RUN-ON / RUN-OFF CONTROL

RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

ASH LANDFILL 1

Oak Grove Steam Electric Station

Submitted To: LUMINANT
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Dallas, Texas 75201

Submitted By: Golder Associates, Inc.
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Registration Number F-2578

October 2016 **Project No. 1648164**

Golder Associates

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List of Attachments

1.0 INTRODUCTION

This Run-On and Run-off Control System Plan (RRCSP) was prepared for the Ash Landfill 1 at Luminant's Oak Grove Steam Electric Station (OGSES) in accordance with 40 Code of Federal Regulations (40 CFR) §257.81 (Run-on and run-off controls for Coal Combustion Residuals (CCR) landfills). The CCR Rule (40 CFR 257 Subpart D) was promulgated October 19, 2015. This RRCSP documents how the facility's run-on and run-off control systems have been designed to meet the requirements of 40 CFR §257.81 and is supported by appropriate engineering calculations.

Ash Landfill 1, located in Robertson County, Texas, was registered with the Texas Commission on Environmental Quality (TCEQ) as a Class 2 Non-hazardous Waste Landfill in 2008; the registration was updated in 2011 and 2012. The original design of the landfill included five cells, Cells 1 through 5; however, Luminant notified the TCEQ on September 2, 2016 that Cell 5 would not be constructed. . All four cells, 1 through 4, commenced construction prior to October 19, 2015 and have been constructed as of the date of this report.

2.0 REGULATORY REQUIREMENTS

2.1 Federal CCR Rule

As required by §257.81, the owner or operator of a Coal Combustion Residuals (CCR) landfill must design, construct, operate, and maintain the CCR landfill to convey run-off generated from at least a 25-year, 24-hour storm event. This includes the following:

- A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from the 25-year, 24-hour storm event.
- A run-off control system from the active portion of the CCR unit to collect and control the peak discharge from the 25-year, 24-hour storm event. Run-off from the active portion of the CCR unit must be managed in accordance with the requirements of 40 CFR §257.3-3 (prohibition against pollution of waters of the United States).

In the context of the CCR Rule, "active portion" is defined as that part of the CCR unit that has received or is receiving CCR or non-CCR waste and that has not completed closure in accordance with §257.102. It is understood that the intent of the run-off control system is to manage the contact water at the landfill, i.e. stormwater run-off that has come into contact with exposed CCR so that the facility shall not cause a discharge of pollutants into the waters of the Unites States in accordance with the surface water requirements under §257.3-3. Once a cell or portions of a cell has been closed/capped (either with a permanent cap or with a temporary soil cover), stormwater that falls on the closed/capped area will be considered non-contact stormwater run-off and will be diverted away from the active portion of the landfill. This report addresses run-off control for the contact water (run-off that has contacted CCR).

Currently at Ash Landfill 1, Cells 2 and 3 are receiving waste and are considered active. The status of each cell is as follows:

- Cell 1 was closed in 2015 with a final cover system consisting of 3-ft thick clay soil (hydraulic conductivity ≤ 1×10-7 cm/sec) overlain with vegetative cover.
- Cell 2 is approaching final grades and is anticipated to be closed with a final cover system in 2017.
- Cell 3 is currently used for two purposes: the eastern portion is receiving waste and the western portion is used as contact water management pond. Design of the contact water management pond is discussed in Section 5 of this report.
- Cell 4 has been constructed but has not started receiving waste.
- As waste placement in Cell 3 progresses, the contact water management pond may be moved to Cell 4, per the design discussed in Section 5.

2.2 Preamble to the Federal CCR Rule

The preamble to the federal CCR Rule provides additional description regarding the intent of the requirements. Regarding run-off control, the following quotation from the preamble is relevant.

> *The owner or operator must design, construct, operate, and maintain the CCR landfill in such a way that any runoff generated from at least a 24-hour, 25-year storm must be collected through hydraulic structures, such as drainage ditches, toe drains, swales, or other means, and controlled so as to not adversely affect the condition of the CCR landfill. EPA has promulgated these requirements to minimize the detention time of run-off on the CCR landfill and minimize infiltration into the CCR landfill, to dissipate storm water run-off velocity, and to minimize erosion of CCR landfill slopes. An additional concern with run-off from CCR landfills is the water quality of the run-off, which may collect suspended solids from the landfill slopes.*

A description of run-on and run-off control systems is included in the following sections of this report.

3.0 DESIGN METHODOLOGY

3.1 Design Storm

Run-on and run-off control systems were designed for hydraulic capacity for at least the 25-year, 24-hour storm event as required by local and federal regulations. Site-specific precipitation estimates were obtained from Technical Paper No. 40 – Rainfall Frequency Atlas of the United States at the landfill location. The 25-year, 24-hour storm event generates 8.3 inches of precipitation at this location. Design calculations utilizing this design storm are included in Attachment A.

3.2 Rainfall Abstractions

Rainfall abstractions are defined as all losses before run-off begins. Losses may consist of infiltration, depression storage, and other factors. Rainfall abstractions can be estimated using the SCS Method as presented in the following series of equations:

$$S = \frac{1000}{CN} - 10$$ [Equation 1]

$$I_a = 0.2S$$ [Equation 2]

Therefore:

$$I_a = \frac{200}{CN} - 2$$ [Equation 3]

Where:

S = potential maximum retention after run-off begins (in)

CN = curve number

I_a = initial abstraction (in)

The initial abstraction is a function of the land use conditions as represented by the composite curve number for the tributary drainage area. The curve number for uncovered CCR material in the landfill has been conservatively assumed at 94. For example, the initial abstraction for run-off from CCR material with a curve number of 94 is calculated as follows:

$$I_a = \frac{200}{94} - 2 = 0.13\ inches$$

3.3 Run-off and Routing Methodology

Stormwater calculations were performed using computer software that utilizes Soil Conservation Service (SCS) Method for estimating run-off. Computer software modeling suitable for both the calculations of run-on and run-off is utilized to simulate the hydraulic performance of each system.

A composite curve number of 94.3 for uncovered CCR material and water in the contact water area. The composite curve number is based on a conservative curve number of 94 for ash and a curve number of 98 for contact water. Approximately 92% of the sub-basin run-off area is comprised of ash and the remaining 8% is comprised of contact water.

3.4 Drawings

The topography of the site, along with the locations and construction details of the run-on and run-off control system features are presented in the Attachment A.

4.0 RUN-ON CONTROL SYSTEM

4.1 Overview

Run-on as defined in §257.53 of the CCR rule, means any rainwater, leachate, or other liquid that drains over land onto any part of a CCR landfill or lateral expansion of a CCR landfill. Based on the topography of Ash Landfill 1 at OGSES and surrounding areas, run-on potential from the outside of the landfill footprint is limited. Within the landfill waste footprint, run-on control is also required to divert the stormwater away from the active portion of the landfill.

4.2 Run-on Control System Design and Construction

Attachment A presents the run-on control system design at Ash Landfill 1. Currently, a perimeter berm has been constructed around the entire landfill waste footprint, with a minimum height of 6 feet and a typical height of 20 feet, exceeding the required berm height of 4 feet as shown in the original design in Attachment A. This existing perimeter berm has adequate height to prevent flow from outside the landfill waste footprint onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm.

Within the landfill waste footprint, stormwater that falls on the closed area and the area with temporary soil cover is diverted away from the portion of the landfill with exposed waste, via proper grading and soil berms (i.e. diversion berms/ditches). Stormwater structures on the closed area are constructed in accordance with the final cover design. Stormwater diversion berms on the areas with temporary soil covers are typically 2 feet high with 3H:1V sideslope, at 1% longitudinal slopes and spaced 200 feet horizontally on the 3H:1V soil cover slopes.

4.3 Operation and Maintenance

Stormwater drainage features along the exterior of Ash Landfill 1 will be operated and maintained to ensure that proper stormwater run-on control is maintained throughout the life of the landfill. Stormwater run-on operation and maintenance activities will be include weekly inspections by a qualified person in accordance with §257.84(a) and annual inspections by a professional engineer in accordance with §257.84(b). Recordkeeping of the inspection and maintenance activities will be in accordance with §257.84(c).

5.0 RUN-OFF CONTROL SYSTEM

5.1 Overview

Run-off management from the active portion of the landfill is recognized as two types of run-off:

- Contact water (run-off that has contacted CCR): Contact water run-off for the active ash placement area of the landfill is managed via contact water management areas.
- Non-contact stormwater (run-off that has not contacted CCR): This includes stormwater run-off from temporary soil cover (for stormwater management on slopes that have a soil cover).

Contact water management is addressed in Section 5.2 and non-contact stormwater management is addressed in Section 5.3. Calculations are presented in Attachment A.

Contact water that is collected can be applied to the CCR for dust control and/or is allowed to evaporate. Contact water will not be discharged from the landfill unless authorized by TCEQ permit or similar authorization.

5.2 Contact Water Run-off

5.2.1 Contact Water Management Area

The contact water management plan is based on constructing a contact water management area within the lined footprint of the landfill to contain run-off from a 25-year, 24-hour storm event with a 2-foot freeboard. The size of the contact water management area was calculated for each construction phase. The calculation in Attachment A presents the required contact water management area for various sizes of run-off contributing areas. Actual size of the contact water management area required during operation can be determined based on the actual run-off contributing area at the time. The ash grades of each phased construction area will be sloped towards the contact water management area so run-off can be collected in the designed area. Figure 1-1 in Attachment A shows the plan view of the contact water management area. Cross-sections of the contact water management area is shown on Figure 1-3 in Attachment A. Detailed engineering calculations are also included in Attachment A. Note Attachment A includes calculations for both 25-year and 100-year, 24-hour storms.

The contact water management areas are typically long and narrow ponds running along the toe of the ash. Based on the calculations presented in Attachment A, the contact water management areas are typically 12 feet deep with a bottom width ranging from 42 feet to 92 feet.

It is noted that the site will actively manage the contact water management area to a level of 2 feet or less (i.e. standing water less than 2 feet) so the storage capacity required to contain contact water from a 25-year, 24-hour storm event is available.

5.2.2 Run-off Control of Active Disposal Area In Final Cell

As the waste placement at the landfill is progressing to the last cell, Cell 4, the site plans to manage the active waste disposal area in a way to minimize or potentially eliminate the need for a separate contact water management area discussed in Section 5.2.1.

Run-on and run-off controls for active disposal areas will be utilized to minimize the potential for stormwater contamination. The working face of the active disposal area will be separated from areas with soil cover or final cover by a run-on berm (top berm) and a run-off berm (toe berm) for the purpose of segregating potentially contaminated and non-contact stormwater. The containment berms are designed to accommodate the 25-year, 24-hour storm, the equivalent of an 8.3-inch rainfall event. The top berm is designed to accommodate upstream watersheds that may flow toward the working face and divert the collected uncontaminated stormwater around the working area. The toe berm is designed to accommodate storage of stormwater that has potentially contacted the open working face. The berm height requirements and design configurations are detailed in Attachment B.

As a result of progressive disposal and filling operations, ongoing berm extensions/construction may be required to accommodate adequate stormwater run-on diversion (top berm) and proper storage of run-off contact waters (toe berm). The daily disposal operations will include an evaluation of the existing containment berm's capability to manage stormwater run-on and run-off. Outside the active waste disposal area, an interim soil cover will be placed on top of the waste so the stormwater will not come into contact with waste. The interim cover will be inspected regularly and maintained as needed.

5.3 Non-Contact Water Run-off

During waste filling operations, areas of the landfill that are not actively receiving waste, may be covered with temporary soil cover as CCR placement progresses. Proper grading and/or soil diversion berms on the temporary soil cover will divert stormwater run-off away from the portion of the landfill with exposed waste. Stormwater structures on the closed area will be constructed per the final cover design. Stormwater diversion berms on the areas with temporary soil covers are typically 2 feet high with 3H:1V sideslope, at 1% longitudinal slopes and spaced 200 feet horizontally on the 3H:1V soil cover slopes. The diversion berms will convey stormwater to downslope channels, in the same fashion as the final cover stormwater system design, and into the perimeter channel system described in the final cover stormwater system design.

Non-contact stormwater runoff will be kept separate from contact water within the limits of the landfill during filling operations.

5.4 Operation and Maintenance

The contact water management area and the active area run-off control berm will be operated and maintained to ensure that proper stormwater run-off control is maintained throughout the life of the landfill. Stormwater run-off operation and maintenance activities will include weekly inspections by a qualified person in accordance with §257.84(a) and annual inspections by a professional engineer in accordance with §257.84(b). Recordkeeping of the inspection and maintenance activities will be in accordance with §257.84(c).

6.0 UPDATES TO RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

In accordance with §257.81(c)(3) of the CCR Rule, this initial RRCSP must be prepared and placed in the Oak Grove Facility operating record no later than October 17, 2016. Subsequent periodic RRCSP must be completed every five years from the completion date of this initial plan. In addition, the RRCSP must be amended whenever there is a change in conditions that would substantially affect the Plan.

7.0 CLOSING

As required by 40 §CFR 257.81, Ash Landfill 1 at OGSES run-on control system is designed to prevent flow onto the active portion of the CCR unit during the peak discharge from a 25-year, 24-hour storm, and the run-off control system is designed to collect and control at least the contact water volume resulting from a 25-year, 24-hour storm.

GOLDER ASSOCIATES, INC.

May Xin, PE
Senior Engineer

Jeffrey B. Fassett, PE
Senior Consultant and Associate

MX/JBF/kc

8.0 CERTIFICATION

I hereby certify that this Run-on and Run-off Control System Plan has been prepared in general accordance with normally accepted civil engineering practices and in accordance with the requirements of 40 CFR §257.81.

STATE OF TEXAS
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10/11/2016

May Xin, PE
Golder Associates Inc.
Firm Registration Number F-2578

Golder Associates

ATTACHMENT A

CONTACT WATER PLAN

CONTACT WATER PLAN

Date: January 7, 2011 **Project No.:** 103-94574

LUMINANT POWER – OAK GROVE STEAM ELECTRIC STATION – ASH LANDFILL CONTACT WATER MANAGEMENT PLAN

This technical memorandum is provided to document the contact water management plan and basis for the ash landfill at Luminant Power's (Luminant) Oak Grove Steam Electric Station (SES). The sections below describe the design summary, design method, design assumptions, and design results for contact water management.

1.0 DESIGN SUMMARY

Runoff - Contain all contact water within the lined landfill footprint for a 100-year, 24-hour storm event.

This contact water management plan is based on constructing a contact water management area within the lined footprint of the landfill to contain runoff from a 25-year, 24-hour storm event with two feet of freeboard and to contain runoff from a 100-year, 24-hour storm event with no freeboard. The size of the contact water management area was calculated for each construction phase. The total volume of runoff from the storm event, an assumed berm height on the upslope end of the contact water management area, an assumed existing depth of water in the contact water area prior to the storm event, and an estimated contact water area length were used to determine the minimum bottom width of the contact water management area, which will have a trapezoidal cross-section with 3:1 side slopes. The ash grades of each phased construction area will be sloped toward the contact water area to contain runoff. See Figure 1-1 for a drawing showing how the runon area was delineated.

Runon - Prevent runon to the landfill from surrounding area for a 100-year, 24-hour storm event.

Potential areas of runon were reviewed, and while most of the surrounding areas will naturally channel runon away from the landfill, there is an area to the west of Cell 2 and Cell 3 that is sloped towards the landfill and will likely produce runon during Cell 2 and Cell 3 construction and operation. The contributing area is largest during construction and operation of Cell 2 (see Figure 1-2) and is based on existing ground topography that was obtained from an aerial survey performed by Geodetix, Inc. on May 27, 2010. The height of the berm necessary to prevent runon was determined by assuming a natural channel forms along the outside of the contact water management area berm.

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2.0 DESIGN METHOD

Runoff

The bottom width of the contact water management area necessary to contain runoff from active portions of the landfill was based on spreadsheet calculations that take into account curve number, area of contributing basin (see Figure 1-1), magnitude of storm event, selected internal berm height, freeboard, and water depth prior to the storm. See Figure 1-3 for a cross-section of the contact water management area berm. An acceptable bottom width of the contact water management area for the 25-year, 24-hour storm event was based on two feet of freeboard with two feet of water in the contact water management area prior to the storm event. An acceptable bottom width of the contact water management area for the 100-year, 24-hour storm event was based on no freeboard with two feet of water in the contact water management area prior to the storm event.

Runon

To prevent runon from entering active portions of the landfill, a HEC-HMS model based on curve numbers, contributing basin area, Manning's number, and flow paths was run. The area contributing to maximum runon (Figure 1-2) is approximately 1,652,000 square feet. To determine the berm height necessary to prevent runon from this area to the active landfill (see Figure 1-3), a channel geometry and flow path were assumed and a normal flow depth was obtained.

3.0 DESIGN ASSUMPTIONS

The size of the contact water management area for runoff control was designed based on the following assumptions:

- Composite curve number of 94.3 for uncovered ash in the landfill and water in the contact water area (see Appendix 1-1) (Haan et. al., 1994). The composite curve number is based on a curve number of 94 for ash and a curve number of 98 for contact water. Approximately 92% of the subbasin runoff area is comprised of ash and the remaining 8% is comprised of contact water.
- Minimum freeboard in contact water area of 2 ft (25-year, 24-hour storm event)
- Minimum freeboard in contact water area of 0 ft (100-year, 24-hour storm event)
- 25-year, 24-hour storm event equal to 8.3 inches (see Appendix 1-2) (Herschfield, 1961)
- 100-year, 24-hour storm event equal to 10.5 inches (see Appendix 1-3) (Herschfield, 1961)
- 2 feet of existing water in contact water area prior to either storm event
- Selected internal berm height of 12 feet
- The following progressive closure schedule:
  - 20 acres concurrent with construction of Cell 2 upper containment dike
  - 20 acres concurrent with construction of Cell 3 upper containment dike
  - 20 acres concurrent with construction of Cell 4 liner and lower containment dike
  - 20 acres concurrent with construction of Cell 4 upper containment dike
  - 20 acres concurrent with construction of Cell 5 liner and lower containment dike
  - 20 acres concurrent with construction of Cell 5 upper containment dike
  - Remaining 29 acres when the landfill is at capacity

The external berm height of the contact water area for runon control was designed with the following assumptions:

- Composite curve number of 73 for the contributing basin (see Appendix 1-1) (Haan et. al., 1994). Composite of 30% wooded area (CN=70) and 70% pasture (CN=74).
- Area of contributing basin west of Cell 2 construction equal to 1,652,000 sq. ft. (see Figure 1-2)
- Manning's number of 0.025 for earth-lined channels
- Minimum freeboard in channel of 2 ft
- Channel bottom width of 5 ft
- Channel side slopes are 3:1

4.0 DESIGN RESULTS

Runoff

Based on the calculations presented in Appendix 1-4 and an inside berm height of 12 feet, the contact water management area bottom widths range from 42 feet to 92 feet with the maximum width occurring during Cell 4 Lower construction. Appendix 1-4 contains runoff calculations for both the 100-year and 25-year storm events, and a summary of the results is provided below.

Stage	Bottom Width of Contact Water Management Area (ft)	
	100-year 24-hour Storm Event	25-year 24-hour Storm Event
Cell 2 Lower	79	82
Cell 2 Upper	42	45
Cell 3 Lower	90	92
Cell 3 Upper	53	56
Cell 4 Lower	86	89
Cell 4 Upper	42	45
Cell 5 Lower	67	70
Cell 5 Upper	Interim cover will be placed concurrently with ash placement to minimize the area contributing to runoff and the contact water management area.	

It is important that Luminant actively manage the contact water management area to a level of 2 feet or less so the storage capacity required to contain contact water from a 25-year or 100-year storm event is available. For instance, in the event of a 25-year, 24-hour storm, Luminant personnel will need to pump at a maximum rate of 1,450 gpm for one week to empty the captured water. For a 100-year, 24-hour storm, Luminant personnel will need to pump at a maximum rate of 1,860 gpm for one week to empty the captured water. Note that when selecting a pump, specific operating conditions such as head and pumping distance should be taken into account.

Runon

Using HEC-HMS, the maximum flow from the runon subbasin was determined to be 174 cfs for a 100-year, 24-hour storm. Using the assumed channel geometry, this flow corresponds to a 2.2-foot deep channel at 0.8% slope with a peak velocity of 6.6 ft/sec and a velocity head of 0.7 feet along the outside of the contact water management area berm. See Appendix 1-5 for the 100-year, 24-hour storm results. With a 25-year, 24-hour storm, the maximum runon flow reporting to the runon channel is 124.5 cfs, which corresponds to a 1.9-foot deep channel at 0.8% slope with a peak velocity of 6.0 ft/sec and a velocity head of 0.6 feet. See Appendix 1-6 for the 25-year, 24-hour storm results. Based on these results, the contact water management area outside berm is to be at least 4 feet above existing grade to allow for runon control with approximately 2 feet of freeboard.

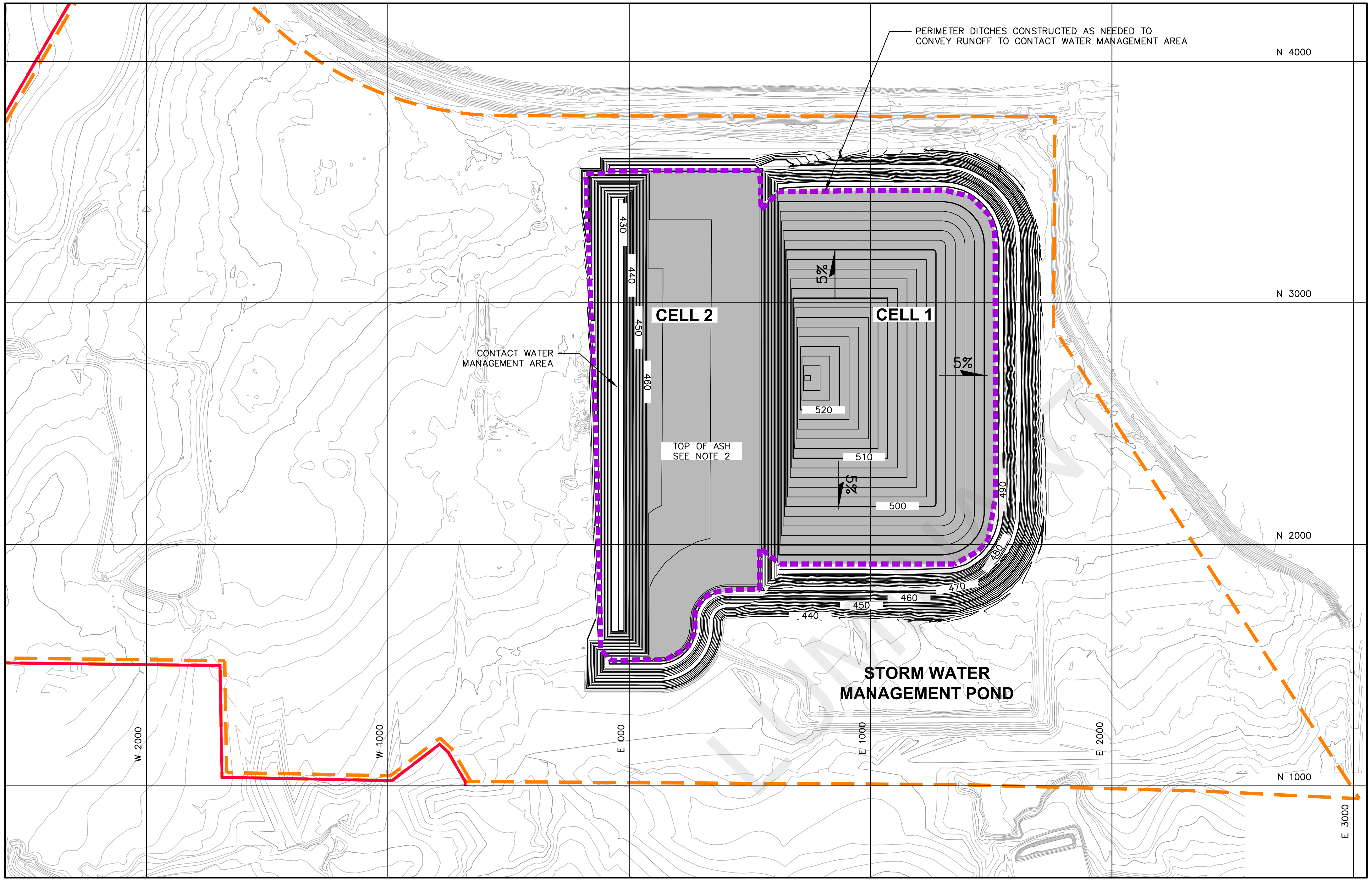
Because the peak flow velocities are greater than 3 ft/sec, which is the recommended maximum flow for an earth-lined channel, additional erosion control measures may need to be implemented on the outside berm. These measures may include straw bales, silt fences, or a sacrificial channel in front of the berm.

5.0 REFERENCES

Haan, Barfield, and Hayes. “Design Hydrology and Sedimentology for Small Catchments.” 1994.

Hershfield. “Technical Paper No. 40 - Rainfall Frequency Atlas of the United States.” 1961.

FIGURES



LEGEND

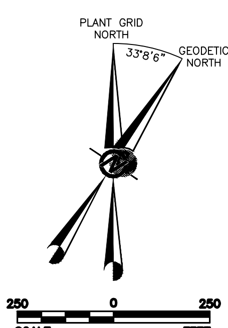
- EXISTING GROUND TOPOGRAPHY
- LANDFILL GRADES
- LIMIT OF RUNOFF AREA
- LIMIT OF 1987 REGISTERED LANDFILL AREA
- PROPERTY BOUNDARY

NOTES

1. TYPICAL SIDESLOPE FOR LINER AND CONTAINMENT DIKE IS 3H:1V.
2. GRAY SHADING INDICATES UNCOVERED ASH.
3. CONTACT WATER WILL BE MANAGED IN THE LANDFILL FOOTPRINT. EXCESS CONTACT WATER WILL BE PUMPED FROM THE LANDFILL TO PERMITTED MANAGEMENT FACILITIES.

REFERENCES

1. EXISTING GROUND TOPOGRAPHY IS FROM AN AERIAL SURVEY PERFORMED BY GEODETIX, INC., ON MAY 27, 2010. ADDITIONAL SURVEY INFORMATION FROM THE AREA SOUTH OF NORTHING N 1000 IS FROM FLUOR ENTERPRISES, INC., DRAWING A2YF00-0-CV-0-SW.PL.-06-2.
2. COORDINATES ARE BASED ON OAK GROVE STEAM ELECTRIC STATION PLANT GRID SYSTEM.
3. ELEVATIONS ARE BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 2 FT.



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PROJECT
OAK GROVE STEAM ELECTRIC STATION
ASH LANDFILL EXPANSION
ROBERTSON COUNTY, TEXAS

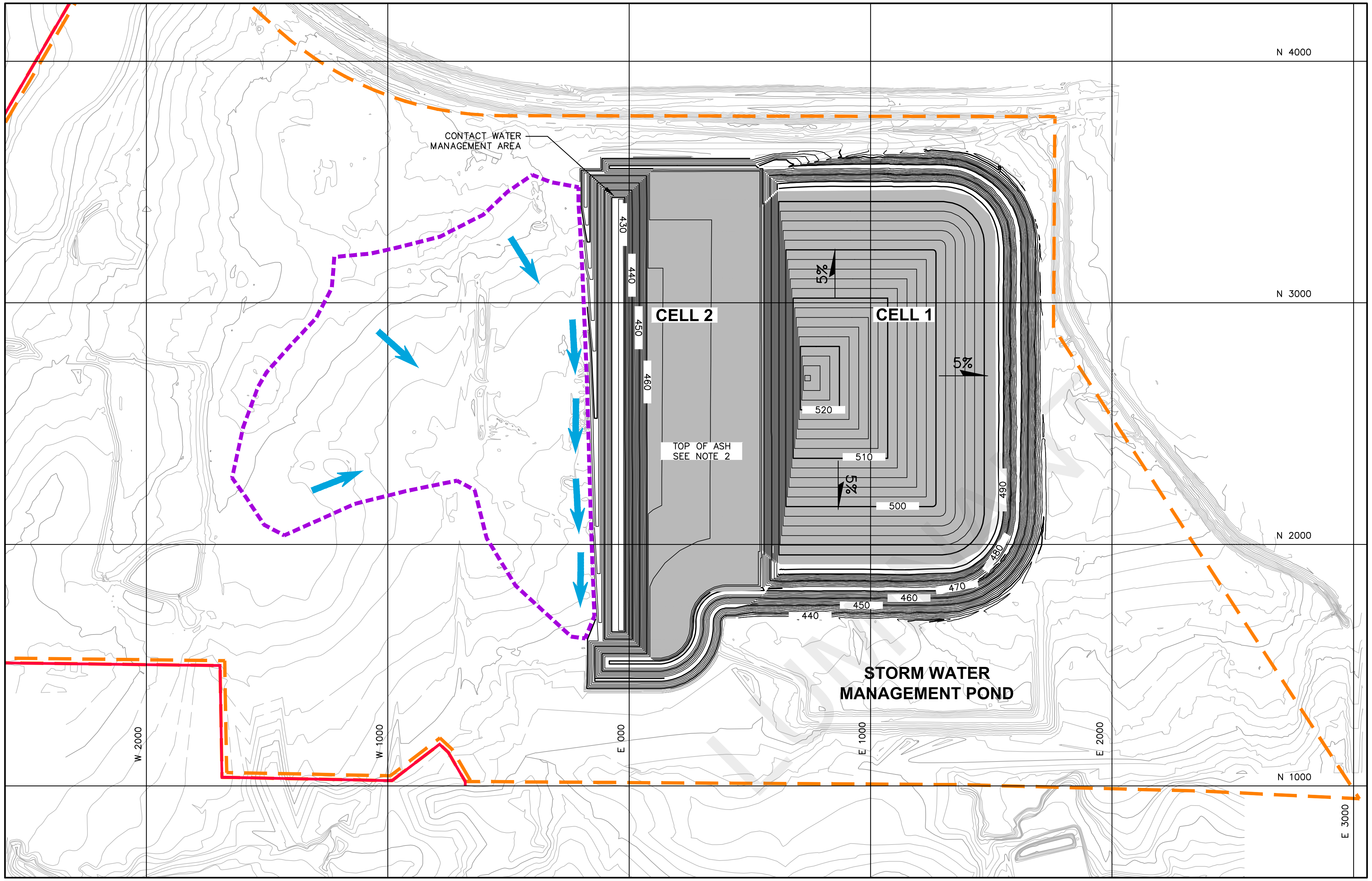
TITLE
TYPICAL DELINEATION OF RUNOFF AREA

Golder Associates

PROJECT No.		103-94574
DESIGN	CCS	01/05/11
CADD	CCS	01/05/11
CHECK	ECB	01/05/11
REVIEW	TJS	01/05/11

FILE No. 10394574SW005
SCALE N\A REV. B

FIGURE 1-1



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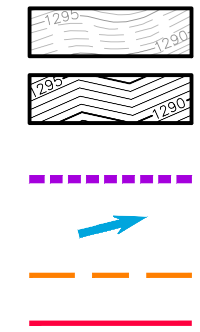


EXISTING GROUND TOPOGRAPHY

LANDFILL GRADES

LIMIT OF RUNON AREA

FLOW DIRECTION

LIMIT OF 1987 REGISTERED LANDFILL AREA

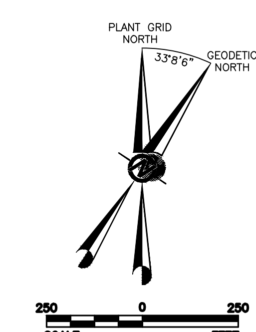
PROPERTY BOUNDARY

NOTES

1. TYPICAL SIDESLOPE FOR LINER AND CONTAINMENT DIKE IS 3H:1V.
2. GRAY SHADING INDICATES UNCOVERED ASH.
3. THE AREA OF THE SUBBASIN CONTRIBUTING TO RUNON IS APPROXIMATELY 1,652,000 SQUARE FEET.

REFERENCES

1. EXISTING GROUND TOPOGRAPHY IS FROM AN AERIAL SURVEY PERFORMED BY GEODETIX, INC., ON MAY 27, 2010. ADDITIONAL SURVEY INFORMATION FROM THE AREA SOUTH OF NORTHING N 1000 IS FROM FLUOR ENTERPRISES, INC., DRAWING A2YF00-0-CV-0-SW.PL.-06-2.
2. COORDINATES ARE BASED ON OAK GROVE STEAM ELECTRIC STATION PLANT GRID SYSTEM.
3. ELEVATIONS ARE BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 2 FT.



PROJECT

OAK GROVE STEAM ELECTRIC STATION
ASH LANDFILL EXPANSION
ROBERTSON COUNTY, TEXAS

TITLE

MAXIMUM RUNON AREA

Golder Associates

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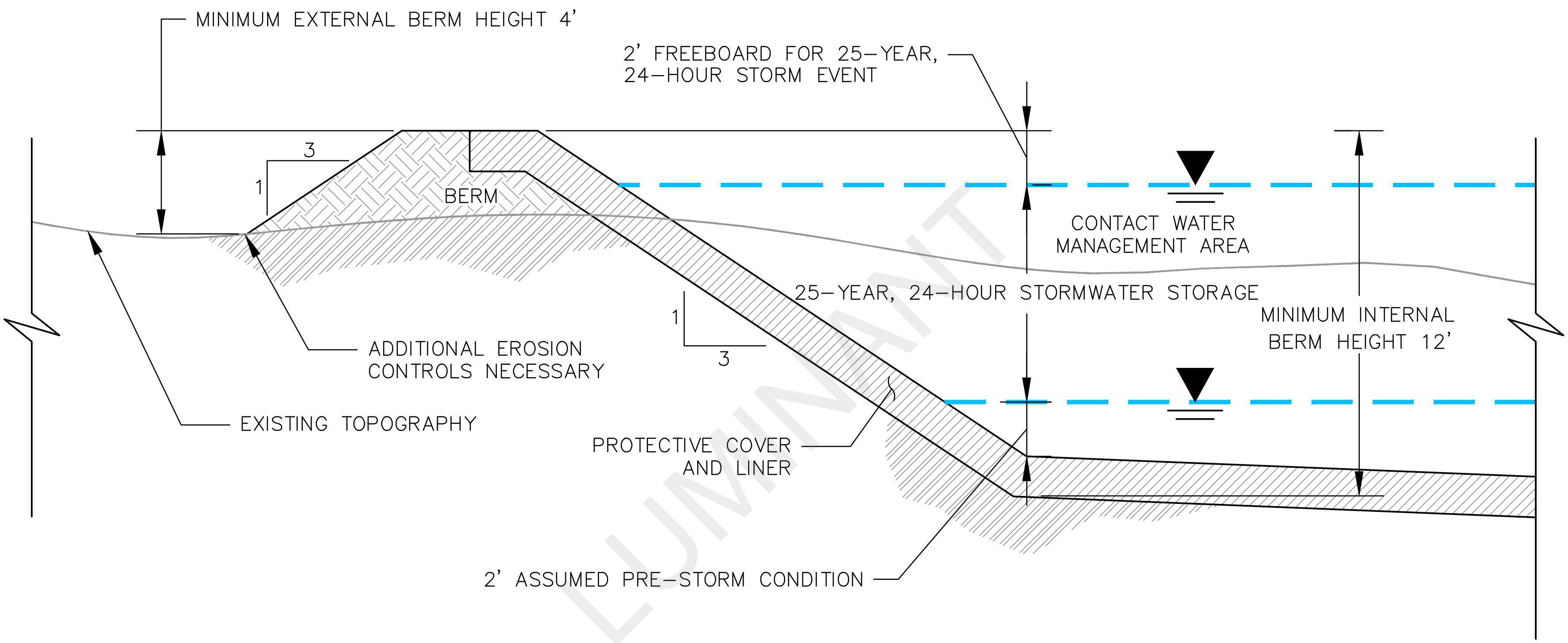

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PROJECT

OAK GROVE STEAM ELECTRIC STATION
ASH LANDFILL EXPANSION
ROBERTSON COUNTY, TEXAS

TITLE

CONTACT WATER MANAGEMENT AREA BERM

Golder Associates

PROJECT No.		103–94574	FILE No.	10394574SW003
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CHECK	ECB	11/15/10		
REVIEW	TJS	11/15/10		

FIGURE 1-3

APPENDICES

APPENDIX 1-1

Table 3.16 Runoff Curve Numbers for Selected Land Uses (Soil Conservation Service, 1986)

Land use description		Hydrologic soil group A	B	C	D
Cultivated land[a]					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture or range land					
Poor condition		68	79	86	89
Good condition		39	61	74	80
Meadow					
Good condition		30	58	71	78
Wood or forest land					
Thin stand, poor cover, no mulch		45	66	77	83
Good cover[b]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
Good condition (grass cover on 75% or more of the area)		39	61	74	80
Fair condition (grass cover on 50 to 75% of the area)		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[c]					
Average lot size	Average percentage impervious[d]				
$\frac{1}{8}$ acre or less	65	77	85	90	92
$\frac{1}{4}$ acre	38	61	75	83	87
$\frac{1}{3}$ acre	30	57	72	81	86
$\frac{1}{2}$ acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[e]		98	98	98	98
Streets and roads					
Paved with curbs and storm sewers[e]		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89

[a]For a more detailed description of agricultural and land use curve numbers refer to "National Engineering Handbook," Sect. 4, "Hydrology" Chap. 9, 1972.

[b]Good cover is protected from grazing, litter, and brush cover soil.

[c]Curve numbers are computed assuming the runoff from the house and driveway is directed toward the street with a minimum of roof water directed to lawns where additional infiltrations could occur.

[d]The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

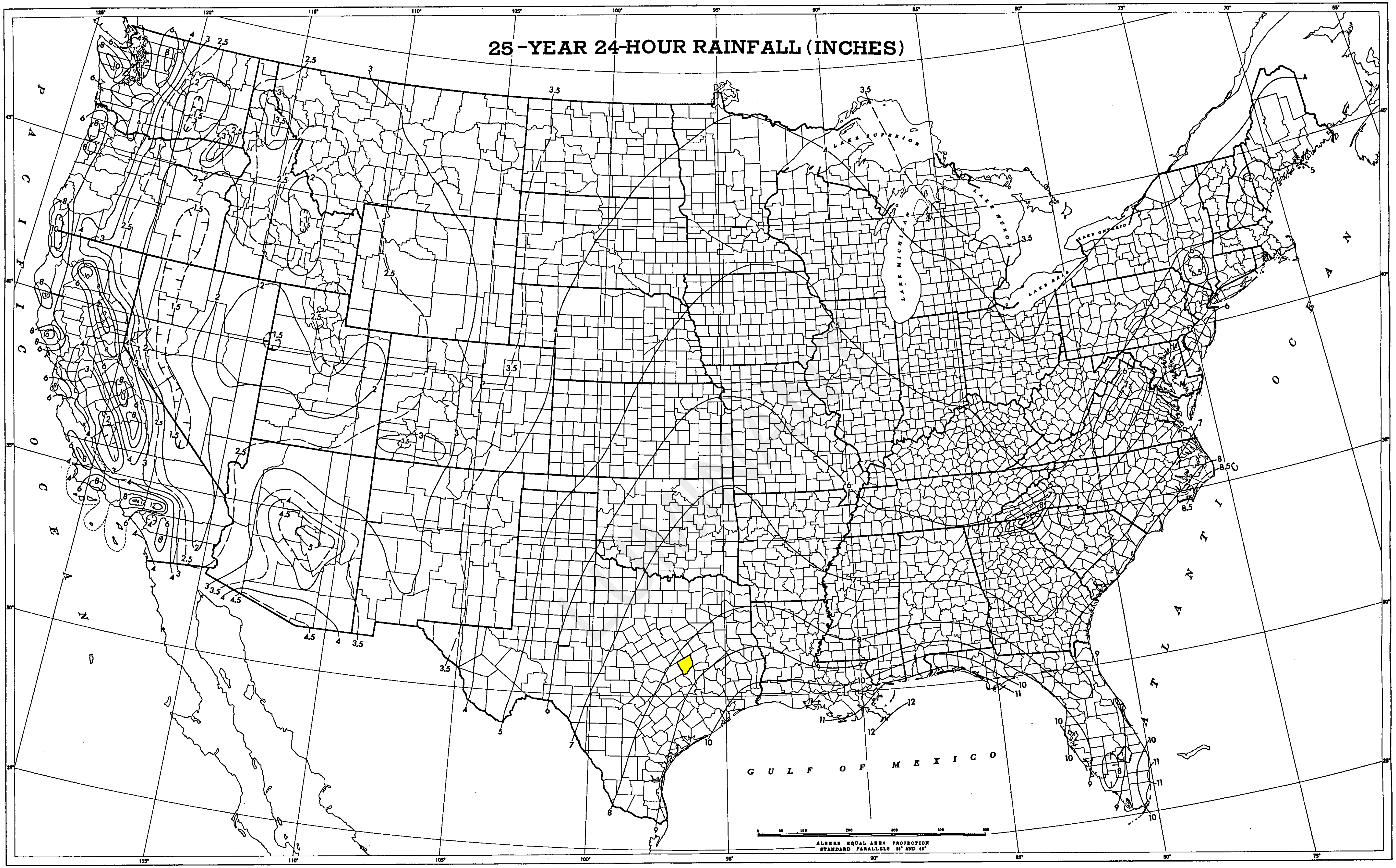
[e]In some warmer climates of the country a curve number of 95 may be used.

where CN_i corresponds to the appropriate CN for the part of the catchment having area A_i.

Once the proper CN is obtained, Eq. (3.21) and (3.22) can be used to estimate the accumulated rainfall excess as a function of total accumulated rainfall. Figure 3.21 has been prepared to simplify the solution of Eq. (3.21).

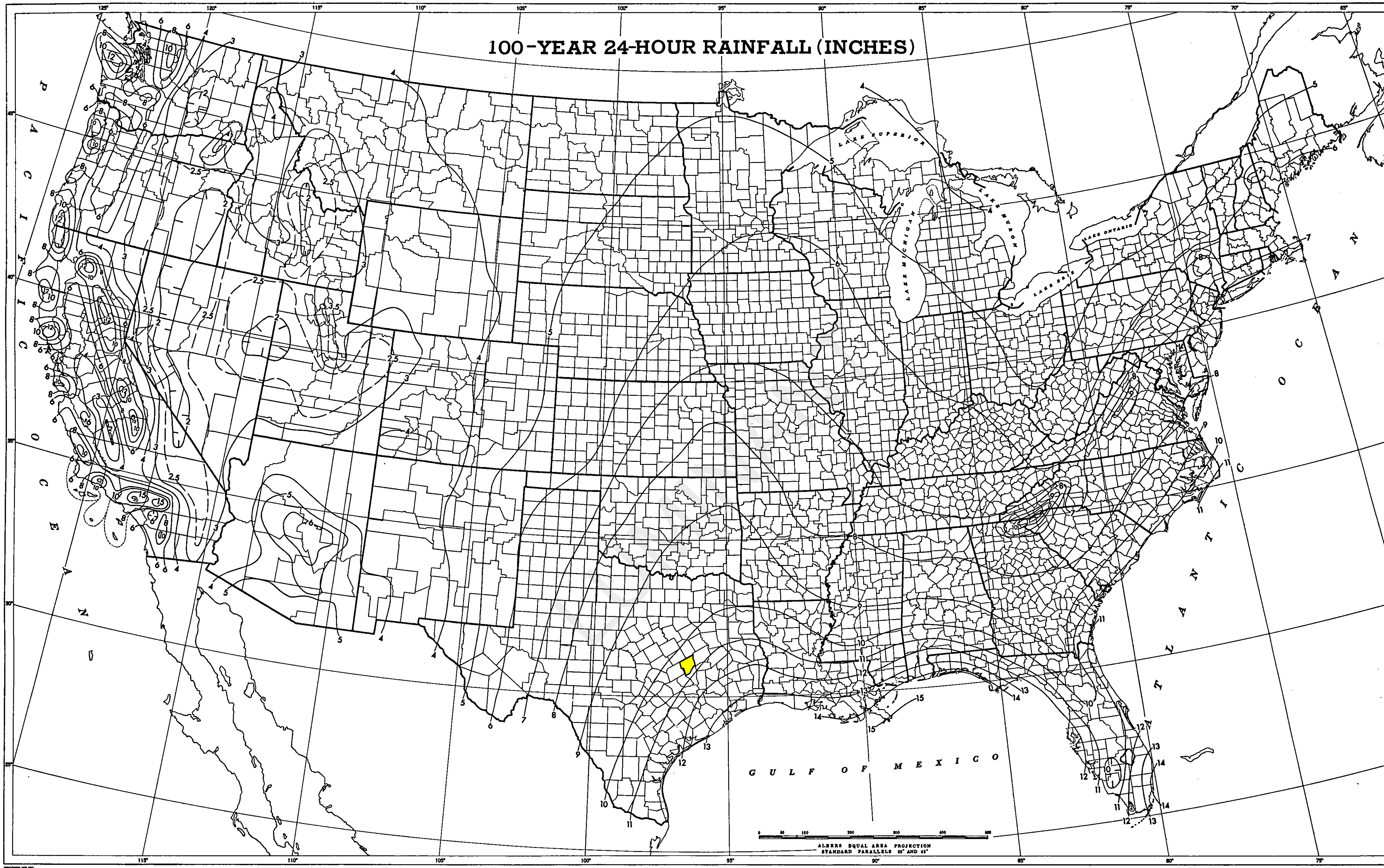
In some cases, a straightforward weighting of infiltration indices, whether they are CNs or Φ indices or some other index, may not be appropriate. Such would be the case when there is a large difference in the indices and the areas with a high runoff potential are directly connected to the drainage system. In such cases, runoff from the nearly impervious area may

APPENDIX 1-2


25-YEAR 24-HOUR RAINFALL (INCHES)
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°

APPENDIX 1-3

100-YEAR 24-HOUR RAINFALL (INCHES)



APPENDIX 1-4

TABLE 1
RUNOFF CALCULATIONS FOR THE 100-YR, 24-HR STORM EVENT

Date:	1/7/11
By:	ECB
Chkd:	MBR
Apprvd:	TTS

Depth of Water (ft) =	10	Composite CN =	94.3
Freeboard (ft) =	0		
Existing Water (ft) =	2	Storm Event (in) =	10.5
Total Depth of Water (ft) =	12		
Total Berm Height (ft) =	**12**		

Q (runoff, in) = $\frac{(P-0.2S)^2}{P+0.8S}$ = 9.8

S (in)= (1000/CN) - 10 = 0.60

	Area Contributing to Runoff (sq. ft.) [a]
Cell 2 Lower	2,818,000
Cell 2 Upper	1,947,000
Cell 3 Lower	3,071,000
Cell 3 Upper	2,200,000
Cell 4 Lower	2,513,000
Cell 4 Upper	1,642,000
Cell 5 Lower	2,139,000
Cell 5 Upper	[b]

	Total Runoff (cu. ft.)	**Total Runoff (gal)**
Cell 2 Lower	2,303,803	17,232,450
Cell 2 Upper	1,591,734	11,906,168
Cell 3 Lower	2,510,639	18,779,579
Cell 3 Upper	1,798,569	13,453,297
Cell 4 Lower	2,054,456	15,367,334
Cell 4 Upper	1,342,387	10,041,051
Cell 5 Lower	1,748,700	13,080,273
Cell 5 Upper	[b]	[b]

	Contact Water Pool Length (ft)
Cell 2 Lower	1,900
Cell 2 Upper	1,900
Cell 3 Lower	1,900
Cell 3 Upper	1,900
Cell 4 Lower	1,600
Cell 4 Upper	1,600
Cell 5 Lower	1,600
Cell 5 Upper	[b]

	Bottom Width of Pool (ft) [c]
Cell 2 Lower	79
Cell 2 Upper	42
Cell 3 Lower	90
Cell 3 Upper	53
Cell 4 Lower	86
Cell 4 Upper	42
Cell 5 Lower	67
Cell 5 Upper	[b]

Maximum bottom width of pool (ft) = 90

Footnotes:

[a] See Table 3 in Appendix 1-4 for the areas contributing to runoff for each phased construction stage.

[b] Interim cover will be placed concurrently with ash placement to minimize the area contributing to runoff and the contact water management area.

[c] Based on 3:1 side slopes, total depth of water, existing water in pool, and pool length.

TABLE 2
RUNOFF CALCULATIONS FOR THE 25-YR, 24-HR STORM EVENT

Date:	1/7/11
By:	ECB
Chkd:	MBR
Apprvd:	TJS

Depth of Water (ft) =	8	Composite CN =	94.3
Freeboard (ft) =	2		
Existing Water (ft) =	2	Storm Event (in) =	8.3
Total Depth of Water (ft) =	10		
Total Berm Height (ft) =	**12**		

Q (runoff, in) = $\frac{(P-0.2S)^2}{P+0.8S}$ = 7.6

S (in)= (1000/CN) - 10 = 0.60

	Area Contributing to Runoff (sq. ft.) [a]
Cell 2 Lower	2,818,000
Cell 2 Upper	1,947,000
Cell 3 Lower	3,071,000
Cell 3 Upper	2,200,000
Cell 4 Lower	2,513,000
Cell 4 Upper	1,642,000
Cell 5 Lower	2,139,000
Cell 5 Upper	b

	Total Runoff (cu. ft.)	Total Runoff (gal)
Cell 2 Lower	1,789,113	13,382,564
Cell 2 Upper	1,236,126	9,246,222
Cell 3 Lower	1,949,739	14,584,051
Cell 3 Upper	1,396,752	10,447,708
Cell 4 Lower	1,595,472	11,934,132
Cell 4 Upper	1,042,485	7,797,789
Cell 5 Lower	1,358,024	10,158,022
Cell 5 Upper	b	b

	Contact Water Pool Length (ft)
Cell 2 Lower	1,900
Cell 2 Upper	1,900
Cell 3 Lower	1,900
Cell 3 Upper	1,900
Cell 4 Lower	1,600
Cell 4 Upper	1,600
Cell 5 Lower	1,600
Cell 5 Upper	b

	Bottom Width of Pool (ft) [c]
Cell 2 Lower	82
Cell 2 Upper	45
Cell 3 Lower	92
Cell 3 Upper	56
Cell 4 Lower	89
Cell 4 Upper	45
Cell 5 Lower	70
Cell 5 Upper	b

Maximum bottom width of pool (ft) = 92

Footnotes:

[a] See Table 3 in Appendix 1-4 for the areas contributing to runoff for each phased construction stage.

[b] Interim cover will be placed concurrently with ash placement to minimize the area contributing to runoff and the contact water management area.

[c] Based on 3:1 side slopes, total depth of water, existing water in pool, and pool length.

TABLE 3
CONTRIBUTING RUNOFF AREAS

Date:	1/7/11
By:	CCS
Chkd:	JEO
Apprvd:	TJS

Stage	Additional Landfill Area	Cumulative Landfill Area	Area Covered	Cumulative Area Covered	Area Contributing to Runoff (at end of Stage)	
	ft^2	ft^2	ft^2	ft^2	ft^2	acre
Cell 1	1,806,000	1,806,000	-	-	1,806,000	41
Cell 2 Lower	1,012,000	2,818,000	-	-	2,818,000	65
Cell 2 Upper (+cover 20 acres)	-	2,818,000	871,000	871,000	1,947,000	45
Cell 3 Lower	1,124,000	3,942,000	-	871,000	3,071,000	71
Cell 3 Upper (+cover 20 acres)	-	3,942,000	871,000	1,742,000	2,200,000	51
Cell 4 Lower (+cover 20 acres)	1,184,000	5,126,000	871,000	2,613,000	2,513,000	58
Cell 4 Upper (+cover 20 acres)	-	5,126,000	871,000	3,484,000	1,642,000	38
Cell 5 Lower (+cover 20 acres)	1,368,000	6,494,000	871,000	4,355,000	2,139,000	49
Cell 5 Upper (+cover 20 acres)	-	6,494,000	871,000	5,226,000	1,268,000	29
Final Cover	-	6,494,000	1,268,000	6,494,000	-	-

APPENDIX 1-5

TABLE 1
SUBBASIN SUMMARY TABLE

Client: Luminant
Project Description: Oak Grove Surface Water
Project Number: 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJS

Design Storm — **100 -Year Reccurence Interval**

Storm Duration (hours)	2-Year Depth (inches)	100 -Year Depth (inches)	Storm Distribution
24	4.4	10.5	III

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	30% CN = 70 Wooded (acres)	70% CN = 74 Pasture (acres)	Composite SCS Curve No.	$S = \frac{1000}{CN} - 10$	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
Cell 2 Runon	1,652,000	37.92	0.0593	11.38	26.55	CN = 73	3.70	7.08	22.37	974,413

TABLE 2
BASIN TIME OF CONCENTRATION CALCULATIONS

Client: Luminant
Project Description: Oak Grove Surface Water
Project Number: 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	

3.6 is minimum total lag time

					Flow Segment 1							Flow Segment 2							Flow Segment 3						
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Total Lag (0.6*Tc) (min)	Total Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
Cell 2 Runon	0.059	73	17.1	28.5	Sheet	300	0.032	E	Short Grass		16.7	Shallow	1100.0	0.011	U	Unpaved		10.6	Channel	513	0.008	E	Earth-lined	1.53	1.2

TABLE 3
FLOW RESULTS FROM HEC-HMS

Client: Luminant
Project Description: Oak Grove Surface Water
Project Number: 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJJ

HEC-HMS Basin Model:	Runon
HEC-HMS Met. Model:	100yr 24hr
HEC-HMS Control Specs:	36hr 6min

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
Cell 2 Runon	0.059	174.1	01Jan2020, 13:18	22.3

Table 4
Channel Hydraulic Calculations

Client: Luminant
Project Description: Oak Grove Surface Water
PROJECT NO. 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJJ

			Channel Design Geometry						Channel Roughness Parameters			Hydraulic Calculations							Channel Evaluations
Reach Designation	Q100 from HEC-HMS (cfs)	HEC HMS Element ID for Q	Approximate Channel Length (ft)	Bed Slope (ft/ft)	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Minimum Channel Depth (ft)	Design Channel Lining	Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)	Maximum Velocity (ft/sec)	Maximum Normal Flow Depth (ft)	Froude Number	Normal Depth Shear Stress (lb/ft^2)	Stream Power (W/m^2)	Top Width of Flow (ft)	Top Width of Channel (ft)	Available Freeboard (ft)
Cell 2 Runon	174.1	Cell 2 Runon	513	0.008	3.0	3.0	5	4.0	E Earth-lined	0.025	0.025	6.6	2.25	0.97	1.12	107.3	18.5	29.0	2

APPENDIX 1-6

TABLE 1
SUBBASIN SUMMARY TABLE

Client: Luminant
Project Description: Oak Grove Surface Water
Project Number: 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJJ

Design Storm		25 -Year Reccurence Interval	
Storm Duration (hours)	**2-Year Depth (inches)**	**25 -Year Depth (inches)**	**Storm Distribution**
24	4.4	8.3	III

				30%	70%					
				CN = 70	CN = 74					
Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	Wooded (acres)	Pasture (acres)	Composite SCS Curve No.	$S = \frac{1000}{CN} - 10$	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
Cell 2 Runon	1,652,000	37.92	0.059	11.4	26.5	CN = 73	3.70	5.08	16.04	698,888

TABLE 2
BASIN TIME OF CONCENTRATION CALCULATIONS

Client: Luminant
Project Description: Oak Grove Surface Water
Project Number: 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJ

3.6 is minimum total lag time

					Flow Segment 1							Flow Segment 2							Flow Segment 3						
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Total Lag (0.6*Tc) (min)	Total Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
Cell 2 Runon	0.059	73	17.3	28.8	Sheet	300	0.032	E	Short Grass		16.7	Shallow	1100.0	0.011	U	Unpaved		10.8	Channel	513	0.008	E	Earth-lined	1.34	1.3

TABLE 3
FLOW RESULTS FROM HEC-HMS

Client: **Luminant**
Project Description: **Oak Grove Surface Water**
Project Number: **103-94574**

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJS

HEC-HMS Basin Model:	Runon
HEC-HMS Met. Model:	25yr 24hr
HEC-HMS Control Specs:	36hr 6min

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
Cell 2 Runon	0.059	124.5	01Jan2020, 13:18	16.0

Table 4
Channel Hydraulic Calculations

Client: Luminant
Project Description: Oak Grove Surface Water
PROJECT NO. 103-94574

Date:	1/5/11
By:	ECB
Chkd:	MBR
Apprvd:	TJS

			Channel Design Geometry						Channel Roughness Parameters			Hydraulic Calculations							Channel Evaluations
Reach Designation	Q25 from HEC-HMS (cfs)	HEC HMS Element ID for Q	Approximate Channel Length (ft)	Bed Slope (ft/ft)	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Minimum Channel Depth (ft)	Design Channel Lining	Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)	Maximum Velocity (ft/sec)	Maximum Normal Flow Depth (ft)	Froude Number	Normal Depth Shear Stress (lb/ft^2)	Stream Power (W/m^2)	Top Width of Flow (ft)	Top Width of Channel (ft)	Available Freeboard (ft)
Cell 2 Runon	124.5	Cell 2 Runon	513	0.008	3.0	3.0	5	4.0	E Earth-lined	0.025	0.025	6.0	1.92	0.95	0.96	83.8	16.5	29.0	2

ATTACHMENT B

ACTIVE FACE BERM SIZING

ACTIVE FACE BERM SIZING

Made By: MX
Checked by: MGC
Reviewed by: JBF

1.0 OBJECTIVE

Calculate the required size of the stormwater containment berm at the landfill active face as a function of plane area of the active area.

Golder Associates Inc.
Firm Registration Number F-2578

2.0 GIVEN

- Waste slope of 4H:IV
- 25-year, 24-hour storm event of 8.3 inches (see reference in Attachment A);
- Berm slope of 2H:1V;
- 1.0 ft. freeboard on berm

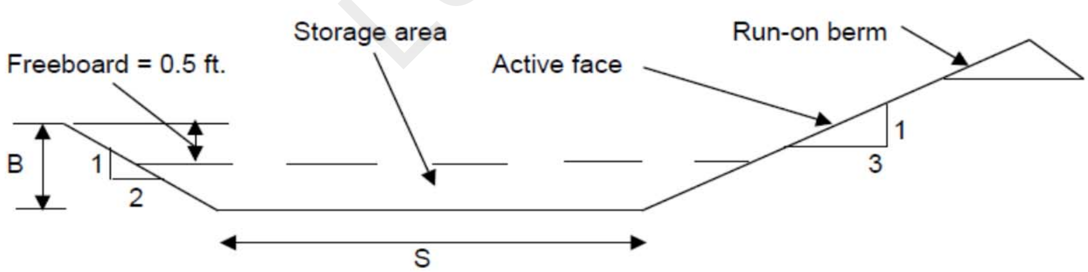
3.0 ASSUMPTIONS

- Stormwater run-on to the active face will not be allowed
- 100 percent run-off from the active face, i.e., conservatively assume no infiltration

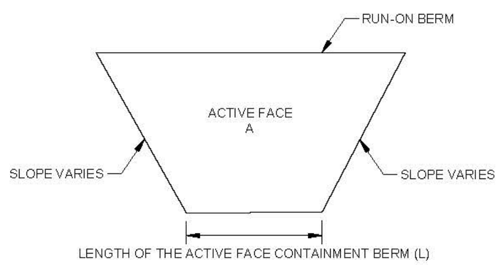
4.0 CALCULATION

Derive relationships for the amount of runoff from the 8.3 inch design storm and the available storage volume as a function of the active face area.

Cross-section of the Active Face and Containment Berm



Elevation View of the Active Face and Containment Berm



4.1 Runoff, R

$$R = 8.3 \text{ inches} \times A = 0.69 \times A \text{ cubic feet}$$

Where:

R = total runoff into the active area containment berm (cf)

A = total area of the active face (sf)

4.2 Storage, V

$$V = L \times \left(\frac{S + [S + (B - 0.5) \times (2) + (B - 0.5) \times (3)]}{2} \right) \times (B - 0.5)$$

$$V = L \times (2.5B^2 + (S - 2.5)B - 0.5S + 0.625)$$

Where:

V = storage capacity an active face containment berm (cf)

L = length of the active face containment berm (ft)

S = setback distance (ft)

B = berm height (ft)

4.3 Height of Berm, B

Now set runoff, R, equal to storage, V, and solve for the height of berm, B.

$$B = \frac{2.5 - S \pm \sqrt{S^2 + 6.9 \times A / L}}{5}$$

For typical site operations, the maximum berm height will be 6 ft. The operator can vary the berm length and setback distance to limit the berm height to 6 ft.

Now plot B versus L for various values of S and A. Figures 1 through 4 present the plots for active working areas of 10,000, 20,000, 30,000, and 40,000 sf, respectively.

4.4 Procedure To Select Berm Size

Procedure to select berm size using Figures 1 trough 4:

1) Determine the active face area (A);

2) Select a figure from Figures 1-4 that has an active area closest to, but no less than the actual A. For example, if A=25,000, choose Figure 3 (A=30,000);

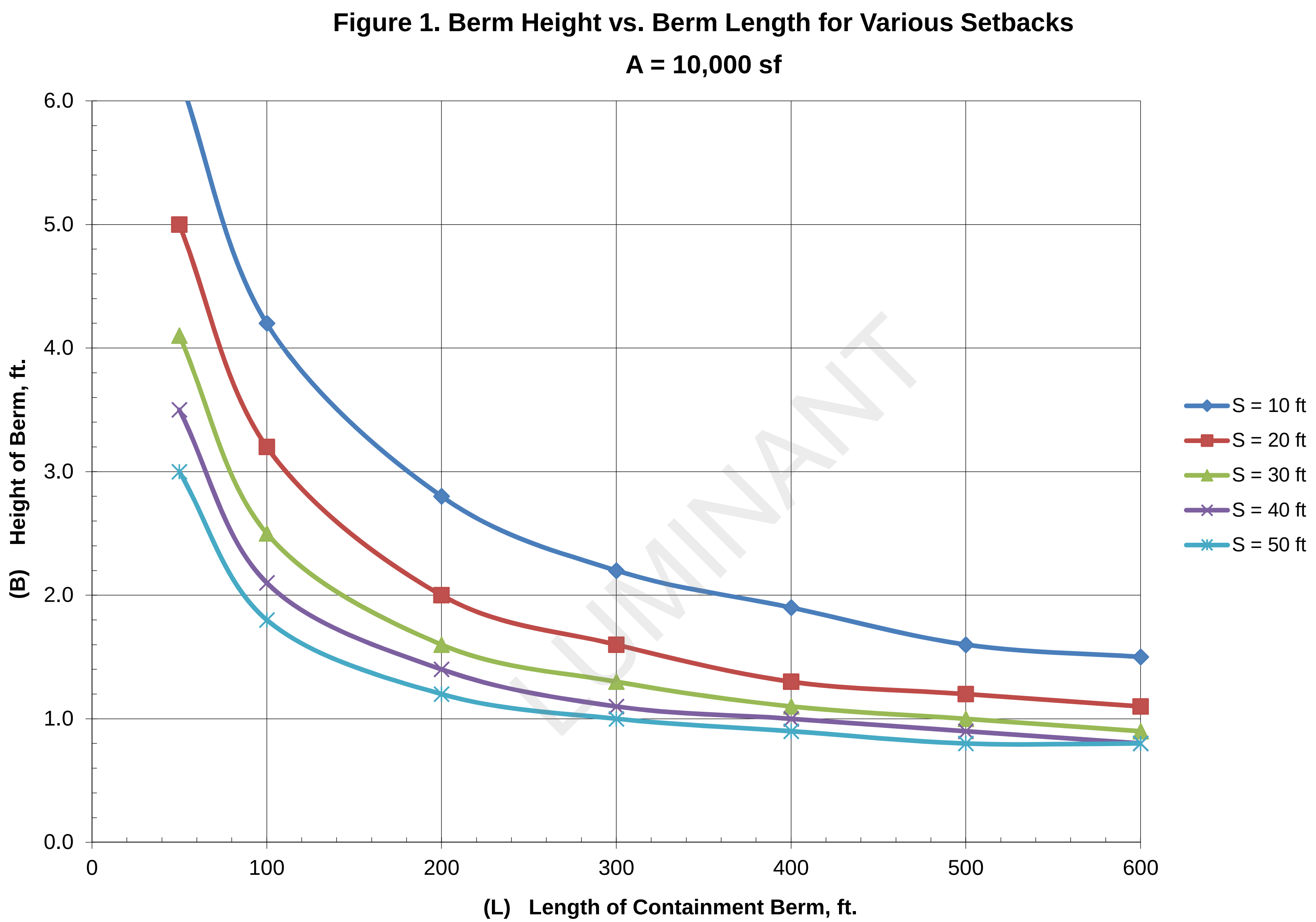
3) Determine the minimum setback distance (S) for the daily operation, and select the corresponding curve. If the setback distance falls between the numbers shown on the figure, the closest but smaller value of S will be used. For example, if S=25 ft, choose the curve representing 20 ft; and

4) Measure the length of the active face containment berm, and determine the required berm height from the selected curve. Figures 1 through 4 cover a wide range of berm length (i.e. toe width of the active face) for normal waste fill operations. If the actual berm length is longer than the maximum value on the curve, the maximum berm length can be used to determine a conservative berm height. If the actual berm length is shorter than the minimum value on the curve, the operator can use equation (1) above to determine berm height.

Example using attached figures: A = 10,000 sf, s = 20 ft, L = 200 ft => B = 2 ft (from Figure 1, curve S = 20 ft).

5.0 CONCLUSION

Figures 1 through 4 and the procedure discussed above provide guidance for determining the size of the stormwater containment berm based on the size of the active face (runoff area), the length of the containment berm, and the setback distance from the active face. The equations presented in this calculation may be used to determine the required berm height for various active face areas, berm lengths, and setback distances.



P:_2016 Project Folders\1648164 Luminant - 2016 CCR Support\OakGrove\AshLandfillRunOnRunOff\Attachment B_Active Face Berm Sizing_Rev0.xlsx
Submitted: September 2016

Figure 2. Berm Height vs. Berm Length for Various Setbacks

A = 20,000 sf

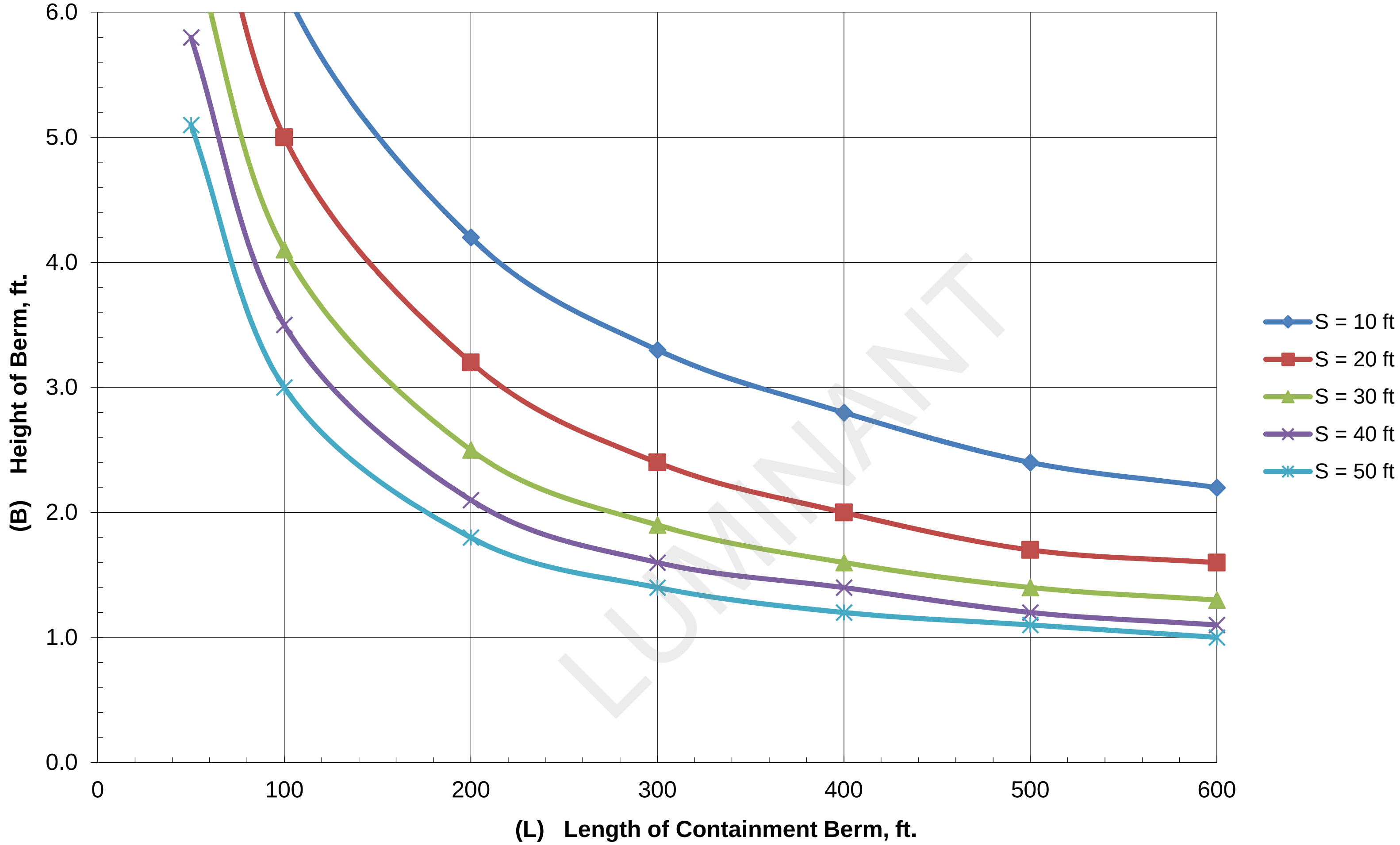
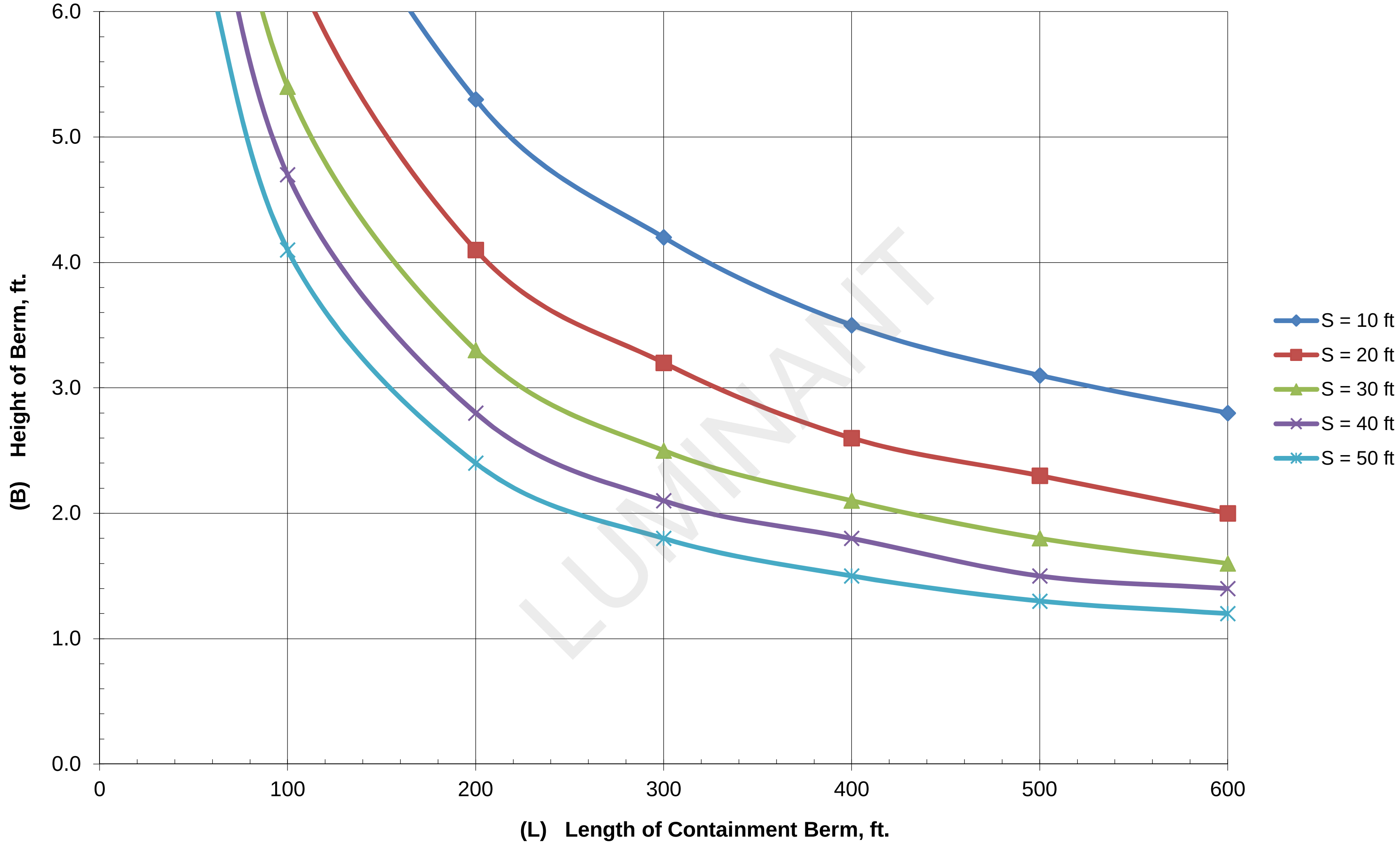


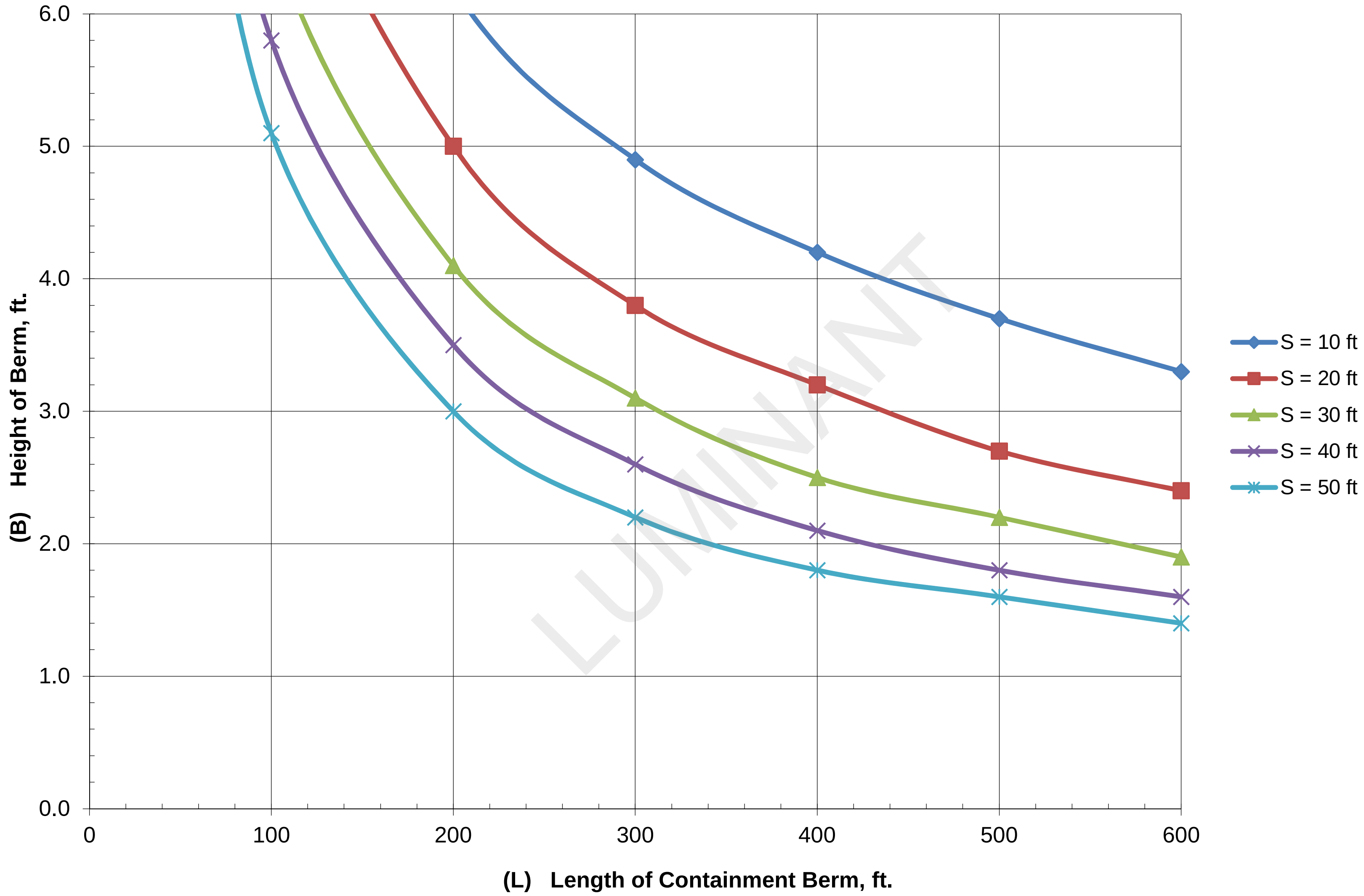
Figure 3. Berm Height vs. Berm Length for Various Setbacks

A = 30,000 sf



P:_2016 Project Folders\1648164 Luminant - 2016 CCR Support\OakGrove\AshLandfillRunOnRunOff\Attachment B_Active Face Berm Sizing_Rev0.xlsx
Submitted: September 2016

Figure 4. Berm Height vs. Berm Length for Various Setbacks
A = 40,000 sf



P:_2016 Project Folders\1648164 Luminant - 2016 CCR Support\OakGrove\AshLandfillRunOnRunOff\Attachment B_Active Face Berm Sizing_Rev0.xlsx
Submitted: September 2016

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