INITIAL SAFETY FACTOR ASSESSMENT
PLANT BARRY GYPSUM STORAGE FACILITY
ALABAMA POWER COMPANY

EPA's "Disposal of Coal Combustion Residuals from Electric Utilities" Final Rule (40 C.F.R. Part 257 and Part 261), §257.73(e), requires the owner or operator of an existing CCR surface impoundment to conduct periodic safety factor assessments. The owner or operator must document that the minimum safety factors outlined in §257.73(e)(1)(i) through (iv) for the critical embankment section are achieved.

The CCR surface impoundment located at Alabama Power Company's Plant Barry also referred to as the Plant Barry Gypsum Storage Facility is located on Plant Barry property, near Bucks, Alabama. The lined CCR surface impoundment is formed by an engineered perimeter embankment. The critical section of this CCR unit has been determined to be located on the west side of the unit.

The analyses used to determine the minimum safety factor for the critical section resulted in the following minimum safety factors:

Loading Condition	Minimum Calculated Safety Factor	Minimum Required Safety Factor
Long-term Maximum Storage Pool (Static)	1.8	1.5
Maximum Surcharge Pool (Static)	1.7	1.4
Seismic	1.7	1.0

The embankments are constructed of well compacted clayey sands that are not susceptible to liquefaction. Therefore, a minimum liquefaction safety factor determination was not required.

I hereby certify that the safety factor assessment was conducted in accordance with 40 C.F.R. Part 257.73 (e)(1).

10/17/16

James C. Pegues, P.E.
Licensed State of Alabama, PE No. 16516

SOUTHERN COMPANY

Engineering and Construction Services Calculation

Calculation Number:
TV-BA-APC387586-591-002

Project/Plant:	**Unit(s):**	**Discipline/Area:**
Plant Barry Gypsum Storage Facility	Units 1-5	ES&FS
Title/Subject: Factor of Safety Assessment for CCR Rule		
Purpose/Objective: Analyze slope stability of Gypsum Storage Facility		
System or Equipment Tag Numbers: NA	**Originator:** Rajendra S. Gondhalekar	

Contents

Topic	Page	Attachments (Computer Printouts, Tech. Papers, Sketches, Correspondence)	# of Pages
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Total # of pages including cover sheet & attachments:	13		

Revision Record

Rev. No.	Description	Originator Initial / Date	Reviewer Initial / Date	Approver Initial / Date
0	Issued for Information	RSG/10-04-16	JAL/10-04-16	JCP/10-04-16

Notes:

Purpose of Calculation

Barry Steam Plant is owned and operated by Alabama Power Company and located 30 miles north of Mobile, Alabama, off of Hwy 43 near Bucks, Alabama. Plant Barry is a seven unit generating facility, including two natural gas fired combined cycle units and five coal fired units. Plant Barry is in the process has installed a flue gas desulfurization system (scrubber) on Unit 5. This process produces gypsum as a by-product. The FGD gypsum is sluiced to a lined facility for final storage or disposal.

The gypsum storage facility will be constructed in a four cell arrangement with construction of Cell 1 currently completed. Additional cells will be completed as capacity demands dictate. Construction of the Cell 1 involved grading of the existing ground surface and the constructing of a perimeter dike out of compacted fill. The inside of Cell 1 was be lined with a high-density polyethylene (HDPE) liner to prevent infiltration of decant water into the subsurface. A drainage system utilizing a layer of geogrid sandwiched between layers of geofabric (i.e. TexDrain) carries decant water from the bottom of the cell to collection pipes which discharge into a sediment basin. A plan view of the Cell 1 design is shown in the Attachments.

The perimeter dike has been constructed using compacted fill from a nearby borrow area. This fill consists of silty and clayey sands. The dike averages approximately 20 feet in height and will varies in top width from 16 to 32 feet. The top of the dike at the critical section is at approximately elevation EL31 based on the latest topographic map. The exterior slope of the dikes is at 3H:1V and the interior slope of dikes within Cell 1 is at 2H:1V.

During operation, gypsum slurry is sluiced into the cell and allowed to decant through the drainage system. The dry gypsum that remains is used to create perimeter dikes, allowing the sluiced gypsum to be raised in levels to a final height of approximately 77 feet. A 3H:1V exterior slope will be maintained for the gypsum, and a 16 foot set-back will be constructed between the gypsum levels. Cross-sections showing the levels of gypsum placement in Cell 1 are shown in the Attachments.

The purpose of this calculation is to evaluate the stability of Plant Barry's gypsum storage facility and dike at the critical analysis section located on the after the final level of gypsum placement in Cell 1.

Methodology

The calculation was performed using the following methods and software:

GeoStudio 2012 (Version 8.15, Build 11777), Copyright 1991-2016, GEO-SLOPE International, Ltd.

Strata (Version alpha, Revision 0.2.0), Geotechnical Engineering Center, Department of Civil, Architectural, and Environmental Engineering, University of Texas.

Morgenstern-Price analytical method was run and reported.

Criteria and Assumptions

The slope stability models were run using the following assumptions and design criteria:

- Seismic site response was determined using a one-dimensional equivalent linear site response analysis. The analysis was performed using Strata, utilizing random vibration theory. The input motion consisted of the USGS published 2008 Uniform Hazard Response Spectrum (UHRS) for Site Class B/C at a 2% Probability of Exceedance in 50 years. The UHRS was converted to a Fourier Amplitude Spectrum, and propagated through a representative one dimensional soil column using linear wave propagation with strain-dependent dynamic soil properties. The input soil properties and layer thickness were randomized based on defined statistical distributions to perform Monte Carlo simulations for 100 realizations, which were used to generate a median estimate of the surface ground motions.
- The median surface ground motions were then used to calculate a pseudostatic seismic coefficient for utilization in the stability analysis using the approach suggested by Bray and Tavasarou (2009). The procedure calculates the seismic coefficient for an allowable seismic displacement and a probability exceedance of the displacement. For this analysis, an allowable displacement of 0.5 ft, and a probability of exceedance of 16% were conservatively selected, providing a seismic coefficient of 0.008g for use as a horizontal acceleration in the stability analysis.
- The current required minimum criteria (factors of safety) were taken from the Structural Integrity Criteria for existing CCR surface impoundment from 40 CFR 257.73, published April 17, 2015.
- The soil properties of unit weight, phi angle, and cohesion were obtained from historical laboratory and in-situ test results.
- Soil stratigraphy and piezometric data was estimated from the historical boring logs.
- The properties of unit weight, phi angle, and cohesion for the gypsum were derived from laboratory test data from Plant Scholz gypsum samples including the following: sedimented – consolidation samples, cast and sedimented triaxial samples, cast gypsum samples, and in-situ tests on sedimented gypsum
- The COE EM 1110-2-1902, October 2003, allows the use of the phreatic surface established for the maximum storage condition (normal pool) in the analysis for the maximum surcharge loading condition. This is based on the short term duration of the surcharge loading relative to the permeability of the embankment and the foundation materials. This method is used in the analysis for the impoundments at this facility with surcharge loading.

The Cross-Section and materials used in this survey calculation were generally gathered from historical slope stability analyses for the gypsum storage facility. The critical section for the storage facility was identified to be located along the west side of Cell 1.

Input Data

The following soil properties were used in the analyses.

Soil Type	Unit Weight, pcf	Cohesion, psf	Phi Angle, deg
Gypsum	85	0	30
Dike Fill	122	500	26
Base Soil	110	300	20

Hydrologic Considerations

Since the analysis condition consists of the gypsum stack being at a significantly higher elevation than the perimeter dikes and drainage channels, the gypsum will not receive any runoff from the surrounding areas. For the purpose of the analyses, the hydrologic conditions in the gypsum stack were conservatively assumed to be at the operating pool elevation for the previous level for the long term maximum storage condition, and at the surface of the gypsum top deck for the maximum surcharge condition.

Load Conditions

The stability of the Plant Barry gypsum storage facility was evaluated for the load conditions indicated in the following table. When appropriate, cases were run both in the gypsum and the dike.

Summary of Conclusions

The following table lists the factors of safety for various slope stability failure conditions. All conditions are steady state except where noted. Construction cases were not considered. Based on the results of these analyses all structures are stable.

North East Main Dike		
Case	**Computed Factor of Safety**	**Typical Minimum Factor of Safety**
Long-term Maximum Storage Pool (Static)	1.8	1.5
Maximum Surcharge Pool (Static)	1.7	1.4
Seismic	1.7	1.0

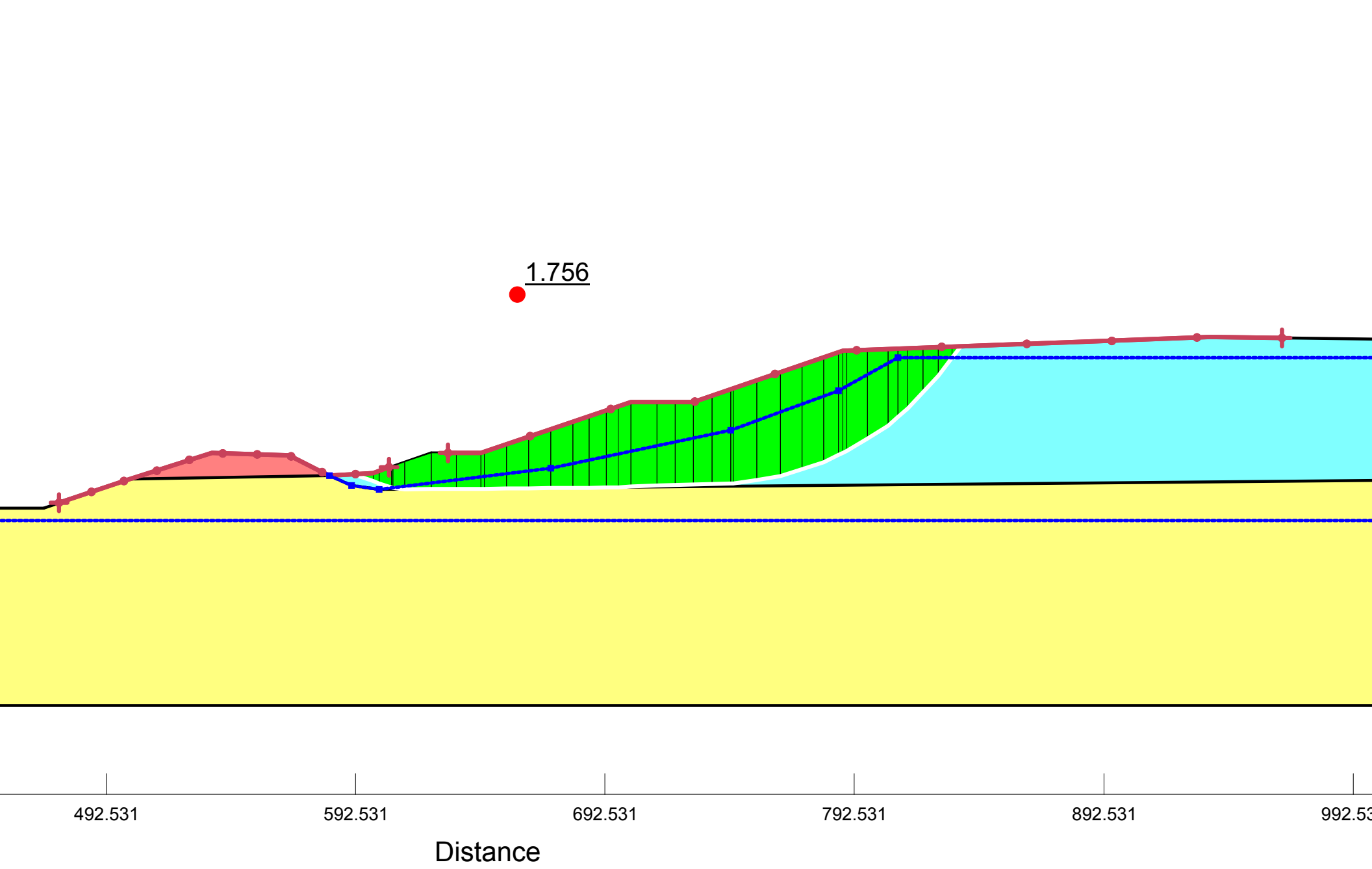
The analyses indicate that in all cases, the factors of safety are above the required minimums.

Design Inputs/References

- USGS Earthquake Hazards website, http://www.usgs.gov/hazards/earthquakes/.
- US Corps of Engineers Manual EM 1110-2-1902, October 2003
- Bray, J. D. and Travasarou, T., *Pseudostatic Coefficient for Use in Simplified Seismic Slope Stability Evaluation*, Journal of Geotechnical and Environmental Engineering, American Society of Civil Engineers, September 2009

Body of Calculation

Calculation consists of Slope-W modeling attached.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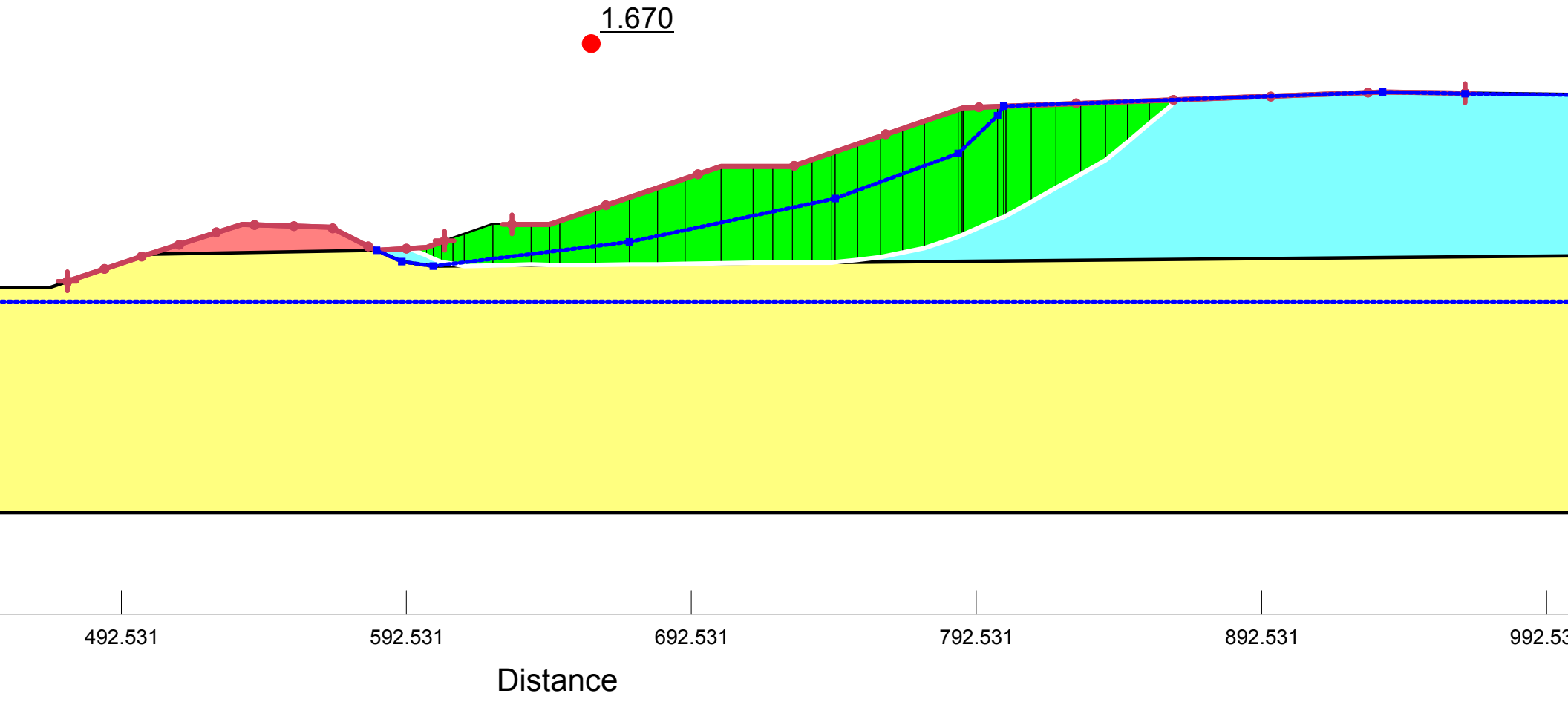
592.531
692.531
792.531
892.531
992.53
Distance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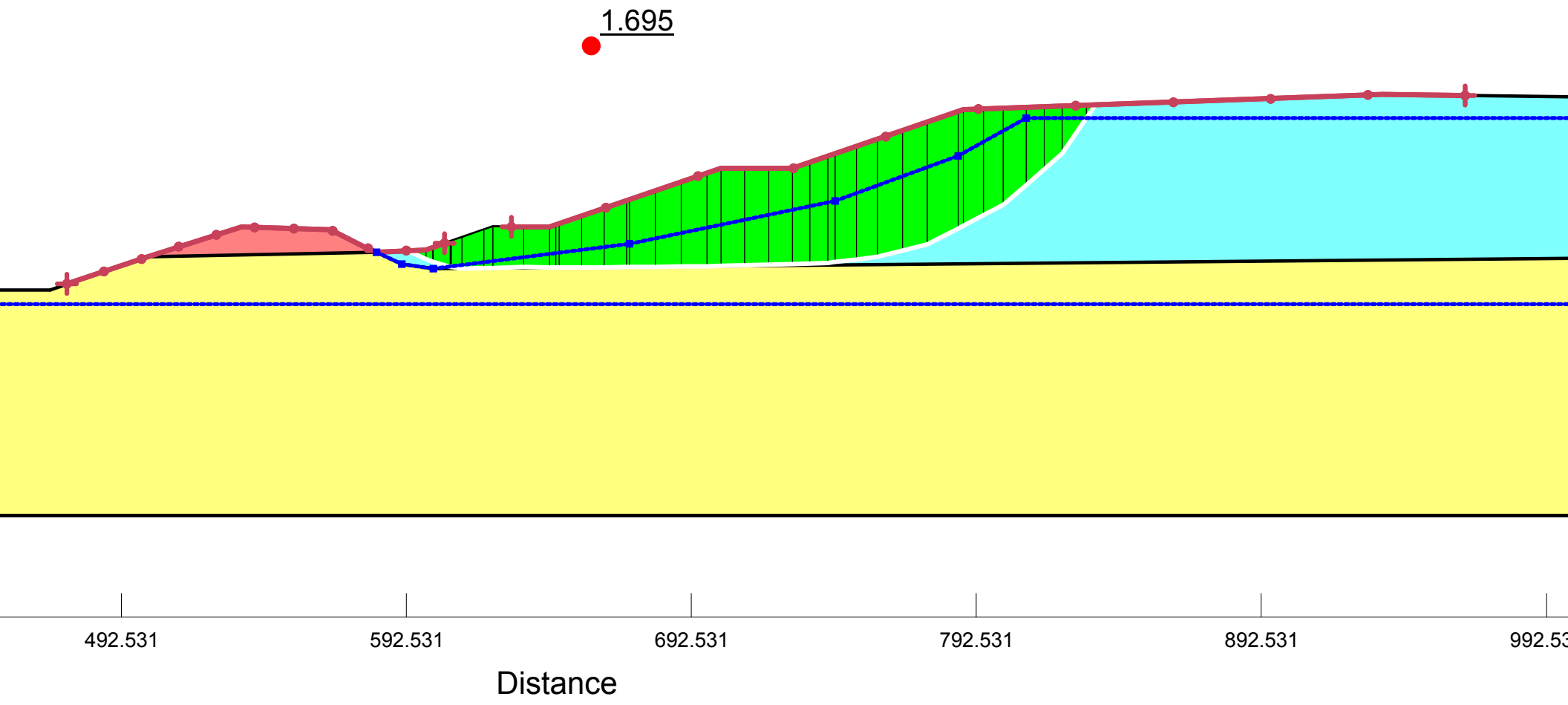
692.531
792.531
892.531
992.53
Distance



492.531 592.531 692.531 792.531 892.531 992.53

Distance

Attachment A

Figure – Cell 1 Construction Drawings

CELL NO. 1 - SEDIMENTATION POND DETAIL PLAN FOR INITIAL DIKE CONSTRUCTION

PLANT NORTH

APPROX. LOCATION OF ELECTRICAL DUCT RUN AND PULL BOXES FROM ELEC BLDG (SEE ELECTRICAL DRAWINGS FOR DETAILS AND EXACT LOCATION)

APPROX. LOCATION OF GYPSUM SLUICE PIPING(3). (SEE MECHANICAL DRAWINGS FOR GYPSUM SLUICE PIPING DETAILS)

GYPSUM MARKET STACKING AREA
(APPROX 2 AC. SEE SHEET E5C11054 FOR DETAILS)

EMERGENCY GYPSUM SLURRY POND POND BOTT. EL. 9.00

CELL NO. 1
STORAGE APPROX AREA 21.23 ACRES
TOP OF DIKE EL 31.00

RETURN WATER PIPING AND PIPE SLEEVES SEE MECHANICAL DRAWINGS FOR EXACT LOCATION DETAILS

PIPE AND PIPE SLEEVE FROM EMERGENCY GYPSUM SLURRY POND PUMPS. (SEE SECTION MM–MM SHT E5C11039)

VEHICULAR SWING GATE. SEE PERIMETER CHAIN LINK FENCE SPEC. SHEET E5C11030.

BEGIN GUARDRAIL N 2445.78 E 7277.70

END GUARDRAIL N 2319.11 E 7170.61

277.43 L.F. 12" ø PERF. HDPE COLLECTION PIPES (2 PIPES) @ 0.00% GRADE

234.78 L.F. 12" ø PERF. HDPE COLLECTION PIPES (2 PIPES) @ 0.00% GRADE

247.50 L.F. 12" ø PERF. HDPE COLLECTION PIPES (2 PIPES) @ 0.00% GRADE

24.72 L.F. 12" ø PERF. HDPE COLLECTION PIPES (2 PIPES) @ 59.34% GRADE

251.36 L.F. 12" ø PERF. HDPE COLLECTION PIPES (2 PIPES) @ 0.00% GRADE

N 2441.26 E 7284.52 PIPE INV. EL. 31.00

N 2419.86 E 7272.15 PIPE INV. EL. 16.33

N 2179.67 E 7133.32 PIPE INV. EL. 16.33

N 2168.42 E 7126.82 PIPE INV. EL. 16.33

N 1954.14 E 7002.97 INV. EL. 16.33

N 1750.87 E 6885.48 PIPE INV. EL. 16.33

N 1756.49 E 6888.73 PIPE INV. EL. 16.33

N 1739.61 E 6878.97 PIPE INV. EL. 16.33

N 1733.98 E 6875.72 PIPE INV. EL. 16.33

N 1739.61 E 6878.97 PIPE INV. EL. 16.33

N 1500.58 E 6740.81 PIPE INV. EL. 31.00

RISER ASSEMBLY TO BE ADDED WHEN CELL 2 IS CONSTRUCTED

EXTEND PIPE WHEN FUTURE CELL 2 IS CONSTRUCTED

SEE DETAIL PLAN AREA C SHT E5C11041

12" SLEEVE W/ 4" PIPE

29.34 L.F. 12" ø PERF. HDPE COLLECTION PIPES (2 PIPES) @ 50% GRADE

OUTFALL PIPES

OUTFALL PIPES (2)
TOP OF DIKE EL. 31.00

OUTFALL PIPES

PUMP STATION, PIPES, PIPE SUCTION, ELECT DUCT RUN, AND ELECT. BLDG FOUNDATION. SEE MECHANICAL, ELECTRICAL AND STRUCTURAL DWGS FOR EXACT LOCATION AND PIPING DETAILS

GUARD POSTS 2 PLACES TO BE LOCATED IN FIELD. SEE SHEET E5C11038)

SOUTH EVACUATION ROAD

2'–0" THICK CLASS I RIPRAP WITH FILTER FABRIC EXTENDING FROM TOE OF SLOPE UP TO EL. 17.50

P.I. N 2463.94 E 6953.01

P.I. N 2067.53 E 6565.31

SOUTH EVACUATION ROAD

TOP OF UNDERWATER SEDIMENT CONTROL DIKE EL. 12.00 (3:1 SIDE SLOPES)

SEDIMENTATION POND BOTT. EL. 9.0

HDPE LINER TO EXTEND ABOVE TOP OF UNDERWATER SEDIMENT CONTROL DIKE

PERIMETER CHAIN LINK FENCE AROUND POND ONLY. LOCATED ON EDGE OF ROAD. SEE NOTES ON SHEET E5C11030

PERIMETER CHAIN LINK FENCE AROUND POND ONLY. LOCATED 13' FROM ℄ OF ROAD. SEE NOTES ON SHEET E5C11030

SEE DETAIL PLAN AREA D SHT E5C11041

TOP OF DIKE EL 31.33

EDGE OF WETLANDS

ALDOT GALVANIZED STEEL BEAM GUARDRAIL WITH BLOCKED OUT TREATED TIMBER OR GALVANIZED STEEL POSTS. SEE TYPICAL GUARDRAIL DETAIL SHEET E5C11052.

END GUARDRAIL N 1840.55 E 6209.19

P.I. N 1844.44 E 6239.64

P.I. N 1513.21 E 6688.06

PVI N 1695.28 E 6021.88 EL 26.62

P.C. N 1575.45 E 5846.96

P.I. N 1541.15 E 5796.89

P.T. N 1529.01 E 5737.43

P.I. N 1524.56 E 5715.63 EL. 28.00±

ENSURE POSITIVE DRAINAGE AND NO PONDING OF STORMWATER IN ROAD

SOUTH EVACUATION ROAD TO HIGHWAY TO BE WIDENED TO 30' AND TO INCLUDE 12" THICK GRADED AGGREGATE BASE TRACKING SURFACE

SISTERS CREEK

WETLANDS

WETLANDS

N 1500 N 2000 N 2500 N 3000 E 7500 E 7000 E 6500 E 6000

NOTES:

1. GRIDLINES AND COORDINATES SHOWN ARE IN PLANT GRID.

GRAPHIC SCALE
50 0 25 50 100 200
(IN FEET)
1 inch = 50 ft.

Southern Company Generation Engineering and Construction Services
FOR
Alabama Power Company

PLANT BARRY UNIT 5
FGD PROJECT
GYPSUM STORAGE AREA
CELL NO. 1–SEDIMENTATION POND DETAIL PLAN
FOR INITIAL DIKE CONSTRUCTION

REVISION	DATE	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR

REVISION 6	DATE 12-19-11	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
A. ADDED AS-BUILT CONDITIONS	ECS5517	CSM	DPK	JBS				

REVISION 5	DATE 08-14-09	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
A. B–2 CHANGED GAB TO 12" B. C–3, E–6, F–8, ADDED SOUTH EVACUATION NOTE. C. D–5, CHANGED SECTION C–C TO C'–C' D. E–2, REVISED DISTANCE TO CL E. H–7, ADDED GYPSUM MARKET STACKING AREA EWO 2161DE		EEJ	PMG	BRH	JTM	KAH	TDJ	CKT

REVISION 4	DATE 07-02-09	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
A. C–4, F–7 ADDED GUARDRAIL AND SWING GATE	EWO 2161DE	JWM	PMG	BRH	JTM	KAH	TDJ	CKT

REVISION 3	DATE 03-05-09	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
A. G–7 ADDED PIPE SLEEVES AND PIPING B. H–7 ADDED ELECT DUCT RUN C. B–6 ADDED ELECT DUCT RUN D. F–7 ADDED ELECT DUCT RUN AND EDITED NOTE E. F–8 ADDED PIPE SLEEVE AND PIPING	EWO 2161DE	JWM	PMG	BRH	JTM	KAH	TDJ	CKT

REVISION 2	DATE 11-14-08	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
ISSUED FOR CONSTRUCTION GENERAL REVISION	EWO 2161DE	JWM	PMG	BRH	JTM	KAH	TDJ	CKT

REVISION 1	DATE 04-11-08	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
ISSUED FOR CONSTRUCTION GENERAL REVISION	EWO 2161DE	JWM	PMG	BRH	JTM	KAH	RAM	CKT

REVISION 0	DATE 12-03-07	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
ISSUED FOR CONSTRUCTION	EWO 2161DE	JWM	PMG	BRH	JTM	KAH	RAM	CKT

SCALE	PROJ I.D.	DRAWING NUMBER	SHEET	CONT'D	REV
1"=50'		E5C11034	1	FINAL	6

ANSI E 44x34 Acad2004

WETLANDS EXTEND EASTWARD BEYOND WHAT IS SHOWN HERE

PLANT NORTH

WETLANDS

WETLANDS

GYPSUM SLUICE LINES TO BE EXTENDED UP THE GYPSUM DIKE SLOPES TO LEVEL 2 AND LEVEL 3

GYPSUM SLUICE LINES TO BE EXTENDED UP THE GYPSUM DIKE SLOPES TO LEVEL 2 AND LEVEL 3

SLUICE LINES AND DITCH TO BE EXTENDED WHEN CELL 2 IS CONSTRUCTED

GYPSUM MARKET LOADING AREA

GYPSUM MARKET STACKING AREA

TOP OF DIKE EL. 31.00

TOP OF DIKE EL. 31.00

CELL NO. 1

STORAGE AREA APPROX 18.61 ACRES
(SEE STORAGE CAPACITY AND STORAGE LIFE CALCULATIONS THIS SHEET)

FOR TYPICAL RAMP SECTIONS SEE SHT E5C11050

FOR TYPICAL RAMP SECTIONS SEE SHT E5C11050

FOR TYPICAL RAMP SECTIONS SEE SHT E5C11050

TOP EL. 77±

SIPHON SHOWN EXTENDED TO LEVEL 2. AFTER 2ND LEVEL FILLING, SIPHON SHALL BE REMOVED. SEE SHEET E5C11051 FOR DETAILS.

FIRST LEVEL SIPHON EXTENDING ACROSS ROAD SHALL BE REMOVED AFTER SIPHON IS RELOCATED TO THE SECOND LEVEL

RISER ASSEMBLY TO BE ADDED WHEN CELL 2 IS CONSTRUCTED

EXTEND PIPE WHEN FUTURE CELL 2 IS CONSTRUCTED

RISER STRUCTURE AND OUTFALL PIPE TO BE CONCRETE GROUTED, CAPPED, AND ABANDONED IN PLACE AFTER SIPHON OPERATIONS BEGIN.

CELL NO. 2
(FUTURE TO BE DESIGNED)

EMERGENCY GYPSUM SLURRY POND

POND BOTT. EL. 9.00

TOP OF DIKE EL. 17.00

SEDIMENTATION POND BOTT. EL. 9.0

SEE DISCHARGE THRUST ANCHOR SHT D5C11051

N 2121.88
E 7451.94
EL 24.19

N 2121.88
E 7451.94
EL 24.31

CELL 1–STORAGE CAPACITY AND STORAGE LIFE

DESIGN OF CELL BASED ON 0.6% SULFUR COAL
INCOMING FLOW RATE – 280,218 LBS/HR
GYPSUM PRODUCTION RATE = 26,462 LBS/HR = 231,807,120 LBS/YR

FINAL CELL 1 STACK (0.6% SULFUR)
STORAGE VOLUME CAPACITY – 730,458 CY = 19,722,366 C.F.
OR 1,380,565,620 LBS (ASSUMING 70 LBS/C.F.)
STORAGE LIFE – 5.96 YEARS

DESIGN OF CELL BASED ON 1.0% SULFUR COAL
INCOMING FLOW RATE – 288,718 LBS/HR
GYPSUM PRODUCTION RATE = 46,270 LBS/HR = 405,325,200 LBS/YR

FINAL CELL 1 STACK (1.0% SULFUR)
STORAGE VOLUME CAPACITY – 730,458 CY = 19,722,366 C.F.
OR 1,380,565,620 LBS (ASSUMING 70 LBS/C.F.)
STORAGE LIFE – 3.41 YEARS

DESIGN OF CELL BASED ON 2.5% SULFUR COAL
INCOMING FLOW RATE – 584,623 LBS/HR
GYPSUM PRODUCTION RATE = 111,909 LBS/HR = 980,322,840 LBS/YR

FINAL CELL 1 STACK (2.5% SULFUR)
STORAGE VOLUME CAPACITY – 730,458 CY = 19,722,366 C.F.
OR 1,380,565,620 LBS (ASSUMING 70 LBS/C.F.)
STORAGE LIFE – 1.41 YEARS

CELL NO. 1 - OPERATIONS AND CONSTRUCTION FINAL STACKING PLAN

NOTES:

1. GRIDLINES AND COORDINATES SHOWN ARE IN PLANT GRID.

GRAPHIC SCALE
50 0 25 50 100 200
(IN FEET)
1 inch = 50 ft.

REVISION	DATE	BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	DISC MGR
REVISION 1	09-04-09	EEJ	PMG	BRH	JTM	KAH	TDJ	CKT
GENERAL REVISION	EWO 2161DE							
REVISION 0	12-31-08	JWM	PMG	BRH	JTM	KAH	TDJ	CKT
ISSUED FOR CONSTRUCTION	EWO 2161DE							

Southern Company Generation Engineering and Construction Services FOR

Alabama Power Company

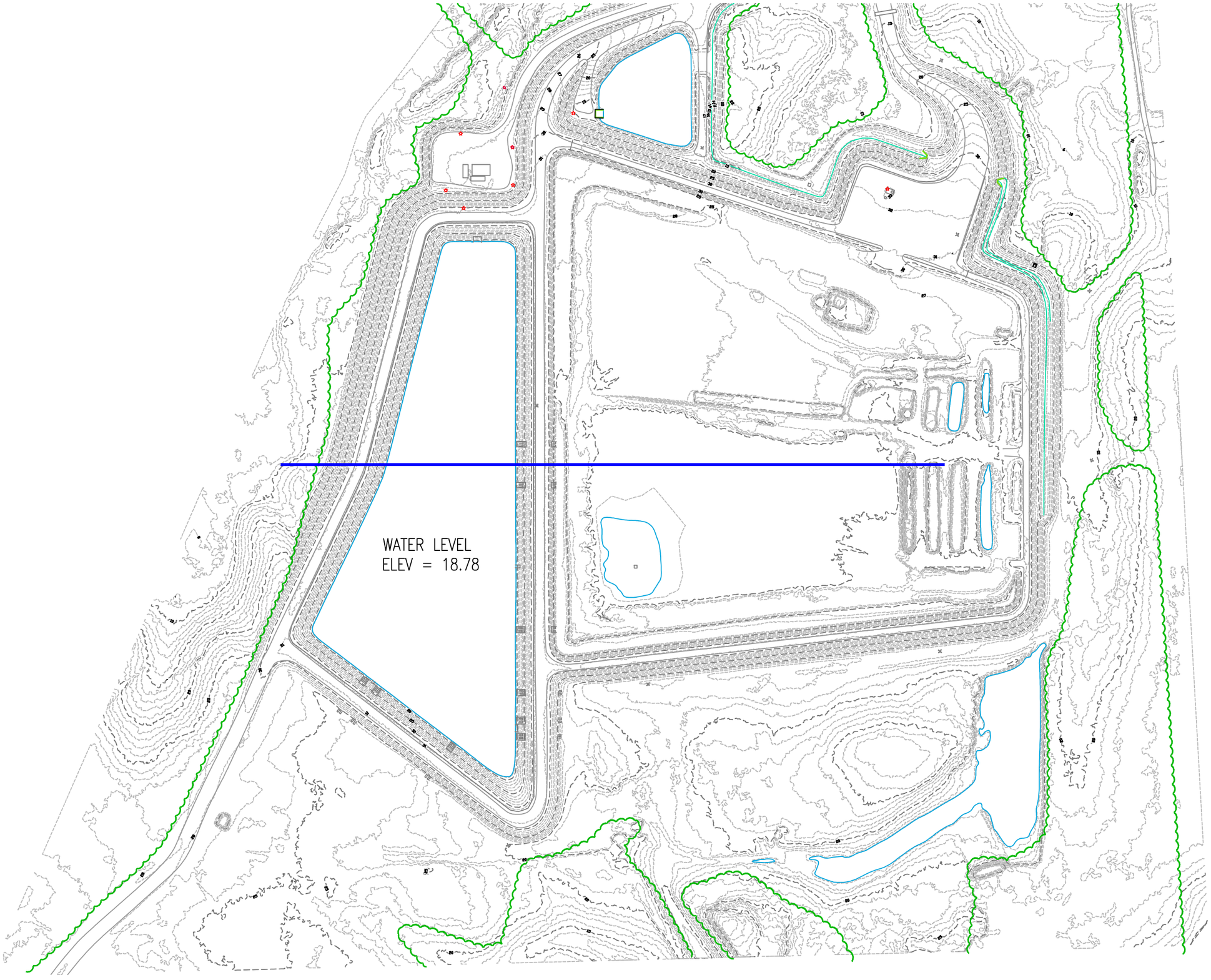
PLANT BARRY UNIT 5
FGD PROJECT
GYPSUM STORAGE AREA
CELL NO. 1–OPERATIONS PLAN
FINAL STACKING PLAN

SCALE	PROJ I.D.	DRAWING NUMBER	SHEET	CONT'D	REV
1"=50'	210800	E5C11048	1	FINAL	1

ANSI E: 44x34 Acad2004

Attachment B

Figure – Analysis Section Location


WATER LEVEL
ELEV = 18.78