5 and Table 6)
- Side Slopes = 3H:1V
- Bottom Width = 5 ft
- Available Depth of Flow = 3.0 ft
- **100-year Calculated Depth of Flow** = 0.25 to 2.31 ft
- ***Calculated Depth of Flow < Available Depth of Flow***

- Allowable Tractive Stress = 1.0 psf (grass-lined) or 2.0 psf (turf reinforcement mat) (Table 12)
- **25-year Calculated Average Tractive Stress** = 0.16 to 1.48 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

<u>Western Perimeter Drainage Channel (Reach 9 to Reach 12)</u>

- 100-year Rainfall Design Discharge = 13.92 to 123.70 cfs
- Top Width = 20 ft
- Channel Slope = 1.7 to 3.3% (Table 15)
- Manning's *n* = 0.030 to 0.033 (Table 5 and Table 6)
- Side Slopes = 3H:1V
- Bottom Width = 5 ft
- Available Depth of Flow = 2.5 ft
- **100-year Calculated Depth of Flow** = 0.49 to 1.73 ft
- ***Calculated Depth of Flow < Available Depth of Flow***
- Allowable Tractive Stress = 1.0 psf (grass-lined) or 2.0 psf (turf reinforcement mat) (Table 12)
- **25-year Calculated Average Tractive Stress** = 0.42 to 1.05 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

<u>Southern Perimeter Drainage Channel (Reach 8 and Reach 13)</u>

- 100-year Rainfall Design Discharge = 142.26 to 263.57 cfs
- Top Width = 26 ft
- Channel Slope = 1.6 to 2.0% (Table 15)
- Manning's *n* = 0.030 (Table 6)
- Side Slopes = 3H:1V
- Bottom Width = 8 ft
- Available Depth of Flow = 3.0 ft
- **100-year Calculated Depth of Flow** = 1.53 to 2.22 ft
- ***Calculated Depth of Flow < Available Depth of Flow***
- Allowable Tractive Stress = 2.0 psf (turf reinforcement mat) (Table 12)
- **25-year Calculated Average Tractive Stress** = 1.13 to 1.25 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

Chambered Sediment/Stormwater Detention Pond Hydraulic Design

The SCS Curve Number method is used for hydrologic design of the chambered sediment/stormwater detention pond. This method is evaluated with HEC-HMS software and is used as input for the hydraulic design of the stormwater detention pond. Stormwater runoff is routed through the detention pond which is sized to detain water from a 25-year, 24-hour rainfall event. The pond outlet structure was sized to convey the peak flow rate for the 100-year, 24-hour storm event without overtopping the pond berm. The primary pond outlet structure consists of two 36 inch diameter pipes with an invert elevation of 340-ft. A tiered concrete headwall is designed up gradient from the outlet culverts to manage outflows from the pond. The headwall consists of a tiered weir design with a lower weir crest at elevation 342.25-ft and length of 15 ft. The upper weir crest is at elevation 343.0-ft and has a length of 20 ft. A series of low flow orifices are spaced within the headwall structure. The orifices are six inches in diameter and spaced eight inches apart vertically in two rows and four columns (for a total of eight orifices). An emergency overflow spillway is modeled as a broad-crested weir at elevation 345-ft with a crest length of 100 ft and crest breadth of 13 ft.

The proposed chambered sediment/stormwater detention pond is designed to convey the peak flow rate for the 100-year, 24-hour storm event as required by TCEQ TG-3 (TCEQ, 2009). The 100-year, 24-hour peak flow rate is conveyed through the overflow spillway keeping 1.0 feet of freeboard. Modeling results for the peak flow rates and maximum water surface elevations are presented in Table 16 of this calculation package.

CONCLUSIONS

Results from calculations presented in this calculation package indicate that the surface water management system for the proposed Cell 1 vertical expansion and Cell 2 lateral expansion of the Coal Combustion Byproduct Landfill at the LCRA Fayette Power Project site in La Grange, Texas will collect and control the runoff resulting from a 100-year, 24-hour design storm event. The proposed surface water management system includes drainage downchutes, mid-slope drainage benches, perimeter drainage channels, an access road channel, and a chambered sediment/stormwater detention pond which will collect runoff from the landfill final cover system and adjacent up gradient undeveloped areas. Stormwater runoff will be routed to the facility's site outfall point.

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TABLES

- Table 11 – Retardation Class for Lining Materials (from TxDOT, 2011)
- Table 12 – Permissible Shear Stresses for Various Linings (from TxDOT, 2011)
- Table 13 – Manning's Roughness Coefficient and Design Summary for ACB
- Table 14 – Mid-Slope Drainage Bench and Drainage Downchute Geometry and Results
- Table 15 – Perimeter Drainage Channel Geometry and Results
- Table 16 – HEC-HMS Model Results

Table 1 – Subcatchment Areas, Time of Concentration, and Peak Discharge Calculations

SUBCATCHMENT DESIGNATION	Area Acres (Ac.)	Sheet Flow				Shallow Concentrated Flow or Channel Flow									T_c	Runoff Coefficient for Rural Watersheds				25-year Return Interval			100-year Return Interval		
		Length L (ft)	Slope S (ft/ft)	Manning's n	Time T_t (min)	Length L (ft)	Depth d (ft)	Area A (ft^2)	Wetted P (ft)	Hydraulic Radius R (ft)	Manning's n	Slope S (ft/ft)	Velocity V (ft/s)	Time T_t (min)	Design T_c (min)	Relief C_r	Soil Infiltration C_i	Vegetal Cover C_v	Surface C_s	Intensity I_{25} (in/hr)	Runoff Coefficient C_{25}	Peak Flow Rate Q_{25} (cfs)	Intensity I_{100} (in/hr)	Runoff Coefficient C_{100}	Peak Flow Rate Q_{100} (cfs)
1	0.35	40	0.333	0.150	1.42	180	3.0	42.0	24.0	1.75	0.033	0.015	7.98	0.38	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**1.87**	10.00	0.800	**2.80**
2A	15.54	300	0.030	0.150	18.66	700	1.0	33.3	66.7	0.50	0.027	0.009	3.20	3.64	22.30	0.12	0.16	0.06	0.12	5.98	0.51	**47.03**	7.61	0.575	**67.98**
2B	1.39	25	0.333	0.150	0.98	1050	2.0	18.0	18.5	0.97	0.027	0.020	7.67	2.28	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**7.44**	10.00	0.800	**11.12**
2C	3.42	115	0.333	0.150	3.31	1250	2.0	18.0	18.5	0.97	0.027	0.02	7.67	2.72	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**18.30**	10.00	0.800	**27.36**
2D	0.61	150	0.333	0.150	4.09	170	2.0	18.0	18.5	0.97	0.027	0.02	7.67	0.37	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**3.26**	10.00	0.800	**4.88**
2E	0.23	50	0.333	0.150	1.70	120	3.0	42.0	24.0	1.75	0.033	0.015	7.98	0.25	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**1.23**	10.00	0.800	**1.84**
3	0.53	60	0.333	0.150	1.97	250	3.0	42.0	18.5	2.27	0.033	0.01	7.28	0.57	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**2.84**	10.00	0.800	**4.24**
4	0.13	65	0.333	0.150	2.10	70	3.0	42.0	24.0	1.75	0.033	0.020	9.30	0.13	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**0.70**	10.00	0.800	**1.04**
5A	12.63	300	0.030	0.150	18.66	425	1.0	33.3	66.7	0.50	0.027	0.007	2.93	2.42	21.08	0.12	0.16	0.06	0.12	6.19	0.51	**39.55**	7.91	0.575	**57.44**
5B	2.03	160	0.333	0.150	4.31	460	2.0	18.0	18.5	0.97	0.027	0.020	7.67	1.00	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**10.86**	10.00	0.800	**16.24**
5C	0.82	150	0.333	0.150	4.09	230	2.0	18.0	18.5	0.97	0.027	0.020	7.67	0.50	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**4.39**	10.00	0.800	**6.56**
5D	0.59	70	0.333	0.150	2.22	250	2.0	18.0	18.5	0.97	0.033	0.021	6.44	0.65	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**3.16**	10.00	0.800	**4.72**
6	1.15	130	0.333	0.150	3.65	0	3.0	42.0	24.0	1.75	0.033	0.016	8.30	0.00	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**6.15**	10.00	0.800	**9.20**
7	0.53	130	0.333	0.150	3.65	170	3.0	42.0	24.0	1.75	0.033	0.017	8.43	0.34	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**2.84**	10.00	0.800	**4.24**
8	5.49	150	0.333	0.150	4.09	1130	3.0	51.0	27.0	1.89	0.033	0.016	8.70	2.16	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**29.37**	10.00	0.800	**43.92**
9	1.74	70	0.285	0.150	2.37	320	2.5	31.3	20.8	1.50	0.033	0.033	10.72	0.50	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**9.31**	10.00	0.800	**13.92**
10	0.16	50	0.426	0.150	1.54	70	2.5	31.3	20.8	1.50	0.033	0.017	7.67	0.15	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**0.86**	10.00	0.800	**1.29**
11A	3.57	250	0.030	0.150	16.13	0	1.0	33.3	66.7	0.50	0.027	0.014	4.04	0.00	16.13	0.12	0.16	0.06	0.12	7.27	0.51	**13.14**	9.51	0.575	**19.53**
11B	1.32	75	0.333	0.150	2.35	700	2.0	18.0	18.5	0.97	0.027	0.020	7.67	1.52	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**7.06**	10.00	0.800	**10.56**
11C	1.63	200	0.333	0.150	5.15	0	2.0	12.0	12.6	0.95	0.027	0.080	15.07	0.00	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**8.72**	10.00	0.800	**13.04**
11D	2.44	100	0.333	0.150	2.96	880	2.0	18.0	18.5	0.97	0.027	0.032	9.70	1.51	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**13.05**	10.00	0.800	**19.52**
11E	2.21	140	0.333	0.150	3.87	560	2.0	18.0	18.5	0.97	0.027	0.020	7.67	1.22	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**11.82**	10.00	0.800	**17.68**
11F	1.24	80	0.333	0.150	2.47	500	2.0	18.0	18.5	0.97	0.027	0.02	7.67	1.09	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**6.63**	10.00	0.800	**9.92**
11G	0.69	80	0.333	0.150	2.47	0	2.5	31.3	20.8	1.50	0.033	0.02	7.67	0.00	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**3.69**	10.00	0.800	**5.52**
12	1.59	80	0.333	0.150	2.47	550	2.5	31.3	20.8	1.50	0.033	0.018	7.94	1.15	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**8.51**	10.00	0.800	**12.72**
13	2.32	150	0.333	0.150	4.09	460	2.5	35.0	23.8	1.47	0.033	0.020	8.19	0.94	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**12.41**	10.00	0.800	**18.56**
14A	0.59	80	0.333	0.150	2.47	220	2.0	18.0	18.5	0.97	0.027	0.020	7.67	0.48	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**3.16**	10.00	0.800	**4.72**
14B	1.64	90	0.333	0.150	2.72	0	2.0	18.0	18.5	0.97	0.027	0.020	7.67	0.00	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**8.77**	10.00	0.800	**13.12**
14C	1.33	140	0.333	0.150	3.87	320	2.0	18.0	18.5	0.97	0.027	0.020	7.67	0.70	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**7.12**	10.00	0.800	**10.64**
14D	3.67	140	0.333	0.150	3.87	1000	2.0	18.0	18.5	0.97	0.027	0.020	7.67	2.17	10.00	0.30	0.16	0.06	0.12	7.60	0.70	**19.64**	10.00	0.800	**29.36**
OS1	13.20	300	0.033	0.150	17.89	400						0.030	1.21	5.50	23.39	0.30	0.16	0.06	0.12	5.81	0.70	**54.01**	7.36	0.800	**77.74**
OS2	22.82	300	0.040	0.150	16.63	800						0.038	1.36	9.84	26.47	0.30	0.16	0.06	0.12	5.39	0.70	**86.64**	6.76	0.800	**123.41**
OS3	8.11	300	0.020	0.150	21.94	550						0.044	1.46	6.27	28.21	0.30	0.16	0.06	0.12	5.19	0.70	**29.63**	6.47	0.800	**41.97**

2-year, 24-hr Design Rainfall Depth, $P_{2\text{-}24}$ =	3.7	inches
25-year, 15-min Design Rainfall Depth =	1.9	inches
25-year, 30-min Design Rainfall Depth =	2.5	inches
100-year, 15-min Design Rainfall Depth =	2.5	inches
100-year, 30-min Design Rainfall Depth =	3.1	inches

Notes:

1. Manning's Roughness coefficients: n = 0.150 represents grass (short grass prairie) for sheet flow (USDA, 1986); n = 0.027 to 0.033 represents the range for excavated open channel of earth that is straight and uniform with short grass and few weeds (Chow, 1959).

2. Travel Time (T_t) is calculated using Manning's kinematic solutions for sheet flow (USDA, 1986).

$$T_t = 0.007(nL)^{0.8} / (P_{2\text{-}24})^{0.5} S^{0.4}$$

4. Open Channel Velocity (V) is calculated using Manning's equation (USDA, 1986).

$$V = (1.49 r^{2/3} S^{1/2}) / n$$ *where: r = hydraulic radius (ft) and is equal to A/P [area (ft^2)/wetted perimeter (ft)]*

5. Travel Time (T_t) is calculated as the ration of flow length to flow velocity (USDA, 1986).

$$T_t = L / V * (1/60)$$ *where: (1/60) is a conversion from seconds to minutes*

6. Intensity was calculated using the 25-year or 100-year design rainfall depth for a storm of duration equal to time of concentration for Fayette County provided by USGS (2004).

7. The runoff coefficient is based on rural watersheds using guidance provided by TxDOT (2011).

8. The Rational Method was used to estimate peak discharge rates (Q) for each subcatchment area.

9. The Design Rainfall Depths are taken from USGS (2004) rainfall depth for Fayette County.

Table 2 – Runoff Coefficients (C) for Rural Watersheds
(from TxDOT, 2011)

Watershed characteristic	Extreme	High	Normal	Low
Relief - C_r	0.28-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.14-0.20 Rolling, with average slopes of 5-10%	0.08-0.14 Relatively flat land, with average slopes of 0-5%
Soil infiltration - C_i	0.12-0.16 No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	0.06-0.08 Normal; well drained light or medium textured soils, sandy loams	0.04-0.06 Deep sand or other soil that takes up water readily; very light, well-drained soils
Vegetal cover - C_v	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface Storage - C_s	0.10-0.12 Negligible; surface depressions few and shallow, drainageways steep and small, no marshes	0.08-0.10 Well-defined system of small drainageways, no ponds or marshes	0.06-0.08 Normal; considerable surface depression, e.g., storage lakes and ponds and marshes	0.04-0.06 Much surface storage, drainage system not sharply defined; large floodplain storage, large number of ponds or marshes
Table 4-11 note: The total runoff coefficient based on the 4 runoff components is $C = C_r + C_i + C_v + C_s$				

Table 3 – Manning's Roughness Coefficient for Sheet Flow (from USDA, 1986)

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Table 4 – Upland Method Velocity Factors for Shallow Concentrated Flow

Surface Description	K_V [ft/sec]	K_V [m/sec]
Paved	20.33	6.2
Unpaved	16.13	4.92
Grassed Waterway	15.0	4.57
Nearly Bare & Untilled	10.0	3.05
Cultivated Straight Rows	9.0	2.74
Short Grass Pasture	7.0	2.13
Woodland	5.0	1.52
Forest w/Heavy Litter	2.5	0.76

Table 5 – Manning's Roughness Coefficient for Open Channel Flow

(from Chow, 1959)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140

Table 6 – Typical Roughness Coefficients for Selected Linings

(from FHWA, 2005)

Lining Category	Lining Type	Manning's n[1] Maximum	Manning's n[1] Typical	Manning's n[1] Minimum
Rigid	Concrete	0.015	0.013	0.011
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil[2]	0.025	0.020	0.016
	Rock Cut (smooth, uniform)	0.045	0.035	0.025
RECP	Open-weave textile	0.028	0.025	0.022
	Erosion control blankets	0.045	0.035	0.028
	Turf reinforcement mat	0.036	0.030	0.024

[1]Based on data from Kouwen, et al. (1980), Cox, et al. (1970), McWhorter, et al. (1968) and Thibodeaux (1968).
[2]Minimum value accounts for grain roughness. Typical and maximum values incorporate varying degrees of form roughness.

Table 7 – Contributing Areas to each Storm Water Management System Component

System Component	Drainage Areas Upstream of Stormwater Management System Component														
Reach 1	1														
Reach 2	1	2A	2B	2C	2D	2E									
Reach 3	1	2A	2B	2C	2D	2E	3								
Reach 4	1	2A	2B	2C	2D	2E	3	4							
Reach 5	1	2A	2B	2C	2D	2E	3	4	5A	5B	5C	5D			
Reach 6	1	2A	2B	2C	2D	2E	3	4	5A	5B	5C	5D	6		
Reach 7	1	2A	2B	2C	2D	2E	3	4	5A	5B	5C	5D	6	7	
Reach 8	1	2A	2B	2C	2D	2E	3	4	5A	5B	5C	5D	6	7	8
Reach 9	9														
Reach 10	9	10													
Reach 11	9	10	11A	11B	11C	11D	11E	11F	11G						
Reach 12	9	10	11A	11B	11C	11D	11E	11F	11G	12					
Reach 13	9	10	11A	11B	11C	11D	11E	11F	11G	12	13				
Outfall Ditch	Pond Ouflow		Undeveloped Areas												
Downchute 1	2A	2B	2C	2D											
Downchute 2	5A	5B	5C												
Downchute 3	11A	11B	11C	11D	11E	11F									
Downchute 4	14A	14B	14C	14D											

Table 8 – Calculated Design Discharges for Each Stormwater Management System Component

System Component	Flow Rates from Contributing Areas Upstream of Stormwater Management Component (100-year event)															100-year Total Flow (cfs)	25-year Total Flow (cfs)
Reach 1	2.80															2.80	1.87
Reach 2	2.80	67.98	11.12	27.36	4.88	1.84										115.98	79.13
Reach 3	2.80	67.98	11.12	27.36	4.88	1.84	4.24									120.22	81.97
Reach 4	2.80	67.98	11.12	27.36	4.88	1.84	4.24	1.04								121.26	82.67
Reach 5	2.80	67.98	11.12	27.36	4.88	1.84	4.24	1.04	57.44	16.24	6.56	4.72				206.21	140.62
Reach 6	2.80	67.98	11.12	27.36	4.88	1.84	4.24	1.04	57.44	16.24	6.56	4.72	9.20			215.41	146.77
Reach 7	2.80	67.98	11.12	27.36	4.88	1.84	4.24	1.04	57.44	16.24	6.56	4.72	9.20	4.24		219.65	149.61
Reach 8	2.80	67.98	11.12	27.36	4.88	1.84	4.24	1.04	57.44	16.24	6.56	4.72	9.20	4.24	43.92	263.57	178.98
Reach 9	13.92															13.92	9.31
Reach 10	13.92	1.29														15.21	10.17
Reach 11	13.92	1.29	19.53	10.56	13.04	19.52	17.68	9.92	5.52							110.98	74.30
Reach 12	13.92	1.29	19.53	10.56	13.04	19.52	17.68	9.92	5.52	12.72						123.70	82.81
Reach 13	13.92	1.29	19.53	10.56	13.04	19.52	17.68	9.92	5.52	12.72	18.56					142.26	95.22
Outfall Ditch	424.30	130.50														554.80	306.60
Downchute 1	67.98	11.12	27.36	4.88												111.34	76.03
Downchute 2	57.44	16.24	6.56													80.24	57.95
Downchute 3	19.53	10.56	13.04	19.52	17.68	9.92										90.25	60.44
Downchute 4	4.72	13.12	10.64	29.36												57.84	38.68
Mid Slope Bench 2B	11.12															11.12	7.44
Mid Slope Bench 2C	27.36															27.36	18.30
Mid Slope Bench 2D	4.88															4.88	3.26
Mid Slope Bench 5B	16.24															16.24	10.86
Mid Slope Bench 5C	6.56															6.56	4.39
Mid Slope Bench 11B	10.56															10.56	7.06
Mid Slope Bench 11C	13.04															13.04	8.72
Mid Slope Bench 11D	13.04	19.52														32.56	21.78
Mid Slope Bench 11E	17.68															17.68	11.82
Mid Slope Bench 11F	9.92															9.92	6.63
Mid Slope Bench 14A	4.72															4.72	3.16
Mid Slope Bench 14B	13.12															13.12	8.77
Mid Slope Bench 14C	10.64															10.64	7.12
Mid Slope Bench 14D	29.36															29.36	19.64

Table 9 – Runoff Curve Numbers for Other Agricultural Lands (from USDA, 1986)

Cover description: Cover type	Hydrologic condition	Curve numbers for hydrologic soil group: A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 10 – SCS Method Lag Time Calculations

SUBCATCHMENT DESIGNATION	Area (mi^2)	Length (ft)	Slope (%)	CN	T_{lag} (min)	Sheet Flow, T_t	Shallow Conc or Channel, T_t
1	0.000547	220	7.265	84	6.00	1.42	0.38
2A	0.024281	1000	1.495	84	13.38	18.66	3.64
2B	0.002172	1075	2.728	84	6.00	0.98	2.28
2C	0.005344	1365	4.637	84	6.00	3.31	2.72
2D	0.000953	320	16.672	84	6.00	4.09	0.37
2E	0.000359	170	10.839	84	6.00	1.70	0.25
3	0.000828	310	7.147	84	6.00	1.97	0.57
4	0.000203	135	17.076	84	6.00	2.10	0.13
5A	0.019734	725	1.658	84	12.65	18.66	2.42
5B	0.003172	620	10.077	84	6.00	4.31	1.00
5C	0.001281	380	14.355	84	6.00	4.09	0.50
5D	0.000922	320	8.933	84	6.00	2.22	0.65
6	0.001797	130	33.300	84	6.00	3.65	0.00
7	0.000828	300	15.365	84	6.00	3.65	0.34
8	0.008578	1280	5.306	84	6.00	4.09	2.16
9	0.002719	390	7.814	84	6.00	2.37	0.50
10	0.000252	120	18.747	84	6.00	1.54	0.15
11A	0.005578	250	3.000	84	9.68	16.13	0.00
11B	0.002063	775	5.029	84	6.00	2.35	1.52
11C	0.002547	200	33.300	84	6.00	5.15	0.00
11D	0.003813	980	6.271	84	6.00	2.96	1.51
11E	0.003453	700	8.260	84	6.00	3.87	1.22
11F	0.001938	580	6.317	84	6.00	2.47	1.09
11G	0.001078	80	33.300	84	6.00	2.47	0.00
12	0.002484	630	5.800	84	6.00	2.47	1.15
13	0.003625	610	9.674	84	6.00	4.09	0.94
14A	0.000922	300	10.347	84	6.00	2.47	0.48
14B	0.002563	90	33.300	84	6.00	2.72	0.00
14C	0.002078	460	11.526	84	6.00	3.87	0.70
14D	0.005734	1140	5.844	84	6.00	3.87	2.17
OS1	0.020625	600	3.5	73	14.03	17.54	3.82
OS2	0.035656	1050	3.1429	73	15.88	18.31	10.07
OS3	0.012672	1406	2.7027	73	16.93	19.45	16.02

Table 11 – Retardation Class for Lining Materials (from TxDOT, 2011)

Retardance Class	Cover	Condition
A	Weeping Lovegrass	Excellent stand, tall (average 30 in. or 760 mm)
	Yellow Bluestem Ischaemum	Excellent stand, tall (average 36 in. or 915 mm)
B	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (average 12 in. or 305 mm)
	Native grass mixture little bluestem, bluestem, blue gamma, other short and long stem medwest grasses	Good stand, unmowed
	Weeping lovegrass	Good Stand, tall (average 24 in. or 610 mm)
	Lespedeza sericea	Good stand, not woody, tall (average 19 in. or 480 mm)
	Alfalfa	Good stand, uncut (average 11 in or 280 mm)
	Weeping lovegrass	Good stand, unmowed (average 13 in. or 330 mm)
	Kudzu	Dense growth, uncut
	Blue gamma	Good stand, uncut (average 13 in. or 330 mm)
C	Crabgrass	Fair stand, uncut (10-to-48 in. or 55-to-1220 mm)
	Bermuda grass	Good stand, mowed (average 6 in. or 150 mm)
	Common lespedeza	Good stand, uncut (average 11 in. or 280 mm)
	Grass-legume mixture: summer (orchard grass redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6-8 in. or 150-200 mm)
	Centipedegrass	Very dense cover (average 6 in. or 150 mm)
	Kentucky bluegrass	Good stand, headed (6-12 in. or 150-305 mm)
D	Bermuda grass	Good stand, cut to 2.5 in. or 65 mm
	Common lespedeza	Excellent stand, uncut (average 4.5 in. or 115 mm)
	Buffalo grass	Good stand, uncut (3-6 in. or 75-150 mm)
	Grass-legume mixture: fall, spring (orchard grass Italian ryegrass, and common lespedeza	Good Stand, uncut (4-5 in. or 100-125 mm)
	Lespedeza sericea	After cutting to 2 in. or 50 mm (very good before cutting)
E	Bermuda grass	Good stand, cut to 1.5 in. or 40 mm
	Bermuda grass	Burned stubble

Table 12 – Permissible Shear Stresses for Various Linings (from TxDOT, 2011)

Protective Cover	(lb./sq.ft.)	t_p (N/m^2)
Retardance Class A Vegetation (See the "Retardation Class for Lining Materials" table above)	3.70	177
Retardance Class B Vegetation (See the "Retardation Class for Lining Materials" table above)	2.10	101
Retardance Class C Vegetation (See the "Retardation Class for Lining Materials" table above)	1.00	48
Retardance Class D Vegetation (See the "Retardation Class for Lining Materials" table above)	0.60	29
Retardance Class E Vegetation (See the "Retardation Class for Lining Materials" table above)	0.35	17
Woven Paper	0.15	7
Jute Net	0.45	22
Single Fiberglass	0.60	29
Double Fiberglass	0.85	41
Straw W/Net	1.45	69
Curled Wood Mat	1.55	74
Synthetic Mat	2.00	96
Gravel, D_{50} = 1 in. or 25 mm	0.40	19
Gravel, D_{50} = 2 in. or 50 mm	0.80	38
Rock, D_{50} = 6 in. or 150 mm	2.50	120
Rock, D_{50} = 12 in. or 300 mm	5.00	239
6-in. or 50-mm Gabions	35.00	1675
4-in. or 100-mm Geoweb	10.00	479
Soil Cement (8% cement)	>45	>2154
Dycel w/out Grass	>7	>335
Petraflex w/out Grass	>32	>1532
Armorflex w/out Grass	12-20	574-957
Erikamat w/3-in or 75-mm Asphalt	13-16	622-766
Erikamat w/1-in. or 25 mm Asphalt	<5	<239
Armorflex Class 30 with longitudinal and lateral cables, no grass	>34	>1628
Dycel 100, longitudinal cables, cells filled with mortar	<12	<574
Concrete construction blocks, granular filter underlayer	>20	>957
Wedge-shaped blocks with drainage slot	>25	>1197

Table 13 – Manning's Roughness Coefficient and Design Summary for ACB (from Ayres, 2001)

Table 3.1. Summary of Hydraulic Conditions, Channel Lock 450 System.

Test Number	1	2	3	4	5
Nominal Overtopping depth, ft	0.75	1.25	2	3	4
Discharge, ft^3/s (based on pint velocities)	6.0	14.10	28.8	50.8	80.0
Bed slope, ft/ft (vert./horiz.)	0.33	0.33	0.33	0.33	0.33
Stations used for analysis (ft)	19.7 - 31.1	19.7 - 31.1	18.0 - 25.4	19.7 - 29.2	21.6 - 27.5
Energy slope, ft/ft (along slope)	0.33	0.30	0.23	0.22	0.15
Representative depth, ft	0.15	0.25	0.49	0.77	1.05
Representative velocity, ft/s	10.0	14.2	14.7	16.6	19.0
Range of shear stress, lb/ft^2	2.7 - 3.1	3.6 - 4.6	6.7 - 7.0	9.1 - 10.7	7.5 - 9.1
Manning's n value	0.024	0.023	0.030	0.036	0.030
Darcy friction factor	0.128	0.095	0.134	0.161	0.104
Comments	Stable	Stable	Stable	Minor, isolated voids in soil downstream of sta. 37.0 ft. Intimate contact maintained.	Failed downstream of Sta. 27.5

Table 14 – Mid-Slope Drainage Bench and Drainage Downchute Geometry and Results

Contributing Drainage Area	Channel Slope (ft/ft)	Channel Dimensions (minimum)						25-year				100-year				Channel Lining
		Length (ft)	Bottom Width (ft)	Depth (ft)	Left Side Slope (H:V)	Right Side Slope (H:V)	Top Width (ft)	Peak Flow (cfs)	Peak Depth (ft)	Peak Velocity (ft/s)	Tractive Stress (psf)	Peak Flow (cfs)	Peak Depth (ft)	Peak Velocity (ft/s)	Tractive Stress (psf)	
2B	0.020	1072	0.0	2.0	3:1	6:1	18	7.44	0.67	3.69	0.41	11.12	0.78	4.08	0.47	Grass
2C	0.020	1205	0.0	2.0	3:1	6:1	18	18.30	0.94	4.63	0.57	27.36	1.09	5.11	0.66	Grass
2D	0.020	175	0.0	2.0	3:1	6:1	18	3.26	0.49	3.01	0.30	4.88	0.57	3.32	0.35	Grass
5B	0.020	613	0.0	2.0	3:1	6:1	18	10.86	0.77	4.06	0.47	16.24	0.90	4.49	0.54	Grass
5C	0.020	231	0.0	2.0	3:1	6:1	18	4.39	0.55	3.24	0.33	6.56	0.64	3.58	0.39	Grass
11B	0.020	1307	0.0	2.0	3:1	6:1	18	7.06	0.66	3.65	0.40	10.56	0.76	4.03	0.46	Grass
11C	0.080	631	0.0	2.0	3:1	3:1	12	8.72	0.67	6.52	1.58	13.04	0.78	7.21	1.84	TRM
11D	0.028	882	0.0	2.0	3:1	6:1	18	21.78	0.94	5.48	0.80	32.56	1.09	6.06	0.93	Grass
11E	0.020	1142	0.0	2.0	3:1	6:1	18	11.82	0.80	4.15	0.48	17.68	0.93	4.59	0.56	Grass
11F	0.020	892	0.0	2.0	3:1	6:1	18	6.63	0.64	3.59	0.39	9.92	0.75	3.97	0.45	Grass
14A	0.020	305	0.0	2.0	3:1	6:1	18	3.16	0.49	2.98	0.29	4.72	0.56	3.30	0.34	Grass
14B	0.020	997	0.0	2.0	3:1	6:1	18	8.77	0.71	3.85	0.43	13.12	0.83	4.26	0.50	Grass
14C	0.020	445	0.0	2.0	3:1	6:1	18	7.12	0.66	3.65	0.40	10.64	0.77	4.04	0.46	Grass
14D	0.020	1124	0.0	2.0	3:1	6:1	18	19.64	0.96	4.71	0.58	29.36	1.12	5.21	0.68	Grass
Downchute 1	0.333	245	8.0	2.0	3:1	3:1	20	76.03	0.55	14.29	9.62	111.34	0.68	16.19	11.59	ACB
Downchute 2	0.333	255	6.0	2.0	3:1	3:1	18	57.95	0.55	13.86	9.19	80.24	0.66	15.35	10.70	ACB
Downchute 3	0.333	333	6.0	2.0	3:1	3:1	18	60.44	0.56	14.04	9.37	90.25	0.70	15.91	11.30	ACB
Downchute 4	0.333	323	6.0	2.0	3:1	3:1	18	38.68	0.44	12.16	7.55	57.84	0.55	13.85	9.18	ACB

Table 15 – Perimeter Drainage Channel Geometry and Results

Perimeter Channel Segment	Channel Slope (ft/ft)	Channel Dimensions (minimum)					25-year				100-year				Channel Lining
		Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slopes (H:V)	Top Width (ft)	Peak Flow (cfs)	Peak Depth (ft)	Peak Velocity (ft/s)	Tractive Stress (psf)	Peak Flow (cfs)	Peak Depth (ft)	Peak Velocity (ft/s)	Tractive Stress (psf)	
Reach 1	0.015	196	5.0	3.0	3:1	23	1.87	0.20	1.72	0.16	2.80	0.25	1.98	0.20	Grass
Reach 2	0.015	127	5.0	3.0	3:1	23	79.13	1.52	5.47	0.92	115.98	1.83	6.05	1.07	Grass
Reach 3	0.009	249	5.0	3.0	3:1	23	81.97	1.76	4.54	0.61	120.22	2.11	5.03	0.71	Grass
Reach 4	0.020	66	5.0	3.0	3:1	23	82.67	1.37	6.63	1.15	121.26	1.66	7.35	1.34	TRM
Reach 5	0.021	252	5.0	3.0	3:1	23	140.62	1.76	7.78	1.48	206.21	2.11	8.61	1.72	TRM
Reach 6	0.016	335	5.0	3.0	3:1	23	146.77	1.92	7.11	1.20	215.41	2.30	7.87	1.40	TRM
Reach 7	0.017	218	5.0	3.0	3:1	23	149.61	1.92	7.23	1.24	219.65	2.31	8.00	1.44	TRM
Reach 8	0.016	1250	8.0	3.0	3:1	26	178.98	1.82	7.29	1.25	263.57	2.22	8.12	1.46	TRM
Reach 9	0.033	301	5.0	2.5	3:1	20	9.31	0.39	3.85	0.66	13.92	0.49	4.38	0.80	Grass
Reach 10	0.017	77	5.0	2.5	3:1	20	10.17	0.50	3.16	0.42	15.21	0.62	3.57	0.50	Grass
Reach 11	0.017	273	5.0	2.5	3:1	20	74.30	1.42	5.63	0.99	110.98	1.73	6.27	1.16	Grass
Reach 12	0.018	496	5.0	2.5	3:1	20	82.81	1.41	6.37	1.05	123.70	1.72	7.10	1.23	TRM
Reach 13	0.020	641	8.0	3.0	3:1	26	95.22	1.24	6.57	1.13	142.26	1.53	7.38	1.34	TRM
Outfall Ditch	0.010	550	10.0	4.0	3:1	34	306.60	2.49	7.05	1.05	554.80	3.35	8.28	1.34	TRM

Table 16 – HEC-HMS Model Results

	25-year, 24-hour Design Storm Event	100-year, 24-hour Design Storm Event
Peak Discharge to Detention Pond (cfs)	383.0	550.6
Peak Outflow from Detention Pond (cfs)	214.5	424.3
Peak Pond Water Surface Elevation (ft)	345.4	346.0
Peak Storage in Detention Pond (ac-ft)	13.7	15.6
Peak Discharge to Site Outfall (cfs)	297.3	574.2

FIGURES

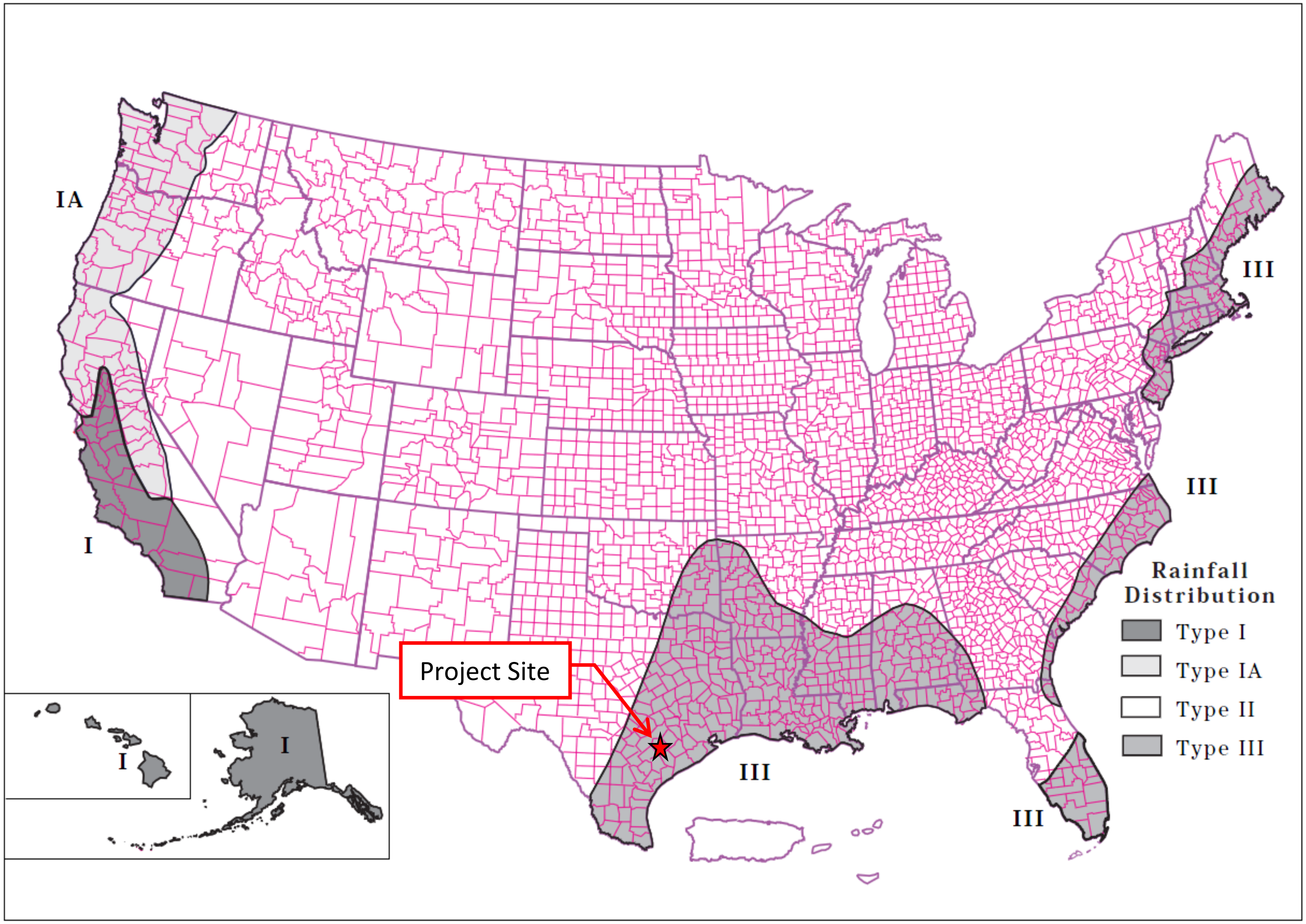


Figure 1 – Rainfall Distribution Map of the United States (from USDA, 1986)

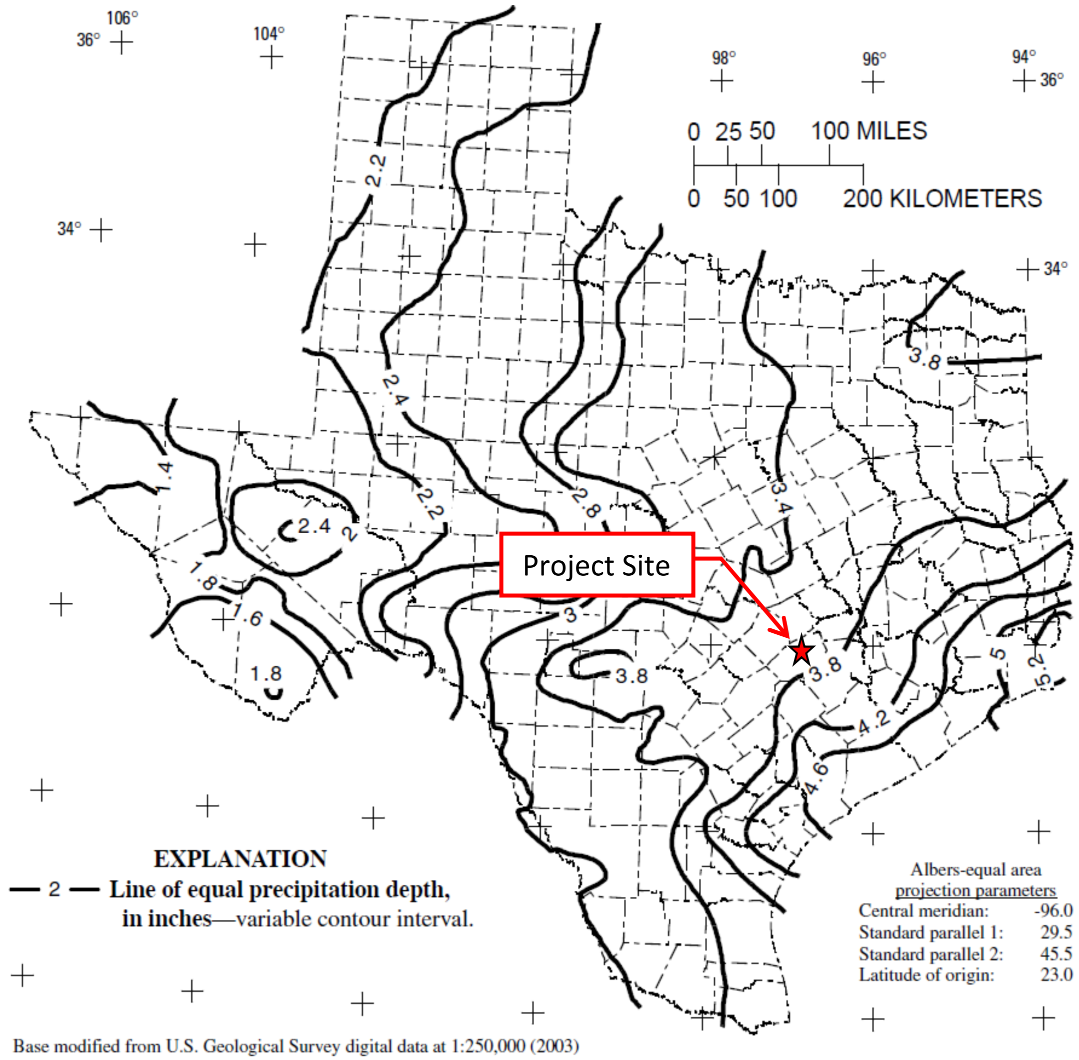


Figure 2 – Depth of Precipitation for 2-year Storm for 24-hour Duration in Texas (from USGS, 2004)

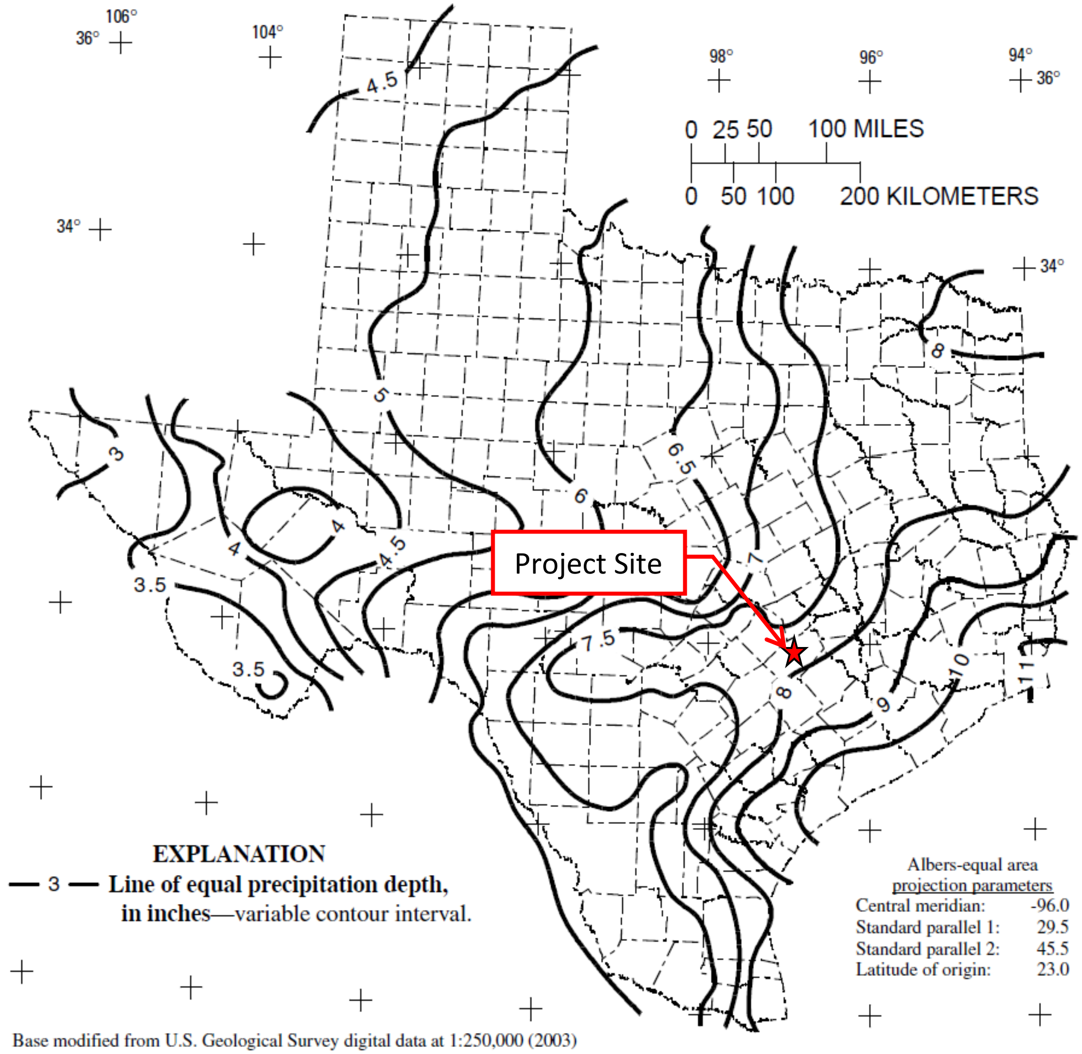


Figure 3 – Depth of Precipitation for 25-year Storm for 24-hour Duration in Texas (from USGS, 2004)

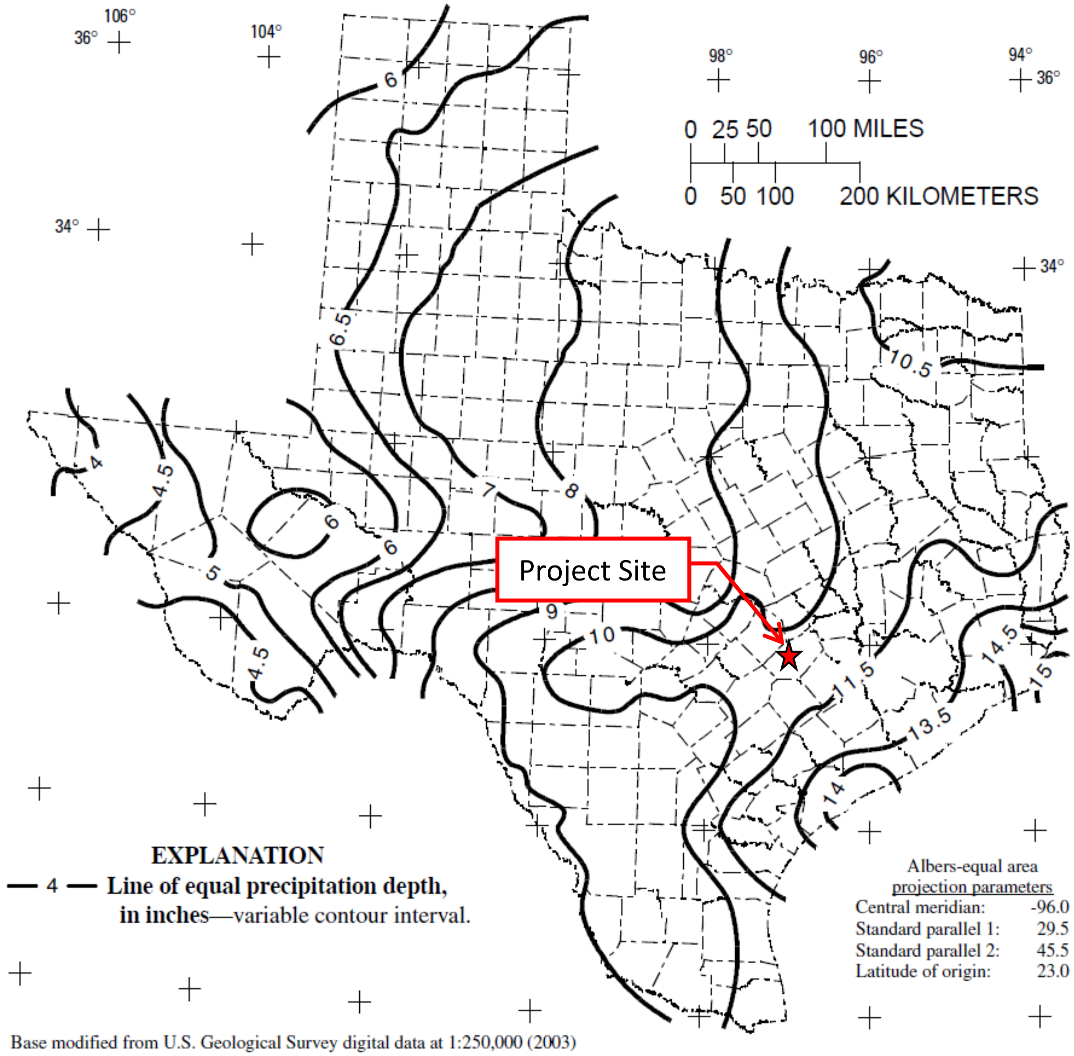
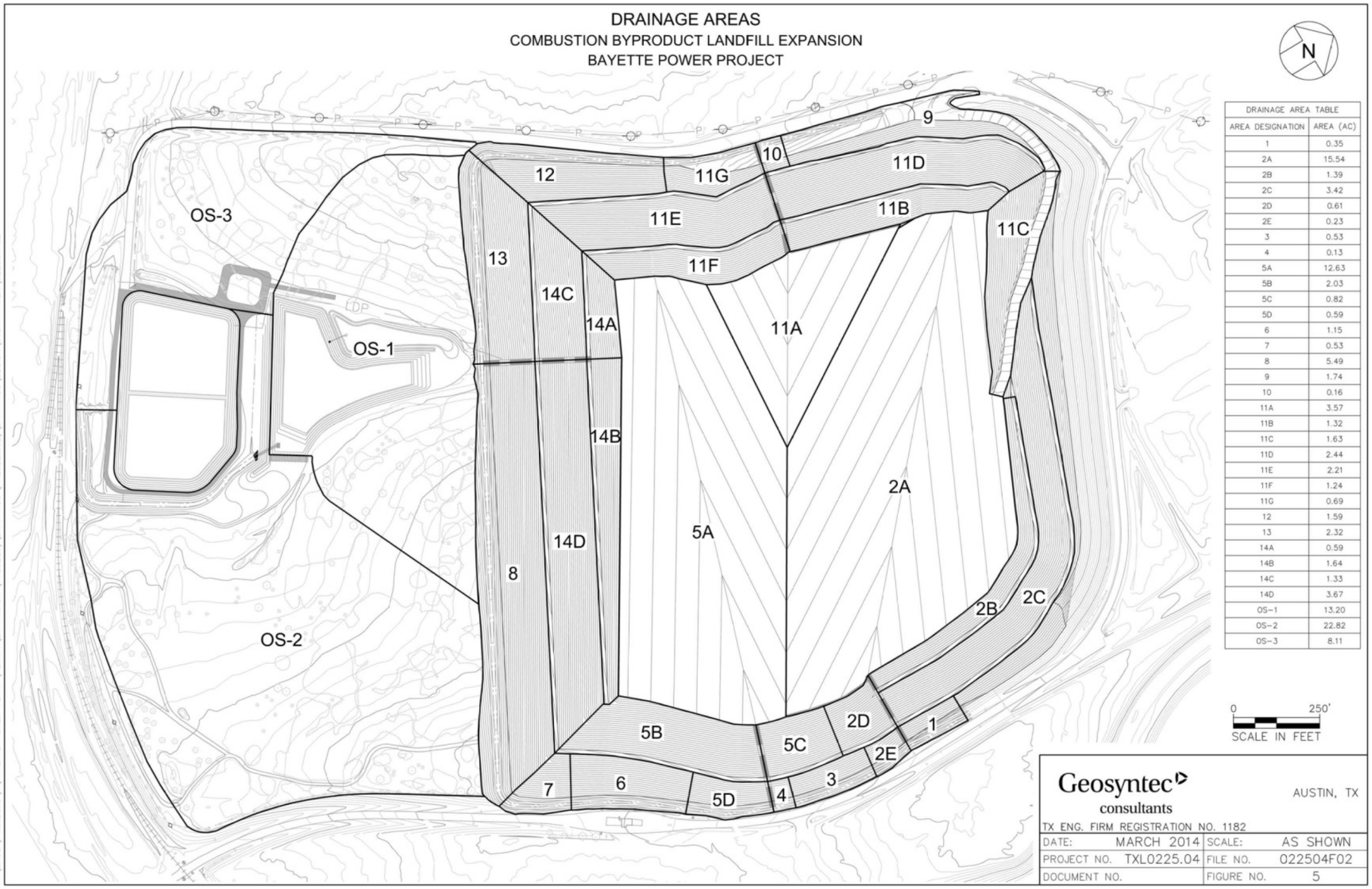


Figure 4 – Depth of Precipitation for 100-year Storm for 24-hour Duration in Texas (from USGS, 2004)



DRAINAGE AREA TABLE	
AREA DESIGNATION	AREA (AC)
1	0.35
2A	15.54
2B	1.39
2C	3.42
2D	0.61
2E	0.23
3	0.53
4	0.13
5A	12.63
5B	2.03
5C	0.82
5D	0.59
6	1.15
7	0.53
8	5.49
9	1.74
10	0.16
11A	3.57
11B	1.32
11C	1.63
11D	2.44
11E	2.21
11F	1.24
11G	0.69
12	1.59
13	2.32
14A	0.59
14B	1.64
14C	1.33
14D	3.67
OS-1	13.20
OS-2	22.82
OS-3	8.11

Figure 5 – Contributing Drainage Areas for Surface Water Management Components

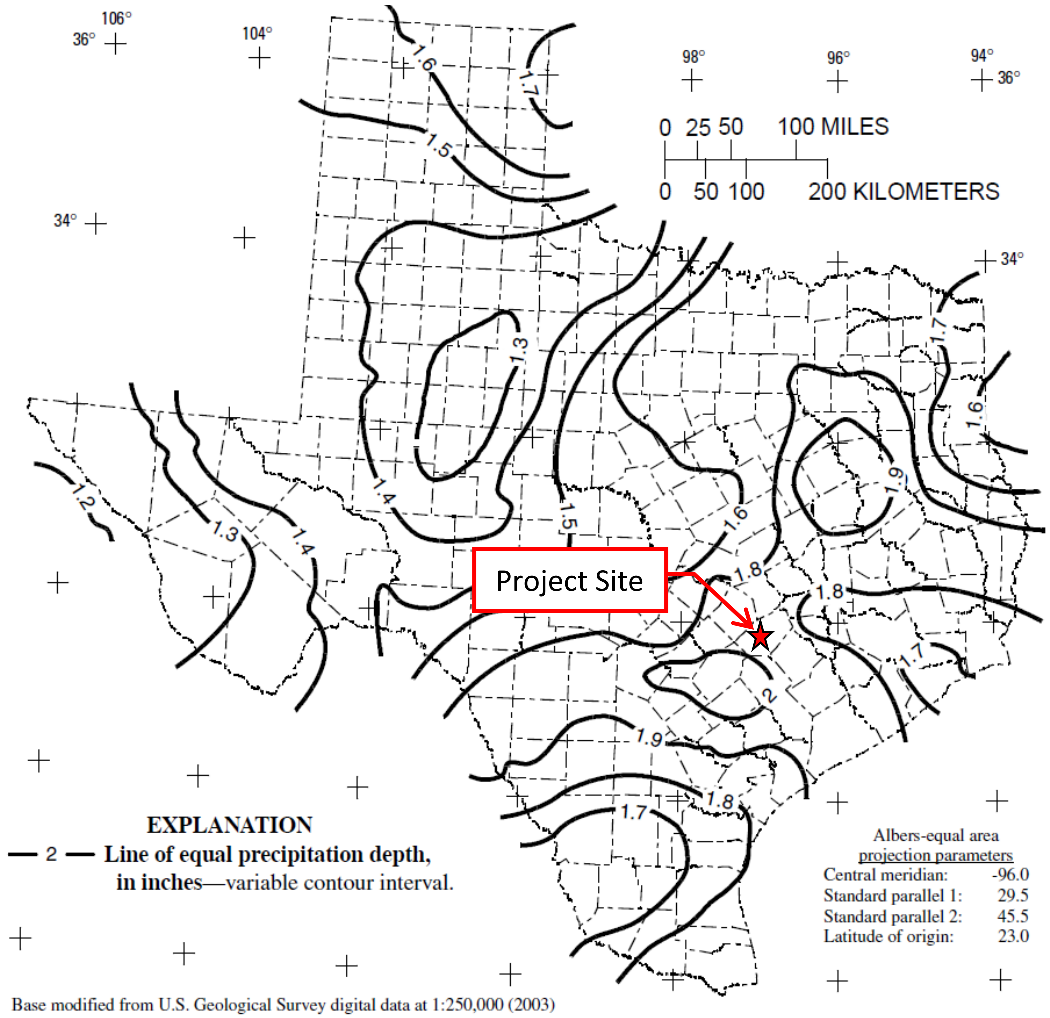


Figure 6 – Depth of Precipitation for 25-year Storm for 15-minute Duration in Texas (from USGS, 2004)

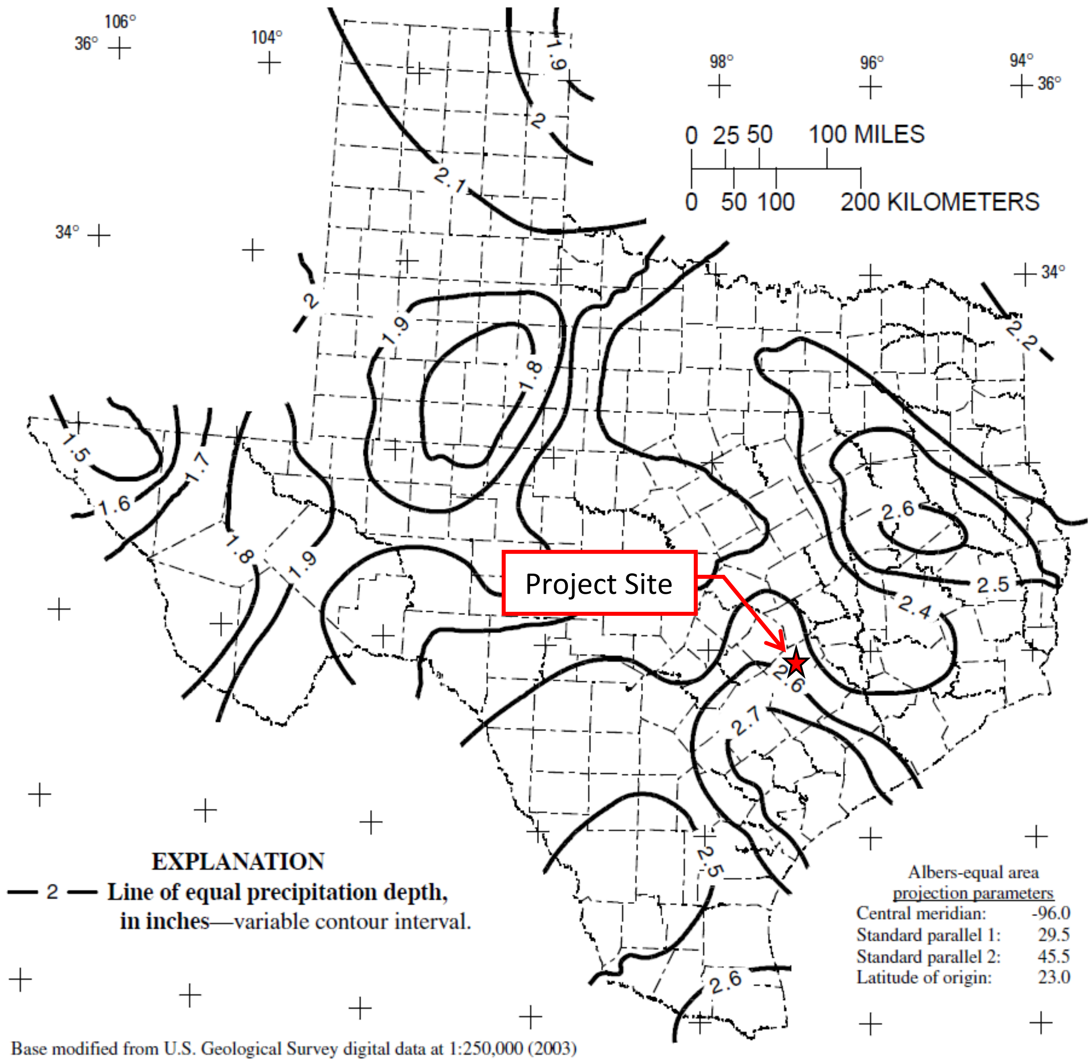


Figure 7 – Depth of Precipitation for 25-year Storm for 30-minute Duration in Texas (from USGS, 2004)

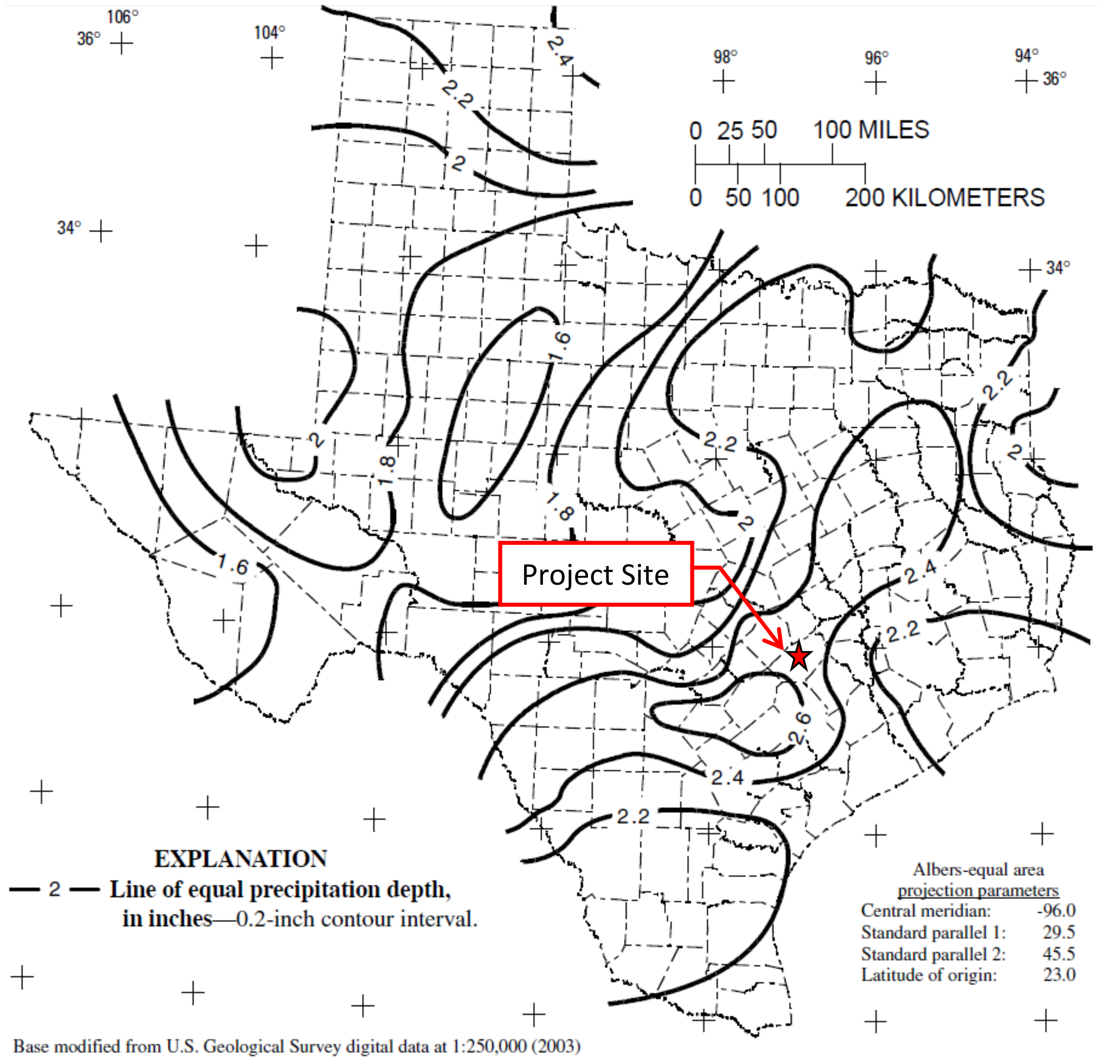


Figure 8 – Depth of Precipitation for 100-year Storm for 15-minute Duration in Texas (from USGS, 2004)

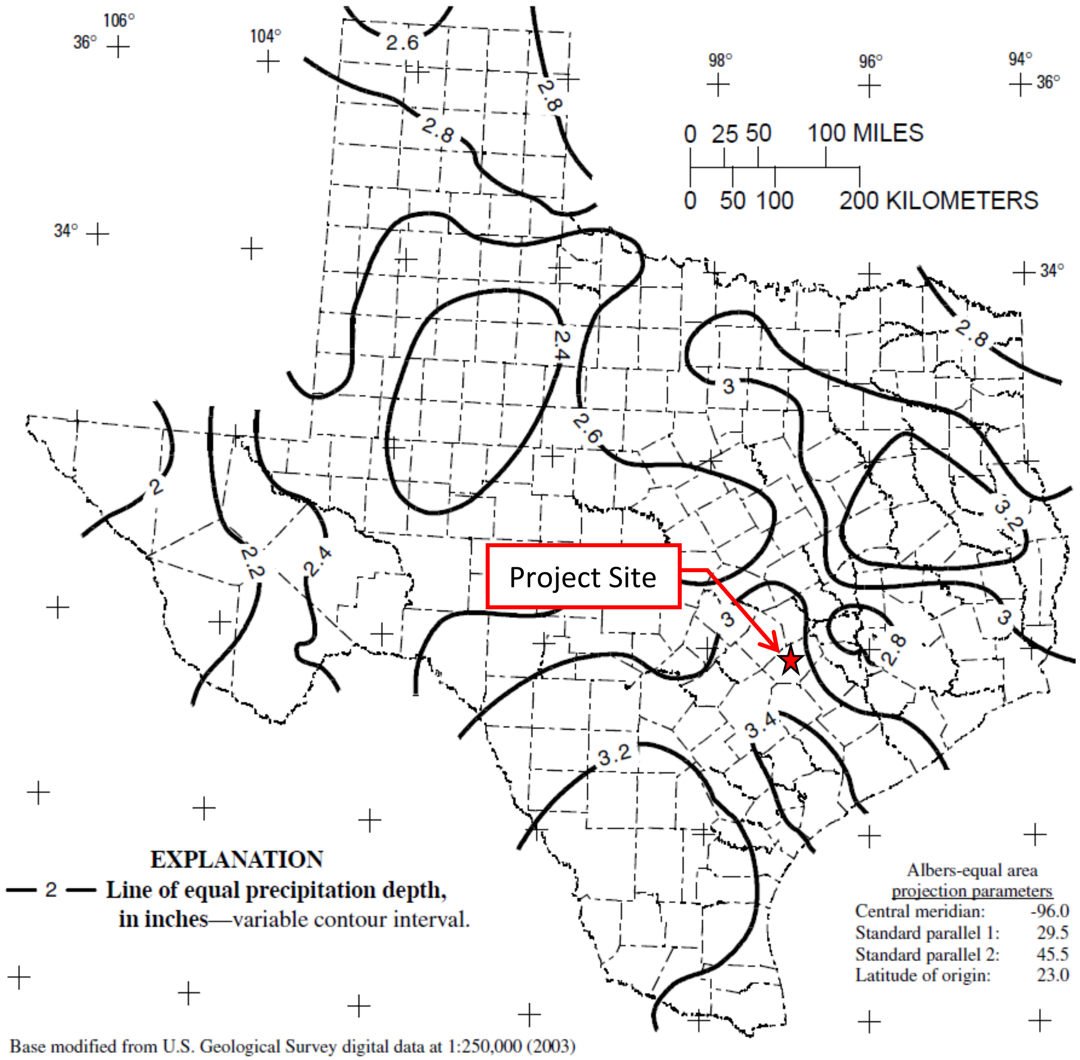


Figure 9 – Depth of Precipitation for 100-year Storm for 30-minute Duration in Texas (from USGS, 2004)

APPENDIX A-1
HYDRAULIC DESIGN CALCULATIONS
FOR LARGEST FLOW RATE

Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

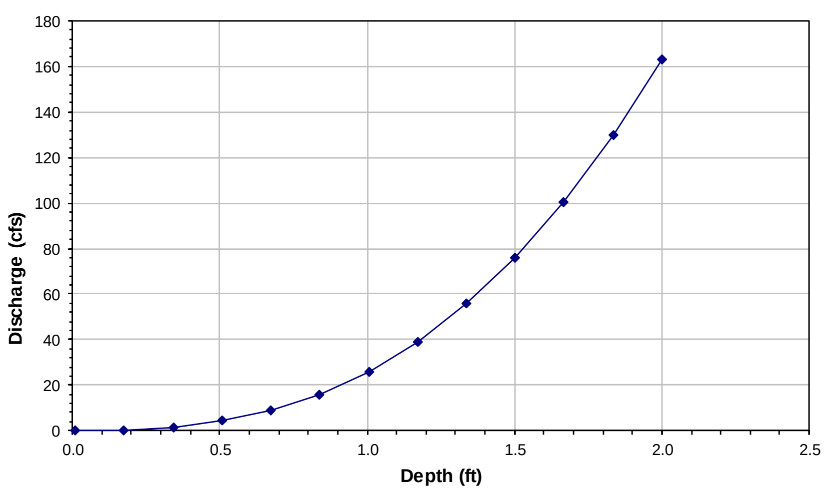
Project: LCRA Fayette Power Project, La Grange, TX

Ditch ID: Mid-Slope Drainage Bench 11D - 100-yr Flow

Peak Discharge, Q_{100} =	32.56	cfs
Bottom Width, B =	0.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	6.00	horizontal :1 vertical
Channel Depth, Y =	2.00	ft
Top Width, T =	18.00	ft
Manning's Roughness Coeff., n =	0.027	
Longitudinal Channel Slope, S_o =	0.0280	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.00	0.09	0.00	0.26	0.0	0.01	
0.18	0.14	1.63	0.09	1.79	0.2	0.15	
0.34	0.53	3.16	0.17	2.79	1.5	0.29	
0.51	1.16	4.69	0.25	3.63	4.2	0.43	
0.67	2.04	6.22	0.33	4.39	9.0	0.57	
0.84	3.17	7.76	0.41	5.08	16.1	0.71	
1.01	4.55	9.29	0.49	5.73	26.1	0.85	
1.17	6.17	10.82	0.57	6.35	39.1	1.00	
1.34	8.04	12.36	0.65	6.93	55.7	1.14	
1.50	10.16	13.89	0.73	7.49	76.1	1.28	
1.67	12.53	15.42	0.81	8.04	100.7	1.42	
1.83	15.14	16.96	0.89	8.56	129.6	1.56	
2.00	18.00	18.49	0.97	9.07	163.3	1.70	
1.09	5.37	10.10	0.53	6.06	32.56	0.93	DESIGN Q

Discharge versus Depth Relationship



Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

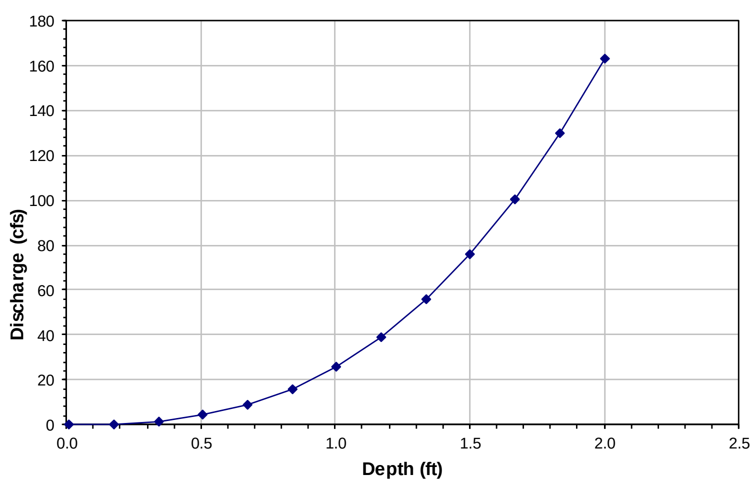
Project: LCRA Fayette Power Project, La Grange, TX

Ditch ID: Mid-Slope Drainage Bench 11D - 25-yr Flow

Peak Discharge, Q_{25} =	21.78	cfs
Bottom Width, B =	0.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	6.00	horizontal :1 vertical
Channel Depth, Y =	2.00	ft
Top Width, T =	18.00	ft
Manning's Roughness Coeff., n =	0.027	
Longitudinal Channel Slope, S_o =	0.0280	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.00	0.09	0.00	0.26	0.0	0.01	
0.18	0.14	1.63	0.09	1.79	0.2	0.15	
0.34	0.53	3.16	0.17	2.79	1.5	0.29	
0.51	1.16	4.69	0.25	3.63	4.2	0.43	
0.67	2.04	6.22	0.33	4.39	9.0	0.57	
0.84	3.17	7.76	0.41	5.08	16.1	0.71	
1.01	4.55	9.29	0.49	5.73	26.1	0.85	
1.17	6.17	10.82	0.57	6.35	39.1	1.00	
1.34	8.04	12.36	0.65	6.93	55.7	1.14	
1.50	10.16	13.89	0.73	7.49	76.1	1.28	
1.67	12.53	15.42	0.81	8.04	100.7	1.42	
1.83	15.14	16.96	0.89	8.56	129.6	1.56	
2.00	18.00	18.49	0.97	9.07	163.3	1.70	
0.94	3.97	8.69	0.46	5.48	21.78	0.80	DESIGN Q

Discharge versus Depth Relationship



Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

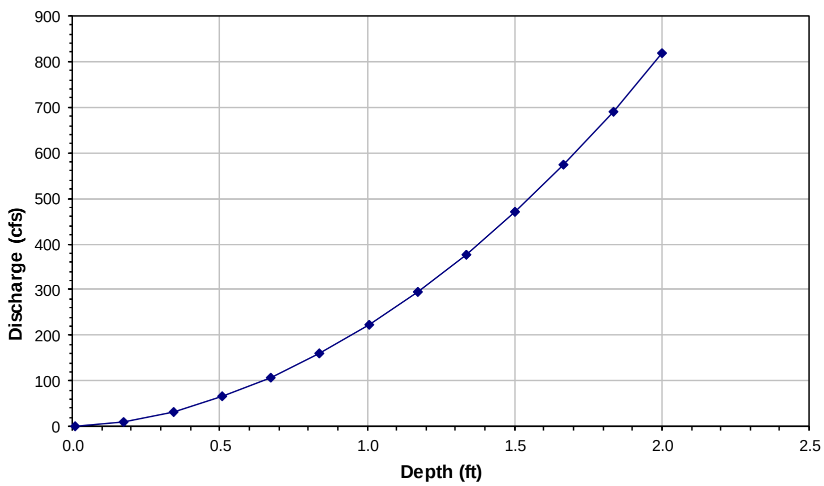
Project: LCRA Fayette Power Project, La Grange, TX

Ditch ID: **Downchute 1 - Area 2 - 100-yr Flow**

Peak Discharge, Q_{100} =	111.34	cfs
Bottom Width, B =	8.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Channel Depth, Y =	2.00	ft
Top Width, T =	20.00	ft
Manning's Roughness Coeff., n =	0.036	
Longitudinal Channel Slope, S_o =	0.3330	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.08	8.06	0.01	1.10	0.1	0.21	
0.18	1.50	9.11	0.16	7.17	10.7	3.42	
0.34	3.08	10.16	0.30	10.78	33.2	6.31	
0.51	4.83	11.21	0.43	13.63	65.9	8.96	
0.67	6.75	12.26	0.55	16.04	108.2	11.44	
0.84	8.83	13.31	0.66	18.16	160.3	13.78	
1.01	11.07	14.36	0.77	20.08	222.3	16.02	
1.17	13.48	15.41	0.87	21.85	294.5	18.18	
1.34	16.05	16.45	0.98	23.49	377.2	20.27	
1.50	18.79	17.50	1.07	25.04	470.6	22.31	
1.67	21.70	18.55	1.17	26.51	575.3	24.30	
1.83	24.77	19.60	1.26	27.92	691.4	26.26	
2.00	28.00	20.65	1.36	29.26	819.4	28.18	
0.68	6.88	12.33	0.56	16.19	111.34	11.59	DESIGN Q

Discharge versus Depth Relationship



Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

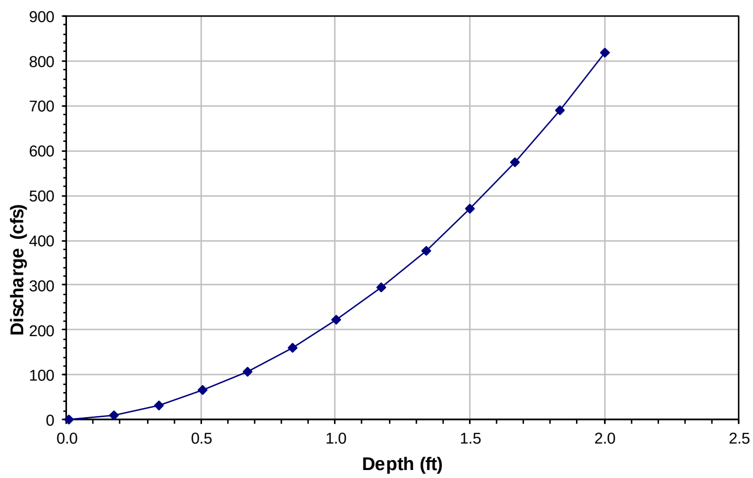
Project: LCRA Fayette Power Project, La Grange, TX

Ditch ID: Downchute 1 - Area 2 - 25-yr Flow

Peak Discharge, Q_{25} =	76.03	cfs
Bottom Width, B =	8.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Channel Depth, Y =	2.00	ft
Top Width, T =	20.00	ft
Manning's Roughness Coeff., n =	0.036	
Longitudinal Channel Slope, S_o =	0.3330	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.08	8.06	0.01	1.10	0.1	0.21	
0.18	1.50	9.11	0.16	7.17	10.7	3.42	
0.34	3.08	10.16	0.30	10.78	33.2	6.31	
0.51	4.83	11.21	0.43	13.63	65.9	8.96	
0.67	6.75	12.26	0.55	16.04	108.2	11.44	
0.84	8.83	13.31	0.66	18.16	160.3	13.78	
1.01	11.07	14.36	0.77	20.08	222.3	16.02	
1.17	13.48	15.41	0.87	21.85	294.5	18.18	
1.34	16.05	16.45	0.98	23.49	377.2	20.27	
1.50	18.79	17.50	1.07	25.04	470.6	22.31	
1.67	21.70	18.55	1.17	26.51	575.3	24.30	
1.83	24.77	19.60	1.26	27.92	691.4	26.26	
2.00	28.00	20.65	1.36	29.26	819.4	28.18	
0.55	5.32	11.49	0.46	14.29	76.03	9.62	DESIGN Q

Discharge versus Depth Relationship



Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

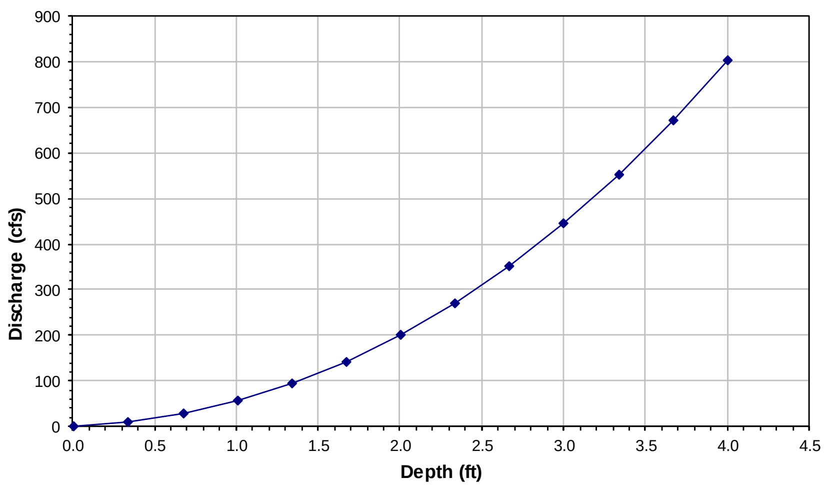
Project: LCRA Fayette Power Project, La Grange, TX

Ditch ID: **Outfall Ditch - 100-yr Flow**

Peak Discharge, Q_{100} =	554.80	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Channel Depth, Y =	4.00	ft
Top Width, T =	34.00	ft
Manning's Roughness Coeff., n =	0.030	
Longitudinal Channel Slope, S_o =	0.0100	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.10	10.06	0.01	0.23	0.0	0.01	
0.34	3.78	12.17	0.31	2.28	8.6	0.19	
0.68	8.12	14.27	0.57	3.41	27.7	0.35	
1.01	13.12	16.37	0.80	4.28	56.2	0.50	
1.34	18.79	18.47	1.02	5.02	94.4	0.63	
1.67	25.12	20.58	1.22	5.67	142.5	0.76	
2.01	32.11	22.68	1.42	6.26	201.1	0.88	
2.34	39.77	24.78	1.60	6.81	270.7	1.00	
2.67	48.09	26.89	1.79	7.32	352.0	1.12	
3.00	57.07	28.99	1.97	7.80	445.3	1.23	
3.34	66.72	31.09	2.15	8.26	551.4	1.34	
3.67	77.03	33.20	2.32	8.71	670.7	1.45	
4.00	88.00	35.30	2.49	9.13	803.8	1.56	
3.35	67.02	31.16	2.15	8.28	554.80	1.34	DESIGN Q

Discharge versus Depth Relationship



Design/Check: Trapezoidal/Triangular Channel

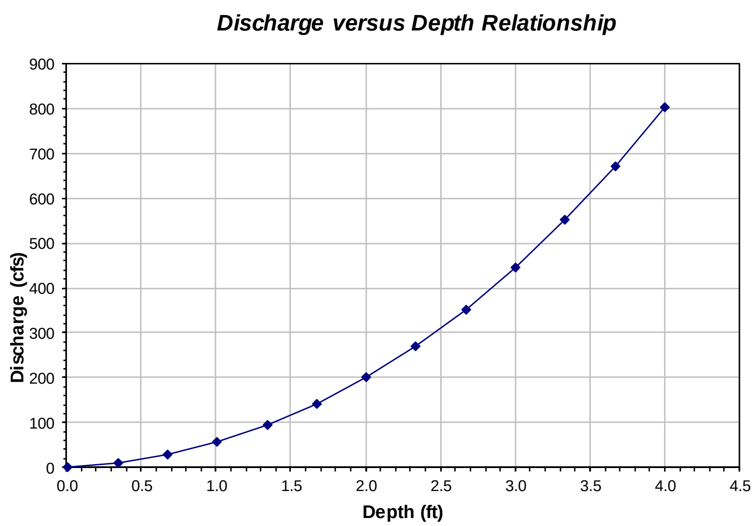
Methodology: Manning's Equation

Project: LCRA Fayette Power Project, La Grange, TX

Ditch ID: **Outfall Ditch - 25-yr Flow**

Peak Discharge, Q_{25} =	306.60	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Channel Depth, Y =	4.00	ft
Top Width, T =	34.00	ft
Manning's Roughness Coeff., n =	0.030	
Longitudinal Channel Slope, S_o =	0.0100	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.10	10.06	0.01	0.23	0.0	0.01	
0.34	3.78	12.17	0.31	2.28	8.6	0.19	
0.68	8.12	14.27	0.57	3.41	27.7	0.35	
1.01	13.12	16.37	0.80	4.28	56.2	0.50	
1.34	18.79	18.47	1.02	5.02	94.4	0.63	
1.67	25.12	20.58	1.22	5.67	142.5	0.76	
2.01	32.11	22.68	1.42	6.26	201.1	0.88	
2.34	39.77	24.78	1.60	6.81	270.7	1.00	
2.67	48.09	26.89	1.79	7.32	352.0	1.12	
3.00	57.07	28.99	1.97	7.80	445.3	1.23	
3.34	66.72	31.09	2.15	8.26	551.4	1.34	
3.67	77.03	33.20	2.32	8.71	670.7	1.45	
4.00	88.00	35.30	2.49	9.13	803.8	1.56	
2.49	43.51	25.75	1.69	7.05	306.60	1.05	DESIGN Q



APPENDIX A-2
HEC-HMS OUTPUT RESULTS

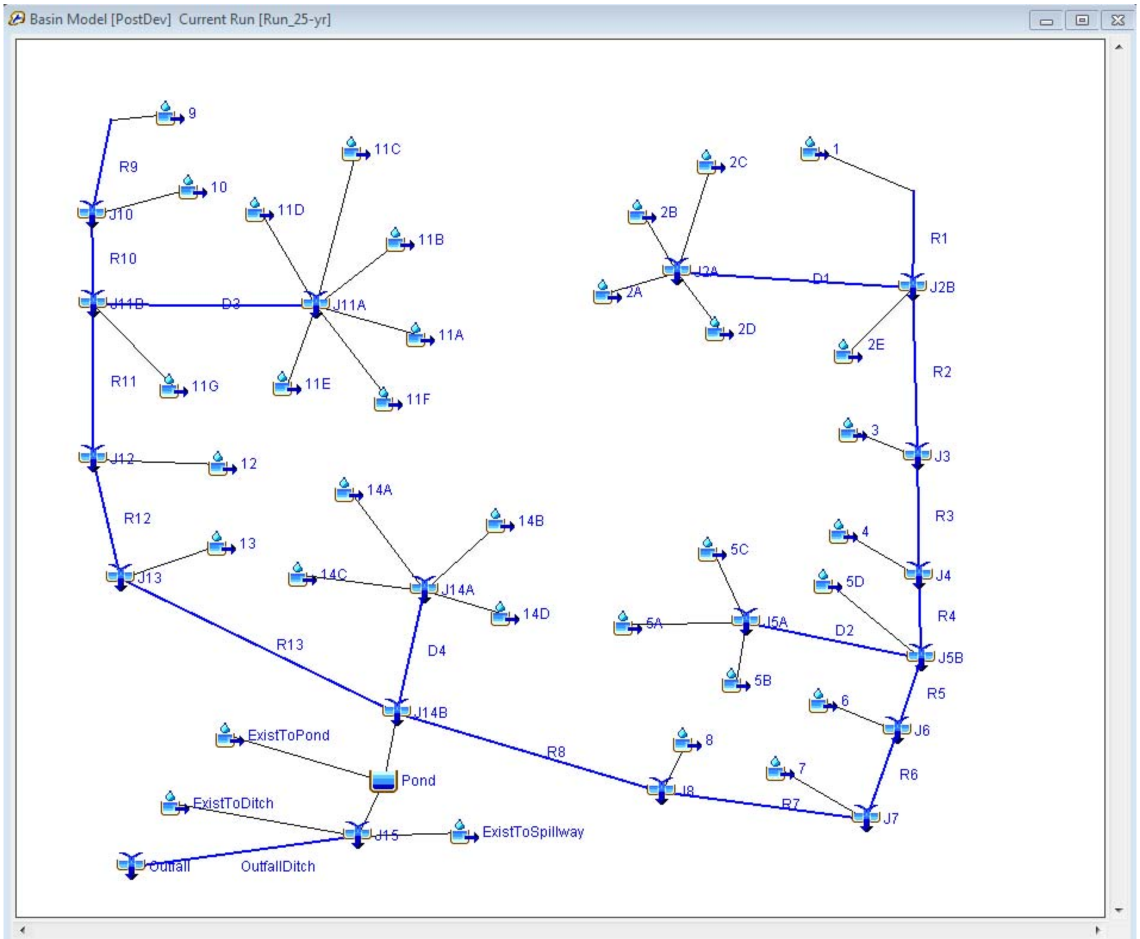


Figure B.1 – HEC-HMS Nodal Network

Table B.1 – 25-Year HEC-HMS Results

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (ac-ft)
1	0.000547	2	01Jan2013, 12:07	0.2
10	0.000252	0.9	01Jan2013, 12:07	0.1
11A	0.005578	17.9	01Jan2013, 12:11	1.8
11B	0.002063	7.5	01Jan2013, 12:07	0.6
11C	0.002547	9.2	01Jan2013, 12:07	0.8
11D	0.003813	13.8	01Jan2013, 12:07	1.2
11E	0.003453	12.5	01Jan2013, 12:07	1.1
11F	0.001938	7	01Jan2013, 12:07	0.6
11G	0.001078	3.9	01Jan2013, 12:07	0.3
12	0.002484	9	01Jan2013, 12:07	0.8
13	0.003625	13.1	01Jan2013, 12:07	1.1
14A	0.000922	3.3	01Jan2013, 12:07	0.3
14B	0.002563	9.3	01Jan2013, 12:07	0.8
14C	0.002078	7.5	01Jan2013, 12:07	0.7
14D	0.005734	20.8	01Jan2013, 12:07	1.8
2A	0.024281	69.7	01Jan2013, 12:15	7.6
2B	0.002172	7.9	01Jan2013, 12:07	0.7
2C	0.00534	19.4	01Jan2013, 12:07	1.7
2D	0.000953	3.5	01Jan2013, 12:07	0.3
2E	0.000359	1.3	01Jan2013, 12:07	0.1
3	0.000828	3	01Jan2013, 12:07	0.3
4	0.000203	0.7	01Jan2013, 12:07	0.1
5A	0.019734	57.9	01Jan2013, 12:14	6.2
5B	0.003172	11.5	01Jan2013, 12:07	1
5C	0.001281	4.6	01Jan2013, 12:07	0.4
5D	0.000922	3.3	01Jan2013, 12:07	0.3
6	0.001797	6.5	01Jan2013, 12:07	0.6
7	0.000828	3	01Jan2013, 12:07	0.3
8	0.008578	31.1	01Jan2013, 12:07	2.7
9	0.002719	9.9	01Jan2013, 12:07	0.9
D1	0.032746	93.2	01Jan2013, 12:12	10.3
D2	0.024187	70.3	01Jan2013, 12:12	7.6
D3	0.019392	66.7	01Jan2013, 12:08	6.1
D4	0.011297	40.9	01Jan2013, 12:08	3.6
J10	0.002971	10.7	01Jan2013, 12:08	0.9
J11A	0.019392	66.9	01Jan2013, 12:08	6.1

J11B	0.023441	81.4	01Jan2013, 12:08	7.4
J12	0.025925	90.1	01Jan2013, 12:09	8.2
J13	0.02955	102.3	01Jan2013, 12:10	9.3
J14A	0.011297	41	01Jan2013, 12:07	3.6
J14B	0.111842	333.9	01Jan2013, 12:12	35.2
J15	0.168132	274.8	01Jan2013, 12:29	49.1
J2A	0.032746	93.3	01Jan2013, 12:12	10.3
J2B	0.033652	96.1	01Jan2013, 12:12	10.6
J3	0.03448	98.6	01Jan2013, 12:12	10.9
J4	0.034683	99	01Jan2013, 12:12	10.9
J5A	0.024187	70.4	01Jan2013, 12:12	7.6
J5B	0.059792	172	01Jan2013, 12:12	18.8
J6	0.061589	177	01Jan2013, 12:13	19.4
J7	0.062417	179.3	01Jan2013, 12:13	19.7
J8	0.070995	203.7	01Jan2013, 12:12	22.4
OS1	0.02063	49.8	01Jan2013, 12:14	5.1
OS2	0.03566	76.4	01Jan2013, 12:18	8.8
OS3	0.01267	24.5	01Jan2013, 12:23	3.1
Outfall	0.180802	297.3	01Jan2013, 12:30	52.2
OutfallDitch	0.168132	274.5	01Jan2013, 12:30	49.1
Pond	0.132472	214.5	01Jan2013, 12:30	40.2
R1	0.000547	2	01Jan2013, 12:09	0.2
R10	0.002971	10.7	01Jan2013, 12:09	0.9
R11	0.023441	81.3	01Jan2013, 12:09	7.4
R12	0.025925	89.9	01Jan2013, 12:10	8.2
R13	0.02955	102.2	01Jan2013, 12:11	9.3
R2	0.033652	96	01Jan2013, 12:12	10.6
R3	0.03448	98.4	01Jan2013, 12:13	10.9
R4	0.034683	99	01Jan2013, 12:13	10.9
R5	0.059792	171.9	01Jan2013, 12:13	18.8
R6	0.061589	176.9	01Jan2013, 12:13	19.4
R7	0.062417	178.9	01Jan2013, 12:13	19.7
R8	0.070995	203.1	01Jan2013, 12:14	22.4
R9	0.002719	9.8	01Jan2013, 12:08	0.9

Table B.2 – 100-Year HEC-HMS Results

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (ac-ft)
1	0.000547	2.8	01Jan2013, 12:07	0.2
10	0.000252	1.3	01Jan2013, 12:07	0.1
11A	0.005578	25.4	01Jan2013, 12:11	2.5
11B	0.002063	10.6	01Jan2013, 12:07	0.9
11C	0.002547	13.1	01Jan2013, 12:07	1.2
11D	0.003813	19.6	01Jan2013, 12:07	1.7
11E	0.003453	17.7	01Jan2013, 12:07	1.6
11F	0.001938	9.9	01Jan2013, 12:07	0.9
11G	0.001078	5.5	01Jan2013, 12:07	0.5
12	0.002484	12.7	01Jan2013, 12:07	1.1
13	0.003625	18.6	01Jan2013, 12:07	1.6
14A	0.000922	4.7	01Jan2013, 12:07	0.4
14B	0.002563	13.2	01Jan2013, 12:07	1.2
14C	0.002078	10.7	01Jan2013, 12:07	0.9
14D	0.005734	29.4	01Jan2013, 12:07	2.6
2A	0.024281	98.8	01Jan2013, 12:15	11
2B	0.002172	11.1	01Jan2013, 12:07	1
2C	0.00534	27.4	01Jan2013, 12:07	2.4
2D	0.000953	4.9	01Jan2013, 12:07	0.4
2E	0.000359	1.8	01Jan2013, 12:07	0.2
3	0.000828	4.2	01Jan2013, 12:07	0.4
4	0.000203	1	01Jan2013, 12:07	0.1
5A	0.019734	82	01Jan2013, 12:14	9
5B	0.003172	16.3	01Jan2013, 12:07	1.4
5C	0.001281	6.6	01Jan2013, 12:07	0.6
5D	0.000922	4.7	01Jan2013, 12:07	0.4
6	0.001797	9.2	01Jan2013, 12:07	0.8
7	0.000828	4.2	01Jan2013, 12:07	0.4
8	0.008578	44	01Jan2013, 12:07	3.9
9	0.002719	14	01Jan2013, 12:07	1.2
D1	0.032746	132.2	01Jan2013, 12:12	14.9
D2	0.024187	99.7	01Jan2013, 12:12	11
D3	0.019392	94.6	01Jan2013, 12:08	8.8
D4	0.011297	57.8	01Jan2013, 12:08	5.1
J10	0.002971	15.2	01Jan2013, 12:08	1.3
J11A	0.019392	94.8	01Jan2013, 12:08	8.8

J11B	0.023441	115.3	01Jan2013, 12:08	10.6
J12	0.025925	127.5	01Jan2013, 12:09	11.8
J13	0.02955	145.3	01Jan2013, 12:09	13.4
J14A	0.011297	58	01Jan2013, 12:07	5.1
J14B	0.111842	475.8	01Jan2013, 12:12	50.8
J15	0.168132	537.7	01Jan2013, 12:21	72
J2A	0.032746	132.2	01Jan2013, 12:12	14.9
J2B	0.033652	136.2	01Jan2013, 12:12	15.3
J3	0.03448	139.7	01Jan2013, 12:12	15.7
J4	0.034683	140.5	01Jan2013, 12:12	15.8
J5A	0.024187	99.8	01Jan2013, 12:12	11
J5B	0.059792	244	01Jan2013, 12:12	27.2
J6	0.061589	251.2	01Jan2013, 12:12	28
J7	0.062417	254.3	01Jan2013, 12:13	28.4
J8	0.070995	289.7	01Jan2013, 12:12	32.2
OS1	0.02063	75.5	01Jan2013, 12:13	7.8
OS2	0.03566	116	01Jan2013, 12:18	13.5
OS3	0.01267	37.2	01Jan2013, 12:23	4.8
Outfall	0.180802	574.2	01Jan2013, 12:22	76.8
OutfallDitch	0.168132	537	01Jan2013, 12:22	72
Pond	0.132472	424.3	01Jan2013, 12:21	58.5
R1	0.000547	2.8	01Jan2013, 12:08	0.2
R10	0.002971	15.2	01Jan2013, 12:08	1.3
R11	0.023441	115.1	01Jan2013, 12:09	10.6
R12	0.025925	127.3	01Jan2013, 12:10	11.8
R13	0.02955	144.9	01Jan2013, 12:10	13.4
R2	0.033652	136.2	01Jan2013, 12:12	15.3
R3	0.03448	139.6	01Jan2013, 12:12	15.7
R4	0.034683	140.4	01Jan2013, 12:12	15.8
R5	0.059792	243.6	01Jan2013, 12:13	27.2
R6	0.061589	251	01Jan2013, 12:13	28
R7	0.062417	254.1	01Jan2013, 12:13	28.4
R8	0.070995	288.9	01Jan2013, 12:14	32.2
R9	0.002719	13.9	01Jan2013, 12:08	1.2

APPENDIX B

Final Cover Soil Erosion Loss Calculation

Geosyntec consultants

Written by:	**V. Krishnan**	Date:	**10/12/2015**	Reviewed & Revised by:	**Z. Islam**	Date:	**10/29/2015**
Client:	**LCRA**	Project:	**FPP CBL Expansion**	Project No.:	**TXL0225**	Phase No.:	**08**

FINAL COVER SOIL EROSION LOSS CALCULATIONS
LCRA FPP COMBUSTION BYPRODUCT LANDFILL

Beth Ann Gross

10/13/2016

GEOSYNTEC CONSULTANTS, INC.
TX ENG FIRM REGISTRATION NO. F-1182

1 PURPOSE

The purpose of this calculation package is to present the evaluation of the long term effects of erosion and soil loss for the completed final cover system of the LCRA FPP Combustion Byproduct Landfill (site) in La Grange, Texas. This package provides calculations for the annual soil loss from the vegetative support layer of the final cover system on the top deck and side slopes of Cells 1 and 2 of the landfill. The estimated amount of erosion was calculated using the Revised Universal Soil Loss Equation (RUSLE).

2 PROJECT BACKGROUND

The final cover placement and closure of the landfill is expected to be completed when the design capacity of Cells 1 and 2 is reached. The top deck of the landfill will have a surface slope of approximately 3% and the external side slopes will be graded to 3 horizontal to 1 vertical (3H:1V). The final cover is designed with a surface water management system with permanent drainage features, including drainage downchutes, mid-slope drainage benches, perimeter drainage channels, and a chambered sediment/storm water detention pond. The drainage downchutes will convey flow from the top deck to the perimeter drainage channel and will be lined with articulated concrete block (ACB). The mid-slope drainage benches will collect and convey storm water runoff from the side slopes to the downchutes. The perimeter drainage channel will also collect and convey flow from the downchutes and side slopes to the storm water detention pond.

3 FINAL COVER SOIL EROSION LOSS CALCULATION METHODOLOGY

The method to calculate the soil erosion loss over the project area was obtained from the guidance document *Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)* (USDA, 1997) as well as previously published information provided by USDA. This document presents the RUSLE methodology and rationale for selecting each of the equation's parameters. The RUSLE is written as follows:

$$A = R \times K \times LS \times C \times P$$

where: A = computed spatial average annual soil loss (tons/acre/year);

R = average annual rainfall runoff erosivity factor;

K = soil erodibility factor;

LS = topographic factor;

C = cover management factor; and

P = erosion control practice factor.

4 RUSLE INPUT PARAMETERS

4.1 Rainfall Runoff Erosivity Factor (R)

The rainfall runoff erosivity factor is defined as the average annual rainfall erosion index specific for the project area. Based on USDA (1997), the value was determined to be approximately 330 for Fayette County, Texas, as shown in Figure 1 at the end of this document.

4.2 Soil Erodibility Factor (K)

The soil erodibility factor is a function of the physical and chemical properties of the soil and is specific to the source of the cover material. The soil erodibility factor can be thought of as the ease with which soil is detached by splash during rainfall or by surface flow. The soils to be used for the final cover system of the landfill may be from native soils available at the project site or from local off-site sources. For soil loss calculation purposes, assessments were made of on-site soils and those nearby, using the Fayette

County soil survey (USDA, 2004). This information shows that the site and nearby area has soils that are a combination of Straber gravelly loamy fine sand with 2-5% slopes (SxC), Latium gravelly clay with 5-12% slopes (LgD), Rek extremely gravelly coarse sandy loam with 2-5% slopes (RkC), and Frelsburg clay with 3-5% slopes (FrC). The Straber gravelly loamy fine sand formation constitute the majority of the site and will be used for cover material as shown in Figure 2 at the end of this document.

The Web Soil Survey tool operated by the USDA Natural Resources Conservation Service (NRCS) (USDA, 2014) was consulted for Fayette County for information on the corresponding soil erodibility factors. Near-surface soils (i.e., topsoil) will be used to construct the topsoil layer of the final cover system. The value of K for the project location soils near the surface varies from 0.24 to 0.32, where the estimate considers the erodibility of fine-earth fraction for material less than two mm in size (using the Kf erosion factor provided in Table 1). The surface layer soils which are proposed to be used for cover materials are Straber gravelly loamy fine sand, and value of K for this soil is 0.32. The use of 0.32 in the calculation is using a conservative value of the formations that are predominant at the site and surrounding areas (i.e., a likely candidate source of future final cover topsoil).

4.3 Topographic Factor (LS)

The slope length factor and slope steepness factor are typically combined into one topographic factor, LS, to facilitate field application of these equation components. USDA (1997) presents values of the LS factor for slope lengths in feet up to 1,000 feet and percent slopes up to 60%, as shown in Table 2, for soils with vegetated cover with consolidated soil conditions.

The longest slope lengths for the side slope and top deck surfaces of the final cover system were used to select the LS factor for each area, and these lengths were applied to compute the soil loss for both portions of the landfill. The top deck surface will consist of a 3% slope with maximum length of 370 ft. The final cover system will consist of 3H:1V (33.3%) side slopes with mid-slope drainage benches. The maximum length of 3H:1V final cover side slope between benches is 170 ft. Also, a computation was performed for a hypothetical scenario of a 200 ft long side slope at 33.3% (in order to back-calculate the maximum bench spacing that would yield an acceptably low soil loss design). Based on these slope lengths, the following LS factors were selected (and interpolated if necessary) from Table 2:

- Side Slopes – 3H:1V (33.3%) over the maximum design slope length (between benches) of 170 ft, LS = 8.46

- Side Slopes – 3H:1V (33.3%) over a hypothetical design slope length (between benches) of 200 ft, LS = 9.44

- Top Deck – 3% slope over the maximum design slope length of 370 ft, LS = 0.59

4.4 Cover Management Factor (C)

The cover management factor is a function of the type of land cover, based on three factors: (i) the vegetative cover in direct contact with the soil surface, (ii) the canopy cover, and (iii) the effects at and beneath the surface. The final cover is categorized as having no appreciable canopy with a vegetated cover of grass, grass-like plants, decaying compacted duff or litter ("litter" is an agronomic term which refers to mulch, leaves, and similar organic matter) at least 2 inches deep. The long-term post-closure ground cover condition is estimated to be 95-100% ground cover, which results in a C value of 0.003, as shown in Table 3 (USDA, 1977).

4.5 Erosion Control Practice Factor (P)

The erosion control practice factor considers topographical practices that will reduce erosion by altering runoff drainage patterns. This factor generally applies to agricultural cropping practices and is not anticipated for the landfill. Therefore, the P factor is assumed to be equal to one (1).

4.6 Tolerable Soil Loss (T)

The calculated soil loss should be compared to the tolerable (i.e., permissible) soil loss (T). A draft guidance document from Texas Commission on Environmental Quality (TCEQ, 2007) suggests that landfill final cover designs should have a permissible soil loss rate of 2 to 3 tons/acre/year. Also, the USDA soil-specific survey of Fayette County soils (USDA, 2014) lists the "T" factors recommended for each soil type. This value represents the maximum average annual rate of soil erosion "*that can occur without affecting crop productivity over a sustained period*". For the landfill case, the term "crop productivity" refers to vegetation sustainability (lack of excessive erosion). As shown in Table 1, the USDA's recommended permissible soil loss rate for the Frelsburg clay, Latium gravelly clay, Rek extremely gravelly coarse sandy loam and Straber gravelly loamy fine sand in the site is 5 tons/acre/year. Based on the TCEQ and USDA publications, a maximum permissible soil loss value of 3 tons/acre/year will be used as the comparison criteria for this evaluation. However, it is important to recognize that the area/site-specific USDA soil survey indicates the properties of these soils can tolerate greater soil loss without affecting long-term conditions.

5 SOIL EROSION LOSS RESULTS

Applying the RUSLE with the parameters defined above, the computed soil loss in tons/acre/year is calculated as follows:

$$A = R \times K \times LS \times C \times P$$

- Side Slopes, Design Case (maximum spacing of 170 ft between benches): A = 330 × 0.32 × 8.46 × 0.003 × 1 = 2.68 tons/acre/year
- Side Slopes, Back-Calculated Hypothetical Case (200 ft between benches): A = 330 × 0.32 × 9.44 × 0.003 × 1 = 2.99 tons/acre/year
- Top Deck, Design Case: A = 330 × 0.32× 0.59 × 0.003 × 1 = 0.19 tons/acre/year

6 CONCLUSIONS

Based on the analyses presented herein, the following conclusions are drawn:

- Overall, the calculated soil loss from the final cover system design is below or within the permissible soil loss of 2 to 3 tons/acre/year suggested by TCEQ (2007), and is also below the permissible soil loss recommended by USDA (2014) for the area/site-specific soils. Specifically, results are:
  - The average annual soil loss from the final cover on the external side slopes as-designed for all of the variables selected as the design case is 2.68 tons/acre/year, which is within the permissible rate of soil loss suggested by TCEQ (2007) for the final cover, and also below the permissible soil loss recommended by USDA (2014) for the area/site-specific soils.
  - The annual soil loss from the final cover on the top deck surface as-designed for all of the variables selected as the design case is 0.19

tons/acre/year. This is much lower than the 2 to 3 tons/acre/year permissible rate of soil loss suggested by TCEQ (2007) for the final cover, and even further below permissible soil loss recommended by USDA (2014) for the area/site-specific soils.

- To provide effective erosional stability against soil loss, the maximum spacing of the final cover side slope drainage benches on the 3H:1V external side slopes should be 200 ft or less. The design meets this spacing requirement.

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TABLES

Table 1. Soil Erodibility Factor K for Site Soils (from USDA, 2014)

RUSLE2 Related Attributes–Fayette County, Texas								
Map symbol and soil name	Pct. of map unit	Slope length (ft)	Hydrologic group	Kf	T factor	Representative value		
						% Sand	% Silt	% Clay
FrC—Frelsburg clay, 3 to 5 percent slopes								
Frelsburg	85	180	D	.24	5	22.0	28.0	50.0
LgD—Latium gravelly clay, 5 to 12 percent slopes								
Latium	100	125	D	.24	5	22.1	27.9	50.0
RkC—Rek extremely gravelly coarse sandy loam, 2 to 5 percent slopes								
Rek	100	180	D	.24	5	65.2	23.3	11.5
SxC—Straber gravelly loamy fine sand, 2 to 5 percent slopes								
Straber	100	180	D	.32	5	86.4	6.6	7.0

Table 2. Values for Topographic Factor, LS, for Low Ratio of Rill to Interrill Erosion[1]

(from USDA, 1997)

Table 4-2.
Values for topographic factor, LS, for moderate ratio of rill to interrill erosion.[1]

Slope (%)	Horizontal slope length (ft)																
	3	6	9	12	15	25	50	75	100	150	200	250	300	400	600	800	1000
0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
0.5	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
1.0	0.11	0.11	0.11	0.11	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.20
2.0	0.17	0.17	0.17	0.17	0.17	0.19	0.22	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.41	0.44	0.47
3.0	0.22	0.22	0.22	0.22	0.22	0.25	0.32	0.36	0.39	0.44	0.48	0.52	0.55	0.60	0.68	0.75	0.80
4.0	0.26	0.26	0.26	0.26	0.26	0.31	0.40	0.47	0.52	0.60	0.67	0.72	0.77	0.86	0.99	1.10	1.19
5.0	0.30	0.30	0.30	0.30	0.30	0.37	0.49	0.58	0.65	0.76	0.85	0.93	1.01	1.13	1.33	1.49	1.63
6.0	0.34	0.34	0.34	0.34	0.34	0.43	0.58	0.69	0.78	0.93	1.05	1.16	1.25	1.42	1.69	1.91	2.11
8.0	0.42	0.42	0.42	0.42	0.42	0.53	0.74	0.91	1.04	1.26	1.45	1.62	1.77	2.03	2.47	2.83	3.15
10.0	0.46	0.48	0.50	0.51	0.52	0.67	0.97	1.19	1.38	1.71	1.98	2.22	2.44	2.84	3.50	4.06	4.56
12.0	0.47	0.53	0.58	0.61	0.64	0.84	1.23	1.53	1.79	2.23	2.61	2.95	3.26	3.81	4.75	5.56	6.28
14.0	0.48	0.58	0.65	0.70	0.75	1.00	1.48	1.86	2.19	2.76	3.25	3.69	4.09	4.82	6.07	7.15	8.11
16.0	0.49	0.63	0.72	0.79	0.85	1.15	1.73	2.20	2.60	3.30	3.90	4.45	4.95	5.86	7.43	8.79	10.02
20.0	0.52	0.71	0.85	0.96	1.06	1.45	2.22	2.85	3.40	4.36	5.21	5.97	6.68	7.97	10.23	12.20	13.99
25.0	0.56	0.80	1.00	1.16	1.30	1.81	2.82	3.65	4.39	5.69	6.83	7.88	8.86	10.65	13.80	16.58	19.13
30.0	0.59	0.89	1.13	1.34	1.53	2.15	3.39	4.42	5.34	6.98	8.43	9.76	11.01	13.30	17.37	20.99	24.31
40.0	0.65	1.05	1.38	1.68	1.95	2.77	4.45	5.87	7.14	9.43	11.47	13.37	15.14	18.43	24.32	29.60	34.48
50.0	0.71	1.18	1.59	1.97	2.32	3.32	5.40	7.17	8.78	11.66	14.26	16.67	18.94	23.17	30.78	37.65	44.02
60.0	0.76	1.30	1.78	2.23	2.65	3.81	6.24	8.33	10.23	13.65	16.76	19.64	22.36	27.45	36.63	44.96	52.70

[1]Such as for row-cropped agricultural and other moderately consolidated soil conditions with little-to-moderate cover (not applicable to thawing soil)

Table 3. C Factor Cover Values for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland[1] (from USDA, 1977)

Vegetal Canopy		Cover That Contacts the Surface						
Type and Height of Raised Canopy[2/]	Canopy Cover[3/] %	Type[4/]	Percent Ground Cover					
			0	20	40	60	80	95-100
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Appreciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years. Also to be used for burned forest land and forest land that has been harvested less than three years ago.

2/ Average fall height of waterdrops from canopy to soil surface: m = meters.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

4/ G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface), and/or undecayed residue.

FIGURES

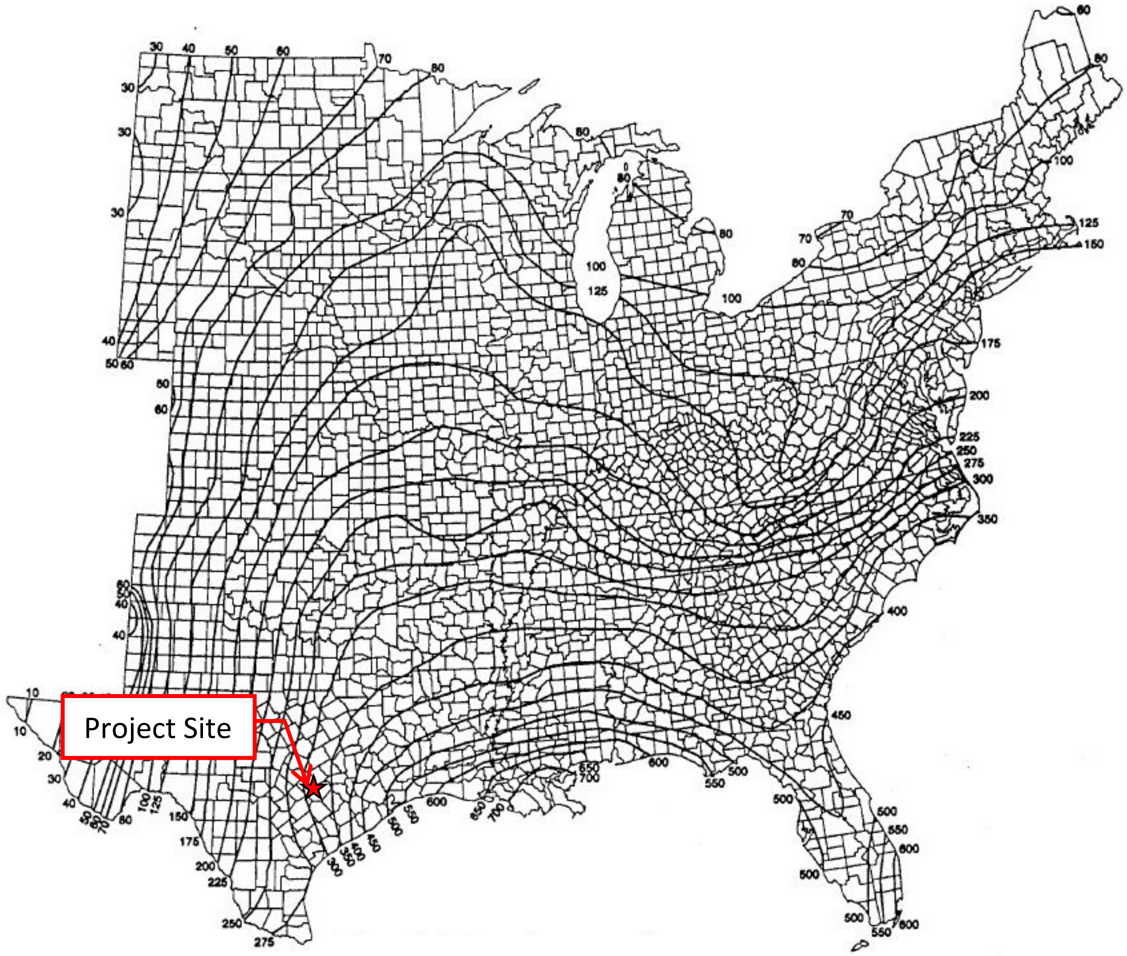

Figure 1. Average Annual Rainfall Runoff Erosivity Factor, R, Isoerodent Map (from USDA, 1997)

Figure 2. Soil Survey Map (from USDA, 2014)

APPENDIX C

Stormwater Management System – Active Conditions

Geosyntec consultants

Written by:	O. Bramlet	Date:	6/14/2021	Reviewed & Revised by:	B. Klenzendorf	Date:	6/28/2021
Client:	LCRA	Project:	FPP Run-on Run-off Plan Update	Project No.:	TXW8067	Phase No.:	03

SURFACE WATER MANAGEMENT SYSTEM – ACTIVE CONDITIONS

STATE OF TEXAS
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8/11/2021

GEOSYNTEC CONSULTANTS, INC.
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PURPOSE

The purpose of this calculation package is to present the analysis of the surface water management system for the active conditions of the Combustion Byproduct Landfill (CBL) at LCRA's Fayette Power Project (FPP) in La Grange, Texas. The term "active" refers to that part of a coal combustion residuals (CCR) unit that has received or is receiving waste and has not completed closure (40 CFR §257.53). Thus, the active portion includes areas where waste is being disposed and inactive areas, including areas overlain with intermediate cover.

The United States Environmental Protection Agency (USEPA) CCR rule (40 CFR 257.81(a)) and Title 30 Texas Administrative Code (30 TAC), Chapter 352.821 (30 TAC §352.821) require that runoff control systems be designed to collect and control flow from a 25-year, 24-hour storm. The engineering calculations described herein were performed to ensure that the features used for managing surface water from the active portion of the CBL are equipped to convey runoff from the current 25-year, 24-hour storm event.

SURFACE WATER MANAGEMENT SYSTEM COMPONENTS AND OPERATIONAL PROCEDURES

Runoff from active areas in Cell 1 of the CBL currently drains to the Runoff Retention Pond via the runoff channel (Drawing 2). Contact water from the Subcell 2D Contact Water Retention Pond is managed through a permanent pumping system which routes flow to the runoff channel. The runoff channel conveys contact water flow to the Runoff Retention Pond which is permitted under LCRA's Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0002105000 and is designated as the "CBL Pond" in the permit. The permit allows water in the CBL Pond to be managed by pumping to the FPP Reclaim Pond or, if effluent limitations are met, by discharging via Outfall 004. The CBL Pond will be used for management of contact water from the active area until the Leachate Evaporation Pond (Drawing 4) is constructed, which will occur prior to disposal of CCR in Subcell 2A (Drawing 4).

Facility personnel monitor the water levels of the Subcell 2D Contact Water Retention Pond, Runoff Retention Pond, and the FPP Reclaim Pond to manage the surface water throughout the facility in order to minimize off-site discharge from the Runoff Retention Pond and FPP Reclaim Pond. Facility personnel are on-site 24-hours per day, 7-days per week and monitor the weather forecast to identify anticipated storm events and manage pumping of the Subcell 2D Contact Water Retention Pond and Runoff Retention Pond accordingly. The Subcell 2D Contact Water Retention Pond is equipped with a permanent pumping system which conveys flow from the pond to the runoff channel. The pump at the Subcell 2D Contact Water Retention Pond is manually operated by facility personnel to maintain an appropriate freeboard before each forecasted storm event. The Subcell 2D Contact Water Retention Pond is approximately 11-feet deep and must maintain a minimum water depth of 15-inches. The Runoff Retention Pond is equipped with a permanent pump system with an underground HDPE pipe to the concrete storm drainage system leading to the FPP Reclaim Pond. The pump at the Runoff Retention Pond is manually operated by facility personnel to maintain an appropriate freeboard before each forecasted storm event. The FPP Reclaim Pond is a settling and scrubber evaporation pond without a direct surface water discharge. Additionally, water from the FPP Reclaim Pond can be recycled through facility processing areas as appropriate.

Improvements to the Runoff Retention Pond inflow structure where recently completed which included construction of a concrete let-down structure equipped with energy dissipation blocks constructed in 2021. The let-down structure was constructed to reduce the potential for erosion at the inflow of the runoff channel into the Runoff Retention Pond. A bathymetric survey of the Runoff Retention Pond was completed on 28 February 2008 to develop pond volume rating curves. An additional bathymetric survey was completed in December 2015 to develop updated pond volume rating curves and to provide estimates of the sediment accumulation near the pond inflow structure. An updated sediment accumulation survey was completed in 24 April 2020 which estimated an approximate depth of accumulated sediment of 3 feet across the entire bottom of the pond. During the site visit conducted by Geosyntec on 7 June 2021, it was confirmed that there has been no excavation of the 3 feet of sediment accumulation to date.

Therefore, for the purposes of the calculations described in this package, Geosyntec deducted the volume occupied by the sediment accumulation from the total pond volume generated by the bathymetric surveys to account for sediment accumulation (i.e., removed the bottom 3 feet from the storage curve).

CALCULATION METHODOLOGY

Design Storm Return Period

In accordance with 40 CFR 257.81(a) and 30 TAC §352.821 runoff control systems for CCR management units be designed to collect and control flow from a 25-year, 24-hour storm.

Rainfall Information

Latest available precipitation frequency estimates were obtained from the National Oceanic Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS). The current 25-year, 24-hour rainfall depth at the CBL is 9.36 inches, as shown in Table 1 (NOAA, 2018).

Hydrology

Intensity of rainfall for design is based on calculations for times of concentration and intensity-duration-frequency relationships using the procedures outlined by the TxDOT *Hydraulic Design Manual* (TxDOT, 2019). Peak design discharges are calculated based on the Rational Method recommended for small basins for either undeveloped or developed lands. The Rational Method is appropriate for estimating peak discharges for drainage areas less than 200 acres (TxDOT, 2019).

The SCS Curve Number method outlined in TR-55 (USDA, 1986) is used to estimate runoff volumes as recommended by TCEQ (2020) and to evaluate the capacity of the Runoff Retention Pond and Subcell 2D Contact Water Retention Pond.

Hydraulic Analysis

Hydraulic design of the runoff channel was evaluated using Manning's equation for open channel flow (Chow, 1959). Manning's equation was used to estimate the average maximum velocity and tractive stress within the channel.

The storage capacity of the Runoff Retention Pond, generated from the latest available bathymetric survey, was reviewed to ensure that the pond contains the appropriate capture volume for the estimated runoff volume from the CBL. The stage-storage curve for the Runoff Retention Pond is presented in Figure 1. Available freeboard in the Runoff Retention Pond during the 25-year, 24-hour storm event was calculated based on the updated pond bottom (328-feet rather than 325-feet, accounting for sediment accumulation) and the spillway overflow elevation of 338-feet.

Additionally, the storage capacity of the Subcell 2D Contact Water Retention Pond was reviewed to ensure that the pond contains the appropriate capture volume for the estimated runoff volume from the Subcell 2D drainage area. The stage-storage curve for the Subcell 2D Contact Water Retention Pond is presented in Figure 2. Available freeboard during the 25-year, 24-hour storm event was calculated based on the top of berm elevation of 352-feet.

COMPUTATIONS

Rational Method for Hydrologic Analysis

The Rational Method was applied to evaluate the design of the stormwater management features. The Rational Method is expressed as follows:

$$Q = C \times I \times A$$

where:
Q = flow rate (cfs);
C = runoff coefficient;
I = rainfall intensity (in./hr); and
A = contributing drainage area (acres).

Estimation of Contributing Drainage Area

The contributing drainage area for the Runoff Retention Pond is delineated in Figure 3. The total contributing drainage area of approximately 30-acres was estimated based on existing contours provided by LCRA.

The contributing drainage area for the Subcell 2D Contact Water Retention Pond is also delineated in Figure 3. The total contributing drainage area of approximately 8acres was estimated based on design contours.

Estimation of Runoff Coefficient for Rational Method

The runoff coefficient is estimated from the TxDOT *Hydraulic Design Manual* (TxDOT, 2019) for rural watersheds as presented in Table 2. The total runoff coefficient is conservatively estimated to be equal to 0.70 based on the following equation:

$$C = C_r + C_i + C_v + C_s$$

where:
- C = total runoff coefficient = 0.70;
- C_r = relief runoff coefficient = 0.28;
- C_i = soil infiltration runoff coefficient = 0.16;
- C_v = vegetal cover runoff coefficient = 0.16; and
- C_s = surface runoff coefficient = 0.10.

Estimation of Time of Concentration and Peak Rainfall Intensity for Rational Method

TxDOT (2019) recommends 10 minutes as the minimum time of concentration for the Rational Method because small areas with exceedingly short times of concentration could result in design rainfall intensities that are unrealistically high. The rainfall intensity for the 25-year, 10-minute duration storm event at the CBL is 8.61 inches per hour, as shown in Table 3 (NOAA, 2018).

Estimation of Peak Design Discharge

The Rational Method was used to estimate the peak discharge rate during the 25-year, 10-minute storm event for the contributing drainage area as described above.

SCS Curve Number Method for Hydrologic Analysis

It is recommended (TCEQ, 2020) to use the TR-55 SCS Curve Number Method to compute runoff volumes. The runoff depth in inches is calculated based on the following equation from USDA, 1986:

$$Q = (P - 0.2S)^2 / (P + 0.8S)$$

where: Q = runoff depth (in);
P = rainfall depth (in); and
S = potential maximum retention after runoff begins (in).

The potential maximum retention, S, is calculated based on the following equation from USDA, 1986:

$$S = (1000 / CN) - 10$$

where: CN = Curve Number.

The Curve Number was selected to be 84 as the most conservative case, as recommended by TCEQ (2020) for North Central Texas areas in hilly regions with clay soils.

Surface Water Management System Components Hydraulic Analysis

Manning's equation was used to estimate the average peak velocity within the runoff channel. The average flow velocities were estimated for the 25-year water depth using the following equation (Chow, 1959):

$$V = \frac{1.49}{n} R_h^{2/3} S^{1/2}$$

where:

- V = average velocity (ft/sec);
- n = Manning's roughness coefficient;
- R_h = hydraulic radius (ft) = A/P;
- A = cross sectional area (ft^2);
- P = wetted perimeter (ft); and
- S = slope of hydraulic grade line (channel slope, ft/ft).

Manning's roughness coefficient was selected from Table 4 for a grass-lined channel. Average discharge is equal to the average velocity times the area of cross-section of flow (i.e., $Q = VA$).

Written by:	**O. Bramlet**	Date:	**6/14/2021**	Reviewed & Revised by:	**B. Klenzendorf**	Date:	**6/28/2021**
Client:	**LCRA**	Project:	**FPP Run-on Run-off Plan Update**	Project No.:	**TXW8067**	Phase No.:	**03**

The tractive stresses in the runoff channel for various depths of flow are estimated using the following equation (Chow, 1959):

$$\tau_0 = \gamma_w R_h S$$

where:
τ_o = average tractive stress (lb/ft^2);
γ_w = unit weight of water (lb/ft^3);
R_h = hydraulic radius of flow (ft); and
S = channel slope (ft/ft).

Permissible tractive stresses for grass-lined channels range from 0.35 psf to 3.70 psf depending on the retardation class of vegetation. Retardation Class C (which includes Bermuda and Crab grasses among others) is selected for the design of grass-lined channels (

Table 5) and has a maximum permissible tractive stress of 1.0 psf (Table 6) according to TxDOT (2019).

RESULTS

Hydraulic calculations for the runoff channel are provided in Appendix C-1. The results of the hydraulic analysis are summarized below.

Summary of Runoff Channel

- 25-year Rainfall Design Discharge = 180.8 cfs
- Top Width = 28.0 ft
- Channel Slope = 1.27%
- Manning's *n* = 0.027 (**Error! Reference source not found.**2)
- Side Slopes = 3H:1V
- Bottom Width = 10.0 ft
- Available Depth of Flow = 3.0 ft
- **25-year Calculated Depth of Flow** = 1.68 ft
- ***Calculated Depth of Flow < Available Depth of Flow***
- Allowable Tractive Stress = 1.0 psf (Table 6)
- **25-year Calculated Average Tractive Stress** = 0.97 psf
- ***Calculated Average Tractive Stress < Allowable Tractive Stress***

The results of the hydraulic analysis of the Runoff Retention Pond and the Subcell 2D Contact Water Retention Pond are summarized below.

Summary of Runoff Retention Pond

- Drainage Area for the CBL = 30 acres
- Original Pond Bottom Elevation = 325.0 ft
- Updated Pond Bottom Elevation (accounting for approximately 3-feet of sediment accumulation) = 328.0 ft
- Spillway Overflow Elevation = 338.0 ft
- Available Storage Volume at Spillway Overflow Elevation = 18.96 ac-ft
- **25-year, 24-hour Runoff Volume for the CBL = 18.52 ac-ft**
- ***Calculated 25-year Runoff Volume < Available Storage Volume***

Summary of Subcell 2D Contact Water Retention Pond

- Drainage Area for Subcell 2D Retention Pond = 8 acres
- Pond Bottom Elevation = 341.0 ft
- Top of Berm Elevation = 352.0 ft
- Available Storage Volume = 12.40 ac-ft
- **25-year, 24-hour Runoff Volume for the CBL = 4.83 ac-ft**
- ***Calculated 25-year Runoff Volume < Available Storage Volume***

CONCLUSIONS

Results presented in this calculation package indicate that the surface water management system for the active conditions is sufficient to convey runoff from the current 25-year, 24-hour storm event. The existing surface water management system at the Coal Combustion Byproduct Landfill at the LCRA Fayette Power Project site in La Grange, Texas is anticipated to collect and control the runoff resulting from a 25-year, 24-hour storm event and the Runoff Retention Pond and the Subcell 2D Contact Water Retention Pond will maintain adequate capacity during the specified design storm.

REFERENCES

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USDA (1986). *Urban Hydrology for Small Watersheds*, Technical Release 55, Natural Resources Conservation Service, United States Department of Agriculture, Washington, D.C.

TABLES

Table 1 – NOAA Precipitation Depth Estimates for the CBL (from NOAA, 2018)

NOAA Atlas 14, Volume 11, Version 2
Location name: La Grange, Texas, USA*
Latitude: 29.9075°, Longitude: -96.7565°
Elevation: 381.96 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite
NOAA, National Weather Service, Silver Spring, Maryland

PF tabular | PF graphical | Maps & aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.470 (0.356-0.621)	0.543 (0.416-0.713)	0.665 (0.507-0.874)	0.764 (0.573-1.02)	0.898 (0.652-1.23)	1.00 (0.707-1.41)	1.10 (0.759-1.60)	1.21 (0.810-1.79)	1.35 (0.874-2.07)	1.45 (0.920-2.30)
10-min	0.746 (0.565-0.986)	0.864 (0.661-1.13)	1.06 (0.807-1.39)	1.22 (0.914-1.62)	1.44 (1.04-1.97)	1.60 (1.13-2.26)	1.76 (1.22-2.56)	1.92 (1.29-2.86)	2.13 (1.38-3.27)	2.28 (1.44-3.60)
15-min	0.946 (0.716-1.25)	1.09 (0.835-1.43)	1.33 (1.01-1.75)	1.53 (1.15-2.03)	1.79 (1.30-2.46)	1.99 (1.41-2.81)	2.19 (1.51-3.17)	2.39 (1.61-3.56)	2.66 (1.73-4.10)	2.87 (1.82-4.54)
30-min	1.35 (1.02-1.78)	1.55 (1.18-2.03)	1.88 (1.43-2.47)	2.15 (1.61-2.86)	2.51 (1.82-3.43)	2.78 (1.96-3.91)	3.05 (2.10-4.42)	3.34 (2.24-4.97)	3.73 (2.43-5.76)	4.05 (2.56-6.39)
60-min	1.76 (1.33-2.32)	2.03 (1.56-2.67)	2.49 (1.90-3.27)	2.86 (2.15-3.81)	3.36 (2.43-4.60)	3.73 (2.64-5.26)	4.12 (2.84-5.97)	4.55 (3.06-6.77)	5.15 (3.35-7.94)	5.64 (3.57-8.91)
2-hr	2.13 (1.62-2.79)	2.52 (1.94-3.26)	3.15 (2.42-4.11)	3.69 (2.79-4.88)	4.43 (3.23-6.02)	5.01 (3.55-7.00)	5.62 (3.90-8.09)	6.33 (4.28-9.37)	7.38 (4.81-11.3)	8.25 (5.24-13.0)
3-hr	2.33 (1.79-3.04)	2.81 (2.16-3.60)	3.57 (2.74-4.62)	4.22 (3.20-5.56)	5.16 (3.78-6.98)	5.89 (4.20-8.21)	6.69 (4.66-9.60)	7.64 (5.18-11.3)	9.06 (5.92-13.8)	10.3 (6.53-16.1)
6-hr	2.67 (2.06-3.46)	3.32 (2.54-4.17)	4.29 (3.32-5.50)	5.17 (3.95-6.76)	6.46 (4.77-8.71)	7.52 (5.40-10.4)	8.71 (6.09-12.4)	10.1 (6.88-14.8)	12.2 (8.03-18.6)	14.0 (8.97-21.8)
12-hr	2.99 (2.32-3.85)	3.82 (2.91-4.69)	5.00 (3.89-6.35)	6.13 (4.72-7.96)	7.85 (5.86-10.5)	9.32 (6.76-12.9)	11.0 (7.75-15.6)	13.0 (8.88-18.9)	16.0 (10.5-24.2)	18.6 (11.9-28.7)
24-hr	3.33 (2.61-4.25)	4.36 (3.31-5.24)	5.77 (4.52-7.26)	7.18 (5.57-9.25)	9.36 (7.06-12.5)	11.3 (8.28-15.6)	13.6 (9.59-19.1)	16.1 (11.0-23.2)	19.9 (13.2-29.8)	23.1 (14.9-35.5)
2-day	3.73 (2.94-4.73)	4.98 (3.79-5.88)	6.66 (5.25-8.31)	8.38 (6.55-10.7)	11.1 (8.48-14.8)	13.6 (10.1-18.7)	16.4 (11.7-22.9)	19.4 (13.3-27.7)	23.6 (15.6-34.9)	26.9 (17.4-41.0)
3-day	4.05 (3.21-5.11)	5.41 (4.14-6.38)	7.26 (5.75-9.01)	9.12 (7.16-11.6)	12.0 (9.24-16.0)	14.7 (10.9-20.2)	17.7 (12.6-24.6)	20.8 (14.4-29.6)	25.1 (16.7-37.1)	28.5 (18.4-43.3)
4-day	4.34 (3.45-5.46)	5.74 (4.44-6.80)	7.69 (6.12-9.53)	9.61 (7.57-12.2)	12.6 (9.66-16.7)	15.3 (11.3-20.8)	18.3 (13.0-25.3)	21.4 (14.8-30.4)	25.8 (17.1-38.0)	29.2 (19.0-44.3)
7-day	5.04 (4.04-6.30)	6.49 (5.10-7.74)	8.57 (6.87-10.6)	10.5 (8.35-13.3)	13.5 (10.4-17.7)	16.1 (12.0-21.7)	19.0 (13.6-26.2)	22.1 (15.4-31.3)	26.6 (17.8-39.1)	30.3 (19.7-45.7)
10-day	5.62 (4.52-7.00)	7.11 (5.65-8.52)	9.29 (7.49-11.4)	11.3 (8.99-14.2)	14.3 (11.0-18.6)	16.8 (12.5-22.6)	19.6 (14.1-27.0)	22.8 (15.9-32.1)	27.3 (18.3-40.0)	31.1 (20.2-46.7)
20-day	7.31 (5.92-9.04)	8.93 (7.25-10.8)	11.4 (9.32-14.0)	13.6 (10.9-17.0)	16.8 (12.9-21.6)	19.3 (14.4-25.6)	22.0 (15.9-30.0)	24.9 (17.5-35.0)	29.2 (19.7-42.5)	32.7 (21.4-48.7)
30-day	8.71 (7.09-10.7)	10.4 (8.57-12.7)	13.2 (10.8-16.2)	15.6 (12.5-19.3)	18.8 (14.6-24.1)	21.4 (16.0-28.2)	24.0 (17.4-32.6)	26.8 (18.9-37.4)	30.8 (20.8-44.6)	33.9 (22.2-50.5)
45-day	10.7 (8.78-13.2)	12.6 (10.5-15.4)	15.8 (13.0-19.3)	18.4 (14.8-22.7)	21.8 (16.9-27.8)	24.4 (18.3-32.1)	27.0 (19.7-36.5)	29.7 (21.0-41.3)	33.4 (22.6-48.1)	36.2 (23.8-53.6)
60-day	12.6 (10.3-15.3)	14.6 (12.2-17.8)	18.1 (15.0-22.0)	20.9 (16.9-25.7)	24.5 (19.1-31.2)	27.2 (20.5-35.6)	29.8 (21.8-40.2)	32.4 (22.9-44.9)	35.8 (24.3-51.5)	38.3 (25.2-56.6)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Table 2 – Runoff Coefficients (C) for Rural Watersheds (from TxDOT, 2019)

Watershed characteristic	Extreme	High	Normal	Low
Relief - C_r	0.28-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.14-0.20 Rolling, with average slopes of 5-10%	0.08-0.14 Relatively flat land, with average slopes of 0-5%
Soil infiltration - C_i	0.12-0.16 No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	0.06-0.08 Normal; well drained light or medium textured soils, sandy loams	0.04-0.06 Deep sand or other soil that takes up water readily; very light, well-drained soils
Vegetal cover - C_v	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface Storage - C_s	0.10-0.12 Negligible; surface depressions few and shallow, drainageways steep and small, no marshes	0.08-0.10 Well-defined system of small drainageways, no ponds or marshes	0.06-0.08 Normal; considerable surface depression, e.g., storage lakes and ponds and marshes	0.04-0.06 Much surface storage, drainage system not sharply defined; large floodplain storage, large number of ponds or marshes
Table 4-11 note: The total runoff coefficient based on the 4 runoff components is $C = C_r + C_i + C_v + C_s$				

Table 3 – NOAA Precipitation Intensity Estimates for the CBL (from NOAA, 2018)

NOAA Atlas 14, Volume 11, Version 2
Location name: La Grange, Texas, USA*
Latitude: 29.9075°, Longitude: -96.7565°
Elevation: 381.96 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF tabular | PF graphical | Maps & aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	5.64 (4.27-7.45)	6.52 (4.99-8.56)	7.98 (6.08-10.5)	9.17 (6.88-12.2)	10.8 (7.82-14.8)	12.0 (8.48-16.9)	13.2 (9.11-19.2)	14.5 (9.72-21.5)	16.2 (10.5-24.9)	17.4 (11.0-27.6)
10-min	4.48 (3.39-5.92)	5.18 (3.97-6.80)	6.35 (4.84-8.35)	7.31 (5.48-9.74)	8.61 (6.26-11.8)	9.61 (6.80-13.6)	10.6 (7.29-15.3)	11.5 (7.75-17.1)	12.8 (8.29-19.6)	13.7 (8.64-21.6)
15-min	3.78 (2.86-5.00)	4.36 (3.34-5.72)	5.32 (4.06-7.00)	6.10 (4.58-8.13)	7.16 (5.20-9.82)	7.96 (5.63-11.2)	8.75 (6.03-12.7)	9.56 (6.43-14.2)	10.7 (6.92-16.4)	11.5 (7.27-18.1)
30-min	2.69 (2.04-3.56)	3.09 (2.37-4.06)	3.75 (2.86-4.94)	4.29 (3.22-5.72)	5.02 (3.64-6.87)	5.55 (3.92-7.82)	6.09 (4.20-8.83)	6.67 (4.49-9.94)	7.47 (4.85-11.5)	8.09 (5.12-12.8)
60-min	1.76 (1.33-2.32)	2.03 (1.56-2.67)	2.49 (1.90-3.27)	2.86 (2.15-3.81)	3.36 (2.43-4.60)	3.73 (2.64-5.26)	4.12 (2.84-5.97)	4.55 (3.06-6.77)	5.15 (3.35-7.94)	5.64 (3.57-8.91)
2-hr	1.06 (0.812-1.40)	1.26 (0.968-1.63)	1.58 (1.21-2.05)	1.84 (1.39-2.44)	2.22 (1.62-3.01)	2.50 (1.78-3.50)	2.81 (1.95-4.05)	3.17 (2.14-4.68)	3.69 (2.41-5.66)	4.13 (2.62-6.48)
3-hr	0.776 (0.594-1.01)	0.937 (0.719-1.20)	1.19 (0.914-1.54)	1.41 (1.07-1.85)	1.72 (1.26-2.32)	1.96 (1.40-2.73)	2.23 (1.55-3.20)	2.54 (1.72-3.75)	3.02 (1.97-4.61)	3.42 (2.17-5.35)
6-hr	0.446 (0.344-0.578)	0.554 (0.425-0.696)	0.717 (0.554-0.919)	0.863 (0.660-1.13)	1.08 (0.797-1.45)	1.26 (0.902-1.74)	1.45 (1.02-2.07)	1.69 (1.15-2.47)	2.04 (1.34-3.10)	2.35 (1.50-3.65)
12-hr	0.248 (0.193-0.319)	0.317 (0.242-0.389)	0.415 (0.323-0.527)	0.509 (0.392-0.661)	0.651 (0.486-0.875)	0.774 (0.561-1.07)	0.915 (0.643-1.30)	1.08 (0.737-1.57)	1.33 (0.875-2.01)	1.54 (0.989-2.38)
24-hr	0.139 (0.109-0.177)	0.182 (0.138-0.218)	0.241 (0.188-0.302)	0.299 (0.232-0.385)	0.390 (0.294-0.522)	0.471 (0.345-0.650)	0.565 (0.400-0.795)	0.672 (0.460-0.968)	0.831 (0.549-1.24)	0.964 (0.620-1.48)
2-day	0.078 (0.061-0.098)	0.104 (0.079-0.122)	0.139 (0.109-0.173)	0.174 (0.136-0.223)	0.231 (0.177-0.309)	0.283 (0.209-0.389)	0.342 (0.243-0.478)	0.404 (0.278-0.577)	0.491 (0.325-0.728)	0.560 (0.362-0.854)
3-day	0.056 (0.045-0.071)	0.075 (0.058-0.089)	0.101 (0.080-0.125)	0.127 (0.099-0.161)	0.167 (0.128-0.223)	0.204 (0.152-0.280)	0.246 (0.176-0.342)	0.289 (0.199-0.412)	0.349 (0.232-0.515)	0.396 (0.256-0.602)
4-day	0.045 (0.036-0.057)	0.060 (0.046-0.071)	0.080 (0.064-0.099)	0.100 (0.079-0.127)	0.131 (0.101-0.174)	0.159 (0.118-0.217)	0.190 (0.136-0.264)	0.223 (0.154-0.316)	0.268 (0.179-0.396)	0.305 (0.197-0.462)
7-day	0.030 (0.024-0.038)	0.039 (0.030-0.046)	0.051 (0.041-0.063)	0.063 (0.050-0.079)	0.080 (0.062-0.106)	0.096 (0.071-0.129)	0.113 (0.081-0.156)	0.132 (0.092-0.186)	0.159 (0.106-0.233)	0.180 (0.117-0.272)
10-day	0.023 (0.019-0.029)	0.030 (0.024-0.035)	0.039 (0.031-0.048)	0.047 (0.037-0.059)	0.060 (0.046-0.078)	0.070 (0.052-0.094)	0.082 (0.059-0.112)	0.095 (0.066-0.134)	0.114 (0.076-0.167)	0.129 (0.084-0.194)
20-day	0.015 (0.012-0.019)	0.019 (0.015-0.022)	0.024 (0.019-0.029)	0.028 (0.023-0.035)	0.035 (0.027-0.045)	0.040 (0.030-0.053)	0.046 (0.033-0.062)	0.052 (0.036-0.073)	0.061 (0.041-0.088)	0.068 (0.044-0.102)
30-day	0.012 (0.010-0.015)	0.014 (0.012-0.018)	0.018 (0.015-0.022)	0.022 (0.017-0.027)	0.026 (0.020-0.033)	0.030 (0.022-0.039)	0.033 (0.024-0.045)	0.037 (0.026-0.052)	0.043 (0.029-0.062)	0.047 (0.031-0.070)
45-day	0.010 (0.008-0.012)	0.012 (0.010-0.014)	0.015 (0.012-0.018)	0.017 (0.014-0.021)	0.020 (0.016-0.026)	0.023 (0.017-0.030)	0.025 (0.018-0.034)	0.028 (0.019-0.038)	0.031 (0.021-0.045)	0.033 (0.022-0.050)
60-day	0.009 (0.007-0.011)	0.010 (0.008-0.012)	0.013 (0.010-0.015)	0.014 (0.012-0.018)	0.017 (0.013-0.022)	0.019 (0.014-0.025)	0.021 (0.015-0.028)	0.022 (0.016-0.031)	0.025 (0.017-0.036)	0.027 (0.017-0.039)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Table 4 – Manning's Roughness Coefficient for Open Channel Flow (from Chow, 1959)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140

Table 5 – Retardation Class for Lining Materials (from TxDOT, 2019)

Retardance Class	Cover	Condition
A	Weeping Lovegrass	Excellent stand, tall (average 30 in. or 760 mm)
	Yellow Bluestem Ischaemum	Excellent stand, tall (average 36 in. or 915 mm)
B	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (average 12 in. or 305 mm)
	Native grass mixture little bluestem, bluestem, blue gamma, other short and long stem midwest grasses	Good stand, unmowed
	Weeping lovegrass	Good Stand, tall (average 24 in. or 610 mm)
	Lespedeza sericea	Good stand, not woody, tall (average 19 in. or 480 mm)
	Alfalfa	Good stand, uncut (average 11 in or 280 mm)
	Weeping lovegrass	Good stand, unmowed (average 13 in. or 330 mm)
	Kudzu	Dense growth, uncut
	Blue gamma	Good stand, uncut (average 13 in. or 330 mm)
C	Crabgrass	Fair stand, uncut (10-to-48 in. or 55-to-1220 mm)
	Bermuda grass	Good stand, mowed (average 6 in. or 150 mm)
	Common lespedeza	Good stand, uncut (average 11 in. or 280 mm)
	Grass-legume mixture: summer (orchard grass redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6-8 in. or 150-200 mm)
	Centipedegrass	Very dense cover (average 6 in. or 150 mm)
	Kentucky bluegrass	Good stand, headed (6-12 in. or 150-305 mm)
D	Bermuda grass	Good stand, cut to 2.5 in. or 65 mm
	Common lespedeza	Excellent stand, uncut (average 4.5 in. or 115 mm)
	Buffalo grass	Good stand, uncut (3-6 in. or 75-150 mm)
	Grass-legume mixture: fall, spring (orchard grass Italian ryegrass, and common lespedeza	Good Stand, uncut (4-5 in. or 100-125 mm)
	Lespedeza sericea	After cutting to 2 in. or 50 mm (very good before cutting)
E	Bermuda grass	Good stand, cut to 1.5 in. or 40 mm
	Bermuda grass	Burned stubble

Table 6 – Permissible Shear Stresses for Various Linings (from TxDOT, 2019)

Protective Cover	(lb./sq.ft.)	t_p (N/m^2)
Retardance Class A Vegetation (See the "Retardation Class for Lining Materials" table above)	3.70	177
Retardance Class B Vegetation (See the "Retardation Class for Lining Materials" table above)	2.10	101
Retardance Class C Vegetation (See the "Retardation Class for Lining Materials" table above)	1.00	48
Retardance Class D Vegetation (See the "Retardation Class for Lining Materials" table above)	0.60	29
Retardance Class E Vegetation (See the "Retardation Class for Lining Materials" table above)	0.35	17
Woven Paper	0.15	7
Jute Net	0.45	22
Single Fiberglass	0.60	29
Double Fiberglass	0.85	41
Straw W/Net	1.45	69
Curled Wood Mat	1.55	74
Synthetic Mat	2.00	96

FIGURES

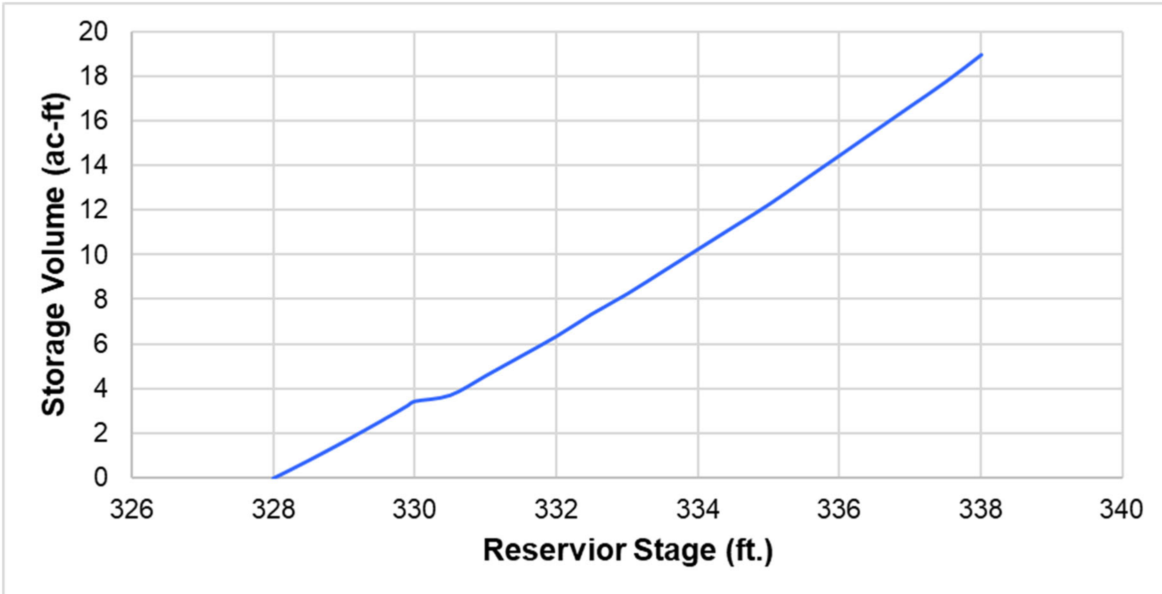

Figure 1 – Runoff Retention Pond Stage-Storage Curve

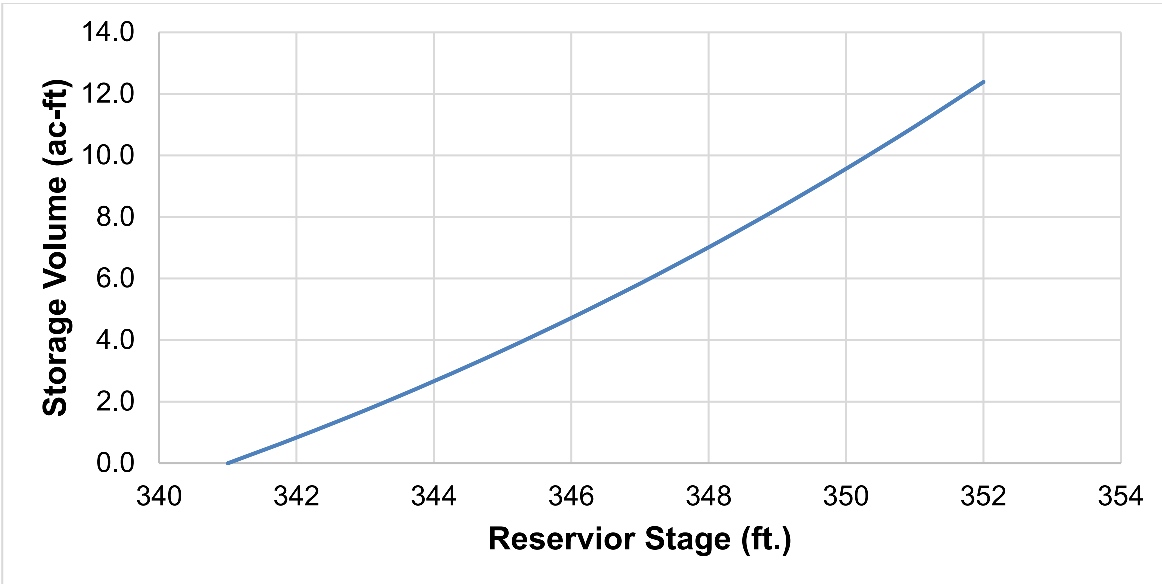

Figure 2 – Subcell 2D Contact Water Retention Pond Stage-Storage Curve

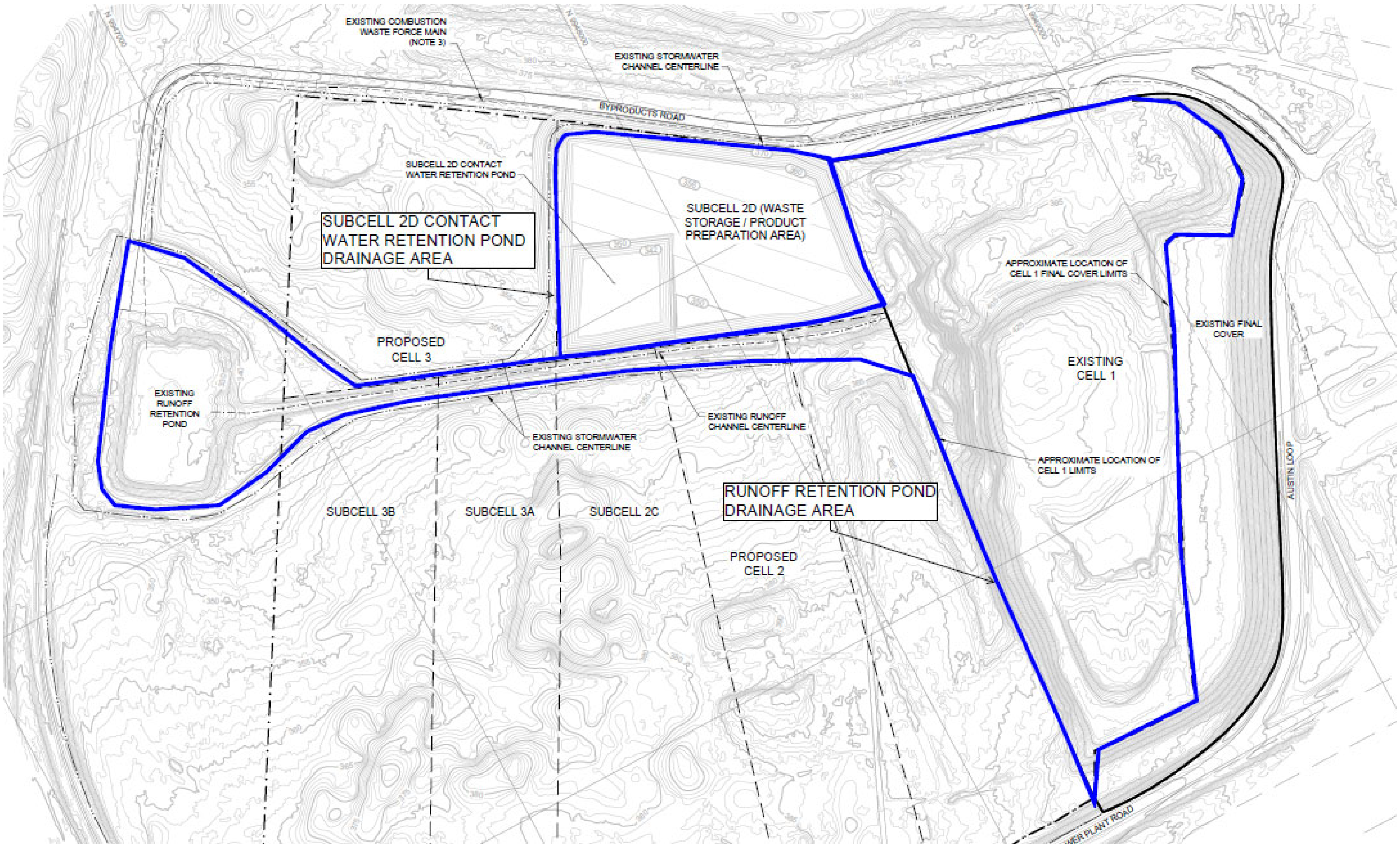

Figure 3 – Contributing Drainage Areas

APPENDIX C-1
HYDRAULIC ANALYSIS CALCULATIONS

Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

Project: FPP CBL Run-on Run-off Active Landfill Conditions

Ditch ID: **Runoff Channel**

Peak Discharge, Q_{25} =	180.81	cfs (25-yr Event)
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Channel Depth, Y =	3.00	ft
Top Width, T =	28.0	ft
Manning's Roughness Coeff., n =	0.027	
Longitudinal Channel Slope, S_o =	0.013	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_0 lb/ft^2	Comments
0.01	0.10	10.06	0.01	0.29	0.0	0.01	
0.16	1.67	11.01	0.15	1.77	3.0	0.12	
0.31	3.38	11.95	0.28	2.68	9.0	0.22	
0.46	5.22	12.90	0.40	3.40	17.7	0.32	
0.61	7.19	13.85	0.52	4.02	28.9	0.41	
0.76	9.30	14.79	0.63	4.56	42.4	0.50	
0.91	11.54	15.74	0.73	5.06	58.3	0.58	
1.06	13.91	16.68	0.83	5.51	76.7	0.66	
1.21	16.42	17.63	0.93	5.93	97.4	0.74	
1.36	19.07	18.57	1.03	6.33	120.7	0.81	
1.51	21.85	19.52	1.12	6.70	146.5	0.89	
1.65	24.76	20.46	1.21	7.06	174.8	0.96	
1.80	27.80	21.41	1.30	7.40	205.8	1.03	
1.95	30.98	22.36	1.39	7.73	239.6	1.10	
2.10	34.30	23.30	1.47	8.05	276.0	1.17	
2.25	37.75	24.25	1.56	8.35	315.4	1.23	
2.40	41.33	25.19	1.64	8.65	357.6	1.30	
2.55	45.05	26.14	1.72	8.94	402.8	1.37	
2.70	48.90	27.08	1.81	9.22	451.0	1.43	
2.85	52.88	28.03	1.89	9.50	502.3	1.50	
3.00	57.00	28.97	1.97	9.77	556.7	1.56	
1.68	25.33	20.65	1.23	7.13	180.60	**0.97**	Q (25-yr Event)