PERMIT MODIFICATION REQUEST
(VOLUME II OF II)
Reconfiguration of Block O

City of Nacogdoches Landfill
Nacogdoches, Texas
TCEQ Permit No. MSW-720

Prepared for:
City of Nacogdoches
4602 NW Stallings Drive
Nacogdoches, Texas 75964

Prepared by:

SCS ENGINEERS

File No. 16209006.26 | January 2024

Texas Board of Professional Engineers Registration No. F-3407
12651 Briar Forest Drive, Suite 205
Houston, TX 77077
(281) 293-8494

Attachment No. 6

Redline/Strikeout Pages

TABLE OF CONTENTS

REPLACMENT PAGES

TABLE OF CONTENTS

VOLUME 1

UPDATED

FOR PERMITTING
PURPOSES ONLY

JEFFREY K. REED
80103

6/24/11

UPDATED

FOR PERMITTING PURPOSES ONLY

STATE OF TEXAS
JEFFREY K. REED
80103
REGISTERED PROFESSIONAL ENGINEER

6/24/11

FOR PERMITTING PURPOSES ONLY

STATE OF TEXAS
JEFFREY K. REED
80103
PROFESSIONAL REGISTERED ENGINEER

UPDATED

6/24/11

FOR PERMITTING PURPOSES ONLY

UPDATED

JEFFREY K. REED
80103

6/24/11

SDP NARRATIVE

REPLACMENT PAGES

f. Site Operating Life: The operating life of a landfill is dependent on many variables, several of which can be controlled through proper planning and management techniques. Some of these controllable variables include the amount of daily cover used; trench depths; the proper use of compaction equipment; maximizing available trench space; and possibly the institution of a recycling program to reduce the waste stream. The main uncontrollable variable is the population utilizing the facility. For the purposes of this Plan, the estimated life of the landfill will be computed based on the usable area shown in Section III.11.a and the following parameters:

1. 2’ clay liner or Geosynthetic Clay Liner
2. Flexible membrane liner
3. 12” drainage layer or Geocomposite Drainage layer
4. Filter fabric
5. 12” protective soil cover or 24” protective soil cover (with geocomposite)
6. 6” daily cover
7. 18” clay cover
8. Flexible membrane liner
9. 6” topsoil
10. Compaction rate of 1050 lbs/CY
11. Solid waste generation rate of 322 CY/day

The total available area for landfilling is 320 acres. However, when buffer zones, easements, floodplain, previously closed trenches and unsuitable area are deleted 79.14 acres remain for landfilling.

Site life calculations have been performed considering Blocks O and P contain remaining useable capacity by the City. The site life calculated is an estimate of the number of useful years.

Available volumes are computed for each trench by measuring areas from the cross sections as shown in Section III11.b., and utilizing the method of average end areas. The results of these computations along with site life calculations are presented below;

BLOCK	VOLUME (CY)
O	~~3,546,892~~3.544.797
P	1,772,164

Total Volume Available = **~~5,319,056~~5,316,961 CY (Blocks P and O)**
Assume Daily Compacted Fill: 240 TPD/(1050lb)/CY x 1 ton/2000 lb) = 457 CY

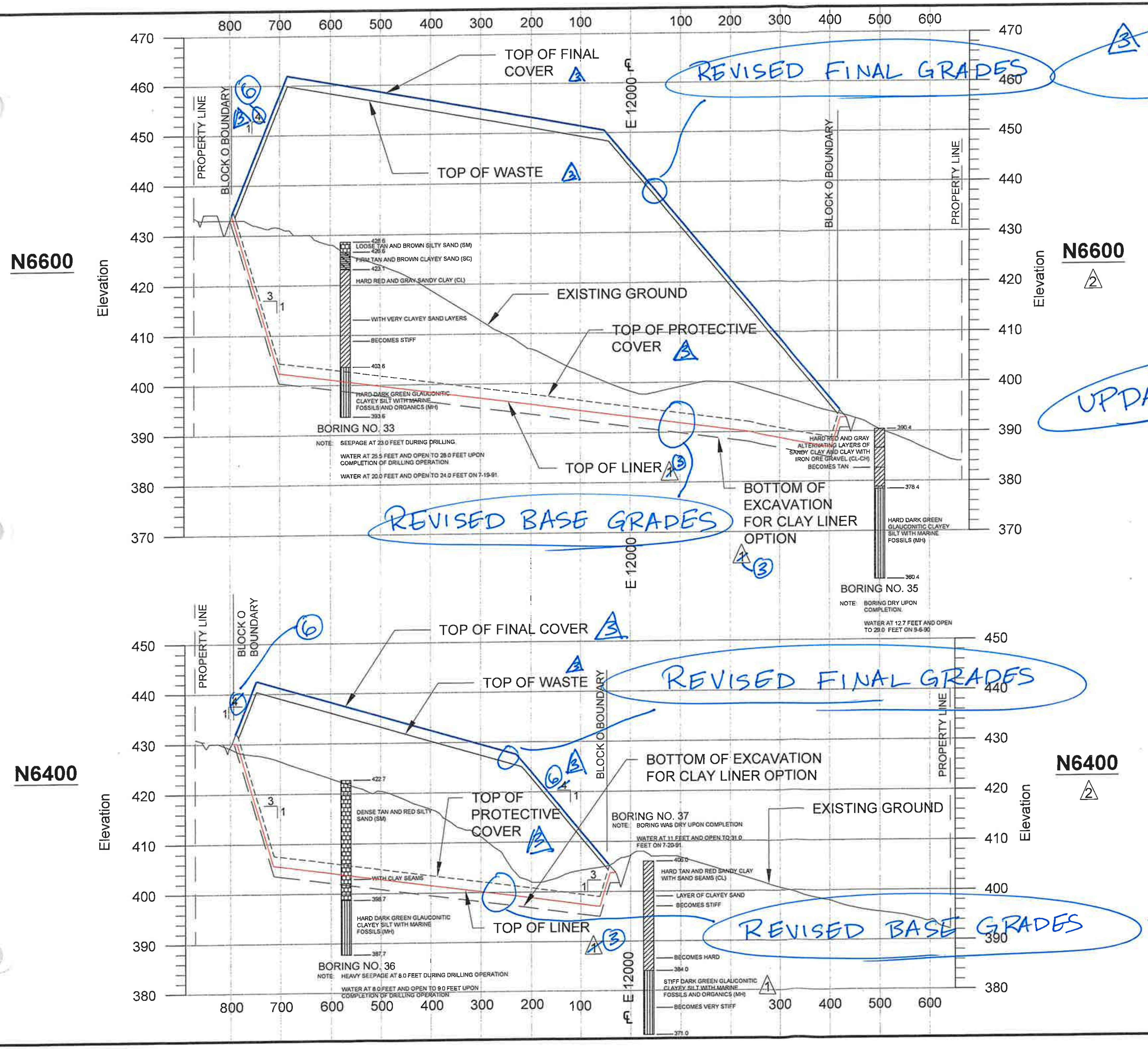
Volume Daily Cover Required: 457 CY x 20% = 91 CY

Site Life = Total Volume Available /Daily Volume
= **~~5,319,056~~5,316,961 CY/457 CY**
= **~~11,639~~11,634 days**

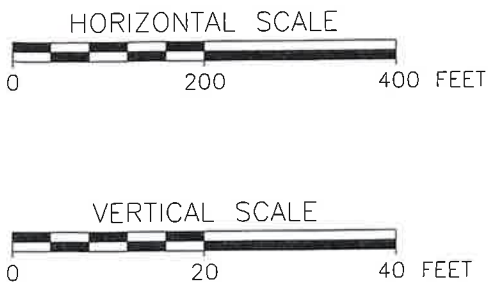
Total Years = ~~11639~~11.634 days/312 working days per year
= 37 years 4 months

PART III, ATTACHMENT 2

REPLACEMENT PAGES



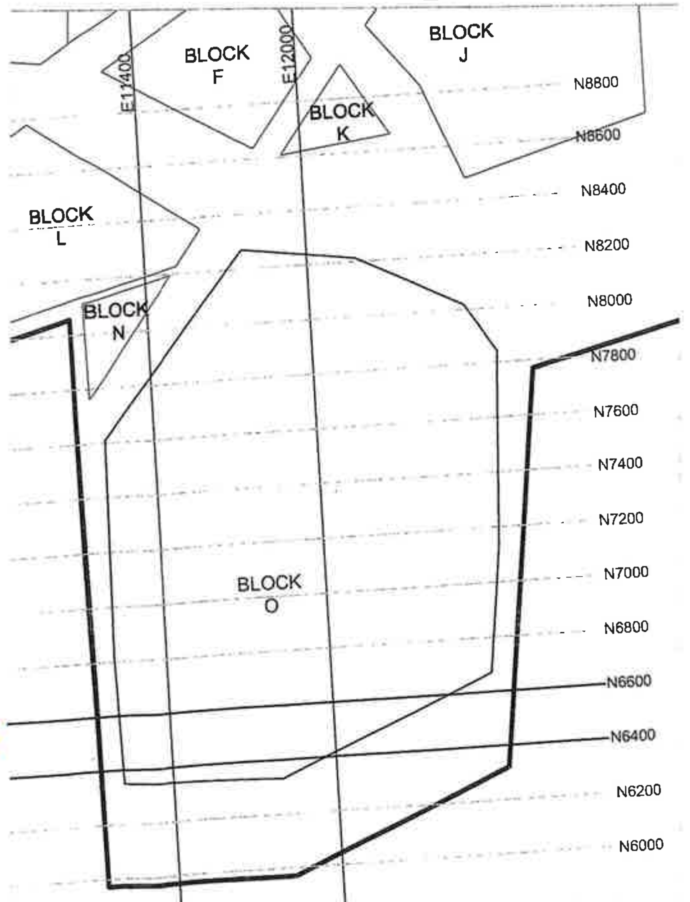
3 REVISED BASE AND FINAL COVER GRADES 12/2023 SCS



UPDATED

JEFFREY L. REED
80103
9/30/19

KEY MAP 2



FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
△			
△			
△			
△			
2	8/2019	Revised Sections & Key Map	JKR
1	8/2013	REVISED LINER SYSTEM	JKR

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.b ATTACHMENT 2
FILL CROSS SECTION

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

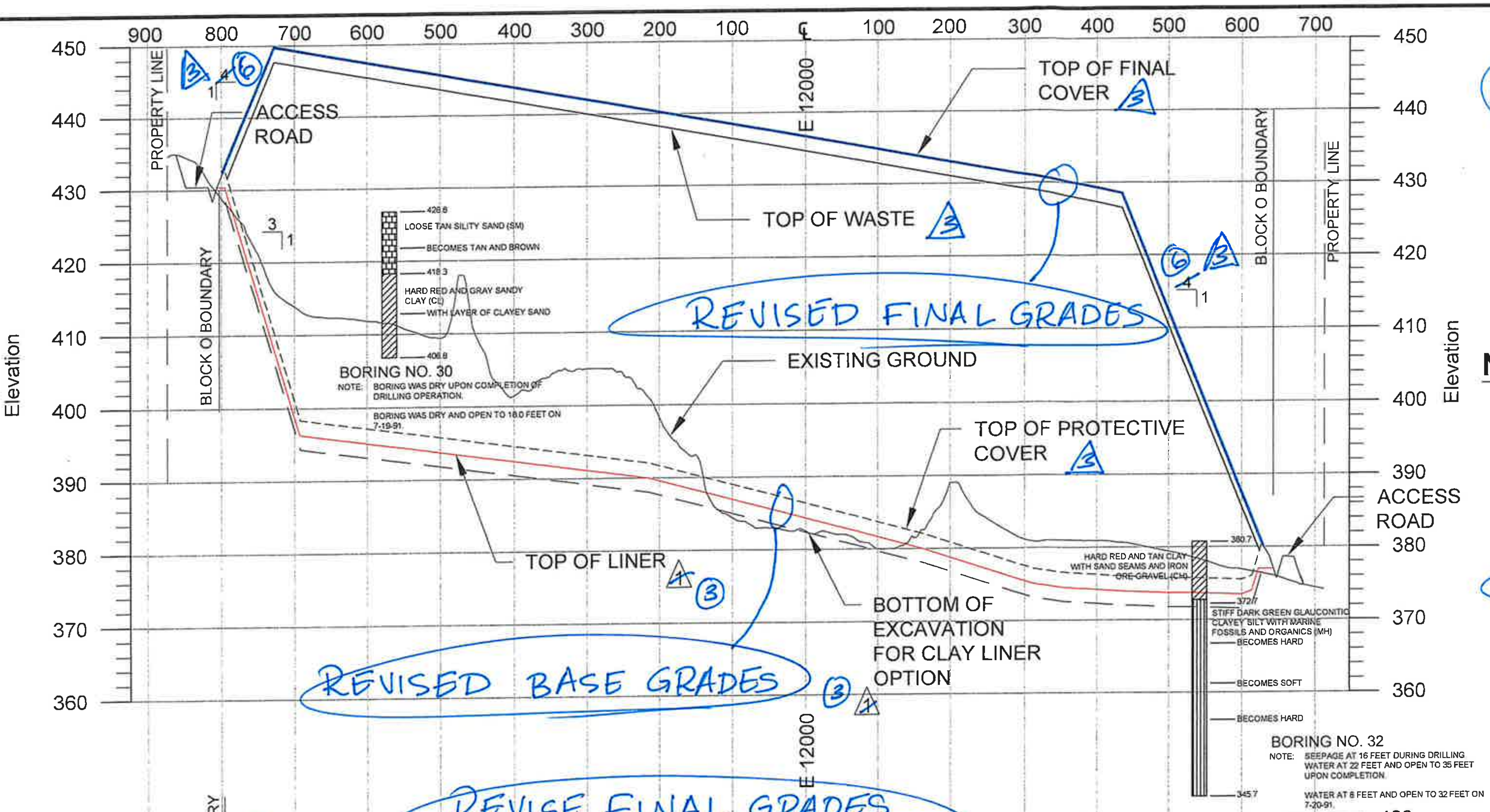
CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16200906.02
DSN. BY: RLD
DWN. BY: RLD
CHK. BY: JKR
Q/A RVW BY: JRM
APP. BY: JKR

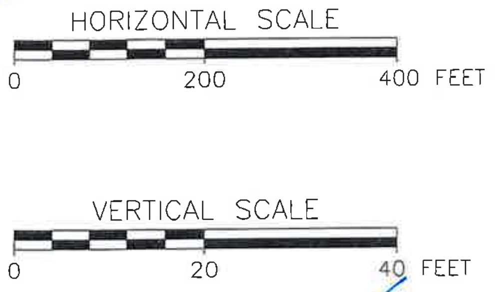
CADD FILE: CROSS SECTIONS2
DATE: 5–2011
SCALE: AS SHOWN
DRAWING NO. 2E

N7000
Elevation



Elevation
N7000
2

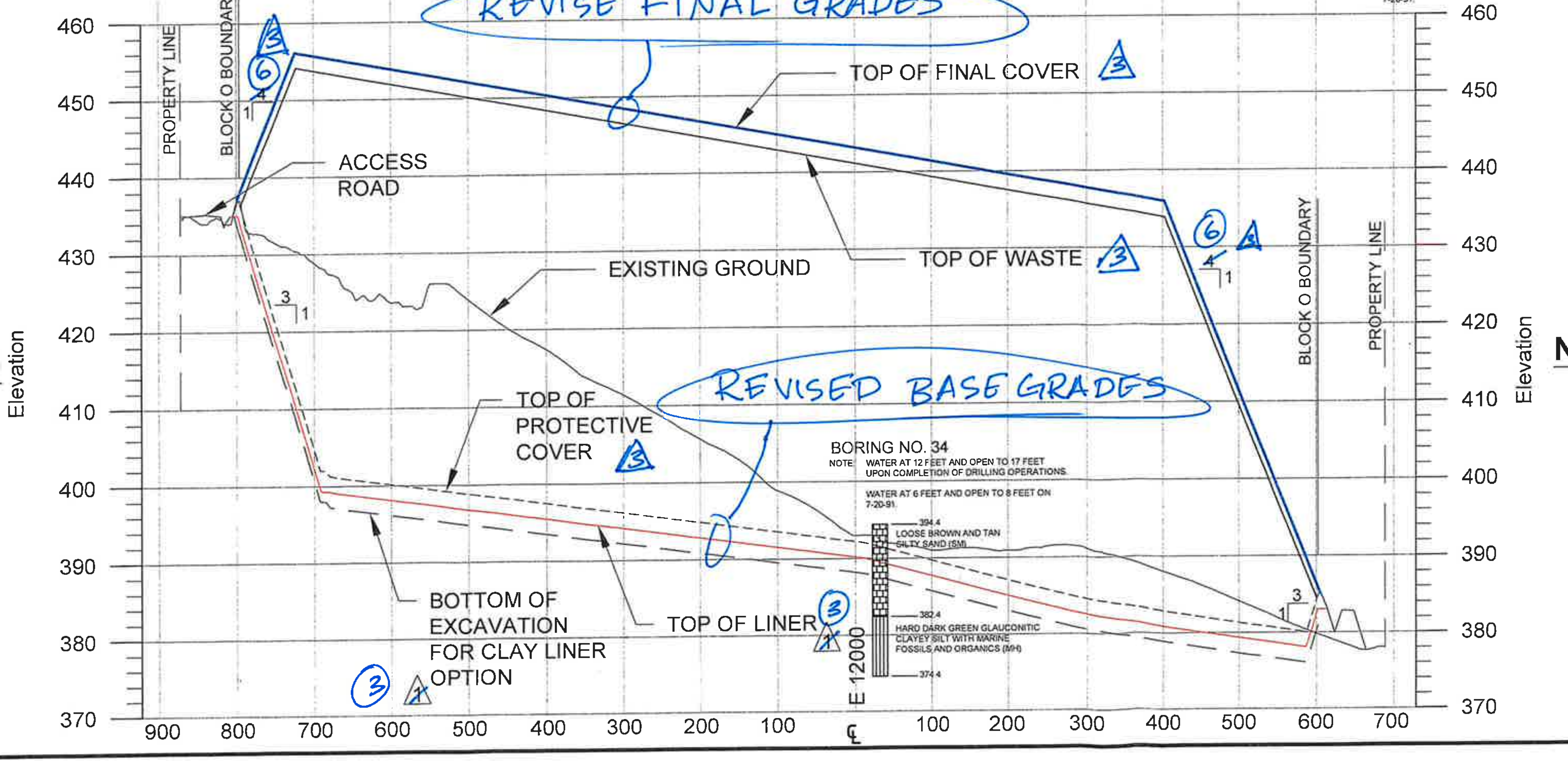
3 REVISED BASE AND FINAL COVER GRADES
12/2023 SCS



UPDATED

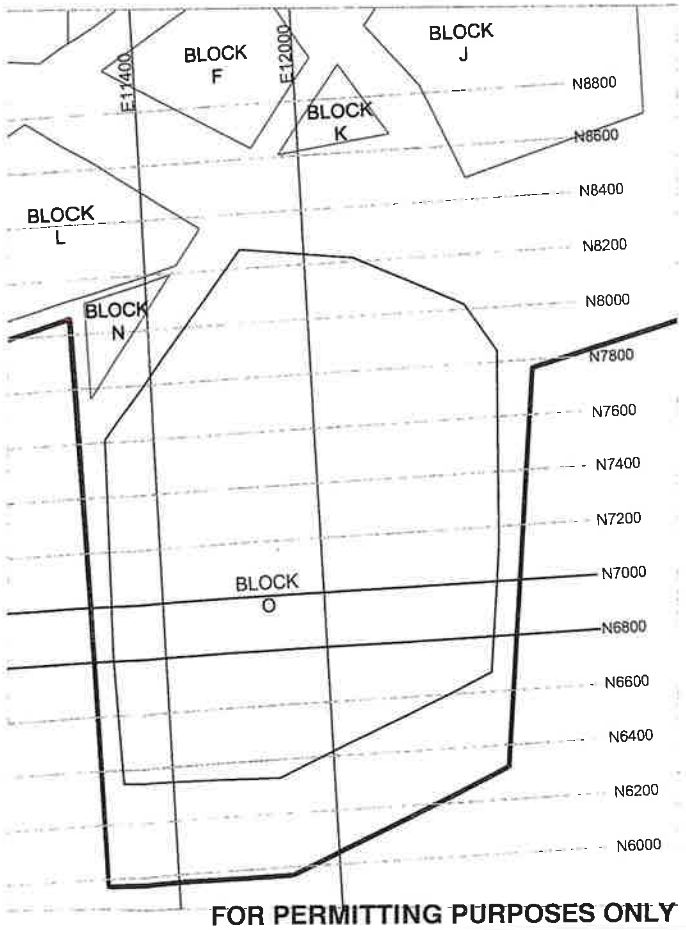
JEFFREY K. REED
80103
9/30/19

N6800
Elevation



Elevation
N6800
2

KEY MAP 2



FOR PERMITTING PURPOSES ONLY

7/3/2019 2:05 PM Z:\RJR\Dgns\dgn\Nacogdo\16209006.02 Reconfiguration Mod\Cross Sections2

REV	DATE	DESCRIPTION	BY
2	8/2019	Revised Sections & Key Map	JKR
1	8/2013	REVISED LINER SYSTEM	JKR

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.b ATTACHMENT 2
FILL CROSS SECTION

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16200906.02	DWN. BY: RLD	Q/A RVW BY: JRM
DSN. BY: RLD	CHK. BY: JKR	APP. BY: JKR

CADD FILE: CROSS SECTIONS2

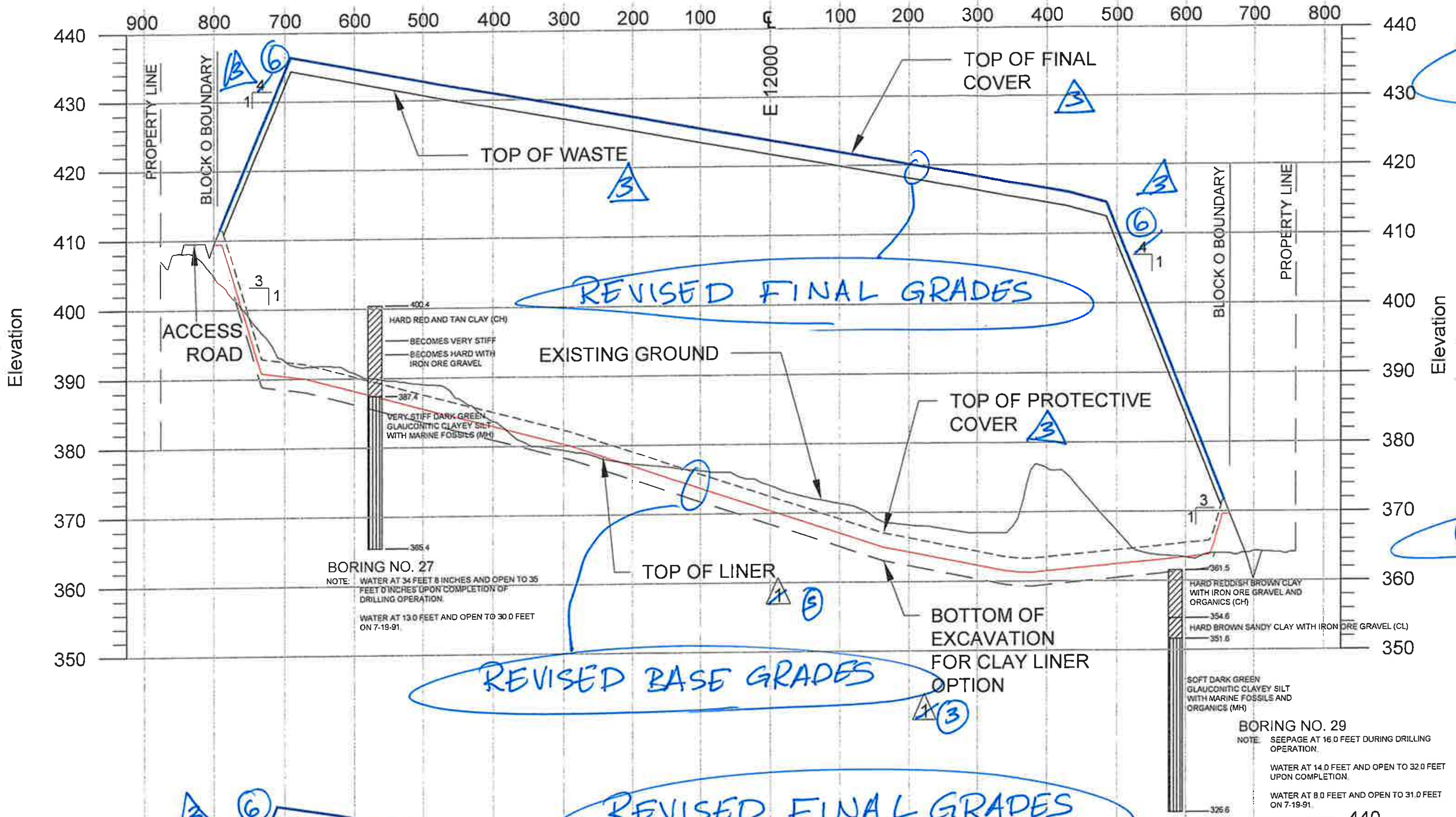
DATE: 5–2011

SCALE: AS SHOWN

DRAWING NO.
2F

△3 12/2023 REVISED BASE AND FINAL GRADES SCS

N7400 △2



BORING NO. 27

NOTE: WATER AT 34 FEET 8 INCHES AND OPEN TO 35 FEET 0 INCHES UPON COMPLETION OF DRILLING OPERATION.

WATER AT 13.0 FEET AND OPEN TO 30.0 FEET ON 7-19-91.

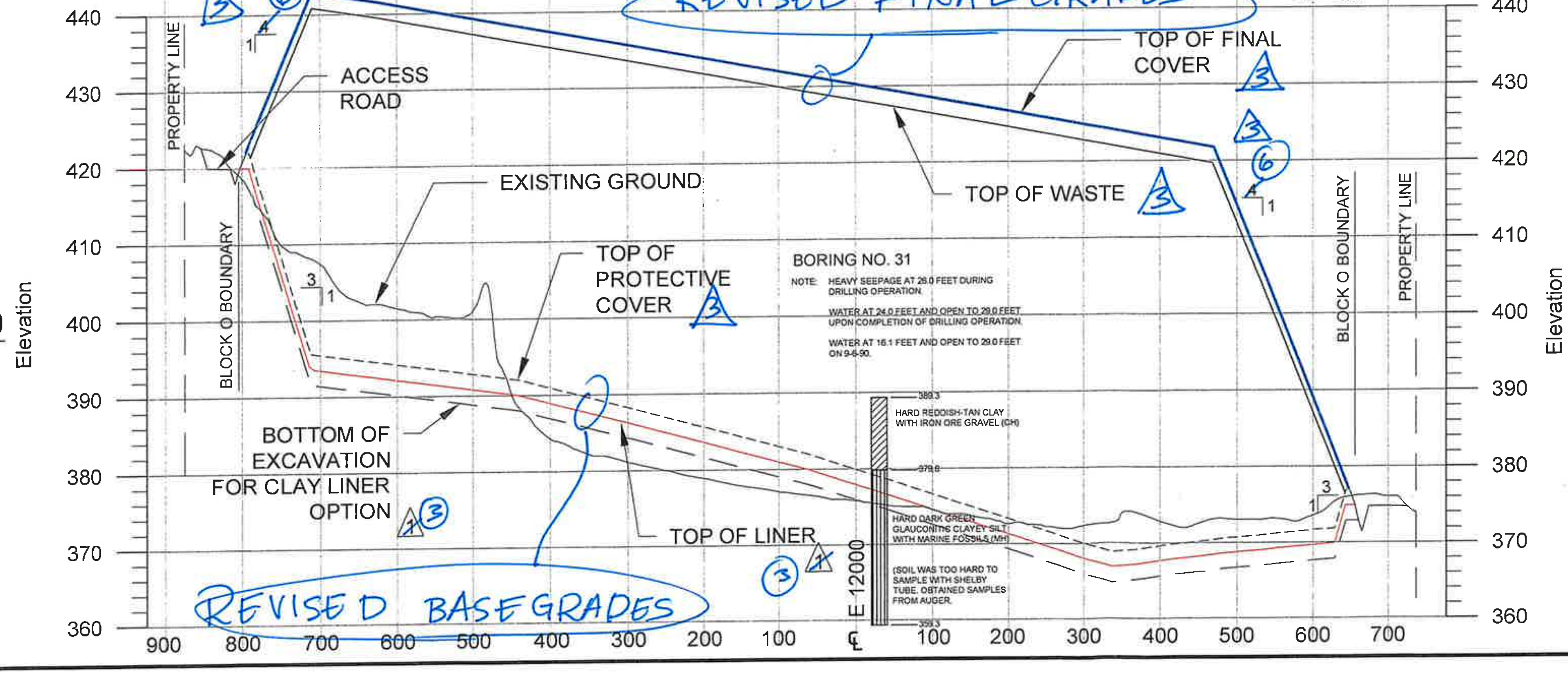
BORING NO. 29

NOTE: SEEPAGE AT 16.0 FEET DURING DRILLING OPERATION.

WATER AT 14.0 FEET AND OPEN TO 32.0 FEET UPON COMPLETION.

WATER AT 8.0 FEET AND OPEN TO 31.0 FEET ON 7-19-91.

N7200 △2

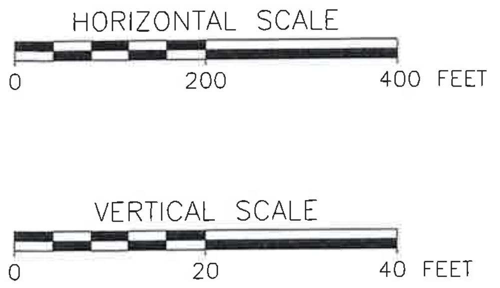


BORING NO. 31

NOTE: HEAVY SEEPAGE AT 26.0 FEET DURING DRILLING OPERATION.

WATER AT 24.0 FEET AND OPEN TO 29.0 FEET UPON COMPLETION OF DRILLING OPERATION.

WATER AT 16.1 FEET AND OPEN TO 29.0 FEET ON 9-6-90.



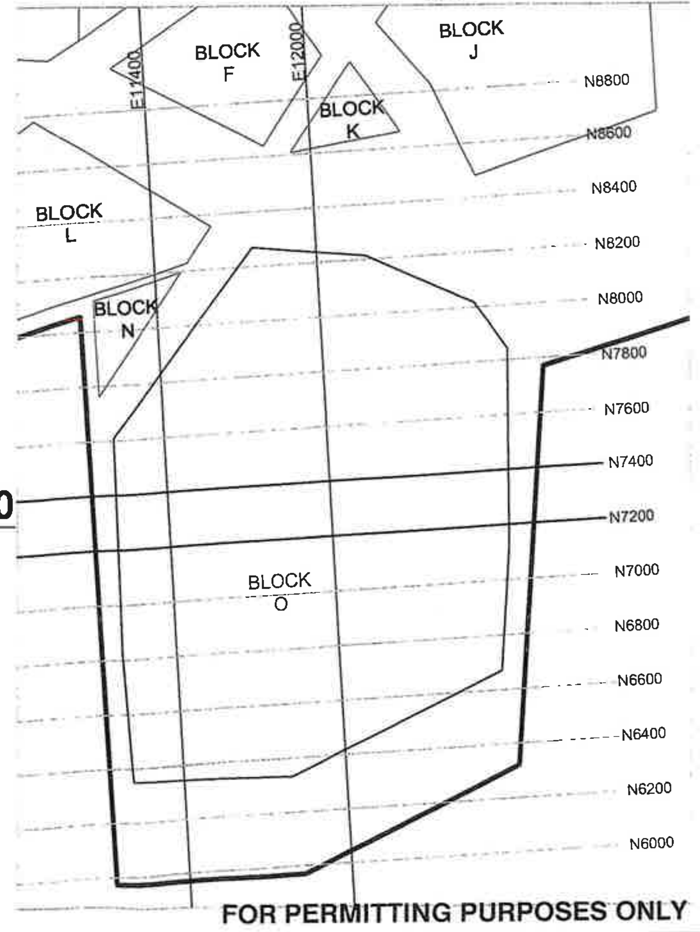
9/30/19

JEFFREY K. REED

80103

UPDATED

KEY MAP △2



FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
△			
△			
△			
△			
△2	8/2019	Revised Sections & Key Map	JKR
△1	8/2013	REVISED LINER SYSTEM	JKR

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.b ATTACHMENT 2
FILL CROSS SECTION

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

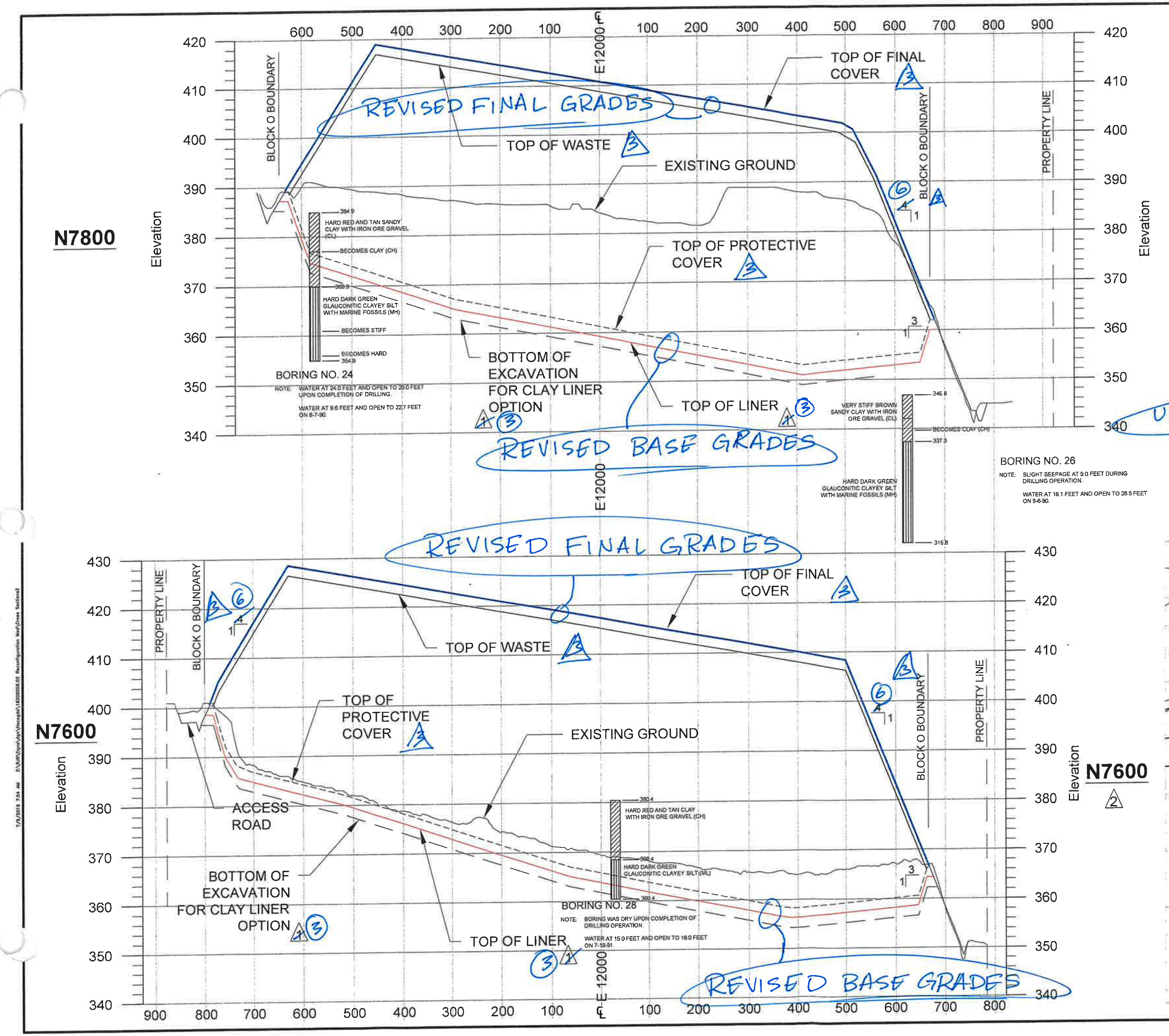
PROJ. NO. 16200906.02
DWN. BY: RLD
Q/A RVW BY: JRM
DSN. BY: RLD
CHK. BY: JKR
APP. BY: JKR

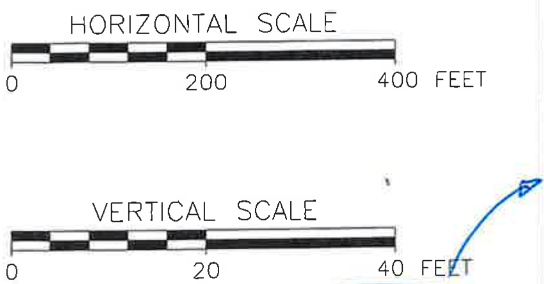
CADD FILE: CROSS SECTIONS2

DATE: 5–2011

SCALE: AS SHOWN

DRAWING NO. 2G

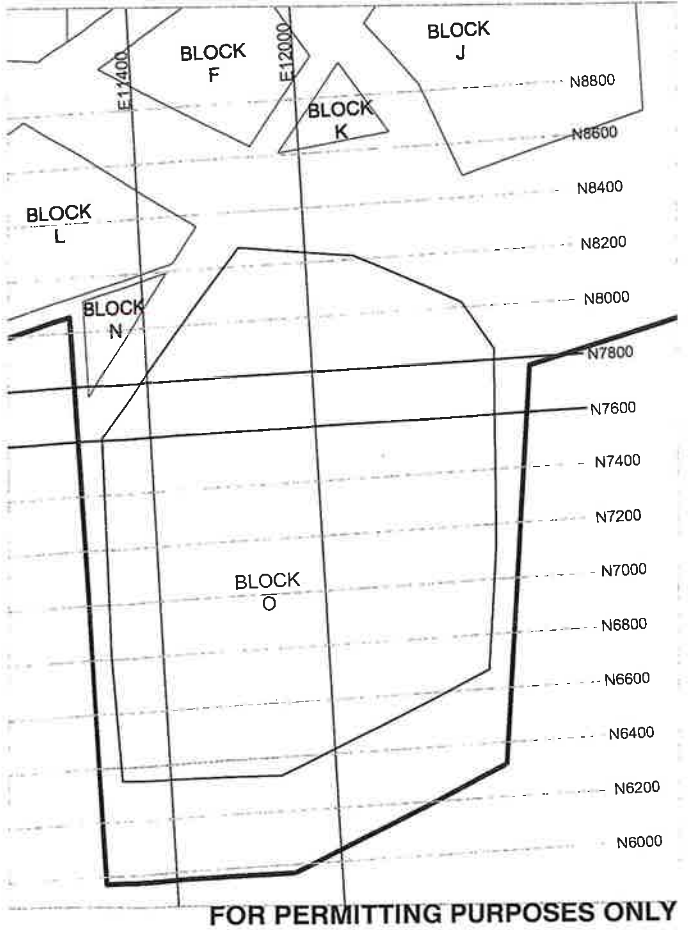




△3 12/2023 REVISE BASE AND FINAL GRADES SCS

JEFFREY K. REED
80103
9/30/19

KEY MAP △2



FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
△			
△			
△			
△			
△2	8/2019	Revised Sections & Key Map	JKR
△1	8/2013	REVISED LINER SYSTEM	JKR

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.b ATTACHMENT 2
FILL CROSS SECTION

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

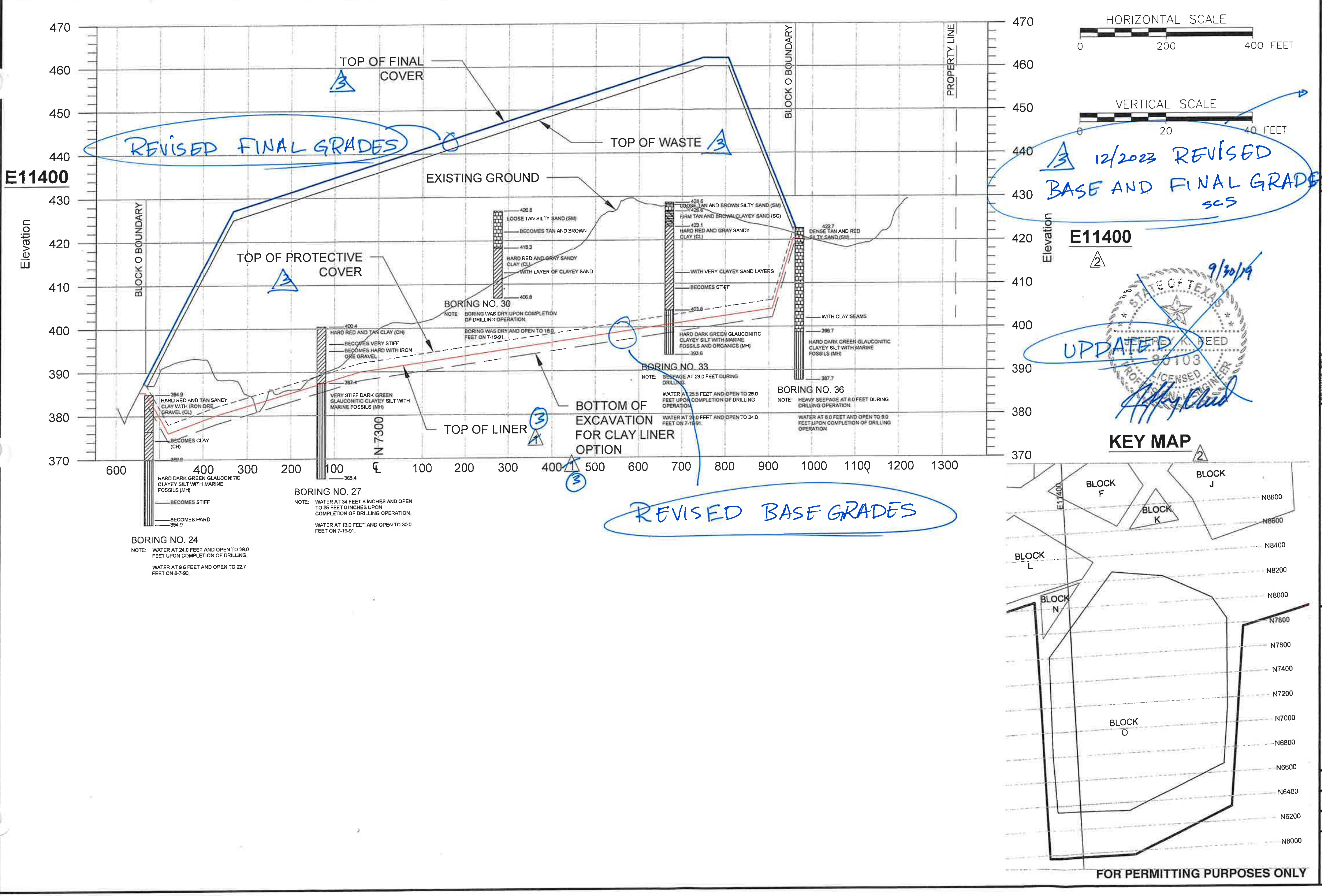
PROJ. NO. 16200906.02	DWN. BY: RLD	Q/A RVW BY: JRM
DSN. BY: RLD	CHK. BY: JKR	APP. BY: JKR

CADD FILE: CROSS SECTIONS2

DATE: 5–2011

SCALE: AS SHOWN

DRAWING NO.
2H



REVISED FINAL GRADES

3 12/2023 REVISED BASE AND FINAL GRADES
SCS

REVISED BASE GRADES

UPDATED

JEFFREY K. REED
80103
9/30/19

FOR PERMITTING PURPOSES ONLY

7/3/2018 2:54 PM Z:\RJR\Dgns\dgn\Nacogdo\16209006.02 Reconfiguration Mod\Cross Sections2

REV.	DATE	DESCRIPTION	BY
△			
△			
△			
△			
△			
△			

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.b ATTACHMENT 2
FILL CROSS SECTION

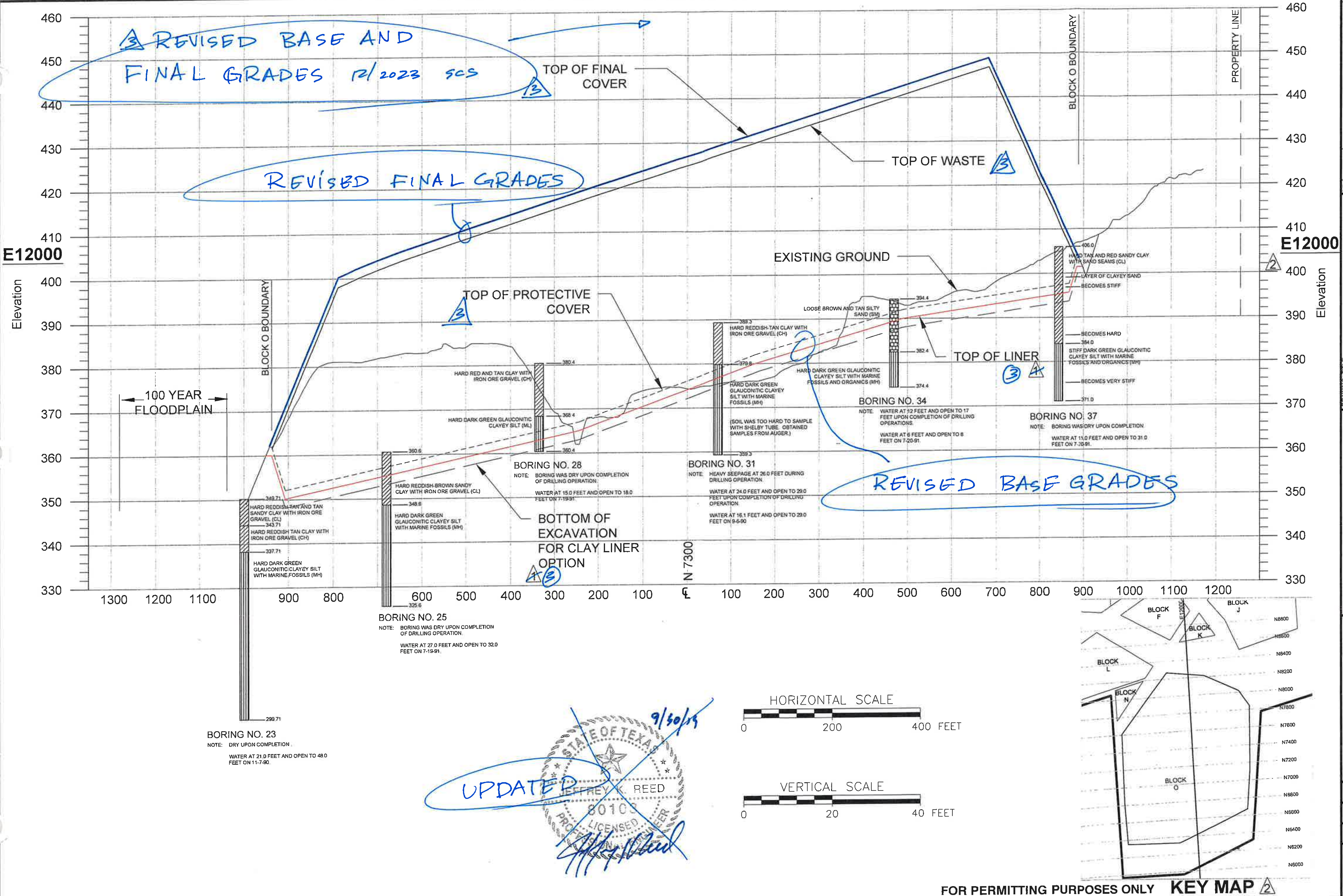
PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7876

PROJ. NO. 16200906.02
DSN. BY: RLD
DWN. BY: RLD
CHK. BY: JKR
Q/A RVW BY: JRM
APP. BY: JKR

CADD FILE: CROSS SECTIONS2
DATE: 5–2011
SCALE: AS SHOWN
DRAWING NO.
2X-1



3 REVISED BASE AND FINAL GRADES 12/2023 SCS

REVISED FINAL GRADES

REVISED BASE GRADES

UPDATED

BORING NO. 23
NOTE: DRY UPON COMPLETION
WATER AT 21.0 FEET AND OPEN TO 48.0 FEET ON 11-7-90.

BORING NO. 25
NOTE: BORING WAS DRY UPON COMPLETION OF DRILLING OPERATION.
WATER AT 27.0 FEET AND OPEN TO 32.0 FEET ON 7-19-91.

BORING NO. 28
NOTE: BORING WAS DRY UPON COMPLETION OF DRILLING OPERATION.
WATER AT 15.0 FEET AND OPEN TO 18.0 FEET ON 7-19-91.

BORING NO. 31
NOTE: HEAVY SEEPAGE AT 26.0 FEET DURING DRILLING OPERATION.
WATER AT 24.0 FEET AND OPEN TO 29.0 FEET UPON COMPLETION OF DRILLING OPERATION.
WATER AT 16.1 FEET AND OPEN TO 29.0 FEET ON 9-6-90.

BORING NO. 34
NOTE: WATER AT 12 FEET AND OPEN TO 17 FEET UPON COMPLETION OF DRILLING OPERATIONS.
WATER AT 6 FEET AND OPEN TO 8 FEET ON 7-20-91.

BORING NO. 37
NOTE: BORING WAS DRY UPON COMPLETION.
WATER AT 11.0 FEET AND OPEN TO 31.0 FEET ON 7-20-91.

JEFFREY K. REED
80103
9/30/19

FOR PERMITTING PURPOSES ONLY

KEY MAP 2

REV	DATE	DESCRIPTION	BY
△			
△			
△			
△			
2	8/2019	Revised Sections & Key Map	JKR
1	8/2013	REVISED LINER SYSTEM	JKR

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.b ATTACHMENT 2
FILL CROSS SECTION

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY, TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16200906.02
DSN. BY: RLD
DWN. BY: RLD
CHK. BY: JKR
Q/A RVW BY: JRM
APP. BY: JKR

CADD FILE: CROSS SECTIONS2
DATE: 5–2011
SCALE: AS SHOWN
DRAWING NO. 2Y

9/4/2019 8:31 AM Z:\RJR\Dgns\dgn\Nacogdo\16200906.02 Reconfiguration Mod\Cross Sections2

PART III, ATTACHMENT 6

REPLACEMENT PAGES

III.11.f. GROUNDWATER AND SURFACE WATER PROTECTION PLAN AND DRAINAGE PLAN

1. Two drawings showing the drainage areas along with drainage calculations are attached. In addition, for Blocks P and O, peak flows for the 2019 and 2023 revised final grades, respectively were compared and were less than the 2011 final grades. See calculations in Part III, Attachment 6, Appendix B.

2. There will not be any levees constructed at this site. Refer to Section III.11.b. for detailed cross sections throughout this site. As shown on drawing number 6A and in Section 111.11.g. the proposed layout of the blocks will have little effect on the natural drainage patterns. This site drains to a creek which traverses the site from west to east. This creek is fed by several tributary creeks. This natural pattern will not be altered.

3. The 100 year floodplain is shown on drawings 6A and 6B. A full floodplain is shown on drawings 6A and 6B. A full floodplain report can be found in Appendix IV.

4. A. Drainage and Run-off Control Analysis:

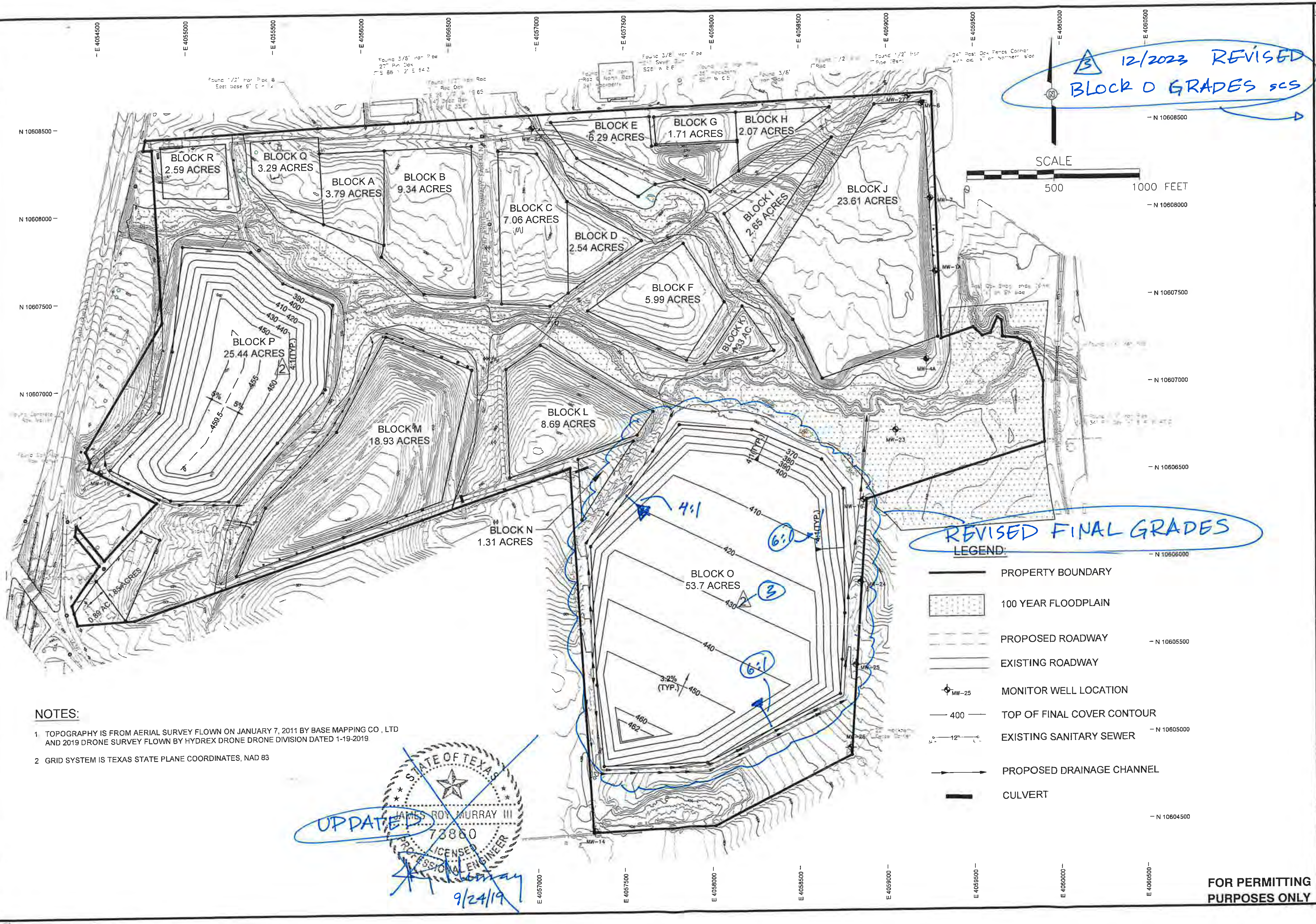
   1. The hydrologic method that will be used to estimate peak flow rates and run-off volumes will be the rational method for areas under 200 acres and the TxDOT Bridge Division Hydraulic Manual regression equations for areas over 200 acres.

      As previously discussed in this Site Development Plan the actual design calculations for control of run-off and drainage will be submitted as each individual trench is developed. At this time the calculations for drainage and run-off control for Blocks L and M can be seen in Section V. The runoff drainage for Block P will continue to sheet flow off the hill directly into the natural drainage tributaries. Drainage from Block O will drain to perimeter ditches that will drain to the north and flow to the existing drainage tributary. See Block O drainage calculations in Part III, Attachment 6, Appendix C.

      Attached is a copy of the figure depicting the 25-year 24-hour rainfall in inches for the State of Texas. This figure was taken from the Weather Bureau TP No. 40. For Nacogdoches County the rainfall in inches for this storm is 8.75. A copy of the NOAA Atlas 14, Volume 11, Version 2, Point Precipitation Frequency Estimates for the site location has been included. The 25-year 24-hour rainfall for the site is 8.44 inches. Therefore, the 8.75 inches is a conservative assumption. It is a requirement that the owner or operator shall design, construct and maintain a run-off management system from the active portion of the landfill to collect and control at least the water resulting from a 24-hour 25-year storm.

      At this landfill there is a 12 inch sanitary sewer line which traverses the site from the west to east. The City maintains two portable pumps which they use to pump contaminated water directly into the sewer and on to the treatment plant. The City proposes at this time to continue to practice this procedure. On drawing number 6B, the flowlines of the manholes located throughout the site are shown.

      The capacity of the two portable pumps, 275 GPM and 400 GPM will dictate the amount of actual storage volume that will be required to handle the contaminated water. Individual calculations and procedures will be submitted for each block in conjunction with construction



12/2023 REVISED BLOCK O GRADES SCS

REVISED FINAL GRADES

LEGEND:

▬	PROPERTY BOUNDARY
▨	100 YEAR FLOODPLAIN
- - -	PROPOSED ROADWAY
═	EXISTING ROADWAY
⌖ MW-25	MONITOR WELL LOCATION
— 400 —	TOP OF FINAL COVER CONTOUR
—12"—	EXISTING SANITARY SEWER
→	PROPOSED DRAINAGE CHANNEL
▬	CULVERT

NOTES:

1. TOPOGRAPHY IS FROM AERIAL SURVEY FLOWN ON JANUARY 7, 2011 BY BASE MAPPING CO., LTD AND 2019 DRONE SURVEY FLOWN BY HYDREX DRONE DRONE DIVISION DATED 1-19-2019
2. GRID SYSTEM IS TEXAS STATE PLANE COORDINATES, NAD 83

JAMES ROY MURRAY III
73860

UPDATED

J R Murray
9/24/19

FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
1	6/2011	REVISED BLOCKS P&O GRADES	SCS
2	8/2019	REVISED BLOCKS P&O GRADES	SCS

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.f ATTACHMENT 6 - GROUNDWATER & SURFACE WATER PROTECTION & DRAINAGE PLAN

PROJECT TITLE
LANDFILL RECONFIGURATION PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY, TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16209006.21	DWN. BY: JG	Q/A RVW BY: RE
DSN. BY: JRM	CHK. BY: JKR	APP. BY: PJW

CADD FILE: DWG 6B - GROUNDWATER & SURFACE WATER PROTECTION & DRAINAGE PLAN

DATE: 8/2019

SCALE: AS SHOWN

DRAWING NO.
6B

6/4/2019 1:57 PM

PART III, ATTACHMENT 6, APPENDIX A
REPLACEMENT PAGES

PART III, ATTACHMENT 6, APPENDIX A

Top Dome Surface and External Embankment Erosion Control Plan

CITY OF NACOGDOCHES LANDFILL
TCEQ PERMIT MSW-720
NACOGDOCHES, TEXAS

TOP DOME SURFACE AND EXTERNAL EMBANKMENT EROSION CONTROL PLAN

PART III, ATTACHMENT 6, APPENDIX A

Prepared for:

CITY OF NACOGDOCHES
P.O. Box 635030
Nacogdoches, Texas 75963

Prepared by:

SCS ENGINEERS
Texas Board of Professional Engineers Registration No. F-3407
12651 Briar Forest Dr., Suite 205
Houston, Texas 77077

FEBRUARY 2011
Revis~~ed~~ion 1 – September 2019
Revision 2 – December 2023

TABLE OF CONTENTS

APPENDICIES

FIGURES

a) those above grade slopes that directly drain to the site perimeter stormwater management system (i.e., areas where the stormwater directly flows to a perimeter channel or detention pond designed in accordance with 30 TAC §§330.63(c), 330.303, and 330.305);

b) have received intermediate or final cover; and,

c) have either reached their permitted elevation, or will subsequently remain inactive for longer than 180 days.

For example, after an above grade slope has reached the permitted elevation, the intermediate cover will be provided and structural erosion control features (e.g., diversion dikes, letdown structures, and/or silt fence) will be in-place within 180 days of placement of intermediate cover. If an external slope has received intermediate cover, but is not at the final permitted grade and the area will not receive waste for a period greater than 180 days, erosion control features will be in-place within 180 days of placement of the intermediate cover.

1.0.1 EROSION ANALYSIS RESULTS

Existing vegetated intermediate covered slopes with a minimum of 60 percent vegetated coverage will not require additional structural erosion controls for top dome surfaces with ~~1,710~~1,670 feet or less drainage flow lengths, and 25% external embankment side slopes with 780 feet or less drainage flow lengths. All Blocks yet to receive final cover (Blocks O and P) have soil losses well below the TCEQ minimum of 50 tons per acre per year. Block O, with a flow length of ~~1,930~~1,890 feet and 60 percent vegetative coverage, has a soil loss of 21.20 tons per acre per year. Block P, with a flow length of 480 feet and 60 percent vegetative coverage, has a soil loss of 22.76 tons per acre per year. These calculations are included in Appendix III-6A-2. For additional discussion, see Section 1.1.1.1, Non-erosive Slopes.

Slopes which drain to ongoing waste placement areas, pre-excavated areas, areas that have received only daily cover or areas under construction which have not received waste are not considered external side slopes.

Site perimeter drainage features such as perimeter drainage channels and toe berms will be constructed adjacent to and downstream of areas to be excavated for waste fill. In some cases, the slopes drain directly into the existing creek. These drainage features will be constructed in accordance with the Part III, Attachment 6, Groundwater and Surface Water Protection Plan and Drainage Plan.

The top dome surfaces will be filled to non-erosive grades, not exceeding 5 percent. Top dome surfaces will be graded to sheet flow with non erosive velocities and acceptable soil losses and therefore will not require any water diversion. The top dome surface will establish a minimum 60 percent vegetative coverage or utilize mulch stabilization or erosion control matting to accomplish the 60 percent coverage within 180 days. Water handling devices; including diversion dikes, let-down structures, and silt fence, as described in Section 1.1.2, will be utilized at the base of the surface.

Top dome surfaces will have a maximum sheetflow length of ~~1,710~~1,670 feet (130 feet for 10% slopes and 1,540 feet for 3.~~7~~2% slopes) and 350 feet for 5% slopes. Top dome surfaces with 3.~~7~~2% slopes will have velocities of 1.~~82~~62 feet per second (fps) and a shear stress of 0.1~~6~~4 pounds per square foot (psf). Top dome surfaces with 5% slopes will have velocities of 1.14 feet per second (fps) and a shear stress of 0.08 pounds per square foot (psf). Top dome surfaces with 10% slopes will have velocities of 0.60 feet per second (fps) and a shear stress of 0.18 pounds per square foot (psf). According to the Texas Department of Transportation Hydraulic Design Manual, Revised March 2009 (TxDOT Manual) the values for "Permissible Shear Stresses for Various Linings" for a vegetated lining is 0.35 psf to 3.70 psf. The top dome surface will establish a minimum 60 percent vegetative coverage or equivalent cover with primary grind mulch. Where vegetative cover is utilized, interim top dome and external embankment slopes may be seeded with winter rye or other seed mixture determined to be effective at stabilizing soils. Native grasses are the most likely vegetation to establish and thrive on the top dome and external embankment slopes. The native grasses in the area of the landfill consist primarily of Bermuda, with some Foxtail Millet. Other grasses that are found in the vicinity of the landfill include Little Bluestem, Indian Grass, and Switchgrass. These grasses are similar to the Retardance Class C from the "Retardance Class for Lining Materials" table found in the TxDOT Manual and are reflective of the grasses and cover conditions evident on the existing waste hills at the site. Retardance Class E consists of Burmuda Grass in either good stand, cut to 1.5 inches, or burned stubble. Since this scenario is not reflective of any the grasses or cover conditions seen at the site, Retardance Class E is eliminated. For determining the Permissible Shear Stress, Retardance Class C, with a Permissible Shear Stress of 1.00 would correspond to the conditions evident at the landfill; however, to be conservative, for these calculations, a Permissible Shear Stress for Retardance Class D of 0.60 is used to evaluate top dome and external embankment flows. The 5 percent top dome surface with 350 feet of sheetflow will have a maximum shear stress of 0.08 psf, well below the 0.60 psf permissible shear stress. The 3.~~7~~2 percent top dome surface with ~~1,710~~1,540 feet of sheetflow will have a maximum shear stress of 0.1~~6~~4 psf, also well below the 0.60 psf permissible shear stress. The 10 percent top dome surface with 130 feet of sheetflow will have a maximum shear stress of 0.18 psf, also well below the 0.60 psf permissible shear stress.

Maximum permissible velocities were computed for sheetflow conditions for 10 percent, 3.~~7~~2 percent and 5 percent slopes based on a permissible shear stress of 0.60 psf. The maximum permissible velocity for 3.~~7~~2 percent slopes is 4.349 fps, well above the 1.~~82~~62 fps velocity calculated in the sheetflow condition. For 10 percent slopes, the maximum permissible velocity is 1.92 fps, well above the 0.60 fps velocity calculated in the sheetflow condition. For 5 percent slopes, the maximum permissible velocity is 4.10 fps, also well above the 1.14 fps velocity calculated in the sheetflow condition. Additionally, the calculated velocities are less than the Maximum Velocities from Table 6.7 of the Erosion and Sediment Control Handbook, which lists that the native Bermuda grass has a maximum permissible velocity of 6 fps for 0-5 percent slopes.

The external embankment slopes will be filled to non-erosive grades, typically 25 percent. The external embankment slopes will establish a minimum 60 percent vegetative coverage. The 25 percent slopes will have a maximum flow length of 780 feet without water diversion. Block O is the only block which has not received final cover that will have a flow length requiring diversion. Block P has maximum flow lengths shorter than 780 feet. External embankment slopes will be graded to sheet flow and will have non erosive velocities and acceptable soil losses and therefore will not require any water diversion for distances less than 780 feet for 25 percent slopes. Water handling devices; including diversion dikes, let-down structures, and silt fence, as described in Section 1.1.2, will be utilized as required to maintain these maximum flow lengths.

Recently completed or external embankment slopes that do not have an established vegetative cover of at least 60 percent, will have a maximum sheetflow length of 780 feet. The 25 percent slopes will have velocities of ~~3.05~~2.72 feet per second (fps) and a shear stress of 0.58 pounds per square foot (psf). The external embankment slope will establish a minimum 60 percent vegetative coverage or equivalent cover using primary grind mulch. The Permissible Shear Stress for top dome and external embankment flows, as calculated above, is 0.60 psf. The 25 percent external embankment slope with 780 feet of sheetflow will have a maximum shear stress of 0.58 psf, less than the 0.60 psf permissible shear stress.

A maximum permissible velocity was computed for a sheetflow condition on a 25 percent slope based on a permissible shear stress of 0.60 psf. The maximum permissible velocity in this case is 3.0~~5~~0 fps, which is ~~equal to~~above the ~~3.05~~2.72 fps velocity calculated in the sheetflow condition. Additionally, the calculated velocities are less than the Maximum Velocities from Table 6.7 of the Erosion and Sediment Control Handbook, which lists that the native Bermuda grass has a maximum permissible velocity of 4 fps for slopes greater than 10 percent. Therefore, the flows from external embankment slopes with 25percent slopes and a maximum drainage length of 780 feet will have non-erosive velocities. For all velocity and shear stress calculations, see Appendix III-6A-1.

Top dome surfaces and external embankment side slopes will have erosion control structures, including vegetation, established within 180 days of placement of the intermediate cover. Vegetation will be in accordance with Section 1.2.1.

1.1.2 WATER HANDLING PRACTICES

Water handling practices include diversion and flow spreading of water.

Diversion is the use of strategically placed control devices to intercept runoff and divert it to another location. A diversion will be installed to keep clean water from crossing and eroding a disturbed area or to move runoff with silt to a location where it can be treated more effectively.

Diversion structures will be constructed with the construction of intermediate cover and within 180 days of the construction of top dome or external side slopes surfaces.

1.1.2.1 Diversion Dike

A diversion dike intercepts runoff from upland areas and diverts it away from exposed slopes to a let-down structure or a stabilized outlet. Diversion dikes are a ridge of compacted soil located in such a manner as to direct water to a desired location. Diversion dikes will be located above external embankment fill slopes. These diversion dikes have been designed for the 25 year, 24 hour peak flowrate. Diversion dikes will be constructed so that 780 feet is the maximum drainage length to a 4:1 slope. Diversion dikes will be constructed on the top slope so that the maximum drainage area to any one diversion dike is ~~15.2~~14.1 acres. The calculated maximum shear stress caused by the 25 year storm event in the diversion dike is ~~1.05~~0.99 pounds per square foot for a diversion dike built with a 4% drainage slope. Block O is the only block requiring water diversion.

Diversion dikes will be constructed with a minimum slope of 2 percent and a maximum slope of 4 percent. Diversion dikes will be lined with an erosion protection with a minimum permissible shear stress of greater than 1.0 pounds per square foot. This includes straw mat, curled wood mat (Excelsior), rock (d_{50} = 6"), or other TCEQ approved materials that provide a minimum permissible shear stress greater than 1.0 pounds per square foot.

Diversion dikes will be constructed to direct stormwater to a let-down structure or stabilized outlet such as a stone rip-rap pad or approved alternate. For more information on let-down structures, see 1.1.2.2

Calculations for these diversion dikes are included in Appendix III-6A-1.

1.1.2.2 Let-Down Structure

A let-down structure will convey concentrated runoff down steep slopes. The let-down structure will be used on the external embankment side slopes. Runoff will be directed to the let-down structure by means of diversion dikes. The let-down structure will consist of a channel with either a 6 inch gabion, geomembrane, or Reno Mattress (or similar) lining.

These channels have been designed for the 25 year, 24 hour peak flowrate. Block O is the only block that requires installation of a let-down structure. The maximum area to be directed to any one let-down structure is ~~29.1~~24.6 acres. Let-down structures will be constructed down the external embankment side slope with a maximum slope of 25 percent. The let-down structure lining will have erosion protection including a 6 inch gabion and geomembrane lining, or other TCEQ approved material with a minimum permissible shear stress greater than 20 lbs/sq. ft. According to TxDOT Manual, Permissible Shear Stresses for Various Linings, 6 inch gabions have a permissible shear stress of 35 psf. The table does not include permissible shear stresses for geomembrane. Geomembrane lining is significantly more resistant to shear forces than gabions, so assuming a permissible shear stress equal to that of gabions, 35 psf, is a conservative assumption. Let down structures will discharge to stone rip-rap pads as detailed on Figure III-6A.3.

Calculations for these let-down structures are included in Appendix III-6A-1.

1.1.2.3 Silt Fence

Silt fence is a temporary barrier fence of non-woven textile material which is water permeable but will trap water-borne sediment. The silt fence reduces runoff velocity and allows the deposition of transported sediment to occur. Silt fencing shall consist of posts with pervious synthetic filter fabric (polypropylene, nylon, polyester or other suitable fabric) stretched across the posts. The fabric should contain UV inhibitors and stabilizers for increased product life with a removal capability of approximately 80 percent.

Silt fence will be placed at the base of external embankment slopes that have less than 60 percent vegetative coverage. Additional lines of silt fence will be placed with a maximum spacing of 125 feet up the 4:1 external embankment slopes that do no have 60 percent vegetative coverage.

The silt fence will be used to intercept sediment laden runoff from small drainage areas. The silt fence will be placed across slopes, on the contour (level), as possible. The silt fence shall be trenched in with a spade, mechanical trencher, or similar equipment. The trench must be a minimum of 6 inches deep and 6 inches wide to allow for the silt fence fabric to be laid in the ground and backfilled with compacted material. No section of silt fence should exceed a grade of 5 percent for a distance of 50 feet. The maximum drainage area shall be 0.25 acres per 100 linear feet of fencing. The length of flow contributing to the silt fence is limited to 125 feet on external embankment side slopes and 150 feet on top dome surfaces.

During inspections, the silt fences should be checked for structural defects (i.e., channeling under the silt fence, sagging or collapse of the silt fence, fabric failure) and sediment accumulation. Sediment accumulation should not be allowed to exceed one-half of the silt fence height.

1.1.2.4 Stone Check Dam

The stone check dams are stone barriers placed in series in channels. Stone check dams will be constructed in un-vegetated or non-stabilized perimeter channels (i.e.: channels with less than 80 percent vegetative coverage) to reduce runoff velocities to non-erosive rates and to prevent channel erosion. Stone check dams are typically located so as to provide maximum velocity reduction. The check dams should be placed in reasonably straight channel sections to minimize the potential for erosion in the channel bend.

Stone check dams will be placed in the perimeter drainage channels that do not have a minimum 60 percent vegetative cover.

Two types of stone check dams are included to cover both trapezoidal and v-shaped channels.

Trapezoidal Channels - For trapezoidal channels, the stone check dams will be constructed with 4" to 7" stone or recycled concrete equivalent and shall be placed to form a weir. The check dam should be keyed into the sides and bottom of the channel. The distance between the stone check dams will vary with the longitudinal ditch slope. The outlet crest or the top of the stone weir shall be at least 6" lower than the outer edges. Geotextile fabric will be placed under the bottom and sides of the dam prior to placement of stone.

The height of the stone check dam should not exceed one-half the depth of the channel. Additionally, the maximum height of the dam must not exceed 2.0 feet to prevent scour of the toe of the dam. The stone check dam should be wide enough to reach from bank to bank of the channel with the weir section in the center of the dam.

The maximum spacing on a trapezoidal channel check dam is determined as:

$$x = y/S$$

where:

x = Check dam spacing, feet;
y = Check dam height, feet; and
S = Channel slope, feet per foot.

Therefore, a channel with a 1 percent slope (0.01 feet/foot) and a 1 foot tall check dam, would have a check dam spacing of 100 feet. For more details about trapezoidal channel stone check dams, see Figure III-6A.2.

V-Shaped Channels – The stone check dams will be constructed with 2" to 10" stone. Dam height measured to the center of the dam should be 2 feet maximum and must be 9 inches below the outer edges. The side slopes will be 2:1 or flatter. The distance between the stone check dams will vary with the longitudinal ditch slope, but the maximum spacing should be that the toe of the upstream dam is at the same elevation as the top of the downstream dam. Sediment should be removed when it reaches a depth of one-half the dam height. For more details about V-shaped channel stone check dams, see Figure III-6A.2.

1.2 VEGETATIVE PRACTICES

Vegetation serves as a cover for barren soil protecting it from the forces of erosion. When soil is stabilized, the soil is less likely to erode and more likely to allow infiltration of rainfall, thereby reducing sediment loads and runoff to downstream areas. These vegetative practices include the use of vegetative stabilization and erosion control matting.

Sediment control practices and devices must remain in place during grading, seedbed preparation, seeding, mulching, and vegetative establishment to prevent erosion.

1.2.1 VEGETATIVE STABILIZATION

Vegetative and mulch stabilization practices are used to reduce runoff and erosion of exposed soil. These vegetative stabilization practices include mulch stabilization and/or seeding stabilization.

Vegetative cover or mulch stabilization will be established within 180 days of the placement of intermediate cover on the top dome surfaces and external embankment slopes. These areas that have been seeded and do not have at least 60 percent vegetative cover within 180 days will be reseeded and reevaluated in 30 days. Water handling practices will remain in place during the 30 days that the vegetative cover is reseeded and reevaluated and until a minimum 60 percent vegetative cover is obtained as described in Section 1.1.1.1, Non-erosive Slopes.

1.2.1.1 Mulch Stabilization

Mulch stabilization involves the application of plant residue or other suitable material on the soil surface. This will temporarily conserve moisture, prevent surface compaction or crusting, reduce runoff and erosion and control weeds prior to the establishment of plant cover.

Mulch may be used either by itself or with seeding stabilization. Mulch is used with seeding stabilization to help promote vegetative growth.

Mulch will include either straw, wood chips, wood cellulose fiber, mulch nettings, primary grind mulch, crushed rock, stones, gravel, or synthetic soil stabilizers.

Straw, wood chips, primary grind mulch and wood cellulose fiber shall be installed in uniform depths from one to two inches. These mulches should be anchored by tracking with a tractor or other appropriate tractor pulled mulch anchoring tool to punch the mulch into the soil. Tracking should be done up and down the slope with cleat marks running across the slope. These mulches may also be anchored with mulch nettings or mulch liquid binders.

When utilized, synthetic soil stabilizers will, at minimum, be applied at rates recommended by the manufacturer.

Mulch will be applied to assist with seeding stabilization when required as described in Section 1.2.1.2. Mulch is not required for the establishment of vegetation on the top dome surface or external embankment slopes; however, it will be used if the landfill operator determines that mulch is needed to promote vegetative growth as described in Section 1.2.1.2 or to provide additional erosional stability to the soil surface.

1.2.1.2 Seeding Stabilization

Seeding stabilization involves the planting of vegetation. Seeding stabilization helps in stabilizing the soil and reduces damages from erosion and sediment and runoff to downstream areas.

Vegetative cover will be established within 180 days of placement of intermediate cover on the top dome surface or external embankment slopes as described in Section 1.2.1.

If the area to be seeded is packed, crusted and hard, the top layer of soil shall be loosened by plowing, discing, raking, or other acceptable means before seeding. On sloping fills, the harrowing or discing operation should be on the contour. Topsoil will be brought in as additional fill or to enhance the fill soil, if needed. Fertilizer shall be applied to the soil at a rate appropriate to establish vegetative growth. A seed mixture should be selected of native grasses that are appropriate for the soil, climate, and slope conditions. The seed will be selected with the recommendation of a local Agricultural Extension Agent or local expert with experience with local soils and grasses. Seed should be applied uniformly with a cyclone seeder, drill, cultipacker seeder, or hydroseeder (slurry includes seed, fertilizer, and binder). Sod grass may be used in place of seed. Mulch may be applied immediately when seeding in adverse soil conditions or on other than optimum seeding dates or conditions.

Any areas that do not reach 60 percent vegetative coverage within 180 days will be reviewed by the vegetative expert, revisions to the seeding, fertilizer, and soil may be modified based on this review. The area with insufficient vegetative growth will be re-seeded and watered in accordance with the recommendations of the vegetative expert and monitored again in the subsequent 30 days until 60 percent vegetative coverage is obtained. Water handling practices will remain in place during the 30 days that the vegetative cover is reseeded and reevaluated and until a minimum 60 percent vegetative cover is obtained as described in Section 1.1.1.1, Non-erosive Slopes. Once established, vegetation will be mowed at least annually to prevent woody growth and maintain a healthy stand of vegetation.

1.2.2 Erosion Control Matting

Erosion control matting may be used to temporarily stabilize channels or steep slopes until vegetation is established. There are many types of matting available. The erosion control matting that is used must withstand velocities of 8 feet per second.

Mattings are used to stabilize the flow channels of dikes and swales where the velocity is over 5 feet per second. They may also be used on banks where moving water is likely to wash out new vegetative planting.

Some channels will require multiple widths of matting, with two widths being the most commonly used. The matting should be installed in accordance with the manufacturer's recommendations.

1.3 INSPECTION, MAINTENANCE, ADEQUACY OF EROSION CONTROLS, AND TRAINING

Top dome surfaces, external embankment slopes and erosion controls will be routinely inspected, maintained and evaluated for adequacy.

1.3.1 INSPECTION

The top dome surfaces, external embankment slopes and erosion controls will be inspected on a weekly basis and after significant rainfall events (rainfall events of 0.5 inches or more) to assure that the erosion control structures are stable and functioning according to their design, that flow velocities are within permissible non-erodible velocities, that soil loss is within the allowable maximum, and that vegetation is established as required.

Inspections will include:

- Checking erosion controls for signs of failure due to erosion including erosion of the controls, blow outs due to excessive concentrated flows, and sedimentation that causes ponding;
- Checking erosion controls for signs of damage or degradation not attributed to erosion, including degradation of the materials, such as silt fencing, or mechanical damage (accidental damage from machinery);
- Checking top dome surfaces, external embankment slopes, erosion controls, and perimeter drainage channels for signs of erosion (any erosion of 4" or more as measured from the horizontal surface will

be considered excessive and should be noted for repair);

- Checking top dome surfaces, external embankment slopes, erosion controls, and perimeter drainage channels for signs of excessive sedimentation (any sedimentation accumulation of 4" or more as measured from the horizontal surface will be considered excessive and should be noted for removal);
- Checking top dome surfaces and external embankment slopes for adequate vegetative cover (at least 60 percent coverage); and
- Checking for obstructions to drainage features.

The landfill manager or supervisor will review both the weekly and significant rainfall event inspection logs. The inspection logs will be placed in the facility's Site Operating Record.

1.3.2 MAINTENANCE

Erosion or other damage to the top dome surface, external embankment slopes or erosion controls will be repaired within five days of detection as weather and soil conditions permit by restoring the cover material, grading, compacting, seeding, rebuilding or replacing cover soils or erosion controls. If conditions warrant, a letter will be submitted to the commission's regional office for an extension of the five day requirement based on the extent of the damage, time to repair, or weather conditions. The date of detection of erosion or damage and date of completion of repairs, including any reasons for delays, will be documented in the cover inspection report.

1.3.3 ADEQUACY EVALUATION

If erosion or damage occurs or continues to occur to the top dome surfaces, external embankment slopes or erosion controls, the erosion and/or sediment control structures or practices will be re-evaluated, and strengthened, replaced or substituted, as the case warrants.

The landfill manager's evaluation of the state of the erosion or damage and any proposed revisions in the grading or additional erosion controls will be noted on the weekly inspection record.

1.3.4 TRAINING

The installation, regular inspection, maintenance, and record keeping of plan practices will be included in the training curricula of appropriate landfill personnel.

1.4 REPLACEMENT OF TEMPORARY EROSION CONTROLS WITH PERMANENT EROSION AND SEDIMENT CONTROL DEVICES

The temporary erosion controls will be replaced with permanent erosion controls with the construction of the final cover. Temporary sediment controls may include diversion dikes, let-down structures, silt fencing, and stone check dams. The diversion dikes, let-down structures, and up-slope silt fencing will be removed with the construction of the final cover and replaced with the erosion control measures specified in the final closure plan. Silt fencing will remain in place at the base of the external embankment slope and up-slope until 60 percent vegetation is established below the lowest drainage terrace on the final covered external embankment slope. Then the silt fence may be removed. Silt fencing is not required up-slope of the lowest drainage terrace. Stone check dams will remain in place in the perimeter drainage channels until 60 percent vegetative coverage is achieved in the perimeter drainage channel upstream of the stone check dam or to the next upstream stone check dam, whichever comes first.

PART III, ATTACHMENT 6, APPENDIX A-1
REPLACEMENT PAGES

TOP DOME SURFACE AND EXTERNAL EMBANKMENT SLOPE DRAINAGE CALCULATIONS
PART III, ATTACHMENT 6, APPENDIX III-6A-1

CITY OF NACOGDOCHES LANDFILL
TOP DOME SURFACE AND EXTERNAL EMBANKMENT SLOPE
RATIONAL METHOD FLOWRATE CALCULATIONS

~~SEPTEMBER 2019~~ DECEMBER 2023

ADD ROW: 10% Slope - 1'x 130' | 10 | 8.70 | 0.0030 | 0.70 | 0.018

Channel	Contributing Areas	Tc	I-25	Area (acres)	C	Q-25 (cfs)
Top Dome Slope Sheet Flow	10% & ~~3.7%~~ 3.2% Slope-1' x ~~1710'~~ (130' & 1540')	~~11~~ 10	~~9.2~~ 8.7	~~0.0393~~ 0.0354	~~0.40~~ 0.42	~~0.144~~ 0.130
	5% Slope - 1' x 350'	10	~~9.5~~ 8.7	0.008	0.418	~~0.032~~ 0.029
				0.0179		0.109
External Embankment Slope Sheet Flow	**Max Flow Length:** 25% Slope-1' x 780'	10	~~9.5~~ 8.7	~~0.018~~	0.70	~~0.120~~
	3.2%			14.10		53.975
Diversion Dike	~~3.7%~~ Topslope	10	~~9.5~~ 8.7	~~15.20~~	0.40	~~63.809~~
				24.60		164.295
Let Down Structure		10	~~9.5~~ 8.7	~~29.10~~	0.70	~~213.780~~

III-A6.A-15.1

UPDATED

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED PROFESSIONAL ENGINEER

10/29/19

Sheets III-A6.A-15.1 through III-A6.A-15.28

SCS Engineers
TBPE Reg. # F-3407

City of Nacogdoches Landfill
Top Dome Surface and External Embankment Slope
Maximum Shear Stress at Normal Depth Calculation

~~September 2019~~ DECEMBER 2023

ADD ROWS: Topslope Sheetflow - 10% Slope - 60% Coverage.....
10% Topslop Max. Velocity Calc. (see note).....

Channel Type	Channel Slope	Side Slope Left	Side Slope Right	Channel Bottom Width	Normal Depth	Cross Section Area	Wet Perimeter	Hydraulic Radius	Maximum Shear Stress	Maximum Allowable Shear Stress	Flow Velocity
	(ft/ft)	(H:V)	(H:V)	(ft)	(ft)	(sq ft)	(ft)	(ft)	(lb/sqft)	(lb/sqft)	(fps)
Topslope Sheetflow - 5% Slope-60% Coverage	0.05	0	0	1	0.028	0.028	**1.06**	**0.03**	**0.08**	0.60	1.14
Topslope Sheetflow - 3.7% Slope-60% Coverage	~~0.037~~	0	0	1	0.080	0.080	**1.16**	**0.07**	~~0.16~~	0.60	~~1.82~~
5% Topslope Max. Velocity Calc. (see note)	0.05	0	0	1	0.310	0.310	**1.62**	**0.19**	**0.60**	0.60	4.10
3.7% Topslope Max. Velocity Calc. (see note)	~~0.037~~	0	0	1	~~0.550~~	~~0.550~~	~~2.10~~	~~0.26~~	**0.60**	0.60	~~4.34~~
4:1 Embankment Sheetflow-60% Coverage	0.25	0	0	1	0.040	0.040	**1.08**	**0.04**	**0.58**	0.60	~~3.057~~
4:1 Embankment Max. Velocity Calc. (see note)	0.25	0	0	1	0.042	0.042	**1.08**	**0.04**	**0.60**	0.60	~~3.05~~
3.2%											
Diversion Dike - ~~3.7%~~ Topslope	0.02	2	27	0.1	~~0.96~~	~~13.47~~	~~28.18~~	~~0.48~~	~~0.59~~	1.40	~~4.81~~
Diversion Dike - ~~3.7%~~ Topslope	0.04	2	27	0.1	~~0.84~~	~~10.38~~	~~24.67~~	~~0.42~~	~~1.05~~	1.40	6.24
Let-Down Channel 6" Gabions	0.25	2	2	14	~~0.74~~	~~11.39~~	~~17.31~~	~~0.66~~	~~10.27~~	35	~~18.77~~
Let-Down Channel HDPE Plastic	0.25	2	2	26	~~0.3~~	~~7.89~~	~~27.34~~	~~0.29~~	~~4.50~~	>35	~~27.08~~

Note: Maximum Velocity corresponds to the velocity calculated for the normal depth and cross sectional areas calculated. See Normal Depth Calculations.

Topographic Factor for Irregular Slopes

Block O Worst Case Slope: **25%**

Slope(s): 10%, 25%, ~~3.7%~~ 3.2%
Total Slope Length: ~~1930~~ 1890
# of Segments: 2
m: 0.5

ADD new segment 1: 10 | 130 | 1.65 | 0.35 | 0.58

Segment	Percent Slope	Slope Length (ft)	Topographic Factor (Figure 4)	Fraction of Soil Loss (Table 4)	Product
~~1~~ 2	~~3.7~~ 3.2	~~1710~~ 1540	~~1~~ 0.85	0.35	~~0.35~~ 0.30
~~2~~ 3	25	220	8.70	0.65	5.66
		~~1930~~ 1890		**LS=**	**~~6.01~~** 6.53

Block P Worst Case Slope: **25%**

Slope(s): 25%, 5%
Total Slope Length: 480
# of Segments: 2
m: 0.5

Segment	Percent Slope	Slope Length (ft)	Topographic Factor (Figure 4)	Fraction of Soil Loss (Table 4)	Product
1	5	220	0.79	0.35	0.28
2	25	260	9.50	0.65	6.18
		480		**LS=**	**6.45**

Note: LS values were calculated according to the Irregular Slope method from the USDA Agriculture Handbook Number 537.

REPLACED III-A6.A-15.4 to 15.7
with Tx DOT 09/2019 Version

Runoff Coefficient

The assignment of the runoff coefficient (C) is somewhat subjective. At the time the rainfall producing runoff occurs, the coefficient varies with topography, land use, vegetal cover, soil type, and moisture content of the soil. In selecting the runoff coefficient, consider the future characteristics of the watershed. If land use varies within a watershed, you must consider watershed segments individually, and you can calculate a weighted runoff coefficient value.

The following table suggests ranges of C values for various categories of ground cover. This table is typical of design guides found in civil engineering texts dealing with hydrology. You must subjectively assign a C value based on what you see or anticipate in the watershed with reference to the table.

Runoff Coefficients for Urban Watersheds

Type of Drainage Area	Runoff Coefficient
Business:	
◆ downtown areas	0.70-0.95
◆ neighborhood areas	0.30-0.70
Residential:	
◆ single-family areas	0.30-0.50
◆ multi-units, detached	0.40-0.60
◆ multi-units, attached	0.60-0.75
◆ suburban	0.35-0.40
◆ apartment dwelling areas	0.30-0.70
Industrial:	
◆ light areas	0.30-0.80
◆ heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.30-0.40
Railroad yards	0.30-0.40
Unimproved areas:	
◆ sand or sandy loam soil, 0-3%	0.15-0.20
◆ sand or sandy loam soil, 3-5%	0.20-0.25
◆ black or loessial soil, 0-3%	0.18-0.25
◆ black or loessial soil, 3-5%	0.25-0.30
◆ black or loessial soil, >5%	0.70-0.80

REPLACED

Runoff Coefficients for Urban Watersheds

Type of Drainage Area	Runoff Coefficient
◆ deep sand area	0.05-0.15
◆ steep grassed slopes	0.70
Lawns:	
◆ sandy soil, flat 2%	0.05-0.10
◆ sandy soil, average 2-7%	0.10-0.15
◆ sandy soil, steep 7%	0.15-0.20
◆ heavy soil, flat 2%	0.13-0.17
◆ heavy soil, average 2-7%	0.18-0.22
◆ heavy soil, steep 7%	0.25-0.35
Streets:	
◆ asphaltic	0.85-0.95
◆ concrete	0.90-0.95
◆ brick	0.70-0.85
Drives and walks	0.75-0.95
Roofs	0.75-0.95

The following table shows an alternate, systematic approach for developing the runoff coefficient. This table applies to rural watersheds only, addressing the watershed as a series of aspects. For each of four aspects, make a systematic assignment of a runoff coefficient "component." Using Equation 5-5, add the four assigned components to form an overall runoff coefficient for the specific watershed segment.

$C_{\underset{3.7\%}{\cancel{3\%}}}$ Top Slope $= (\underset{.12}{\cancel{0.116}} + 0.10 + 0.04 + 0.10) \times 1.1 = \underset{0.396}{\cancel{0.392}}$ > 0.30 → Use $\underset{0.40}{\cancel{0.392}}$

$C_{5\%}$ Top Slope $= (0.14 + 0.10 + 0.04 + 0.10) \times 1.1 = 0.418$ > 0.30 → Use 0.418

$C_{20\%}$ Embankment $= (0.24 + 0.10 + 0.04 + 0.10) \times 1.1 = 0.528$ < 0.70 → Use 0.70

Block P $C_{\text{Partial } 5\%}$ Partial 20% $= \left[0.418\left(\frac{1050}{1300}\right) + 0.70\left(\frac{250}{1300}\right)\right] = 0.469$

k O $C_{\text{Partial } 5\%}$ Partial $\underset{25}{\cancel{20}}\%$ $= \left[\overset{0.40}{\cancel{0.418}}\left(\frac{\overset{1716}{\cancel{1756}}}{\underset{1930}{\cancel{2120}}}\right) + 0.70\left(\frac{\overset{220}{\cancel{370}}}{\underset{1930}{\cancel{2120}}}\right)\right] = \overset{0,4342}{\cancel{0.467}}$

REPLACED

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

Equation 5-5.

Runoff Coefficient for Rural Watersheds

	Extreme	High	Normal	Low
Relief - C_f	*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 negligble 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 plan 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 over 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 culitvated crops	0.04-0.06 good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface - C_s	0.10-0.12 negligible; surface depression 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 storage lakes and ponds and marshes	0.04-0.06 much surface storage, drainage system not sharply defined; large floodplain storage of large number of ponds or marshes

NOTE: The total runoff coefficient based on the four runoff components is $C = C_r + C_i + C_v + C_s$

Runoff coefficients, listed in for urban and rural watersheds and others apply to storms of two-year, five-year, and 10-year frequencies. Higher frequency storms require modifying the runoff coefficient because infiltration and other abstractions have a proportionally smaller effect on runoff. Adjust the runoff coefficient by the factor C_f as indicated in the table titled Runoff Coefficient Adjustment Factors for Rational Method. The product of C and C_f should not exceed 1.0.

Runoff Coefficient Adjustment Factors for Rational Method

Recurrence Intervals (years)	C_f
25	1.1

REPLACED

Runoff Coefficient Adjustment Factors for Rational Method

Recurrence Intervals (years)	C_f
50	1.2
100	1.25

The Rational formula now becomes Equation 5-6.

$$Q = \frac{CC_f IA}{360}$$

Equation 5-6.

where:

360 = for metric calculations only

Rational Procedure

The following procedure outlines the Rational method for estimating peak discharge:

1. Determine the watershed area in acres (hectares).
2. Determine the time of concentration, with consideration for future characteristics of the watershed.
3. Assure consistency with the assumptions and limitations for application of the Rational Method.
4. Determine the rainfall IDF coefficients. Extract the Rainfall Intensity-Duration Frequency Coefficients e, b, and d values from the list in Hydrology according to the locality in Texas and the design frequency.
5. Use Equation 5-4 to calculate the rainfall intensity in in./hr (mm/hr).
6. Select or develop appropriate runoff coefficients for the watershed. Where the watershed comprises more than one characteristic, you must estimate C values for each area segment individually. You may then estimate a weighted C value using Equation 5-7. The runoff coefficient is dimensionless.

$$C = \frac{\sum_{n=1}^{m} C_n A_n}{\sum_{n=1}^{m} A_n}$$

Equation 5-7.

```
                 TRAPEZOIDAL CHANNEL ANALYSIS
                   NORMAL DEPTH COMPUTATION

                       October 11, 2019
```

3.7% Top Dome Surface Sheetflow

```
==============================================================================
                      PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
------------------------------------------------------------------------------
Flow Rate (cfs).............................................        0.15
Channel Bottom Slope (ft/ft)................................        0.037
Manning's Roughness Coefficient (n-value)...................        0.027
Channel Left Side Slope (horizontal/vertical)...............        0.0
Channel Right Side Slope (horizontal/vertical)..............        0.0
Channel Bottom Width (ft)...................................        1.0

==============================================================================
                      COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
------------------------------------------------------------------------------
Normal Depth (ft)...........................................         0.08
Flow Velocity (fps).........................................         1.82
Froude Number...............................................         1.12
Velocity Head (ft)..........................................         0.05
Energy Head (ft)............................................         0.13
Cross-Sectional Area of Flow (sq ft)........................         0.08
Top Width of Flow (ft)......................................         1.0

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

Flow Rate 0.15 — 0.144 used 0.15

Normal Depth 0.08 ✓

Flow Velocity 1.82 ✓

Cross-Sectional Area of Flow 0.08 ✓

REPLACED with III-A6.A-15.8a &b
for 10% areas

~~III-A6.A-15.8~~

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 11, 2019
```

3.7% Topslope Max Permissible Velocity

```
===============================================================================
                         PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Flow Rate (cfs)..............................................       2.4
Channel Bottom Slope (ft/ft).................................       0.037
Manning's Roughness Coefficient (n-value)....................       0.027
Channel Left Side Slope (horizontal/vertical)................       0.0
Channel Right Side Slope (horizontal/vertical)...............       0.0
Channel Bottom Width (ft)....................................       1.0

===============================================================================
                         COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Normal Depth (ft)............................................        0.55
Flow Velocity (fps)..........................................        4.34
Froude Number................................................        1.03
Velocity Head (ft)...........................................        0.29
Energy Head (ft).............................................        0.85
Cross-Sectional Area of Flow (sq ft).........................        0.55
Top Width of Flow (ft).......................................        1.0

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED with III-A6.A-15.9a & b for 3.2% areas

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 11, 2019
```

25% External Embankment Sheetflow

```
==============================================================================
                        PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
------------------------------------------------------------------------------
Flow Rate (cfs)..............................................       0.12 ✓
Channel Bottom Slope (ft/ft).................................       0.25
Manning's Roughness Coefficient (n-value)....................       0.027
Channel Left Side Slope (horizontal/vertical)................       0.0
Channel Right Side Slope (horizontal/vertical)...............       0.0
Channel Bottom Width (ft)....................................       1.0

==============================================================================
                        COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
------------------------------------------------------------------------------
Normal Depth (ft)............................................        0.04 ✓
Flow Velocity (fps)..........................................        3.05 ✓
Froude Number................................................        2.708
Velocity Head (ft)...........................................        0.14
Energy Head (ft).............................................        0.18
Cross-Sectional Area of Flow (sq ft).........................        0.04 ✓
Top Width of Flow (ft).......................................        1.0

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 11, 2019
          25% External Embankment Sheetflow- Max. Permissible Velocity
===============================================================================
                          PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Flow Rate (cfs)............................................        0.12 ✓
Channel Bottom Slope (ft/ft)...............................        0.25
Manning's Roughness Coefficient (n-value)..................        0.027
Channel Left Side Slope (horizontal/vertical)..............        0.0
Channel Right Side Slope (horizontal/vertical).............        0.0
Channel Bottom Width (ft)..................................        1.0

===============================================================================
                         COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Normal Depth (ft)..........................................        0.04 -0.042 use 0.04
Flow Velocity (fps)........................................        3.05
Froude Number..............................................        2.708
Velocity Head (ft).........................................        0.14
Energy Head (ft)...........................................        0.18
Cross-Sectional Area of Flow (sq ft).......................        0.04
Top Width of Flow (ft).....................................        1.0

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                      NORMAL DEPTH COMPUTATION

                          October 31, 2019
```

Block O: Diversion Dike - 2% Slope

```
===============================================================================
                         PROGRAM INPUT DATA
DESCRIPTION                                                               VALUE
-------------------------------------------------------------------------------
Flow Rate (cfs)...........................................            63.81
Channel Bottom Slope (ft/ft)..............................             0.02
Manning's Roughness Coefficient (n-value).................             0.027
Channel Left Side Slope (horizontal/vertical).............             2.0
Channel Right Side Slope (horizontal/vertical)............            27.0
Channel Bottom Width (ft).................................             0.1

===============================================================================
                        COMPUTATION RESULTS
DESCRIPTION                                                               VALUE
-------------------------------------------------------------------------------
Normal Depth (ft)..........................................             0.96
Flow Velocity (fps)........................................             4.76
Froude Number..............................................             1.21
Velocity Head (ft).........................................             0.35
Energy Head (ft)...........................................             1.31
Cross-Sectional Area of Flow (sq ft).......................            13.41
Top Width of Flow (ft).....................................            27.89

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED RAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                      NORMAL DEPTH COMPUTATION

                          October 31, 2019
```

Block O: Diversion Dike - 4% Slope

```
==============================================================================
                         PROGRAM INPUT DATA
DESCRIPTION                                                           VALUE
------------------------------------------------------------------------------
Flow Rate (cfs)..................................................    63.81
Channel Bottom Slope (ft/ft).....................................     0.04
Manning's Roughness Coefficient (n-value)........................     0.027
Channel Left Side Slope (horizontal/vertical)....................     2.0
Channel Right Side Slope (horizontal/vertical)...................    27.0
Channel Bottom Width (ft)........................................     0.1

==============================================================================
                        COMPUTATION RESULTS
DESCRIPTION                                                           VALUE
------------------------------------------------------------------------------
Normal Depth (ft)................................................      0.84
Flow Velocity (fps)..............................................      6.15
Froude Number....................................................      1.667
Velocity Head (ft)...............................................      0.59
Energy Head (ft).................................................      1.43
Cross-Sectional Area of Flow (sq ft).............................     10.38
Top Width of Flow (ft)...........................................     24.53

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                      NORMAL DEPTH COMPUTATION

                          October 31, 2019
```

Block O: Let-Down Channel - Gabion

```
==============================================================================
                          PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
------------------------------------------------------------------------------
Flow Rate (cfs)..........................................          213.78
Channel Bottom Slope (ft/ft)..............................            0.25
Manning's Roughness Coefficient (n-value).................            0.03
Channel Left Side Slope (horizontal/vertical).............            2.0
Channel Right Side Slope (horizontal/vertical)............            2.0
Channel Bottom Width (ft).................................           14.0

==============================================================================
                          COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
------------------------------------------------------------------------------
Normal Depth (ft).........................................            0.74
Flow Velocity (fps).......................................           18.77
Froude Number.............................................            4.036
Velocity Head (ft)........................................            5.48
Energy Head (ft)..........................................            6.21
Cross-Sectional Area of Flow (sq ft)......................           11.39
Top Width of Flow (ft)....................................           16.94

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED PAGE

```
              TRAPEZOIDAL CHANNEL ANALYSIS
               NORMAL DEPTH COMPUTATION

                   October 31, 2019
```

Block O: Let-Down Channel - HDPE

```
==============================================================================
                         PROGRAM INPUT DATA
DESCRIPTION                                                            VALUE
------------------------------------------------------------------------------
Flow Rate (cfs)..................................................    213.78
Channel Bottom Slope (ft/ft).....................................      0.25
Manning's Roughness Coefficient (n-value)........................      0.012
Channel Left Side Slope (horizontal/vertical)....................      2.0
Channel Right Side Slope (horizontal/vertical)...................      2.0
Channel Bottom Width (ft)........................................     26.0

==============================================================================
                        COMPUTATION RESULTS
DESCRIPTION                                                            VALUE
------------------------------------------------------------------------------
Normal Depth (ft)................................................       0.3
Flow Velocity (fps)..............................................      27.08
Froude Number....................................................       8.86
Velocity Head (ft)...............................................      11.4
Energy Head (ft).................................................      11.69
Cross-Sectional Area of Flow (sq ft).............................       7.89
Top Width of Flow (ft)...........................................      27.19

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

REPLACED PAGE

Hydraulic Design Manual

REPLACED III-Ab.A-15.16 to 15.19
with TxDOT 09/2019 Version

Texas
Department
of Transportation

Revised March 2009

REPLACED

S = channel slope (m/m)

Retardation Class for Lining Materials

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)

REPLACED

Retardation Class for Lining Materials

Retardance Class	Cover	Condition
	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

Permissible Shear Stresses for Various Linings

Protective Cover	(lb./sq.ft.)	tp (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

REPLACED

Permissible Shear Stresses for Various Linings

Protective Cover	(lb./sq.ft.)	tp (N/m^2)
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

Trial Runs

To optimize the roadside channel system design, you generally need to make several trial runs before a final design is achieved. Refer to HEC-15 for more information on channel design techniques and considerations.

III - A6. A- 15, 19

Hydraulic Jump Calculation - Let Down Channel

	By	Date	Initial
Calculated:	~~JRM~~ RJE	~~10/24/2019~~ 12/5/2023	
Checked:	~~JKR~~ JRM	~~10/24/2019~~ 12/15/2023	

Project: Nacogdoches Municipal Landfill
Project Number: 16209006.~~21~~ 26
Page 1 of 1

Purpose: Determine the sequential depth (Y_2) caused by a potential hydraulic jump for flows in the Block O let down channel for a 25-year storm event. Determine the channel width needed to contain the increase in depth for a gabion or reno mattress lined channel.

Given/Assumptions:

1. Use the FHWA HEC Number 14 Technical Report, titled "Hydraulic Design of Energy Dissipators for Culverts and Channels", September 1983
2. Design for worst case side slope = 25%
3. Use Figure 6-9. Hydraulic Jump - Horizontal, Trapezoidal Channel (actual depth), from Chapter 6 of HEC 14.
4. The depth of the channel is 3.0 feet.

Input Parameters:

Base of Channel (b) :	12 Feet	
Channel Side Slopes (Z) :	2 (Horizontal/Vertical)	
Initial Depth in Channel (Y_1) :	0.74 Feet	See Note 1
Froude Number (F_r) :	4.036	See Note 1

Equations:

$t = b/(Z*Y_1)$ See Note 2

$J = Y_2/Y_1$ See Note 2

Solve:

t = ~~8.1~~ 9.4

J = 4.0 From Figure 6-9 on page III-A6.A-14.32 using t = 35.9 and F_r = 7.953

Sequential Depth

Y_2 = ~~3.0~~ 2.6 Feet = 3.0 Feet (Channel Depth)

Conclusion: The let-down channel will be 14 feet wide at the base and 3 feet deep if it is lined with a gabion or reno mattress.

Notes:

1 From Trapezoidal Channel Analysis Normal Depth Calculation, see Page III-A6.A-14.15.

2 From the General Equation for a hydraulic jump in a horizontal channel, Chapter 6 of HEC 14.

		By	Date	Initial
Hydraulic Jump Calculation - Let Down Channel	Calculated:	~~JRM~~ RJE	~~10/24/2019~~ 12/5/2023	______
	Checked:	~~JRK~~ JRM	10/~~24/2019~~ 12/15/2023	______
Project: Nacogdoches Municipal Landfill				
Project Number: 16209006.~~21~~ 26			Page	1 of 1

Purpose: Determine the sequential depth (Y_2) caused by a potential hydraulic jump for flows in the Block O let down channel for a 25-year storm event. Determine the channel width needed to contain the increase in depth for a geomembrane lined channel.

Given/Assumptions:

1. Use the FHWA HEC Number 14 Technical Report, titled "Hydraulic Design of Energy Dissipators for Culverts and Channels", September 1983
2. Design for worst case side slope = 25%
3. Use Figure 6-9. Hydraulic Jump - Horizontal, Trapezoidal Channel (actual depth), from Chapter 6 of HEC 14.
4. The depth of the channel is 3.0 feet.

Input Parameters:

Base of Channel (b) :	22 Feet	
Channel Side Slopes (Z) :	2 (Horizontal/Vertical)	
Initial Depth in Channel (Y_1) :	0.3 Feet	See Note 1
Froude Number (F_r) :	8.86	See Note 1

Equations:

$t = b/(Z*Y_1)$ See Note 2

$J = Y_2/Y_1$ See Note 2

Solve:

t = ~~36.7~~ 42.3

J = 9.8 From Figure 6-9 on page III-A6.A-14.32 using t = 35.9 and F_r = 7.953

Sequential Depth

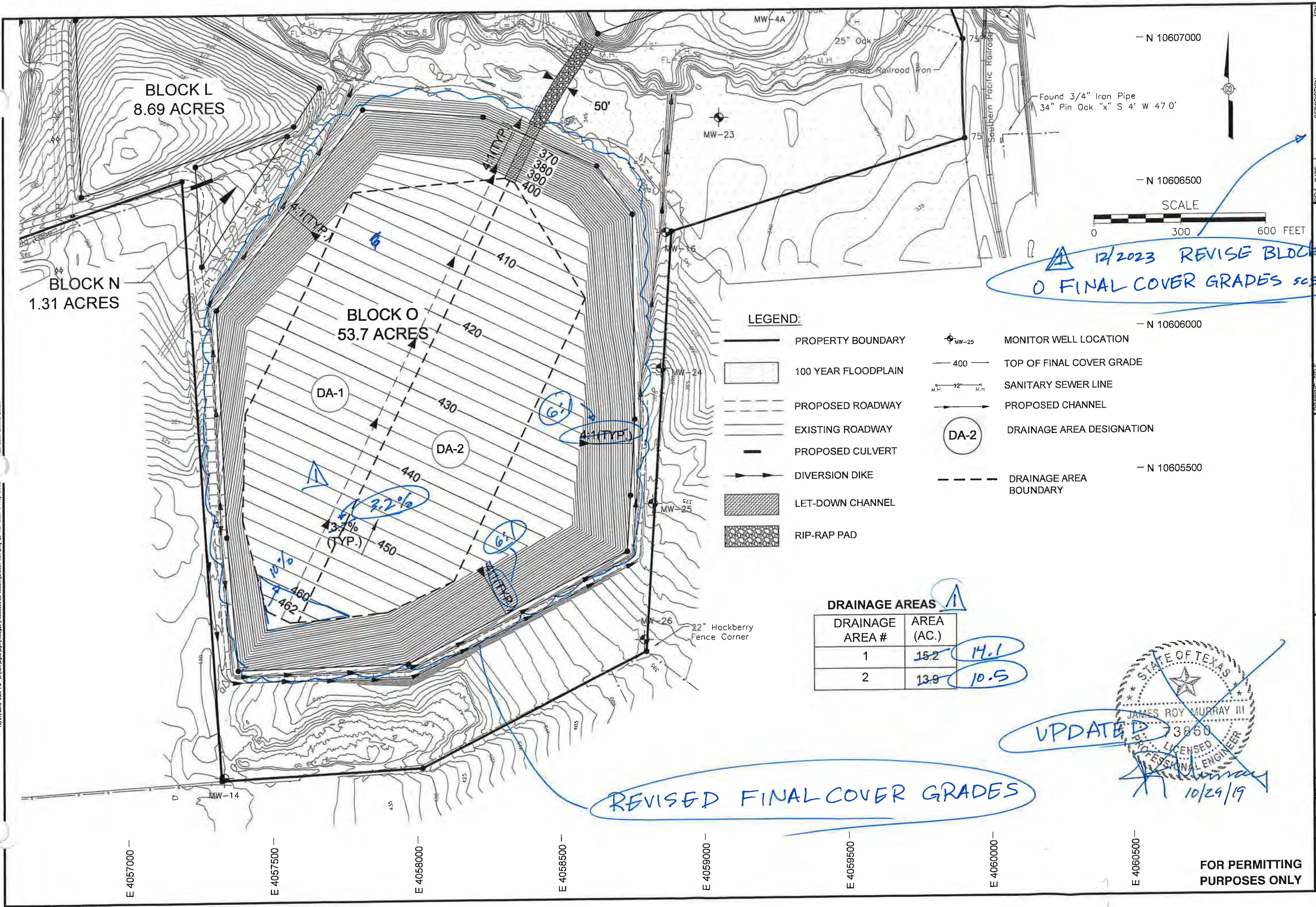
Y_2 = ~~2.9~~ 2.5 Feet = 3.0 Feet (Channel Depth)

Conclusion: The let-down channel will be 26 feet wide at the base and 3 feet deep if it is lined with geomembrane.

Notes:

1 From Trapezoidal Channel Analysis Normal Depth Calculation, see Page III-A6.A-14.16.

2 From the General Equation for a hydraulic jump in a horizontal channel, Chapter 6 of HEC 14.



REVISED FINAL COVER GRADES

LEGEND:

—	PROPERTY BOUNDARY	⌖ MW-25	MONITOR WELL LOCATION
▭	100 YEAR FLOODPLAIN	— 400 —	TOP OF FINAL COVER GRADE
- - -	PROPOSED ROADWAY	M.H. 12" M.H.	SANITARY SEWER LINE
═	EXISTING ROADWAY	→	PROPOSED CHANNEL
▬	PROPOSED CULVERT	DA-2	DRAINAGE AREA DESIGNATION
→→	DIVERSION DIKE	- - - -	DRAINAGE AREA BOUNDARY
▨	LET-DOWN CHANNEL		
▩	RIP-RAP PAD		

DRAINAGE AREAS 1

DRAINAGE AREA #	AREA (AC.)
1	~~15.2~~ 14.1
2	~~13.9~~ 10.5

JAMES ROY MURRAY III
73860
UPDATED
10/29/19

FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
1	12/2023	REVISE BLOCK O FINAL COVER GRADES	SCS

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
BLOCK O PROPOSED DIVERSION DIKE AND LET-DOWN CHANNEL EXHIBIT

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY, TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16209006.21
DSN. BY: JRM
DWN. BY: JG
CHK. BY: JKR
Q/A RVW BY: RE
APP. BY: PJW

CADD FILE:
DWG EX-16A BLOCK O PROP DIVERSION DIKE AND LET-DOWN CHANNEL EXHIBIT

DATE: 8/2019

SCALE: AS SHOWN

DRAWING NO.
EX-16A

PART III, ATTACHMENT 6, APPENDIX A-2

REPLACEMENT PAGES

TOP DOME SURFACE AND EXTERNAL EMBANKMENT SLOPE UNIVERSAL SOIL LOSS EQUATION CALCULATIONS

PART III, ATTACHMENT 6, APPENDIX III-6A-2

Universal Soil Loss Calculation - Block O

	By	Date	Initial
Calculated:	RJE ~~IKR~~	~~7/24/2019~~ 12/5/2023	
Checked:	~~IRM~~ JRM	~~9/28/2019~~ 12/15/2023	

Project: Nacogdoches Municipal Landfill
Project Number: 16209006.~~21~~ 26
Page 1 of 1

Purpose: Determine the rate of max. soil loss of cover for the interim fill periods

Given/Assumptions:

1. Use the TNRCC Procedural Handbook "Use of the Universal Soil Loss Equation in Final Cover/ Configuration Design", October 1993.
2. Design for worst case final cover slope = 25%
3. Cover soil density = 110 lb/cf
4. Vegetative cover - 60%
5. Assume clay loam soil type with 4% organic content

Input Parameters:

Final Cover Slopes:	25 Percent	
Maximum Length of Slope:	~~1930~~ 1890 Feet	
Vegetated Cover Canopy:		
Type:	No canopy	
Percent Coverage	60 Percent	
Cover Organic Content:	4 Percent	
Cover Soil Type:	Clay Loam	
Rainfall Erosion Index (R):	400	See Note 1
Texture Factor (K):	0.21	See Note 2
Cover Factor (C):	0.042	See Note 3
Contouring Factor (P):	1	See Note 4
Topographic Factor (LS):	~~6.01~~ 6.53	See Note 5

Equation:

$A = R*K*LS*C*P$ (Universal Soil Loss Equation)

Solve:

Anticipated Long Term Soil Loss

$A_{(4-30)} =$ ~~21.20~~ 23.04 tons/acre/year < 50.0 tons/acre/year

Notes:

1 From Figure 1 - Average Annual Values of the Rainfall Erosion Index
2 From Table 1 of the USDA, Agricultural Handbook Number 537
3 From Table 2 of the USDA, Agricultural Handbook Number 537
4 From page 187 of the US Department of Commerce Handbook, Predicting Soil Erosion by Water
5 From Figure 4 and Table 4 of the USDA, Agricultural Handbook Number 537.

Topographic Factor for Irregular Slopes

Block O Worst Case Slope: **25%**

Slope(s): 25%, 10%, ~~3.7%~~ 3.2%
Total Slope Length: ~~1930~~ 1890
# of Segments: 2
m: 0.5

ADD new segment 1: 10| 130| 1.65| 0.35| 0.58

Segment	Percent Slope	Slope Length (ft)	Topographic Factor (Figure 4)	Fraction of Soil Loss (Table 4)	Product
~~1~~ 2	~~3.7~~ 3.2	~~1710~~ 1540	~~1~~ 0.85	0.35	~~0.35~~ 0.30
~~2~~ 3	25	220	8.70	0.65	5.66
		1930		**LS=**	~~**6.01**~~ 6.53

Block P Worst Case Slope: **25%**

Slope(s): 25%, 5%
Total Slope Length: 480
# of Segments: 2
m: 0.5

Segment	Percent Slope	Slope Length (ft)	Topographic Factor (Figure 4)	Fraction of Soil Loss (Table 4)	Product
1	5	220	0.79	0.35	0.28
2	25	260	9.50	0.65	6.18
		480		**LS=**	**6.45**

Note: LS values were calculated according to the Irregular Slope method from the USDA Agriculture Handbook Number 537.

PART III, ATTACHMENT 6, APPENDIX B
REPLACEMENT PAGES

PART III, ATTACHMENT 6, APPENDIX B

COMPARISON OF PROPOSED AND PERMIT DRAINAGE CONDITION CALCULATIONS

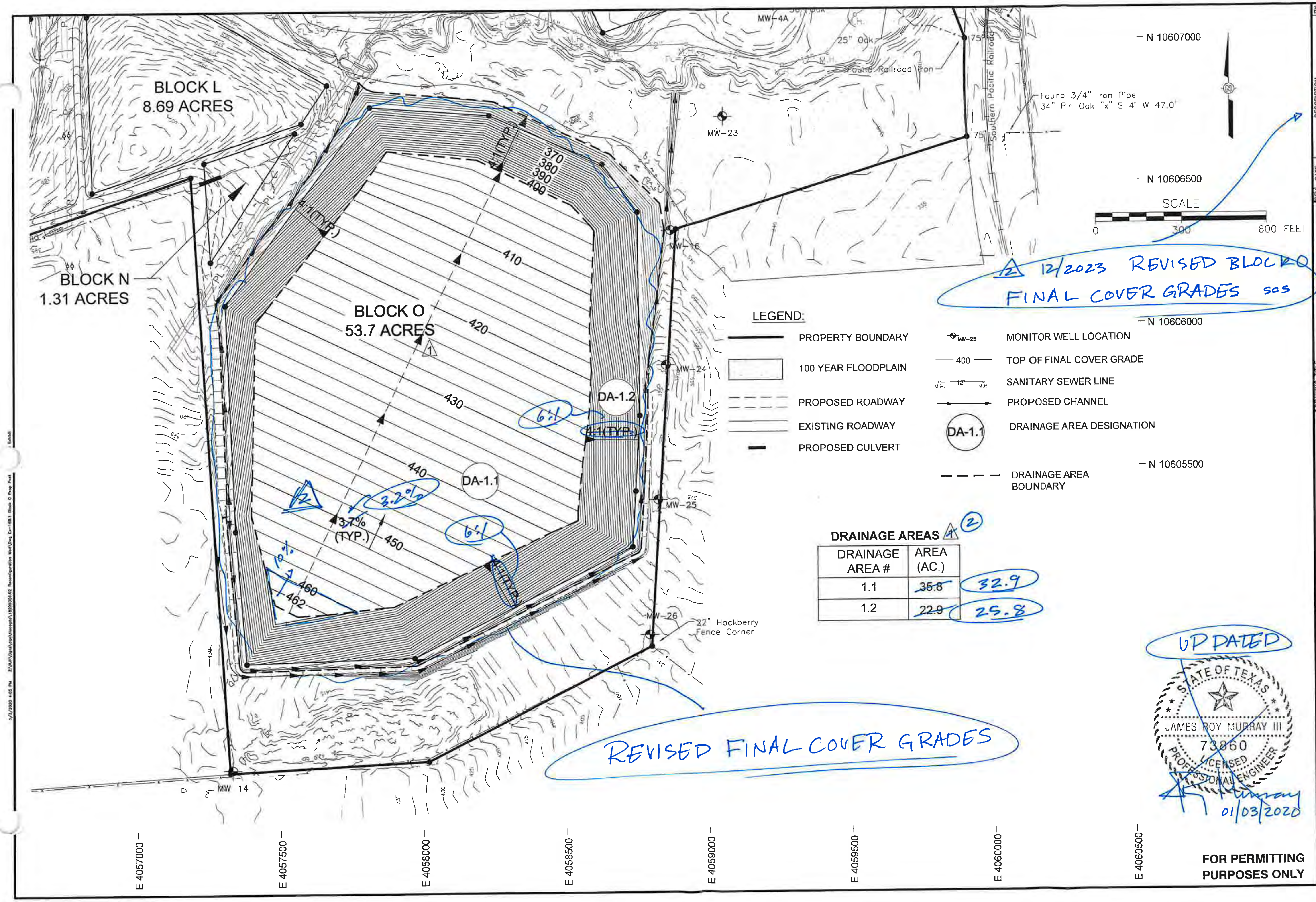
NACOGDOCHES LANDFILL
COMPARISON OF PROPOSED AND PERMIT DRAINAGE CONDITION CALCULATIONS
~~SEPTEMBER 2019~~ DECEMBER 2023

Block	Condition	Contributing Areas	Area	Runoff Coefficient	Overland Flow				Shallow Channel Flow				Channel Flow			Tc	I 25	Q 25-year	Q Total
					Length	Slope	Velocity	Tc	Length	Slope	Velocity	Tc	Length	Velocity	Tc				
			(acres)	new segment	(feet)	(percent)	(feet per second)	(min.)	(feet)	(percent)	(feet per second)	(min.)	(feet)	(feet per second)	(min.)	(min.)	(inches per hour)	(cubic feet per second)	(cubic feet per second)
					130	10.0	1.40	2											
O	Proposed	DA-1.1	~~35.8~~	~~0.41~~	~~400~~	~~3.7~~	~~0.96~~	~~7~~	~~1310~~	~~3.7~~	~~3~~	7	0	5	0	14	~~8.2~~	~~132~~	~~267~~
O	Proposed	DA-1.2	~~22.9~~	0.56	250	25.0	2.50	2	0	0.0	1	0	0	5	0	10	~~9.5~~	~~135~~	
O	Permit	DA-2.1	~~43.3~~	~~0.41~~	~~400~~	~~3.2~~	~~0.85~~	~~8~~	~~1490~~	~~3.2~~	~~2.9~~	~~9~~	~~0~~	~~5~~	~~0~~	~~16~~	~~7.6~~	~~147~~	~~288~~
O	Permit	DA-2.2	~~24.0~~	~~0.56~~	~~250~~	~~25.0~~	~~2.50~~	~~2~~	~~0~~	~~0.0~~	~~1~~	~~0~~	~~0~~	~~5~~	~~0~~	~~10~~	~~9.5~~	~~141~~	
P	Proposed	DA-3.1	7.4	0.43	220	5.0	1.20	3	0	0.0	1	0	0	5	0	10	~~9.5~~	~~33~~	~~139~~
P	Proposed	DA-3.2	18.0	0.56	250	25.0	2.50	2	0	0.0	1	0	0	5	0	10	~~9.5~~	~~106~~	
P	Permit	DA-4.1	15.7	0.40	400	3.0	0.83	8	800	3.0	2.7	5	0	5	0	13	~~8.5~~	~~59~~	~~116~~
P	Permit	DA-4.2	9.7	0.56	125	25.0	2.50	1	0	0.0	1	0	0	5	0	10	~~9.5~~	~~57~~	

Notes:

1. See Exhibits EX-16.B1 through EX-16.B4 for more details about areas, slopes, and drainage lengths.

BLOCK O: Proposed becomes Permitted



△2 12/2023 REVISED BLOCK O FINAL COVER GRADES SCS

REVISED FINAL COVER GRADES

LEGEND:

▬	PROPERTY BOUNDARY
▭	100 YEAR FLOODPLAIN
- - -	PROPOSED ROADWAY
═	EXISTING ROADWAY
▬	PROPOSED CULVERT
⌖ MW-25	MONITOR WELL LOCATION
— 400 —	TOP OF FINAL COVER GRADE
M.H. 12" M.H.	SANITARY SEWER LINE
→	PROPOSED CHANNEL
DA-1.1	DRAINAGE AREA DESIGNATION
— — —	DRAINAGE AREA BOUNDARY

DRAINAGE AREAS △1 ②

DRAINAGE AREA #	AREA (AC.)	
1.1	~~35.8~~	32.9
1.2	~~22.9~~	25.8

UPDATED

JAMES ROY MURRAY III
73860

Murray
01/03/2020

FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
△1	8/2019	REVISE BLOCK O	SCS
△2	1/2020	REVISED DRAINAGE AREA CALL OUTS	SCS
△			
△			
△			
△			

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
BLOCK O PROPOSED POST DEVELOPMENT DRAINAGE EXHIBIT

PROJECT TITLE
LANDFILL RECONFIGURATION PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY, TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16209006.21	DWN. BY: JG	Q/A RVW BY: RE
DSN. BY: JRM	CHK. BY: JKR	APP. BY: PJW

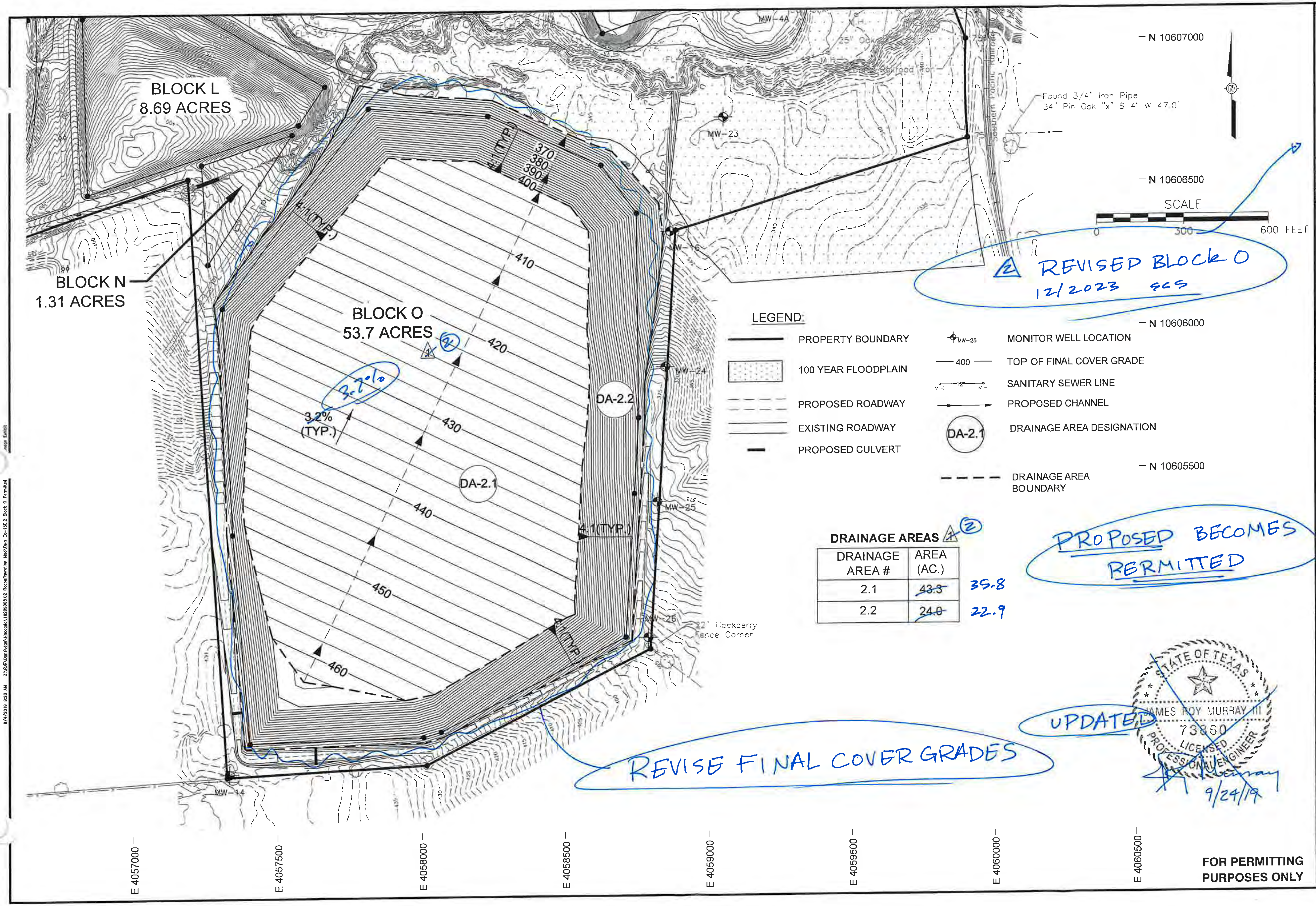
CADD FILE: DWG EX-16B.1 BLOCK O PROP POST DEV DRAINAGE EXHIBIT

DATE: 8/2019

SCALE: AS SHOWN

DRAWING NO.
EX-16B.1

1/3/2020 4:05 PM Z:\[illegible]\16209006.02 Reconfiguration Mod\Dwg Ex-16B.1 Block O Prop Post Exhibit



3.2%

2

REVISED BLOCK O
12/2023 SCS

DRAINAGE AREAS ~~1~~ 2

DRAINAGE AREA #	AREA (AC.)
2.1	~~43.3~~ 35.8
2.2	~~24.0~~ 22.9

PROPOSED BECOMES PERMITTED

UPDATED

REVISE FINAL COVER GRADES

JAMES ROY MURRAY III
73860
9/24/19

FOR PERMITTING PURPOSES ONLY

9/4/2019 9:28 AM Z:\RJR\Dgns\dgn\Nacogdo\16209006.02 Reconfiguration Mod\Dwg Ex-16B.2 Block O Permitted ...age Exhibit

REV	DATE	DESCRIPTION	BY
~~1~~ 2	8/2019	REVISE BLOCK O	SCS

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
BLOCK O PERMITTED POST
DEVELOPMENT DRAINAGE EXHIBIT

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16209006.21
DWN. BY: JG
Q/A RVW BY: RE
DSN. BY: JRM
CHK. BY: JKR
APP. BY: JKR

CADD FILE:
DWG EX-16B.2 BLOCK O PERMITTED POST DEV DRAINAGE EXHIBIT

DATE:
8/2019

SCALE:
AS SHOWN

DRAWING NO.
EX-16B.2

PART III, ATTACHMENT 6, APPENDIX C

REPLACEMENT PAGES

PART III, ATTACHMENT 6, APPENDIX C

BLOCK O POST DEVELOPMENT DRAINAGE

NACOGDOCHES LANDFILL
DEVELOPED RATIONAL METHOD DRAINAGE FEATURE CALCULATIONS

~~OCTOBER 2019~~ DECEMBER 2023

Channel	Contributing Drainage Areas	Area	Runoff Coefficient	Overland Flow				Shallow Channel Flow				Channel Flow			Tc	I 25	I 100	Q 25-year	Q 100-year
				Length	Slope	Velocity	Tc	Length	Slope	Velocity	Tc	Length	Velocity	Tc					
		(acres)		(feet)	(percent)	(feet per second)	(min.)	(feet)	(percent)	(feet per second)	(min.)	(feet)	(feet per second)	(min.)	(min.)	(inches per hour)	(inches per hour)	(cubic feet per second)	(cubic feet per second)
Perimeter Channels																			
1	1	8.6	0.63	400	3.7	0.96	6.9	700	3.7	3	3.9	100	5	0.3	11.2	9.1	10.7	54	72
2a	6	4.0	0.70	65	25.0	2.50	0.4	0	0.0	1	0.0	1050	5	3.5	10.0	9.5	11.2	29	39
2b	2, 6	8.1	0.70	300	5.0	1.20	4.2	0	0.0	1	0.0	450	5	1.5	10.0	9.5	11.2	60	79
3	2, 3, 6	20.2	0.61	400	3.7	0.96	6.9	1260	3.7	3	7.0	0	5	0.0	13.9	8.2	9.7	112	150
4	2, 3, 4, 6	25.5	0.57	400	3.7	0.96	6.9	1260	3.7	3	7.0	185	5	0.6	14.6	8.1	9.5	129	173
5	2, 3, 4, 5, 6	37.3	0.52	400	3.7	0.96	6.9	1260	3.7	3	7.0	455	5	1.5	15.5	7.8	9.3	166	223
6a	OS-6.1	2.8	0.20	200	5.0	1.20	2.8	0	0.0	1	0.0	675	5	2.3	10.0	9.5	11.2	6	8
6b	OS-6.1, OS-6.2	14.4	0.20	300	5.0	1.20	4.2	0	0.0	1	0.0	150	5	0.5	10.0	9.5	11.2	30	40
6c	OS-6.1, OS-6.2, OS-6.3	15.1	0.20	400	5.0	1.20	5.6	370	5.0	1	6.2	150	5	0.5	12.2	8.8	10.3	29	39

new segment

III-A6.C-1

SCS Engineers
TBPE Reg. # F-3407

JAMES ROY MURRAY III
73860

01/03/2020

channelflows 01032020

```
                 TRAPEZOIDAL CHANNEL ANALYSIS
                  NORMAL DEPTH COMPUTATION

                      October 22, 2019
```

Channel 1A

```
==============================================================================
                       PROGRAM INPUT DATA
DESCRIPTION                                                             VALUE
------------------------------------------------------------------------------
Flow Rate (cfs)............................................           54.0
Channel Bottom Slope (ft/ft)...............................            0.051
Manning's Roughness Coefficient (n-value)..................            0.033
Channel Left Side Slope (horizontal/vertical)..............            3.0
Channel Right Side Slope (horizontal/vertical).............            3.0
Channel Bottom Width (ft)..................................            0.1

==============================================================================
                      COMPUTATION RESULTS
DESCRIPTION                                                             VALUE
------------------------------------------------------------------------------
Normal Depth (ft)..........................................            1.48
Flow Velocity (fps)........................................            8.07
Froude Number..............................................            1.646
Velocity Head (ft).........................................            1.01
Energy Head (ft)...........................................            2.49
Cross-Sectional Area of Flow (sq ft).......................            6.69
Top Width of Flow (ft).....................................            8.96

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

< 2'

→ use Turf Mat

∴ use 

with Turf Mat

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 22, 2019
                           Channel 1B
===============================================================================
                        PROGRAM INPUT DATA
                                                                    VALUE
DESCRIPTION
-------------------------------------------------------------------------------
Flow Rate (cfs)............................................        54.0
Channel Bottom Slope (ft/ft)...............................         0.065
Manning's Roughness Coefficient (n-value)..................         0.033
Channel Left Side Slope (horizontal/vertical)..............         3.0
Channel Right Side Slope (horizontal/vertical).............         3.0
Channel Bottom Width (ft)..................................         0.1

===============================================================================
                       COMPUTATION RESULTS
                                                                    VALUE
DESCRIPTION
-------------------------------------------------------------------------------
Normal Depth (ft)..........................................          1.41 < 2'
Flow Velocity (fps)........................................          8.84 → use Turf Mat
Froude Number..............................................          1.845
Velocity Head (ft).........................................          1.21
Energy Head (ft)...........................................          2.62
Cross-Sectional Area of Flow (sq ft).......................          6.11
Top Width of Flow (ft).....................................          8.56

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

∴ Use

with Turf Mat

REPLACED RAGE

```
               TRAPEZOIDAL CHANNEL ANALYSIS
                 NORMAL DEPTH COMPUTATION

                     October 22, 2019
                       Channel 1C
=============================================================================
                       PROGRAM INPUT DATA
DESCRIPTION                                                           VALUE
-----------------------------------------------------------------------------
Flow Rate (cfs)...............................................      54.0
Channel Bottom Slope (ft/ft)..................................       0.047
Manning's Roughness Coefficient (n-value).....................       0.033
Channel Left Side Slope (horizontal/vertical).................       3.0
Channel Right Side Slope (horizontal/vertical)................       3.0
Channel Bottom Width (ft).....................................       0.1

=============================================================================
                      COMPUTATION RESULTS
DESCRIPTION                                                           VALUE
-----------------------------------------------------------------------------
Normal Depth (ft).............................................       1.5 < 2'
Flow Velocity (fps)...........................................       7.83 → Use Turf Mat
Froude Number.................................................       1.584
Velocity Head (ft)............................................       0.95
Energy Head (ft)..............................................       2.45
Cross-Sectional Area of Flow (sq ft)..........................       6.9
Top Width of Flow (ft)........................................       9.1

=============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

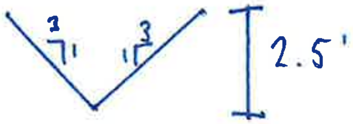
∴ Use

with Turf Mat

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                      NORMAL DEPTH COMPUTATION

                          October 22, 2019
                          Channel 2A
========================================================================
                          PROGRAM INPUT DATA
                                                                  VALUE
DESCRIPTION
------------------------------------------------------------------------
Flow Rate (cfs)..................................................  29.0
Channel Bottom Slope (ft/ft).....................................   0.0267
Manning's Roughness Coefficient (n-value)........................   0.033
Channel Left Side Slope (horizontal/vertical)....................   3.0
Channel Right Side Slope (horizontal/vertical)...................   3.0
Channel Bottom Width (ft)........................................   0.1

========================================================================
                         COMPUTATION RESULTS
                                                                  VALUE
DESCRIPTION
------------------------------------------------------------------------
Normal Depth (ft)................................................   1.32 <2.5'
Flow Velocity (fps)..............................................   5.42 → Use Turf Mat
Froude Number....................................................   1.17
Velocity Head (ft)...............................................   0.46
Energy Head (ft).................................................   1.78
Cross-Sectional Area of Flow (sq ft).............................   5.35
Top Width of Flow (ft)...........................................   8.01

========================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

∴ Use

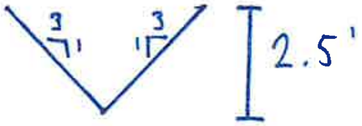


with Turf Mat

REPLACED PAGE

```
                 TRAPEZOIDAL CHANNEL ANALYSIS
                  NORMAL DEPTH COMPUTATION

                     October 29, 2019
                      Channel 2B
==========================================================================
                      PROGRAM INPUT DATA
                                                                     VALUE
DESCRIPTION
--------------------------------------------------------------------------
Flow Rate (cfs)...............................................    60.0
Channel Bottom Slope (ft/ft)..................................     0.021
Manning's Roughness Coefficient (n-value).....................     0.033
Channel Left Side Slope (horizontal/vertical).................     3.0
Channel Right Side Slope (horizontal/vertical)................     3.0
Channel Bottom Width (ft).....................................     0.1

==========================================================================
                     COMPUTATION RESULTS
                                                                     VALUE
DESCRIPTION
--------------------------------------------------------------------------
Normal Depth (ft)...............................................    1.82 <2.5'
Flow Velocity (fps).............................................    5.95 ⟶ Use Turf Mat
Froude Number...................................................    1.096
Velocity Head (ft)..............................................    0.55
Energy Head (ft)................................................    2.37
Cross-Sectional Area of Flow (sq ft)............................   10.08
Top Width of Flow (ft)..........................................   11.0

==========================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

∴ Use



With Turf Mat

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 29, 2019
```

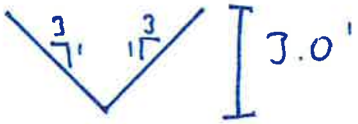
Channel 3A

```
==============================================================================
                         PROGRAM INPUT DATA
                                                                   VALUE
DESCRIPTION
------------------------------------------------------------------------------
Flow Rate (cfs)..............................................    112.0
Channel Bottom Slope (ft/ft).................................      0.024
Manning's Roughness Coefficient (n-value)....................      0.033
Channel Left Side Slope (horizontal/vertical)................      3.0
Channel Right Side Slope (horizontal/vertical)...............      3.0
Channel Bottom Width (ft)....................................      0.1

==============================================================================
                        COMPUTATION RESULTS
                                                                   VALUE
DESCRIPTION
------------------------------------------------------------------------------
Normal Depth (ft)............................................      2.24
Flow Velocity (fps)..........................................      7.32
Froude Number................................................      1.214
Velocity Head (ft)...........................................      0.83
Energy Head (ft).............................................      3.07
Cross-Sectional Area of Flow (sq ft).........................     15.31
Top Width of Flow (ft).......................................     13.55

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

2.24 < 3.0'

7.32 → Use Turf Mat

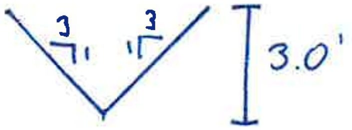
∴ Use



With Turf Mat

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 29, 2019
                           Channel 3B
===============================================================================
                        PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Flow Rate (cfs)..............................................      112.0
Channel Bottom Slope (ft/ft).................................        0.058
Manning's Roughness Coefficient (n-value)....................        0.033
Channel Left Side Slope (horizontal/vertical)................        3.0
Channel Right Side Slope (horizontal/vertical)...............        3.0
Channel Bottom Width (ft)....................................        0.1

===============================================================================
                       COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Normal Depth (ft)............................................        1.9 <3.0'
Flow Velocity (fps)..........................................       10.18 ---> Use Turf Mat
Froude Number................................................        1.835
Velocity Head (ft)...........................................        1.61
Energy Head (ft).............................................        3.51
Cross-Sectional Area of Flow (sq ft).........................       11.0
Top Width of Flow (ft).......................................       11.49

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```



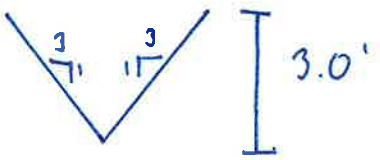
With Turf Mat

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                      NORMAL DEPTH COMPUTATION

                          October 29, 2019
```

Channel 3C

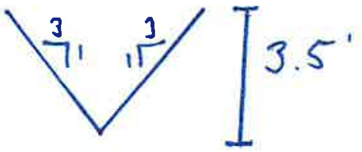
```
================================================================================
                          PROGRAM INPUT DATA
                                                                         VALUE
DESCRIPTION
--------------------------------------------------------------------------------
Flow Rate (cfs)............................................            112.0
Channel Bottom Slope (ft/ft)...............................              0.04
Manning's Roughness Coefficient (n-value)..................              0.033
Channel Left Side Slope (horizontal/vertical)..............              3.0
Channel Right Side Slope (horizontal/vertical).............              3.0
Channel Bottom Width (ft)..................................              0.1

================================================================================
                         COMPUTATION RESULTS
                                                                         VALUE
DESCRIPTION
--------------------------------------------------------------------------------
Normal Depth (ft)..........................................               2.04 < 3.0' → Use Turf Mat
Flow Velocity (fps)........................................               8.86
Froude Number..............................................               1.542
Velocity Head (ft).........................................               1.22
Energy Head (ft)...........................................               3.26
Cross-Sectional Area of Flow (sq ft).......................              12.64
Top Width of Flow (ft).....................................              12.32

================================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```



With Turf Mat

REPLACED PAGE

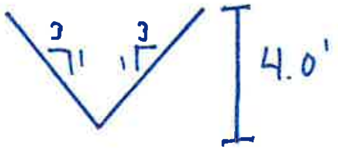
```
                  TRAPEZOIDAL CHANNEL ANALYSIS
                    NORMAL DEPTH COMPUTATION

                        October 29, 2019
                           Channel 4
=============================================================================
                       PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
-----------------------------------------------------------------------------
Flow Rate (cfs)..........................................         129.0
Channel Bottom Slope (ft/ft).............................           0.013
Manning's Roughness Coefficient (n-value)................           0.033
Channel Left Side Slope (horizontal/vertical)............           3.0
Channel Right Side Slope (horizontal/vertical)...........           3.0
Channel Bottom Width (ft)................................           0.1

=============================================================================
                      COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
-----------------------------------------------------------------------------
Normal Depth (ft)........................................           2.66 < 3.5'
Flow Velocity (fps)......................................           6.01 ——> Use Turf Mat
Froude Number............................................           0.917
Velocity Head (ft).......................................           0.56
Energy Head (ft).........................................           3.22
Cross-Sectional Area of Flow (sq ft).....................          21.45
Top Width of Flow (ft)...................................          16.04

=============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```



With Turf Mat

REPLACED PAGE

```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 29, 2019
                           Channel 5
===============================================================================
                         PROGRAM INPUT DATA
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Flow Rate (cfs)..........................................         166.0
Channel Bottom Slope (ft/ft).............................           0.012
Manning's Roughness Coefficient (n-value)................           0.033
Channel Left Side Slope (horizontal/vertical)............           3.0
Channel Right Side Slope (horizontal/vertical)...........           3.0
Channel Bottom Width (ft)................................           0.1

===============================================================================
                        COMPUTATION RESULTS
DESCRIPTION                                                          VALUE
-------------------------------------------------------------------------------
Normal Depth (ft)........................................            2.97 < 4.0'
Flow Velocity (fps)......................................            6.22 ——> Use Turf Mat
Froude Number............................................            0.897
Velocity Head (ft).......................................            0.6
Energy Head (ft).........................................            3.57
Cross-Sectional Area of Flow (sq ft).....................           26.71
Top Width of Flow (ft)...................................           17.9

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```



With Turf Mat

REPLACED PAGE

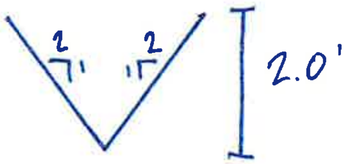
```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                     NORMAL DEPTH COMPUTATION

                         October 29, 2019
```

Channel 6A

```
=============================================================================
                         PROGRAM INPUT DATA
DESCRIPTION                                                           VALUE
-----------------------------------------------------------------------------
Flow Rate (cfs)..............................................      6.0
Channel Bottom Slope (ft/ft).................................      0.017
Manning's Roughness Coefficient (n-value)....................      0.033
Channel Left Side Slope (horizontal/vertical)................      2.0
Channel Right Side Slope (horizontal/vertical)...............      2.0
Channel Bottom Width (ft)....................................      0.1

=============================================================================
                        COMPUTATION RESULTS
DESCRIPTION                                                           VALUE
-----------------------------------------------------------------------------
Normal Depth (ft)............................................      0.92
Flow Velocity (fps)..........................................      3.33
Froude Number................................................      0.852
Velocity Head (ft)...........................................      0.17
Energy Head (ft).............................................      1.1
Cross-Sectional Area of Flow (sq ft).........................      1.8
Top Width of Flow (ft).......................................      3.8

=============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

< 2'

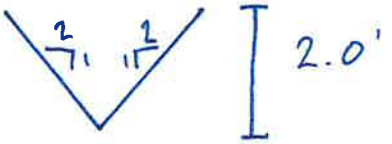
< 5.0 fps



Grass Lined

REPLACED PAGE

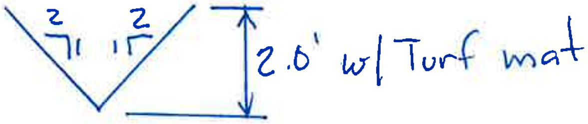
```
                    TRAPEZOIDAL CHANNEL ANALYSIS
                      NORMAL DEPTH COMPUTATION

                          October 29, 2019
                          Channel 6B
===============================================================================
                          PROGRAM INPUT DATA
DESCRIPTION                                                            VALUE
-------------------------------------------------------------------------------
Flow Rate (cfs)............................................          30.0
Channel Bottom Slope (ft/ft)...............................           0.036
Manning's Roughness Coefficient (n-value)..................           0.033
Channel Left Side Slope (horizontal/vertical)..............           2.0
Channel Right Side Slope (horizontal/vertical).............           2.0
Channel Bottom Width (ft)..................................           0.1

===============================================================================
                         COMPUTATION RESULTS
DESCRIPTION                                                            VALUE
-------------------------------------------------------------------------------
Normal Depth (ft)..........................................            1.49 <2.0'
Flow Velocity (fps)........................................            6.57 → Use Turf Mat
Froude Number..............................................            1.334
Velocity Head (ft).........................................            0.67
Energy Head (ft)...........................................            2.16
Cross-Sectional Area of Flow (sq ft).......................            4.56
Top Width of Flow (ft).....................................            6.04

===============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```



With Turf Mat

REPLACED PAGE

```
                  TRAPEZOIDAL CHANNEL ANALYSIS
                   NORMAL DEPTH COMPUTATION

                        January 3, 2020
                       Channel 6C
==============================================================================
                        PROGRAM INPUT DATA
DESCRIPTION                                                        VALUE
------------------------------------------------------------------------------
Flow Rate (cfs)...............................................    29.0
Channel Bottom Slope (ft/ft)..................................     0.019
Manning's Roughness Coefficient (n-value).....................     0.033
Channel Left Side Slope (horizontal/vertical).................     2.0
Channel Right Side Slope (horizontal/vertical)................     2.0
Channel Bottom Width (ft).....................................     0.1

==============================================================================
                       COMPUTATION RESULTS
DESCRIPTION                                                        VALUE
------------------------------------------------------------------------------
Normal Depth (ft).............................................     1.66 < 2.0'
Flow Velocity (fps)...........................................     5.14 → Use turf
Froude Number.................................................     0.988  mat
Velocity Head (ft)............................................     0.41
Energy Head (ft)..............................................     2.07
Cross-Sectional Area of Flow (sq ft)..........................     5.64
Top Width of Flow (ft)........................................     6.72

==============================================================================
HYDROCALC Hydraulics for Windows, Version 2.0.1, Copyright(c) 1996-2010
Dodson & Associates, Inc., 5629 FM 1960 West, Suite 314, Houston, TX 77069
Email:software@dodson-hydro.com, All Rights Reserved.
```

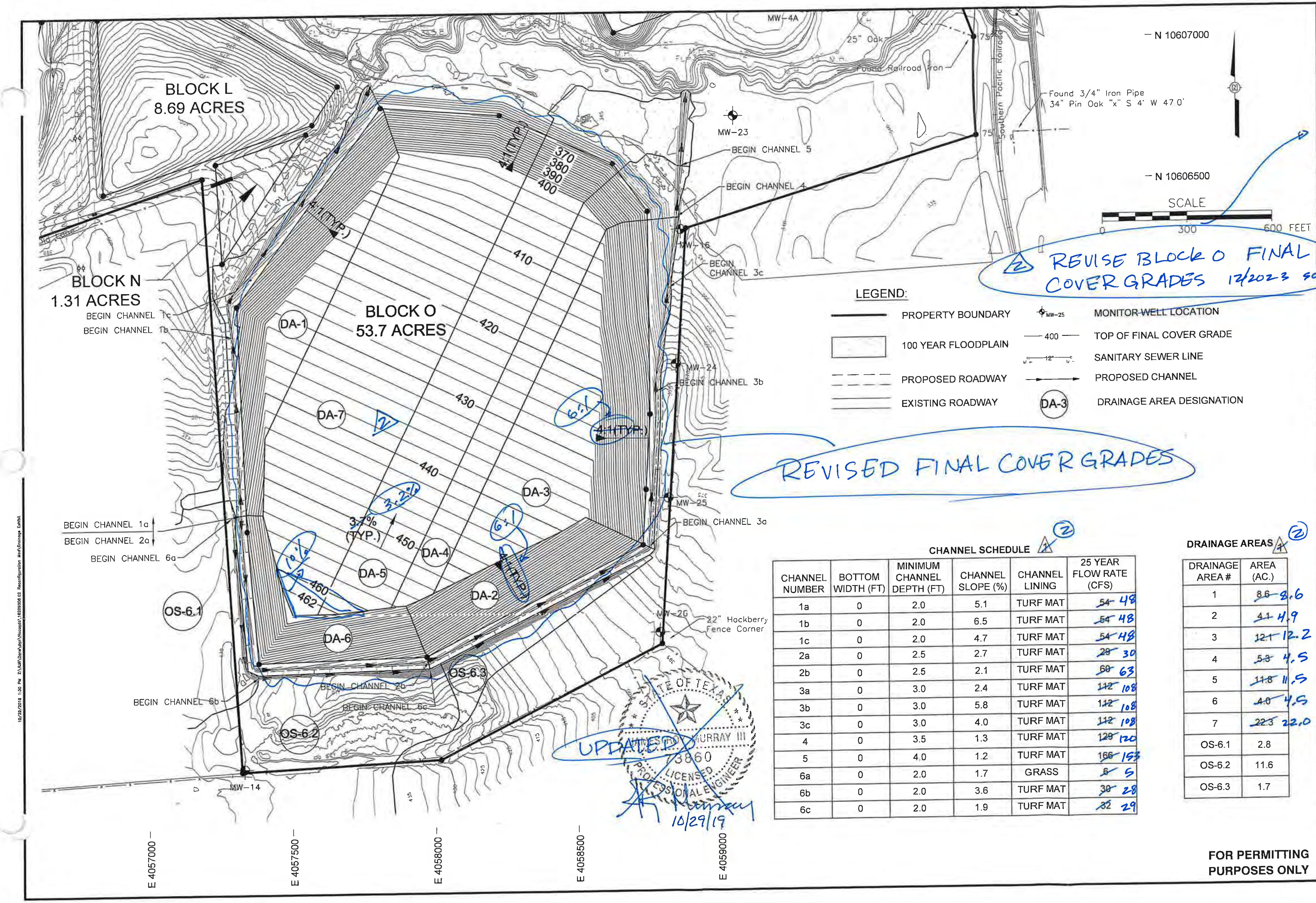


REPLACED PAGE

~~SCS Engineers~~
~~TBPE Reg. # F-3407~~

~~JAMES ROY MURRAY III~~
~~73860~~

~~J R Murray~~
01/03/2020



2 REVISE BLOCK O FINAL COVER GRADES 12/2023 SCS

REVISED FINAL COVER GRADES

UPDATED

MURRAY III
3860
10/29/19

LEGEND:

PROPERTY BOUNDARY
100 YEAR FLOODPLAIN
PROPOSED ROADWAY
EXISTING ROADWAY
MW-25 MONITOR WELL LOCATION
400 TOP OF FINAL COVER GRADE
12" SANITARY SEWER LINE
PROPOSED CHANNEL
DA-3 DRAINAGE AREA DESIGNATION

CHANNEL SCHEDULE ~~1~~ 2

CHANNEL NUMBER	BOTTOM WIDTH (FT)	MINIMUM CHANNEL DEPTH (FT)	CHANNEL SLOPE (%)	CHANNEL LINING	25 YEAR FLOW RATE (CFS)
1a	0	2.0	5.1	TURF MAT	~~54~~ 48
1b	0	2.0	6.5	TURF MAT	~~54~~ 48
1c	0	2.0	4.7	TURF MAT	~~54~~ 48
2a	0	2.5	2.7	TURF MAT	~~29~~ 30
2b	0	2.5	2.1	TURF MAT	~~60~~ 63
3a	0	3.0	2.4	TURF MAT	~~112~~ 108
3b	0	3.0	5.8	TURF MAT	~~112~~ 108
3c	0	3.0	4.0	TURF MAT	~~112~~ 108
4	0	3.5	1.3	TURF MAT	~~129~~ 120
5	0	4.0	1.2	TURF MAT	~~166~~ 153
6a	0	2.0	1.7	GRASS	~~6~~ 5
6b	0	2.0	3.6	TURF MAT	~~30~~ 28
6c	0	2.0	1.9	TURF MAT	~~32~~ 29

DRAINAGE AREAS ~~1~~ 2

DRAINAGE AREA #	AREA (AC.)
1	~~8.6~~ 8.6
2	~~4.1~~ 4.9
3	~~12.1~~ 12.2
4	~~5.3~~ 4.5
5	~~11.8~~ 11.5
6	~~4.0~~ 4.5
7	~~22.3~~ 22.0
OS-6.1	2.8
OS-6.2	11.6
OS-6.3	1.7

FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
1	8/2019	REVISE BLOCK O	SCS

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
BLOCK O POST DEVELOPMENT DRAINAGE EXHIBIT

PROJECT TITLE
LANDFILL RECONFIGURATION PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY, TEXAS

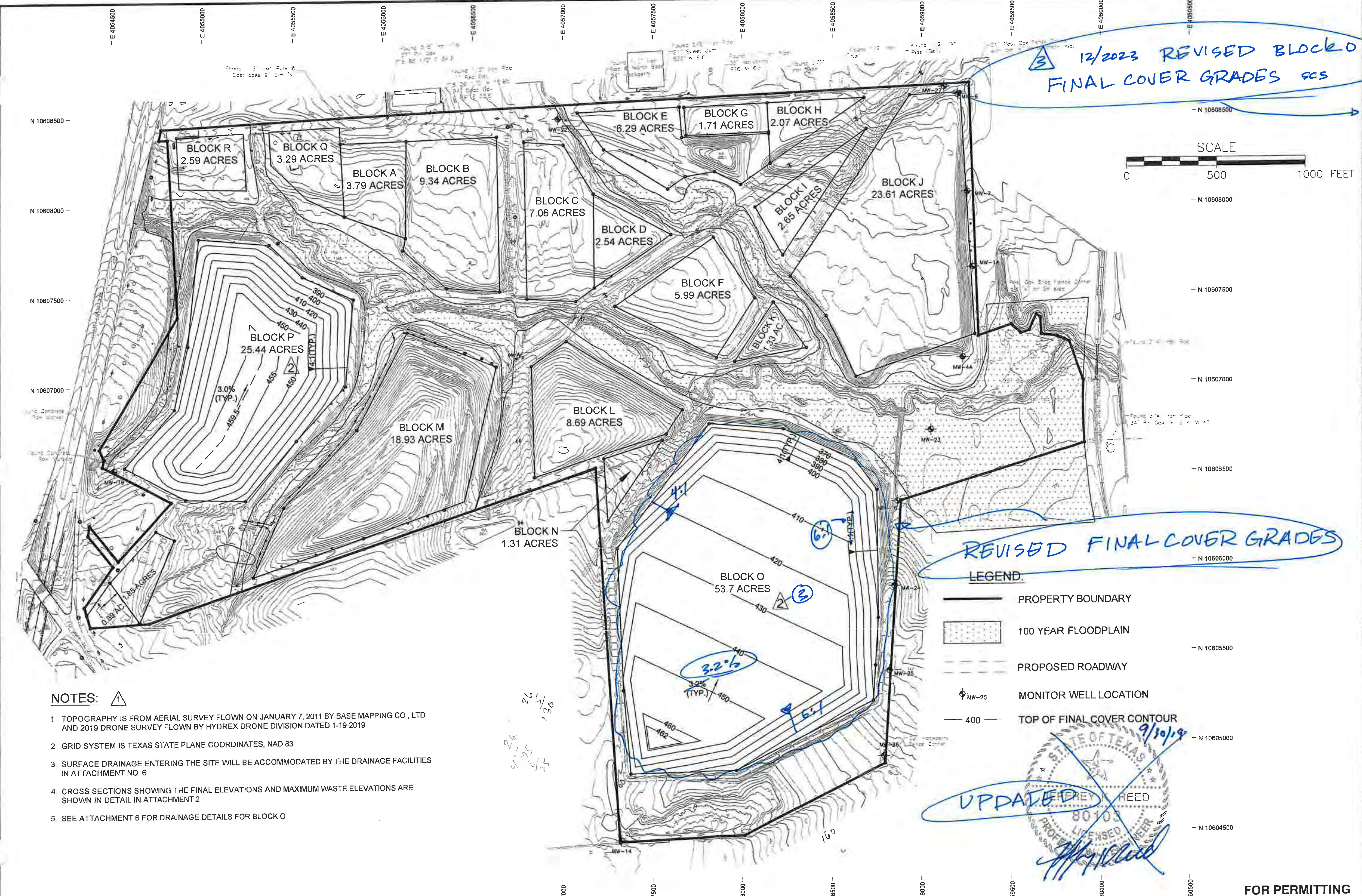
SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

Q/A RVW BY: PJW
APP. BY: JKR
DWN. BY: JG
CHK. BY: JKR
PROJ. NO. 16209006.21
DSN BY: JRM

CADD FILE: DRAINAGE EXHIBIT
DATE: 8–2019
SCALE: AS SHOWN
DRAWING NO.
EX-16C.1

10/28/2019 1:30 PM Z:\RJR\Dane\dgn\Nacogdo\16209006.02 Reconfiguration Mod\Drainage Exhibit

PART III, ATTACHMENT 7
REPLACEMENT PAGES



12/2023 REVISED BLOCK O FINAL COVER GRADES SCS

REVISED FINAL COVER GRADES

4:1

6:1

3.2%

6:1

UPDATED

9/30/19

JEFFREY L. REED
80103

NOTES: △1

1 TOPOGRAPHY IS FROM AERIAL SURVEY FLOWN ON JANUARY 7, 2011 BY BASE MAPPING CO , LTD AND 2019 DRONE SURVEY FLOWN BY HYDREX DRONE DIVISION DATED 1-19-2019

2 GRID SYSTEM IS TEXAS STATE PLANE COORDINATES, NAD 83

3 SURFACE DRAINAGE ENTERING THE SITE WILL BE ACCOMMODATED BY THE DRAINAGE FACILITIES IN ATTACHMENT NO 6

4 CROSS SECTIONS SHOWING THE FINAL ELEVATIONS AND MAXIMUM WASTE ELEVATIONS ARE SHOWN IN DETAIL IN ATTACHMENT 2

5 SEE ATTACHMENT 6 FOR DRAINAGE DETAILS FOR BLOCK O

LEGEND

▬	PROPERTY BOUNDARY
▨	100 YEAR FLOODPLAIN
- - -	PROPOSED ROADWAY
⊕ MW-25	MONITOR WELL LOCATION
— 400 —	TOP OF FINAL COVER CONTOUR

FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	BY
△1	6/2011	REVISED BLOCKS P&O GRADES	SCS
△2	8/2019	REVISED BLOCKS P&O GRADES	SCS
△			
△			
△			
△			

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
III.11.G ATTACHMENT 7 -
FINAL CONTOUR MAP

PROJECT TITLE
LANDFILL RECONFIGURATION
PERMIT MODIFICATION

CLIENT
CITY OF NACOGDOCHES
LANDFILL
PERMIT NO. MSW-720
NACOGDOCHES, NACOGDOCHES COUNTY,
TEXAS

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
12651 BRIAR FOREST, SUITE 205, HOUSTON, TX 77077
PH (281) 397-6747 FAX NO. (281) 293-7878

PROJ. NO. 16209006.02	DWN. BY: RLD	Q/A RVW BY: JRM
DSN. BY: RLD	CHK. BY: JKR	APP. BY: JKR

CADD FILE: DWG 7A – FINAL CONTOUR MAP

DATE: 6–2011

SCALE: AS SHOWN

DRAWING NO.
7A

PART III, ATTACHMENT 10
REPLACEMENT PAGES

CITY OF NACOGDOCHES LANDFILL
NACOGDOCHES COUNTY, TEXAS
TCEQ PERMIT NO. MSW-720

PART III - SITE DEVELOPMENT PLAN
ATTACHMENT 10
SOIL AND LINER QUALITY CONTROL PLAN

Prepared for:

CITY OF NACOGDOCHES

Prepared by:

SCS ENGINEERS
TBPE Registration No. F-3407
Houston Office
12651 Briar Forest, Suite 205
Houston, Texas 77077
281/293-8494

Revision 0 – July 2013
Revision 1 – January 2014
Revision 2 – January 2020
Revision 3 – January 2024
SCS Project No. 16209006.~~11~~26

TABLE OF CONTENTS

Appendices

PART III, ATTACHMENT 10, APPENDIX 10D
REPLACEMENT PAGES

SCS ENGINEERS

CITY OF NACOGDOCHES LANDFILL
BLOCK O SAMPLE CALCULATION

BALLAST CALCULATION @ PT 1

Soil Only Scenario

BOTTOM LINER		BALLAST CALCULATIONS					
LAYER NO.	BALLAST MATERIAL	LAYER THICKNESS (FT.)	ELEV. AT TOP OF LAYER	WET UNIT WEIGHT (PCF)	RESISTING PRESSURE (PSF)	REQ'D SAFETY FACTOR	REDUCED RES. PRESS. (PSF)
1	Final Cover	0.0		120.0	0.00		
2	Waste	0.0	385.48	44.4	-0.72		#DIV/0!
3	Protective Cover	2.5	385.50	120.0	300.00	1.2	250.00
TOTAL OFF-SETTING BALLAST (PSF)							#DIV/0!
HYDROSTATIC PRESSURE CALCULATION							
GW ELEV (FT.)	Final Cover ELEV (FT.)	FML ELEV (FT.)			HYDROSTATIC PRESS. (PSF)		
387.00	431	383.0			249.60		
REQUIRED WASTE THICKNESS NEEDED FOR BALLAST (FEET)							0.0
WASTE THICKNESS AVAILABLE (FEET)							43.0

BALLAST CALCULATION @ PT 2

Waste as Ballast Scenario

BOTTOM LINER		BALLAST CALCULATIONS					
LAYER NO.	BALLAST MATERIAL	LAYER THICKNESS (FT.)	ELEV. AT TOP OF LAYER	WET UNIT WEIGHT (PCF)	RESISTING PRESSURE (PSF)	REQ'D SAFETY FACTOR	REDUCED RES. PRESS. (PSF)
1	Final Cover	0.0		120.0	0.00	1.5	0.00
2	Waste	20.1	406.58	44.4	891.36	1.5	594.24
3	Protective Cover	2.0	386.50	120.0	240.00	1.5	160.00
TOTAL OFF-SETTING BALLAST (PSF)							754.24
HYDROSTATIC PRESSURE CALCULATION							
GW ELEV (FT.)	Final Cover ELEV (FT.)	FML ELEV (FT.)			HYDROSTATIC PRESS. (PSF)		
395.00	420.5	384.5			655.20		
REQUIRED WASTE THICKNESS NEEDED FOR BALLAST (FEET)							20.1
WASTE THICKNESS AVAILABLE (FEET)							31.0

Note: Clay Liner is assumed to be saturated, therefore no contribution to ballast.
Conclusion: Sufficient Soil and waste ballast exists for Low Point based on above parameters. Data to be confirmed in the BER analysis.

SCS Engineers
TBPE Firm Reg. # F-3407
12651 Briar Forest
Suite 205
Houston, TX 77077

JEFFREY K. REED
80103
8/15/13

PE STAMP

FOR PERMITTING PURPOSES ONLY

UPDATED

PART III, ATTACHMENT 10, APPENDIX 10E

REPLACEMENT PAGES

CITY OF NACOGDOCHES LANDFILL
NACOGDOCHES COUNTY, TEXAS
TCEQ PERMIT NO. MSW-720

PART III - SITE DEVELOPMENT PLAN
ATTACHMENT 10, APPENDIX 10E
GEOSYNTHETIC CLAY LINER - ALTERNATE LINER DESIGN DEMONSTRATION

Prepared for:

CITY OF NACOGDOCHES
4602 NW Stallings Drive
Nacogdoches, TX 75964

Prepared By:

SCS ENGINEERS
TBPE Registration No. F-3407
Houston Office
12651 Briar Forrest Drive
Houston, Texas 77077
281/293-8494

Revision 0 - July 2013
Revision 1 – September 2019
Revision 2 – January 2024
SCS Project No. 16209006.~~11~~26

Table of Contents

Section **Page**

APPENDICES

1.2 PROPOSED ALTERNATE LINER SYSTEM

The GCL alternate liner system option for Block "O" Phases 3 through 6 is comprised of barrier components, including a GCL overlain by a 60-mil HDPE geomembrane liner. Above these barrier layers, the leachate collection system (LCS) will include a 200-mil lateral drainage layer (geocomposite) that will convey leachate to the LCS piping, which will be overlain by a 24-inch-thick protective soil cover. The leachate collection system design is included in Attachment 15, Appendix G – Block O – Leachate Generation Model. As described in Attachment 15, Appendix G, the bottom liner system for Block "O" will drain at varying slopes, with a minimum 2 percent and maximum 5 percent slope, towards perforated LCS piping (i.e., lateral and header pipes) located throughout the block, as shown on Drawing 15-2. As described in Attachment 15, Appendix G, the leachate generation model was based on two slope and drainage length scenarios, as follows:

1. Drainage length between LCS piping of 200 feet for slopes ranging from 2 to 2.8 percent; and

2. Drainage length between LCS piping of 325 feet for slopes greater than 2.8 percent.

Based on review of the HELP model results contained in Attachment 15, Appendix G, the leachate head on the liner was greater for Scenario 2 described above (i.e., drainage length of 325 feet and slope greater than or equal to 2.8 percent). Therefore, the analysis of the GCL alternate liner system contained in this appendix is based on the liner system described above, and the drainage length and slope criteria for Scenario 2. This scenario was selected since the leachate head and liner percolation is proportional, such that the greater the leachate head on the liner, the higher the potential percolation rate through the liner.

The layout, design details, and design calculations for the LCS are provided in Attachment 15.

1.3 SITE GEOLOGY AND HYDROGEOLOGY

The geology and hydrogeology information used in this ALDD are described in detail in Attachments 4 and 5 of the permit application.

2.0 ALTERNATE LINER DEMONSTRATION METHODS

2.1 HELP MODEL

The U.S. Army Corp of Engineer's Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 and 4.0, was used to estimate the rate of percolation through the alternate liner system. The HELP model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of the disposal facility. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, field capacity, soil moisture storage, evapotranspiration, and lateral drainage. The HELP model provides a variety of outputs; however, for this analysis the average annual percolation through the liner is the output parameter of interest.

The model input parameters used in the HELP model for this demonstration for the active, interim, and closed conditions are the same parameters used for Scenario 2 in the leachate generation model (see Attachment 15, Appendix G – Block O - Leachate Generation Model), as described in Section 1.2. The notable difference for this analysis is the change in the barrier layer to account for the installation of a GCL

Further details concerning the following input parameters are discussed in Attachment 15, Appendix G, Section 1.4 – Model Setup.

2.1.1 Model Setup

2.1.1.1 Phases

For this demonstration, a one-acre unit area was modeled for the following conditions (note, input parameters are described below):

- Active condition with 10 feet of waste, daily cover, and 0% runoff potential;
- Interim condition with ~~57~~ 60 feet of waste (maximum waste thickness), intermediate cover, and 100% runoff potential; and
- Closed condition with ~~57~~ 60 feet of waste, final cover, and 100% runoff potential.

In the HELP model, runoff is represented by two terms, "Runoff Potential" and "Curve Number (CN)", each of which is used differently by the model. These terms are further defined in Attachment 15, Appendix G, Section 1.4.1 – Phases. Consistent with Attachment 15, Appendix G, for this demonstration the Runoff Potential was user-selected as zero percent for the active condition, since precipitation contacting these areas will be contained at the working face by containment berms. For the interim and closed conditions, the Runoff Potential was user-selected as 100 percent, as these areas of the landfill will be properly graded and equipped with temporary or permanent drainage features to allow stormwater to runoff. A CN value of 85 was used for all landfill conditions, which is consistent with hydrological soil group C, antecedent moisture content III for wet soil and good grass cover greater than 75 percent.

2.1.1.2 Climatological Data

The climatological data required by the HELP model is a function of the geographical location, leaf area index (LAI), evaporative zone depth, and the number of years to be modeled. From these user inputs, the HELP model can generate synthetic precipitation, temperature, and solar radiation data.

For this demonstration, the LAI was assumed zero for the active landfill condition (representing bare soil cover), 2.0 for the interim landfill condition (representing fair vegetative cover), and 3.5 for the closed landfill condition. The evaporative zone depth was assumed to be 6 inches for the active conditions, 12 inches for the interim condition, and 6 inches for the closed condition, which correspond to the upper-most soil layer thickness.

As previously performed for the leachate generation model contained in Attachment 15, Appendix G, a synthetic storm was generated in HELP, and the various landfill development conditions were modeled for a duration of 30 years for all conditions using the generated weather data. Average monthly precipitation data for Lufkin, Texas was entered into the HELP model to generate a synthetic storm event over the 30 year time duration modeled for the various landfill conditions. The average monthly precipitation data for Lufkin, Texas, Cooperative Station ID 415424 is related to years 1971 to 2000, as referenced from the National Oceanic and Atmospheric Administration, National Climate Data Center.

The default temperature and solar radiation data for Houston, Texas, which is the nearest city to the proposed landfill with available data and comparable climate, was used as a basis for generation of this data for all HELP model simulations.

Output from the HELP model includes the peak daily, monthly, and annual precipitation, temperature, and solar radiation.

2.1.1.3 Model Profiles

The model profiles or layer characteristics for each condition are presented in the HELP Model Summary Sheets included in Appendix 10E-2. Information provided in the table includes the layer thickness, porosity, field capacity, wilting point, and hydraulic conductivity used by the model for each layer. Default soil and waste characteristics (i.e., hydraulic conductivity, porosity, field capacity, and wilting point) in the HELP model were used for the model profiles, and are considered representative of onsite soils, geosynthetic materials that will be used in construction of the alternate liner system, or waste that will be placed in the landfill. With exception to the addition of the GCL as the barrier layer, these inputs are the same as the HELP model characteristics provided in Attachment 15, Appendix G.

GCL and Flexible Membrane Liner

The GCL was modeled as a barrier layer using default values from the HELP model table of soil characteristics (HELP default texture 17). However, the hydraulic conductivity was set to 5 x 10^{-9} cm/s consistent with industry standards for GCLs.

The flexible geomembrane liner (60-mil HDPE), which is placed directly over the GCL, was also modeled using default values from the HELP model table of soil characteristics (HELP default texture 35). The geomembrane liner was modeled for good installation quality which is represented by four defects per acre and a pinhole density of one hole per acre (reference: HELP 3.07 and 4.0 User Manual).

Leachate Drainage System Layer

The LCS drainage layer is a geonet drainage layer with a geotextile adhered to one or both sides (referred to as a geocomposite). The geocomposite modeled in this ALDD is equivalent to the geocomposite modeled in the leachate generation model contained in Attachment 15, Appendix G. The manufactured thickness of the geocomposite is 200-mil (approximately 0.20 inches), which was reduced for compression depending on the amount of overlying waste and soil cover for each condition modeled in HELP. The reduction in thickness of the geocomposite drainage layer, as well as reduction factors associated with creep, geotextile intrusion, and environmental conditions, were considered to account for changes in long-term performance relative to the hydraulic conductivity. This geocomposite evaluation is contained in Attachment 15, Appendix G2.

Cover Soils

A clay soil (CL soil classification, HELP default texture 11) was used for all cover soils, such as protective, daily, and intermediate cover soils, since this soil classification is representative of onsite soils. Default soil characteristics were used for these cover soils, including a hydraulic conductivity of 6.4 x 10^{-5} cm/s.

Waste

The waste thicknesses described in Section 2.1.1.1 were utilized for the various landfill conditions in the HELP model. A default hydraulic conductivity of 1.0 x 10^{-3} cm/s was utilized in the model to represent municipal solid waste (HELP default texture 18).

Final Cover

The final cover from top to bottom will consist of a 6-inch-thick erosion layer, a 40-mil geomembrane, and an 18-inch-thick infiltration layer (compacted clay). For the purposes of this model, it was assumed that the erosion layer will consist of a clay soil with a hydraulic conductivity of 6.4 x 10^{-5} cm/s, consistent with soil modeled for other cover soils, as described above. The geomembrane was modeled for good installation quality, 4 defects per acre, and a pinhole density of 1 hole/acre (reference: HELP 3.07 and 4.0 User Manual). The infiltration layer will consist of compacted soil with a hydraulic conductivity of 1.0 x 10^{-5} cm/s or less. Default soil characteristics from the HELP model were selected to represent the layers within the final cover system.

2.1.2 HELP Model Results

The HELP model results for percolation through the liner are presented in the attached HELP Model Summary Sheet (see Appendix 10E-2). Additionally, the HELP model output is also provided in Appendix 10E-2.

2.2 MULTIMED MODEL

The MULTIMED Model Version 1.01 was used to assess contaminant fate and transport between the landfill base and the point-of-compliance (POC). MULTIMED was developed by the Athens Environmental Research Laboratory for the EPA. MULTIMED estimates the capacity of the hydrogeologic system modeled to dilute and attenuate contaminant

PART III, ATTACHMENT 10, APPENDIX 10E-2

REPLACEMENT PAGES

APPENDIX 10E-2

HELP MODEL ANALYSIS

(Includes Pages 10E-2-1 through 10E-2-~~26~~23)

RJB
Prep'd By: ~~BRK~~
Date: ~~6/17/13~~

CITY OF NACOGDOCHES LANDFILL
BLOCK O - HELP MODEL SUMMARY SHEET
GCL ALTERNATE LINER DEMONSTRATION

		ACTIVE	INTERIM	CLOSED
GENERAL INFORMATION	Model Duration (Years)	30	30	30
	Ground Cover	BARE	FAIR	GOOD
	SCS Runoff Curve No.	85	85	85
	Model Area (acre)	1	1	1
	Runoff Area (%)	0	100	100
	Maximum Leaf Area Index	0.0	2.0	3.5
	Evaporative Zone Depth (inch)	6	12	6
EROSION LAYER (Texture = 11)	Thickness (in)			6
	Porosity (vol/vol)			0.4640
	Field Capacity (vol/vol)			0.3100
	Wilting Point (vol/vol)			0.1870
	Init. Moisture Content (vol/vol)			0.4535
	Hyd. Conductivity (cm/s)			6.4E-05
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)			0.04
	Hyd. Conductivity (cm/s)			4.0E-13
	Pinhole Density (holes/acre)			1
	Install. Defects (holes/acre)			4
	Placement Quality			GOOD
INFILTRATION LAYER (Texture = 0)	Thickness (in)			18
	Porosity (vol/vol)			0.4270
	Field Capacity (vol/vol)			0.4180
	Wilting Point (vol/vol)			0.3670
	Init. Moisture Content (vol/vol)			0.4094
	Hyd. Conductivity (cm/s)			1.0E-05
INTERMEDIATE / DAILY COVER (Texture = 11)	Thickness (in)	6	12	6
	Porosity (vol/vol)	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3709	~~0.3443~~	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
WASTE (Texture = 18)	Thickness (in)	120	~~684~~	~~684~~
	Porosity (vol/vol)	0.6710	0.6710	0.6710
	Field Capacity (vol/vol)	0.2920	0.2920	0.2920
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3054	~~0.2946~~	0.2920
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
PROTECTIVE COVER (Texture = 11)	Thickness (in)	24	24	24
	Porosity (vol/vol)	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3466	0.3433	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
LEACHATE COLLECTION (Texture = 0)	Thickness (in)	0.20	0.19	0.19
	Porosity (vol/vol)	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0255	~~0.0040~~	~~0.0107~~
	Hyd. Conductivity (cm/s)	16.00	5.00	5.00
	Slope (%)	2.8	2.8	2.8
	Slope Length (ft)	325	325	325
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.6
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	1	1	1
	Install. Defects (holes/acre)	4	4	4
	Placement Quality	GOOD	GOOD	GOOD
GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)	0.24	0.24	0.24
	Porosity (vol/vol)	0.7500	0.7500	0.7500
	Field Capacity (vol/vol)	0.7470	0.7470	0.7470
	Wilting Point (vol/vol)	0.4000	0.4000	0.4000
	Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500
	Hyd. Conductivity (cm/s)	5.0E-09	5.0E-09	5.0E-09
PRECIPITATION	Average Annual (in)	45.1	45.1	45.1
RUNOFF	Average Annual (in)	0.0	3.5	14.0
EVAPOTRANSPIRATION	Average Annual (in)	26.7	31.2	31.1
PERCOLATION	Average Annual (in)	3.31E-06	~~3.86E-06~~	~~1.38E-06~~

```
~~******************************************************************************~~
~~******************************************************************************~~
~~**                                                                          **~~
~~**                                                                          **~~
~~**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **~~
~~**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **~~
~~**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **~~
~~**                 USAE WATERWAYS EXPERIMENT STATION                        **~~
~~**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **~~
~~**                                                                          **~~
~~**                                                                          **~~
~~******************************************************************************~~
~~******************************************************************************~~


~~PRECIPITATION DATA FILE:      m:\help307\nacog\30YR_AVG.D4~~
~~TEMPERATURE DATA FILE:        m:\help307\nacog\30YR_AVG.D7~~
~~SOLAR RADIATION DATA FILE:    m:\help307\nacog\30YR_AVG.D13~~
~~EVAPOTRANSPIRATION DATA:      m:\help307\nacog\INTERIM.D11~~
~~SOIL AND DESIGN DATA FILE:    m:\help307\nacog\INT_CCL.D10~~
~~OUTPUT DATA FILE:             m:\help307\nacog\INT_CCL.OUT~~


~~TIME: 11:35       DATE:  5/ 1/2013~~


~~******************************************************************************~~

~~     TITLE: Interim, 57-ft Waste, 2.8% Slope, 325-ft Drainage Length with CCL~~

~~******************************************************************************~~


~~     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE~~
~~            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.~~


~~                                      LAYER  1~~
~~                                      --------~~

~~                          TYPE 1 - VERTICAL PERCOLATION LAYER~~
~~                              MATERIAL TEXTURE NUMBER 11~~
~~           THICKNESS                     =    12.00    INCHES~~
~~           POROSITY                      =     0.4640 VOL/VOL~~
~~           FIELD CAPACITY                =     0.3100 VOL/VOL~~
~~           WILTING POINT                 =     0.1870 VOL/VOL~~
~~           INITIAL SOIL WATER CONTENT    =     0.3443 VOL/VOL~~
~~           EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC~~
~~         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00~~
~~                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.~~
```

```
~~                              LAYER  2~~
~~                              --------~~

~~                 TYPE 1 - VERTICAL PERCOLATION LAYER~~
~~                     MATERIAL TEXTURE NUMBER 18~~
~~      THICKNESS                    =   684.00    INCHES~~
~~      POROSITY                     =     0.6710 VOL/VOL~~
~~      FIELD CAPACITY               =     0.2920 VOL/VOL~~
~~      WILTING POINT                =     0.0770 VOL/VOL~~
~~      INITIAL SOIL WATER CONTENT   =     0.2946 VOL/VOL~~
~~      EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC~~


~~                              LAYER  3~~
~~                              --------~~

~~                 TYPE 1 - VERTICAL PERCOLATION LAYER~~
~~                     MATERIAL TEXTURE NUMBER 11~~
~~      THICKNESS                    =    24.00    INCHES~~
~~      POROSITY                     =     0.4640 VOL/VOL~~
~~      FIELD CAPACITY               =     0.3100 VOL/VOL~~
~~      WILTING POINT                =     0.1870 VOL/VOL~~
~~      INITIAL SOIL WATER CONTENT   =     0.3433 VOL/VOL~~
~~      EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC~~


~~                              LAYER  4~~
~~                              --------~~

~~                   TYPE 2 - LATERAL DRAINAGE LAYER~~
~~                     MATERIAL TEXTURE NUMBER  0~~
~~      THICKNESS                    =     0.19    INCHES~~
~~      POROSITY                     =     0.8500 VOL/VOL~~
~~      FIELD CAPACITY               =     0.0100 VOL/VOL~~
~~      WILTING POINT                =     0.0050 VOL/VOL~~
~~      INITIAL SOIL WATER CONTENT   =     0.0400 VOL/VOL~~
~~      EFFECTIVE SAT. HYD. COND.    =   5.00000000000     CM/SEC~~
~~      SLOPE                        =     2.80    PERCENT~~
~~      DRAINAGE LENGTH              =   325.0     FEET~~
```

```
                                  ~~LAYER 5~~
                                  ~~--------~~

                      ~~TYPE 4 - FLEXIBLE MEMBRANE LINER~~
                        ~~MATERIAL TEXTURE NUMBER 35~~
            ~~THICKNESS                  =      0.06    INCHES~~
            ~~POROSITY                   =      0.0000 VOL/VOL~~
            ~~FIELD CAPACITY             =      0.0000 VOL/VOL~~
            ~~WILTING POINT              =      0.0000 VOL/VOL~~
            ~~INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL~~
            ~~EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC~~
            ~~FML PINHOLE DENSITY        =      1.00    HOLES/ACRE~~
            ~~FML INSTALLATION DEFECTS   =      4.00    HOLES/ACRE~~
            ~~FML PLACEMENT QUALITY      =  3 - GOOD~~


                                  ~~LAYER 6~~
                                  ~~--------~~

                        ~~TYPE 3 - BARRIER SOIL LINER~~
                        ~~MATERIAL TEXTURE NUMBER  0~~
            ~~THICKNESS                  =      0.24    INCHES~~
            ~~POROSITY                   =      0.7500 VOL/VOL~~
            ~~FIELD CAPACITY             =      0.7470 VOL/VOL~~
            ~~WILTING POINT              =      0.4000 VOL/VOL~~
            ~~INITIAL SOIL WATER CONTENT =      0.7500 VOL/VOL~~
            ~~EFFECTIVE SAT. HYD. COND.  =  0.499999997000E-08 CM/SEC~~


                  ~~GENERAL DESIGN AND EVAPORATIVE ZONE DATA~~
                  ~~----------------------------------------~~

           ~~NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.~~

         ~~SCS RUNOFF CURVE NUMBER            =      85.00~~
         ~~FRACTION OF AREA ALLOWING RUNOFF   =     100.0    PERCENT~~
         ~~AREA PROJECTED ON HORIZONTAL PLANE =       1.000  ACRES~~
         ~~EVAPORATIVE ZONE DEPTH             =      12.0    INCHES~~
         ~~INITIAL WATER IN EVAPORATIVE ZONE  =       4.132  INCHES~~
         ~~UPPER LIMIT OF EVAPORATIVE STORAGE =       5.568  INCHES~~
         ~~LOWER LIMIT OF EVAPORATIVE STORAGE =       2.244  INCHES~~
         ~~INITIAL SNOW WATER                 =       0.000  INCHES~~
         ~~INITIAL WATER IN LAYER MATERIALS   =     214.037  INCHES~~
         ~~TOTAL INITIAL WATER                =     214.037  INCHES~~
         ~~TOTAL SUBSURFACE INFLOW            =       0.00   INCHES/YEAR~~
```

~~EVAPOTRANSPIRATION AND WEATHER DATA~~

~~NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM~~
~~NACOGDOCHES TEXAS~~

~~STATION LATITUDE = 31.37 DEGREES~~
~~MAXIMUM LEAF AREA INDEX = 2.00~~
~~START OF GROWING SEASON (JULIAN DATE) = 55~~
~~END OF GROWING SEASON (JULIAN DATE) = 336~~
~~EVAPORATIVE ZONE DEPTH = 12.0 INCHES~~
~~AVERAGE ANNUAL WIND SPEED = 11.30 MPH~~
~~AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 69.00 %~~
~~AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 69.00 %~~
~~AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 62.00 %~~
~~AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 69.00 %~~

~~NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING~~
~~COEFFICIENTS FOR HOUSTON TEXAS~~

~~NORMAL MEAN MONTHLY PRECIPITATION (INCHES)~~

~~JAN/JUL~~	~~FEB/AUG~~	~~MAR/SEP~~	~~APR/OCT~~	~~MAY/NOV~~	~~JUN/DEC~~
~~4.45~~	~~3.17~~	~~3.53~~	~~3.13~~	~~5.29~~	~~4.18~~
~~2.60~~	~~3.08~~	~~4.08~~	~~4.13~~	~~4.54~~	~~4.44~~

~~NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING~~
~~COEFFICIENTS FOR HOUSTON TEXAS~~

~~NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)~~

~~JAN/JUL~~	~~FEB/AUG~~	~~MAR/SEP~~	~~APR/OCT~~	~~MAY/NOV~~	~~JUN/DEC~~
~~51.40~~	~~54.50~~	~~61.00~~	~~68.70~~	~~74.90~~	~~80.60~~
~~83.10~~	~~82.60~~	~~78.40~~	~~69.70~~	~~60.10~~	~~54.00~~

~~NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING~~
~~COEFFICIENTS FOR HOUSTON TEXAS~~
~~AND STATION LATITUDE = 29.39 DEGREES~~

```
~~*******************************************************************************~~

~~          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    30~~
~~-------------------------------------------------------------------------------~~

~~                         JAN/JUL   FEB/AUG   MAR/SEP   APR/OCT   MAY/NOV   JUN/DEC~~
~~                         -------   -------   -------   -------   -------   -------~~

~~   PRECIPITATION~~
~~   -------------~~

~~     TOTALS                4.83      3.29      3.27      2.87      4.23      3.67~~
~~                           2.91      2.99      4.09      3.65      5.36      3.91~~

~~     STD. DEVIATIONS       2.78      1.90      2.12      1.75      2.50      3.50~~
~~                           1.39      1.77      1.70      2.64      2.94      1.93~~

~~   RUNOFF~~
~~   ------~~

~~     TOTALS               0.461     0.140     0.172     0.179     0.552     0.358~~
~~                          0.052     0.104     0.147     0.332     0.768     0.252~~

~~     STD. DEVIATIONS      0.744     0.256     0.423     0.328     0.768     0.727~~
~~                          0.125     0.226     0.193     0.521     0.774     0.374~~

~~   EVAPOTRANSPIRATION~~
~~   ------------------~~

~~     TOTALS               2.369     2.523     2.774     2.822     3.015     2.885~~
~~                          2.845     2.808     3.390     2.083     1.683     2.025~~

~~     STD. DEVIATIONS      0.454     0.590     1.025     1.349     1.230     2.012~~
~~                          1.256     1.455     1.281     0.891     0.292     0.237~~

~~   LATERAL DRAINAGE COLLECTED FROM LAYER  4~~
~~   ----------------------------------------~~

~~     TOTALS              1.4923    1.4139    1.8096    1.3655    0.8411    0.5874~~
~~                         0.5474    0.2949    0.1100    0.1874    0.4628    1.0951~~

~~     STD. DEVIATIONS     0.8576    0.8038    1.1902    1.1460    0.9151    0.5666~~
~~                         0.6165    0.4351    0.1534    0.2758    0.5737    0.7217~~

~~   PERCOLATION/LEAKAGE THROUGH LAYER  6~~
~~   ------------------------------------~~

~~     TOTALS              0.0000    0.0000    0.0000    0.0000    0.0000    0.0000~~
~~                         0.0000    0.0000    0.0000    0.0000    0.0000    0.0000~~

~~     STD. DEVIATIONS     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000~~
~~                         0.0000    0.0000    0.0000    0.0000    0.0000    0.0000~~
```

```
~~-------------------------------------------------------------------------------~~
~~              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)~~
~~-------------------------------------------------------------------------------~~


~~   DAILY AVERAGE HEAD ON TOP OF LAYER  5~~
~~   -------------------------------------~~

~~     AVERAGES                   0.0197   0.0205   0.0239   0.0187   0.0111   0.0080~~
~~                                0.0072   0.0039   0.0015   0.0025   0.0063   0.0145~~

~~     STD. DEVIATIONS            0.0113   0.0117   0.0157   0.0157   0.0121   0.0077~~
~~                                0.0081   0.0058   0.0021   0.0036   0.0078   0.0095~~

~~*******************************************************************************~~


~~*******************************************************************************~~

~~      AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   30~~
~~-------------------------------------------------------------------------------~~
~~                                      INCHES             CU. FEET      PERCENT~~
~~                                 ------------------   -------------   ---------~~
~~  PRECIPITATION                   45.09     (  6.729)     163658.6      100.00~~

~~  RUNOFF                           3.517    ( 1.6114)     12768.24      7.802~~

~~  EVAPOTRANSPIRATION              31.222    ( 2.6898)    113336.70     69.252~~

~~  LATERAL DRAINAGE COLLECTED      10.20750 ( 3.91099)     37053.215   22.64056~~
~~    FROM LAYER  4~~

~~  PERCOLATION/LEAKAGE THROUGH      0.00000 ( 0.00000)         0.014     0.00001~~
~~    LAYER  6~~

~~  AVERAGE HEAD ON TOP              0.011 (   0.004)~~
~~    OF LAYER  5~~

~~  CHANGE IN WATER STORAGE          0.138    ( 3.4408)       500.37      0.306~~

~~*******************************************************************************~~
```

```
~~*******************************************************************************~~

~~                   PEAK DAILY VALUES FOR YEARS     1 THROUGH   30~~
~~          ------------------------------------------------------------------------~~
~~                                                      (INCHES)      (CU. FT.)~~
~~                                                     ----------    -------------~~
~~       PRECIPITATION                                   4.62          16770.600~~

~~       RUNOFF                                          2.340          8495.6143~~

~~       DRAINAGE COLLECTED FROM LAYER  4                0.19509         708.19135~~

~~       PERCOLATION/LEAKAGE THROUGH LAYER  6            0.000000          0.00014~~

~~       AVERAGE HEAD ON TOP OF LAYER  5                 0.080~~

~~       MAXIMUM HEAD ON TOP OF LAYER  5                 0.158~~

~~       LOCATION OF MAXIMUM HEAD IN LAYER  4~~
~~             (DISTANCE FROM DRAIN)                     3.2 FEET~~

~~       SNOW WATER                                      0.70           2542.1436~~


~~       MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.4517~~

~~       MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.1870~~


~~        ***  Maximum heads are computed using McEnroe's equations.  ***~~

~~             Reference:  Maximum Saturated Depth over Landfill Liner~~
~~                         by Bruce M. McEnroe, University of Kansas~~
~~                         ASCE Journal of Environmental Engineering~~
~~                         Vol. 119, No. 2, March 1993, pp. 262-270.~~

~~*******************************************************************************~~
```

```
~~*************************************************************************~~

~~          FINAL WATER STORAGE AT END OF YEAR    30~~
~~     ----------------------------------------------------------------~~
~~              LAYER        (INCHES)        (VOL/VOL)~~
~~              -----        --------        ---------~~
~~                1           3.6990           0.3083~~

~~                2         204.9276           0.2996~~

~~                3           9.3218           0.3884~~

~~                4           0.0440           0.2317~~

~~                5           0.0000           0.0000~~

~~                6           0.1800           0.7500~~

~~            SNOW WATER      0.000~~

~~*************************************************************************~~
~~*************************************************************************~~
```

```
~~******************************************************************************~~
~~******************************************************************************~~
~~**                                                                          **~~
~~**                                                                          **~~
~~**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **~~
~~**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **~~
~~**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **~~
~~**                  USAE WATERWAYS EXPERIMENT STATION                       **~~
~~**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **~~
~~**                                                                          **~~
~~**                                                                          **~~
~~******************************************************************************~~
~~******************************************************************************~~


~~PRECIPITATION DATA FILE:      m:\help307\nacog\30YR_AVG.D4~~
~~TEMPERATURE DATA FILE:        m:\help307\nacog\30YR_AVG.D7~~
~~SOLAR RADIATION DATA FILE:    m:\help307\nacog\30YR_AVG.D13~~
~~EVAPOTRANSPIRATION DATA:      m:\help307\nacog\FINAL.D11~~
~~SOIL AND DESIGN DATA FILE:    m:\help307\nacog\FIN_CCL.D10~~
~~OUTPUT DATA FILE:             m:\help307\nacog\FIN_CCL.OUT~~


~~TIME: 11:36     DATE:  5/ 1/2013~~


~~******************************************************************************~~

~~     TITLE: Closed, 2.8% Slope, 325-foot Drainage Length with CCL~~

~~******************************************************************************~~


~~     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE~~
~~            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.~~


~~                                  LAYER  1~~
~~                                  --------~~

~~                        TYPE 1 - VERTICAL PERCOLATION LAYER~~
~~                           MATERIAL TEXTURE NUMBER  11~~
~~          THICKNESS                     =     6.00    INCHES~~
~~          POROSITY                      =     0.4640 VOL/VOL~~
~~          FIELD CAPACITY                =     0.3100 VOL/VOL~~
~~          WILTING POINT                 =     0.1870 VOL/VOL~~
~~          INITIAL SOIL WATER CONTENT    =     0.4535 VOL/VOL~~
~~          EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC~~
~~        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63~~
~~               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.~~
```

```
                        ~~LAYER  2~~
                        ~~--------~~

              ~~TYPE 4 - FLEXIBLE MEMBRANE LINER~~
                ~~MATERIAL TEXTURE NUMBER 36~~
      ~~THICKNESS                  =       0.04    INCHES~~
      ~~POROSITY                   =       0.0000 VOL/VOL~~
      ~~FIELD CAPACITY             =       0.0000 VOL/VOL~~
      ~~WILTING POINT              =       0.0000 VOL/VOL~~
      ~~INITIAL SOIL WATER CONTENT =       0.0000 VOL/VOL~~
      ~~EFFECTIVE SAT. HYD. COND.  =   0.399999993000E-12 CM/SEC~~
      ~~FML PINHOLE DENSITY        =       1.00    HOLES/ACRE~~
      ~~FML INSTALLATION DEFECTS   =       4.00    HOLES/ACRE~~
      ~~FML PLACEMENT QUALITY      =   3 - GOOD~~


                        ~~LAYER  3~~
                        ~~--------~~

             ~~TYPE 1 - VERTICAL PERCOLATION LAYER~~
                ~~MATERIAL TEXTURE NUMBER  0~~
      ~~THICKNESS                  =      18.00    INCHES~~
      ~~POROSITY                   =       0.4270 VOL/VOL~~
      ~~FIELD CAPACITY             =       0.4180 VOL/VOL~~
      ~~WILTING POINT              =       0.3670 VOL/VOL~~
      ~~INITIAL SOIL WATER CONTENT =       0.4094 VOL/VOL~~
      ~~EFFECTIVE SAT. HYD. COND.  =   0.999999975000E-05 CM/SEC~~


                        ~~LAYER  4~~
                        ~~--------~~

             ~~TYPE 1 - VERTICAL PERCOLATION LAYER~~
                ~~MATERIAL TEXTURE NUMBER 11~~
      ~~THICKNESS                  =       6.00    INCHES~~
      ~~POROSITY                   =       0.4640 VOL/VOL~~
      ~~FIELD CAPACITY             =       0.3100 VOL/VOL~~
      ~~WILTING POINT              =       0.1870 VOL/VOL~~
      ~~INITIAL SOIL WATER CONTENT =       0.3100 VOL/VOL~~
      ~~EFFECTIVE SAT. HYD. COND.  =   0.639999998000E-04 CM/SEC~~
```

~~LAYER 5~~
~~--------~~

~~TYPE 1 - VERTICAL PERCOLATION LAYER~~
~~MATERIAL TEXTURE NUMBER 18~~
~~THICKNESS = 684.00 INCHES~~
~~POROSITY = 0.6710 VOL/VOL~~
~~FIELD CAPACITY = 0.2920 VOL/VOL~~
~~WILTING POINT = 0.0770 VOL/VOL~~
~~INITIAL SOIL WATER CONTENT = 0.2920 VOL/VOL~~
~~EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC~~

~~LAYER 6~~
~~--------~~

~~TYPE 1 - VERTICAL PERCOLATION LAYER~~
~~MATERIAL TEXTURE NUMBER 11~~
~~THICKNESS = 24.00 INCHES~~
~~POROSITY = 0.4640 VOL/VOL~~
~~FIELD CAPACITY = 0.3100 VOL/VOL~~
~~WILTING POINT = 0.1870 VOL/VOL~~
~~INITIAL SOIL WATER CONTENT = 0.3100 VOL/VOL~~
~~EFFECTIVE SAT. HYD. COND. = 0.639999998000E-04 CM/SEC~~

~~LAYER 7~~
~~--------~~

~~TYPE 2 - LATERAL DRAINAGE LAYER~~
~~MATERIAL TEXTURE NUMBER 0~~
~~THICKNESS = 0.19 INCHES~~
~~POROSITY = 0.8500 VOL/VOL~~
~~FIELD CAPACITY = 0.0100 VOL/VOL~~
~~WILTING POINT = 0.0050 VOL/VOL~~
~~INITIAL SOIL WATER CONTENT = 0.0107 VOL/VOL~~
~~EFFECTIVE SAT. HYD. COND. = 5.00000000000 CM/SEC~~
~~SLOPE = 2.80 PERCENT~~
~~DRAINAGE LENGTH = 325.0 FEET~~

```
~~                                   LAYER  8~~
~~                                   --------~~

~~                    TYPE 4 - FLEXIBLE MEMBRANE LINER~~
~~                      MATERIAL TEXTURE NUMBER  35~~
~~          THICKNESS                    =        0.06    INCHES~~
~~          POROSITY                     =        0.0000 VOL/VOL~~
~~          FIELD CAPACITY               =        0.0000 VOL/VOL~~
~~          WILTING POINT                =        0.0000 VOL/VOL~~
~~          INITIAL SOIL WATER CONTENT   =        0.0000 VOL/VOL~~
~~          EFFECTIVE SAT. HYD. COND.    =    0.199999996000E-12 CM/SEC~~
~~          FML PINHOLE DENSITY          =        1.00    HOLES/ACRE~~
~~          FML INSTALLATION DEFECTS     =        4.00    HOLES/ACRE~~
~~          FML PLACEMENT QUALITY        =    3 - GOOD~~


~~                                   LAYER  9~~
~~                                   --------~~

~~                      TYPE 3 - BARRIER SOIL LINER~~
~~                      MATERIAL TEXTURE NUMBER   0~~
~~          THICKNESS                    =        0.24    INCHES~~
~~          POROSITY                     =        0.7500 VOL/VOL~~
~~          FIELD CAPACITY               =        0.7470 VOL/VOL~~
~~          WILTING POINT                =        0.4000 VOL/VOL~~
~~          INITIAL SOIL WATER CONTENT   =        0.7500 VOL/VOL~~
~~          EFFECTIVE SAT. HYD. COND.    =    0.499999997000E-08 CM/SEC~~


~~                GENERAL DESIGN AND EVAPORATIVE ZONE DATA~~
~~                ----------------------------------------~~

~~        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.~~

~~       SCS RUNOFF CURVE NUMBER                 =     85.00~~
~~       FRACTION OF AREA ALLOWING RUNOFF        =    100.0     PERCENT~~
~~       AREA PROJECTED ON HORIZONTAL PLANE      =     1.000    ACRES~~
~~       EVAPORATIVE ZONE DEPTH                  =       6.0    INCHES~~
~~       INITIAL WATER IN EVAPORATIVE ZONE       =     2.721    INCHES~~
~~       UPPER LIMIT OF EVAPORATIVE STORAGE      =     2.784    INCHES~~
~~       LOWER LIMIT OF EVAPORATIVE STORAGE      =     1.122    INCHES~~
~~       INITIAL SNOW WATER                      =     0.000    INCHES~~
~~       INITIAL WATER IN LAYER MATERIALS        =   219.300    INCHES~~
~~       TOTAL INITIAL WATER                     =   219.300    INCHES~~
~~       TOTAL SUBSURFACE INFLOW                 =      0.00    INCHES/YEAR~~
```

```
~~EVAPOTRANSPIRATION AND WEATHER DATA~~
~~-----------------------------------~~

~~NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM~~
~~       NACOGDOCHES           TEXAS~~

~~STATION LATITUDE                        =  31.37 DEGREES~~
~~MAXIMUM LEAF AREA INDEX                 =   3.50~~
~~START OF GROWING SEASON (JULIAN DATE)   =     55~~
~~END OF GROWING SEASON (JULIAN DATE)     =    336~~
~~EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES~~
~~AVERAGE ANNUAL WIND SPEED               =  11.30 MPH~~
~~AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  69.00 %~~
~~AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  69.00 %~~
~~AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  62.00 %~~
~~AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  69.00 %~~


~~NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING~~
~~       COEFFICIENTS FOR     HOUSTON                TEXAS~~

~~NORMAL MEAN MONTHLY PRECIPITATION (INCHES)~~

~~JAN/JUL    FEB/AUG    MAR/SEP    APR/OCT    MAY/NOV    JUN/DEC~~
~~-------    -------    -------    -------    -------    -------~~
~~  4.45       3.17       3.53       3.13       5.29       4.18~~
~~  2.60       3.08       4.08       4.13       4.54       4.44~~


~~NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING~~
~~       COEFFICIENTS FOR     HOUSTON                TEXAS~~

~~NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)~~

~~JAN/JUL    FEB/AUG    MAR/SEP    APR/OCT    MAY/NOV    JUN/DEC~~
~~-------    -------    -------    -------    -------    -------~~
~~ 51.40      54.50      61.00      68.70      74.90      80.60~~
~~ 83.10      82.60      78.40      69.70      60.10      54.00~~


~~NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING~~
~~       COEFFICIENTS FOR     HOUSTON                TEXAS~~
~~       AND STATION LATITUDE  =  29.39 DEGREES~~
```

```
~~******************************************************************************~~

~~          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    30~~
~~------------------------------------------------------------------------------~~

~~                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC~~
~~                          -------  -------  -------  -------  -------  -------~~

~~   PRECIPITATION~~
~~   -------------~~

~~     TOTALS                  4.83     3.29     3.27     2.87     4.23     3.67~~
~~                             2.91     2.99     4.09     3.65     5.36     3.91~~

~~     STD. DEVIATIONS         2.78     1.90     2.12     1.75     2.50     3.50~~
~~                             1.39     1.77     1.70     2.64     2.94     1.93~~

~~   RUNOFF~~
~~   ------~~

~~     TOTALS                 2.481    1.152    0.662    0.357    1.140    0.831~~
~~                            0.124    0.175    0.399    1.169    3.259    2.227~~

~~     STD. DEVIATIONS        2.614    1.443    1.309    0.728    1.503    1.757~~
~~                            0.349    0.413    0.650    1.723    2.669    1.753~~

~~   EVAPOTRANSPIRATION~~
~~   ------------------~~

~~     TOTALS                 2.314    2.506    2.909    2.885    3.040    2.883~~
~~                            2.826    2.809    3.478    2.081    1.479    1.851~~

~~     STD. DEVIATIONS        0.334    0.510    1.046    1.361    1.276    2.004~~
~~                            1.247    1.475    1.245    0.918    0.245    0.200~~

~~   PERCOLATION/LEAKAGE THROUGH LAYER  2~~
~~   ------------------------------------~~

~~     TOTALS                0.0084   0.0058   0.0037   0.0015   0.0015   0.0012~~
~~                           0.0004   0.0005   0.0017   0.0034   0.0083   0.0095~~

~~     STD. DEVIATIONS       0.0028   0.0026   0.0024   0.0013   0.0013   0.0016~~
~~                           0.0007   0.0007   0.0015   0.0025   0.0025   0.0021~~

~~   LATERAL DRAINAGE COLLECTED FROM LAYER  7~~
~~   ----------------------------------------~~

~~     TOTALS                0.0084   0.0059   0.0037   0.0015   0.0015   0.0012~~
~~                           0.0004   0.0005   0.0017   0.0034   0.0082   0.0096~~

~~     STD. DEVIATIONS       0.0028   0.0026   0.0024   0.0013   0.0013   0.0016~~
~~                           0.0007   0.0007   0.0015   0.0025   0.0025   0.0021~~

~~   PERCOLATION/LEAKAGE THROUGH LAYER  9~~
~~   ------------------------------------~~

~~     TOTALS                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000~~
~~                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000~~

~~     STD. DEVIATIONS       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000~~
~~                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000~~
```

```
~~-------------------------------------------------------------------------------~~
~~              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)~~
~~-------------------------------------------------------------------------------~~


~~   DAILY AVERAGE HEAD ON TOP OF LAYER  2~~
~~   -------------------------------------~~
~~     AVERAGES                   3.8446   2.8787   1.6275   0.6795   0.6574   0.5567~~
~~                                0.1797   0.2131   0.7706   1.5356   3.9236   4.3583~~

~~     STD. DEVIATIONS            1.3390   1.3304   1.1158   0.5922   0.5903   0.7440~~
~~                                0.3155   0.3285   0.6873   1.1473   1.2137   1.0120~~

~~   DAILY AVERAGE HEAD ON TOP OF LAYER  8~~
~~   -------------------------------------~~
~~     AVERAGES                   0.0001   0.0001   0.0000   0.0000   0.0000   0.0000~~
~~                                0.0000   0.0000   0.0000   0.0000   0.0001   0.0001~~

~~     STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000~~
~~                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000~~

~~ *******************************************************************************~~


~~ *******************************************************************************~~

~~      AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS     1 THROUGH   30~~
~~-------------------------------------------------------------------------------~~
~~                                         INCHES            CU. FEET      PERCENT~~
~~                                   -------------------  -------------  ---------~~
~~  PRECIPITATION                      45.09   (   6.729)     163658.6     100.00~~

~~  RUNOFF                             13.976  (   5.1218)     50733.25     30.999~~

~~  EVAPOTRANSPIRATION                 31.061  (   2.7502)    112750.86     68.894~~

~~  PERCOLATION/LEAKAGE THROUGH         0.04595 (  0.00676)      166.816     0.10193~~
~~    LAYER  2~~

~~  AVERAGE HEAD ON TOP                 1.769 (    0.268)~~
~~    OF LAYER  2~~

~~  LATERAL DRAINAGE COLLECTED          0.04596 (  0.00675)      166.818     0.10193~~
~~    FROM LAYER  7~~

~~  PERCOLATION/LEAKAGE THROUGH         0.00000 (  0.00000)        0.005     0.00000~~
~~    LAYER  9~~

~~  AVERAGE HEAD ON TOP                 0.000 (    0.000)~~
~~    OF LAYER  8~~

~~  CHANGE IN WATER STORAGE             0.002  (   0.5686)         7.59      0.005~~

~~ *******************************************************************************~~
```

```
~~*******************************************************************************~~

~~                 PEAK DAILY VALUES FOR YEARS   1 THROUGH   30~~
~~     ------------------------------------------------------------------------~~
~~                                                 (INCHES)      (CU. FT.)~~
~~                                                ----------    -------------~~
~~       PRECIPITATION                              4.62          16770.600~~

~~       RUNOFF                                     4.085         14827.0752~~

~~       PERCOLATION/LEAKAGE THROUGH LAYER  2       0.000415          1.50594~~

~~       AVERAGE HEAD ON TOP OF LAYER  2            6.000~~

~~       DRAINAGE COLLECTED FROM LAYER  7           0.00041           1.49786~~

~~       PERCOLATION/LEAKAGE THROUGH LAYER  9       0.000000          0.00003~~

~~       AVERAGE HEAD ON TOP OF LAYER  8            0.000~~

~~       MAXIMUM HEAD ON TOP OF LAYER  8            0.005~~

~~       LOCATION OF MAXIMUM HEAD IN LAYER  7~~
~~             (DISTANCE FROM DRAIN)                0.0 FEET~~

~~       SNOW WATER                                 0.70           2542.1436~~


~~       MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.4640~~

~~       MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1870~~


~~        ***  Maximum heads are computed using McEnroe's equations.  ***~~

~~             Reference:  Maximum Saturated Depth over Landfill Liner~~
~~                         by Bruce M. McEnroe, University of Kansas~~
~~                         ASCE Journal of Environmental Engineering~~
~~                         Vol. 119, No. 2, March 1993, pp. 262-270.~~


~~*******************************************************************************~~
```

```
~~*****************************************************************************~~

~~            FINAL WATER STORAGE AT END OF YEAR   30~~
~~       ----------------------------------------------------------------------~~
~~              LAYER          (INCHES)         (VOL/VOL)~~
~~              -----          --------         ---------~~
~~                1             2.7840           0.4640~~

~~                2             0.0000           0.0000~~

~~                3             7.3688           0.4094~~

~~                4             1.8600           0.3100~~

~~                5           199.7280           0.2920~~

~~                6             7.4400           0.3100~~

~~                7             0.0020           0.0104~~

~~                8             0.0000           0.0000~~

~~                9             0.1800           0.7500~~

~~            SNOW WATER        0.000~~

~~*****************************************************************************~~
~~*****************************************************************************~~
```

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Interim, 60' Waste, 2.8% Slope... **Simulated On:** 12/1/2023 15:30

NEW Model!

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
CL - Clay Loam
Material Texture Number 11

Thickness = 12 inches
Porosity = 0.464 vol/vol
Field Capacity = 0.31 vol/vol
Wilting Point = 0.187 vol/vol
Initial Soil Water Content = 0.3419 vol/vol
Effective Sat. Hyd. Conductivity = 6.40E-05 cm/sec

Layer 2

Type 1 - Vertical Percolation Layer (Waste)
Municipal Solid Waste (MSW) (900 pcy)
Material Texture Number 18

Thickness = 720 inches
Porosity = 0.671 vol/vol
Field Capacity = 0.292 vol/vol
Wilting Point = 0.077 vol/vol
Initial Soil Water Content = 0.2945 vol/vol
Effective Sat. Hyd. Conductivity = 1.00E-03 cm/sec

Layer 3

Type 1 - Vertical Percolation Layer
CL - Clay Loam
Material Texture Number 11

Thickness = 24 inches
Porosity = 0.464 vol/vol
Field Capacity = 0.31 vol/vol
Wilting Point = 0.187 vol/vol
Initial Soil Water Content = 0.3431 vol/vol
Effective Sat. Hyd. Conductivity = 6.40E-05 cm/sec

Layer 4

Type 2 - Lateral Drainage Layer
Custom Geonet 2
Material Texture Number 44

Thickness = 0.19 inches
Porosity = 0.85 vol/vol
Field Capacity = 0.01 vol/vol
Wilting Point = 0.005 vol/vol
Initial Soil Water Content = 0.0555 vol/vol
Effective Sat. Hyd. Conductivity = 5.00E+00 cm/sec
Slope = 2.8 %
Drainage Length = 325 ft

Layer 5

Type 4 - Flexible Membrane Liner
HDPE Membrane
Material Texture Number 35

Thickness = 0.06 inches
Effective Sat. Hyd. Conductivity = 2.00E-13 cm/sec
FML Pinhole Density = 1 Holes/Acre
FML Installation Defects = 4 Holes/Acre
FML Placement Quality = 3 Good

Layer 6

Type 3 - Barrier Soil Liner
GCL
Material Texture Number 45

Thickness = 0.24 inches
Porosity = 0.75 vol/vol
Field Capacity = 0.747 vol/vol
Wilting Point = 0.4 vol/vol
Initial Soil Water Content = 0.75 vol/vol
Effective Sat. Hyd. Conductivity = 5.00E-09 cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number = 85
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 1 acres
Evaporative Zone Depth = 12 inches
Initial Water in Evaporative Zone = 4.103 inches
Upper Limit of Evaporative Storage = 5.568 inches
Lower Limit of Evaporative Storage = 2.244 inches
Initial Snow Water = 0 inches
Initial Water in Layer Materials = 224.559 inches
Total Initial Water = 224.559 inches

Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	31.37 Degrees
Maximum Leaf Area Index	=	2
Start of Growing Season (Julian Date)	=	55 days
End of Growing Season (Julian Date)	=	336 days
Average Wind Speed	=	11.3 mph
Average 1st Quarter Relative Humidity	=	69 %
Average 2nd Quarter Relative Humidity	=	69 %
Average 3rd Quarter Relative Humidity	=	62 %
Average 4th Quarter Relative Humidity	=	69 %

Note: Evapotranspiration data was obtained for NACOGDOCHES, TEXAS

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
4.45	3.17	3.53	3.13	5.29	4.18
2.6	3.08	4.08	4.13	4.54	4.44

Note: Precipitation was simulated using HELP v3.07 data files for the following location: HOUSTON, TEXAS

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
51.4	54.5	61	68.7	74.9	80.6
83.1	82.6	78.4	69.7	60.1	54

Note: Temperature was simulated using HELP v3.07 data files for the following location: HOUSTON, TEXAS
Solar radiation was simulated using HELP v3.07 data files for the following location: HOUSTON, TEXAS (Latitude: 31.37)

Average Annual Totals Summary

Title: Interim, 60' Waste, 2.8% Slope, 325' Length w/ GCL
Simulated on: 12/1/2023 15:31

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	45.09	[6.73]	163,658.6	100.00
Runoff	3.516	[1.61]	12,763.0	7.80
Evapotranspiration	31.213	[2.692]	113,304.1	69.23
Subprofile1				
Lateral drainage collected from Layer 4	10.2139	[3.9156]	37,076.4	22.65
Percolation/leakage through Layer 6	0.000004	[0.000001]	0.0137	0.00
Average Head on Top of Layer 5	0.0115	[0.0044]	---	---
Water storage				
Change in water storage	0.1419	[3.4512]	515.1	0.31

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Interim, 60' Waste, 2.8% Slope, 325' Length w/ GCL
Simulated on: 12/1/2023 15:31

	Peak Values for Years 1 - 30*	
	(inches)	(cubic feet)
Precipitation	4.62	16,770.6
Runoff	2.340	8,495.8
Subprofile1		
Drainage collected from Layer 4	0.1943	705.2
Percolation/leakage through Layer 6	0.000000	0.0001
Average head on Layer 5	0.0796	---
Maximum head on Layer 5	0.1579	---
Location of maximum head in Layer 4	2.37 (feet from drain)	
Other Parameters		
Snow water	0.7003	2,542.1
Maximum vegetation soil water	0.4516 (vol/vol)	
Minimum vegetation soil water	0.1870 (vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Interim, 60' Waste, 2.8% Slope, 325' Length w/ GCL
Simulated on: 12/1/2023 15:31
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	3.7279	0.3107
2	215.5460	0.2994
3	9.3178	0.3882
4	0.0437	0.2299
5	0.0000	0.0000
6	0.1800	0.7500
Snow water	0.0000	---

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Closed, 2.8% Slope, 325' Lengt... **Simulated On:** 12/1/2023 15:45

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
CL - Clay Loam
Material Texture Number 11

Thickness = 6 inches
Porosity = 0.464 vol/vol
Field Capacity = 0.31 vol/vol
Wilting Point = 0.187 vol/vol
Initial Soil Water Content = 0.4536 vol/vol
Effective Sat. Hyd. Conductivity = 6.40E-05 cm/sec

Layer 2

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness = 0.04 inches
Effective Sat. Hyd. Conductivity = 4.00E-13 cm/sec
FML Pinhole Density = 1 Holes/Acre
FML Installation Defects = 4 Holes/Acre
FML Placement Quality = 3 Good

Layer 3

Type 1 - Vertical Percolation Layer
Custom Soil 1
Material Texture Number 43

Thickness = 18 inches
Porosity = 0.427 vol/vol
Field Capacity = 0.418 vol/vol
Wilting Point = 0.367 vol/vol
Initial Soil Water Content = 0.4094 vol/vol
Effective Sat. Hyd. Conductivity = 1.00E-05 cm/sec

Layer 4

Type 1 - Vertical Percolation Layer
CL - Clay Loam
Material Texture Number 11

Thickness = 6 inches

Porosity = 0.464 vol/vol
Field Capacity = 0.31 vol/vol
Wilting Point = 0.187 vol/vol
Initial Soil Water Content = 0.31 vol/vol
Effective Sat. Hyd. Conductivity = 6.40E-05 cm/sec

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
Municipal Solid Waste (MSW) (900 pcy)
Material Texture Number 18

Thickness = 720 inches
Porosity = 0.671 vol/vol
Field Capacity = 0.292 vol/vol
Wilting Point = 0.077 vol/vol
Initial Soil Water Content = 0.292 vol/vol
Effective Sat. Hyd. Conductivity = 1.00E-03 cm/sec

Layer 6

Type 1 - Vertical Percolation Layer
CL - Clay Loam
Material Texture Number 11

Thickness = 24 inches
Porosity = 0.464 vol/vol
Field Capacity = 0.31 vol/vol
Wilting Point = 0.187 vol/vol
Initial Soil Water Content = 0.31 vol/vol
Effective Sat. Hyd. Conductivity = 6.40E-05 cm/sec

Layer 7

Type 2 - Lateral Drainage Layer
Custom Geonet 1
Material Texture Number 123

Thickness = 0.19 inches
Porosity = 0.85 vol/vol
Field Capacity = 0.01 vol/vol
Wilting Point = 0.005 vol/vol
Initial Soil Water Content = 0.0107 vol/vol
Effective Sat. Hyd. Conductivity = 5.00E+00 cm/sec
Slope = 2.8 %
Drainage Length = 325 ft

Layer 8

Type 4 - Flexible Membrane Liner
HDPE Membrane
Material Texture Number 35

Thickness = 0.06 inches
Effective Sat. Hyd. Conductivity = 2.00E-13 cm/sec
FML Pinhole Density = 1 Holes/Acre
FML Installation Defects = 4 Holes/Acre
FML Placement Quality = 3 Good

Layer 9

Type 3 - Barrier Soil Liner
Custom Soil 2
Material Texture Number 44

Thickness = 0.24 inches
Porosity = 0.75 vol/vol
Field Capacity = 0.747 vol/vol
Wilting Point = 0.4 vol/vol
Initial Soil Water Content = 0.75 vol/vol
Effective Sat. Hyd. Conductivity = 5.00E-09 cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number = 85
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 1 acres
Evaporative Zone Depth = 6 inches
Initial Water in Evaporative Zone = 2.721 inches
Upper Limit of Evaporative Storage = 2.784 inches
Lower Limit of Evaporative Storage = 1.122 inches
Initial Snow Water = 0 inches
Initial Water in Layer Materials = 229.812 inches
Total Initial Water = 229.812 inches
Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude = 31.37 Degrees
Maximum Leaf Area Index = 3.5
Start of Growing Season (Julian Date) = 55 days
End of Growing Season (Julian Date) = 336 days
Average Wind Speed = 11.3 mph
Average 1st Quarter Relative Humidity = 69 %
Average 2nd Quarter Relative Humidity = 69 %

Average 3rd Quarter Relative Humidity = 62 %
Average 4th Quarter Relative Humidity = 69 %

Note: Evapotranspiration data was obtained for NACOGDOCHES, TEXAS

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
4.45	3.17	3.53	3.13	5.29	4.18
2.6	3.08	4.08	4.13	4.54	4.44

Note: Precipitation was simulated using HELP v3.07 data files for the following location:
HOUSTON, TEXAS

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
51.4	54.5	61	68.7	74.9	80.6
83.1	82.6	78.4	69.7	60.1	54

Note: Temperature was simulated using HELP v3.07 data files for the following location:
HOUSTON, TEXAS
Solar radiation was simulated using HELP v3.07 data files for the following location:
HOUSTON, TEXAS (Latitude: 31.37)

Average Annual Totals Summary

Title: Closed, 2.8% Slope, 325' Length w/ GCL
Simulated on: 12/1/2023 15:46

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	45.09	[6.73]	163,658.6	100.00
Runoff	13.984	[5.121]	50,761.5	31.02
Evapotranspiration	31.053	[2.761]	112,722.7	68.88
Subprofile1				
Percolation/leakage through Layer 2	0.045954	[0.006734]	166.8	0.10
Average Head on Top of Layer 2	1.7634	[0.2677]	---	---
Subprofile2				
Lateral drainage collected from Layer 7	0.0460	[0.0067]	166.8	0.10
Percolation/leakage through Layer 9	0.000001	[0]	0.0050	0.00
Average Head on Top of Layer 8	0.0001	[0]	---	---
Water storage				
Change in water storage	0.0021	[0.568]	7.5756	0.00

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Closed, 2.8% Slope, 325' Length w/ GCL
Simulated on: 12/1/2023 15:46

	Peak Values for Years 1 - 30*	
	(inches)	(cubic feet)
Precipitation	4.62	16,770.6
Runoff	4.085	14,827.1
Subprofile1		
Percolation/leakage through Layer 2	0.000415	1.5059
Average head on Layer 2	6.0000	
Subprofile2		
Drainage collected from Layer 7	0.0004	1.4978
Percolation/leakage through Layer 9	0.000000	0.0000
Average head on Layer 8	0.0002	---
Maximum head on Layer 8	0.0003	---
Location of maximum head in Layer 7	0.00	(feet from drain)
Other Parameters		
Snow water	0.7003	2,542.1
Maximum vegetation soil water	0.4640	(vol/vol)
Minimum vegetation soil water	0.1870	(vol/vol)

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Closed, 2.8% Slope, 325' Length w/ GCL
Simulated on: 12/1/2023 15:46
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	2.7840	0.4640
2	0.0000	0.0000
3	7.3688	0.4094
4	1.8600	0.3100
5	210.2400	0.2920
6	7.4400	0.3100
7	0.0020	0.0104
8	0.0000	0.0000
9	0.1800	0.7500
Snow water	0.0000	---