Phillips 66 WRB Refinery
Spur 119 North Phillips School 217
Borger, TX 79008

May 20, 2020

Karen Scott
Industrial and Hazardous Waste Permits Section
Waste Permits Division, Mail Code 130
Texas Commission on Environmental Quality
12100 Park 35 Circle, Building F
Austin, Texas 78753

Re: Transmittal of Technical NOD 1 Response to Class 3 Permit Modification Application
Phillips 66, Borger Refinery
Hazardous Waste Permit No. 50078
EPA ID # TXD980626774
Solid Waste Registration No. 30111

Dear Ms. Scott:

Please see attached Technical NOD 1 Response Key and changed pages in response to the Technical NOD 1 letter issued by the TCEQ on April 21, 2020 via email regarding the Class 3 Permit Modification referenced above for the Phillips 66 Borger Refinery. Redline strikeout pages of the original January 2020 application and for the Technical NOD 1 pages are provided. Please replace the original pages submitted in the application dated January 30, 2020 as summarized in the table below.

In addition to the NOD Response Key attached, Phillips 66 is providing below additional explanation of the need for the Class 3 permit modification, particularly regarding the proposed alternative cap design for the North Holding Pond as requested by NOD comment ID T1.

Changed Pages Key

Application Section	Replaced pages (replace Jan 2020 pages with pages dated May 2020	Added pages
Part B, Section I	Pages 4-10	Page 11 (new signature page)
Waste Analysis Plan	TOC, Pg 2-2, Appendices cover, Appendix 2	Appendix 3
Section VI	Table VI.B.3.b. – page 114 Table VI.B.3.c. – page 122	
Section VII	Table VII.A. – page 123 Table VII.B. – pages 124 – 125 Table VII.D. – pages 127-130 Table VII.E.1 – page 1 Table VII.E.2 – page 1	Table VII.D. – pages 131-132
NHP Closure Plan	Complete NHP Closure Plan replaced	A copy of the TCEQ approval of the Class 2 delay of closure of NHP is attached.
Post Closure Plan	Complete Post Closure Plan replaced	
Compliance Plan	CP Tables XI.E.1-XI.E.3 – pages 183 – 200 CP Table II – page 205 – 206 CP Tables III and IIIA – pages 207-225 CP Att B Well Design and CP Att C SAP – updated revision date on changed pages	

Explanation of the Need for Proposed Changes in the Class 3 Permit Modification

Changes to Permit Sections
<u>Revised the Closure and Post-Closure Plans for the North Holding Pond (cap design change)</u>: In conjunction with a review of the current closure plan, a site inspection was conducted on November 3, 2016, which identified significant erosional features located in the portions of the arroyo that borders the east and southeast sides of the North Holding Pond (NHP). Evidence of developing erosional features was also noted on the slopes immediately adjacent to the southeast side of the NHP. Soils in the area are reported to have a moderate to severe erosion hazard ratings. This Class III permit modification is proposed to address the issues identified during the 2016 review of the Closure Plan and site inspection. The issues identified are related to the constructability of the approved final cover system, as well as advancements in construction materials since the original cover system was designed and approved. In addition, some site conditions have changed since the facility original closure plan was developed. For each of the issues identified, alternatives have been identified that are expected to improve constructability, provide equivalent or better short- and long-term performance, and/or reduce potential impacts to adjacent surface water drainage features. The proposed alternative cover design will meet traditional RCRA Subtitle C final cover system goals to provide a low permeability layer to water infiltration, promote runoff, and to stabilize the ground surface. The proposed changes to the NHP cover system require updated design and construction specifications in the Closure and Post Closure Plan and updated closure and post-closure cost estimates implemented through a permit modification. Additional discussion, backup design data, and construction specifications have been added to the NHP Closure Plan provided with the Technical NOD 1 Response.
<u>Revised Table VII.B, VII.D, VII E.1, VII.E.2</u>: Closure costs for North Holding Pond (NHP) were revised due to a change in the closure plan. Costs for other units were updated for inflation to 2019 dollars. <u>Revised Table VI.B.3.b. and Table VI.B.3.c.:</u> Revisions made in response to TCEQ comments on the 2018 Annual Groundwater Monitoring Report in a letter dated June 13, 2019.
<u>Section 2.2 of the Waste Analysis Plan</u>: Revised to clarify that the delisting petition was approved for TDU residue solids and not for sludge generated from the wastewater treatment plant.

Changes to Compliance Plan Sections
<u>Updated CP Tables I through V based on submittal of the RAPs requiring a permit modification for the following Corrective Action Sites</u>: Old Caustic Pond, Litharge Impoundment, HP-7 / South Cobles, New Caustic Pond, and Southeast Canyon
<u>Updated CP Tables XI E.1, E.2, and E.3:</u>

Updated Correction Action costs for New Caustic Pond, (NCP) Old Caustic Pond (OCP), HP-7/South Cobles, Litharge, and Southeast Canyon (SEC) sites in agreement with approved RAPs. Costs for other Corrective Action sites were updated for inflation to 2019 dollars.
Updated CP Attachment B (Well Design): To incorporate well design using alternate screen length.
Updated the CP Attachment C Sampling and Analysis Plan (SAP): Updated Tables 1, 2, and 4 to match permit and compliance plan; text edit in Section 5.4.2 to clarify filtration requirements.
PCLs were updated in CP Tables III, IIIA, IV, and IVA: For changes made in TCEQ PCL tables, and updates to 2018 HH RBELs and the 2017 Eco benchmarks.
Removed the word Philtex from the CP tables: For consistency with current naming convention for the Class 1 Landfill and New Evaporation Pond.

One original and three copies of the changed pages and signature pages have been provided, along with a redline/strikeout version identifying the changes. An electronic copy of the changed pages has been submitted to the TCEQ Region 1 office.

Please call me at 806-275-1817 or email at Spencer.Cave1@p66.com or contact Carson Christie, Remediation Management Program Manager for Phillips 66 at 806-275-2205 or email at Carson.L.Christie@p66.com if there are any questions regarding this response or if you need additional information to process the Permit Modification.

Sincerely,

Sandy Keys
Environmental Team Leader
Phillips 66, Borger Refinery

cc: Spencer Cave, Phillips 66, Borger Refinery
Carson Christie, Phillips 66 Remediation Management

Application Deficiencies – Technical NOD #1

ID[1]	App. Part	App. Section	Location[2]	Citation	Error Type[3]	Deficiency Description/Resolution	Phillips 66 Response
C1						For replaced pages in this modification (MOD) request, please update the facility name from ConocoPhillips to Phillips 66 Company, ensure that the date is included on each modified page, and provide a redline strikeout for all proposed changes. Please note that pages without change should retain their current revision dates. Submit an editable electronic copy of all revised Tables. Reminder: do not change table formats.	A printed copy of redline strikeout version of application is provided; electronic copy of revised tables also provided. Other requested edits completed.
T1	B	Instructions	Pages v and vi	30 TAC 305.69(d)(1)(A) & (D)	Incomplete	Include a description of the exact changes to be made to the permit conditions and supporting documents referenced by the permit application and an explanation of why the Class 3 modification is needed. Please reference Requirements for Class 3 Modification to Hazardous and Industrial Waste Permits - may be found through the following link: https://www.tceq.texas.gov/permitting/waste_permits/ihw_permits/ihw_class_3.html	Phillips 66 has provided additional clarification/explanation of the proposed changes in the Class 3 permit modification in the NOD response transmittal letter.
T2	B	I.D.6. (table)	Page 4	40 FR 270.42	Ambiguous /Incomplete	Please separate the proposed revisions to the Compliance Plan from the other permit sections. In order for the revisions to not be overlooked, they must be listed under a Section XI reference. It is noted that changes to Permit Tables are requested. However, no redline strike out, indicating changes, is provided. Please submit the redline strike out pages. For tables not being revised in this application, please do not revise the page dates (reference C1 above).	Changes to the permit specified in Section I.D.6 have been separated into Permit and Compliance Plan categories. A printed copy of redline strikeout version of application is provided. Other requested edits completed.

[1] Deficiency ID – Key: A#= Administrative deficiency (ex. A12); T#= Technical deficiency relating to Sections I- X and Sections XII- XIII of the Part B application (ex. T10); C#= Comment only (ex. C1); CP#= Technical deficiency relating to Section XI- Compliance Plan of the Part B application (ex. CP14); Number in parenthesis (n) = nth instance of same deficiency (ex. T1(2) is the second instance of deficiency T1 originally identified in previous NOD).
[2] Location of deficiency in submittal/application. Items in square brackets [ ] refer to applicant's supplemental information submitted as attachments to the application form.
[3] Possible Error Types: Ambiguous, Incomplete, Inconsistent, Incorrect, Omitted, Typo, or Format.

ID[1]	App. Part	App. Section	Location[2]	Citation	Error Type[3]	Deficiency Description/Resolution	Phillips 66 Response
T3	B	IV	Attachment B.IV.D. Waste Analysis Plan (WAP), Appendix 2	40 CFR 261, Appendix IX	Incomplete/ Ambiguous	a. As part of the WAP, please include a copy of WRB Refining, LLC's *Wastes Excluded from Non-Specific-Sources*. b. Please explain/confirm the Delisting Levels Maximum Allowable Concentrations (mg/L) listed in *Appendix 2 – Annual LDR Analyte List* for the organic constituents. c. For each constituent listed, please clarify whether it applies to wastewater, non-wastewater, etc. d. Provide the EPA approval document for the organics listed.	a. The requested "Wastes Excluded from Non-Specific Sources" from 40 CFR 21 Appendix IX has been added to Appendix 3 of the WAP. b. The organic parameters are not currently listed in the "Wastes Excluded from Non-Specific Sources" from 40 CFR 21 Appendix IX; however the organics were listed in the FR cited below in Item d. c. Clarified the LDR Analyte List in Appendix 2 applies to non-wastewater samples of treated desorber solids tested for Leachable Concentrations (results in mg/l). d. The Federal Register listing of the "Wastes Excluded from Non-Specific Sources" from 40 CFR 21 Appendix IX is from FR Vol 74 No 146 Friday July 31, 2009, in Table 1 Paragraph 1, copied below. * * * * * * * WRB Refining, LLC .... Borger, TX .... Thermal desorber residual solids (Hazardous Waste Nos. F037, F038, K048, K049, K050, and K051) generated at a maximum annual rate of 5,000 cubic yards per calendar year after September 29, 2009 and disposed in Subtitle D Landfill. For the exclusion to be valid, WRB Refining LLC must implement a verification testing program that meets the following Paragraphs: (1) Delisting Levels: All concentrations for those constituents must not exceed the maximum allowable concentrations in mg/l specified in this paragraph. Thermal Desorber Residual Solid Leachable Concentrations (mg/l): Antimony–0.165; Arsenic–0.0129; Barium–54.8; Beryllium–0.119; Cadmium–0.139; Chromium–3.23; Chromium, Hexavalent–3.23; Cobalt–20.7; Copper–38.6; Cyanide–4.69; Lead–1.07; Mercury–0.104; Nickel–20.6; Selenium–1.0; Silver–5.0; Tin–3790.00; Vanadium–1.46; Zinc–320.0; Acenapthene–16.2; Anthracene–39.5; Benzene–0.117; Carbon Disulfide–86.0; 2-chlorophenol–4.41; Dibenzofuran–0.0226; 1,4-Dichlororbenzene–0.518; Ethylbenzene–16.5; Fluoranthene–3.75; Methylene Chloride–0.077; Naphthalene–0.0498; Phenol–264.0; Pyrene–6.78; Toluene–23.0; 1,2,4-Trichlorobenzene–1.51; Trichlorofluoromethane–23.5; Xylenes–14.6.
T4	B	IV	WAP, page 2-2	40 CFR 264.13	Incomplete	a. The agency received a redline strikeout for page 2-2. This page was corrected during Admin Review. Please submit a clean copy of page 2-2 to replace the corrected page in Phillips 66's WAP. b. Please clarify whether any changes were made to the WAP tables or other parts of the WAP. If yes, please submit the redline strike outs for the pages (e.g., page 2-5).	Clean copy of WAP page 2-2 is provided. No other changes were made to the WAP; however clarifications to Appendix 2 and addition of Appendix 3 were made as part of the Technical NOD1 response.
T5	B	VI	Application Tab – Section VI Tables, Tables VI.B.3.c.	30 TAC 335.164	Incomplete	On page 122, please correct Hazardous Waste Impoundments to read Hazardous Waste Surface Impoundments.	Correction made as requested; a similar change was also made to Table VI.B.3.b.

ID[1]	App. Part	App. Section	Location[2]	Citation	Error Type[3]	Deficiency Description/Resolution	Phillips 66 Response
T6	B	VII	Application Tab – ATT B.VII.A.3, pg. 1-1	40 CFR 270.22(e); 264.310(a) & (b); & 264.14(b)(13)	Incorrect	Section 1.0 a. In the first paragraph, please clarify why Interim Standards under Subchapter E are referenced (30 TAC 335.118). Note: Delay of closure is found under 264.113(d). b. In the second paragraph, please clarify: Solid Waste Registration No. 30111; and Hazardous Waste Permit No. 50078. Also, please include the facility's physical address. Note: Notice of Registration Nos. (NORs) are assigned to units. c. Please include a copy of the referenced letter dated October 2001 or provide its location within the permit application. Section 2.0 d. The agency does not issue permits on speculative information. Please pick a closure path and provide the detailed plans and an engineering report describing the final cover which will be applied to the North Holding Pond (NOR 036) at closure in accordance with §264.310(a), and a description of how the landfill will be maintained and monitored after closure in accordance with §264.310(b). This information should be included in the closure plan and the post-closure care plans submitted under §264.14(b)(13).	a. Corrections were made to the referenced regulatory citations to refer to 40 CFR §264 Subpart G and TCEQ 30 TAC §335.169 requirements. b. The SWR number was corrected and the site address was added as requested. c. A copy of the TCEQ approval of the Class 2 permit modification associated with partial closure and delay of closure of NHP is provided with the Technical NOD 1 response documents. The reference in the Closure Plan to October 2004 appears to be incorrect; the approval letter is dated April 2004. The reference date has been updated in the Closure Plan. d. The Closure Plan has been revised to incorporate elements discussed between TCEQ technical staff and Phillips 66 in a conference call on May 1, 2020.
T7	B	VII	Attachment B.VII.C.1, Table 1-Unit Post-Closure Cost Estimate	Permit Provision VII.A.9	Incorrect	a. Please reference P66's April 25, 2018 Class 1[1] MOD that changed the financial assurance amount for year 2013 to $3,556,800. Please correct the applicable tables and resubmit. b. Please include Post-Closure Care Cost Estimates for units: Surface Impoundment 301 (NOR 031); New Evaporation Pond (NOR066); Class I Landfill (NOR 065);and Old Caustic Pond (NOR 008) For units currently under a compliance plan for groundwater monitoring, include only the above-ground costs. [Reference Permit Table VII.G. – Post-Closure Period] c. Please clarify if Hazardous Waste Landfill is the unit named Class I-H Landfill.	a. Corrected the 2013 Total Post-Closure Cost in Table 1 of the Post-Closure Care Plan to $3,556,800; this cost included Corrective Action Costs, which are now accounted for in the Compliance Plan Financial Assurance Cost, per notes in item (b) below. b. The post-closure cost for SI 301 was included with the cost for SI-302 but the detail was missing; the detail for SI-301 was copied from Part B Table VII.D into Table 1 of the Post-Closure Plan. Post-closure costs for the Class 1 Landfill, New Evaporation Pond, and Old Caustic Pond were previously included in the Compliance Plan Financial Assurance costs. The above-ground Post-Closure costs for these units have been separated from the Compliance Plan and included in Table 1 of the Post-Closure Plan. c. Yes, the Hazardous Waste Landfill (NOR 024) is known as the Class I-H Landfill.
T8	B	VII	Tab Section VII Tables, Table VII.A. – Unit Closure, Pg. 123	40 CFR 270	Incomplete/ Incorrect	In the 1st column enter *equipment* used in closing the Waste Management Unit (trucks, dozers, shovels, etc.) In the 2nd column list the possible methods of decontamination to clean the equipment listed in the 1st column. In the 3rd column list how the residues from the 2nd column will be disposed.	Table VII.A. has been updated as requested.
T9	B	VII	Tab Section VII Tables, Table VII.D. – Unit Post-Closure Cost Estimate	Permit Provision VII.A.9	Incomplete	Please see T7 (b) above regarding inclusion of units currently also under the compliance plan. Correct remaining tables in this Section as applicable.	Above-ground Post-closure costs for the Class 1 Landfill, New Evaporation Pond, and Old Caustic Pond have been separated from the Compliance Plan and included in Tables VII.D. and VII.E2 of the Part B forms.

ID[1]	App. Part	App. Section	Location[2]	Citation	Error Type[3]	Deficiency Description/Resolution	Phillips 66 Response
C2						The following information needs to be updated/corrected on P66's NOR and permit tables: For NOR 006 = Change TCEQ Unit No. 006 for Pitch Pits 12 & 14 to TCEQ Unit No. 007. For NOR 023 = Remove TCEQ Unit No. 007 and Post- Closure Care (SWMU is in a FOA, not in Post- closure care). Change name of unit by removing "12". Should read Pitch Pit Annex.	Please make the changes to the NOR as suggested. The reference to Pitch Pit 12 Annex in CP Table II has been corrected to Pitch Pit Annex.
CP1	B	XI	CP Table III, IIIA	30TAC 335.166 and 335.167	Format	CP Table III and CP Table IIIA: For Columns B, C, and D, Applicant should list the GWPS footnote next to the GWPS. The footnote should not be listed in the header.	CP Tables III and IIIA have been corrected as requested.
CP2	B	XI	CP Table III	30TAC 335.166 and 335.167	Incorrect	CP Table III: Litharge Impoundment: Need to remove NAPL from the table. NAPL should be addressed in CP Table VII.	"NAPL" has been removed from CP Table III as requested.
CP3	B	XI	CP Table IIIA	30TAC 335.166 and 335.167	Incorrect	CP Table IIIA: Litharge Impoundment: Need to remove NAPL from the table. NAPL should be addressed in CP Table VII.	"NAPL" has been removed from CP Table IIIA as requested.
CP4	B	XI.E	Tables XI.E.1-XI.E.3	30TAC 335.165 and 335.166	Incorrect	Financial Assurance. Table XI.E.1 Please adjust cost to the year 2019.	Financial Assurance costs for Corrective Action were also updated to 2019 values in CP Tables XI.E.1 through XI.E.3; Also, closure costs have been updated to 2019 values in Tables VII.B, VII.D, VII.E1, and VII.E2 of the Part B forms.

5. Is the facility within the Coastal Management Program boundary (for Class 3 Modifications, Permit Renewals, and New Permit applications only)?

   ☐ Yes ☒ No

6. Provide a brief description of the portion of the facility covered by this application in the table below, including the changes for which an amendment or modification is requested: *[***Note:*** List all changes requested in the table below. Unlisted requests risk remaining unaddressed or possibly denied if brought to the permit application reviewer's attention at a later time.]*

Changes to Permit Sections are shown below:

Permit/Compliance Plan Application Section	Brief Description of Proposed Change	Modification or Amendment Type	Supporting Regulatory Citation
Part B Section XII	Permit application fee worksheet.	Class 1	30 TAC 305.69(k)(A)(1)
Part B, Tables	Revised Table VII.B, VII.D, VII E.1, VII.E.2: Closure costs for North Holding Pond (NHP) were revised due to a change in the closure plan. Costs for other units were updated for inflation to 2019 dollars. Revised Table VI.B.3.b. and Table VI.B.3.c. in response to TCEQ comments on the 2018 Annual Groundwater Monitoring Report in a letter dated June 13, 2019.	Class 3	30 TAC 305.69(K)(D)(2)
Part B. Waste Analysis Plan	Section 2.2 was revised to clarify that the delisting petition was approved for TDU residue solids and not for sludge generated from the wastewater treatment plant.	Class 1[1]	30 TAC 305 .69(k)(A)(1)
Section VII, NHP Closure Plan	Revised the closure plan for the North Holding Pond (cap design change).	Class 3	30 TAC 305.69(k)(D)(2)
Section VII, NHP Post Closure Plan	Revised the post closure plan for the North Holding Pond to reflect changes in cap design and updated Post Closure costs.	Class 3	30 TAC 305.69(k)(D)(2)

Changes to Compliance Plan Sections are shown in the table below:

Permit/Compliance Plan Application Section	Brief Description of Proposed Change	Modification or Amendment Type	Supporting Regulatory Citation
Section XI, Compliance Plan and CP Tables	Updated CP Tables I through V based on submittal of the following RAPs: Revised RAP Rev 2, Old Caustic Pond Area, Submitted January, 2017; Conditional Approval OCP Revised RAP Rev 2 with Request for a RAP Addendum Received February 2017, Additional Responses to Conditional Approval OCP Revised RAP Rev 2 with Request for a RAP Addendum Submitted August 8, 2017, TCEQ Approval Responses to Conditional Approval OCP Revised RAP Rev 2 with Request for a RAP Addendum Received August 17, 2017, and Additional Responses to Conditional Approval OCP Revised RAP Rev 2 with Request for a RAP Addendum Submitted April 12, 2018; Revised Response Action Plan, Addendum 2, Old Caustic Pond, Submitted June 2019 Revised Response Action Plan, Litharge Impoundment, Submitted April 4, 2015; Response Action Completion Report, Litharge Impoundment, Submitted July 20, 2018 Revised Response Action Plan, HP-7 / South Cobles, Submitted April 30, 2015; Addendum to the 2015 Revised Response Action Plan, HP-7/South Cobles Site, February 1, 2016 Response Action Plan, New Caustic Pond, Submitted December 4, 2017; Revised Response Action Plan, New Caustic Pond, Submitted June 6, 2018 Revised Response Action Plan, Southeast Canyon, Submitted December 18, 2018 Removed the word Philtex from the CP tables for consistency with current naming convention for the Class 1 Landfill and New Evaporation Pond. Updated CP Tables XI E.1, E.2, and E.3 to reflect Correction Action costs for	Class 3	30 TAC 305.69(k)(C)(8)(b)

Permit/Compliance Plan Application Section	Brief Description of Proposed Change	Modification or Amendment Type	Supporting Regulatory Citation
	New Caustic Pond, (NCP) Old Caustic Pond (OCP), HP-7/South Cobles, Litharge, and Southeast Canyon (SEC) sites in agreement with approved RAPs. Costs for other Corrective Action sites were updated for inflation to 2019 dollars. PCLs were updated in CP Tables III, IIIA, IV, and IVA for changes made in TCEQ PCL tables, and updates to 2018 Human Health RBELs and the 2017 Eco benchmarks. Updated the CP Attachment C Sampling and Analysis Plan (SAP): updated Tables 1, 2, and 4 to match permit and compliance plan; text edit in Section 5.4.2 to clarify filtration requirements. Updated CP Attachment B (Well Design) to incorporate well design using alternate screen length.		

7. Total acreage of the facility being permitted: ***The facility has 6,045 acres.***
8. Identify the name of the drainage basin and segment where the facility is located: ***Canadian River Basin – Segment 0101***

E. Facility Siting Summary

Is the facility located or proposed to be located:

1. within a 100-year floodplain?
   ☐Yes ☒ No

2. in wetlands?
   ☐Yes ☒No

3. in the critical habitat of an endangered species of plant or animal?
   ☐Yes ☒No

4. on the recharge zone of a sole-source aquifer?
   ☐Yes ☒ No

5. in an area overlying a regional aquifer?
   ☐Yes ☒ No

6. Within 0.5 mile (2,640 feet) of an established residence, church, school, day care center, surface water body used for a public drinking water supply, or dedicated public park? (Use only for a new commercial hazardous waste management facility or areal expansion of an existing commercial hazardous waste management facility or unit of that facility as defined in 30 TAC 335.202)
   ☐Yes ☐No ☒Not Applicable

   If Yes: the TCEQ shall not issue a permit for this facility.

7. In an area in which the governing body of the county or municipality has prohibited the processing or disposal of municipal hazardous waste or industrial solid waste?
   ☐Yes ☒No

   If Yes: provide a copy of the ordinance or order.

F. Wastewater and Stormwater Disposition

1. Is the disposal of any waste to be accomplished by a waste disposal well at this facility?
   ☐ No ☒Yes (**If Yes**: List WDW Permit No(s):___***WDW325***_______________).

2. Will any point source discharge of effluent or rainfall runoff occur as a result of the proposed activities?
   ☒ Yes ☐No

3. If Yes, is this discharge regulated by a TPDES or TCEQ permit?
   ☒ Yes Permit No._***WQ0001064000***____________(TCEQ)
   Permit No._***TX0009148***____________(TPDES)

4. ☐No Date TCEQ discharge permit application filed: _________
   Date TPDES discharge permit application filed:_________

G. Information Required to Provide Notice

State Officials List

Provide the name and mailing address for the State Senator and State Representative in the district in which the facility is or will be located. Either local district addresses or capitol addresses are acceptable. This list should not be included in the Adjacent Landowners List required below. [30 TAC 39.103(b)]

State Senator	State Representative
The Honorable Kel Seliger ***P.O. Box 12068*** ***Capitol Station*** ***Austin, Texas 78711*** ***(512) 463-0131*** ***Fax (512) 475-3733***	***Representative Four Price*** ***P.O. Box 2910*** ***Austin, TX 78768*** ***(512) 463-0470***

Local Officials List

Provide the name and mailing address of the mayor and health authority of the municipality in whose territorial limits or extraterritorial jurisdiction the facility is or will be located. In addition, please provide the county judge and health authority of the county in which the facility is located. This list should not be included in the Adjacent Landowners List required below. [30 TAC 39.103(c)]

Mayor Marvin Dickson ***600 North Main Street*** ***PO Box 5250*** ***Borger, TX*** ***79008-5250*** ***(806) 273-0900*** ***Fax: 806-878-4048*** ***mdickson@borgertx.gov***	***Judge Cindy Irwin*** ***515 S. Main St, Ste 214*** ***P.O. Box 790 (mail address)*** ***Stinnett, Texas*** ***79083*** ***806-878-4000*** ***Fax: 806-783-6435*** ***judgeirwin@hutchinsoncnty.com***	***Dr. Kimberly Wolboldt, MD, MPH*** ***(or current Medical Director)*** ***Department of State Health Services, PHR1*** ***6302 Iola Avenue*** ***Lubbock, Texas*** ***79424*** ***806-744-3577***

Adjacent Landowners List

Submit a map indicating the boundaries of all adjacent parcels of land, and a list (see samples in the instructions) of the names and mailing addresses of all adjacent landowners and other nearby landowners who might consider themselves affected by the activities described by this application. Cross-reference this list to the map through the use of appropriate keying techniques. The map should be a USGS map, a city or county plat, or another map, sketch, or drawing with a scale adequate enough to show the cross-referenced affected landowners. The list should be updated prior to any required public notice. It is the applicant's responsibility to ensure that the list is up-to-date for any required public notice. For all applications (with the exception of Class 1 and Class 1[1] modifications) this mailing list should be submitted on:

1. a Compact Disk (CD) using software compatible with MS Word [30 TAC 39.5(b)]; or
2. four sets of printed labels.

If the adjacent landowners list is submitted on a compact disk (CD), please label the disk with the applicant's name and permit number. Within the file stored on the disk, type the permit number and applicant's name on the top line before typing the addresses. Names and addresses must be typed in the format indicated below. This is the format required by the U.S. Postal Service for machine readability. Each letter in the name and address must be capitalized, contain no punctuation, and the appropriate two-character abbreviation must be used for the state. Each entity listed must be blocked and spaced consecutively as shown below. The list is to be 30 names, addresses, etc. (10 per column) per page (MS WORD Avery Standard 5160 – ADDRESS template).

Example:

Industrial Hazardous Waste Permit No. 50000, Texas Chemical Plant

HEAVY METALS LP
PO BOX 85624
PUMPKIN PARK TX 79998-5624

MR AND MRS W R NEIGHBOURLY
1405 ACROSSTHE WAY
GREATER METRO CITY TX 79199

A list submitted on compact disk (CD) should be the only item on that disk. Please do not submit a list on a disk that includes maps or other materials submitted with your application.

If you wish to provide the list on printed labels, please use sheets of labels that have 30 labels to a page (10 labels per column) (for example: Avery® Easy Peel® White Address Labels for Laser Printers 5160). Please provide four complete sets of labels of the adjacent landowners list.

See Attachment B.1 - Adjacent Landowners List

Based on the questions in the Bilingual Notice Instructions for this form, are you required to make alternate (Bilingual) notice for this application?

☒Yes ☐No

Bilingual Language(s):***Spanish***

H. TCEQ Core Data Form

The TCEQ requires that a Core Data Form CDF (Form 10400) be submitted on all incoming applications. Please ensure that the submitted CDF does not show a change for any information that will remain the same as previously submitted. For more information regarding the Core Data Form, call (512) 239 1575 or go to the TCEQ Web site at http://www.tceq.texas.gov/permitting/central_registry/guidance.html

Attached

I. Signature on Application

It is the duty of the operator to submit an application for a permit. The person who signs the application form will often be the operator himself; when another person signs on behalf of the applicant, his title or relationship to the applicant will be shown. In all cases, the person signing the form must be authorized to do so by the applicant. An application submitted by a corporation must be signed by a responsible corporate officer such as a president, secretary, treasurer, vice president, or by his duly authorized representative, if such representative is responsible for the overall operation of the facility from which the activity described in the form originates. In the case of a partnership or a sole proprietorship, the application must be signed by a general partner or the proprietor, respectively. In the case of a municipal, state, federal, or other public facility, the application must be signed by a principal executive officer, a ranking elected official, or another duly authorized employee. A person signing an application on behalf of an applicant must provide notarized proof of authorization.

Signature Page

I, ***Darrel L. Hail***, ***Refinery Manager, Phillips 66 (Borger Refinery)***
(Operator) *(Title)*

certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature: Darrel L. Hail Date: 5-19-2020

- -

To be completed by the Operator if the application is signed by an Authorized Representative for the Operator

I,____________________, hereby designate ____________________
[Print or Type Name] *[Print or Type Name]*

as my representative and hereby authorize said representative to sign any application, submit additional information as may be requested by the Commission; and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my authorized representative in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

____
Printed or Typed Name of Operator or Principal Executive Officer

____
Signature

- -

SUBSCRIBED AND SWORN to before me by the said

On this 19th day of May, 2020

My commission expires on the 20th day of June, 2023

Notary Public in and for Hutchinson County, Texas

*[**Note**: Application Must Bear Signature & Seal of Notary Public]*

Denise Webb

DENISE WEBB
Notary Public, State of Texas
Comm. Expires 06-20-2023
Notary ID 4705732

NOTARY PUBLIC STATE OF TEXAS

Attachment B.IV.D
Waste Analysis Plan

Table of Contents

Attachment B.IV.D
Waste Analysis Plan

Table of Contents (Continued)

2.2 Waste Classification

One of the most important facets of waste evaluation is making a determination of whether a particular solid waste stream is a hazardous waste. In order to make this determination, the regulatory criteria established in 40 CFR Part 261 and 30 TAC Chapter 335 must be evaluated (see Figure 2 for guidance).

As demonstrated by Figure 2, a determination of whether or not a particular solid waste is a hazardous waste begins with an assessment of whether it is a listed hazardous waste. Since the listed hazardous wastes (F, K, P, and U-list) have certain "generation conditions" that must be satisfied to classify them as a listed hazardous waste, an evaluation of the production process is typically conducted as the first step to determine if the solid waste is a listed hazardous waste.

If it is determined that a listing does not apply, then information will be gathered to determine applicability of any of the RCRA hazardous characteristics. This determination will be based on either process knowledge or analytical data. Applicable EPA waste codes and TCEQ classification and form codes are then assigned to the waste at the point of generation.

The (thermal desorption unit TDU) residue solids generated by the facility have been delisted for the Hazardous Waste Numbers: F037, F038, K048, K049, K050, and K051. This delisting petition was posted in the Federal Register as EPA-RO6-RCRA-2008-0418; SW-FRL-8933-3. This exclusion applies to 5,000 cubic yards per year of the TDU residual solids. Accordingly, this final rule excludes the waste from the requirements of hazardous waste regulations under the RCRA when it is disposed in a Subtitle D Landfill. A copy of the delisting requirements from 40 CFR 261 Appendix IX is included as Appendix 3.

2.3 Properties for Waste Management Units

Acceptable operating criteria vary according to the specific waste management units that will receive the waste. To verify that a waste is within acceptable operating criteria for a particular waste management unit, the following information will be evaluated:

- Physical and chemical characteristics of the waste;
- Volume of the waste;
- Construction materials of the specific waste management unit; and
- Specific permit conditions associated with a waste management unit.

2.4 Land Disposal Restrictions

The LDRs specify the level of treatment or specific treatment technology, on a waste code basis, that must be achieved prior to placing hazardous wastes on or in the land. The treatment standards specified

Appendices to Waste Analysis Plan

Appendix 2
Annual LDR Analyte List

Method[a]	Analyte	Delisting Levels Maximum Allowable Concentrations[c] (mg/L)	Method Detection Limit (mg/L)
SW8260B	Acenaphthene	16.2	0.0085
	Benzene	0.117	0.0016
	Carbon Disulfide	86.0	0.0024
	Ethylbenzene	16.5	0.0016
	Methylene Chloride	0.077	0.0012
	Toluene	23.0	0.0017
	Trichlorofluoromethane	23.5	0.0024
	Xylenes	14.6	0.0019
SW8270C	Anthracene	39.5	0.0042
	2-Chlorophenol	4.41	0.0055
	1,4-Dichlorobenzene[b]	0.518	0.0070
	Fluoranthene	3.75	0.025
	Naphthalene[b]	0.0498	0.0075
	Phenol	264.0	0.020
	Pyrene	6.78	0.0018
	1,2,4-Trichlorobenzene[b]	1.51	0.0060
SW6010B or SW6020	Antimony	0.165	0.016
	Arsenic	1.29	0.022
	Barium	54.8	0.0020
	Beryllium	0.119	0.0020
	Cadmium	0.139	0.0020
	Chromium	3.23	0.0030
	Cobalt	20.7	0.0060
	Copper	38.6	0.0060
	Lead	1.07	0.013
	Nickel	20.6	0.0060
	Selenium	1.0	0.024
	Silver	5.0	0.0040

Appendix 2
Annual LDR Analyte List (Continued)

Method[a]	Analyte	Delisting Levels Maximum Allowable Concentraions (mg/L)	Method Detection Limit (mg/L)
SW6010 or SW6020 (Continued)	Tin	3790.00	0.029
	Vanadium	1.46	0.0060
	Zinc	320.0	0.022
	Mercury	0.104	0.000030
SW7196	Hexavalent Chromium	3.23	0.0040
SW9012 / SW9014	Cyanide	4.69	0.0020

[a]Method is from SW-846, 3rd edition or most recent update.

[b]This analyte may be analyzed by either SW-846 SW-8260 or SW-8270 as long as detection limits are met.

[c] Delisting levels in the above table refer to samples of Thermal Desorber Residual Solids (non-wastewater), tested for Leachable Concentrations (results in mg/l).

Appendix 3
Wastes Excluded From Non-Specific Sources

Appendix IX to Part 261—Wastes Excluded Under §§260.20 and 260.22

Facility	Address	Waste description
WRB Refining, LLC	Borger, TX	Thermal desorber residual solids (Hazardous Waste Nos. F037, F038, K048, K049, K050, and K051) generated at a maximum annual rate of 5,000 cubic yards per calendar year after September 29, 2009 and disposed in Subtitle D Landfill.
		For the exclusion to be valid, WRB Refining LLC must implement a verification testing program that meets the following Paragraphs:
		(1) Delisting Levels: All concentrations for those constituents must not exceed the maximum allowable concentrations in mg/l specified in this paragraph. Thermal Desorber Residual Solid Leachable Concentrations (mg/l): Antimony—0.165; Arsenic—1.29; Barium—54.8; Beryllium—0.119; Cadmium—0.139; Chromium—3.23; Chromium, Hexavalent—3.23; Cobalt—20.7; Copper—38.6; Cyanide—4.69; Lead—1.07; Mercury—0.104; Nickel—20.6; Selenium—1.0; Silver—5.0; Tin—3790.00; Vanadium—1.46; Zinc—320.0.
		(2) Waste Holding and Handling:
		(A) Waste classification as non-hazardous can not begin until compliance with the limits set in paragraph (1) for thermal desorber residual solids has occurred for two consecutive quarterly sampling events.
		(B) If constituent levels in any sample taken by WRB Refining LLC exceed any of the delisting levels set in paragraph (1) for the thermal desorber residual solids, WRB Refining LLC must do the following:
		(i) Notify EPA in accordance with paragraph (6) and
		(ii) Manage and dispose the thermal desorber residual solids as hazardous waste generated under Subtitle C of RCRA.
		(3) Testing Requirements:
		Upon this exclusion becoming final, WRB Refining LLC may perform quarterly analytical testing by sampling and analyzing the desorber residual solids as follows:
		(A) Quarterly Testing:

		(i) Collect two representative composite samples of the sludge at quarterly intervals after EPA grants the final exclusion. The first composite samples may be taken at any time after EPA grants the final approval. Sampling should be performed in accordance with the sampling plan approved by EPA in support of the exclusion.
		(ii) Analyze the samples for all constituents listed in paragraph (1). Any composite sample taken that exceeds the delisting levels listed in paragraph (1) for the sludge must be disposed as hazardous waste in accordance with the applicable hazardous waste requirements.
		(iii) Within thirty (30) days after taking its first quarterly sample, WRB Refining LLC will report its first quarterly analytical test data to EPA. If levels of constituents measured in the samples of the sludge do not exceed the levels set forth in paragraph (1) of this exclusion for two consecutive quarters, WRB Refining LLC can manage and dispose the non-hazardous thermal desorber residual solids according to all applicable solid waste regulations.
		(B) Annual Testing: (i) If WRB Refining LLC completes the quarterly testing specified in paragraph (3) above and no sample contains a constituent at a level which exceeds the limits set forth in paragraph (1), WRB Refining LLC may begin annual testing as follows: WRB Refining LLC must test two representative composite samples of the thermal desorber residual solids for all constituents listed in paragraph (1) at least once per calendar year.
		(ii) The samples for the annual testing shall be a representative composite sample according to appropriate methods. As applicable to the method-defined parameters of concern, analyses requiring the use of SW-846 methods incorporated by reference in 40 CFR 260.11 must be used without substitution. As applicable, the SW-846 methods might include Methods 0010, 0011, 0020, 0023A, 0030, 0031, 0040, 0050, 0051, 0060, 0061, 1010A, 1020B,1110A, 1310B, 1311, 1312, 1320, 1330A, 9010C, 9012B, 9040C, 9045D, 9060A, 9070A (uses EPA Method 1664, Rev. A), 9071B, and 9095B. Methods must meet Performance Based Measurement System Criteria in which the Data Quality Objectives are to demonstrate that samples of the WRB Refining thermal desorber residual solids are representative for all constituents listed in paragraph (1).
		(iii) The samples for the annual testing taken for the second and subsequent annual testing events shall be taken within the same calendar month as the first annual sample taken.

		(iv) The annual testing report should include the total amount of delisted waste in cubic yards disposed as non-hazardous waste during the calendar year.
		(4) Changes in Operating Conditions: If WRB Refining LLC significantly changes the process described in its petition or starts any processes that generate(s) the waste that may or could affect the composition or type of waste generated (by illustration, but not limitation, changes in equipment or operating conditions of the treatment process), it must notify EPA in writing and it may no longer handle the wastes generated from the new process as non-hazardous until the wastes meet the delisting levels set in paragraph (1) and it has received written approval to do so from EPA.
		WRB Refining LLC must submit a modification to the petition, complete with full sampling and analysis, for circumstances where the waste volume changes and/or additional waste codes are added to the waste stream, if it wishes to dispose of the material as non-hazardous.
		(5) Data Submittals:
		WRB Refining LLC must submit the information described below. If WRB Refining LLC fails to submit the required data within the specified time or maintain the required records on-site for the specified time, EPA, at its discretion, will consider this sufficient basis to reopen the exclusion as described in paragraph (6). WRB Refining LLC must:
		(A) Submit the data obtained through paragraph (3) to the Chief, Corrective Action and Waste Minimization Section, Multimedia Planning and Permitting Division, U.S. Environmental Protection Agency Region 6, 1445 Ross Ave., Dallas, Texas, 75202, within the time specified. All supporting data can be submitted on CD-ROM or comparable electronic media.
		(B) Compile records of analytical data from paragraph (3), summarized, and maintained on-site for a minimum of five years.
		(C) Furnish these records and data when either EPA or the State of Texas requests them for inspection.
		(D) Send along with all data a signed copy of the following certification statement, to attest to the truth and accuracy of the data submitted:
		“Under civil and criminal penalty of law for the making or submission of false or fraudulent statements or representations (pursuant to the applicable provisions of the

		Federal Code, which include, but may not be limited to, 18 U.S.C. §1001 and 42 U.S.C. §6928), I certify that the information contained in or accompanying this document is true, accurate and complete.
		As to the (those) identified section(s) of this document for which I cannot personally verify its (their) truth and accuracy, I certify as the company official having supervisory responsibility for the persons who, acting under my direct instructions, made the verification that this information is true, accurate and complete.
		If any of this information is determined by EPA in its sole discretion to be false, inaccurate or incomplete, and upon conveyance of this fact to the company, I recognize and agree that this exclusion of waste will be void as if it never had effect or to the extent directed by EPA and that the company will be liable for any actions taken in contravention of the company's RCRA and CERCLA obligations premised upon the company's reliance on the void exclusion."
		(6) Re-opener
		(A) If, anytime after disposal of the delisted waste WRB Refining LLC possesses or is otherwise made aware of any environmental data (including but not limited to leachate data or ground water monitoring data) or any other data relevant to the delisted waste indicating that any constituent identified for the delisting verification testing is at level higher than the delisting level allowed by the Division Director in granting the petition, then the facility must report the data, in writing, to the Division Director within 10 days of first possessing or being made aware of that data.
		(B) If either the quarterly or annual testing of the waste does not meet the delisting requirements in paragraph 1, WRB Refining LLC must report the data, in writing, to the Division Director within 10 days of first possessing or being made aware of that data.
		(C) If WRB Refining LLC fails to submit the information described in paragraphs (5), (6)(A) or (6)(B) or if any other information is received from any source, the Division Director will make a preliminary determination as to whether the reported information requires EPA action to protect human health and/or the environment. Further action may include suspending, or revoking the exclusion, or other appropriate response necessary to protect human health and the environment.
		(D) If the Division Director determines that the reported information requires action by EPA, the Division Director will notify the facility in writing of the actions the Division

		Director believes are necessary to protect human health and the environment. The notice shall include a statement of the proposed action and a statement providing the facility with an opportunity to present information as to why the proposed EPA action is not necessary. The facility shall have 10 days from the date of the Division Director's notice to present such information.
		(E) Following the receipt of information from the facility described in paragraph (6)(D) or (if no information is presented under paragraph (6)(D)) the initial receipt of information described in paragraphs (5), (6)(A) or (6)(B), the Division Director will issue a final written determination describing EPA actions that are necessary to protect human health and/or the environment. Any required action described in the Division Director's determination shall become effective immediately, unless the Division Director provides otherwise.
		(7) Notification Requirements
		WRB Refining LLC must do the following before transporting the delisted waste. Failure to provide this notification will result in a violation of the delisting petition and a possible revocation of the decision.
		(A) Provide a one-time written notification to any state Regulatory Agency to which or through which it will transport the delisted waste described above for disposal, 60 days before beginning such activities.
		(B) Update the one-time written notification if it ships the delisted waste into a different disposal facility.
		(C) Failure to provide this notification will result in a violation of the delisting variance and a possible revocation of the decision.

Table VI.B.3.b. – Unit Groundwater Detection Monitoring Systems

Waste Management Unit/Area Name[1]	Hazardous Waste Surface Impoundment (Surface Impoundments NORs 031 and 032, wells apply to the two impoundments)					
Well Number(s):	0582/HWI-MW-01	0584/HWI-02B	0586/HWI-MW-03B	0587/HWI-MW-04	0588/HWI-MW-05	0589/HWI-MW-06
Hydrogeologic Unit Monitored	Permian Whitehorse Formation	Permian Whitehorse Formation	Permian Whitehorse Formation	Permian Whitehorse Formation	Permian Whitehorse Formation	Permian Whitehorse Formation
Type (e.g., point of compliance, background, observation, etc.)	BG	POC	POC	POC	POC	POC
Up or Down Gradient	UG	DG	DG	DG	DG	DG
Casing Diameter and Material	2 in. PVC and Teflon	2 in. PVC and Teflon	2 in. PVC and Teflon	2 in. PVC and Teflon	2 in. PVC and Teflon	2 in. PVC and Teflon
Screen Diameter and Material	2 in. Teflon	2 in. Teflon	2 in. Teflon	2 in. Teflon	2 in. Teflon	2 in. Teflon
Screen Slot Size (in.)	0.010	0.010	0.010	0.010	0.010	0.010
Top of Casing Elevation (Ft, MLGL or MSL)	2911.17	2906.68	2913.11	2907.70	2907.37	2912.55
Grade or Surface Elevation (Ft, MLGL or MSL)	2908.48	2904.10	2910.43	2904.72	2904.56	2909.97
Well Depth (Ft, Below Grade Surface *[BGS]*)	35	127.5	145.1	127.5	127.5	127.5
Well Depth (Ft, Below Top of Casing *[BTOC]*)						
Screen Interval From(Ft, MSL) To(Ft, MSL)	2886.17-2876.17	2799.18-2779.1880	2788-2778	2800.2-2780.2	2799.87-2779.87	2805.05-2785.05
Screen Interval From(Ft, BTOC) To(Ft, BTOC)						
Facility Coordinates (e.g., lat./long. or company coordinates)	N1216, E4801	N1734, E5113	N1372, E5431	N1522, E5031	N1426, E5265	N1136, E5224

1From Tables in Section V.
MSL: Mean Sea Level; *MLGL*: Mean Low-tide Gulf Level; *BGS*: Below Grade Surface; *BTOC*: Below Top of Casing

Table VI.B.3.c. –Groundwater Detection Monitoring Parameters

Unit/Waste Management Area: Hazardous Waste Surface Impoundments:

Well No(s): Wells 0582/HWI-MW-01, 0584/HWI-MW-02B, 0586/HWI-MW-03B, 0587/HWI-MW-04, 0588/HWI-MW-05, 0589/HWI-MW-06.

Parameter	Sampling Frequency	Analytical Method	Method Detection Limit (MDL) or Method Quantification Limit (MQL) Value, (units), MDL or MQL[2]	Concentration Limit[1]
Lead	Semi-annual	SW6010C / SW6020A	0.05 mg/L	0.075 mg/L
Chromium	Semi-annual	SW6010C / SW6020A	0.01 mg/L	0.0235 mg/L
Phenol	Semi-annual	SW8270D	0.05 mg/L	0.075 mg/L
Benzene	Semi-annual	SW8021B / SW8260B	0.001 mg/L	0.0015 mg/L
Toluene	Semi-annual	SW8021B / SW8260B	0.001 mg/L	0.0015 mg/L

1 The concentration limit is the basis for determining whether a release has occurred from the waste management unit/area.

2 a. Enter the laboratory expected *Method Detection Limit* if determination of *Statistically Significant Increase* (SSI) occurrence is based on detection of the presence of the constituent of concern in the sample.

2 b. Enter the laboratory expected Method Quantification Limit if determination of SSI is based on statistical analysis of detection monitoring data or direct comparison to a limit value.

This should be based on the laboratory's minimum expected level of performance. Please designate which type of limit has been entered for each constituent, with its value and units.

TABLE VII.A. - UNIT CLOSURE

For each unit to be permitted, list the facility components to be decontaminated, the possible methods of decontamination, and the possible methods of disposal of wastes and waste residues generated during unit closure:

Equipment of HWM Unit	*Possible Methods of Decontamination*[1]	*Possible Methods of Disposal*[1]
Surface Impoundment 301 / 302; unit will be closed in place using earthmoving equipment such as dozers, excavators, and dump trucks.	Equipment will be inspected for presence of waste on equipment body or wheels before exiting the unit. Waste will be removed using dry methods such as brooms or shovel, or will be pressure washed to remove waste.	Residuals generated during closure and equipment decontamination will be managed in on-site disposal units permitted to manage the class of waste generated or will be shipped to permitted off-site disposal facilities.
North Holding Pond; unit will be closed in place using earthmoving equipment such as dozers, excavators, and dump trucks.	Equipment will be inspected for presence of waste on equipment body or wheels before exiting the unit. Waste will be removed using dry methods such as brooms or shovel, or will be pressure washed to remove waste.	Residuals generated during closure and equipment decontamination will be managed in on-site disposal units permitted to manage the class of waste generated or will be shipped to permitted off-site disposal facilities.
Class I-H Landfill; unit will be closed in place using earthmoving equipment such as dozers, excavators, and dump trucks.	Equipment will be inspected for presence of waste on equipment body or wheels before exiting the unit. Waste will be removed using dry methods such as brooms or shovel, or will be pressure washed to remove waste.	Residuals generated during closure and equipment decontamination will be managed in on-site disposal units permitted to manage the class of waste generated or will be shipped to permitted off-site disposal facilities.

[1]Applicants may list more than one appropriate method.

TABLE VII.B. - UNIT CLOSURE COST ESTIMATE)

Task	Cost
Hazardous Waste Landfill	
Installation of Undifferentiated Fill	$1,025,374
Installation of Clay Layer	$505,233
Installation of Geomembrane	$94,710
Installation of Drainage Layer	$258,652
Installation of Native Soil	$514,565
Establishment of Vegetative Cover	$26,935
Installation of Storm Water Control	$37,099
Decontamination	$3,529
Subtotal of Closure Costs	*$2,466,098*
Engineering Expenses (10%)	$246,610
Survey Plat	$6,720
Certification of Closure	$4,118
subtotal	$2,723,545
Contingency (10% minimum)	$272,355
Total Unit Closure Cost	**$2,995,900 (2009)**
Total Unit Closure Cost	**$3,092,000 (2011)**
Total Unit Closure Cost	**$3,194,036 (2013)**
Total Unit Closure Cost	**$3,512,000 (2019)**

Task	Cost
Surface Impoundment 301	
Removal of Free Liquid	*$275,500*
Stabilization of Waste	*$102,750*
Backfill and Grading	*$2,144*
Decontamination	*$6,000*
Transportation	*$917,064*
Treatment and Disposal	*$6,237,450*
Subtotal of Closure Costs	$7,540,908
Engineering Expenses (10%)	$754,091
Certification of Closure	$4118
subtotal	$8,299,117
Contingency (10% minimum)	$829,912
Cap	$819,153
Total Unit Closure Cost	**$9,948,182 (2009)**
Total Unit Closure Cost	**$10,430,528 (2011)**
Total Unit Closure Cost	**$10,774,734 (2013)**
Total Unit Closure Cost	**$11,850,000 (2019)**

TABLE VII.B. - UNIT CLOSURE COST ESTIMATE (Continued)

Surface Impoundment 302	
Removal of Free Liquid	$358,478
Stabilization of Waste	$133,680
Backfill and Grading	$1,322
Decontamination	$5,999
Transportation	$1,192,860
Treatment and Disposal	$8,117,694
Subtotal of Closure Costs	*$9,810,033*
Engineering Expenses (10%)	$981,003
Certification of Closure	$4,118
subtotal	$10,795,135
Contingency (10% minimum)	$1,079,515
Cover Installation	$403,913
Total Unit Closure Cost	**$12,278,583 (2009)**
Total Unit Closure Cost	**$12,672,000 (2011)**
Total Unit Closure Cost	**$13,090,175 (2013)**
Total Unit Closure Cost	**$14,396,000 (2019)**

Task	Cost
North Holding Pond	
Installation of Unclassified Fill	$31,000
Installation of Clay layer	$181,000
Installation of Geosynthetic Clay Liner	$122,000
Installation of Geomembrane w drainage layer, engineered turf, and sand ballast	$568,000
Installation of Storm Water Control	$29,000
Decontamination	$4,000
Subtotal of Closure Costs	*$935,000*
Engineering Expenses (10%)	$94,000
Survey Plat	$5,000
Certification of Closure	$10,000
subtotal	$1,044,000
Contingency (10% minimum)	$104,000
Total Unit Closure Cost	**$1,224,000 (2019)**

TOTAL PERMITTED FACILITY CLOSURE COST (all unit costs combined)	**$26,753,031 (2009)**
	27,773,922 (2011)
	$28,690,460 (2013)
	$30,982,000 (2019)

TABLE VII.D. - UNIT POST-CLOSURE COST ESTIMATE

Task	Cost
Hazardous Waste Landfill	
Maintenance and Inspection	$930
Groundwater Monitoring (5 wells x 2 events)	$11,597
Subtotal of Post-closure Costs	*$12,526*
Engineering Expenses (10%)	$1,253
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$13,779
Contingency (10% minimum)	$1,378
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$466,471 (2009)**
	481,398 (2011)
	$497,414 (2013)
	$547,000 (2019)

Surface Impoundments 301 and 302	
SI 301	
Maintenance and Inspection	$642
Groundwater Monitoring	$0[a]
Subtotal of Post-closure Costs	*$642*
Engineering Expenses (10%)	$64
Subtotal of Annual Post-Closure Costs	*$706*
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
SI 302	
Maintenance and Inspection	$549
Groundwater Monitoring (7 wells x 2 events)	$15,512
Subtotal of Post-closure Costs	*$16,061*
Engineering Expenses (10%)	$1,606
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal SI 301 and SI 302	18,373
Contingency (10% minimum)	1,837
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$629,820 (2009)**
	$625,702 (2011)
	$646,519 (2013)
	$711,000 (2019)

[a]Groundwater monitoring is priced in the SI 302 Closure Costs. The units are too close together to separate.

TABLE VII.D. - UNIT POST-CLOSURE COST ESTIMATE (Continued)

North Holding Pond	
Site Security (one-time only)	$25,000
Site Security (annual)	$500
Maintenance and Inspection	$1,000
Groundwater Monitoring (6 wells x 2 events)	$13,000
Non-destructive engineered turf testing (annual)	$500
Engineered turf replacement (one-time if needed)	$200,000
Subtotal of Annual Post-closure Costs	$15,000
Engineering Expenses (10%)	$1,500
Deed Notation	$7,000
Final Certification of Post-Closure Care	$10,000
subtotal	$16,500
Contingency (10% minimum)	$1,650
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$952,000 (2019)**

Task	Cost
Pitch Pits 11, 12 &14	
Maintenance and Inspection	$2,440
Groundwater Monitoring (7 wells x 2 events)	$16,292
Subtotal of Annual Post-closure Costs	*$19,217*
Engineering Expenses (10%)	$1,922
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$21,139
Contingency (10% minimum)	$2,114
	$337,295 (2009)
	$348,088(2011)
	$359,669 (2013)
TOTAL UNIT POST-CLOSURE CARE COST x 14 yrs. (or other post-closure care period)	**$395,000 (2019)**

TABLE VII.D. - UNIT POST-CLOSURE COST ESTIMATE (Continued)

Filter Slurry Pond		
Maintenance and Inspection		$2,627
Groundwater Monitoring (5 wells x 2 events)		$17,326
Subtotal of Post-closure Costs		*$20,476*
Engineering Expenses (10%)		$2,048
Deed Notation		$6,880
Final Certification of Post-Closure Care		$4,960
	subtotal	$22,524
	Contingency (10% minimum)	$2,252
TOTAL UNIT POST-CLOSURE CARE COST	x 13 yrs. (or other post-closure care period)	**$333,854 (2009)**
		$346,601 (2011)
		$358,132 (2013)
		$394,000 (2019)

New Caustic Pond (Post-closure groundwater and corrective action costs for NCP in Compliance Plan)		
Maintenance and Inspection		$1,363
Subtotal of Post-closure Costs		*$1,363*
Engineering Expenses (10%)		$136
Deed Notation		$6,800
Final Certification of Post-Closure Care		$10,000
	subtotal	$1,499
	Contingency (10% minimum)	$150
TOTAL UNIT POST-CLOSURE CARE COST	x 30 yrs. (or other post-closure care period)	**$84,000 (2019)**

TABLE VII.D. - UNIT POST-CLOSURE COST ESTIMATE (Continued)

Task	Cost
Surge Pond	
Maintenance and Inspection	$1,908
Groundwater Monitoring (5 wells x 2 events)	$14,838
Subtotal of Post-closure Costs	*$17,105*
Engineering Expenses (10%)	$1,710
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$18,815
Contingency (10% minimum)	$1,882
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$398,689 (2009)**
	$424,613 (2011)
	$438,740 (2013)
	$483,000 (2019)
Off-Test Pond	
Maintenance and Inspection	$1,908
Groundwater Monitoring (5 wells x 2 events)	$12,377
Subtotal of Post-closure Costs	*$14,643*
Engineering Expenses (10%)	$1,464
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$16,107
Contingency (10% minimum)	$1,611
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$348,400 (2009)**
	$359,549 (2011)
	$371,511 (2013)
	$408,000 (2019)

Task	Cost
Old Caustic Pond (Post-closure groundwater and corrective action costs for OCP in Compliance Plan)	
Maintenance and Inspection	$1,363
Subtotal of Post-closure Costs	*$1,363*
Engineering Expenses (10%)	$136
Deed Notation	$6,800
Final Certification of Post-Closure Care	$10,000
subtotal	$1,499
Contingency (10% minimum)	$150
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$84,000 (2019)**

Task	Cost
Class I Landfill (Post-closure groundwater costs for this unit in Compliance Plan)	
Maintenance and Inspection	$913
Subtotal of Post-closure Costs	$913
Engineering Expenses (10%)	$91
Subtotal of Annual Post-Closure Costs	$1,004
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$1,004
Contingency (10% minimum)	$100
TOTAL UNIT POST-CLOSURE CARE COST x 9 yrs. (or other post-closure care period)	**$29,000 (2019)**

Task	Cost
New Evaporation Pond (Post-closure groundwater costs for this unit in Compliance Plan)	
Maintenance and Inspection	$1,567
Subtotal of Post-closure Costs	$1,567
Engineering Expenses (10%)	$157
Subtotal of Annual Post-Closure Costs	$1,723
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$1,724
Contingency (10% minimum)	$172
TOTAL UNIT POST-CLOSURE CARE COST x 10 yrs. (or other post-closure care period)	**$40,000 (2019)**

TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$3,167,830(2009)**
TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$3,229,903 (2011)**
TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$3,556,800 (2013)**
TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$4,127,000 (2019)**

One-time only costs such as Deed Notation and Fencing have not been multiplied by the number of years left in post-closure care but added to the total cost.

TABLE VII.E.1. - PERMITTED UNIT CLOSURE COST SUMMARY

Closure Cost Estimate	
Unit	Cost
Hazardous Waste Landfill (Class I-H)	$3,512,000
Surface Impoundment 301	$11,850,000
Surface Impoundment 302	$14,396,000
North Holding Pond	$1,224,000
TOTAL EXISTING UNIT CLOSURE COST ESTIMATE	$30,982,000 (2019) [1]

Proposed Unit Closure Cost Estimate	
Unit	Cost

[1] As units are added or deleted from these tables through future permit amendments or modifications, the remaining itemized unit costs should be updated for inflation when re-calculating the revised total cost in current dollars.

TABLE VII.E.2. - PERMITTED UNIT POST-CLOSURE COST SUMMARY

Existing Unit Post-Closure Cost Estimate	
Unit	Cost
Hazardous Waste Landfill	$547,000
Surface Impoundment 301/302	$711,000
North Holding Pond	$952,000
Pitch Pits 11, 12 & 14	$395,000
Filter Slurry Pond	$394,000
Surge Pond	$483,000
Off-Test Pond	$408,000
New Caustic Pond	$84,000
Class I Landfill	$29,000
New Evaporation Pond	$40,000
Old Caustic Pond	$84,000
TOTAL EXISTING UNIT POST-CLOSURE COST ESTIMATE	**4,127,000 (2019)**

Proposed Unit Post-Closure Cost Estimate	
Unit	Cost

Note: **Post-closure care inspection/maintenance costs for the New Caustic Pond , Old Caustic Pond, Class I Landfill, and New Evaporation Pond are included above; corrective action costs for these units are included in the Compliance Plan.**

TABLE XI.E.1. – CORRECTIVE ACTION PROGRAM COST ESTIMATE
FOA East Segment

1. Pumping Capacity Per Year:		
A. Daily average system pumping rate	____________	gal/day
B. Annual groundwater volume recovered	____________	gal/yr
2. Off-Site Liquid Treatment / Disposal Cost:		
A. Volume of treated contaminated water to be disposed of off-site yearly	____________	gal/yr
B. Transportation of liquid waste disposed of off-site yearly		
(1) Transportation cost per gallon	____________	$/gal
(2) Gallons of contaminated water shipped per year	____________	gal/yr
(3) Annual cost of transportation (1 x 2)	____________	$/yr
C. On-site yearly storage cost prior to off-site disposal	____________	$/yr
D. Off-site yearly treatment cost of liquid waste		
(1) Treatment charge per gallon	____________	$/gal
(2) Total volume to be treated per year	____________	gal/yr
(3) Annual treatment cost (1 x 2)	____________	$/yr
E. Off-site disposal cost of liquid waste per year		
(1) Disposal charge per gallon	____________	$/gal
(2) Total volume to be disposed per year	____________	gal/yr
(3) Annual disposal cost (1 x 2)	____________	$/yr
***ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST** (2B3 + 2C +2D3 + 2E3)	____________	$
3. On-site Waste Water Treatment System Cost and On-site Treatment / Disposal Cost: Submit a cost estimate for a treatment system specifically designed and used exclusively for the groundwater corrective action program and operational after some start up maintenance. Estimates to clean out the system should also be included in the following cost.		
A. Initial capital expenditure for treatment system including start up maintenance	____________	$
***ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST** (3A)	____________	$
B. Gallons of contaminated water to be treated on-site per year	____________	gal/yr
C. Cost of on-site treatment per gallon	____________	$/gal
D. Cost of sludge, or solids disposal per year	____________	$/yr
E. Cost per year of maintenance on treatment system and recovery system, along with any additional equipment and repairs needed for the systems	____________	$/yr
F. Cost of on-site disposal per year	____________	$/yr
***ANNUAL ON-SITE TREATMENT / DISPOSAL COST** [(3B X 3C) + 3D + 3E + 3F]	____________	$
4. Inspections, Maintenance and Operation Cost for the Corrective Action Program:		
A. Operator's time on-site for inspections and maintenance per year	____________	hour/yr
B. Charge of salary per hour	____________	$/hr
C. Annual cost of labor (4A x 4B)	____________	$/yr
D. Replacement of parts and equipment per year	____________	$/yr
E. Electricity cost per year	____________	$/yr
***ANNUAL INSPECTIONS / MAINTENANCE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM** (4C + 4D + 4E)	____________	$

TABLE XI.E.2. – GROUNDWATER MONITORING COST ESTIMATE
FOA East Segment

1. Annual Sampling and Analysis Cost:

A. Background Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
B. Point of Compliance Wells		
(1) Number of wells	7	
(2) Sample analysis cost per well	648.57	$/well
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	9,080.00	$
C. Recovery Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
D. Corrective Action Observation Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
E. Point of Exposure Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
F. Supplemental Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
G. Field Quality Control Sampling		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
H. Sediment Sampling		
(1) Number of samples	2	
(2) Sample analysis cost per sample	1,115.09	$/sample
(3) Number of sampling events per year	2	/yr

(4) Sampling cost (1 x 2 x 3)	4,460.36	$
I. Surface Water Sampling		
(1) Number of samples	2	
(2) Sample analysis cost per sample	1,083.44	$/sample
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	4,333.76	$
2. Sampling Labor Cost:		
A. Hours of sampling per well	4	hrs/well
B. Number of sampling technicians per well	2	
C. Charge per hour	104.36	$/hr
D. Total number of wells to be sampled annually		Wells
E. Total number of wells sampled semi-annually	7	Wells
F. Total number of wells sampled quarterly		Wells
G. Total number of wells sampled monthly		Wells
H. Total number of wells sampled per year (2D) + (2E x 2) + (2F x 4) + (2G x 12)	14	total wells sampled/yr
I. Sampling Labor Cost (2A x 2B x 2C x 2H)	11,688.32	$
***ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST**	29,562.44	$
3. Well Installation (typical cost):		
A. Monitor well installation cost per well		$/well
B. Number of monitor wells to be installed		Wells
C. Cost of monitor well system (A x B)		$
D. Recovery well installation cost per well		$/well
E. Number of Recovery Wells to be installed		Wells
F. Cost of Recovery well system (D x E)		$
***TOTAL WELL INSTALLATION COST** (3C + 3F)		$
4. Administrative Cost:		
A. Annual cost for record-keeping and report preparation	50,000	$
***ANNUAL ADMINISTRATIVE COST** (4A)	50,000	$
5. Inspection and Maintenance Cost for the Monitoring Program:		
A. Operator's time (hours) on-site for inspections and maintenance per year		hour/yr
B. Charge or salary per hour		$/hr
C. Annual cost of labor (4A x 4B)		$/yr
D. Replacement of parts and equipment per year		$/yr
***ANNUAL INSPECTIONS / MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM** (5C + 5D)		$

TABLE XI.E.3. – FINANCIAL ASSURANCE SUMMARY
FOA East Segment

ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST	$	
ANNUAL ON-SITE TREATMENT / DISPOSAL COST	$	
ANNUAL INSPECTION / MAINTENACE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM	$	
ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST	$	29,562.44
ANNUAL ADMINISTRATIVE COST	$	50,000
ANNUAL INSPECTION AND MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM	$	
ANNUAL SUB TOTAL	$	79,562.44
TOTAL YEARS USED FOR CALCULATING FINANCIAL ASSURANCE		30 Yrs
REMEDIATION COST (Annual Sub Total x Total Years Used)	$	2,386,873
SOIL DELINEATION		
1. Sample analysis		
Number of samples		
Cost per sample		$
Total		$
2. Sampling cost		
3. Drilling cost		
4. Decontamination cost		
ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST	$	
TOTAL WELL COST	$	
10% Engineering expenses	$	238,687
Subtotal	$	2,625,560
10% Contingency	$	262,556

GRAND TOTAL COST (nearest $1000)

2007	**$2,888,000**
2013	**$3,263,000**
2019	**$3,587,000**

TABLE XI.E.1. – CORRECTIVE ACTION PROGRAM COST ESTIMATE
FOA West Segment

1. **Pumping Capacity Per Year:**
   - A. Daily average system pumping rate ____________ gal/day
   - B. Annual groundwater volume recovered ____________ gal/yr
2. **Off-Site Liquid Treatment / Disposal Cost:**
   - A. Volume of treated contaminated water to be disposed of off-site yearly ____________ gal/yr
   - B. Transportation of liquid waste disposed of off-site yearly
     - (1) Transportation cost per gallon ____________ $/gal
     - (2) Gallons of contaminated water shipped per year ____________ gal/yr
     - (3) Annual cost of transportation (1 x 2) ____________ $/yr
   - C. On-site yearly storage cost prior to off-site disposal ____________ $/yr
   - D. Off-site yearly treatment cost of liquid waste
     - (1) Treatment charge per gallon ____________ $/gal
     - (2) Total volume to be treated per year ____________ gal/yr
     - (3) Annual treatment cost (1 x 2) ____________ $/yr
   - E. Off-site disposal cost of liquid waste per year
     - (1) Disposal charge per gallon ____________ $/gal
     - (2) Total volume to be disposed per year ____________ gal/yr
     - (3) Annual disposal cost (1 x 2) ____________ $/yr

   ***ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST**
   (2B3 + 2C +2D3 + 2E3) ____________ $
3. **On-site Waste Water Treatment System Cost and On-site Treatment / Disposal Cost:**
   Submit a cost estimate for a treatment system specifically designed and used exclusively for the groundwater corrective action program and operational after some start up maintenance. Estimates to clean out the system should also be included in the following cost.
   - A. Initial capital expenditure for treatment system including start up maintenance ____________ $

   ***ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST** (3A) ____________ $
   - B. Gallons of contaminated water to be treated on-site per year ____________ gal/yr
   - C. Cost of on-site treatment per gallon ____________ $/gal
   - D. Cost of sludge, or solids disposal per year ____________ $/yr
   - E. Cost per year of maintenance on treatment system and recovery system, along with any additional equipment and repairs needed for the systems ____________ $/yr
   - F. Cost of on-site disposal per year ____________ $/yr

   ***ANNUAL ON-SITE TREATMENT / DISPOSAL COST** [(3B X 3C) + 3D + 3E + 3F] ____________ $
4. **Inspections, Maintenance and Operation Cost for the Corrective Action Program:**
   - A. Operator's time on-site for inspections and maintenance per year ____________ hour/yr
   - B. Charge of salary per hour ____________ $/hr
   - C. Annual cost of labor (4A x 4B) ____________ $/yr
   - D. Replacement of parts and equipment per year ____________ $/yr
   - E. Electricity cost per year ____________ $/yr

   ***ANNUAL INSPECTIONS / MAINTENANCE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM** (4C + 4D + 4E) ____________ $

TABLE XI.E.2. – GROUNDWATER MONITORING COST ESTIMATE
FOA West Segment

1. Annual Sampling and Analysis Cost:

A. Background Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
B. Point of Compliance Wells		
(1) Number of wells	3	
(2) Sample analysis cost per well	811.25	$/well
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	4,867.50	$
C. Recovery Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
D. Corrective Action Observation Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
E. Point of Exposure Wells		
(1) Number of wells	1	
(2) Sample analysis cost per well	811.25	$/well
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	1,622.50	$
F. Supplemental Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
G. Field Quality Control Sampling		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
H. Sediment Sampling		
(1) Number of samples	4	
(2) Sample analysis cost per sample	791.34	$/sample
(3) Number of sampling events per year	2	/yr

(4) Sampling cost (1 x 2 x 3)	6,330.72	$
I. Surface Water Sampling		
(1) Number of samples	4	
(2) Sample analysis cost per sample	759.69	$/sample
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	6,077.52	$
2. Sampling Labor Cost:		
A. Hours of sampling per well	4	hrs/well
B. Number of sampling technicians per well	2	
C. Charge per hour	73.59	$/hr
D. Total number of wells to be sampled annually		Wells
E. Total number of wells sampled semi-annually	4	Wells
F. Total number of wells sampled quarterly		Wells
G. Total number of wells sampled monthly		Wells
H. Total number of wells sampled per year (2D) + (2E x 2) + (2F x 4) + (2G x 12)	8	total wells sampled/yr
I. Sampling Labor Cost (2A x 2B x 2C x 2H)	4,709.76	$
***ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST**	23,608.00	$
3. Well Installation (typical cost):		
A. Monitor well installation cost per well		$/well
B. Number of monitor wells to be installed		Wells
C. Cost of monitor well system (A x B)		$
D. Recovery well installation cost per well		$/well
E. Number of Recovery Wells to be installed		Wells
F. Cost of Recovery well system (D x E)		$
***TOTAL WELL INSTALLATION COST** (3C + 3F)		$
4. Administrative Cost:		
A. Annual cost for record-keeping and report preparation		$
***ANNUAL ADMINISTRATIVE COST** (4A)		$
5. Inspection and Maintenance Cost for the Monitoring Program:		
A. Operator's time (hours) on-site for inspections and maintenance per year		hour/yr
B. Charge or salary per hour		$/hr
C. Annual cost of labor (4A x 4B)		$/yr
D. Replacement of parts and equipment per year		$/yr
***ANNUAL INSPECTIONS / MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM** (5C + 5D)		$

TABLE XI.E.3. – FINANCIAL ASSURANCE SUMMARY
FOA West Segment

ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST	$	
ANNUAL ON-SITE TREATMENT / DISPOSAL COST	$	
ANNUAL INSPECTION / MAINTENACE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM	$	
ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST	$	23,608.00
ANNUAL ADMINISTRATIVE COST	$	
ANNUAL INSPECTION AND MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM	$	Included in engineering estimate
ANNUAL SUB TOTAL	$	23,608.00
TOTAL YEARS USED FOR CALCULATING FINANCIAL ASSURANCE		30 Yrs
REMEDIATION COST (Annual Sub Total x Total Years Used)	$	708,240
SOIL DELINEATION		
1. Sample analysis		
Number of samples		
Cost per sample		$
Total		$
2. Sampling cost		
3. Drilling cost		
4. Decontamination cost		
ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST	$	
TOTAL WELL COST	$	
10% Engineering expenses	$	70,824
Subtotal	$	779,064
10% Contingency	$	77,906

GRAND TOTAL COST (nearest $1000)	**2007 $**	**857,000**
	2013 $	**968,000**
	2019 $	**1,064,000**

TABLE XI.E.1. – CORRECTIVE ACTION PROGRAM COST ESTIMATE
FOA Northwest Segment

1. **Pumping Capacity Per Year:**
   - A. Daily average system pumping rate ____________ gal/day
   - B. Annual groundwater volume recovered ____________ gal/yr
2. **Off-Site Liquid Treatment / Disposal Cost:**
   - A. Volume of treated contaminated water to be disposed of off-site yearly ____________ gal/yr
   - B. Transportation of liquid waste disposed of off-site yearly
     - (1) Transportation cost per gallon ____________ $/gal
     - (2) Gallons of contaminated water shipped per year ____________ gal/yr
     - (3) Annual cost of transportation (1 x 2) ____________ $/yr
   - C. On-site yearly storage cost prior to off-site disposal ____________ $/yr
   - D. Off-site yearly treatment cost of liquid waste
     - (1) Treatment charge per gallon ____________ $/gal
     - (2) Total volume to be treated per year ____________ gal/yr
     - (3) Annual treatment cost (1 x 2) ____________ $/yr
   - E. Off-site disposal cost of liquid waste per year
     - (1) Disposal charge per gallon ____________ $/gal
     - (2) Total volume to be disposed per year ____________ gal/yr
     - (3) Annual disposal cost (1 x 2) ____________ $/yr

   ***ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST**
   (2B3 + 2C +2D3 + 2E3) ____________ $
3. **On-site Waste Water Treatment System Cost and On-site Treatment / Disposal Cost:**
   Submit a cost estimate for a treatment system specifically designed and used exclusively for the groundwater corrective action program and operational after some start up maintenance. Estimates to clean out the system should also be included in the following cost.
   - A. Initial capital expenditure for treatment system including start up maintenance ____________ $

   ***ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST** (3A) ____________ $
   - B. Gallons of contaminated water to be treated on-site per year ____________ gal/yr
   - C. Cost of on-site treatment per gallon ____________ $/gal
   - D. Cost of sludge, or solids disposal per year ____________ $/yr
   - E. Cost per year of maintenance on treatment system and recovery system, along with any additional equipment and repairs needed for the systems ____________ $/yr
   - F. Cost of on-site disposal per year ____________ $/yr

   ***ANNUAL ON-SITE TREATMENT / DISPOSAL COST** [(3B X 3C) + 3D + 3E + 3F] ____________ $
4. **Inspections, Maintenance and Operation Cost for the Corrective Action Program:**
   - A. Operator's time on-site for inspections and maintenance per year ____________ hour/yr
   - B. Charge of salary per hour ____________ $/hr
   - C. Annual cost of labor (4A x 4B) ____________ $/yr
   - D. Replacement of parts and equipment per year ____________ $/yr
   - E. Electricity cost per year ____________ $/yr

   ***ANNUAL INSPECTIONS / MAINTENANCE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM** (4C + 4D + 4E) ____________ $

TABLE XI.E.2. – GROUNDWATER MONITORING COST ESTIMATE
FOA Northwest Segment

1. Annual Sampling and Analysis Cost:

A. Background Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
B. Point of Compliance Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
C. Recovery Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
D. Corrective Action Observation Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
E. Point of Exposure Wells		
(1) Number of wells	1	
(2) Sample analysis cost per well	2,075	$/well
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	4,150	$
F. Supplemental Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
G. Field Quality Control Sampling		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
H. Sediment Sampling		
(1) Number of samples	5	
(2) Sample analysis cost per sample	726.59	$/sample
(3) Number of sampling events per year	2	/yr

(4) Sampling cost (1 x 2 x 3)	7,265.90	$
I. Surface Water Sampling		
(1) Number of samples	5	
(2) Sample analysis cost per sample	694.94	$/sample
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	6,949.40	$
2. Sampling Labor Cost:		
A. Hours of sampling per well	4	hrs/well
B. Number of sampling technicians per well	2	
C. Charge per hour	73.58	$/hr
D. Total number of wells to be sampled annually		Wells
E. Total number of wells sampled semi-annually	1	Wells
F. Total number of wells sampled quarterly		Wells
G. Total number of wells sampled monthly		Wells
H. Total number of wells sampled per year (2D) + (2E x 2) + (2F x 4) + (2G x 12)	2	total wells sampled/yr
I. Sampling Labor Cost (2A x 2B x 2C x 2H)	1,177.28	$
***ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST**	19,542.58	$
3. Well Installation (typical cost):		
A. Monitor well installation cost per well		$/well
B. Number of monitor wells to be installed		Wells
C. Cost of monitor well system (A x B)		$
D. Recovery well installation cost per well		$/well
E. Number of Recovery Wells to be installed		Wells
F. Cost of Recovery well system (D x E)		$
***TOTAL WELL INSTALLATION COST** (3C + 3F)		$
4. Administrative Cost:		
A. Annual cost for record-keeping and report preparation		$
***ANNUAL ADMINISTRATIVE COST** (4A)		$
5. Inspection and Maintenance Cost for the Monitoring Program:		
A. Operator's time (hours) on-site for inspections and maintenance per year		hour/yr
B. Charge or salary per hour		$/hr
C. Annual cost of labor (4A x 4B)		$/yr
D. Replacement of parts and equipment per year		$/yr
***ANNUAL INSPECTIONS / MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM** (5C + 5D)		$

TABLE XI.E.3. – FINANCIAL ASSURANCE SUMMARY
FOA Northwest Segment

ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST	$	
ANNUAL ON-SITE TREATMENT / DISPOSAL COST	$	
ANNUAL INSPECTION / MAINTENACE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM	$	
ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST	$	19,542.58
ANNUAL ADMINISTRATIVE COST	$	
ANNUAL INSPECTION AND MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM	$	
ANNUAL SUB TOTAL	$	19,542.58
TOTAL YEARS USED FOR CALCULATING FINANCIAL ASSURANCE		30 Yrs
REMEDIATION COST (Annual Sub Total x Total Years Used)	$	586,280
SOIL DELINEATION		
1. Sample analysis		
Number of samples		
Cost per sample		$
Total		$
2. Sampling cost		
3. Drilling cost		
4. Decontamination cost		
ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST	$	
TOTAL WELL COST	$	
10% Engineering expenses	$	58,628
Subtotal	$	644,908
10% Contingency	$	64,491
GRAND TOTAL COST (nearest $1000)	**2007$**	**710,000**
	2013$	**802,000**
	2019$	**882,000**

TABLE XI.E.1. – CORRECTIVE ACTION PROGRAM COST ESTIMATE
FOA Northeast Segment

1. Pumping Capacity Per Year:		
A. Daily average system pumping rate	____________	gal/day
B. Annual groundwater volume recovered	____________	gal/yr
2. Off-Site Liquid Treatment / Disposal Cost:		
A. Volume of treated contaminated water to be disposed of off-site yearly	____________	gal/yr
B. Transportation of liquid waste disposed of off-site yearly		
(1) Transportation cost per gallon	____________	$/gal
(2) Gallons of contaminated water shipped per year	____________	gal/yr
(3) Annual cost of transportation (1 x 2)	____________	$/yr
C. On-site yearly storage cost prior to off-site disposal	____________	$/yr
D. Off-site yearly treatment cost of liquid waste		
(1) Treatment charge per gallon	____________	$/gal
(2) Total volume to be treated per year	____________	gal/yr
(3) Annual treatment cost (1 x 2)	____________	$/yr
E. Off-site disposal cost of liquid waste per year		
(1) Disposal charge per gallon	____________	$/gal
(2) Total volume to be disposed per year	____________	gal/yr
(3) Annual disposal cost (1 x 2)	____________	$/yr
***ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST** (2B3 + 2C +2D3 + 2E3)	____________	$
3. On-site Waste Water Treatment System Cost and On-site Treatment / Disposal Cost: Submit a cost estimate for a treatment system specifically designed and used exclusively for the groundwater corrective action program and operational after some start up maintenance. Estimates to clean out the system should also be included in the following cost.		
A. Initial capital expenditure for treatment system including start up maintenance	____________	$
***ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST** (3A)	____________	$
B. Gallons of contaminated water to be treated on-site per year	____________	gal/yr
C. Cost of on-site treatment per gallon	____________	$/gal
D. Cost of sludge, or solids disposal per year	____________	$/yr
E. Cost per year of maintenance on treatment system and recovery system, along with any additional equipment and repairs needed for the systems	____________	$/yr
F. Cost of on-site disposal per year	____________	$/yr
***ANNUAL ON-SITE TREATMENT / DISPOSAL COST** [(3B X 3C) + 3D + 3E + 3F]	____________	$
4. Inspections, Maintenance and Operation Cost for the Corrective Action Program:		
A. Operator's time on-site for inspections and maintenance per year	____________	hour/yr
B. Charge of salary per hour	____________	$/hr
C. Annual cost of labor (4A x 4B)	____________	$/yr
D. Replacement of parts and equipment per year	____________	$/yr
E. Electricity cost per year	____________	$/yr
***ANNUAL INSPECTIONS / MAINTENANCE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM** (4C + 4D + 4E)	____________	$

TABLE XI.E.2. – GROUNDWATER MONITORING COST ESTIMATE
FOA Northeast Segment

1. Annual Sampling and Analysis Cost:

A. Background Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
B. Point of Compliance Wells		
(1) Number of wells	4	
(2) Sample analysis cost per well	713.75	$/well
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	5,710.00	$
C. Recovery Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
D. Corrective Action Observation Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
E. Point of Exposure Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
F. Supplemental Wells		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
G. Field Quality Control Sampling		
(1) Number of wells		
(2) Sample analysis cost per well		$/well
(3) Number of sampling events per year		/yr
(4) Sampling cost (1 x 2 x 3)		$
H. Sediment Sampling		
(1) Number of samples	3	
(2) Sample analysis cost per sample	899.26	$/sample
(3) Number of sampling events per year	2	/yr

(4) Sampling cost (1 x 2 x 3)	5,395.56	$
I. Surface Water Sampling		
(1) Number of samples	3	
(2) Sample analysis cost per sample	867.62	$/sample
(3) Number of sampling events per year	2	/yr
(4) Sampling cost (1 x 2 x 3)	5,205.70	$
2. Sampling Labor Cost:		
A. Hours of sampling per well	4	hrs/well
B. Number of sampling technicians per well	2	
C. Charge per hour	73.59	$/hr
D. Total number of wells to be sampled annually		Wells
E. Total number of wells sampled semi-annually	4	Wells
F. Total number of wells sampled quarterly		Wells
G. Total number of wells sampled monthly		Wells
H. Total number of wells sampled per year (2D) + (2E x 2) + (2F x 4) + (2G x 12)	8	total wells sampled/yr
I. Sampling Labor Cost (2A x 2B x 2C x 2H)	4,709.76	$
***ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST**	21,021.02	$
3. Well Installation (typical cost):		
A. Monitor well installation cost per well		$/well
B. Number of monitor wells to be installed		Wells
C. Cost of monitor well system (A x B)		$
D. Recovery well installation cost per well		$/well
E. Number of Recovery Wells to be installed		Wells
F. Cost of Recovery well system (D x E)		$
***TOTAL WELL INSTALLATION COST** (3C + 3F)		$
4. Administrative Cost:		
A. Annual cost for record-keeping and report preparation		$
***ANNUAL ADMINISTRATIVE COST** (4A)		$
5. Inspection and Maintenance Cost for the Monitoring Program:		
A. Operator's time (hours) on-site for inspections and maintenance per year		hour/yr
B. Charge or salary per hour		$/hr
C. Annual cost of labor (4A x 4B)		$/yr
D. Replacement of parts and equipment per year		$/yr
***ANNUAL INSPECTIONS / MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM** (5C + 5D)		$

TABLE XI.E.3. – FINANCIAL ASSURANCE SUMMARY
FOA Northeast Segment

OFF-SITE LIQUID TREATMENT / DISPOSAL COST	$	
ANNUAL ON-SITE TREATMENT / DISPOSAL COST	$	
ANNUAL INSPECTION / MAINTENACE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM	$	
ANNUAL GROUNDWATER/SURFACE WATER/SEDIMENT MONITORING COST	$	21,021
ANNUAL ADMINISTRATIVE COST	$	
ANNUAL INSPECTION AND MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM	$	Included in engineering expenses
ANNUAL SUB TOTAL	$	21,021
TOTAL YEARS USED FOR CALCULATING FINANCIAL ASSURANCE		30 Yrs
REMEDIATION COST (Annual Sub Total x Total Years Used)	$	630,630
SOIL DELINEATION		
1. Sample analysis		
Number of samples		
Cost per sample		$
Total		$
2. Sampling cost		
3. Drilling cost		
4. Decontamination cost		
ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST	$	
TOTAL WELL COST	$	
10% Engineering expenses	$	63,063
Subtotal	$	693,693
10% Contingency	$	69,369
GRAND TOTAL COST (nearest $1000)	**2007 $**	**763,000**
	2013 $	**862,000**
	2019 $	**948,000**

TABLE XI.E.3. – FINANCIAL ASSURANCE SUMMARY

Grand Total

ANNUAL OFF-SITE LIQUID TREATMENT / DISPOSAL COST	$		
ANNUAL ON-SITE TREATMENT / DISPOSAL COST	$		
ANNUAL INSPECTION / MAINTENACE / OPERATION COST FOR THE CORRECTIVE ACTION PROGRAM	$		
ANNUAL GROUNDWATER MONITORING COST	$	93,734	
ANNUAL ADMINISTRATIVE COST	$	50,000	
ANNUAL INSPECTION AND MAINTENANCE COST FOR THE GROUNDWATER MONITORING PROGRAM	$	Covered in engineering costs	
ANNUAL SUB TOTAL	$	143,734	
TOTAL YEARS USED FOR CALCULATING FINANCIAL ASSURANCE		30	Yrs
REMEDIATION COST (Annual Sub Total x Total Years Used)	$	4,312,020	
ON-SITE WASTE WATER TREATMENT SYSTEM CAPITAL COST	$		
TOTAL WELL COST	$		
10% Engineering expenses	$	431,202	
Subtotal	$	4,743,222	
10% Contingency	$	474,322	
Subtotal (Facilities Operation Area [FOA] Segments) (**Adjusted for 2019 $**)	$	**6,481,000**	
Caustic Pits 1-4	$	91,000	
HP-7 South Cobles	$	8,034,000	
Lead Pits North	$	3,392,000	
Lead Pits South	$	3,400,000	
NAPL Recovery	$	2,955,000	
Litharge Impoundment	$	372,000	
New Canyon Dam	$	202,000	
New Caustic Pond	$	4,848,000	
NGL Truck Loading Rack UST	$	53,000	
Odens Dam	$	473,000	
Old Canyon Dam	$	1,742,000	
Old Caustic Pond	$	9,187,000	
Pantex Reservoir	$	57,000	
Phillips Camp Dump-WWTSLF	$	2,684,000	
Philtex Drum Disposal Area	$	196,000	
Pitch Pit 13	$	1,510,000	
Pitch Pit 15	$	1,504,000	

Pitch Pit 16	$	1,835,000
Pitch Pit Annex	$	169,000
Pitch Pits 1-5	$	2,216,000
Pitch Pits 8-10	$	556,000
Rocky Station Lead Pits	$	2,127,000
Sandblast Yards	$	248,000
Sawtooth UST	$	959,000
Sludge Drying Pond –WWTSDS	$	1,453,000
Southeast Canyon	$	2,767,000
Taubman Yard	$	1,388,000
Transfer Box	$	44,000
ULSD	$	45,000
Area 2 (West FOA Segment)	$	636,000
Class 1 Landfill and New Evaporation Pond	$	327,000
Areas 1-5 O&M	$	5,832,000

TOTAL COST (excluding FOA Segments) (nearest $1000)	**(2019) $61,302,000**
TOTAL COST (FOA Segments) (nearest $1000)	**(2019) $6,481,000**
TOTAL COST of Closure/O&M	**(2019) $67,783,000**

CP Table II: Solid Waste Management Units and/or Areas of Concern for which Corrective Action applies pursuant to 30 TAC 335.167

Unit Number[1]	Unit Name	Notice of Registration (NOR) Number, if applicable	SWMU or AOC	Media Affected[2]	Date Program Requirement and Remedy Standard Completed[3]
1	Surge Pond	037	SWMU		Proof of Deed Recordation Letter July 27, 2000 a, RRS3
2	Off-Test Pond	039	SWMU		Proof of Deed Recordation Letter July 27, 2000 [a], RRS3
3	North Holding Pond	036	SWMU		October 17, 2002 c
12	Class I/II Landfill	020	SWMU		No Further Action – November 17, 2008 e
15	Pitch Pit Annex	023	SWMU		August 1, 1984 f
16	West Sludge Drying Pond	018	SWMU		November 15, 1994 g
17	Rocky Station Tank Lead Pits – Tanks 5532 / 8032	Z	SWMU	Soil / Groundwater	
17	South Refinery Tank Lead Pits – Tanks 5521, 5554, 5555, 5556	Z	SWMU		No Further Action – TCEQ Letter July 24, 2001 b
22	Sunset Heights Class 1 Landfill	043	SWMU		No Further Action – TCEQ Letter July 24, 2001 b
23	Asbestos Landfill	012	SWMU		No Further Action – TCEQ Letter April 24, 2005 d
23	Landfill (Regional Asbestos Landfill)	034	SWMU		No Further Action – TCEQ Letter April 24, 2005 d
27	Pitch Pit 15	054	SWMU		No Further Action – TCEQ July 24, 2001 a
29	Area 2 (West FOA Segment North)		AOC	Sediment / Groundwater / Surface Water	

Unit Number[1]	Unit Name	Notice of Registration (NOR) Number, if applicable	SWMU or AOC	Media Affected[2]	Date Program Requirement and Remedy Standard Completed[3]
29	Area 2 (West FOA Segment South)		AOC	Sediment / Groundwater / Surface Water	
34	AvGas Spill		AOC	Soil / Groundwater / Surface water	No Further Action (Groundwater)– TCEQ November 25, 2013 h
38	Philtex Canyon/Sawtooth (East FOA Segment)		AOC	Groundwater / Surface Water	

Foot Notes:

SWMU ‘ Solid Waste Management Unit
AOC ‘ Area of Concern

a Proof of Deed Recordation for Risk Reduction Standard No. 3 (RRS3) Off-Test Pond/Surge Pond. Letter from TNRCC to Phillips Petroleum dated July 27, 2000.
b Response to TNRCC Request for Additional Information with Respect to Review of May 15, 2000 Phase II/III RCRA Facility Investigation Report, dated March 9, 2001 Letter from TNRCC to Phillips Petroleum dated July 24, 2001.
c TCEQ Acknowledgment of Phillips 66 April 11, 2002 Response to TCEQ Letter dated April 11, 2002. North Holding Pond (RCRA Facility Investigation Unit K). Letter from TCEQ to Phillips 66 dated October 17, 2002.
d Approval of Closure – Request for Change in Status, dated May 16, 2005. Letter from TCEQ to Phillips 66 dated August 24, 2005.
e RCRAInfo Comprehensive Corrective Action Report provided by TCEQ to Phillips 66, dated July 7, 2010
f Notice of Registration, WRB Refining LLC (Owner), Phillips 66 Company (Operator), dated February 23, 2011
g Response to RFI Phase II Report, December 1999. Response to TNRCC Comment I.B.3, Attachment 3. Closure Plan, Certification of Closure and Deed Recordation
h Approval of No Further Action for Groundwater with Comments and Request for Information, Response Action Completion Report dated October 25, 2013. Letter from TCEQ to Phillips 66 dated November 25, 2013.
i Potentially affected media based on current data

1 For sites with FOA Authorization, list SWMUs and/or AOCs that were not included in the FOA, and are subject to corrective action.
2 Specify affected media groundwater, soils, etc.
3 Specify the date of Commissions No Further Action approval letter for program requirement and remedy standard completed for all media of concern.

CP Table III: Corrective Action Program Table of Detected Hazardous and Solid Waste Constituents and the Groundwater Protection Standard

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Groundwater Point of Exposure (mg/l)) Industrial/Residential*	COLUMN C Surface Water Point of Exposure (mg/l)
1. **Old Caustic Pond**	Fluoride (upper sand zone and lower gravel zone)	4.0E+00 $^{GW}GW_{Ing}$ / 4.0E+00 $^{GW}GW_{Ing}$	1.0E+01 ^{SW}SW
	2,4-Dimethylphenol (lower gravel zone only)	1.5E+00 $^{GW}GW_{Ing}$ / 4.9E-01 $^{GW}GW_{Ing}$	
	2-Methylphenol (o-Cresol, lower gravel zone only)	3.7E+00 $^{GW}GW_{Ing}$ / 1.2E+00 $^{GW}GW_{Ing}$	
	3-Methylphenol (m-Cresol, lower gravel zone only)	3.7E-01 $^{GW}GW_{Ing}$ / 1.2E-01 $^{GW}GW_{Ing}$	
	4-Methylphenol (p-Cresol, lower gravel zone only)	3.7E-01 $^{GW}GW_{Ing}$ / 1.2E-01 $^{GW}GW_{Ing}$	
	Sulfolane (upper sand zone and lower gravel zone)	9.5E-01 $^{GW}GW_{Ing}$ / 3.2E-01 $^{GW}GW_{Ing}$	2.5E+01 ^{SW}SW

$^{GW}GW_{Ing}$ – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018Table 3.

Reference: Revised Response Action Plan, Old Caustic Pond Area, Submitted August 8, 2017; TCEQ Responses to Conditional Approval with Request for a Response Action Plan Addendum, Old Caustic Pond, Received August 17, 2017; Addendum to Response Action Plan, Old Caustic Pond, Submitted March 2018; Revised Response Action Plan, Addendum 2, Old Caustic Pond, Submitted June 2019

* Off-site wells comply with residential PCLs.

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B: FOA Boundary of Compliance (mg/l)	COLUMN C: FOA Point of Exposure (mg/l)	COLUMN D: FOA Point of Exposure (mg/kg)
2. FOA East Segment **3. FOA West Segment** **4. FOA Northwest Segment** **5. FOA Northeast Segment**	Acetone (2-propanone)	1.0E+02 ^{SW}GW	1.0E+02 ^{SW}SW	1.5E+02 ^{SED}SED$_{Eco}$
	Benzene	1.3E-01 ^{SW}GW	1.3E-01 ^{SW}SW	1.5E+00 ^{SED}SED$_{Eco}$
	Benzyl alcohol	8.6E-03 ^{SW}GW	8.6E-03 ^{SW}SW	NA
	Bromomethane	1.1E-01 ^{SW}GW	1.1E-01 ^{SW}SW	2.7E-01 ^{SED}SED$_{Eco}$
	Carbon disulfide	1.1E-01 ^{SW}GW	1.1E-01 ^{SW}SW	4.5E-01 ^{SED}SED$_{Eco}$
	Chlorobenzene	6.4E-02 ^{SW}GW	6.4E-02 ^{SW}SW	1.9E+00 ^{SED}SED$_{Eco}$
	Chloroform	1.8E+00 ^{SW}GW	1.8E+00 ^{SW}SW	3.8E+00 ^{SED}SED$_{Eco}$
	Chloromethane	2.8E+01 ^{SW}GW	2.8E+01 ^{SW}SW	6.2E+01 ^{SED}SED$_{Eco}$
	Dichlorobenzene, 1,4-	1.1E-01 ^{SW}GW	1.1E-01 ^{SW}SW	2.7E+00 ^{SED}SED$_{Eco}$
	Dichloroethane, 1,1-	2.1E-01 ^{SW}GW	2.1E-01 ^{SW}SW	8.1E+00 ^{SED}SED$_{Eco}$
	Dichloroethane, 1,2-	3.6E+00 ^{SW}GW	3.6E+00 ^{SW}SW	1.9E+01 ^{SED}SED$_{Eco}$
	cis-1,2-Dichloroethene	1.4E+01 ^{SW}GW	1.4E+01 ^{SW}SW	4.8E+01 ^{SED}SED$_{Eco}$
	Ethylbenzene	1.0E+00 ^{SW}GW	1.0E+00 ^{SW}SW	5.3E+00 ^{SED}SED$_{Eco}$
	Ethyl ether	4.4E+03 ^{SW}GW	4.4E+03 ^{SW}SW	NA
	2-Butanone	4.2E+01 ^{SW}GW	4.2E+01 ^{SW}SW	9.0E+01 ^{SED}SED$_{Eco}$
	Iodomethane	3.4E+01 ^{SW}GW	3.4E+01 ^{SW}SW	NA
	Methylene chloride	2.2E+01 ^{SW}GW	2.2E+01 ^{SW}SW	3.1E+01 ^{SED}SED$_{Eco}$
	MTBE (methyl tert-butyl ether)	5.1E+01 ^{SW}GW	5.1E+01 ^{SW}SW	1.3E+02 ^{SED}SED$_{Eco}$
	Styrene	1.3E+00 ^{SW}GW	1.3E+00 ^{SW}SW	3.6E+01 ^{SED}SED$_{Eco}$

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B: FOA Boundary of Compliance (mg/l)	COLUMN C: FOA Point of Exposure (mg/l)	COLUMN D: FOA Point of Exposure (mg/kg)
	Tetrachloroethene	1.3E+00 ^{SW}GW	1.3E+00 ^{SW}SW	5.5E+00 ^{SED}SED$_{Eco}$
	Toluene	3.4E+00 ^{SW}GW	3.4E+00 ^{SW}SW	1.4E+01 ^{SED}SED$_{Eco}$
	Trichloroethene	7.2E-01 ^{SW}GW	7.2E-01 ^{SW}SW	9.1E+00 ^{SED}SED$_{Eco}$
	Trimethylbenzene, 1,2,4-	7.7E-02 ^{SW}GW	7.7E-02 ^{SW}SW	2.7E+00 ^{SED}SED$_{Eco}$
	Trimethylbenzene, 1,3,5-	7.1E-02 ^{SW}GW	7.1E-02 ^{SW}SW	2.7E+00 ^{SED}SED$_{Eco}$
	Vinyl chloride	1.6E-01 ^{SW}GW	1.6E-01 ^{SW}SW	6.9E+00 ^{SED}SED$_{Eco}$
	Xylenes (total)	1.3E+00 ^{SW}GW	1.3E+00 ^{SW}SW	8.0E+00 ^{SED}SED$_{Eco}$
	Acenaphthene	2.3E-02 ^{SW}GW *	2.3E-02 ^{SW}SW *	Evaluate as Total PAHs
	Acenaphthylene	1.9E+01 ^{SW}GW *	1.9E+01 ^{SW}SW *	Evaluate as Total PAHs
	Acetophenone	1.5E+04 ^{SW}GW	1.5E+04 ^{SW}SW	NA
	Anthracene	3.0E-04 ^{SW}GW *	3.0E-04 ^{SW}SW *	Evaluate as Total PAHs
	Benzenethiol	2.1E-02 ^{SW}GW	2.1E-02 ^{SW}SW	1.6E-01 ^{SED}SED$_{Eco}$
	Benzo(a)anthracene	2.5E-04 ^{SW}GW *	2.5E-04 ^{SW}SW *	Evaluate as Total PAHs
	Benzo(a)pyrene	1.0E-04 ^{MQL} *	1.0E-04 ^{MQL} *	Evaluate as Total PAHs
	Benzo(b)fluoranthene	1.8E-03 ^{SW}GW *	1.8E-03 ^{SW}SW *	Evaluate as Total PAHs
	Benzo(g,h,i)perylene	8.4E-02 ^{SW}GW *	8.4E-02 ^{SW}SW *	Evaluate as Total PAHs

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B: FOA Boundary of Compliance (mg/l)	COLUMN C: FOA Point of Exposure (mg/l)	COLUMN D: FOA Point of Exposure (mg/kg)
	Benzo(k)fluoranthene	1.8E-03 ^{SW}GW *	1.8E-03 ^{SW}SW *	Evaluate as Total PAHs
	Bis (2-ethylhexyl) phthalate	1.4E-02 ^{SW}GW	1.4E-02 ^{SW}SW	1.1E+01 $^{SED}SED_{Eco}$
	Chrysene	7.0E-03 ^{SW}GW *	7.0E-03 ^{SW}SW *	Evaluate as Total PAHs
	2-Methylphenol (o-Cresol)	5.6E-01 ^{SW}GW	5.6E-01 ^{SW}SW	NA
	3-Methylphenol (m-Cresol)	9.3E+01 ^{SW}GW	9.3E+01 ^{SW}SW	1.1E+03 $^{SED}SED_{Eco}$
	4-Methylphenol (p-Cresol)	2.7E-01 ^{SW}GW	2.7E-01 ^{SW}SW	1.1E+00 $^{SED}SED_{Eco}$
	Cresol, m and p isomers	2.7E-01 ^{SW}GW	2.7E-01 ^{SW}SW	1.1E+00 $^{SED}SED_{Eco}$
	Dibenz(a,h)anthracene	1.0E-04 ^{MQL} *	1.0E-04 ^{MQL} *	Evaluate as Total PAHs
	Dibenzofuran	9.4E-02 ^{SW}GW	9.4E-02 ^{SW}SW	4.4E-01 $^{SED}SED_{Eco}$
	2,4-Dimethylphenol	1.1E-01 ^{SW}GW	1.1E-01 ^{SW}SW	NA
	Fluoranthene	6.2E-03 ^{SW}GW *	6.2E-03 ^{SW}SW *	Evaluate as Total PAHs
	Fluorene	1.1E-02 ^{SW}GW *	1.1E-02 ^{SW}SW *	Evaluate as Total PAHs
	Indene	4.0E+01 ^{SW}GW	4.0E+01 ^{SW}SW	NA
	Indeno(1,2,3)cd-pyrene	1.3E-04 ^{SW}GW *	1.3E-04 ^{SW}SW *	Evaluate as Total PAHs
	1-Methylnaphthalene	2.1E-03 ^{SW}GW *	2.1E-03 ^{SW}SW *	Evaluate as Total PAHs

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B: FOA Boundary of Compliance (mg/l)	COLUMN C: FOA Point of Exposure (mg/l)	COLUMN D: FOA Point of Exposure (mg/kg)
	2-Methylnaphthalene	6.3E-02 ^{SW}GW *	6.3E-02 ^{SW}SW *	Evaluate as Total PAHs
	Naphthalene	2.5E-01 ^{SW}GW *	2.5E-01 ^{SW}SW *	Evaluate as Total PAHs
	Phenanthrene	3.0E-02 ^{SW}GW *	3.0E-02 ^{SW}SW *	Evaluate as Total PAHs
	Phenol	1.1E-01 ^{SW}GW	1.1E-01 ^{SW}SW	NA
	Pyrene	7.0E-03 ^{SW}GW *	7.0E-03 ^{SW}SW *	Evaluate as Total PAHs
	Total PAHs	6.8E-02 ^{SW}GW ***	6.8E-02 ^{SW}SW ***	1.2E+01 ^{SED}SED$_{Eco}$
	Antimony	2.2E+00 ^{SW}GW	2.2E+00 ^{SW}SW	6.2E+00 ^{SED}SED$_{Eco}$
	Arsenic	1.0E-01 ^{SW}GW ^{D}	1.0E-01 ^{SW}SW ^{D}	2.1E+01 ^{SED}SED$_{Eco}$
	Barium	2.6E+00 ^{SW}GW	2.6E+00 ^{SW}SW	3.4E+02 $^{BKG\ ****}$
	Beryllium	5.3E-03 ^{SW}GW	5.3E-03 ^{SW}SW	2.6E+02 ^{SED}SED$_{Eco}$
	Cadmium	1.0E-03 $^{MQL\ D**}$	1.0E-03 $^{MQL\ D**}$	3.0E+00 ^{SED}SED$_{Eco}$
	Chromium	3.2E-01 ^{SW}GW ^{D**}	3.2E-01 ^{SW}SW ^{D**}	7.7E+01 ^{SED}SED$_{Eco}$
	Cobalt	1.5E+00 ^{SW}GW	1.5E+00 ^{SW}SW	5.0E+01 ^{SED}SED$_{Eco}$
	Lead	1.6E-02 ^{SW}GW ^{D**}	1.6E-02 ^{SW}SW ^{D**}	8.2E+01 ^{SED}SED$_{Eco}$
	Mercury	2.0E-04 ^{MQL}	2.0E-04 ^{MQL}	6.2E-01 ^{SED}SED$_{Eco}$
	Nickel and compounds	2.3E-01 ^{SW}GW ^{D**}	2.3E-01 ^{SW}SW ^{D**}	3.6E+01 ^{SED}SED$_{Eco}$
	Selenium	5.0E-03 ^{SW}GW	5.0E-03 ^{SW}SW	1.7E+00 $^{BKG\ ****}$
	Vanadium	2.0E-02 ^{SW}GW	2.0E-02 ^{SW}SW	2.2E+01 $^{BKG\ ****}$

Notes:
BKG Background as determined in accordance with 30 TAC 350.51(l).
D – Dissolved
NA – Not applicable
*** - For information only; PAHs will be evaluated as Total PAHs**

Boundary of Compliance and Point of Exposure (Aqueous) lower of Incidental Fishery (TCEQ, 2018), Surface Water Benchmark (TCEQ, 2017), or Wildlife PCL (COP, 2007)
Point of Exposure (Sediment) lower of Sediment Benchmark (TCEQ, 2017) or Wildlife PCL (COP, 2007)

MCL – Maximum Contaminant Level
MQL – Method Quantitation Limit
^{SW}GW, ^{SW}SW, and ^{SED}SED PCLs obtained from *Step 3 FOA Pre-Qualification Monitoring and Corrective Action Report Table 3.4-1 (August 2007)* except as modified below:

** - Conditional Approval of Phillips 66' *Request for Revision of Cadmium, Chromium, Lead, and Nickel Protective Concentration Levels in Surface Water*, dated March 7, 2011, Letter from TCEQ dated May 17, 2011
*** - Approval of *Request for Revision of Total Polycyclic Aromatic Hydrocarbon Protective Concentration Level in Surface Water and Groundwater*, dated October 27, 2010, Letter from TCEQ dated January 24, 2011.
**** - Approval of Response to TCEQ Comments on Request for Revision of Barium, Selenium, and Vanadium Protective Concentration Levels in Sediment, Letter from TCEQ to Phillips 66 dated May 17, 2011

References:

Step 3 FOA Pre-Qualification Monitoring and Corrective Action Program Report, dated July 21, 2006 and modified by Addendums dated August 2, 2006, February 8, 2007, August 3, 2007, and December 1, 2007.
Response to October 9, 2007 TCEQ Letter Containing TCEQ Comments to Phillips 66 Response dated August 3, 2007 to TCEQ Comments Letter dated June 4, 2007 and to Additional TCEQ Comment Letter, dated June 25, 2007, dated December 1, 2007
Conditional Approval of Phillips 66' *Response to October 9, 2007 TCEQ Letter Containing TCEQ Comments to Phillips 66 Response* dated August 3, 2007 to *TCEQ Comments Letter dated June 4, 2007 and to Additional TCEQ Comment Letter, dated June 25, 2007*, dated December 1, 2007, Letter from TCEQ, February 15, 2008.
Texas Commission on Environmental Quality (TCEQ). 2017. Ecological Benchmarks. RG263B. January 31, 2017.
Texas Commission on Environmental Quality (TCEQ). 2018. Human Health Risk Bisk Exposure Limit. March 1, 2018

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Groundwater Point of Exposure (mg/l)	COLUMN C Surface Water Point of Exposure (mg/l)	COLUMN D Surface Water Point of Exposure (mg/l)	COLUMN E Sediment Point of Exposure (mg/kg)
6. **Southeast Canyon**	Benzene	5.0E-03 $^{GW}GW_{Ing}$	1.3E-01 ^{SW}GW	1.3E-01 ^{SW}SW	NA

$^{GW}GW_{Ing}$ PCL – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018 Table 3.
S – Retained due to soil exceedance; no groundwater exceedance

Reference: Response Action Plan (RAP) for Southeast Canyon Site, dated February 16, 2007; Approval of Response Action Plan, dated February 16, 2007 Southeast Canyon Site. Letter from Eleanor Wehner dated April 20, 2007; Revised Response Action Plan, Southeast Canyon, Submitted December 18, 2018.

Texas Commission on Environmental Quality (TCEQ). 2017. Ecological Benchmarks. RG263B. January 31, 2017.

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Groundwater Point of Exposure (mg/l)	COLUMN C Surface Water Point of Exposure (mg/l)	COLUMN D Sediment Point of Exposure (mg/kg)
7. **HP-7/South Cobles**	Benzene	1.3E-01 ^{SW}GW	1.3E-01 ^{SW}SW	2.2E+01 ^{SED}SED$_{Eco}$
	Ethylbenzene	1.1E+00 ^{SW}GW	1.1E+00 ^{SW}SW	1.0E+01 ^{SED}SED$_{Eco}$
	Toluene	1.5E+00 ^{SW}GW	1.5E+00 ^{SW}SW	1.0E+01 ^{SED}SED$_{Eco}$
	Xylenes (total)	1.3E+00 ^{SW}GW	1.3E+00 ^{SW}SW	8.0E+00 ^{SED}SED$_{Eco}$
	Total Petroleum Hydrocarbons	4.4E+00 ^{SW}GW	NA	NA

Reference: Response Action Plan for HP-7/South Cobles dated September 2010; Conditional Approval of HP-7/South Cobles Site Corrective Measures Implementation Work plan / Response Action Plan, dated September 15, 2010, letter dated December 22, 2010 from Eleanor Wehner; Revised Response Action Plan, HP-7 / South Cobles, Submitted April 30, 2015; Addendum to the 2015 Revised Response Action Plan, HP-7/South Cobles Site, February 1, 2016.

Texas Commission on Environmental Quality (TCEQ). 2017. Ecological Benchmarks. RG263B. January 31, 2017.

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Point of Exposure (mg/l)	COLUMN C Point of Exposure (mg/l)
8. **Litharge Impoundment**	Arsenic	1.0E-02 $^{GW}GW_{Ing}$	1.0E+00 $^{GW}GW_{Class3}$
	Benzene	5.0E-03 $^{GW}GW_{Ing}$	5.0E-01 $^{GW}GW_{Class3}$

Notes:
MCL – Maximum Contaminant Level
$^{GW}GW_{Ing}$ – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018, Table 3

Reference: Revised Response Action Plan, Litharge Impoundment, Submitted April 4, 2015; Response Action Completion Report, Litharge Impoundment, Submitted July 20, 2018

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Point of Exposure (mg/l)
9. **New Caustic Pond**	Arsenic	1.0E-02 $^{GW}GW_{Ing}$
	Vanadium	1.3E-01 $^{GW}GW_{Ing}$
	Fluoride	4.0E+00 $^{GW}GW_{Ing}$
	2,4-Dimethylphenol	1.5E+00 $^{GW}GW_{Ing}$
	2-Methylphenol	3.7E+00 $^{GW}GW_{Ing}$
	3&4-Methylphenol	3.7E-01 $^{GW}GW_{Ing}$
	Phenol	2.2E+01 $^{GW}GW_{Ing}$
	Sulfolane	9.5E-01 $^{GW}GW_{Ing}$

$^{GW}GW_{Ing}$ – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018, Table 3

Reference: Response Action Plan, New Caustic Pond, Submitted December 4, 2017; Revised Response Action Plan, New Caustic Pond, Submitted June 6, 2018

[**Note:** This Table should present the long list of hazardous constituents that are reasonably expected to be in or derived from waste placed in the units, and may not necessarily be detected and that are to be monitored semi-annually. Also, instead of listing individual constituents of concern (COCs), Appendix IX can be referenced in this table. If Appendix IX list and associated Practical Quantitation Limit (PQL) or Method Quantitation Limit (MQLs) are being required instead of listing individual COCs, add this sentence: The Permittee may petition the Executive Director for deletion of specific parameters from Appendix IX analysis if the Permittee can demonstrate that the constituents were never used in the facility's operation or were never disposed in the waste management area.]
[*Add COLUMN C if there is a GWPS assigned at a Point of Exposure (POE) (e.g. monitored natural attenuation and Plume Management Zone established in accordance with 30 TAC 350, if applicable). Modify Table and footnotes as necessary.]
Foot Note:
Use the following GWPS footnote designations if Risk Reduction Rules (RRR) or Texas Risk Reduction Program (TRRP) apply:
* For RRR use the following GWPS designation:*

MSC ACL pursuant to 30 TAC §335.160(b) based upon the Groundwater Medium-Specific Concentration, Residential {...or Industrial...) Risk Reduction Standard No. 2 {...or No. 3}specified in 30 TAC §335 Subchapter S.
MCL ACL pursuant to 30 TAC §335.160(b) based upon the Groundwater Maximum Contaminant Level specified in 40 CFR Part 141, National Primary Drinking Water Regulations Subparts B and G.
SMCL ALC pursuant to 30 TAC §335.160(b) based upon the Groundwater Secondary Maximum Contaminant Level (MCL) specified in 40 CFR Part 143, National Secondary Drinking Water Regulations.
AL ACL pursuant to 30 TAC §335.160(b) based upon the Action Level specified in 40 CFR Part 141, National Primary Drinking Water Regulations Subpart I.
BKG Background as determined in accordance with 30 TAC 350.4(a)(6).
ND Non-detectable at PQL as determined by the analytical methods of the EPA SW-846 most recent edition, and as listed in the July 8, 1987 edition of the Federal Register and later editions. PQL is indicated in parentheses. PQL is the lowest concentrations of analytes in groundwaters that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating condition.
* or Use the following GWPS designation if TRRP applies:*
GWGWIng ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB (Residential or Commercial /Industrial) for Class 1 or Class 2 Groundwater ingestion PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.. In accordance with §350.72(b), GWGWIng, PCLs may need to be adjusted to lower concentrations to meet the cumulative carcinogenic risk level (less than or equal to 1x10-4) and hazard index criteria (less than or equal to 10) when there are more than 10 carcinogenic and/or more than 10 non-carcinogenic chemicals of concern within a source medium.
GWGWClass3 ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB (Residential or Commercial /Industrial), Tier I for Class 3 Groundwater ingestion PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.
AirGWInh-V ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB (Residential or Commercial /Industrial) for Class 1 or Class 2 Groundwater inhalation PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.
SWGW ACL pursuant to 30 TAC §335.160(b) based upon the Protective PCL determined under RSA or RSB for Groundwater- to-surface water PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.
SEDGW ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB for Groundwater- to-sediment PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.
ECOGW ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB for Groundwater- based on ecological receptor(s) PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.
AAL ACL derived pursuant to 30 TAC §335.160(b) based upon the Protective Concentration level (PCL) established as an Attenuation Action Level as defined in 30 TAC §350(a)(4).
BKG Background as determined in accordance with 30 TAC 350.4(a)(6).
ND Non-detectable at MQL as determined by the analytical methods of the EPA SW-846 most recent edition, and as listed in the July 8, 1987 edition of the Federal Register and later editions. MQL is indicated in parentheses. MQL is defined in 30 TAC §350.4 (54) as the lowest non-zero concentration standard in the laboratory's initial calibration curve and is based on the final volume of extract (or sample) used by the laboratory.

CP Table IIIA: Corrective Action Program Table of Indicator Parameters and Groundwater Protection Standard

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Groundwater Point of Exposure (mg/l)) Industrial/Residential*	COLUMN C Surface Water Point of Exposure (mg/l)
1. **Old Caustic Pond**	Fluoride (upper sand zone and lower gravel zone)	4.0E+00 $^{GW}GW_{Ing}$ / 4.0E+00 $^{GW}GW_{Ing}$	1.0E+01 ^{SW}SW
	2,4-Dimethylphenol (lower gravel zone only)	1.5E+00 $^{GW}GW_{Ing}$ / 4.9E-01 $^{GW}GW_{Ing}$	
	2-Methylphenol (o-Cresol, lower gravel zone only)	3.7E+00 $^{GW}GW_{Ing}$ / 1.2E+00 $^{GW}GW_{Ing}$	
	3-Methylphenol (m-Cresol, lower gravel zone only)	3.7E-01 $^{GW}GW_{Ing}$ / 1.2E-01 $^{GW}GW_{Ing}$	
	4-Methylphenol (p-Cresol, lower gravel zone only)	3.7E-01 $^{GW}GW_{Ing}$ / 1.2E-01 $^{GW}GW_{Ing}$	
	Sulfolane (upper sand zone and lower gravel zone)	9.5E-01 $^{GW}GW_{Ing}$ / 3.2E-01 $^{GW}GW_{Ing}$	2.5E+01 ^{SW}SW

$^{GW}GW_{Ing}$ – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018 Table 3.

Reference: Revised Response Action Plan, Old Caustic Pond Area, Submitted August 8, 2017; TCEQ Responses to Conditional Approval with Request for a Response Action Plan Addendum, Old Caustic Pond, Received August 17, 2017; Addendum to Response Action Plan, Old Caustic Pond, Submitted March 2018; Revised Response Action Plan, Addendum 2, Old Caustic Pond, Submitted June 2019

* Off-site wells comply with residential PCLs.

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B: FOA Boundary of Compliance (mg/l)	COLUMN C: FOA Point of Exposure (mg/l)	COLUMN D: FOA Point of Exposure (mg/kg)
2. FOA East Segment **3. FOA West Segment** **4. FOA Northwest Segment** **5. FOA Northeast Segment**	Benzene	1.3E-01 ^{SW}GW	1.3E-01 ^{SW}SW	1.5E+00 $^{SED}SED_{eco}$
	Ethylbenzene	1.0E+00 ^{SW}GW	1.0E+00 ^{SW}SW	5.3E+00 $^{SED}SED_{eco}$
	Toluene	3.4E+00 ^{SW}GW	3.4E+00 ^{SW}SW	1.4E+01 $^{SED}SED_{eco}$
	Acenaphthene	2.3E-02 ^{SW}GW *	2.3E-02 ^{SW}SW *	Evaluate as Total PAHs
	Acenaphthylene	1.9E+01 ^{SW}GW *	1.9E+01 ^{SW}SW *	Evaluate as Total PAHs
	Anthracene	3.0E-04 ^{SW}GW *	3.0E-04 ^{SW}SW *	Evaluate as Total PAHs
	Fluorene	1.1E-02 ^{SW}GW *	1.1E-02 ^{SW}SW *	Evaluate as Total PAHs
	1-Methylnaphthalene	2.1E-03 ^{SW}GW *	2.1E-03 ^{SW}SW *	Evaluate as Total PAHs
	2-Methylnaphthalene	6.3E-02 ^{SW}GW *	6.3E-02 ^{SW}SW *	Evaluate as Total PAHs
	Naphthalene	2.5E-01 ^{SW}GW *	2.5E-01 ^{SW}SW *	Evaluate as Total PAHs
	Phenanthrene	3.0E-02 ^{SW}GW *	3.0E-02 ^{SW}SW *	Evaluate as Total PAHs
	Total PAHs	6.8E-02 ^{SW}GW ***	6.8E-02 ^{SW}SW ***	1.2E+01 $^{SED}SED_{eco}$
	Chromium	3.2E-01 ^{SW}GW $^{/D**}$	3.2E-01 ^{SW}SW $^{/D**}$	7.7E+01 $^{SED}SED_{eco}$
	Lead	1.6E-02 ^{SW}GW $^{/D**}$	1.6E-02 ^{SW}SW $^{/D**}$	8.2E+01 $^{SED}SED_{eco}$

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B: FOA Boundary of Compliance (mg/l)	COLUMN C: FOA Point of Exposure (mg/l)	COLUMN D: FOA Point of Exposure (mg/kg)
	Selenium	5.0E-03 ^{SW}GW	5.0E-03 ^{SW}SW	1.7E+00 ^{BKG****}

*** - For information only; PAHs will be evaluated as Total PAHs**
Boundary of Compliance and Point of Exposure (Aqueous) lower of Incidental Fishery (TCEQ, 2018), Surface Water Benchmark (TCEQ, 2017), or Wildlife PCL (COP, 2007)
Point of Exposure (Sediment) lower of Sediment Benchmark (TCEQ, 2017) or Wildlife PCL (COP, 2007)

MCL – Maximum Contaminant Level
MQL – Method Quantitation Limit
^{SW}GW, ^{SW}SW, and ^{SED}SED PCLs obtained from *Step 3 FOA Pre-Qualification Monitoring and Corrective Action Report Table 3.4-1 (August 2007)* except as modified below:
** - Conditional Approval of Phillips 66' *Request for Revision of Cadmium, Chromium, Lead, and Nickel Protective Concentration Levels in Surface Water*, dated March 7, 2011, Letter from TCEQ dated May 17, 2011
*** - Approval of *Request for Revision of Total Polycyclic Aromatic Hydrocarbon Protective Concentration Level in Surface Water and Groundwater*, dated October 27, 2010, Letter from TCEQ dated January 24, 2011.
**** - Approval of Response to TCEQ Comments on Request for Revision of Barium, Selenium, and Vanadium Protective Concentration Levels in Sediment, Letter from TCEQ to Phillips 66 dated May 17, 2011

References: *Step 3 FOA Pre-Qualification Monitoring and Corrective Action Program Report*, dated July 21, 2006 and modified by Addendums dated August 2, 2006, February 8, 2007, August 3, 2007, and December 1, 2007.
Response to October 9, 2007 TCEQ Letter Containing TCEQ Comments to Phillips 66 Response dated August 3, 2007 to TCEQ Comments Letter dated June 4, 2007 and to Additional TCEQ Comment Letter, dated June 25, 2007, dated December 1, 2007
Conditional Approval of Phillips 66' *Response to October 9, 2007 TCEQ Letter Containing TCEQ Comments to Phillips 66 Response* dated August 3, 2007 to *TCEQ Comments Letter dated June 4, 2007 and to Additional TCEQ Comment Letter, dated June 25, 2007*, dated December 1, 2007, Letter from TCEQ, February 15, 2008.
Texas Commission on Environmental Quality (TCEQ). 2017. Ecological Benchmarks. RG263B. January 31, 2017.
Texas Commission on Environmental Quality (TCEQ). 2018. Human Health Risk Bisk Exposure Limit. March 1, 2018

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Groundwater Point of Exposure (mg/l)	COLUMN C Surface Water Point of Exposure (mg/l)	COLUMN D Surface Water Point of Exposure (mg/l)	COLUMN E Sediment Point of Exposure (mg/kg)
6. **Southeast Canyon**	Benzene	5.0E-03 $^{GW}GW_{Ing}$	1.3E-01 ^{SW}GW	1.3E-01 ^{SW}SW	NA

$^{GW}GW_{Ing}$ PCL – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018Table 3.
S – Retained due to soil exceedance; no groundwater exceedance
$^{**\text{ - }Tot}SED_{Comb}$ PCL – Protective Concentration Level, March 31, 2006.

Reference: Response Action Plan (RAP) for Southeast Canyon Site, dated February 16, 2007; Approval of Response Action Plan, dated February 16, 2007 Southeast Canyon Site. Letter from Eleanor Wehner dated April 20, 2007; Revised Response Action Plan, Southeast Canyon, Submitted December 18, 2018.

Texas Commission on Environmental Quality (TCEQ). 2017. Ecological Benchmarks. RG263B. January 31, 2017.

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Groundwater Point of Exposure (mg/l)	COLUMN C Surface Water Point of Exposure (mg/l)	COLUMN D Sediment Point of Exposure (mg/kg)
7. **HP-7/South Cobles**	Benzene	1.3E-01 ^{SW}GW	1.3E-01 ^{SW}SW	2.2E+01 ^{SED}SED$_{Eco}$
	Ethylbenzene	1.1E+00 ^{SW}GW	1.1E+00 ^{SW}SW	1.0E+01 ^{SED}SED$_{Eco}$
	Toluene	1.5E+00 ^{SW}GW	1.5E+00 ^{SW}SW	1.0E+01 ^{SED}SED$_{Eco}$
	Xylenes (total)	1.3E+00 ^{SW}GW	1.3E+00 ^{SW}SW	8.0E+00 ^{SED}SED$_{Eco}$
	Total Petroleum Hydrocarbons	4.4E+00 ^{SW}GW	NA	NA

Reference: Response Action Plan for HP-7/South Cobles dated September 2010; Conditional Approval of HP-7/South Cobles Site Corrective Measures Implementation Work plan / Response Action Plan, dated September 15, 2010, letter dated December 22, 2010 from Eleanor Wehner; Revised Response Action Plan, HP-7 / South Cobles, Submitted April 30, 2015; Addendum to the 2015 Revised Response Action Plan, HP-7/South Cobles Site, February 1, 2016.

Texas Commission on Environmental Quality (TCEQ). 2017. Ecological Benchmarks. RG263B. January 31, 2017.

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Point of Exposure (mg/l)	COLUMN C Point of Exposure (mg/l)
8. **Litharge Impoundment**	Arsenic	1.0E-02 $^{GW}GW_{Ing}$	1.0E+00 $^{GW}GW_{Class3}$
	Benzene	5.0E-03 $^{GW}GW_{Ing}$	5.0E-01 $^{GW}GW_{Class3}$

Notes:
MCL – Maximum Contaminant Level
$^{GW}GW_{Ing}$ – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018, Table 3

Reference: Revised Response Action Plan, Litharge Impoundment, Submitted April 4, 2015; Response Action Completion Report, Litharge Impoundment, Submitted July 20, 2018

Unit Name	COLUMN A: Hazardous Constituents	COLUMN B Point of Exposure (mg/l)
9. **New Caustic Pond**	Arsenic	1.0E-02 $^{GW}GW_{Ing}$
	Vanadium	1.3E-01 $^{GW}GW_{Ing}$
	Fluoride	4.0E+00 $^{GW}GW_{Ing}$
	2,4-Dimethylphenol	1.5E+00 $^{GW}GW_{Ing}$
	2-Methylphenol (o-Cresol)	3.7E+00 $^{GW}GW_{Ing}$
	3&4-Methylphenol (m-Cresol)	3.7E-01 $^{GW}GW_{Ing}$
	Phenol	2.2E+01 $^{GW}GW_{Ing}$

$^{GW}GW_{Ing}$ – Protective Concentration Level, Commercial/Industrial Worker, April 27, 2018, Table 3

Reference: Response Action Plan, New Caustic Pond, Submitted December 4, 2017; Revised Response Action Plan, New Caustic Pond, Submitted June 6, 2018

[**Note:** This Table should list the short list of constituents (i.e., indicator parameters) developed from CP Table III – Corrective Action Program Table of Detected Hazardous and Solid Waste Constituents and the Groundwater Protection Standard to be monitored semiannually during the Corrective Action Program to verify GWPSs are met.]
[*Add COLUMN C if there is a GWPS assigned at a Point of Exposure (POE) (e.g. monitored natural attenuation and Plume Management Zone established in accordance with 30 TAC 350, if applicable). Modify Table and footnotes as necessary.]
Foot Note:
Use the following GWPS footnote designations if Risk Reduction Rules (RRR) or Texas Risk Reduction Program (TRRP) apply:
*** For RRR use the following GWPS designation:***
MSC ACL pursuant to 30 TAC §335.160(b) based upon the Groundwater Medium-Specific Concentration, Residential {...or Industrial...} Risk Reduction Standard No. 2 {...or No. 3}specified in 30 TAC §335 Subchapter S.
MCL ACL pursuant to 30 TAC §335.160(b) based upon the Groundwater Maximum Contaminant Level specified in 40 CFR Part 141, National Primary Drinking Water Regulations Subparts B and G.
SMCL ALC pursuant to 30 TAC §335.160(b) based upon the Groundwater Secondary Maximum Contaminant Level (MCL) specified in 40 CFR Part 143, National Secondary Drinking Water Regulations.
AL ACL pursuant to 30 TAC §335.160(b) based upon the Action Level specified in 40 CFR Part 141, National Primary Drinking Water Regulations Subpart I.
BKG Background as determined in accordance with 30 TAC 350.4(a)(6).

ND Non-detectable at PQL as determined by the analytical methods of the EPA SW-846 most recent edition, and as listed in the July 8, 1987 edition of the Federal Register and later editions. PQL is indicated in parentheses. PQL is the lowest concentrations of analytes in groundwaters that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating condition.

*** or Use the following GWPS designation if TRRP applies:***

GWGWIng ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB (Residential or Commercial /Industrial) for Class 1 or Class 2 Groundwater ingestion PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table. In accordance with §350.72(b), GWGWIng, PCLs may need to be adjusted to lower concentrations to meet the cumulative carcinogenic risk level (less than or equal to 1x10-4) and hazard index criteria (less than or equal to 10) when there are more than 10 carcinogenic and/or more than 10 non-carcinogenic chemicals of concern within a source medium.

GWGWClass3 ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB (Residential or Commercial /Industrial), Tier I for Class 3 Groundwater ingestion PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.

AirGWInh-V ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB (Residential or Commercial /Industrial) for Class 1 or Class 2 Groundwater inhalation PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.

SWGW ACL pursuant to 30 TAC §335.160(b) based upon the Protective PCL determined under RSA or RSB for Groundwater- to-surface water PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.

SEDGW ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB for Groundwater- to-sediment PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.

ECOGW ACL pursuant to 30 TAC §335.160(b) based upon the PCL determined under RSA or RSB for Groundwater- based on ecological receptor(s) PCL of 30 TAC Chapter 350. The PCL value, Column B, will change as updates to the rule are promulgated. Changes to the rule automatically change the concentration value established in Column B in this table.

AAL ACL derived pursuant to 30 TAC §335.160(b) based upon the Protective Concentration level (PCL) established as an Attenuation Action Level as defined in 30 TAC §350(a)(4).

BKG Background as determined in accordance with 30 TAC 350.4(a)(6).

ND Non-detectable at MQL as determined by the analytical methods of the EPA SW-846 most recent edition, and as listed in the July 8, 1987 edition of the Federal Register and later editions. MQL is indicated in parentheses. MQL is defined in 30 TAC §350.4 (54) as the lowest non-zero concentration standard in the laboratory's initial calibration curve and is based on the final volume of extract (or sample) used by the laboratory.

CP Attachment B: Well Design, Construction, Installation, Certification, Plugging and Abandonment Procedures and Specifications

1. The Permittee shall use well drilling methods that minimize potential adverse effects on the quality of water samples withdrawn from the well, and that minimize or eliminate the introduction of foreign fluids into the borehole.

2. All wells constructed to meet the terms of this Compliance Plan shall be constructed such that the wells can be routinely sampled with a pump, bailer, or alternate sampling device. Piping associated with recovery wells should be fitted with sample ports or an acceptable alternative sampling method to facilitate sampling of the recovered groundwater on a well by well basis.

3. Above the saturated zone the well casing may be two (2)-inch diameter or larger schedule 4o or 8o polyvinyl chloride (PVC) rigid pipe or stainless steel or polytetrafluoroethylene (PTFE or "teflon") or an approved alternate material. The PVC casing must bear the National Sanitation Foundation logo for potable water applications (NSF-pw). Solvent cementing compounds shall not be used to bond joints and all connections shall be flush-threaded. In and below the saturated zone, the well casing shall be stainless steel or PTFE.

   The Permittee may use PVC or fiberglass reinforced resin as an alternate well casing material in and below the saturated zone provided that it yields samples for groundwater quality analysis that are unaffected by the well casing material.

4. The Permittee shall replace any well that has deteriorated due to incompatibility of the casing material with the groundwater contaminants or due to any other factors. Replacement of the damaged well shall be completed within ninety (90) days of the date of the inspection that identified the deterioration.

5. Well casings and screens shall be steam cleaned prior to installation to remove all oils, greases, and waxes. Well casings and screens made of fluorocarbon resins shall be cleaned by detergent washing.

6. For wells constructed after the date of issuance of this Compliance Plan, the screen length shall typically be ten (10) feet within a given transmissive zone unless location-specific hydrogeologic considerations support a screen length exceeding ten feet. Screen lengths exceeding ten (10) feet may be installed in groundwater recovery or injection wells to optimize the groundwater remediation process in accordance with standard engineering practice.

7. The Permittee shall design and construct the intake portion of a well so as to allow sufficient water flow into the well for sampling purposes and minimize the passage of formation materials into the well during pumping. The intake portion of a well shall consist of commercially manufactured stainless steel or PTFE screen or approved alternate material. The annular space between the screen and the borehole shall be filled with clean siliceous granular material (i.e., filter pack) that has a proper size gradation to provide mechanical retention of the formation sand and silt. The well screen slot size shall be compatible with the filter pack size as recommended by well screen manufacturer. The filter pack should extend no more than three (3) feet above the well screen. A silt trap, no greater than one (1) foot in length, may be added to the bottom of the well screen to collect any silt that may enter the well. The bottom of the well casing shall be capped with PTFE or stainless steel or approved alternate material.

Groundwater recovery and injection wells shall be designed in accordance with standard engineering practice to ensure adequate well production and accommodate ancillary equipment. Silt traps exceeding one (1) foot may be utilized to accommodate ancillary equipment. Well heads shall be fitted with mechanical well seals, or equivalent, to prevent entry of surface water or debris.

8. A minimum of two (2) feet of pellet or granular bentonite shall immediately overlie the filter pack in the annular space between the well casing and borehole. Where the saturated zone extends above the filter pack, pellet or granular bentonite shall be used to seal the annulus. The bentonite shall be allowed to settle and hydrate for a sufficient amount of time prior to placement of grout in the annular space. Above the minimum two (2)-foot thick bentonite seal, the annular-space shall be sealed with a cement/bentonite grout mixture. The grout shall be placed in the annular space by means of a tremie pipe or pressure grouting methods equivalent to tremie gouting standards.

   The cement/bentonite grout mixture or TCEQ approved alternative grout mixture shall fill the annular space to within two (2) feet of the surface. A suitable amount of time shall be allowed for settling to occur. The annular space shall be sealed with concrete, blending into a cement apron at the surface that extends at least two (2) feet from the outer edge of the monitor well for above-ground completions. Alternative annular-space seal, material may be proposed with justification and must be approved by the Executive Director prior to installation.

   In cases where flush-to-ground completions are unavoidable, a protective structure such as a utility vault or meter box should be installed around the well casing and the concrete pad design should prevent infiltration of water into the vault. In addition, the Permittee must ensure that 1) the well/cap juncture is watertight; 2) the bond between the cement surface seal and the protective structure is watertight; and 3) the protective structure with a steel lid or manhole cover has a rubber seal or gasket.

9. Water added as a drilling fluid to a well shall contain no bacteriological or chemical constituents that could interfere with the formation or with the chemical constituents being monitored. For groundwater recovery and injection wells, drilling fluids containing freshwater and treatment agents may be utilized in accordance with standard engineering practice to facilitate proper well installation. In these cases, the water and agents added should be chemically analyzed to evaluate their potential impact on in-situ water quality and to assess the potential for formation damage. All such additives shall be removed to the extent practicable during well development.

10. Upon completion of installation of a well, the well must be developed to remove any fluids used during well drilling and to remove fines from the formation to provide a particulate-free discharge to the extent achievable by accepted completion methods and by commercially available well screens. Development shall be accomplished by reversing flow direction, surging the well or by air lift procedures. No fluids other than formation water shall be added during development of a well unless the aquifer to be screened is alow-yielding water-bearing aquifer. In these eases, the water to be added should be chemically analyzed to evaluate its potential impact on in-situ water quality, and to assess the potential for formation damage.

    For recovery and injection wells, well development methods may be utilized in accordance with standard engineering practice to remove fines and maximize well efficiency and specific capacity. Addition of freshwater and treatment agents may be utilized during well development or re-development to remove drilling fluids, inorganic scale or bacterial slime. In these cases, the water and agents added should be chemically analyzed to evaluate their potential impact on in-situ water quality-and to assess the potential for formation damage. All such additives shall be removed to the extent practicable during well development.

11. Each well shall be secured and/or designed to maintain the integrity of the well borehole and groundwater.

12. The Permittee shall protect the above-ground portion of the well by bumper guards and/or metal outer casing protection when wells are located in traffic areas or outside the secured plant area.

13. The attached Table Of Well Construction Details is to be completed or updated for each well installed and kept on site. Items in the table that require a yes or no answer indicate diagrams plans, or procedures that shall be kept on site and made available to inspection. The completed table and other records shall include all of the following information:

    - name/number of well (well designation);
    - intended use of the well(sampling, recovery, etc.);
    - date/time of construction;
    - drilling method and drilling fluid used;
    - well location (+ 0.5 ft.);
    - bore hole diameter and well casing diameter;
    - well depth (+ 0.1 ft.);
    - drilling and lithologic logs;
    - depth to first saturated zone;
    - casing materials;
    - screen materials and design;
    - casing and screen joint type;
    - screen slot size/length;
    - filter pack material/size;
    - filter pack volume (how many bags, buckets, etc.);
    - filter pack placement method;
    - sealant materials;
    - sealant volume (how many bags, buckets, etc.);
    - sealant placement method;
    - surface seal design/construction;
    - well development procedure;
    - type of protective well cap;
    - ground surface elevation (+ 0.01 ft. MSL);
    - top of casing elevation (+ 0.01 ft. MSL); and,
    - detailed drawing of well (include dimensions).

14. The Permittee shall clearly mark and maintain the well number on each well at the site.

15. The Permittee shall measure and keep a record of the elevation of the top of each well casing in feet above mean sea level to the nearest 0.01 foot and permanently mark the measuring point on the well. The Permittee shall compare old and new elevations from previously surveyed wells and determine a frequency of surveying not to exceed five (5) year intervals.

16. A well's screened interval shall be appropriately designed and installed to meet the well's specific objective (i.e., either DNAPL, LNAPL, both, or other objective

of the well). All Wells designed to detect, monitor; or recover DNAPL must be drilled to intercept the bottom confining layer of the aquifer. The screened interval to detect DNAPL should extend from the top of the lower confining layer to above the portion of the aquifer saturated with DNAPL. The screened interval for all wells designed to detect, monitor, or recover LNAPL must extend high enough into the vadose zone to provide for fluctuations in the seasonal water table. In addition, the sandpacks for the recovery or monitoring well's screened interval shall be coarser than surrounding media to ensure the movement of NAPL to the well.

Certification, Plugging and Abandonment Procedures

17. Prior to installation of a Point of Compliance (POC), FOA Boundary of Compliance (FBOC), Point of Exposure (POE), Alternate Point of Exposure (APOE) or Background replacement well listed in CP Table V, the Permittee shall submit to the Executive Director for approval, the replacement well specifications and an explanation of why the well is being replaced, For any such well to be considered as a replacement well and not as a new well, the well shall have no substantive design changes from the well being replaced as determined by the Executive Director. The well shall be drilled within fifteen (15) feet of the well being replaced unless an alternate location is authorized by the Executive Director, The Permittee shall submit a replacement well certification to the Executive Director in accordance with CP Table VII and CP Attachment C, Provision 19.

18. Plugging and abandonment of a Corrective Action System Background, POC, FBOC, POE, and/or APOE wells in Provision XI.B.1 shall be subject to the Compliance Plan modification provisions in 30 TAC ' 305 Subchapter D. Plugging and abandonment of Corrective Action Observation, Corrective Action System and/or Attenuation Monitoring Point wells in Provision XI.B.2, shall commence upon written approval of the Executive Director. The well shall be plugged and abandoned in accordance with requirements of this Attachment C. The Permittee shall certify proper plugging and abandonment in accordance with .CP Table VII and CP Attachment C, Provision 19.

19. The Permittee shall complete construction or plugging and abandonment of each well in accordance with the requirements of this Compliance Plan and 16 TAC Chapter 76 and shall certify such proper construction or plugging and abandonment in the first report submitted pursuant to CP Table VII following installation or plugging and abandonment. Copies of the State of Texas Plugging Report filed with the Texas Department of Licensing and Regulation and completion logs for each newly installed or replaced well shall be included with the report. The certification shall be prepared by a qualified geologist or geotechnical engineer. Each well certification shall be accompanied by a certification report, including an accurate log of the soil boring, which thoroughly describes and depicts the location, elevations, material specifications, construction details, and soil conditions encountered in the boring for the well. A copy of the certification and certification report shall be kept on-site, and a second copy shall be submitted to the Executive Director. Required certification shall be in the following format, edited as appropriate, and shall specify the Compliance Plan Number as indicated:

"This is to certify that installation (or plugging and abandonment) of the following facility components authorized or required by TCEQ Compliance Plan No. (Insert CP number) has been completed, and that construction (or plugging) of said components has been performed in accordance with and in compliance with the design and construction specifications of this Compliance Plan No, (Insert CP number):" (Add description of facility components with reference to applicable Compliance Plan provisions).

20. Wells may be replaced at any time the Permittee or Executive Director determines that the well integrity or materials of construction or well placement no longer enable the well to yield samples representative of groundwater quality.

21. The Permittee shall plug soil test borings and wells removed from service after issuance of the Compliance Plan with a cement/bentonite grout mixture so as to prevent the preferential migration of fluids in the area of the borehole. Certification of each plugging shall be reported in accordance with Provision 19 of CP Attachment C of this Compliance Plan. The plugging of wells shall be in accordance with 16 TAC Chapter 76 dealing with Well Drilling, Completion, Capping and Plugging.

COMPLIANCE PLAN ATTACHMENT C
SAMPLING AND ANALYSIS PLAN
Phillips 66 Borger Refinery

ID NO.: SWR 30111
COMPLIANCE PLAN NO.: CP-50078

Submitted to:
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

Submitted By:
Phillips 66 WRB Borger Refinery
Borger, Hutchinson County, Texas

January 2020

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

REVISION LOG

Rev.	Date	Description
0	**7/17/2011**	**Initial Issue**
1	**7/1/2017**	**Revision: update Tables 1 and 2 to match permit and compliance plan, to field duplicate frequency, clarify metals filtration**
2	**January 2020**	**Revision: update Tables 1, 2, and 4 to match permit and compliance plan; text edit in Section 5.4.2 to clarify filtration requirements**

1.0 Introduction

This Sampling and Analysis Plan (SAP) describes procedures to be implemented for the detection, compliance, and corrective action monitoring programs at the Phillips 66 WRB Borger Refinery (Facility) located in Borger, Hutchinson County, Texas. This SAP incorporates sampling and analysis requirements to support the detection monitoring program for the permitted units and the compliance monitoring or corrective action monitoring programs for the Facility Operations Area (FOA) and the units outside the FOA. The detection monitoring program requirements are described in the RCRA Part B Permit in Section VI and the compliance monitoring, corrective action monitoring, and Facility Operations Area (FOA) monitoring programs are described in Section XI of the RCRA Part B Permit (Compliance Plan). The SAP provides policies, project organization, objectives, functional activities, and quality assurance/quality control (QA/QC) measures intended to achieve the project goals associated with the Resource Conservation and Recovery Act (RCRA) Hazardous Waste Permit HW-50078 and Compliance Plan CP-50078. This SAP is prepared to conform to the requirements of 30 Texas Administrative Code (TAC) 335.165 and 40 Code of Federal Regulations (CFR) 270.30 and 270.31. This SAP was also prepared to conform to the requirements of the Texas Commission on Environmental Quality (TCEQ) *Quality Assurance Project Plan for Environmental Monitoring and Measurement Activities Relating to the Resource Conservation and Recovery Act (RCRA) and Underground Injection Control (UIC)*.

The objectives of the SAP are to ensure that:

- Field methods for detection monitoring are conducted consistent with the requirements of HW-50078 and the TCEQ Quality Assurance Project Plan (QAPP);
- Field methods for compliance and corrective action monitoring are conducted consistent with the TCEQ Texas Risk Reduction Program (TRRP) requirements;
- Consistent field methods are used for monitoring activities;
- Data generated during field monitoring are usable for their intended purpose; and
- Field activities are conducted safely and are compliant with both Facility and Remediation Management (RM) Health and Safety procedures.

Activities covered under this SAP include monitoring well sampling, surface water sampling; and sediment sampling.

1.1 Site Description

Phillips 66 Company (P66), Operator of the Borger Refinery in Borger, Texas, is permitted to manage, store, handle, and dispose of industrial hazardous and non-hazardous waste under the conditions of the RCRA Part B Permit HW-50078. The permit provisions include a Compliance Plan (CP-50078) for compliance monitoring and corrective action monitoring at solid waste management units (SWMUs) and areas of concern (AOCs). The Facility is located on approximately 6,400 acres along State Highway Spur 119, approximately 2 miles north of the City of Borger, Hutchinson County, Texas. Figures within the RCRA Part B Permit and Compliance Plan show the location of the Facility, the hazardous waste management units, SWMUs and AOCs.

1.2 Project Description

Detection monitoring samples are collected semiannually from hazardous waste units listed in the RCRA Part B Permit Tables VI.B.3.b. Samples are analyzed for the parameters in RCRA Part B Permit Table VI.B.3.c. Sample Table 1 summarizes the parameters for the detection monitoring program.

Waste units and areas subject to compliance and corrective action monitoring are listed in Compliance Plan Table 1 (Waste Management Units and Areas Subject to Groundwater Corrective Action and Compliance Monitoring). Corrective action monitoring samples are collected from the locations specified in Compliance Plan Table V (Designation of Wells by Function) and are analyzed for the chemicals of concern (COCs) specified in Compliance Plan Tables III (Table of Detected Hazardous and Solid Waste Constituents and the Groundwater Protection Standard) and IIIA (Table of Indicator Parameters and the Groundwater Protection Standard). Compliance monitoring samples are collected from the locations specified in Compliance Plan Table V (Designation of Wells by Function) and are analyzed for the COCs specified in Compliance Plan Table IV (Compliance Monitoring Program Table of Hazardous and Solid Waste Constituents and Quantitation Limits) and IVA (Compliance Monitoring Program Table of Detected Hazardous Constituents and the Groundwater Protection Standard). SAP Table 2 summarizes the COCs for the compliance and corrective action monitoring programs.

2.0 Health and Safety Plan

The monitoring programs will be conducted in a manner consistent with Facility and RM health and safety procedures and applicable Occupational Safety and Health Administration (OSHA) regulations found in 29 CFR Part 1910.120. A Facility-specific Health and Safety Plan (HASP) will be developed by the Field Sampling Coordinator before starting field sampling activities. The HASP also serves as the Field Emergency Contingency Plan.

Activities to be managed under the HASP include but are not limited to:

- Safety training and monitoring requirements (especially hazard identification, control, and elimination;
- Clearing underground utilities;
- Obtaining necessary work permits from Facility personnel;
- Selecting personal protective equipment (PPE);
- Collecting groundwater samples from monitoring wells;
- Collecting surface water and sediment samples from streams;
- Installing monitoring wells;
- Collecting soil samples during monitoring well or boring installation;
- Decontaminating equipment; and
- Staging of investigation derived wastes (IDW); and
- Surveying field sampling locations.

Subcontractors working under the direction of the Field Sampling Coordinator will be required to abide by the contents of the HASP.

3.0 Sampling Location and Frequency

Pursuant to the provisions outlined in the RCRA Part B Permit and Compliance Plan, Point of Compliance (POC) wells, FOA Boundary of Compliance (BOC) wells, Attenuation Monitoring Point (AMP) wells, and Point of Exposure (POE) locations (including groundwater, surface water, and sediment locations) will be sampled and analyzed at the frequency listed in Table 3 for the parameters identified in Table VI.B.3.c of the RCRA Part B Permit and CP Tables III, IIIA, IV, and IVA. Specific sampling locations for the detection monitoring program are denoted in RCRA Part B Permit Table VI.B.3.b and Figures B.V.A-5 through B.V.A-7 of the RCRA Part B Permit. Specific sampling locations for the compliance and corrective action monitoring programs are listed in Compliance Plan Table V.

The detection monitoring program includes POC wells and background wells. POC wells are placed at the vertical surface located at the hydraulically downgradient limit of the waste management unit that extends down into the uppermost aquifer. If a confirmed statistically significant increase (SSI) over background for any parameter is determined in a detection monitoring POC well, then the waste management unit is placed into compliance monitoring and possibly a corrective action program. Background wells are located hydraulically upgradient of the waste management unit.

The compliance and corrective action monitoring program includes the following sample locations:

- POC Wells – These wells are placed at the vertical surface located at the hydraulically downgradient limit of the waste management unit that extends down into the uppermost aquifer.

- FOA BOC Wells – These wells are placed at the FOA boundary and are used to monitor COC concentrations in groundwater. COCs detected in the groundwater are compared to the FOA BOC groundwater protection standards in Compliance Plan Table III or IIIA.

- AMP Wells – These wells are used within the FOA and within a Plume Management Zone (PMZ). AMP wells are used as "early warning" monitoring points to detect the presence and concentration of COCs in the groundwater upgradient of the FOA BOC wells. Within the PMZ, AMP wells verify conformance with the PMZ response objective (exceedance of the critical PCL at the PMZ POE). COCs detected in the groundwater are compared with the calculated Attenuation Action Levels (AALs) to determine if additional response actions are needed.

- POE Locations – These are located at the nearest downgradient location associated with a potential receptor. POE locations are used to verify that receptors are not exposed to COCs that exceed risk-based exposure levels (RBELs). POE locations can also include surface water and sediment locations. COCs detected in the groundwater, surface water or sediment are compared with calculated RBELs to determine if response actions are needed; and

- Corrective Action Observation (CAO) Wells – These wells or piezometers are used to monitor groundwater elevations, groundwater gradients, and, if necessary, NAPL thickness.

- First –flush Storm Water Samples – These locations are used to determine if any COCs present in the soil above ephemeral drainages might enter the major drainage systems (Patton Creek or Dixon Creek) at concentrations exceeding applicable water quality criteria during storm events.

Table 3 summarizes the sampling frequency for the various monitoring programs.

4.0 Analytes and Chemicals of Concern

Parameters for detection monitoring locations are listed in Table VI.B.3.c of the RCRA Permit Part B. Compliance and corrective action monitoring COCs are listed in Compliance Plan Tables III, IIIA, IV, and IVA. Table 1 summarize the parameters and analytical methods for the detection monitoring program.

Table 2 summarizes the COCs and analytical methods for the compliance and corrective action monitoring programs. The list of COCs was developed by reviewing the following:

- Current and historical Facility process operations;
- A list of standard chemicals associated with refinery operations; and
- Groundwater monitoring results from sampling associated with compliance monitoring, corrective action monitoring, RCRA facility investigations, and FOA investigations.

5.0 Field Methods

This section describes the field methods to be implemented during the monitoring programs. To reduce the potential for cross-contamination, water level measurements, purging, and sampling begin at the well location with the lowest historical concentrations and proceed systematically to the monitoring wells with the highest historical concentrations. Standard operating procedures (SOPs) for field methods implemented during the monitoring program are maintained at the Facility.

At a minimum, PPE worn during all purging and sampling activities will include a hard hat with goggle attached, disposable powder-less vinyl or latex gloves and safety glasses. A new pair of gloves will be worn at each well. The gloves will also be changed if they become cut, torn, or soiled. Refer to the HASP for additional PPE to be worn during sampling procedures.

5.1 Well Inspection

Maintenance inspections are conducted during routine semiannual monitoring events and results are noted on the field sampling forms. Maintenance or repair needs identified during the inspections are addressed as soon as practicable. Maintenance inspections evaluate:

- legibility of well identification numbers;
- presence of visible damage to the well above ground (i.e., outer/inner casing stickup, concrete surface seal, padlock, and guard posts);
- security of cap and monitoring well;
- damage to dedicated well pump components (i.e., tubing, screens, and impellers);
- silt accumulation in well screen based on total well depth measurements; and
- specified location on the top of the well casing to ensure consistent gauging and elevation data.

Any significant silt build-up (greater than 20% of the well screen) is removed by well redevelopment. Well and pump maintenance activities are documented. Wells are resurveyed whenever evidence of heaving, settling, damage or other disturbance that affects the elevation reference measurements is observed. The reporting and, as appropriate, the repair or replacement of damaged wells is in accordance with Compliance Plan Attachment B (Well Design and Construction Specifications).

5.2 Groundwater and NAPL Measurements

The static groundwater elevation, and if present, the thickness of any light non-aqueous phase liquids (LNAPLs) at each monitoring well, is measured and recorded on the field sheets during every sampling event prior to well purging/sample collection. Measurements are consistently recorded from the notch or marked location on the well casing. Dense non-aqueous phase liquids (DNAPL) are not expected given the chemical characteristics of the waste materials. The groundwater elevations and LNAPL thickness are calculated by measuring the depth to LNAPL and the depth to groundwater from a permanently marked and surveyed location on the top of the riser or inner well casing. Measurements are made to the same surveyed reference point at each well for all sampling events. Meter readings are made to 0.01 foot accuracy.

Groundwater and NAPL elevations can be determined with dedicated drawdown meters, static sensing probes, or phase interface probe. Non-dedicated, downhole measurement tools are decontaminated prior to initial use, prior to use at each well location, and after completion of the daily gauging event. Decontamination procedures are presented in Section 5.8.

5.3 Well Purging

Well purging is required to ensure that the water samples collected are representative of the in-situ water present in the aquifer and not stagnant casing water within the well. Where practicable, purging and sampling is accomplished using low-flow groundwater sampling techniques. This technique provides better sample reproducibility over multiple sample events when groundwater conditions are stable through time and can result in more representative sample concentrations.

Well purging utilizes dedicated pumps, including bladder or electrical submersible pumps or portable, non-dedicated equipment such as electrical submersible or peristaltic pumps. The pump must be easily adjustable and reliable at the low flow rates. Bailers and other types of grab samplers are not suitable for low-flow sampling.

5.3.1 Low Flow Approach

Low-flow purging is conducted using a pump, tubing, and an in-line flow-through cell capable of monitoring stabilization parameters in accordance with the following procedures:

1. The portable (non-dedicated) pumps and in-line flow-through cell is decontaminated prior to use at each well;
2. If the well does not have a dedicated pump and tubing, then tubing is replaced prior to use at each well. Dedicated tubing is marked or fixed in position adjacent to the top of casing to allow for accurate placement over multiple sample events;
3. The inlet of the pump is carefully lowered to approximately at the mid-point of the screened interval of each well. Care is taken to minimize re-suspension of solids at the bottom of the well;
4. The pump flow rate is adjusted to remove groundwater at a recommended pumping rate of 0.1 to 0.5 liter per rate, or at a sufficiently low rate to ensure that drawdown in the well is less than 0.1 meter (0.33 feet) relative to the static water level;
5. In-line flow-through cells and water quality meters are utilized to monitor, at a minimum, pH, temperature, specific conductivity, temperature, dissolved oxygen (DO), turbidity, and oxidation-reduction potential (ORP). Water quality measurements are taken every three to five minutes;
6. Purging is complete after parameters have stabilized for three successive readings. These three successive readings should be within the following ranges:
    a. $\pm$ 0.1 unit for pH;
    b. $\pm$ 1°C for temperature; [alternative $\pm$ 3%]
    c. $\pm$5% for specific conductivity;
    d. $\pm$0.3 mg/L for DO; and
    e. $\pm$10% for turbidity (with a goal of < 10 nephelometric turbidity units [NTUs]).

7. If field parameters have not stabilized after three consecutive readings, measurements are continued at three minute intervals up to a maximum of five successive readings. If, after five successive readings, the parameters have not stabilized, an entry is made in the field logbook indicating that the sampling will be conducted without stabilized parameters.

8. Stabilized readings indicate that stagnant water from the well has been removed and the sample will be representative of groundwater in the aquifer. Values for the above parameters are recorded on the Field Data Sheet (Figure 1).

9. Purge water is contained in labeled and sealed Department of Transportation (DOT)-approved containers until proper disposal can be coordinated with the Facility.

5.3.2 Micro-Purge Approach

Micro-purge sampling may be employed for low yield wells. This approach requires removal of the smallest possible purge volume prior to sampling, generally limited to the volume of the sampling system. The sampling system volume is reduced by using very small diameter tubing and the smallest possible pump chamber volume. After removing this combined volume, samples are taken from the subsequent water pumped from the well. Since micro-purge sampling requires the minimum possible disturbance to the water column and surrounding formation, dedicated sampling systems are required for this approach.

The pumping rates used for micro-purge sampling are lower than for low-flow purging, generally 100 ml/minute or less. Drawdown is expected, since it cannot be avoided. It is still advisable to pump at the lowest possible rate to limit drawdown to the minimum possible. As with low-flow/low-stress techniques, the water level in the well should not be lowered below the top of the screen if possible.

Monitoring indicator parameters for stability is not part of this approach, since the intention is not to purge until stabilization of these measurements. However, pumping through a flow cell is still the best way to get field measurements prior to sampling. Where the total volume of water in the well is very small, field measurements can be accomplished with a very small volume flow cell.

5.4 Well Sampling

Groundwater samples are collected from each well for the analysis of parameters identified in the RCRA Permit B Table VI.B.3.c and COCs identified in Compliance Plan Tables III, IIIA, IV or IVA. Sample containers and applicable preservatives are supplied by the analytical laboratory and met the 40 CFR Part 136.3 Table II (Required Containers, Preservation Techniques, and Holding Times) requirements. Table 4 summarizes the applicable containers, preservatives, and holding times for the parameters and COCs in the Facility monitoring programs.

Samples are collected immediately after purging. Immediately before samples are collected, the pump tubing is disconnected from the in-line flow-through cell and the flow rate is adjusted to a range that is optimal for sample collection but at or below that used for purging. The hose should not be placed inside the containers or allowed to encounter the sample containers.

To minimize aeration, samples for volatile organic compounds (VOCs) should be collected at the lower rates (i.e., less than 0.25 L/min). The pump should produce a thin, continuous stream of water, and the water stream should be allowed to flow down the inner wall of the 40-mL volatile organic analysis (VOA) vial to minimize air bubble formation. Each container should be filled to a positive meniscus and then sealed with a Teflon-lined cap furnished by laboratory. Care should be taken during the capping of the VOA vial to avoid trapping any headspace or air bubbles.

5.4.1 Sampling Order

VOC samples are always the collected first during groundwater sampling events. Once VOC samples have been collected, other constituents can be collected at a higher pumping rate, not to exceed the pumping rate at field parameter stabilization, to reduce sampling time. The rate should be controlled to keep drawdown in the well within the specified limits (i.e., <0.1 m or 0.33 ft.). The container filling order is as follows:

1. VOCs;
2. Semivolatile organic compounds (SVOCs) including base/neutral acids, pesticides, total petroleum hydrocarbons (TPH);
3. Metals, total;
4. Anions/cations (such as fluoride, cyanide, sulfide)
5. Nutrients (NH_3, NO_3, NO_2, SO_4);
6. General (pH, alkalinity, total suspended solids, total dissolved solids); and
7. Metals, dissolved (0.45-micron filtered samples).

5.4.2 Filtration

Filtration of aqueous samples is required for the determination of dissolved metals in surface water. Two samples will be collected for surface water: total metals (unfiltered) and dissolved metals (0.45-micron filter). Filtration is also required for groundwater samples collected from monitoring wells where the concentration limit is based on an ecological PCL. Note that two samples will be collected from FOA POE, BOC and POC wells for total metals (unfiltered) and dissolved metals (0.45-micron filter), where the concentration limit is based on an ecological PCL.

Dissolved metals samples are collected last when collecting multiple sample jars for a sample location. Filtration can be completed in the field or in the laboratory. Field filtration utilizes a single-use (disposable) in-line filter cartridge attached directly to the pump discharge line. The filtrate is collected in a separate nitric acid preserved container from the total metals sample. Note that this sample container must be clearly labeled ‘dissolved metals’ to eliminate the possibility of misinterpreting the data. Samples for laboratory filtration are collected in a separate unpreserved container. This sample container must be clearly labeled for ‘laboratory filtration’ and the requirement for laboratory filtration noted on the chain-of-custody (C-O-C):

Since the detection and compliance monitoring programs are not based on ecological PCLs, samples for these programs are not filtered unless the turbidity is greater than 10 NTU. In this case the 10-micron filter is used.

Generally, groundwater samples for total metals analyses should not be filtered. However, if the turbidity of the groundwater sample exceeds 10 NTU, then filtering with a 10.0-micron filter may be appropriate to prepare a soluble metals fraction. Filtration should be completed in the field. Field filtration utilizes a single-use (disposable) in-line filter cartridge attached directly to the pump discharge line.

Field filtration for dissolved metals or soluble metals is recorded on the field sampling forms, including the filter supplier, filter size, and batch number (if available).

5.5 Surface Water Sampling

Surface water samples can be collected using one of four methods: direct sampling with container, Kemmerer bottle, dip sampler or pump. The preferred collection technique for surface water samples at the Facility is direct sampling with a container. This method will allow for the collection of representative samples from a shallow water column. However, if site conditions change, an alternate method for collecting the surface water samples in deeper water are a dip sampler, Kemmerer bottle or pump. Sample collection order is the same as specified for the collection of groundwater samples. Surface water samples for the analysis of dissolved metals will be either field filtered or laboratory filtered using a 0.45-micron filter. The sections below briefly describe the procedures for each technique. Decontamination procedures are described in Section 5.7.

5.5.1 First-Flush Storm Water Sampling

The first-flush storm water sampling method is used to collect storm water samples from normally dry (i.e., ephemeral) drainage features. One of two methods for collection of storm water samples may be used. The preferred method is manual collection of storm water runoff samples (see Section 5.5.2 [Direct Sampling]). The second method is the use of embedded sampling containers in the dry drainages that allow for passive collection of the FOA monitoring samples. An example embedded sampling container can be found at http://www.benmeadows.com/Nalgene-Stormwater-Samplers_31226903. This method is not intended or expected to accurately measure VOOOC concentrations but is expected to meet project objectives for SVOCs and metals.

The first-flush storm water samples using embedded sampling containers are collected directly into the sample bottle contained within the reloadable sample container. The reloadable sample container is permanently installed in the drainage, with the intake slots approximately 0.5-inches above the drainage bed. Two samplers, an inorganic analytes sampler and an organic analytes sampler, are required at each location. The sample containers are unpreserved because the sample collection bottles may remain in a drainage channel for an extended period prior to a rainfall event, which is likely to cause deterioration of the preservatives in the interim. As soon as possible after a rainfall event, the samplers are checked, and if sufficient volume is available in the sample bottles for analyses, the bottles are removed, preservative added, and the samples shipped to the analytical laboratory. The sample container is reloaded with new sample bottles. If insufficient volume is available, the sample bottles are removed, discarded, and the sample container is reloaded with new sample bottles.

5.5.2 Direct Sampling

The direct method may be utilized to collect water samples from the surface directly into a disposable glass container or directly into the sample bottle (if the sample bottle does not contain preservative). This method may not be used when contact with high concentrations of contaminants is a concern. Adequate protective clothing and safe procedures to access the sampling station should be used. Pre-preserved sample bottles must not be used because the collection method will dilute the concentration of preservative necessary for proper sample preservation. Samples must be collected under the water surface while pointing open end of the sample container upstream; also, the container must be located upstream of the sample collector. Disturbing the sediment must be avoided. Water must then be transferred to a pre-preserved sample container as applicable for the sample analyses. The sampling container is replaced between each sample location.

5.5.3 Dip Sampler

The sampler is a wide-mouth container of glass or other inert material attached to an extension pole. The technique is suitable for collecting surface water samples from a structure such as a berm, bridge or pier.

A clean, disposable container is attached to the extension device and the sample is collected by dipping the sampler into the substance. Do not use the pre-preserved sample bottles to collect the sample since that may dilute the concentration of preservative necessary for proper sample preservation. Transfer the water to a pre-preserved sample container as applicable for the sample analyses. The dip sampler should be decontaminated between uses (Section 5.8), if a bottle is used with the dip sampler, it should be replaced between each sample location.

5.5.4 Pump

A peristaltic pump may be used in most situations where site access is from a boat or samples from a certain depth are required. In addition, a peristaltic pump is required for field filtration for dissolved metals. The pump should produce a thin, continuous stream of water, and the water stream should be allowed to flow down the inner wall containers to minimize turbulence and agitation. The hose should not be placed inside the containers or allowed to encounter the sample containers. The pump should be decontaminated (Section 5.8) and the tubing replaced between each sample location.

5.5.5 Kemmerer Bottle

A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. The sampling device is set so that water passes through the device. The Kemmerer sampling device is lowered to a pre-determined depth and the sampling device is closed at that depth to collect a sample. After retrieval, the first 10 to 20 mL of water is discharged to clear potential contamination and the remaining water is transferred to suitable sample containers. The Kemmerer bottle should be decontaminated between each use (Section 5.8).

5.6 Sediment Sampling

Sediment samples can be collected using four techniques: trowel, bucket auger, hand dredge or push core. The preferred collection technique for sediment samples at the Facility is a trowel. This method will allow for the collection of representative sediment samples under a shallow water column. However, if site conditions change, other sample collection techniques, such as a push core, bucket auger, or dredge device may be utilized. Sample collection order is the same as specified for the collection of groundwater samples. The sections below describe the sampling procedures and the homogenization procedures for non-VOC analyses. Decontamination procedures are described in Section 5.8.

5.6.1 Trowel

Tools such as spades, shovels, trowels, and scoops can be used to collect surface sediment below the shallow aqueous layer. Although this method can be used to collect both consolidated and unconsolidated sediment, it is limited somewhat by the depth and movement of the water layer. Deep and rapidly flowing water render this method less accurate than other methods. However, representative samples can be collected with this procedure in shallow sluggish water provided care is demonstrated by the sampling team. A stainless steel or plastic sampling implement will suffice. Care should be exercised to avoid the use of devices that have been painted or are plated with chrome or other materials; plating is particularly common with garden trowels.

Non-dedicated sampling equipment is decontaminated prior to sample collection (Section 5.8). Sediment is transferred directly from the sampling device to a labeled sample or homogenization container(s) of appropriate size and construction for the analyses requested. Surface water should be decanted from the sample or homogenization container; the fine sediment fraction must be retained during this procedure. The homogenization procedure should not be used for volatile organics; in this case, sediment, or multiple grabs of sediment, should be transferred directly from the sample collection device or homogenization container to the sample container.

5.6.2 Bucket Auger

A system consisting of a bucket auger or tube auger, a series of extensions, and a "T" handle can be used to collect surface sediment from beneath a shallow aqueous layer. The use of additional extensions in conjunction with a bucket auger can increase the depth of water from which sediment can be collected from 24 inches to 10 feet or more, however, water clarity must be high enough to permit the sampler to directly observe the sampling operation. Sample handling and manipulation increases in difficulty with increasing depth of water and plasticity of sediment. For deep samples, the bucket auger is used to bore a hole to the upper range of the desired sampling depth and then withdrawn. The tube auger is then lowered down the borehole, and driven into the sediment to the lower range of the desired sampling depth. Alternatively the tube auger may be used alone and the desired interval may be extracted from the tube.

Non-dedicated sample equipment is decontaminated prior to sample collection (Section 5.8). Sediment is transferred directly from the sampling device to a labeled sample or homogenization container(s) of appropriate size and construction for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants. After collection of the VOC sample aliquot, the homogenization procedure should be used for the remaining fractions.

5.6.3 Hand Dredges

A remotely activated device (dredge) and a deployment system can be used to collect the top layer of sediment. This technique consists of lowering a sampling device (dredge) to the surface of the sediment by use of a rope, cable, or extended handle. When the mechanism is activated the device entraps sediment in spring-loaded or lever-operated jaws. An Ekman dredge is a lightweight sediment-sampling device with spring activated jaws. It is used to collect moderately consolidated, fine textured sediment. A Ponar dredge is a heavyweight sediment sampling device with weighted jaws that are lever or spring activated. It is used to collect consolidated fine to coarse textured sediment.

Non-dedicated sample equipment is decontaminated prior to sample collection (Section 5.8). Sediment is transferred directly from the sampling device to a labeled sample or homogenization container(s) of appropriate size and construction for the analyses requested. VOC samples must be collected directly from the dredge before homogenization to minimize volatilization of contaminants. After collection of the VOC sample aliquot, the homogenization procedure should be used for the remaining fractions.

5.6.4 Push Core

A tube sampler, consisting of an acetate liner, eggshell check valve, nosecone, extensions, and "T" handle, or drivehead can be used to collect a subsurface sediment from beneath a shallow aqueous layer. The use of additional extensions can increase the depth of water from which sediment can be collected from 24 inches to 10 feet or more. This sampler may be used with either a drive hammer for firm sediment, or a "T" handle for soft sediment. However, sample handling and manipulation increases in difficulty with increasing depth of water. A disadvantage of coring devices is that a relatively small surface area and sample size is obtained often necessitating repetitive sampling in order to obtain the required amount of sample. This method is advantageous in sampling sediments for trace organic compounds or metals.

Non-dedicated sampling equipment is decontaminated prior to sample collection (Section 5.8). Sediment is transferred directly from the sampling device to a labeled sample or homogenization container(s) of appropriate size and construction for the analyses requested. VOC samples must be collected directly from the acetate liner before homogenization to minimize volatilization of contaminants. After collection of the VOC sample aliquot, the homogenization procedure should be used for the remaining fractions.

5.6.5 Homogenization Procedure

After the VOC samples are collected directly from the sampling device, the remaining sediment is homogenized to obtain a representative sediment sample. The sediment is transferred from the sample device with a decontaminated stainless steel spoon or equivalent into a decontaminated stainless steel or aluminum bowl. The sample is mixed and then aliquots are transferred with a stainless steel spoon or equivalent in the appropriate sample containers.

5.7 Decontamination Procedures

Decontamination of all non-disposable sampling equipment is crucial to prevent potential cross-contamination of both the samples as well as the sampling sites. Each piece of non-dedicated equipment will be cleaned prior to initial use, at each sample location, and at the end of the day.

The usual procedure to be utilized for general equipment decontamination will include a non-ionic metal- and phosphorus-free laboratory-grade detergent and water solution, thorough scrubbing interior and exterior surfaces with a suitably sized brush followed by triple-rinsing with tap water and triple rinsing with deionized water. Additional decontamination steps may be utilized as needed to minimize cross-contamination at the low level (parts per billion or lower) reporting limits. When the equipment has been dried completely, it will be stored in protective casing or aluminum foil, if it will not be used immediately. Adequate decontamination is demonstrated by collecting equipment blanks from the sampling equipment.

5.8 Sample Handling

Sample labels must be checked for completeness and legibility. Containers must be clean and dry when packed for shipping. Chemical preservation requirements are listed in Table 4 of the SAP. Sample storage temperature should be maintained at $<6^{o}$ C from the time the sample is collected. Proper temperature must be maintained in sample storage coolers both in the field, in storage and during shipment to the analytical laboratory. This is best accomplished by ensuring that there is a sufficient supply of ice during both sample collection and shipment. Ice requires the use of sealed plastic bags to contain the melt water. After sample collection is completed, the samples should be securely packed in the shipment coolers.

5.9 Management of Investigative-Derived Waste

Investigation derived waste (IDW) includes: personnel protective equipment (PPE) (e.g., gloves, respirator canisters, or disposable coveralls, disposable sampling equipment (e.g., bailers, rope or twine, or plastic sheeting), groundwater from well development or purging, and decontamination fluids. Liquid and solid IDW is containerized and disposed of as required by the Refinery.

6.0 Documentation and Recordkeeping

This section describes sample naming conventions and field documentation requirements. To minimize bias in the laboratory, field QC samples are submitted to the laboratory as blind samples using the identification codes described below.

6.1 Sample Naming Convention

Example sample IDs for use in this project are as follow:

Monitor Wells

1909/SDP-MW02-071711	Sample collected from monitor well 1909/SDP-MW02 on July 17, 2011.

Sediment Locations

WSeepD4-SW-071711	Surface water (SW) location WSeepD4 on July 17, 2011.

Surface Water Locations

WSeepD4-SD-071711	Sediment (SD) location WSeepD4 on July 17, 2011.

Trip Blanks

TB-071711-01	First (01) trip blank (TB) sample collected on July 17, 2011 (071711).

Equipment Rinse Blank

EB-071711	Equipment blank (EB) sample collected on July 17, 2011 (071711). If needed, additional acronyms such as SW, MW, or SD can be added to differentiate multiple equipment blanks.

Field Duplicate

1909/SDP-MW02D-071711	Field duplicate of monitor well sample collected on July 17, 2011.

6.2 Sample Documentation

The paperwork required for sampling documentation and informational purposes includes the field data sheets, chain of custody (C-O-C) forms, sample labels, custody seals, and split sample acknowledgment/receipt forms as described below.

6.2.1 Field Data Sheets

The field data sheets are both a reference source of essential sampling data as well as a written historical record of pertinent field-generated data and information. The field data sheets are constructed and organized in a standard format to assist field personnel. This serves to reduce the potential for the omission of necessary documentation and performance of procedures. A typical field data sheet is shown in Figure 1.

6.2.2 Chain-of-Custody Forms

Documentation of possession of analytical samples is required on the C-O-C form from the time of sample collection through sample delivery and check-in at the analytical laboratory. The C-O-C records will accompany each set of samples/coolers and will document each time samples change possession. A typical C-O-C form is shown on Figure 2. The C-O-C will also provide the details included on the sample bottles and any additional laboratory analysis and reporting requirements. At a minimum the C-O-C will contain:

- Site identification
- Sample identification (including sampling point);
- Date and time of sample collection;
- Sample type (e.g., groundwater, surface water, sediment);
- Analytical parameters;
- Number of containers;
- Preservatives;
- Signature of sample collector(s);
- Signature(s) of person(s) involved in chain of possession; and
- Inclusive dates and time of possession.

6.2.3 Sample Container Labels

Sample containers will be supplied by the analytical laboratory and will be consistent with 40 CFR 136.3 Table 2 (Required Containers, Preservation Techniques, and Holding Times) for the selected analytical methods. The sample container label is one of the first links in the paper chain that tracks the sample through the sampling and analytical process. Because proper identification of sample containers is necessary, legible, complete, and securely attached labels must be affixed to each sample container and remain legible and intact if wet.

A typical sample container label is shown in Figure 3. At a minimum, the label information will contain:

- Sample identification;
- Name or initials of collection party;
- Date and time of collection;
- Site and project identification (if space permits);
- Preservation technique and/or filtration (if space permits); and
- Parameters required for analysis.

6.2.4 Custody Seal

Custody seals are fastened to both the lid and side of the coolers to aid in detecting unauthorized opening of the coolers prior to arrival at the analytical laboratory receiving/check-in department. The seals should be positioned such that they must be broken when the sample shuttle is opened. The seals should include the signature of the person placing the seal and the date and time that the seal was placed. Seals are not required if the sample coolers are hand-delivered to the lab by the sampling team and the coolers do not leave the sight of the sampling team. A typical custody seal is shown in Figure 3.

6.2.5 Split Sample Acknowledgment/Receipt

If split samples are collected by a regulatory agency, a receipt or acknowledgment of samples collected should be completed and signed by both parties with each party retaining a copy. This receipt should include the sampling details such as date, time, well number, and personnel involved. This can be written and signed in the field data records of both sampling parties.

6.3 Sample Shipment Documentation

The bills of lading or air bills provided by the courier companies require general shipping information - including the shipper's name, address, telephone number, account number, as well as the recipient's name, address, and telephone number. Additional information includes the billing information and the delivery details such as overnight service, Saturday delivery, and cooler weight.

6.4 Sample Shipment

Sample coolers generally require overnight shipment to the analytical laboratory. The courier dispatcher should be made aware of the contents (liquids in glass containers) and also the potential thermal problems with either high or low temperature extremes.

Special cooler handling measures must be undertaken if either extremely high or low temperatures will be encountered during transit to the contact laboratory. High temperatures require that more ice packs be included inside each cooler to avoid exceeding the maximum 6^{o} C internal cooler temperature. Extremely low temperatures necessitate more insulation being added to the cooler(s) as well as the incomplete freezing of cold packs to keep samples from freezing and sample bottles from breaking. Weekend delivery service requires that both laboratory and courier personnel are notified of Saturday delivery service in advance. If ice is used, the ice will be double-bagged in zip-lock style bags.

7.0 Quality Assurance/Quality Control

The detection monitoring and compliance monitoring/corrective action monitoring programs require data of sufficient quality and quantity to define the extent of impacted groundwater, and make informed decisions to manage the associated issues.

7.1 Data Quality Objectives

The data quality objective for groundwater, surface water, and sediment samples is to obtain definitive data suitable for the assessment and evaluation of:

- Statistically significant data trends including, but not limited to statistically significant increases (SSIs) in the detection monitoring program parameters;
- The presence and extent of contamination in the environmental media;
- Compliance with groundwater protection standards; and
- Evaluation of remedial alternatives.

To meet these objectives, SW-846 analytical methods and data review procedures in accordance with USEPA and TCEQ protocols (30 TAC 350.54) are prescribed. Other approved and documented analytical methods from the USEPA, the American Society for Testing and Materials, other organizations nationally recognized as having scientifically valid methods by the TCEQ Executive Director, or a laboratory method that is completely documented in an appropriate SOP approved by the Executive Director may also be utilized.

This data is generated by a laboratory accredited by the State of Texas National Environmental Laboratory Accreditation Program (NELAP) for the parameters listed in Tables 1 and 2.

7.2 Containers, Preservatives, and Holding Times

Table 4 lists containers, preservatives, and holding times applicable for aqueous and solid samples. Dissolved metals samples should be preserved by the laboratory for 24-hours prior to acid digestion in order to solubilize the metals constituents.

Sampling containers are purchased precleaned and treated according to USEPA specifications. Note that sample containers should be filled to the preferred volume listed in Table 4. If sample volume is insufficient to collect the preferred volume, at least the minimum volume listed in Table 4 must be collected for the requested analysis. If only the minimum sample is collected, the lab may have insufficient sample volume in cases where a dilution or reanalysis is required, which may require a resampling event. The laboratory will supply coolers and bottles. The laboratory will supply preservatives listed in Table 4 in sample bottles.

7.3 Sampling Handling and Custody

Samples will be handled and C-O-Cs will be maintained as described previous sections. Sample holding time tracking begins with the collection of the sample and continues until analysis is complete. Holding times are specified in Table 4.

7.4 QA/QC for Sampling Procedures

The quality assurance (QA) objectives for measurement data include considerations of precision, bias, accuracy, representativeness, comparability, and completeness. Precision, bias, and accuracy are evaluated with duplicate and spiked samples. Representativeness is evaluated by blanks to identify trace sources of artificially introduced contamination. Comparability is obtained by consistency in the acquisition, handling, and analysis of samples. Details regarding sampling and analysis procedures are provided earlier in the SAP. The evaluation of QA objectives requires the collection of field quality control (QC) samples. During the course of monitoring activities, samples are collected in the field and analyzed by the laboratory for QA/QC purposes. The following QA/QC samples will be collected:

< Trip blanks;

< Equipment blanks;

< Field duplicates; and

< Extra volume for matrix spike/matrix spike duplicate samples.

QC samples are handled, preserved, and documented in the same manner as the original field samples.

7.4.1 Trip Blanks

Trip blanks are prepared prior to the sampling event by the analytical laboratory in the actual sample container using deionized water. Trip blanks are kept with the field samples throughout the sampling event. They are then packaged for shipment with the field samples and sent for analysis. Sample containers are not opened before they reach the laboratory. If multiple coolers of samples are required, VOC samples are placed in one cooler to minimize sample costs and simplify data review. Trip blanks are analyzed only for VOCs. Trip blanks are labeled as TB-date.

7.4.2 Equipment Blanks

Equipment blanks are defined as samples that are obtained by running deionized water over/through non-disposable, reusable sample collection equipment after it has been cleaned (i.e., rinse water will be poured from the bailer, pumped through the sample pump and tubing, or poured over the trowels). Deionized water is obtained from the laboratory or an equivalent from a commercially available source. These samples are used to determine if decontamination procedures were adequate. One equipment blank is collected each day sampling activities occur. Equipment blanks are collected for each matrix sampled. Equipment blanks are analyzed for metals, SVOC, and VOC analytes associated with the sampling event. Equipment blanks are not collected for dedicated or disposable (one use only) equipment. Equipment blanks are labeled as EB-date.

7.4.3 Field Duplicates

Field duplicate samples are two or more samples collected simultaneously or in immediate succession from the same location under identical conditions. One duplicate sample is collected for each batch of 10 or fewer field samples. The duplicate sample provides a measure of precision, or reproducibility of the sample collection process. Field duplicate samples are analyzed for metals, SVOC, and VOC analytes associated with the sampling event. Field duplicates are labeled as described in Section 6.1.

7.4.4 Matrix Spike/Matrix Spike Duplicate

Matrix spike/matrix spike duplicate (MS/MSD) samples are spiked and analyzed by the laboratory to facilitate identification of effects of the particular matrix of interest on analytical results, particularly biasing of results. Sufficient sample volume will be collected (triple the normal sample volume for aqueous samples - one volume each for the regular sample plus the MS and MSD samples) for at least one sample in each batch of 20 or fewer field samples so that MS/MSD samples can be prepared for analysis. MS/MSD samples are analyzed for the same parameters as the parameter sample. These are not labeled separately, but are denoted as “extra volume for MS/MSD” in the comments column.

7.5 QA/QC for Analytical Procedures

In addition to field samples collected for the evaluation of the QA/QC objectives, laboratory QA/QC samples are analyzed. The procedures and samples described in the following sections are implemented during analytical activities. Details regarding sampling and analysis procedures are provided earlier in the SAP. The following QA/QC samples will be analyzed by the laboratory:

< Trip blanks (supplied by laboratory);

< Equipment blanks (supplied by Facility);

< Field duplicates (supplied by Facility);

< Laboratory preparation blanks;

< Laboratory control samples (LCS) (and if applicable laboratory control sample duplicate [LCSD];

< MS/MSD samples (extra volume supplied by Facility); and

< Detectability check standards.

In addition to QC samples, sample specific quality control is implemented for organic analyses by evaluating surrogate recoveries and internal standard areas.

QC samples are prepared and documented in the same manner as field samples. Tables 6 through 9 summarize quality control requirements for each method used in the detection, compliance and corrective action monitoring programs.

7.5.1 Method Detection Limit, Method Quantitation Limit, and Sample Detection Limit

The method detection limit (MDL) is the defined in 40 CFR 136 as the minimum concentration of an analyte the laboratory would measure and report with 99% confidence that the analyte concentration is greater than zero. The MDL is determined for each analyte in a reagent matrix. The MDL can be determined using the procedures specified in 40 CFR Part 136, Appendix B (as amended), using reagent matrices that are both laboratory grade aqueous and solid materials. The MDL is verified through quarterly analyses of detectability check standards.

The method quantitation limit (MQL) is the lowest non-zero standard concentration in the laboratory’s initial calibration curve based on the laboratory’s standard operating procedures (SOPs) for initial sample mass or volume and the final mass or volume after preparation. Therefore, the MQL is method specific. Generally, the MQL is five to ten times higher than the MDL.

The sample detection limit (SDL) is the MDL adjusted to reflect sample-specific actions, such as dilution or change in aliquots for analysis and sample-specific characteristics, such as moisture content. Non-detected results are reported as less than the numeric value of the SDL. Concentrations greater than the SDL but less than the MQL are reported as estimated ("J") by the laboratory.

7.5.2 Quality Control Measures

In addition to the QC samples discussed for sampling procedures, laboratory QC samples include LCS, laboratory blanks, and MS/MSD samples. Surrogate recoveries and internal standard areas are used to evaluate the method performance for individual samples. Table 9 lists surrogates for organic analyses. LCS and MS/MSD will be spiked with all the COCs specified for the project.

Laboratories generate statistically-derived control limits in accordance with method or accreditation requirements to determine internal acceptability for LCS, MS/MSD and surrogate recoveries and LCS/LCSD and MS/MSD precision. These control limits are updated periodically and reflect the variety of samples analyzed by the laboratory. Table 9 lists acceptance criteria for contractor data review and Data Usability Summaries (DUS). These acceptance criteria are suitable for detection, compliance, and corrective action monitoring.

7.6 Instrument/Equipment Testing, Inspection, and Maintenance

The purpose of this element is to specify procedures used to verify that instruments and equipment are maintained in sound operating condition and are capable of acceptable performance. A proactive preventative maintenance program minimizes downtime and improves analytical performance.

7.6.1 Field Equipment

Acceptable performance for field equipment is defined as meeting the instrument performance and calibration requirements listed in Table 5. The field contractors shall have a preventative maintenance program in place to minimize the downtime of crucial sampling equipment due to unexpected component failure. Maintenance responsibilities are assigned to the Field Investigation Manager who shall establish maintenance procedures and schedules for each major equipment item. The responsibility may be delegated to field personnel, although the manager retains responsibility for ensuring adherence to the protocols and procedures.

Manufacturers' recommendations provide the primary basis for establishing maintenance schedules. In addition to a schedule for maintenance activities, the field contractors shall maintain an adequate inventory of spare parts that are subject to frequent failures, have a limited useful lifetime or cannot be obtained in a timely manner should failure occur. Maintenance and repair of field equipment shall be recorded in field notebooks. These records shall document the serial numbers of the equipment, the person performing the maintenance or repairs, the date of the repair, and the procedures used during the repair.

7.6.2 Laboratory Equipment

Acceptable performance for field equipment is defined as meeting the instrument performance and calibration requirements listed in Tables 6 through 8 and laboratory SOPs. The laboratory contractors shall have a preventative maintenance program in place to minimize the downtime of crucial analytical equipment due to unexpected component failure. Maintenance responsibilities are assigned to the Laboratory Manager who shall establish maintenance procedures and schedules for each major equipment item. The responsibility may be delegated to laboratory personnel, although the manager retains responsibility for ensuring adherence to the protocols and procedures.

Manufacturers' recommendations provide the primary basis for establishing maintenance schedules. In addition to a schedule for maintenance activities, the laboratory contractors shall maintain an adequate inventory of spare parts that are subject to frequent failures, have a limited useful lifetime or cannot be obtained in a timely manner should failure occur. Maintenance and repair of laboratory equipment shall be recorded in laboratory notebooks. These records shall document the serial numbers of the equipment, the person performing the maintenance or repairs, the date of the repair, and the procedures used during the repair.

7.7 Instrument Calibration and Frequency

The purpose of this element is to define calibration procedures that will be used to generate environmental measurements. Calibration frequency is specified in the field and laboratory SOPs. Calibration procedures utilize standards that are traceable to National Institute of Standards and Technology materials (NIST). Field equipment will be calibrated according to manufacturer's specifications prior to use in the field. Laboratory equipment will be calibrated and standardized prior to sample analysis. Specific requirements for calibration and standardization of analytical instruments are described in the field and laboratory SOPs. Instrument/equipment calibration and frequency must be consistent with the accreditation agency criteria.

8.0 Data Management

This element describes the laboratory deliverables, electronic data deliverables, and data review requirements.

8.1 Laboratory Deliverables for Detection Monitoring

The summary data package should be provided within the specified turnaround time. Each summary data package should contain the current version of Table D1.2 (Laboratory Data QA/QC Report Checklist) from the (TCEQ) *Quality Assurance Project Plan for Environmental Monitoring and Measurement Activities Relating to the Resource Conservation and Recovery Act (RCRA) and Underground Injection Control (UIC)*. The data package should also contain the following items:

- Completed C-O-C documentation;
- Sample identification cross-reference;
- Test reports for samples;
- Surrogate recoveries for organic parameters;
- Test reports or summary forms for laboratory blank samples;
- Test reports or summary forms for LCS (and LCSD, if applicable);
- Test reports or summary forms for MS/MSD;
- MQLs; and
- Other problems and anomalies.

Instrument printouts, laboratory notebook records, calibration, instrument performance records and other supporting data are not required as part of the summary data package. These supporting data are archived by the laboratory for a minimum of 5 years and made available by the laboratory upon request by TCEQ or the facility.

8.2 Laboratory Deliverables for Compliance and Corrective Action Monitoring

The summary data package should be provided within the specified turnaround time. Each summary data package should contain Laboratory Review Checklist(s) (LRC), any associated exception reports (ER), and the reportable data. LRCs and ERs should generally comply with the requirements of the TCEQ guidance document RG-366/TRRP-13 (*Review and Reporting of COC Concentration Data*). The data package should also contain the following items:

- Completed C-O-C documentation;
- Sample identification cross-reference;
- Test reports for samples;
- Surrogate recoveries for organic parameters;
- Test reports or summary forms for laboratory blank samples;

< Test reports or summary forms for LCS (and LCSD, if applicable)

< Test reports or summary forms for MS/MSD

< MQLs; and

< Other problems and anomalies.

Instrument printouts, laboratory notebook records, calibration, instrument performance records and other supporting data are not required as part of the summary data package. These supporting data are archived by the laboratory for a minimum of 5 years and made available by the laboratory upon request by TCEQ or the facility

8.2.1 Electronic Data Deliverables

Data is maintained for the project in an electronic database. The laboratory will submit electronic data deliverables in a format suitable for input into the project database. The electronic deliverable format will be specified by Phillips 66. Tables summarizing groundwater, surface water, and sediment data will be prepared from the database to minimize transcription errors. Data for input into statistical programs will also be derived from the database to minimize transcription errors.

8.3 Data Review

Data undergoes two reviews prior to submittal to the TCEQ in the monitoring reports. Data are initially reviewed by the laboratory to determine if it meets their quality control criteria. Deviations from the quality control criteria are documented by the laboratory in Table D1.2 for detection monitoring or in the LRCs/ERs for compliance or corrective action monitoring. After submittal of the data to Phillips 66, data are reviewed for usability and reporting in the specific project reports.

8.3.1 Laboratory Data Review

This element includes checking for data entry, transcription, calculation, reduction, and transformation errors. The laboratory analyst is responsible for the reduction of raw data and shall clearly identify any problems or anomalies that might affect the quality of the data. The analyst shall review 100 percent of the data and shall verify that data reduction protocols are correct. At least 10% of the data shall be reviewed independently by a senior analyst or by the supervisor of the laboratory analyst. Both the analyst and independent review shall include:

< Calibrations and calibration verifications;

< Instrument and system performance checks;

< Instrument calibrations;

< Blanks;

< LCS recoveries and precision (if LCSD analyzed);

< MS/MSD recoveries and precision;

- Duplicate sample precision (if applicable to the method);
- Compound identification and quantification;
- System monitoring or surrogate recoveries (if applicable to the method);
- Internal standard areas (if applicable to the method);
- Serial dilutions (if applicable to the method);
- Interference check sample results (if applicable to the method);
- Post-digestion spike recoveries (if applicable to the method); and
- Other problems and anomalies.

The laboratory QA section shall review the completed data packages and perform a reasonableness check review on the completed data packages. The QA section shall ensure that all deliverables are present, that qualifiers have been applied to the data, and that nonconformance and other issues have been addressed in the case narrative, Table D1.2 (Laboratory Data QA/QC Report Checklist), or laboratory review checklists (LRCs)/exception reports (ERs).

8.3.2 Data Verification for Detection Monitoring

The analytical data package is transmitted electronically to Phillips 66 or their contractor following completion of the laboratory review process described above. One hundred percent of the definitive data undergoes data verification. The specific measures evaluated during verification are specified below:

- Sample preservation and holding times;
- Instrument and system performance checks;
- Instrument calibrations;
- Blank contamination (laboratory method blanks and field-generated blanks);
- Accuracy (MS/MSD and LCS/LCSD recoveries);
- < Precision (field and laboratory duplicate results; MS/MSD results; LCS/LCSD results; total and dissolved metals results; dual column gas chromatographic results);
- System monitoring or surrogate recoveries (if applicable to method);
- C-O-C; and

- Table D1.2. (Laboratory Data QA/QC Report Checklist).

The data verification process is designed to evaluate the QC measures where rejection of data would most likely occur ensuring that the vast majority of cases resulting in data rejection would be identified. If the data verification process indicates that data should be rejected, then the affected monitoring well is resampled for the affected parameter(s).

8.3.3 Data Verification for Compliance and Corrective Action Monitoring

The analytical data package is transmitted electronically to Phillips 66 or their contractor following completion of the laboratory review process described above. Data validation/verification is completed following the requirements of the TCEQ guidance document *Review and Reporting of COC Concentration Data* (RG-366/TRRP-13) (TCEQ, 2010). One hundred percent of the definitive data undergoes data verification. The specific measures evaluated during verification are specified below:

- Sample preservation and holding times;
- Instrument and system performance checks;
- Instrument calibrations;
- Blank contamination (laboratory method blanks and field-generated blanks);
- Accuracy (MS/MSD and LCS/LCSD recoveries);
- Precision (field and laboratory duplicate results; MS/MSD results; LCS/LCSD results; total and dissolved metals results; dual column gas chromatographic results);
- System monitoring or surrogate recoveries (if applicable to method);
- C-O-C; and,
- LRCs/ERs.

Raw data for the field and QC samples are not evaluated during the data verification process; however, the data verification process is designed to evaluate the QC measures where rejection of data would most likely occur.

Data qualifiers and the protocols for evaluation of data usability are described in the RG-366/TRRP-13 guidance document *Review and Reporting of COC Concentration Data*. All data received from the laboratory is validated by means of a Data Usability Summary (DUS), which includes an examination of the following:

- Reportable data;
- LRC and associated ERs for the reportable and supporting data;

- Field notes and data associated with the sampling event(s); and
- Project objectives.

DUS are generated that includes a review of the deficiencies identified in the data, qualifiers identifying biases and unreliable data, assessments of field and laboratory performance, overall precision and accuracy, and representativeness and completeness of the data set. The DUS should provide the following information:

- Samples and analytical parameters reviewed;
- Field data reviewed;
- QC parameters reviewed;
- Review criteria for each QC parameter;
- Specific samples and constituents that did not meet criteria and applied qualifiers;
- Usability of the data; and
- Appropriateness of laboratory's demonstration that "available technology" was used to minimize the sample quantitation limit (SQL), as discussed in 30 TAC 350.51(d) and 350.79.

The DUS will be included in the compliance and corrective action reports submitted to the TCEQ.

8.3.4 Data Reporting

Reports summarizing the sampling, analytical and evaluation results are prepared and submitted to the TCEQ in accordance with the schedules listed in the RCRA Part B Permit and Compliance Plan. Data are presented in summary tables, figures and data analyses. Appendices containing field sampling sheets, laboratory reports, data usability summaries and statistical evaluations are also included in the reports.

9.0 References

ConocoPhillips. 2007. Facility Operations Area Application. Step 3. December 2007.

Texas Commission on Environmental Quality (TCEQ). 2010. Review and Reporting of COC Concentration Data. Regulatory Guidance RG-366/TRRP-13. Revised May 2010 (and subsequent updates).

Texas Commission on Environmental Quality (TCEQ). 2010. Quality Assurance Project Plan for Environmental Monitoring and Measurement Activities Relating to the Resource Conservation and Recovery Act (RCRA) and Underground Injection Control (UIC). Fiscal Year 2011 and subsequent updates.

Texas Natural Resource Conservation Commission (TNRCC). 2001. Total Petroleum Hydrocarbons, TNRCC Method 1005, Revision 03, July 1, 2001 (and subsequent updates).

U.S. Environmental Protection Agency (USEPA). 1983. Methods for the Chemical Analysis of Water and Wastes (EPA 600/4-79-020, March 1983), listed in Federal Register on March 12, 2007 (Volume 72, No. 14, pg 11200) and subsequent updates.

U.S. Environmental Protection Agency (USEPA). 1986. EPA Test Methods for Evaluating Solid Waste - Physical/Chemical Methods", EPA Publication SW-846, 3rd Edition, listed in the Federal Register on January 3, 2008 (Volume 73, No. 2, pg 486) and subsequent updates.

U.S. Environmental Protection Agency (USEPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance. Office of Resource Conservation and Recovery. EPA 530- 4-09-007. March 2009.

Table 1 Parameters List, Analytical Methods and Method Quantitation Limits (MQLs) for Detection Monitoring

Parameter	CAS RN[1]	Method[2]	Aqueous MQL (mg/L)
Chromium (tri)	7440-47-3	SW 6010C/6020A	0.010
Lead	7439-92-1	SW 6010C/6020A	0.005
2-Methylphenol (o-Cresol)	95-48-7	SW 8270D	0.010
4-Methylphenol (p-Cresol)	106-44-5	SW 8270D	0.010
Phenol	108-95-2	SW 8270D	0.010
Benzene	71-43-2	SW 8260B	0.001
Toluene	108-88-3	SW 8260B	0.001
Methanol	67-56-1	SW 8015C	1.0

[1] Chemical Abstracts Service Registry Number

[2] SW: USEPA 1986; MCAWW: USEPA 1983; Method references are updated if USEPA modifies the list of promulgated or approved methods.

MQL – Method Quantitation Limit.

NA – Not Available

Table 2 Chemicals of Concern List, Analytical Methods and Method Quantitation Limits (MQLs) for Compliance or Corrective Action Monitoring

Parameter	CAS RN[1]	Method[2]	Aqueous MQL (mg/L)	Solid MQL (mg/Kg)
Antimony	7440-36-0	SW 6010C/6020A	0.005	0.5
Arsenic	7440-38-2	SW 6010C/6020A	0.005	5
Barium	7440-39-3	SW 6010C/6020A	0.005	20
Beryllium	7440-41-7	SW 6010C/6020A	0.001	5
Cadmium	7440-43-9	SW 6010C/6020A	0.001	0.5
Chromium (tri)	7440-47-3	SW 6010C/6020A	0.005	5
Cobalt	7440-48-4	SW 6010C/6020A	0.005	5
Lead	7439-92-1	SW 6010C/6020A	0.005	5
Mercury	7439-97-6	SW 7470A	0.0002	0.013
Nickel	7440-02-0	SW 6010C/6020A	0.005	5
Selenium	7782-49-2	SW 6010C/6020A	0.005	0.5
Silver	7440-22-4	SW 6010C/6020A	0.005	0.5
Vanadium	7440-62-2	SW 6010C/6020A	0.005	5
Zinc	7440-66-6	SW 6010C/6020A	0.005	5
Cyanide	57-12-5	SW 9010/9014	0.02	NA
Fluoride	7681-49-4*	MCAWW 300.0	0.1	NA
Sulfide	7783-06-4**	SW 9030/9034/9215	1	NA
Ethylene glycol	107-21-1	SW 8015M	25	NA
Methanol	67-56-1	SW 8015C	1.0	NA
Dieldrin	60-57-1	SW 8081B	0.00005	NA
Endosulfan I (alpha)	959-98-8	SW 8081B	0.00005	NA
Isodrin	465-73-6	SW 8081B	0.00001	NA
Acetone	67-64-1	SW 8260B	0.005	0.010
Benzene	71-43-2	SW 8260B	0.001	0.005
Bromomethane	74-83-9	SW 8260B	0.001	0.005
2-Butanone (Methyl ethyl ketone)	78-93-3	SW 8260B	0.002	0.010
Carbon disulfide	75-15-0	SW 8260B	0.001	0.005
Chlorobenzene	108-90-7	SW 8260B	0.001	0.005
Chloroform	67-66-3	SW 8260B	0.001	0.005
Chloromethane	74-87-3	SW 8260B	0.001	0.005
1,4-Dichlorobenzene	106-46-7	SW 8260B	0.001	0.005
1,1-Dichloroethane	75-34-3	SW 8260B	0.001	0.005
1,2-Dichloroethane	107-06-2	SW 8260B	0.001	0.005
cis-1,2-Dichloroethene	156-59-2	SW 8260B	0.001	0.005
Ethylbenzene	100-41-4	SW 8260B	0.001	0.005
Ethyl ether	60-29-7	SW 8260B	0.010	NA
Iodomethane (Methyl iodide)	74-88-4	SW 8260B	0.001	NA

Table 2 Chemicals of Concern List, Analytical Methods and Method Quantitation Limits (MQLs) for Compliance or Corrective Action Monitoring

Parameter	CAS RN[1]	Method[2]	Aqueous MQL (mg/L)	Solid MQL (mg/Kg)
Methyl tert-butyl ether	1634-04-4	SW 8260B	0.001	0.005
Methylene chloride	75-09-2	SW 8260B	0.001	0.005
Naphthalene	91-20-3	SW 8260B	0.001	0.005
2-Nitropropane	76-46-9	SW 8260B	0.040	NA
Styrene	100-42-5	SW 8260B	0.001	0.005
Tetrachloroethene	127-18-4	SW 8260B	0.001	0.005
Toluene	108-88-3	SW 8260B	0.001	0.005
Trichloroethene	79-01-6	SW 8260B	0.001	0.005
1,2,4-Trimethylbenzene	95-63-6	SW 8260B	0.001	0.005
1,3,5-Trimethylbenzene	108-67-8	SW 8260B	0.001	0.005
Vinyl chloride	75-01-4	SW 8260B	0.001	0.005
Xylenes, total	1330-20-7	SW 8260B	0.005	0.015
Acenaphthene *[T]	83-32-9	SW 8270D	0.005	0.33
Acenaphthylene *[T]	208-96-8	SW 8270D	0.005	0.33
Acetophenone	98-86-2	SW 8270D	0.010	0.33
Anthracene *[T]	120-12-7	SW 8270D	0.0001	0.33
Benzenethiol (thiophenol)	108-98-5	SW 8270D	0.020	0.33
Benzo(a)anthracene *[T]	56-55-3	SW 8270D	0.0001	0.33
Benzo(b)fluoranthene *[T]	205-99-2	SW 8270D	0.0001	0.33
Benzo(k)fluoranthene *[T]	207-08-9	SW 8270D	0.0001	0.33
Benzo(ghi)perylene *[T]	191-24-2	SW 8270D	0.005	0.33
Benzo(a)pyrene *[T]	50-32-8	SW 8270D	0.0001	0.33
Benzyl alcohol	100-51-6	SW 8270D	0.005	NA
bis(2-Ethylhexyl)phthalate	117-81-7	SW 8270D	0.005	0.33
Chrysene *[T]	218-01-9	SW 8270D	0.005	0.33
Dibenz(a,h)anthracene *[T]	53-70-3	SW 8270D	0.0001	0.33
Dibenzofuran	132-64-9	SW 8270D	0.005	0.33
7,12-Dimethylbenz(a)anthracene	57-97-6	SW 8270D	0.010	0.33
2,4-Dimethylphenol	105-67-9	SW 8270D	0.010	NA
Fluoranthene *[T]	206-44-0	SW 8270D	0.005	0.33
Fluorene *[T]	86-73-7	SW 8270D	0.005	0.33
Indene	95-13-6	SW 8270D	0.010	0.33
Indeno(1,2,3-cd)pyrene *[T]	193-39-5	SW 8270D	0.0001	0.33
6-Methylchrysene	1705-85-7	SW 8270D	0.010	NA
1-Methylnaphthalene *[T]	90-12-0	SW 8270D	0.001	0.33
2-Methylnaphthalene *[T]	91-57-6	SW 8270D	0.001	0.33
3-Methylphenol (m-Cresol)	108-39-4	SW 8270D	0.010	0.33
2-Methylphenol (o-Cresol)	95-48-7	SW 8270D	0.010	0.33
4-Methylphenol (p-Cresol)	106-44-5	SW 8270D	0.010	0.33

Table 2 Chemicals of Concern List, Analytical Methods and Method Quantitation Limits (MQLs) for Compliance or Corrective Action Monitoring

Parameter	CAS RN[1]	Method[2]	Aqueous MQL (mg/L)	Solid MQL (mg/Kg)
n-Methylpyrrolidone	872-50-4	SW 8270D	0.010	NA
Naphthalene *[T]	91-20-3	SW 8270D	0.001	0.33
Phenanthrene *[T]	85-01-8	SW 8270D	0.005	0.33
Phenol	108-95-2	SW 8270D	0.010	0.33
Pyrene *[T]	129-00-0	SW 8270D	0.005	0.33
Pyridine	110-86-1	SW 8270D	0.010	NA
Sulfolane	126-33-0	SW 8270D	0.010	NA
Total PAHs	NA	SW 8270D	Calculated	Calculated
TPH (C06-C12)	NA	TX1005	1.0	20
TPH (>C12-C28)	NA	TX1005	1.0	20
TPH (>C28-C35)	NA	TX1005	1.0	20

This is a comprehensive parameter list for the units in compliance or corrective action monitoring. Analytes for each unit in corrective action monitoring are specified in Compliance Plan Tables III and IIIA. Analytes for each unit in compliance monitoring are specified in Compliance Plan Tables IV and IVA.

[1] Chemical Abstracts Service Registry Number

[2] SW: USEPA 1986 and subsequent updates; MCAWW: USEPA, 1983 and subsequent updates; TNRCC, 2001 and subsequent updates. Method references are updated if USEPA modifies the list of promulgated or approved methods.

MQL – Method Quantitation Limit.

NA – Not Available

*[T] – Total PAHs

* CAS RN for sodium fluoride

** CAS RN for hydrogen sulfide

Table 3 Sampling Frequency and Analytes

Sample Event	Medium	Locations	Frequency	Analyses
Detection Monitoring	Groundwater	RCRA Part B Permit Table B.VI.A.4	Semiannual	RCRA Part B Permit Table VI.B.3.c
Compliance Monitoring	Groundwater	Compliance Plan Table V	Semiannual	Compliance Plan Table IVA
Compliance Monitoring	Groundwater	Compliance Plan Table V	Annual	Compliance Plan Table IV
Corrective Action Monitoring (Litharge Impoundment, Old Caustic Pond, New Caustic Pond)	Groundwater	Compliance Plan Table V	Semiannual	Compliance Plan Table IIIA (see specific unit tables)
Corrective Action Monitoring (Area 2/West FOA Segment, Philtex/Sawtooth Canyon/East FOA Segment, Southeast Canyon, HP-7/South Cobles)	Groundwater Surface Water Sediment	Compliance Plan Table V	Semiannual	Compliance Plan Table IIIA (see specific unit tables)
Corrective Action Monitoring (West, Northwest, Northeast, East FOA Segments)	Groundwater Surface Water	Compliance Plan Table V	Semiannual	Compliance Plan Table IIIA (FOA)
Corrective Action Monitoring (West, Northwest, Northeast, East FOA Segments)	Sediment	Compliance Plan Table V	Every Five Years	Compliance Plan Table IIIA (FOA)
Corrective Action Monitoring (First-flush storm water)	Surface Water	FOA Step 3 Application Figures 3-2 to 3-5	Quarterly First Year	Compliance Plan Table III (FOA)
Corrective Action Monitoring (First-flush storm water)	Surface Water	FOA Step 3 Application Figures 3-2 to 3-5	Annually years two through four	Compliance Plan Table IIIA (FOA)

Table 4 Analytical Methods, Containers and Holding Times for Aqueous and Solid Samples

Parameter	Minimum Volume	Preferred Volume	Container[1]	Preservative	Holding Time
Fluoride	20 mL	60 mL	One 16-oz narrow-mouth HDPE bottle with Teflon®-lined cap	None	28 days from sample collection
Ethylene glycol / Methanol / RSK-175	40 mL	120 mL	Three 40-mL VOA vials with Teflon®-lined cap	Cool to < 6°C; Fill container completely	14 days from sample collection
Cyanide	500 mL	1000 mL	One 16-oz narrow-mouth HDPE bottle with Teflon®-lined cap	Cool to < 6°C; NaOH to pH > 12	14 days from sample collection
Sulfide	500 mL	1000 mL	One 16-oz narrow-mouth HDPE bottle with Teflon®-lined cap	Cool to < 6°C; Zinc acetate and sodium hydroxide to pH > 9	7 days from sample collection
Metals (Sediment)	5 grams	25 grams	One 8-oz wide-mouth glass jar with Teflon®-lined cap	Cool to < 6°C	Hg: 28 days from sample collection; 6 months for other metals
Metals (Dissolved)	250 mL	500 mL	One 250 ml narrow-mouth HDPE bottle with Teflon®-lined cap	Cool to < 6°C	Laboratory filter with 0.45 μm filter; Laboratory preserve HNO_3 to pH < 2; Hg - 28 days from sample collection; 6 months for other metals
Metals (Total)	250 mL	500 mL	One 250 ml narrow-mouth HDPE bottle with Teflon®-lined cap	Cool to < 6°C; HNO_3 to pH < 2	Hg - 28 days from sample collection; 6 months for other metals
Pesticides	500 mL	2000 mL	Two 32-oz narrow-mouth glass bottles with Teflon®-lined cap	Cool to < 6°C	Extract within 7 days of sample collection; analyze w/in 40 days of extraction
Semivolatiles (Aqueous)	500 mL	2000 mL	Two 250 ml narrow-mouth amber glass bottles with Teflon®-lined cap	Cool to < 6°C	Extract within 7 days of sample collection; analyze w/in 40 days of extraction
Semivolatiles (Sediment)	50 grams	200 grams	One 8-oz wide-mouth glass jar with Teflon®-lined cap	Cool to < 6°C	Extract within 14 days of sample collection; analyze within 40 days of extraction.
Total Petroleum Hydrocarbons	40 mL (i.e., one full VOA vial)	80 mL	Two 40-mL VOA vials with Teflon®-lined cap	Cool to < 6°C; HCl to pH <2. Fill container completely	Extract within 14 days from sample collection; analyze within 14 days of extraction
Volatiles (Liquids)	40 mL (i.e., one full VOA vial)	120 mL	Three 40-mL VOA vials with Teflon®-lined cap	Cool to < 6°C; HCl to pH <2. Fill container completely	Analyzed within 14 days from sample collection.

Table 4 Analytical Methods, Containers and Holding Times for Aqueous and Solid Samples

Parameter	Minimum Volume	Preferred Volume	Container[1]	Preservative	Holding Time
Volatiles (Sediments)	25 grams	25 grams	One 2-oz wide-mouth glass jar with Teflon®-lined cap; fill completely	Cool to < 6°C	Analyze within 14 days from sample collection.
Volatiles (Dry sediments or Soils)	3 x 5 grams	15 grams	Terracore© Sample Kit: 2-oz soil jar, 40-ml VOA vial methanol preserved, and 2 40-ml unpreserved VOA vials	Cool to < 6°C	Freeze samples within 48 hours of sample collection; analyze within 14 days of sample collection.
Triple the sample volume will be required for aqueous samples and volatiles soils samples designated as matrix spike/matrix spike duplicates HDPE – High density polyethylene VOA – Volatile Organic Analysis					

Table 5 Field Measurement Equipment Quality Control

Parameter	Method	Calibration	Reporting Limit
Dissolved oxygen (DO)	Field Meter	Per manufacturer's instructions	Not applicable
Oxidation-reduction potential (ORP)	Field Meter	Per manufacturer's instructions	Not applicable
Nitrate	HACH or Methods approved in 40 CFR 136.3 Table 1B (List of Approved Inorganic Test Procedures)	As stated in kit instructions or analytical methods	1 mg/L
Sulfate	HACH or Methods approved in 40 CFR 136.3 Table 1B (List of Approved Inorganic Test Procedures)	As stated in kit instructions or analytical methods	1 mg/L
Ferrous iron	HACH or Chemetrics Kits	As stated in kit instructions	1 mg/L

Table 6 Quality Control Performance Criteria for Inorganic Methods

Quality Control Parameter	Metals (Total and Dissolved)	Fluoride	Cyanide	Sulfide
Method	**SW 6010C / 6020A, 7470A / 7471B**	**SW 9056A / MCAWW 300.0**	**SW 9010 / 9014**	**SW 9030 / 9034**
MQL	See Table 1 or Table 2	See Table 1 or 2	See Table 2	See Table 2
Holding Times	See Table 4	See Table 4	See Table 4	See Table 4
Equipment Blank	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL
Field Duplicate	1 every 10 samples ≤30 RPD (aqueous) ≤50 RPD (solid)	1 every 10 samples ≤30 RPD (aqueous)	1 every 10 samples ≤30 RPD (aqueous)	1 every 10 samples ≤30 RPD (aqueous)
Trip Blank	NA	NA	NA	NA
Preparation (Laboratory) Blank	Daily per digestion batch (maximum 20 samples) per matrix < ± MQL	Daily per analysis batch (maximum 20 samples) per matrix < ± MQL	Daily per distillation batch (maximum 20 samples) per matrix <MQL	Daily per analysis batch (maximum 20 samples) <MQL
Initial Calibration and Calibration Verification and Interference Check Sample	Analyze blank and three concentrations for initial calibration – correlation coefficient > 0.995; analyze mid-level standard for calibration verification after every 10 samples - % Recovery 90-110; Interference check sample at beginning of run - % Recovery 80 -	Analyze blank and three concentrations for initial calibration – correlation coefficient > 0.995; analyze mid-level standard for calibration verification after every 10 samples - % Recovery 90-110	Analyze blank and six concentrations for initial calibration – correlation coefficient > 0.995; analyze mid-level distilled standard for calibration verification after every 10 samples - % Recovery 90-110	Analyze blank and three concentrations for initial calibration – correlation coefficient > 0.995; analyze mid-level standard for calibration verification after every 10 samples - % Recovery 90-110
Initial Calibration and Continuing Calibration Blank	Analyze immediately after each ICV and CCV	Analyze immediately after each ICV and CCV	NA	NA
Surrogate	NA	Every sample % Recovery (Table 9)	NA	NA
Matrix Spike	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix %Recovery (Table 9)	One per 20 samples per matrix %Recovery (Table 9)

Table 6 Quality Control Performance Criteria for Inorganic Methods

Quality Control Parameter	Metals (Total and Dissolved)	Fluoride	Cyanide	Sulfide
Matrix Spike Duplicate	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)
Internal Standard	NA	NA	NA	NA
Laboratory Control Sample	Daily per digestion batch per matrix %Recovery (Table 9)	Daily per analysis batch per matrix %Recovery (Table 9)	Daily per distillation batch per matrix %Recovery (Table 9)	Daily per analysis batch per matrix %Recovery (Table 9)
Identification Criteria	NA	Retention time window S/N ≥ 2.5	NA	NA
Confirmation Analysis	NA	NA	NA	NA
Method Detection Limit Verification	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits

Note: These are minimum requirements. Additional quality control measures may be necessary if alternative methods are chosen or methods are updated.

MQL – Method quantitation limit

NA – Not applicable
RPD – Relative percent difference

S/N – Signal/noise

Table 7 Quality Control Performance Criteria for Gas Chromatographic Methods

Quality Control Parameter	Total Petroleum Hydrocarbons	Ethylene Glycol or Methanol (Alcohols)	Pesticides	Aromatic Volatiles
Method	**TX1005**	**SW 8015C**	**SW 8081B**	**SW 8021B**
MQL	See Table 2	See Table 1	See Table 2	See Table 1
Holding Times	See Table 4	See Table 4	See Table 4	See Table 4
Equipment Blank	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL
Field Duplicate	1 every 10 samples ≤30 RPD (aqueous)	1 every 10 samples ≤30 RPD (aqueous)	1 every 10 samples ≤30 RPD (aqueous)	1 every 10 samples ≤30 RPD (aqueous)
Trip Blank	NA	NA	NA	One per volatiles sample cooler <MQL
Preparation (Laboratory) Blank	Daily per extraction batch (maximum 20 samples) per matrix < ± MQL	Daily per digestion batch (maximum 20 samples) per matrix < ± MQL	Daily per extraction batch (maximum 20 samples) per matrix <MQL	One per 12 hour shift (maximum 20 samples) <MQL
Initial Calibration and Calibration Verification	Minimum five concentrations: %RSD < 25 or COD > 0.99; Verify daily and every 20 samples maximum %D ≤ 25	Minimum five concentrations: %RSD < 20 or COD > 0.99; Verify daily and every 20 samples maximum %D ≤ 20	Minimum five concentrations: %RSD < 20 or COD > 0.99; Verify daily and every 10 samples maximum %D ≤ 20	Minimum five concentrations: %RSD < 20 or COD > 0.99; Verify daily and every 20 samples maximum %D ≤ 20
Initial Calibration and Continuing Calibration Blank	NA	NA	NA	NA
Surrogate	One per 20 samples per matrix %Recovery (Table 9)	One per 20 samples per matrix %Recovery (Table 9)	Every sample % Recovery (Table 9)	Every sample % Recovery (Table 9)
Matrix Spike	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix %Recovery (Table 9)	One per 20 samples per matrix %Recovery (Table 9)
Matrix Spike Duplicate	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)
Internal Standard	NA	NA	Optional	Optional
Laboratory Control Sample	Daily per extraction batch per matrix %Recovery (Table 9)	Daily per analysis batch per matrix %Recovery (Table 9)	Daily per extraction batch per matrix %Recovery (Table 9)	Daily per analysis batch per matrix %Recovery (Table 9)

Table 7 Quality Control Performance Criteria for Gas Chromatographic Methods

Quality Control Parameter	Total Petroleum Hydrocarbons	Ethylene Glycol or Methanol (Alcohols)	Pesticides	Aromatic Volatiles
Identification Criteria	Retention time window S/N ≥ 2.5	Retention time window S/N ≥ 2.5	Retention time window S/N ≥ 2.5	Retention time window S/N ≥ 2.5
Confirmation Analysis	NA	NA	Second GC column or GC/MS	NA
Method Detection Limit Verification	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits

Note: These are minimum requirements. Additional quality control measures may be necessary if alternative methods are chosen or methods are updated.

COD – Coefficient of determination

%D – percent difference

MQL – Method quantitation limit NA – Not applicable

RPD – Relative percent difference

RSD – Relative Standard deviation

S/N – signal/noise

Table 8 Quality Control Performance Criteria for Semivolatile Organic Compounds and Volatile Organic Compounds

Quality Control Parameter	Semivolatiles	Volatiles
Method	**SW 8270D**	**SW 8260B**
MQL	See Table 1 or Table 2	See Table 1 or Table 2
Holding Times	See Table 4	See Table 4
Equipment Blank	Daily per matrix and equipment type <MQL	Daily per matrix and equipment type <MQL
Field Duplicate	1 every 10 samples ≤30 RPD (aqueous) ≤50 RPD (solid)	1 every 10 samples ≤30 RPD (aqueous) ≤50 RPD (solid)
Trip Blank	NA	One per volatiles sample cooler <MQL
Preparation (Laboratory) Blank	Daily per extraction batch (maximum 20 samples) per matrix <MQL	One per 12 hour shift (maximum 20 samples) <MQL
Initial Calibration and Calibration Verification	Instrument performance check every 12 hours Minimum five concentrations: %RSD < 20 or COD > 0.99 for CCC; Verify every 12 hours maximum %D ≤ 20	Instrument performance check every 12 hours Minimum five concentrations: %RSD < 20 or COD > 0.99 for CCC; Verify every 12 hours maximum %D ≤ 20
Initial Calibration and Continuing Calibration Blank	NA	NA
Surrogate	Every sample % Recovery (Table 9)	Every sample % Recovery (Table 9)
Matrix Spike	One per 20 samples per matrix %Recovery (Table 9)	One per 20 samples per matrix %Recovery (Table 9)
Matrix Spike Duplicate	One per 20 samples per matrix % Recovery / RPD (Table 9)	One per 20 samples per matrix % Recovery / RPD (Table 9)
Internal Standard Area	Each sample 50-100% of amount in calibration standard; Retention time within ±30 seconds from last calibration	Each sample 50-100% of amount in calibration standard; Retention time within ±30 seconds from last calibration
Laboratory Control Sample	Daily per extraction batch per matrix %Recovery (Table 9)	Daily per analysis batch per matrix %Recovery (Table 9)

Table 8 Quality Control Performance Criteria for Semivolatile Organic Compounds and Volatile Organic Compounds

Quality Control Parameter	Semivolatiles	Volatiles
Identification Criteria	Intensities of characteristic ions maximize in same scan or within one scan	Intensities of characteristic ions maximize in same scan or within one scan
Method Detection Limit Verification	Quarterly during sample analyses No control limits	Quarterly during sample analyses No control limits

Note: These are minimum requirements. Additional quality control measures may be necessary if alternative methods are chosen or methods are updated.

CCC – Calibration Check Compound
COD – Coefficient of determination
%D – percent difference
MQL – Method quantitation limit
NA – Not applicable
RPD – Relative percent difference
RRT – Relative Retention Time
RSD – Relative Standard deviation
S/N – signal/noise

Table 9 – LCS, MS/MSD and Surrogate Precision and Accuracy Acceptance Criteria for Data Review

Analyte	LCS	MS/MSD				Surrogate	
		Aqueous		Solid		Aqueous	Solid
	%R	%R	RPD	%R	RPD	%R	%R
Pesticides							
Decachlorobiphenyl	NA	NA	NA	NA	NA	60-140	60-140
Tetrachloro-m-xylene	NA	NA	NA	NA	NA	60-140	60-140
Dieldrin	60-140	60-140	30	60-140	40	NA	NA
Pesticides not listed above	60-140	60-140	30	60-140	40	NA	NA
Polycyclic Aromatic Hydrocarbons							
Nitrobenzene-d_5	NA	NA	NA	NA	NA	60-140	60-140
2-Fluorobiphenyl	NA	NA	NA	NA	NA	60-140	60-140
Terphenyl-d_{14}	NA	NA	NA	NA	NA	60-140	60-140
Acenaphthene	60-140	60-140	30	60-140	40	NA	NA
Pyrene	60-140	60-140	30	60-140	40	NA	NA
PAHs not listed above	60-140	60-140	30	60-140	40	NA	NA
Semivolatile Organic Compounds							
Nitrobenzene-d_5	NA	NA	NA	NA	NA	60-140	60-140
2-Fluorobiphenyl	NA	NA	NA	NA	NA	60-140	60-140
Terphenyl-d_{14}	NA	NA	NA	NA	NA	60-140	60-140
Phenol-d_5	NA	NA	NA	NA	NA	60-140	60-140
2-Fluorophenol	NA	NA	NA	NA	NA	60-140	60-140
2,4,6-Tribomophenol	NA	NA	NA	NA	NA	60-140	60-140
Acenaphthene	60-140	60-140	30	60-140	40	NA	NA
Phenol	60-140	60-140	30	60-140	40	NA	NA
Pyrene	60-140	60-140	30	60-140	40	NA	NA
SVOCs not listed above	60-140	60-140	30	60-140	40	NA	NA
Volatile Organic Compounds							
1,2-Dichloroethane-d_4	NA	NA	NA	NA	NA	60-140	60-140
Toluene-d_8	NA	NA	NA	NA	NA	60-140	60-140
Bromofluorobenzene	NA	NA	NA	NA	NA	60-140	60-140
Trichloroethene	60-140	60-140	30	60-140	40	NA	NA
Benzene	60-140	60-140	30	60-140	40	NA	NA
Toluene	60-140	60-140	30	60-140	40	NA	NA
Chlorobenzene	60-140	60-140	30	60-140	40	NA	NA
VOCs not listed above	60-140	60-140	30	60-140	40	NA	NA
Cyanide, Fluoride, Metals							

Table 9 – LCS, MS/MSD and Surrogate Precision and Accuracy Acceptance Criteria for Data Review

Analyte	LCS	MS/MSD				Surrogate	
		Aqueous		Solid		Aqueous	Solid
	%R	%R	RPD	%R	RPD	%R	%R
Cyanide	70-130	70-130	30	70-130	30	NA	NA
Metals (including mercury)	70-130	70-130	30	70-130	30	NA	NA
Methanol, Ethylene glycol, Total Petroleum Hydrocarbons							
Methanol	60-140	60-140	30	60-140	40	NA	NA
Ethylene glycol	60-140	60-140	30	60-140	40	NA	NA
o-Terphenyl (TPH Surrogate)	NA	NA	NA	NA	NA	60-140	60-140
Trifluoromethylbenzene (TPH Surrogate)	NA	NA	NA	NA	NA	60-140	60-140
TPH	60-140	60-140	30	60-140	40	NA	NA

FIGURES

GROUNDWATER SAMPLING ACTIVITY RECORD

FIELD MEASUREMENT AND PURGE DATA

Site Name: Blank **Well ID:** Blank-MW01 **Sampling Event:** Blank

Personnel:

Well Diameter (in)	2
TOC Elev (Ft. MSL)	3155.6
Total Depth (Ft.)	41.4
Screen Interval	55-75
Well Yeild	High
Packer Interval (Ft.)	
Dedicated Equipment	None

Top Of Casing (Ft. MSL):
Water Level Depth from TOC (Ft.): 44.36
Groundwater Elevation (Ft./MSL):
Bottom Casing Elevation (Ft./MSL):

Casing Volume (gal):
80% Casing Volume:
Water Column (ft):

Silt Measurement Method:
NAPL Measurement Method:
Parameter Stabilization Method:
Purge Method:

Purge Date: **Purge Start Time:** **Purge End Time:**
Purge Volume (Liters): **PID (ppm):** 0 **Purge Rate:** 0
Purge Comments:

Product Depth (Ft.): 0
Product Thickness (Ft.): 0

Well Condition: **Casing:** **Pad:** **Guard:** **Lock:**

Parameter Stabilization

Time	Volume	pH (S.U.)	Temp (°C)	Cond (Mmhols/cm)	Sp Cond (uS/cm)	Redox Poten. (MV)	DO (%)	DO (mg/L)	Turbidity (NTU)	Appearance (Visual)
11:30	0	7.21	17.63	3159.3	3677.2	-45	41.7	3.93	20	
11:34	0	7.26	17.92	3072.8	3553.1	-68	53.1	4.98	15	
11:37	0	7.27	18.15	3048.9	3508	-78	44.1	4.12	10	
11:40	0	7.28	18	3013.2	3478.1	-86	25.6	2.39	9.9	
11:43	0	7.28	18.03	3027.4	3492.4	-93	73.7	6.9	9.8	

SAMPLING AND SHIPPING DATA

Sample Date: 4/2/2011 **Temperature (C):** **Wind Direction:** **Wind Speed:** **Obsev.:** Mild, Sunny, No Precip.

Sample Id	Analysis	*Sample Container* Quantity	Volumne	Type	Presevation	Filtration	Sample Time
BLK-MW01-0411	Dissolved Metals (6010/7040)	1	250 mL	Poly	HNO3	10 micron	11:45
BLK-MW01-0411	SVOA (8270)	2	1 L	Amber	None	None	11:45
BLK-MW01-0411	SVOA SIM (8270 SIM)	1	1 L	Amber	None	None	11:45
BLK-MW01-0411	Total Metals (6010/7470)	1	250 mL	Poly	HNO3	None	11:45
BLK-MW01-0411	VOA (8260)	3	40 mL	Vial	HCl	None	11:45

Additional Samples Collected		
Type	*Sample ID*	*Time*
Duplicate Sample		
Equipment Blank		
Field Blank		
Split Sample		

Filtration	
Method	
Filter Material	
Pore Size	
Filter Lot No.	
Filtrate Volume	

Laboratory:
Custody Seals Used?:
Cooler Temperature: 4° C
Cooler Packing Material: Bubble Wrap
Shipping Date:
Shipping Method:
Chain of Custody Number:

I certify that the monitoring and sampling preceedures were in accordance with applicable EPA, State, and corporate policy.

SAMPLING PERSONNEL SIGNATURE	DATE	SAMPLING PERSONNEL SIGNATURE	DATE	SAMPLING PERSONNEL SIGNATURE	DATE
PRINT NAME		PRINT NAME		PRINT NAME	

Figure 1 Example Field Sheet

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

Section A Required Client Information:		Section B Required Project Information:	Section C Invoice Information:
Company:		Report To:	Attention:
Address:		Copy To:	Company Name:
			Address:
Email To:		Purchase Order No.:	Pace Quote Reference:
Phone:	Fax:	Project Name:	Pace Project Manager:
Requested Due Date/TAT:		Project Number:	Pace Profile #:

REGULATORY AGENCY

- ☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
- ☐ UST ☐ RCRA ☑ OTHER________

SITE LOCATION	☐ GA ☐ IL ☐ IN ☐ MI ☐ NC ☐ OH ☐ SC ☐ WI ☐ OTHER

Filtered (Y/N)

Requested Analysis:

Residual Chlorine (Y/N)

Laboratory Project Number Lab I.D.

Section D Required Client Information

SAMPLE ID
One Character per box
(A-Z, 0-9 / ,-)
Samples IDs MUST BE UNIQUE

Valid Matrix Codes MATRIX	CODE
DRINKING WATER	DW
WATER	WT
WASTE WATER	WW
PRODUCT	P
SOIL/SOLID	SL
OIL	OL
WIPE	WP
AIR	AR
OTHER	OT
TISSUE	TS

ITEM #	SAMPLE ID	MATRIX CODE	SAMPLE TYPE G=GRAB C=COMP	COLLECTED COMPOSITE START DATE	COLLECTED COMPOSITE START TIME	COLLECTED COMPOSITE END/GRAB DATE	COLLECTED COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	

Additional Comments:

RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
							Y/N	Y/N	Y/N
							Y/N	Y/N	Y/N
							Y/N	Y/N	Y/N
							Y/N	Y/N	Y/N

SAMPLER NAME AND SIGNATURE		Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
PRINT Name of SAMPLER:					
SIGNATURE of SAMPLER:	DATE Signed (MM/DD/YY):				

Figure 2 Example Chain-of-Custody

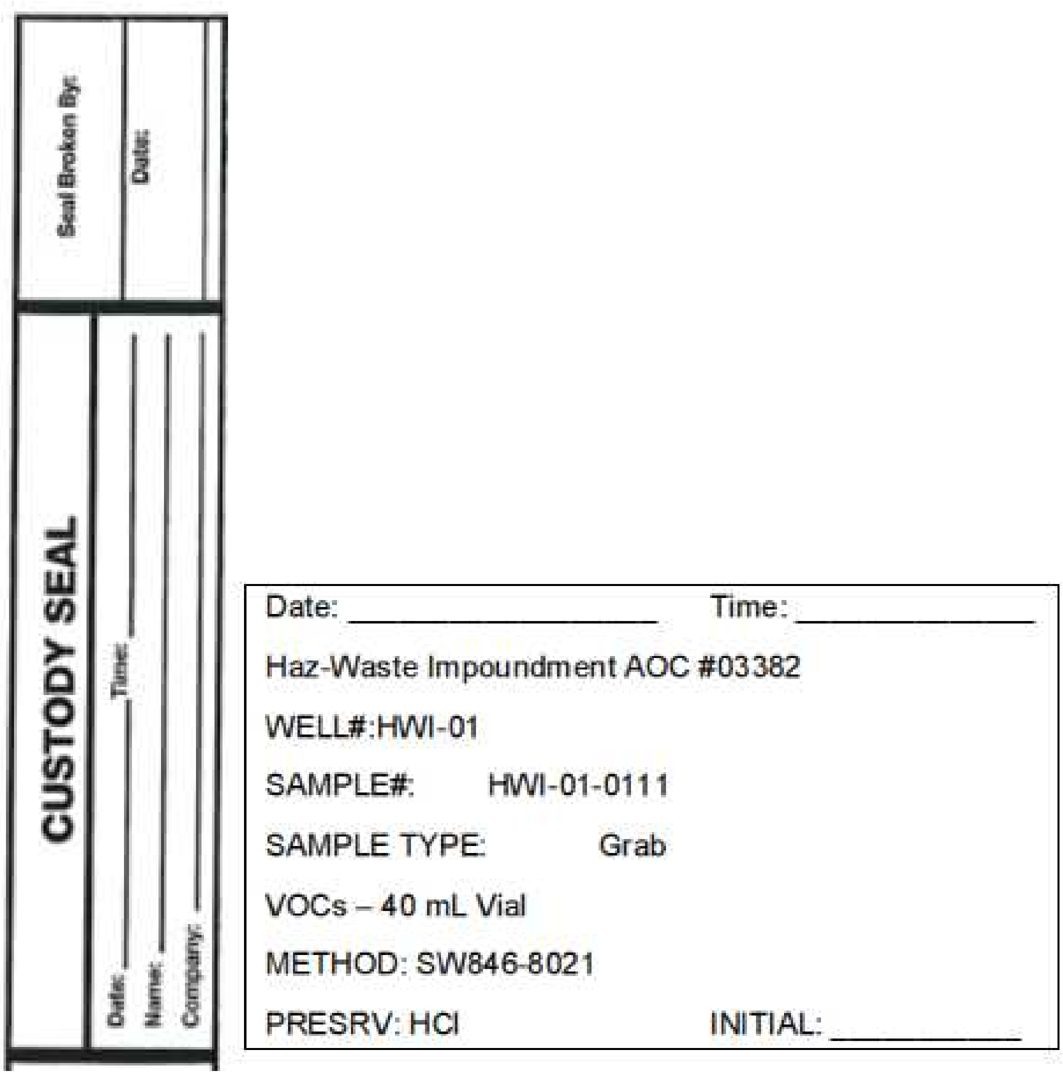


Figure 3 Example Custody Seal (Left) and Sample Label (Right)

Attachment B.VII.A.3
North Holding Pond Closure Plan

Table of Contents

1.0 INTRODUCTION

This closure plan has been prepared to outline the steps that Phillips 66 (P66) will take to close the North Holding Pond Notice of Registration No. 036 (NOR#036), Hazardous Waste Permit No. 50078. This closure plan is prepared in accordance with federal (40 CFR §264 Subpart G, 264.310, and §264.113(d)) and state (30 TAC §335.174) requirements.

Phillips 66 Company (Phillips 66, CN601491608) operates the Borger Refinery (RN102495884), which is owned by a joint venture between Phillips 66 (P66) and Cenovus called WRB Refining LP (WRB, CN603215997). The mailing address to the facility is P.O. Box 271, Borger, Texas 79008. The physical address for the facility is State Highway Spur 119 North, Borger, Texas 79007. P66 has been assigned a hazardous waste generator number by the U.S. Environmental Protection Agency (EPA) TXD980626774 and a Texas Commission on Environmental Quality (TCEQ) Solid Waste Notice of Registration Number 30111. Closure in accordance with this closure plan will begin within 180 days from receipt of the last known shipment of wastes at the North Holding Pond. Amendments to the plan may be proposed as a result of unexpected events that occur during closure and affect the ability of the closure plan to be implemented as designed.

The North Holding Pond is a 3.4-acre double-lined surface impoundment. It is a below-grade unit, constructed of 3 feet of compacted bentonite amended native soils with an overlying 100-mil HDPE liner. The North Holding Pond is in partial closure in accordance with the 1998 closure plan. The free liquid has been removed and the sludge has been stabilized. The impoundment is now being filled with non-hazardous waste. The partial closure permit modification was approved by TCEQ on April 21, 2004.

Closure of the North Holding Pond will generally consist of final grading to establish positive surface drainage and compaction followed by the installation of a clay and synthetic impermeable cover system to close the landfill.

2.0 CLOSURE ACTIVITIES

Closure certification for North Holding Pond (NOR #036) will be submitted to TCEQ upon completion of final closure activities in accordance with federal (40 CFR §264.115) and state (30 TAC §335.155) requirements.

A detailed engineering design report for the final cover system is included as Appendix A. The final cover system design is shown in Figure VII.A.3-1 and Figure VII.A.3-2 (previously presented in the 2001 permit modification). Figure VII.A.3-3 shows additional design details and the previously permitted final cover system. Closure activities are described below:

1. Waste will be covered with fill material as needed to achieve the desired grade and sloped appropriately. The fill will be placed using ordinary compaction techniques and compacted to 95% of maximum dry density and plus or minus three percent moisture content.

2. Final Cover System

   a. The final cover system will be constructed in accordance with the CQA Plan (and Technical Specifications) included in Appendix A. The final cover system consists of the following:

   i. A compacted clay liner (CCL) with a thickness of 1 foot and a permeability that is less than or equal to 1×10^{-7} centimeters per second (cm/sec) will be placed over the waste and/or fill material. The clay will have a plasticity index of greater than or equal to 15. A geosynthetic clay liner (GCL) with a permeability that is less than or equal to 5×10^{-9} cm/sec will be placed on top of the CCL.

   ii. A 50-mil high density polyethylene (HDPE) or linear low-density polyethylene (LLDPE) geomembrane with an integrated drainage layer, will be placed over the GCL.

   iii. A layer of engineered turf will be placed on top of the geomembrane's integrated drainage layer. The engineered turf will consist of synthetic blades of grass looped through two layers of 6-ounce woven geotextiles.

   iv. A 0.5" layer of sand ballast will be incorporated on the surface of the engineered turf.

3. Stormwater run-on to the final cover system will be eliminated by the elevation of the final cover system over surrounding areas. Drainage patterns around the closure unit will be established to promote drainage away from the unit, by grading of surrounding soils. The slope of the final cover system will be a minimum of 2% and a maximum of 5%. The run-on control system will be capable of preventing flow onto the final cover system during peak discharge from at least a 100-year storm. The run-off control

system will be capable of collecting and controlling the water volume resulting from a 24-hour, 100-year storm. Run-on and run-off collection and holding facilities will be managed after storms to maintain design capacity of the system. Run-on and run-off will be managed to prevent eroding or otherwise damaging the final cover. A detailed stormwater analysis is included in Appendix A.

4. Areas outside the final cover system that are regraded or otherwise disturbed during closure activities will be seeded with native species.
5. Appropriate signs will be placed around the closed site.
6. Fencing will be maintained around the closed site.
7. Six brass benchmarks will be permanently mounted on concrete pads on the final cover system. The benchmarks will be spaced across the surface of the final cover system. The location and elevations of the benchmarks will be surveyed at the completion of construction activities, relative to the nearest existing survey monument. The location and elevation of the benchmarks may be used to evaluate potential settlement during the post-closure period.
8. Hazardous wastes are not expected to be contacted during construction due to previous removal and stabilization measures, and subsequent placement of non-hazardous solid waste. In the event that hazardous wastes are encountered during construction, equipment that contacts hazardous waste will be decontaminated with high-pressure water. Wash water will be collected in the wash rack drainage system and pumped to the refinery's wastewater treatment system, or transported to a permitted off-site treatment or disposal facility. This decontamination will be conducted prior to placing the equipment in service in non-waste areas.

3.0 CERTIFICATION

A professional engineer licensed by the State of Texas, and a P66 representative, will certify that the North Holding Pond is closed in accordance with the approved closure plan. After closure activities are completed at the site, a report will be submitted to the TCEQ which includes the closure certification, a list of the maximum waste inventory, a description of the maximum extent of the final cover system footprint, a summary of the activities performed during closure, the results of tests or analyses performed, as-built drawings (including benchmarks), and a description of anticipated future land use as well as area topography reflecting as-built conditions.

A notation of the presence and location of waste disposed of in the NHP will be placed in the real property records of Hutchinson County, Texas when the unit is certified closed, in accordance with 40 CFR §264.116 requirements.

4.0 CLOSURE SCHEDULE

Provided that significant weather and/or contractor delays do not occur, closure activities for the North Holding Pond will be completed according to the following schedule:

1.	Place unclassified fill	8 weeks
2.	Construct final cover system	
	Installation of CCL and GCL	6 weeks
	Installation of geomembrane	4 weeks
	Installation of engineered turf	2 weeks
	Installation of sand ballast	1 week
3.	Reshape Stormwater Run-on/Run-off Controls, Construct Fence	6 weeks
4.	Set and Survey Benchmarks	4 weeks
5.	Submittal of Closure Report and Certification	12 weeks

Total 43 weeks after the start of closure

5.0 CLOSURE COST ESTIMATES

Closure costs for the North Holding Pond are provided in Table 1. These closure costs were developed using a combination of EPA's preferred software, Costpro 6.0 and using 2019 cost estimates from material vendors and contractors . Estimates from Costpro are based upon 2007 unit costs; these costs were updated using standard inflation factors to give 2019 costs.

Tables/Figures/Drawings for North Holding Pond Closure Plan

Tables

Figures

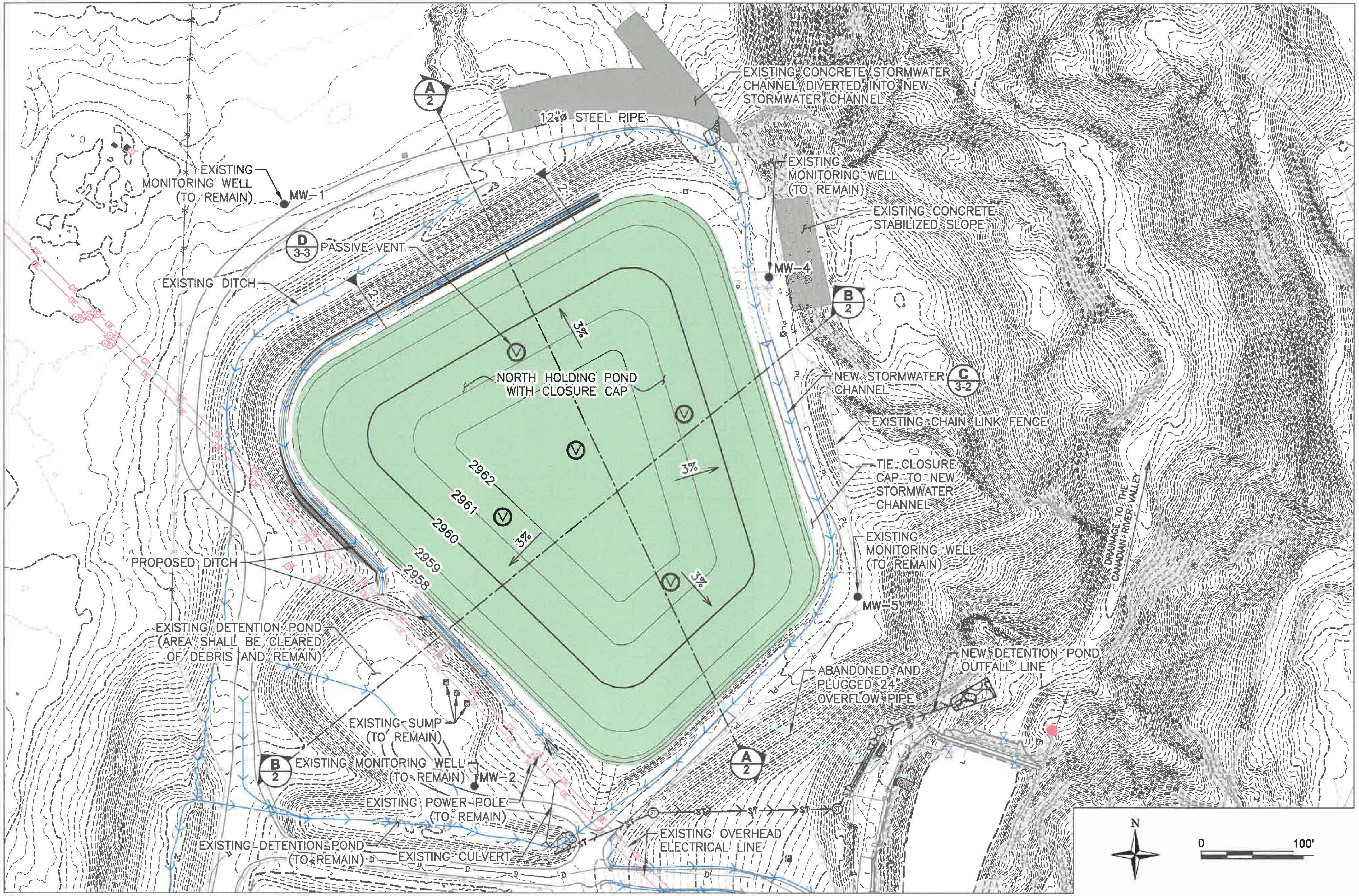
Drawings

None

Table 1. Unit Closure Cost Estimate[1]

Task	Cost
North Holding Pond	
Installation of Unclassified Fill	$31,000
Installation of Clay layer	$181,000
Installation of Geosynthetic Clay Liner	$122,000
Installation of Geomembrane w drainage layer, engineered turf, and sand ballast	$568,000
Installation of Storm Water Control	$29,000
Decontamination	$4,000
Subtotal of Closure Costs	*$935,000*
Engineering Expenses (10%)	$94,000
Survey Plat	$5,000
Certification of Closure	$10,000
subtotal	$1,044,000
Contingency (10% minimum)	$104,000
Total Unit Closure Cost	**$1,224,000 (2019)**

[1]The cost basis for line items in the above table are based on a mixture of 2007 and 2019 costs; these items were adjusted to a common 2019 cost basis in the total closure cost.



NOTES:

1. CARE SHALL BE TAKEN DURING CONSTRUCTION NOT TO DISTURB ANY EXISTING MONITORING WELLS, SUMPS, AND FENCE.

CERTIFICATE OF ENGINEER

STATE OF TEXAS)
) SS:
COUNTY OF HUTCHINSON)

I, CAMERON TWING, HEREBY STATE TO THE BEST OF MY KNOWLEDGE AND UNDERSTANDING THAT THIS DESIGN AND ACCOMPANYING DRAWINGS HAVE BEEN PREPARED BY ME OR UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH STANDARD AND GENERALLY ACCEPTED ENGINEERING PRACTICES AND PROCEDURES IN EFFECT AT THE TIME.

TRIHYDRO CORPORATION:
TEXAS ENGINEERING FIRM F-131

STATE OF TEXAS
Cameron John Twing
105389
LICENSED
PROFESSIONAL ENGINEER

5-18-20

NO.	REVISION	REV. BY / CHECKED	DATE / APPVD.
1	ISSUE FOR APPROVAL	RJ / CT	8/22/2019
2	ISSUE FOR APPROVAL	ST, CT / CT	5/18/20

REFERENCE DRAWINGS:

ISSUED FOR: APPROVAL 5/18/2020

DSN TH
DWN RJ
CHK CT
APD

WRB Refining LP

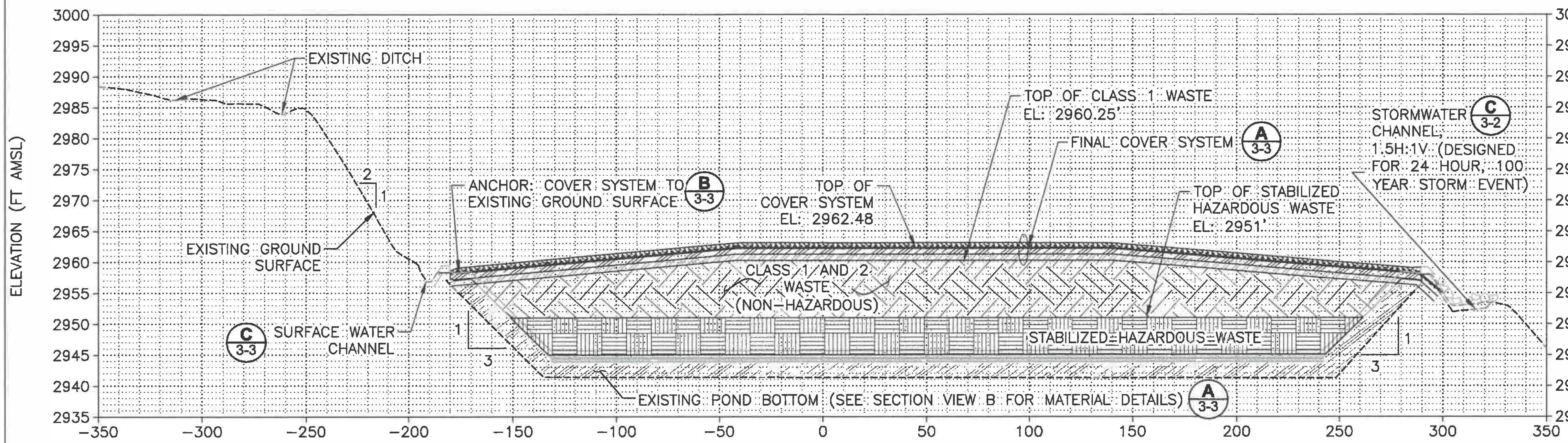
FIGURE B.VII.A.3-1 FINAL COVER DESIGN
(IN-PLACE CLOSURE)
NORTH HOLDING POND

BORGER REFINERY BORGER, TX

NOTIF.# | WO NO. | WFA.# | MOC#

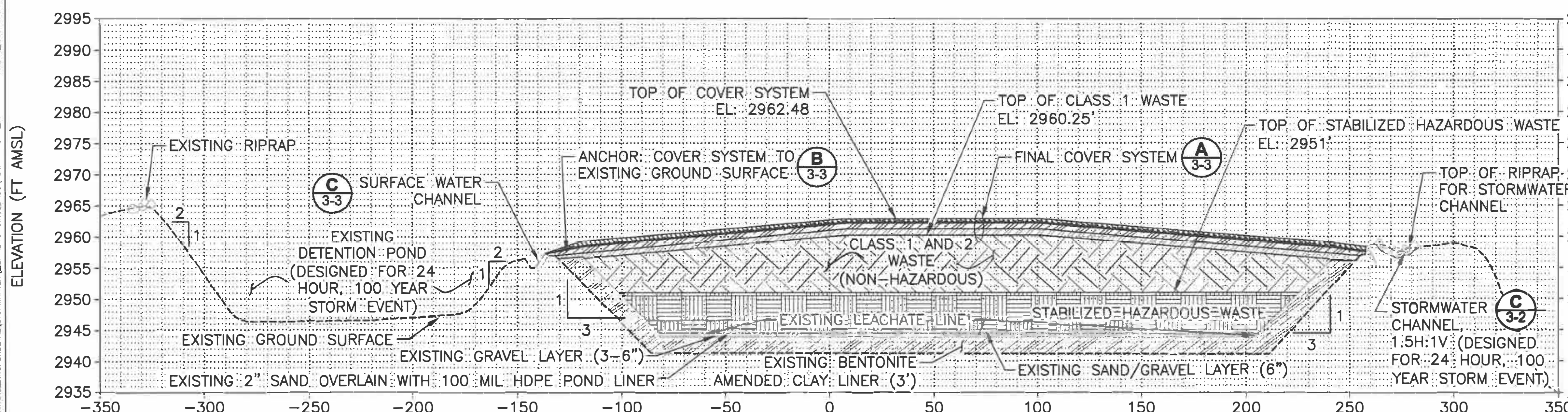
CROSS REFERENCE:

DOCUMENT #:



A PROPOSED COVER SYSTEM: EAST-WEST SECTION VIEW
SCALE H: 1" = 60' V: 1" = 20'

0 60' HORIZONTAL 0 20' VERTICAL



B PROPOSED COVER SYSTEM: NORTH-SOUTH SECTION VIEW
SCALE H: 1" = 60' V: 1" = 20'

0 60' HORIZONTAL 0 20' VERTICAL

NOTES:

1. ORIGINALLY INSTALLED FOR LEAK DETECTION OF SURFACE IMPOUNDMENT. HAS FUNCTIONED AS LEACHATE COLLECTION SYSTEM SINCE PARTIAL CLOSURE IN 2005 AND CONVERSION TO A CLASS 1 AND 2 NON-HAZARDOUS WASTE LANDFILL.

CERTIFICATE OF ENGINEER

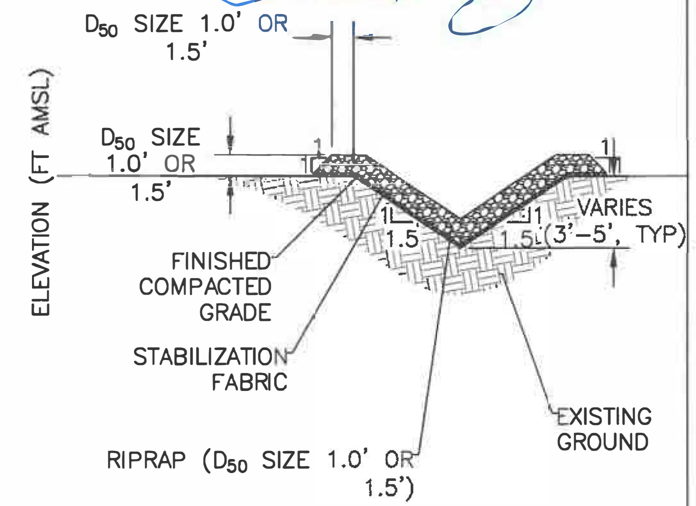
STATE OF TEXAS)
) SS:
COUNTY OF HUTCHINSON)

I, CAMERON TWING, HEREBY STATE TO THE BEST OF MY KNOWLEDGE AND UNDERSTANDING THAT THIS DESIGN AND ACCOMPANYING DRAWINGS HAVE BEEN PREPARED BY ME OR UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH STANDARD AND GENERALLY ACCEPTED ENGINEERING PRACTICES AND PROCEDURES IN EFFECT AT THE TIME.

TRIHYDRO CORPORATION:
TEXAS ENGINEERING FIRM F-131

STATE OF TEXAS
Cameron John Twing
105389
LICENSED PROFESSIONAL ENGINEER

5-18-20



C TYPICAL STORMWATER CHANNEL SECTION
SCALE: N.T.S.

NO.	REVISION	REV. BY / CHECKED	DATE / APPVD.
1	ISSUE FOR APPROVAL	RJ / CT	8/22/19
2	ISSUE FOR APPROVAL	ST / CT	5/18/20 / 5/18/20

REFERENCE DRAWINGS:

ISSUED FOR: APPROVAL 5/18/2020

DSN TH
DWN RJ
CHK CT
APD

WRB Refining LP

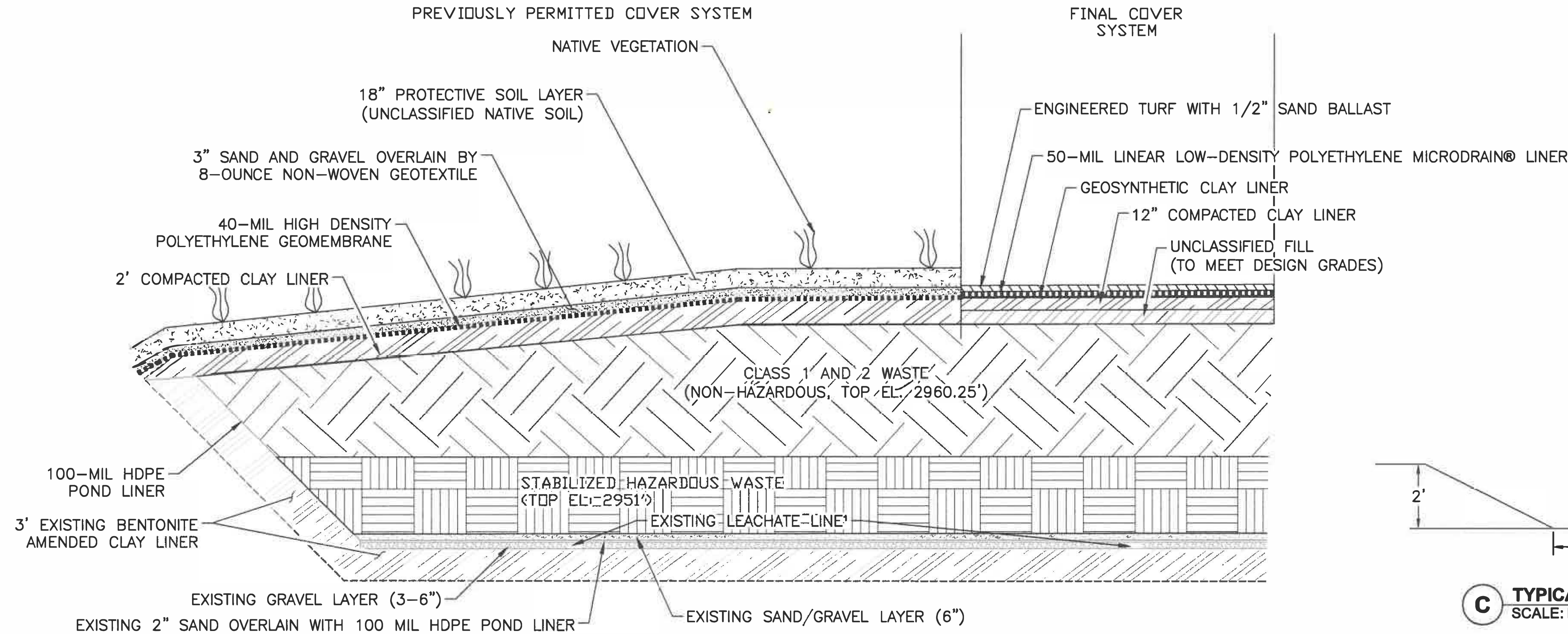
FIGURE B.VII.A.3-2 CROSS SECTIONS
(IN-PLACE CLOSURE)
NORTH HOLDING POND

BORGER REFINERY BORGER, TX

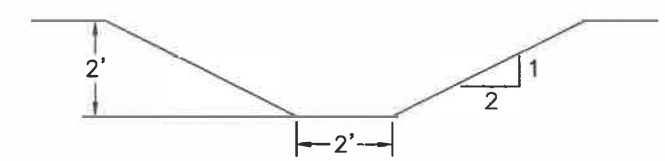
NOTIF.# | WO NO. | WFA.# | MOC#

CROSS REFERENCE:

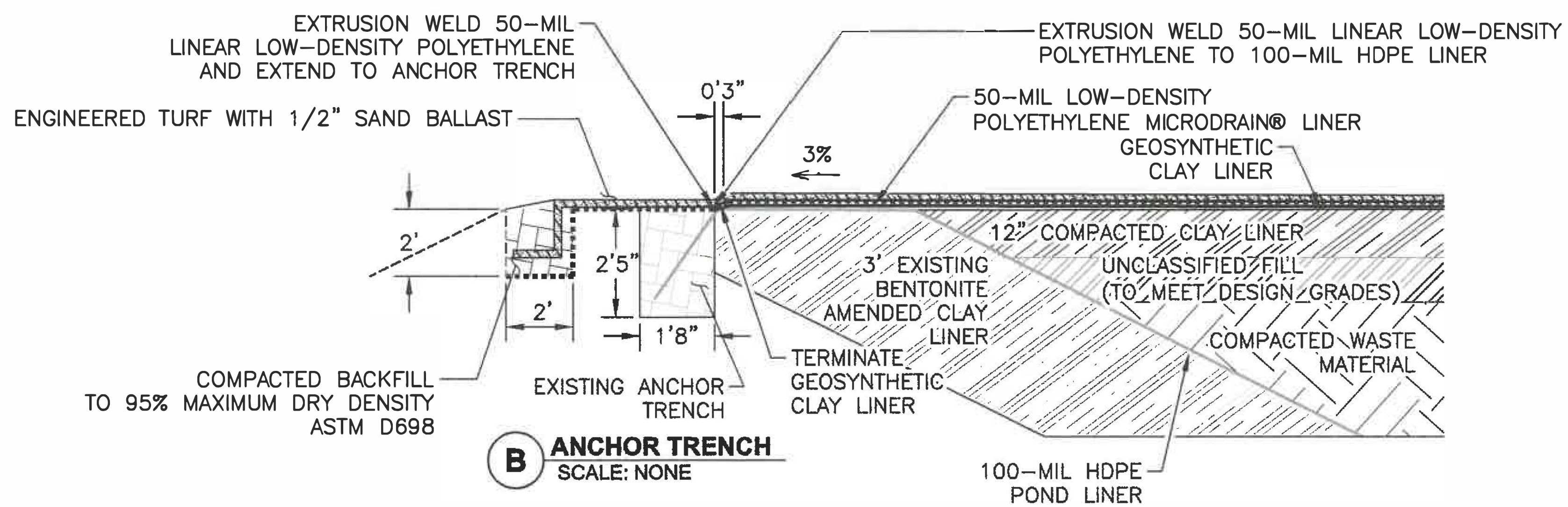
DOCUMENT #:



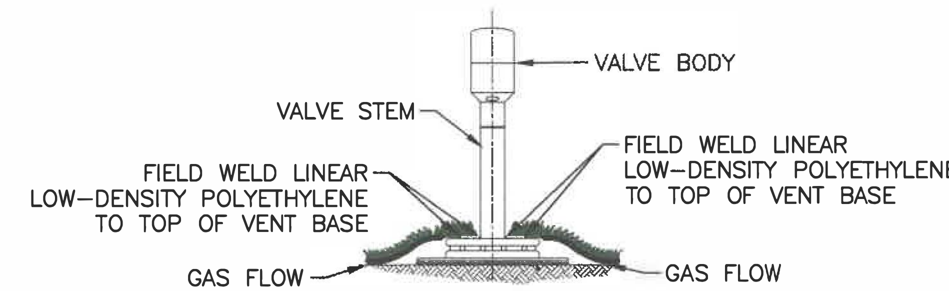
A **CLOSURE CAP: TYPICAL SECTION, PREVIOUSLY PERMITTED AND FINAL COVER SYSTEM**
SCALE: NONE



C **TYPICAL DITCH SECTION**
SCALE: NONE



B **ANCHOR TRENCH**
SCALE: NONE



D **PASSIVE VENT**
SCALE: NONE

CERTIFICATE OF ENGINEER

STATE OF TEXAS)
) SS:
COUNTY OF HUTCHINSON)

I, CAMERON TWING, HEREBY STATE TO THE BEST OF MY KNOWLEDGE AND UNDERSTANDING THAT THIS DESIGN AND ACCOMPANYING DRAWINGS HAVE BEEN PREPARED BY ME OR UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH STANDARD AND GENERALLY ACCEPTED ENGINEERING PRACTICES AND PROCEDURES IN EFFECT AT THE TIME.

TRIHYDRO CORPORATION:
TEXAS ENGINEERING FIRM F-131

NOTES:
1. ORIGINALLY INSTALLED FOR LEAK DETECTION OF SURFACE IMPOUNDMENT. HAS FUNCTIONED AS LEACHATE COLLECTION SYSTEM SINCE PARTIAL CLOSURE IN 2005 AND CONVERSION TO A CLASS 1 AND 2 NON-HAZARDOUS WASTE LANDFILL.

NO.	REVISION	REV. BY / CHECKED	DATE / APPVD.
1	ISSUE FOR APPROVAL	ST / CT	5/18/2020

REFERENCE DRAWINGS:

ISSUED FOR: APPROVAL 5/18/2020
DSN TH
DWN ST
CHK CT
APD

WRB Refining LP

FIGURE B.VII.A.3-3 DETAILS
(IN-PLACE CLOSURE)
NORTH HOLDING POND
BORGER REFINERY **BORGER,TX**

NOTIF.#	WO NO.	WFA.#	MOC#

CROSS REFERENCE:

DOCUMENT #:

\\TRIHYDRO.COM\CLIENTS\OTOR\PHILLIPS66\PROJECTS\BORGERREFINERY\CADD\NORTHHOLDINGPOND\EVAL\STORMWATER_EXHIBITS-SINGLETIES\..._FINALCONTOUR\PLAN_REVISED-05112020

Appendices to North Holding Pond Closure Plan

Appendix A – Engineering Design Report

CLOSURE PLAN MODIFICATION – DESIGN REPORT

NORTH HOLDING POND (PERMIT NO. HW-50078)

BORGER REFINERY, BORGER, TEXAS

May 18, 2020

Project #: 42M-002-008

SUBMITTED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

ENGINEERING SOLUTIONS. ADVANCING BUSINESS.

CERTIFICATE OF ENGINEER

I certify that the Closure Plan Modification, which includes the Design Report, for the North Holding Pond Notice of Registration No. 036, Hazardous Waste Permit No. 50078 and associated structures was prepared by me or under my direct supervision with federal (40 CFR §264 Subpart G, 264.310) and state (30 TAC §335.174) requirements, and to the best of my knowledge is true and correct.

STATE OF TEXAS
Cameron John Twing
105389
LICENSED
PROFESSIONAL ENGINEER

5-18-20

Cameron John Twing
Registered Professional Engineer No. 105389
Trihydro Corporation #131

Table of Contents

List of Appendices

1.0 INTRODUCTION

Phillips 66 Company (Phillips 66, CN601491608) operates the Borger Refinery (RN102495884), which is owned by a joint venture between Phillips 66 (P66) and Cenovus called WRB Refining LP (WRB, CN603215997). This engineering design report has been prepared to support the proposed final cover system design included in the Closure Plan, which outlines the steps that P66 will take to close the North Holding Pond (NHP), Notice of Registration No. 036 (NOR#036), Hazardous Waste Permit No. 50078. This engineering design report is prepared in accordance with federal (40 CFR §264 Subpart G, 264.310) and state (30 TAC §335.174) requirements.

2.0 BACKGROUND

The following general information is provided to describe the facility.

2.1 SITE OPERATING AND REGULATORY HISTORY

NHP was Registered in 1982 as Solid Waste Management Unit No. 36 under Texas Solid Waste Registration No. 30111, Hazardous Waste Permit HW-50078, EPA ID TXD980626774. The July 8, 2011 permit HW-50078 application, revised; June 13, 2013, June 28, 2013, December 10, 2013, April 9, 2014, and September 4, 2014; Modified (Class 1) revised on February 23, 2016, August 22, 2017, and October 11, 2017, and approved on October 25, 2017 [Tracking No. 21896851, RN102495884, CN604065912] authorizes the NHP Closure Plan (Section B.VII.A.3), Post Closure Care Plan (Section B.VII.C.1), and Engineering Report (Attachment B.V.D.2).

The NHP was constructed in the early 1980's as a 3.4-acre surface impoundment with a liner system consisting of 3-feet of bentonite amended clay, leak detection system, and 100-mil high-density polyethylene (HDPE) liner. The NHP's initial permitted waste capacity was 8.7 million gallons and was first put into service in 1982. The impoundment received oily sewer water from the Borger Refinery Drop Out Basins, Tank 3003, and Natural Gas Liquid (NGL) Wastewater System. These liquids were pumped to the Dixon Creek Surge Pond (now closed) prior to treatment at Dixon Creek wastewater treatment plant (WWTP) and discharge via Outfall 001. A Texas Commission on Environmental Quality (TCEQ) letter from 1992 acknowledged that P66 reported the NHP leak detection sumps were receiving liquids, indicating the HDPE liner had been breached. However, P66 maintains that the primary liner (the bentonite clay liner) has not been compromised, as indicated in approximately 25 years of groundwater monitoring. The leak detection sumps now essentially function as a leachate collection system.

The NHP was taken out of service in 1994 and replaced by the North Holding Tanks (Tanks 9600 and 9601), which receive the same oily sewer water. Between 1994 and 2004 the pond received no additional waste and the pond sediments were stabilized in place with a 15% Portland cement mixture. Phillips 66 received permit authorization from the TCEQ for a partial closure of the hazardous waste unit, allowing the available headspace remaining in the pond to be used for non-hazardous remediation related waste materials (mainly hydrocarbon impacted soils). A Class 2 permit modification application for Permit No. HW-50078 was submitted to the TCEQ on December 22, 2003 to seek approval to convert the NHP to a Class 1 and 2 non-hazardous waste landfill. The Class 2 permit modification was approved by the TCEQ on April 21, 2004 and the NHP was closed as a surface impoundment in accordance with 40 CFR 264.228(a)(1), 264.228(a)(2)(i), and 264.228(a)(2)(ii) and the approved Closure Plan in 2005. Following partial closure, Class 1 and 2 non-hazardous landfill operations began.

In November of 2016, P66 assessed potential design/construction issues relative to the closure of NHP. Alternative closure strategies were identified and then incorporated into a letter to Mr. Martin Torres of the TCEQ, *RE: Closure Plan Alternatives, North Holding Pond, WRB Borger Refinery, Phillips 66, Borger, TX, SWR No. 30111: EPA ID TXD980626774: CN603215997; RN 102495884; CP-50078,* dated February 1, 2017 (Phillips 66 2017a). The purpose of the letter was to provide an overview of the review findings and to provide a basis for discussion of possible modifications to the approved closure plan. On February 23, 2017 P66 and TCEQ met to discuss the possible modifications. The TCEQ responded in a letter to Mr. Ben Elliott on April 26, 2017 indicating that proposed alternatives to the NHP Closure Plan would require completion of a Class 3 permit modification in accordance with Texas Administrative Code (TAC) 335.69(k)J.3 (TCEQ 2017a).

A Class 1 permit modification was submitted to TCEQ on August 14, 2017 to meet requirements of the TAC for proposed maintenance activities that included (Phillips 66 2017b):

- Raising the elevation of the leachate collection system sump access
- Repairing tears on the exposed portion of the existing liner system at the banks of the NHP
- Repairing erosional features surrounding the permitted NHP area
- Removing out-of-service ancillary equipment associated with the historic NHP surface impoundment operations

On October 25, 2017, P66 received permit authorization from TCEQ (via Class 1a Modification to HW-50078, Attachment B.V.D.2) to carry out the proposed maintenance activities (TCEQ 2017b). P66 began the maintenance activities in 2017 and completed them in 2019.

On January 31, 2020 P66 submitted a Class 3 permit modification, which included a revised NHP closure plan, revised post closure plan, and supporting figures (Phillips 66 2020). On March 10, 2020 P66 received draft comments from TCEQ, which included a request for more information on the NHP final cover system. P66 and TCEQ met via a conference call on May 1, 2020 to discuss the requested information. The TCEQ formally submitted their comments to P66 on May 4, 2020. This design report has been prepared in response to the TCEQ comments from May 4, 2020 and the discussion held on May 1, 2020.

2.2 SITE CONDITIONS

NHP is operating as a Class 1 and 2 non-hazardous landfill. There is an estimated 1,034 cubic yards of capacity remaining in the unit until permitted waste grades are reached. P66 anticipates the landfill will reach capacity in 2022.

3.0 FINAL COVER SYSTEM

The following information is provided to describe the previously permitted final cover system (FCS) design and the proposed FCS design. The prepared FCS subgrade will be cleared of existing vegetation and soil stockpiles, remaining waste disposal/storage pits will be backfilled to match surrounding grades, and the existing surface profile will be compacted for acceptance of unclassified fill to reach design grades. The Closure Plan calls for placing unclassified fill material up to the desired grade using ordinary compaction techniques and compacted to 95% of maximum dry density and plus or minus three percent moisture content. The unclassified fill material will be graded to form a mound in the center of the impoundment footprint, sloped at 2-5% toward the perimeter, and then covered with a FCS as shown in Figure B.VII.A.3-2. Materials will be placed in accordance with the Construction Quality Assurance (CQA) plan and Engineering Specifications (Appendix A).

3.1 PREVIOUSLY PERMITTED FINAL COVER SYSTEM

The previously permitted FCS constitutes a traditional Resource Conservation Recovery Act (RCRA) Subtitle C (Hazardous Waste) FCS, which is designed to provide a low permeability barrier to prevent water infiltration; promote run-off; and, stabilize the surface. The previously permitted FCS includes the following as shown in Figure B.VII.A.3-3 (from top to bottom):

- 1.5-ft topsoil layer
- Non-woven geotextile
- 3-inch (in) sand or gravel layer (or geonet)
- 40-mil polyethylene membrane
- 2-foot (ft) compacted clay with a permeability of $\leq 1 \times 10^{-7}$ centimeters per second (cm/sec)
- Prepared subgrade

3.2 PROPOSED FINAL COVER SYSTEM

The proposed FCS was selected to improve constructability, short term effectiveness, and long-term reliability. The proposed FCS was designed to improve surface water runoff and provide a lower permeability barrier to water infiltration in comparison to the previously permitted FCS. Also, the proposed FCS will provide immediate stabilization of the surface. The proposed FCS will be constructed over any routine or intermediate cover already in place and include the following as shown in Figure B.VII.A.3-3 (from top to bottom):

- Engineered synthetic turf woven into two 6-ounce woven geotextiles, with ½” sand ballast (ClosureTurf®)
- MicroDrain® barrier layer (50-mil linear low-density polyethylene (LLDPE), with drainage studs on top side, and MicroSpike® on bottom side)

- Geosynthetic clay liner (GCL) with a permeability of ≤ $1x10^{-9}$ cm/sec
- 1-ft compacted clay with a permeability of ≤ $1x10^{-7}$ cm/sec
- Prepared subgrade

The semi-arid climate and the FCS are expected to reduce the potential for infiltration of precipitation, degradation of waste, and generation of leachate. In addition, the types of wastes in place in the unit will result in relatively low landfill gas generation rates. As a protective measure, a minimum of four passive gas vents will be installed to collect any gasses that accumulate below the geomembrane barrier layer. Based on the performance factors noted above, degradation and settlement of waste is not expected to be significant and does not warrant additional stability design or construction measures.

3.3 REGULATORY REQUIREMENTS

The FCS must meet the requirements described in 40 CFR Part 264, Subpart K. Specifically, the FCS must meet the requirements of 40 CFR 264.228(a)(2)(iii), also in 30 Texas Administrative Code (TAC) 335.169(a)(2) listed below.

(iii) Cover the surface impoundment with a final cover designed and constructed to:

(A) Provide long-term minimization of the migration of liquids through the closed impoundment; 264.228(a)(2)(iii)(A)

(B) Function with minimum maintenance; 264.228(a)(2)(iii)(B)

(C) Promote drainage and minimize erosion or abrasion of the final cover; 264.228(a)(2)(iii)(C)

(D) Accommodate settling and subsidence so that the cover’s integrity is maintained; and 264.228(a)(2)(iii)(D)

(E) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present. 264.228(a)(2)(iii)(E)

The analysis considered to demonstrate the FCS is designed in a manner to meet the regulatory requirements listed above is discussed in the following section.

4.0 FINAL COVER SYSTEM DESIGN

The following sections provide comparisons between the previously permitted FCS and the proposed FCS and demonstrate how the proposed FCS meets the regulatory requirements from Section 3.3.

4.1 FINAL COVER SYSTEM PERFORMANCE AND EQUIVALENCY DEMONSTRATION

The previously permitted FCS and Proposed FCS were modeled using the Hydrologic Evaluation of Landfill Performance (HELP) software, which is a standard analysis tool for landfill design. The HELP model demonstrates that the proposed FCS performed superior to the previously permitted FCS with average annual percolation of 0.00000 inches versus 0.00006 inches through the barrier layer, respectively. The lower annual average percolation of the proposed FCS demonstrates its performance will exceed or is equivalent to the previously permitted FCS. Detailed model inputs and results are described in Appendix B.

4.2 FINAL COVER EROSION AND PROTECTION

The FCS drainage component and conveyance channels were designed to provide adequate stormwater capacity for a 24 hour, 100-year storm. Most of the precipitation that falls on the site is expected to be managed as surface water run-off. In 2018, P66 designed and installed a stormwater diversion channel around the east side of NHP to route surface water run-on around the NHP to a stabilized discharge (Figures B.VII.A.3-1, B.VII.A.3-2). Additionally, the stormwater channel has the capacity to convey surface water run-off from the NHP once the final cover system is in place. The stormwater channel typical section is shown on Figure B.VII.A.3-2. Several ditch sections will be graded around the west side of the NHP during final closure activities to convey the remaining run-on and run-off away from the FCS (Figures B.VII.A.3-1, B.VII.A.3-2). A typical section is shown on Figure B.VII.A.3-3. Detailed design calculations for the stormwater capacity are included in Appendix C.

4.3 FINAL COVER SYSTEM STABILITY

During hazardous waste stabilization activities completed in 2005 waste materials were mixed with Portland Type I cement, typically 25% by weight. Stabilized waste materials were required to have a minimum Unconfined Compressive Strength (UCS) of not less than 20 pounds per square inch (psi) at 7 days, in accordance with ASTM D2166 (Weston Solutions 2005). The stabilized hazardous waste is unlikely to be significantly further compressed by placement of the FCS.

Since 2005, non-hazardous waste has periodically been placed and graded in NHP. Construction techniques associated with placing waste materials in NHP was generally to compact soils to 80 to 90 percent of the maximum dry density.

Placement and grading of additional waste and fill materials will add weight at the surface and further consolidate the underlying soils. Additionally, storm events from 2005 to 2020 have periodically inundated the NHP. The saturation of the surface and the ponding of water in the area resulted in consolidation of the soils in NHP.

Based on field observation and a review of historic soil testing data at the refinery and the soil index properties in the greater Borger area, it is highly unlikely that soils with shrink/swell related movements would have been deposited in NHP (Phillips 66 1994). Low to Medium plasticity clay, Plasticity Indices between 10 and 15 have been encountered in the general area, but it is more likely that granular soils that are evident throughout the refinery were likely placed in NHP which have very low potential for movement based on the deposition, waste placement techniques, and the fact that granular soil density increases when fine soil particles are placed and then inundated with stormwater.

The previously permitted FCS thickness is approximately 3.75-feet, while the proposed FCS thickness is approximately 13-inches. The reduced proposed FCS profile and associated load will reduce settlement as a result of consolidation of the waste mass. Settlement areas, if they occur, under the proposed FCS will be readily identifiable through visual inspections and easily repaired. Identification of settlement issues associated with final cover systems similar to the previously permitted FCS may not be as readily identifiable as the soil covered geomembrane will bridge areas experiencing differential settlement.

4.4 FINAL COVER SYSTEM MAINTENANCE

Many typical maintenance activities required for the previously permitted FCS would not be necessary for the proposed FCS including mowing, erosion control, reseeding, fertilizing, and major storm repair. For the previously permitted FCS, a soil loss rate of 0.24 ton/acre/year was calculated using the National Resource Conservation Service (NRCS) Revised Universal Soil Loss Equation (RUSLE), Version 2.5.2.11 modeling software (RUSLE2) (Trihydro 2017). The memorandum describing the RUSLE2 modeling results was included in the letter from P66 to Martin Torres dated February 1, 2017 (P66 2017a). The proposed FCS would require sand ballast replacement at a rate of approximately 2% every 5 years according to Watershed Geo, manufacturer of ClosureTurf®. The reduction in activity and equipment on the FCS necessary for soil replacement reduces the chances of equipment damaging the FCS.

The most critical component of ClosureTurf® relative to UV degradation appears to be the exposed HDPE grass blades (Geosyntec 2015). Geosyntec demonstrated that a conservative half-life (synthetic turf grass blades lose 50% of their manufactured tensile strength) of the HDPE grass blades will be on the order of 100 years (Geosyntec 2015). The half-life has a factor of safety of about 2.8 to 4.0 when considering the tensile capacity performance requirements of the HDPE grass blades (Geosyntec 2015). Annual sampling for tensile strength in accordance with ASTM D2256 of the

HDPE grass blades was included in the Post-Closure Plan to verify integrity of the material throughout the post-closure period. A one-time turf replacement cost was also added to the Post-Closure Plan and cost estimate in the event that the synthetic turf loses 50% or more of its tensile strength through the post-closure period.

Wind tunnel testing was performed by Georgia Tech Research Institute (GTRI) to evaluate the required amount of sand ballast for various environmental conditions. The geotextile turf layer of ClosureTurf® is designed to be installed on top of the geomembrane and to remain in place without an anchoring system linking it to the geomembrane below (GTRI 2010). Rather, it relies on the interface friction and sand ballast added on top of the turf to ensure that it remains in place (GTRI 2010). The highest 2-minute wind speed recorded at the Hutchinson County Airport was 55.9 mph in 2013 according to available wind speed data from the National Oceanic and Atmospheric Administration (NOAA) (NOAA 2020). The highest 5-second wind speed recorded at the Hutchinson County Airport was 94 mph in 2013 (NOAA 2020). Data were available for 1999 to 2019. The wind tunnel testing conducted by GTRI demonstrated that the proposed FCS could sustain wind speeds up to 174 miles per hour, significantly higher than historical sustained and peak wind speeds near the NHP.

4.5 FINAL COVER SYSTEM CONSTRUCTION QUALITY ASSURANCE

The FCS is considered to be an engineered containment system as it includes a synthetic geomembrane barrier layer. A CQA plan is provided in Appendix A, with specifications included within. Contract documents, general requirements, and specifications will be prepared and compiled during the bidding phase of the project, prior to construction.

5.0 REFERENCES

Georgia Tech Research Institute (GTRI). 2010. Letter to Michael Ayres, Closure Turf, LCC. Re: Aerodynamic Evaluations of Closure Turf Ground Cover Materials. July 8, 2010.

Geosyntec. 2015. Letter to Jose Urrutia, Watershed Geosynthetics. Re: Literature Review and Assessment of ClosureTurf® UV Longevity. May 15, 2015.

National Oceanic and Atmospheric Administration (NOAA). 2020. Climate Data Online. Available from: https://www.ncdc.noaa.gov/cdo-web/search.

Phillips 66. 1994. Letter to Chris Peckham, Texas Commission on Environmental Quality. Re: Phillips 66 Co. Borger Complex, ISWR No. 30111, North Holding Pond, TNRCC Facility No. 36. January 3, 1994.

Phillips 66. 2017a. Letter to Martin Torres, Texas Commission on Environmental Quality. Re: Closure Plan Alternatives, North Holding Pond, WRB Borger Refinery, Phillips 66, Borger, TX, SWR No. 30111: EPA ID TXD980626774: CN603215997; RN 102495884; CP-50078. February 1, 2017.

Phillips 66. 2017b. Letter to Martin Torres, Texas Commission on Environmental Quality. Re: Transmittal of Permit Application Modification for RCRA Part B Permit and Notification of Maintenance Activities for North Holding Pond (NHP) NOR Unit #36, Phillips 66, Borger Refinery, Hazardous Waste Permit/Compliance Plan No. 50078, Industrial Solid Waste Registration No. 30111. August 14, 2017.

Phillips 66. 2020. Letter to Karen Scott, Texas Commission on Environmental Quality. Re: Transmittal of Class 3 Permit Modification Application Phillips 66, Borger Refinery, Hazardous Waste Permit No. 50078, EPA ID # TXD980626774, Solid Waste Registration No. 30111. January 31, 2020.

Texas Commission on Environmental Quality (TCEQ). 2017a. Letter to Ben Elliott, Phillips 66 Company. Re: North Holding Pond Closure Cost Alternatives, Phillips 66 - Borger, Hazardous Waste Permit/Compliance Plan No. 50078, Industrial Solid Waste Registration No. 30111, EPA Identification No. 21381125; RN 102495884/CN603215997. April 26, 2017.

TCEQ. 2017b. Letter to Justin Evans, Phillips 66. Re: Transmittal of Class 1 Permit and Compliance Plan Modification, Phillips 66 Company, Borger Refinery – Borger, Hutchinson County, Texas, Hazardous Waste Permit/Compliance Plan No. 50078, Industrial Solid Waste Registration No. 30111, EPA Identification No. TXD980626774, Tracking No. 21896851; RN102495884/CN604065912. October 25, 2017.

Trihydro Corporation (Trihydro). 2017. Memorandum to Ken Schreuder, Soil Loss Analysis (RUSLE2), North Holding Pond Closure, Phillips 66 Borger Refinery. Borger, Texas. January 27, 2017.

Weston Solutions. 2005. Stabilization Report, North Holding Pond, ConocoPhillips Borger Refinery. Borger, Texas. January 2005.

APPENDIX A

CONSTRUCTION QUALITY ASSURANCE PLAN

CONSTRUCTION QUALITY ASSURANCE PLAN

PHILLIPS 66 NORTH HOLDING POND CLOSURE

BORGER, TEXAS

PERMIT NO. HW-50078

May 18, 2020

Project #: 42M-002-008

SUBMITTED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

ENGINEERING SOLUTIONS. ADVANCING BUSINESS.

Table of Contents

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

List of Tables

List of Appendices

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

Phillips 66 Company (Phillips 66, CN601491608) operates the Borger Refinery (RN102495884), which is owned by a joint venture between Phillips 66 (P66) and Cenovus called WRB Refining LP (WRB, CN603215997). The North Holding Pond (NHP) is a 3.4-acre surface impoundment with a liner system consisting of 3-feet of bentonite amended clay, leak detection system, and 100-mil high-density polyethylene (HDPE) liner. The NHP is in partial closure in accordance with the 1998 closure plan. The free liquid has been removed and the sludge has been stabilized. The impoundment is now being filled with non-hazardous waste. The partial closure permit modification was approved by the Texas Commission of Environmental Quality (TCEQ) on April 21, 2004.

The NHP is nearing its permitted waste capacity, thus P66 is planning to close the NHP as required under TCEQ Permit Number HW-50078.

Closure construction will consist of placing unclassified fill; preparing a subgrade for the final cover liner system; construct a composite liner system consisting of 12 inches of compacted soil liner and a Geosynthetic Clay Liner (GCL) for the barrier layer; a geomembrane barrier with an integrated drainage layer; and, a engineered synthetic turf with sand ballast (ClosureTurf®).

1.2 PURPOSE

The purpose of this Construction Quality Assurance (CQA) Plan is to provide a detailed guidance document for systematic and thorough CQA verification procedures which will typically be implemented during construction of the NHP final closure. This plan provides general and specific requirements of the overall CQA program to verify and document that construction is in substantial compliance with the contract documents and the design intent. Requirements of the CQA program include the following:

1. Review of product submittals to verify construction materials are in compliance with the technical specifications.
2. Product quality assurance verification testing to verify all construction materials are in compliance with the technical specifications.
3. Construction monitoring and documentation to verify each unit of construction is in compliance with the technical specifications and construction was executed correctly using industry standard construction methods and the proper materials.

4. Construction verification testing to verify each installed or constructed unit of the closure system is in compliance with the technical specifications.
5. CQA documentation consisting of daily summary reports, CQA field logs, testing forms and reports, installation logs, document control binders, material control logs, photographic documentation, technical revisions, design modifications, as-built record drawings, and corrective action determination and verification reports.
6. Preparation of the final certification report that documents the CQA program implemented during construction and that landfill construction was completed in compliance with the contract documents and the design intent. The final Soil Liner Evaluation Report (SLER) and Geomembrane Liner Evaluation Report (GLER) will be submitted to the TCEQ at the completion of construction.

1.3 PROJECT ORGANIZATION

1.3.1 OWNER

The owner is P66 and is responsible for communicating with the CQA Organization and the TCEQ. The owner will request assistance from the CQA Organization and design engineer to resolve technical or regulatory issues during construction. The Owner is responsible for complying with TCEQ regulatory requirements.

1.3.2 DESIGN ENGINEER

The design engineer is responsible for landfill design and site engineering related to the design. Site engineering includes; 1) review and approval of product and construction submittals required by the contract documents, 2) technical issues related to construction, 3) interpretation of the technical specifications and the construction drawings, and 4) design modifications and technical revisions to the contract documents.

1.3.3 CQA CERTIFYING ENGINEER

The CQA Certifying Engineer is responsible for certifying to the Owner and the TCEQ that landfill construction is in compliance with the contract documents and the design intent. Specific responsibilities of the certifying engineer include; 1) providing a professional engineer registered in the State of Texas, 2) verification that all CQA procedures are correctly and completely implemented, 3) review of all CQA documentation, and 4) preparation of the SLER and GLER report.

1.3.4 CQA ORGANIZATION

The CQA Organization is the firm responsible for the overall construction quality assurance of the project.

1.3.5 GENERAL CONTRACTOR

The general contractor will be responsible for overall performance of the work in accordance with the contract documents and as shown on the construction drawings.

1.4 CQA PLAN FORMAT

This CQA Plan format organizes all necessary CQA verification procedures for each unit of construction, as defined by the technical specifications, into individually complete sections. This plan is presented as follows:

1. Sections 1.0 through 6.0 presents general information about the construction project and the general requirements of the CQA program.
2. Sections 7.0 through 13.0 includes written instructions and directions for the CQA Organization and provides detailed and specific CQA procedures to be implemented for each unit of closure construction as it relates to site work.

2.0 GENERAL REQUIREMENTS

2.1 SECTION SUMMARY

General requirements of the CQA program include:

1. Product quality assurance verification testing
2. Construction monitoring
3. Construction verification testing
4. Project meetings
5. Submittal review
6. Documentation

2.2 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

Products and material sources will be sampled and tested to verify compliance with the technical specifications. Testing requirements, methods and sampling frequencies are specified for each work element described in this plan. All material samples will be recorded into appropriate Testing Control Logs, assigned sample numbers, and processed by the CQA Organization for either on-site or off-site testing.

Testing Control Logs document the following:

1. Sample numbers
2. Product or material types
3. Required testing
4. Sampling locations and dates
5. Testing completion dates
6. Brief summary of the testing results

Each material sampled and tested will be archived on site for a period of one year. Archived samples will be stored and sealed in plastic containers tagged with:

1. Sample number
2. Product or material type

3. Project name and number
4. Date for discarding the sample

The following products or materials require quality assurance verification testing.

1. Earth fill for unclassified fill
2. Liner system subgrade
3. Low-permeability compacted soil liner
4. Geosynthetic clay liner (GCL)
5. Structured geomembrane barrier and drainage layer
6. ClosureTurf® synthetic turf
7. Sand ballast layer

A recommended schedule of testing frequencies is discussed in later sections of this plan.

2.3 CONSTRUCTION MONITORING

The closure will be monitored and documented to verify compliance with the technical specifications and that construction was executed correctly using industry standard construction methods and the proper materials. Monitoring guidelines and procedures are specified for each work element section in this plan.

2.4 CONSTRUCTION VERIFICATION TESTING

Construction verification testing will be performed on installed or constructed components of the final cover system to verify compliance with the technical specifications. Construction verification testing will be performed by either the Contractor or the CQA Organization, as required by this plan. Construction verification testing includes the following:

1. Permeability of fine-grained soils.
2. Nuclear density and moisture content of in-place unclassified fill and soil liner.
3. In-place density by the drive-cylinder method to verify nuclear density/moisture testing gauge (densometer) is providing accurate results.
4. Geomembrane seam analysis.
5. Air pressure testing of fusion welded geomembrane seams.

6. Vacuum testing of extrusion welded geomembrane seams and repairs.
7. Sand ballast material classification and gradation.

A recommended schedule of testing frequencies is discussed later in this plan.

2.5 PROJECT MEETINGS

Project meetings will be held in accordance with Section 4.0 of this CQA Plan.

2.6 SUBMITTAL REVIEW

Submittal review will be completed in accordance with Section 5.0 of this CQA Plan.

2.7 DOCUMENTATION

Documentation will be completed in accordance with Section 6.0 of this CQA Plan.

3.0 REFERENCES

3.1 SECTION SUMMARY

Section 3.1 provides an overview of the following references:

1. Project reference documents
2. Industry standards and technical reference documents
3. Soils testing standards and methods
4. Standard Operating Procedures (SOP) for soils testing
5. Geosynthetics testing standards and methods

3.2 PROJECT REFERENCE DOCUMENTS

The project manual and construction drawings provide background, design, and contractual information, and are used in conjunction with this CQA Plan.

3.3 INDUSTRY STANDARDS AND TECHNICAL REFERENCE DOCUMENTS

The following industry standards and technical reference documents were used in the preparation of this CQA Plan.

1. ASTM Standards and Other Specifications and Test Methods on the Quality Assurance of Landfill Liner Systems. American Society for Testing and Materials. 1994.
2. EPA Technical Guidance Document, Quality Assurance and Quality Control for Waste Containment Facilities. United States Environmental Protection Agency. 1993.
3. Standard Specifications for Transportation Materials and Methods of Sampling and Testing. American Association of State Highway and Transportation Officials (AASHTO). 1987.

3.4 SOILS TESTING STANDARDS AND METHODS

Soils testing standards and methods which apply as referenced in the technical specifications and this CQA Plan are provided in Table 1.

3.5 STANDARD OPERATING PROCEDURES FOR SOILS TESTING

The CQA Organization will perform soils testing on site during construction. The CQA Organization, or their laboratory subconsultant's, Standard Operating Procedures (SOP) for soils testing will be maintained on-site for reference and written direction.

3.6 GEOSYNTHETICS TESTING STANDARDS AND METHODS

Geosynthetics testing standards and methods listed in Table 2 apply as referenced in this CQA Plan.

4.0 PROJECT MEETINGS

4.1 SECTION SUMMARY

Communication and coordination between the Owner, Design Engineer, Contractor, and CQA Organization are important to achieve quality construction. To establish successful communications, coordination, and an overall environment of teamwork, a series of project meetings will be held. The meetings will be administered by the Owner, Design Engineer, or CQA Organization to 1) clearly define responsibility and authority of each organization involved in the project, 2) resolve communication problems, misunderstandings, and misinterpretations, 3) find solutions to unanticipated developments, and 4) to identify, prevent and correct problems and deficiencies that may occur during the construction process. Project meetings include the following:

1. Pre-construction Meeting
2. Progress Meetings
3. Preparatory Meetings

4.2 PRECONSTRUCTION MEETING

The Owner will schedule the pre-construction meeting after the construction contract is awarded and the major subcontractors and material suppliers have been established. The CQA objectives of this meeting are to 1) clearly define the roles, responsibility and authority of each organization and individual involved in the project, 2) review details of the CQA program and expectations, and 3) establish a foundation of cooperation to achieve quality construction. The CQA Organization will address the following agenda:

1. Distribution of this CQA Plan
2. Introduction, role, authority, and responsibilities of each organization and individual involved in the project
3. Establish lines of communications
4. Design review in coordination with the Design Engineer
5. Construction schedule
6. Contractor’s QC procedures and responsibilities
7. Submittal review and approval procedures
8. Non-conformance and corrective action procedures
9. Construction restrictions due to weather conditions
10. Weekly progress and preparatory meetings

Meeting minutes and items for resolution will be recorded by the Owner's Representative and distributed to all parties in attendance.

The following representatives from each organization are required to attend the pre-construction meeting.

1. Owner's Project Manager
2. Design Engineer
3. Contractor's Project Manager and on-site Superintendent
4. CQA Organization's CQA Officer
5. Representatives from the local and state regulatory agencies are encouraged to attend the meeting

4.3 PROGRESS MEETINGS

The Owner will schedule and administer weekly (or other period) progress meetings. The CQA objectives of these meetings are to 1) maintain lines of communication, 2) review procedures and results of the CQA program, and 3) maintain and improve the established foundation of cooperation to achieve quality construction. The CQA Organization will address the following agenda:

1. Review minutes relevant to CQA of previous progress meeting
2. Review work progress
3. Review and update construction schedule. Obtain projected schedule for the next 2 weeks from Contractor
4. CQA and QC related field observations, problems, decisions, and conflicts
5. Presentation of CQA verification testing results
6. Review and up-date Submittal Log in coordination with the Design Engineer and Contractor
7. Coordination of projected work progress
8. Maintenance of quality and work standards
9. Acknowledgments and recognition of quality construction practices and QC procedures

Meeting minutes and items for resolution will be recorded by the Owner and distributed to all parties in attendance. The following representatives from each organization are required to attend the weekly progress meetings:

1. Owner's Project Manager
2. Design Engineer
3. Contractor's on-site Superintendent
4. CQA Organization's CQA Manager

4.4 PREPARATORY MEETINGS

In coordination with the Design Engineer, the CQA Organization will schedule and hold informal preparatory meetings prior to the following units of construction:

1. Embankment operations
2. Landfill subgrade preparation
3. Low-perm soil liner construction and/or geosynthetic clay liner installation
4. Geomembrane installation
5. ClosureTurf® installation
6. Sand ballast installation
7. Perimeter stormwater control structure construction
8. Anchor trench construction

The CQA objective of these preparatory meetings is to establish a thorough understanding of the upcoming unit of construction and of the CQA procedures and testing that will be implemented during construction. To achieve this objective, the CQA Organization's CQA Officer will address the following agenda:

1. Review materials needed for the work and the product section of the technical specifications
2. Review the construction requirements section of the technical specifications
3. Review construction staking and grade control staking needed to complete the work
4. Review test records and Contractor's quality control test procedures
5. CQA test procedures
6. Review required submittals
7. Coordination, scheduling, and sequencing of the work
8. Equipment and manpower

Meeting minutes will be recorded by the CQA Organization and distributed to the Owner and all parties in attendance.

The following representatives from each organization are required to attend the preparatory meetings.

1. Contractor's on-site Superintendent
2. Subcontractors as appropriate to the work
3. CQA Organization's CQA Officer and CQA Monitor(s)

5.0 SUBMITTALS

5.1 SECTION SUMMARY

This section describes methods and procedures required during the submittal review process for the following:

1. Submittal Control Log
2. Submittal review procedures

5.2 SUBMITTAL CONTROL LOG

A Submittal Control Log will be prepared by the CQA Organization that will list all submittals required by the technical specifications. The Submittal Control Log will be issued to the Contractor and will be maintained by the CQA Organization in coordination with the Contractor and Design Engineer during construction. The control log documents:

1. Submittal numbers
2. Referenced specification sections
3. Submittal descriptions
4. Received dates
5. Reviewer
6. Action taken determinations
7. Return dates

5.3 SUBMITTAL REVIEW PROCEDURES

Two copies of each submittal listed in the Submittal Control Log or, if mutually approved, an electronic submittal will be submitted by the Contractor in accordance with the technical specifications. The submittals will be forwarded to the Design Engineer for review. The CQA Organization may perform a preliminary review of submittals for compliance with the technical specifications and issue a verbal *Approval for Use* at the recommendation of the Design Engineer. The CQA Organization will notify the Design Engineer that no corrective action determinations were required prior to issuing a verbal *Approval for Use*. All submittals not in compliance with the technical specifications must be immediately forwarded to the Design Engineer for review and corrective action determinations.

At the completion of the review process the Design Engineer will stamp both copies of each submittal with *Action Taken* determinations. The *Action Taken* determinations and the return dates will be recorded on the Submittal Control Log. One copy of the reviewed submittal will be returned to the Contractor, one copy will be archived in the submittal documentation control binder.

The CQA Organization will review and up-date the Submittal Control Log in coordination with the Contractor and Design Engineer at the weekly progress meetings.

The CQA Organization will inspect materials delivered to the site to verify these materials are the same as what was approved in the submittal process. When material is delivered it will be placed in administrative hold until inspected and approved for use by the CQA Organization. Material different than what was included in the submittal process will subject to corrective action, as discussed in Section 6.6.

6.0 DOCUMENTATION

6.1 SECTION SUMMARY

This section of the CQA Plan summarizes the following documentation required during the project:

1. Daily summary reports
2. CQA field logs
3. Construction and testing forms
4. Testing reports
5. Corrective action determination and verification reports
6. As-built record drawings
7. Photographic documentation
8. Documentation control
9. Final certification report
10. Documentation archive storage

6.2 DAILY SUMMARY REPORTS

A computer generated summary report will be prepared daily by the CQA Organization. This report will summarize all construction activities, CQA verification procedures, CQA testing, and QC testing completed during the day. The daily summary report will contain the following information:

1. Title block containing; 1) project name, 2) project number, 3) project location, 4) Owner, 5) date, and 6) summary report number.
2. Description of weather conditions including low and high temperature readings, cloud cover, and precipitation.
3. Summary of the day's on-going construction activities for each unit of construction. This summary will also include equipment, personnel, and subcontractors utilized for each unit of construction and identification of areas in which the construction is taking place.
4. Summary of CQA verification procedures implemented during the day's construction for each unit of construction. This summary will include construction monitoring, construction verification testing, and quality control procedures.

5. Summary of CQA product verification testing and presentation of testing results.
6. Summary of any project meetings or pertinent discussions including list of attendees, action items and resolutions.
7. Areas of non-conformance for substandard work and corrective action measures.
8. Summary of materials received and accompanying QC documentation provided by supplier.
9. If necessary, attachments of cross-referencing CQA field logs, construction and testing forms, testing reports, and corrective action reports to substantiate any corrective action determinations or CQA decisions.
10. Record of site visitors.
11. Signature of CQA Officer.

Daily summary reports will be submitted to the Owner on a daily basis and to the Design Engineer on a weekly basis.

6.3 CQA FIELD LOGS

CQA Monitors will maintain individual field logs issued by the CQA Officer. Each field log is assigned a unique cross-referencing number and will contain daily entries of the CQA Monitor. The CQA Monitors will provide a written chronological framework of construction activities, construction monitoring, construction testing, production verification testing, and quality control procedures performed during the day in the area of the monitor's responsibility. CQA Monitor's field log entries will be addressed by the CQA Officer in the daily summary report.

CQA field logs will be submitted to the CQA Officer on a daily basis for preparation of the daily summary report and may be reviewed by the Design Engineer on a weekly basis.

6.4 CONSTRUCTION AND TESTING FORMS

Construction activities, CQA procedures, laboratory testing, and construction testing will be recorded on appropriate construction and testing forms. The following construction and testing forms typically are issued by the CQA Officer:

1. Soil Testing Forms
    a. Soils Testing Control Log
    b. Soils Test Request - Sample Custody Log
    c. Sieve Analysis of Granular Soils
    d. Nuclear Density/Moisture Tests
    e. Moisture Content of Soils

2. Geosynthetics Forms
    a. Geosynthetics Testing Control Log
    b. Geosynthetics Delivery and Control Log
    c. Geosynthetics Test Request – Sample Custody Log
    d. Geomembrane Deployment/Seaming Log
    e. Geomembrane Repair Log

Completed construction and testing forms will be submitted to the CQA Officer for review on a daily basis and will be addressed by the CQA Officer in the daily summary report.

6.5 TESTING REPORTS

Testing reports may be issued by independent testing laboratories contracted by the CQA Organization to perform various product verification and construction testing.

Testing reports will be addressed within one day of receipt by the CQA Officer in the daily summary report.

6.6 CORRECTIVE ACTION DETERMINATION AND VERIFICATION REPORTS

Corrective action determination and verification reports will be issued to the Contractor by either the Design Engineer or the CQA Officer for construction or materials not in compliance with the technical specifications or for defective workmanship or materials, even if there is compliance with the technical specifications. Corrective action determination and verification reports will contain the following information:

1. Title block containing; 1) project name, 2) project number, 3) project location, 4) Owner, 5) date, and 6) Corrective action determination and verification report number.
2. Location and description of the problem area or corrective action determination.
3. If necessary, attachments of cross-referencing CQA field logs, construction and testing forms, testing reports, supporting sketches, and photographs to describe and substantiate the corrective action determination.
4. If necessary, additional testing required to determine the extent of corrective action measures.
5. Corrective measures necessary to correct the area of construction or material to compliance with the technical specifications as determined by the Engineer or CQA Officer.

6. Corrective action measures implemented and verification of these measures. Additional verification testing performed to verify compliance with the technical specifications.

7. If necessary, attachments of cross-referencing CQA field logs, construction and testing forms, testing reports, supporting sketches, and photographs to describe and verify the corrective action measures taken.

8. Signature of the issuing Design Engineer or CQA Officer and follow-up signature verifying corrective measures taken.

6.7 AS-BUILT RECORD DRAWINGS

As-built record drawings will be maintained by the Contractor and will be reviewed and verified by the CQA Organization. The record drawings will show actual as-built conditions of landfill construction and will adequately reflect that construction is in substantial compliance with the design intent. Irrelevant deviations in actual construction that do not substantially affect the design intent may not be incorporated into the record drawings, but they will be addressed in the final certification report. Record drawings will be prepared during the construction process by making modifications and red-line markups as they occur to a single set of construction drawings designated as the *"Site As-built Record Drawings."* At the completion of construction, the CQA Organization, in coordination with the Design Engineer, will incorporate all as-built conditions into the *"Final As-built Record Drawings."* The final record drawings will contain revision numbers and dates, review signatures of the Design Engineer and CQA Officer.

The Owner is required by the technical specification to perform as-built surveys and provide record drawings for the following units of construction:

1. Limits, contours, and grade breaks of landfill subgrade and final grades and establishment of 50-foot grid points for soil liner thickness verification.

2. Limits, contours, and grade breaks of soil liner and final grades and layer thickness verification at 50-ft grid points.

3. Limits of geomembrane installation.

4. Contours and grade breaks of borrow area excavation and stockpiles at 100-foot stations (x,y,z) and angle points.

These additional survey records will be incorporated into the final set of record drawings.

6.8 PHOTOGRAPHIC DOCUMENTATION

All construction activities will be continually photographed to clearly show and define construction methods and as-built conditions of completed units of construction. Photographs will include:

1. Product or material sources and stockpiles
2. In progress construction methods for each unit of construction
3. Completed units of construction
4. Damaged, rejected, or substandard units of construction
5. In progress corrective action measures to rectify damaged, rejected, or substandard units of construction
6. Completed units of construction as the result of corrective action measures
7. Design modifications

Photographs will be identified by number, date, and time of the photograph. The CQA Organization will maintain a cross-referencing photographic log documenting the subject matter of each photograph.

6.9 DOCUMENTATION CONTROL

Complete documentation of construction and the CQA program will be controlled and secured in an electronic file management system maintained at the site by the CQA Organization and shared with the Owner and Design Engineer. This documentation control structure organizes and indexes all construction and CQA documents and is intended to allow easy access to all documents for review and audit by the Owner, Design Engineer, or regulatory agencies. The following is a preliminary list and contents of the *CQA Documentation* established by the CQA Organization.

1. Title: Project Administration Documentation.
   - Progress meeting minutes, preparatory meeting minutes, Owner correspondences, Design Engineer correspondences, Contractor correspondences, CQA Organization correspondences, and miscellaneous correspondences.
2. Title: CQA Daily Summary and Contractor Field Reports.
   - Daily summary reports prepared by the CQA Officer and CQA Monitors and field reports prepared by the Contractor dated from the beginning of the project to the completion of the project.
3. Title: Submittals.
   - Submittal Control Log, submittal transmittal cover sheets, and all reviewed submittals required by the technical specifications.

4. Title: Soils CQA.
   - Soils Testing Control Log, moisture content test results, moisture-density relations test results, permeability test results, sieve analysis results, nuclear density test results, cylinder-drive density test results, Atterberg Limits results, soil analysis results, summary of laboratory testing, and summary of nuclear density testing.
5. Title: Geosynthetics CQA.
   - Geosynthetics Testing Control Log, Installer daily field reports, geomembrane test reports, geotextile test reports, geomembrane seam analysis results, panel layout drawings, geosynthetics delivery and control logs, subgrade acceptance forms, geomembrane deployment/welding logs, and geomembrane repair logs.
6. Title: Project Manual and CQA Plan.
   - Project Manual and CQA Plans.
7. Title: Photograph Log.
   - Construction and CQA photographs and cross-referencing photographic log.

6.10 FINAL CERTIFICATION REPORT

At the completion of the project, the Design Engineer and the CQA Organization will prepare the final SLER and GLER. The reports will consist of information and data generated by the CQA program and will document that landfill construction is in compliance with the contract documents and the design intent. At a minimum, the report will contain the following information:

1. Summary of construction methods for each unit of construction completed.
2. Summary of the CQA program implemented during construction and specific CQA verification procedures for each unit of construction completed.
3. Results of product quality assurance verification testing and construction testing.
4. Design modifications and technical revisions to the contract documents.
5. Final as-built record drawings.
6. Statement of compliance.
7. Signature and stamp of the Certifying Engineer.

6.11 DOCUMENTATION ARCHIVE STORAGE

At the completion of the project and following submittal of the final certification report, all original documentation generated by construction and by the CQA program will be archived at the on-site offices of the Owner with duplicate copies stored at the home offices of the CQA Organization.

7.0 UNCLASSIFIED FILL CQA

7.1 GENERAL

7.1.1 SECTION SUMMARY

CQA monitoring, verification procedures, and testing to verify unclassified fill materials and construction methods are in compliance with the technical specifications.

7.2 PRODUCTS

7.2.1 EARTHFILL

Unclassified fill material will be obtained from the on-site borrow area and will meet the following product requirements:

1. Free of organic, saturated, oversized, or other unsuitable materials.
2. Free of frost, ice or snow.
3. Free of contaminants.
4. Maximum particle size of four (4) inches, unless otherwise approved by Design Engineer.

7.2.2 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

Verify that unclassified fill materials are free of organic, saturated, frozen, deleterious, oversized, and other unsuitable materials by performing frequent visual examinations of the material as the material is being excavated from the borrow area.

Perform moisture-density relations (ASTM D 698) testing to determine the maximum dry density and optimum moisture content for each material type used as unclassified fill at frequencies provided in Table 3.

7.3 EXECUTION

7.3.1 CONSTRUCTION AND CQA PREPARATION

Prior to fill operations, perform the following CQA verification procedures.

1. Hold a preparatory meeting in accordance with Section 4.4 of this CQA Plan.
2. If necessary, verify erosion control measures are in place.

3. Verify measures are implemented to protect utilities, temporary benchmarks, and existing structures from damage.
4. Verify base survey is performed on site borrow area (stockpile) for computation of measurement and payment quantities prior to and after embankment operations. Verify borrow area (stockpile) is graded with uniform lines and grades to provide accurate measurement and payment survey.
5. Verify construction and grade control staking.

7.3.2 UNCLASSIFIED FILL CQA MONITORING AND TESTING

To verify compliance of unclassified fill operations with the technical specifications, perform the following CQA verification procedures:

1. Verify fills are placed to the limits, lines and grades as shown on the Drawings.
2. Verify excavated soils not intended or used as fill material are removed and stockpiled.
3. Verify fill material is keyed into subgrade as shown on the Drawings.
4. Verify fill materials are placed and compacted in loose lifts not exceeding 8 inches.
5. Verify the top of each lift is scarified prior to placing subsequent lifts. If a sheepsfoot or pad-foot compactor is used for compaction, scarifying may not be required subject to Design Engineer approval.
6. Verify unclassified fill lift surfaces are maintained to prevent moisture loss and desiccation cracking. Verify repair of desiccated areas prior to placement of subsequent lifts.
7. Perform nuclear density-moisture testing (ASTM D 6938) to verify fill materials are moisture conditioned and compacted to the values specified in the technical specifications. Perform tests every 500 cubic yards of in-place material. (Refer to Earthworks Schedule of Testing Frequencies presented in Table 3).
8. Perform one drive-cylinder density test (ASTM D 2937) for every 30 nuclear density-moisture tests to verify nuclear density gauge is providing accurate results. (Refer to Earthworks Schedule of Testing Frequencies presented in Table 3).

7.3.3 FINAL SURFACE PREPARATION CQA MONITORING

In order to verify compliance of final surface preparation operations with the technical specifications, perform the following CQA verification procedures:

1. Verify that all debris and protrusions greater than 1-inch are pressed into or removed from the final subgrade.
2. Verify final surface is graded to lines and grades shown on the construction drawings and are final graded to a tolerance of ±0.10-foot of design grade at.
3. Verify the completed surface is finished with a pneumatic steel drum compactor. Verify removal of ridges gouges, and ruts greater than 1-inch.
4. Verify moisture conditioning of completed surface as necessary.

7.3.4 BORROW AREA CQA MONITORING

To verify compliance of borrow area excavation operations with the technical specifications, perform the following CQA verification procedures:

1. Verify excavation of borrow area with sides slopes no steeper than 2H:1V.
2. Verify borrow area is maintained with positive drainage patterns directed away from borrow area.
3. Verify borrow area is watered as necessary for dust control.
4. Verify borrow area is graded with uniform lines and grades to provide accurate measurement and payment survey.
5. Verify final borrow area is restored and graded with grades directed to provide positive drainage patterns surrounding the completed borrow area.
6. Verify final surface is track-walked with dozer cleat marks running perpendicular to the slope.

8.0 LANDFILL SUBGRADE PREPARATION CQA

8.1 GENERAL

8.1.1 SECTION SUMMARY

CQA monitoring procedures to verify subgrade preparation operations are in compliance with the technical specifications. Landfill subgrade preparation includes:

1. Grading landfill subgrade
2. Removal and disposal of excavated waste material
3. Final surface preparation

8.2 PRODUCTS

8.2.1 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

Perform moisture-density relations (ASTM D 698) testing on a 5-gallon sample to determine the maximum dry density and optimum moisture content for each subgrade material as described in Table 3.

8.3 EXECUTION

8.3.1 CONSTRUCTION AND CQA PREPARATION

Prior to landfill subgrade preparation operations, perform the following CQA verification procedures:

1. Hold a preparatory meeting in accordance with Section 4.4 of this CQA Plan.
2. If necessary, verify erosion control measures are in place.
3. Verify measures are implemented to protect utilities, temporary benchmarks, and existing structures from damage.
4. Verify construction and grade control staking.
5. Verify dust control operations are available.
6. Verify traffic control and barricades are coordinated with Owner.
7. Verify operations and haul routes are coordinated with landfill operations.
8. Verify subgrade underdrain pipes (if required) are placed along toe before placing subgrade unclassified fill.
9. Verify unclassified fill is placed in accordance with the technical specifications.

10. Verify as-built survey of completed landfill subgrade is performed and provided in accordance with the technical specifications. As-built survey must be completed prior to geosynthetic installations.

8.3.2 CQA MONITORING

To verify compliance of landfill subgrade preparation operations with the technical specifications, perform the following CQA verification procedures:

1. Verify landfill subgrade is graded to provide smooth uniform surface.
2. If necessary, verify removal of excavated waste materials and disposal of in active landfill.
3. Verify removal of all debris, rocks greater than four (4) inches in diameter, and all protruding wood and metal from the completed surface.
4. Verify dust control measures are implemented when necessary.
5. Verify final surface is graded to the lines and grades shown on the Drawings and to a tolerance of ± 0.10-foot of design grade.
6. Verify the completed surface is finished with a pneumatic steel drum roller. Verify removal of ridges gouges, and ruts greater than 2-inches.
7. Verify moisture conditioning of completed surface as necessary.

9.0 SOIL LINER CQA

9.1 GENERAL

9.1.1 SECTION SUMMARY

This section summarizes the following CQA procedures:

1. CQA assistance, monitoring procedures, and testing during soil liner test pad construction.
2. CQA monitoring procedures and testing to verify soil liner materials and construction methods are in compliance with the technical specifications.

9.1.2 SOILS INVESTIGATION OF EXISTING CLAY SOURCES

The Owner will perform investigations and testing on soil liner material from the on-site borrow source to determine its acceptability as a low-perm soil component of the composite liner system. In the event the source does not meet product specifications for soil liner, the owner will conduct laboratory testing to determine the amount of bentonite addition required to meet the specified hydraulic conductivity.

A “Zone of Acceptable Compaction” establishes a relationship of in-place dry density and moisture content that achieves the specified permeability of the soil liner. The “Zone of Acceptable Compaction” is for guidance only, passing criteria for the in-place soil liner is permeability.

9.1.3 SOIL LINER TEST PAD CONSTRUCTION

The Contractor is required to construct a soil liner test pad prior to actual construction of the soil liner in the landfill cell. The intent of the test pad is to simulate construction of the actual soil liner, including processing, moisture conditioning, lift thickness, placement, grading, compaction efforts, and finishing operations. The intent of the test pad is to also verify that requirements of the technical specifications can be met.

9.1.4 SUBMITTALS

Review the following submittal that was due with the Contractor’s with bid.

1. List of proposed equipment and description of construction methods to excavate, moisture condition, haul, place, compact, finish, maintain, and protect soil liner in accordance with the technical specifications.

2. Bentonite technical data including:

    - The type and origin of the bentonite (natural sodium, sodium enriched, or calcium bentonite)
    - The montmorillonite content
    - The content of materials other than montmorillonite
    - The presence or absence of polymers or additives

9.2 PRODUCTS

9.2.1 SOIL LINER MATERIAL VERIFICATION TESTING

Perform the following product verification testing, and as summarized in Table 4, prior to and during test pad construction and actual soil liner operations:

1. Moisture-density relation checkpoints to verify materials correspond with the established "Zone of Acceptable Compaction" and to detect any changes in the consistency of the soil liner material. Perform checkpoints for each material type and at a minimum of one test per each lift.
2. Particle size analysis and hydrometer to verify product gradation requirements of the technical specifications. Perform size analysis and hydrometer for every 1,850 yd^3 of material used to construct the soil liner.
3. Atterberg Limits to verify plasticity index. Perform Atterberg Limits for every 1,850 yd^3 of material used to construct the soil liner.
4. Continually examine soil liner materials to verify materials contain no organic, saturated, oversized, or other unsuitable materials.

9.3 EXECUTION

9.3.1 SOIL LINER MIXING

The soil liner material will be spread in a controlled manner to achieve uniform thickness in a pre-determined mixing location. The bentonite will be applied at a rate equivalent to the percent of bentonite (by dry weight) determined as part of project specific testing prior to liner construction. The bentonite spreader should be equipped with an electronically variable mechanical or weight-controlled spreader allowing an application accuracy of 0.01 pounds per square foot. The CQA Organization will monitor the bentonite deposited over a known area to verify the bentonite application rate. A road reclaimer (CAT RM300 or Design Engineer approved equivalent) will be used to mix the bentonite with the soil using the number of passes determined in the test pad. Controls should be established so the mixing depth does not exceed the lift thickness to prevent mixing the underlying layers. The first three passes will be conducted without adding water. Water may be added after the initial three passes. Once the soils are mixed with bentonite, the soil-bentonite mixture will be hydrated to within 2% of the optimum moisture content and allowed to hydrate for 24 hours prior to placement as liner. Water required to achieve the specified water content may be added to the soil during liner placement and compaction.

Upon completion of mixing operations, the soil liner will be hauled to the test pad and the CQA organization will conduct the CQA activities as described below.

9.3.2 TEST PAD CONSTRUCTION CQA

Verify Contractor schedules test pad construction a minimum of 14 days prior to actual soil liner construction. The test pad will be constructed utilizing the intended mixing, lacing and compaction machinery. The test pad will be designed to provide the following information:

1. Suitability of the mixing method and mixture composition (does not apply to on-site soils which meet soil liner requirements).
2. The ability of the specified soil-bentonite admixture to achieve the permeability requirement.
3. The suitability of the method of placement and compaction requirements to achieve the permeability requirements.
4. Recommendations for the operation and management of the chosen mixing and water addition techniques.
5. Recommendations for the compaction of the liner, including the thickness of each lift, the weight and type of compaction equipment, and minimum number of passes required to achieve the compaction specification.

During test pad construction document the following:

1. Every equipment type and size utilized by the Contractor to haul, place, moisture condition, aerate, compact, grade, and finish the soil liner.
2. Every equipment type and size utilized by the Contractor to place and incorporate bentonite.
3. Moisture conditioning and aeration procedures.
4. Lift thickness prior to and after compaction.
5. Lift bonding procedures.
6. Overall description and chronological framework of construction activities.

Test pad will consist of a minimum 2-foot thick fill of soil liner material. At a minimum, CQA verification of the test pad should include:

1. Verify the test pad is constructed with a top deck of 25-feet wide by 50-foot long, and provides 4H:1V ramps onto and off the pad along the width of the pad.
2. Verify soil liner materials are not contaminated with any other soil materials.
3. Verify test pad is constructed in accordance with the technical specifications. At a minimum, the final 2-foot thick soil liner should have 4 separate compacted lifts but may require 8 or more to achieve the required hydraulic conductivity.
4. Perform the product verification testing outlined in Section 9.2.1 of this CQA Plan and the following construction testing. Work closely with the Contractor in providing accurate and timely testing data. The Contractor will rely heavily on the data provided to adjust or modify the construction methods necessary to achieve the required hydraulic conductivity.
5. Perform nuclear density and moisture content on each compacted lift will be conducted to verify the relative compaction is within the established "Zone of Acceptable Compaction". Perform oven-dried moisture content testing at every nuclear test location to correct nuclear moisture content readings.
6. Conduct in-place density by the drive-cylinder method to verify the nuclear density gauge is working properly and is providing reliable testing results.
7. Perform hydraulic conductivity on undisturbed samples obtained from each compacted lift to verify the hydraulic conductivity of the in-place soil liner.
8. Provide Design Engineer with documentation of test pad construction equipment and methods, product verification testing results, and construction testing results. The Design Engineer will review the results of test pad construction and testing and may modify the construction requirements and testing criteria specified in the technical specifications for actual construction of the soil liner.

9.3.3 SOIL LINER CONSTRUCTION AND CQA PREPARATION

Prior to soil liner construction, perform the following CQA verification procedures:

1. Hold a preparatory meeting in accordance with Section 4.4 of this CQA Plan.
2. Review testing methods and frequencies included in Table 4.
3. If necessary, verify erosion control measures are in place.

4. Verify measures are implemented to protect utilities, temporary benchmarks, and existing structures from damage.
5. Verify construction staking and grade control stakes at 50-foot grid and grade breaks. GPS machine control will be allowed in lieu of staking.
6. Verify landfill subgrade is complete and in accordance with the technical specifications. Verification includes submission and acceptance of as-built survey of completed subgrade.
7. Verify Contractor provides full-time grade checker during soil liner placement to control grade, lift thickness, and tolerances.
8. Verify Contractor utilizes the same equipment and construction methods used to construct the test pad (and achieve the required hydraulic conductivity) to construct the actual soil liner in the landfill cell.
9. Verify Contractor schedules soil liner placement operations to facilitate CQA product verification and construction testing. Placement of succeeding soil liner lifts will not be allowed until passing results for compaction, moisture content, and permeability are achieved from each lift of the in-place soil liner.

9.3.4 SOIL LINER CONSTRUCTION CQA

Perform the following CQA monitoring procedures and testing to verify soil liner materials and construction methods are in compliance with the technical specifications (or as modified by results of soil liner test pad construction).

1. Verify soil liner is placed and graded to the limits, lines and grades as shown on the construction drawings.
2. Perform the product verification testing outlined in Section 9.2.1 of this CQA Plan.
3. Verify first lift of soil liner is placed in a loose lift not exceeding 8-inches and is compacted without penetrating the underlying subgrade material. If subgrade material is penetrated, verify Contractor increases loose lift thickness to prevent contamination of soil liner with subgrade materials.
4. Verify subsequent lifts of soil liner are placed in loose lifts not exceeding 6-inches. The final 1-foot thick soil liner should have a minimum of 2 separate compacted lifts, but may require more to achieve the required hydraulic conductivity.
5. Verify lifts are compacted with fully penetrating foot compactor (sheepsfoot roller) or kneading pad foot roller and moisture content is adjusted to specified range.
6. Perform nuclear density and moisture content on each compacted lift to verify the relative compaction is within the established "Zone of Acceptable Compaction". Perform oven-dried moisture content testing at every nuclear test location to correct nuclear moisture content readings. Perform five (5) nuclear density and moisture content tests per every lift per acre of in-place material.

7. Perform in-place density by the drive-cylinder method to verify the nuclear density gauge is working properly and is providing reliable testing results. At a minimum, perform one test per 20 nuclear density-moisture tests.
8. Perform hydraulic conductivity on undisturbed samples obtained from each compacted lift to verify the hydraulic conductivity of the in-place soil liner. At a minimum, perform one hydraulic conductivity test every acre per 6-inch lift.
9. Verify lifts are scarified, blended, and compacted together to prevent smooth zones and provide bonding between lifts.
10. Verify new soil liner lifts are scarified, blended, compacted, and keyed-into the existing soil liner.
11. Verify completed lifts are protected from damage, desiccation, and moisture loss. Verify complete repair of damaged lifts prior to placing succeeding lifts.
12. The in-place soil liner must have permeability less than or equal to 1×10^{-7} cm/sec. If soil liner does not meet the specified permeability, verify Contractor reworks areas, or removes and replaces materials to meet the specified permeability.

9.3.5 FINAL SURFACE PREPARATION CQA

Perform the following CQA monitoring procedures to verify the final surface of the soil liner is in compliance with the technical specifications.

1. Verify all exposed rock protruding greater than 0.5-inch is removed from the completed soil liner surface. In no case will sharp protrusions be allowed even if less than 0.5-inch.
2. Verify final surface is graded to the lines and grades shown on the construction drawings and within the tolerances specified in the technical specifications. The absolute minimum thickness is 1-foot and maximum thickness is 1.1 feet.
3. Verify the completed surface is finished with a pneumatic steel drum roller. Verify the removal of abrupt edges, ridges, gouges, tire tracks, desiccation cracks, and ruts greater than 0.5 inches.
4. Verify completed surface is moisture conditioned as necessary to prevent surface drying and desiccation.
5. Verify Owner performs and provides as-built surveys (thickness verification) of completed soil liner prior to geomembrane installation.

9.3.6 MAINTENANCE AND REPAIR CQA

1. Verify all hubs, grade control stakes, and survey stakes are removed. Verify repair of all holes, including those excavated or driven for nuclear density testing and permeability testing with approved moisture-conditioned soil liner material or bentonite/soil admixture.

2. Verify soil liner moisture content and surface condition is maintained and protected within the specified moisture content range until covered by geomembrane. Protective measures may include covering the soil liner with temporary plastic sheeting or soil.

3. Verify completed surface is not allowed to desiccate. If desiccation cracks are greater than 0.2 feet deep or 0.5 inches wide, verify the full depth and length of the crack is excavated, and repaired with additional moisture-conditioned soil liner material. If desiccation cracks are less than 0.2 feet deep or 0.5 inches wide, verify moisture conditioning and compaction with steel-drum roller.

4. Verify the repair of all weather and erosion related damage to the soil liner not covered by GCL and geomembrane. Verify the Contractor implements measures to not to allow water to run or collect under the GCL and geomembrane installation. If water runs or collects under the GCL and geomembrane, causing erosion and/or saturation of the soil liner, verify the removal of GCL and geomembrane to allow soil-liner to air dry and/or the removal and replacement of soil liner material entirely, or moisture conditioning, re-compaction, and finishing of soil liner to the requirements of the technical specifications.

5. Verify the repair of soil liner surfaces found to be out-of-grade-tolerance as follows:
   - Scarifying and moisture conditioning (water spray) surface.
   - Placement of additional moisture-conditioned soil liner material.

6. If surface is greater than 0.1 feet out-of-grade-tolerance, re-compact soil liner backfill with sheepsfoot or pad foot roller. If surface is less than 0.1 feet out-of-grade-tolerance, re-compact soil liner backfill with steel drum roller.

7. Grading or trimming of repaired surface within tolerance. Steel-drum rolling the surface smooth.

8. Verify the repair of wheel ruts on soil liner surface caused by geomembrane deployment equipment.

10.0 GEOSYNTHETIC CLAY LINER CQA

10.1 GENERAL

10.1.1 SECTION SUMMARY

CQA verification procedures to verify Geosynthetic Clay Liner (GCL) materials and installation methods are in compliance with the technical specifications.

10.1.2 SUBMITTAL REVIEW AND APPROVAL

The following GCL submittals are required before GCL is shipped to the site in accordance with the technical specifications:

1. Two 1-foot by 1-foot samples representative of the GCL material meeting these specifications of the material that will be shipped to the site
2. Product data sheet and complete description of GCL that meet or exceed the product requirements described in Table 5 and the technical specifications
3. Manufacturer's quality control testing reports for GCL rolls delivered to the site. At a minimum, GCL tests specified in Table 5 must be included in the testing reports.

Collect two copies of each submittal listed above and initiate submittal review and approval process as outlined in Section 5.0 of this CQA plan.

10.1.3 DELIVERY, STORAGE, AND HANDLING

Prior to delivery and storage of the GCL rolls, observe and verify an elevated surface is prepared to store the rolls. This storage area must be elevated off the ground, away from where water can accumulate and prepared in a manner that the GCL rolls do not create a dam for ponding water. <u>If the GCL rolls are to be stored for a long period of time, recommend to the Owner that the rolls be stored in an enclosed facility or in the enclosed shipping trailers.</u>

During delivery of the GCL rolls, perform the following verification procedures:

1. Obtain a copy of the packing list accompanying the GCL rolls.
2. Complete the *Geosynthetics Delivery and Control Log* for shipment of GCL. Attach a copy of the accompanying packing list to the completed *Geosynthetics Delivery and Control Log*. This log documents and controls the following:

- Delivery dates.
- GCL roll numbers.
- GCL roll batch/lot numbers or production dates.
- CQA personnel monitoring the delivery of the GCL rolls.
- Total quantity of GCL delivered with each shipment and the accumulated total quantity of GCL delivered to the site.
- Receipt of manufacturer's quality control test reports for each roll of GCL.
- Completion of quality assurance verification testing.
- Additional notes including rejection of materials, condition of delivered materials and other materials included with the shipments.

3. Verify GCL rolls are unloaded, handled, and transported with nylon or other cloth straps that do not damage the GCL rolls or protective covering.
4. Verify GCL rolls are stored and protected from damage and moisture intrusion. Verify protective coverings are waterproof and damaged coverings are repaired, or removed and replaced completely.
5. Verify GCL rolls are stacked only three rolls high, are supported along the entire width of each roll and that a 3-foot wide access path is left between the stacked rows of GCL.
6. Identify and separate damaged or rejected GCL rolls.
7. If GCL rolls have been contacted by moisture during shipping, separate affected rolls for bentonite moisture content testing. If the moisture content of the bentonite is greater than 50 percent, identify and mark the affected roll as "DRY OUT DURING INSTALLATION".

10.2 PRODUCTS

10.2.1 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

The following quality assurance verification testing will be performed by the geosynthetics testing laboratory to verify compliance with the product requirements of the technical specifications and as summarized in Table 5.

1. Bentonite Mass per Unit Area (ASTM D5993)
2. Bentonite Moisture Content (ASTM D2216)
3. GCL Tensile Strength (ASTM D6768)GCL Index Flux (ASTM D6496)

4. GCL Peel Strength (ASTM D6496)
5. GCL Hydraulic Conductivity (ASTM D5084)
6. Bentonite Free Swell Index (ASTM D5890)
7. Bentonite Fluid Loss (ASTM D5891)

10.3 EXECUTION

10.3.1 CQA PREPARATION

Prior to GCL installation perform the following CQA verification procedures hold a preparatory meeting in accordance with Section 4.4 of this CQA Plan.

10.3.2 EXAMINATION OF GCL SUBGRADE

Prior to GCL installation, examine the GCL subgrade as follows:

1. Verify Geosynthetics Contractor's daily acceptance of the compacted soil liner and document acceptance with the site superintendent's signature on the daily *GCL Deployment/Seaming Log*.

10.3.3 GCL DEPLOYMENT CQA

To verify compliance of GCL deployment operations with the technical specifications perform the following CQA verification procedures:

1. Record the following information on the *GCL Deployment/Seaming Log*:
   - Subgrade Acceptance (SA). Physical description and approximate area of subgrade accepted by the Geosynthetics Contractor and approved by the CQA Organization for daily GCL installation.
   - Temperature (T). Ambient and GCL surface temperatures with a description of the current weather conditions. Record every two hours and document dramatic changes in temperature and weather conditions.
   - Moisture Content (MC). Moisture content of GCL bentonite, roll or area sampled and time of sampling.
   - Panel (P). Assigned panel number, GCL roll number, panel dimensions, and area of panel.
2. Using a graph computation sheet, field sketch a panel layout drawing of the GCL panels deployed during the day. Attach this field sketch to the completed GCL Deployment/Seaming Log. These daily field sketches will be transposed to the master panel layout drawing.
3. In general, verify GCL is installed in accordance with manufacturer's instructions.

4. Verify protective covering on the GCL rolls are not removed until the roll is transported into place of installation and is immediately ready for deployment.
5. Verify GCL is installed with the machine direction (lengthwise) of the roll is oriented down and centered in the drainage troughs.
6. Verify corrections or adjustments are made to panels that become askew to the center line of the trough.
7. Verify GCL is installed with sufficient tension to prevent excessive overlapping, insufficient overlapping, wrinkles, and folds.
8. Verify panels are overlapped a minimum of 12-inches along the width (ends) of the panels.
9. Verify underlying soil liner is not damaged.
10. Verify damaged soil liner is completely repaired.
11. Verify the removal of materials that could damage the GCL or adversely affect the hydraulic conductivity of the GCL.
12. Continually inspect the GCL panels and overlaps for damage, thin areas, excessively hydrated areas, and other items that could damage the GCL or adversely affect the hydraulic conductivity of the GCL.
13. Verify damaged GCL is removed entirely or repaired in accordance with Section 16.3.4 of this CQA Plan.
14. Verify all deployed GCL is completely covered by the overlying geomembrane and secured in one day.
15. Verify small areas of the GCL not covered by the geomembrane, and protected by other temporary means (e.g. plastic sheeting).
16. Verify deployed GCL is protected from becoming excessively hydrated (rain or snow).
17. Verify excessively hydrated GCL material with moisture content greater than 50 percent is dried-out or removed and replaced entirely.
18. Verify GCL is adequately ballasted during placement operations and ballast is left in place until GCL is covered with the overlying geomembrane.
19. Verify geomembrane is also adequately ballasted.

10.3.4 REPAIR CQA

Verify damaged GCL is removed entirely or repaired in accordance with the following guidelines:

1. Verify repair (patching) material is the same material as the damaged GCL.

2. Verify patches extend a minimum of 12-inches in all directions beyond the damaged area and machine direction of the patches aligns with the machine direction of the damaged GCL.

11.0 GEOMEMBRANE CQA

11.1 GENERAL

11.1.1 SECTION SUMMARY

CQA monitoring procedures, guidelines, and testing for the following areas to verify geomembrane material and installation methods are in compliance with the technical specifications:

1. Review and approval of submittals
2. Geomembrane quality assurance verification testing
3. Extrusion welding beads or rods quality assurance verification
4. Geomembrane seam analysis
5. Installation monitoring, verification, and documentation
6. Monitoring, verification, and documentation of Installer's quality control procedures

11.1.2 SUBMITTALS

The following geomembrane submittals are required from the manufacturer in accordance with the technical specifications:

1. Product data sheets and complete description of geomembrane that meets or exceeds the product requirements of the technical specifications. Submittal due with Bid.
2. Sample of geomembrane that is representative of roughness of texturing on both sides. This sample will be used as a standard for manufacturing. A pointed depth micrometer may be used to compare relative roughness of texturing. Submittal due with Bid.
3. Geomembrane resin certificate of compliance with product requirements as presented in the technical specifications. Submittal due before geomembrane shipment to the site.
4. Geomembrane resin specific gravity quality control test reports. Submittal due before geomembrane shipment to the site.
5. Certification listing percentages of processing aids, antioxidants, and additives other than carbon black added to the geomembrane resin. Submittal due before geomembrane shipment to the site.

6. Manufacturer's quality control testing reports for geomembrane rolls delivered to the site. At a minimum, tests specified in the technical specifications or Table 6 must be included in the testing reports. Submittal due before geomembrane shipment to the site.
7. Instructions for handling, storing, installing, and repairing geomembrane. Submittal due before geomembrane shipment to the site.
8. Extrusion welding beads or rod certificate of compliance with product requirements of the technical specifications. Submittal due before geomembrane shipment to the site.
9. Manufacturer's warranty in compliance with the technical specifications. Submittal due after geomembrane delivery.

The following geomembrane submittals are required from the installer in accordance with the technical specifications:

1. Installer's Geomembrane Installation Quality Control Manual. Submittal due 14 days prior to geomembrane installations.
2. Proposed geomembrane panel layout drawings. Submittal due 14 days prior to geomembrane installations.
3. Resume of geomembrane installation superintendent. Submittal due 14 days prior to geomembrane installations.
4. Resume of geomembrane master welder. Submittal due 14 days prior to geomembrane installations.
5. Resume of welding and quality control crew. Submittal due 14 days prior to geomembrane installations.
6. Installation warranty in compliance with the technical specifications. Submittal due at the completion of the geomembrane installation.
7. Completed geomembrane panel layout drawings. Submittal due at the completion of the geomembrane installation.

Collect two copies of each submittal listed above and initiate submittal review process as outlined in Section 5.0 of this CQA Plan.

11.1.3 DELIVERY, STORAGE, AND HANDLING

Prior to delivery and storage of the geomembrane rolls, observe and verify a bedding layer surface is prepared to store the rolls.

During delivery of the geomembrane rolls, perform the following CQA verification procedures:

1. Obtain a copy of the packing list accompanying the geomembrane rolls.
2. Complete the Geomembrane Delivery and Control Log for each shipment of geomembrane rolls. Attach a copy of the accompanying packing list to the completed Geomembrane Delivery and Control Log. This log documents and controls the following:
   - Delivery dates.
   - Geomembrane roll numbers.
   - Geomembrane roll batch/lot numbers or production dates.
   - CQA personnel monitoring the delivery of the geomembrane rolls.
   - Total quantity of geomembrane delivered with each shipment and the accumulated total quantity of geomembrane delivered to the site.
   - Receipt of manufacturer's quality control test reports for each roll of geomembrane.
   - Completion of quality assurance verification testing.
   - Additional notes including rejection of materials, condition of delivered materials and other materials included with the shipments.
3. Verify geomembrane rolls are unloaded, handled, and transported with nylon or other cloth straps that do not damage the geomembrane rolls.
4. Verify geomembrane rolls are stacked only three rolls high and that a 3-foot wide access path is left between the stacked rows of geomembrane.
5. Identify and separate damaged or rejected geomembrane rolls.
6. Determine which geomembrane rolls will be sampled for quality assurance verification testing by either individual roll numbers, batch/lot numbers, or production dates. Select one geomembrane roll for sampling and testing for every 100,000 square feet of material produced for the project. Conformance samples should be obtained and tested by the CQA Organization and/or the CQA laboratory and test results reviewed by the CQA Manager and/or certifying engineer prior to shipment to the site.
7. Sample the selected geomembrane rolls for quality assurance verification testing using the following sampling procedure:

- Cut and remove the first three feet of geomembrane material from across the entire width of the roll. Store this first three feet of material near the stacked rolls of geomembrane for later use by the Installer.
- Cut and remove the next 12 inches of material from across the entire width of the roll. This 12-inch section of material is the quality assurance verification testing sample.
- Assign a quality assurance verification test number to the sample and mark the following information directly on the sample with an indelible marker:
- Machine direction of the sample.
- Manufacturer's geomembrane roll number.
- Quality assurance verification test number.

8. Complete the Geomembrane Test Request and Sample Custody Log and ship samples to the geosynthetics testing laboratory via overnight delivery.

11.2 PRODUCTS

11.2.1 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

The following quality assurance verification testing will be performed by the geosynthetics testing laboratory to verify compliance with the product requirements of the technical specifications included in Table 6:

1. Density (ASTM D 792 or ASTM D 1505)
2. Tensile Properties (ASTM D 6693)
3. Carbon Black Content (ASTM D 1603)
4. Carbon Black Dispersion – core of sheet only (ASTM D 5596)
5. Sheet Thickness (ASTM D 5994)
6. Asperity Height for textured geomembrane (ASTM D 7466)
7. Puncture Resistance (ASTM D 4833)

Upon completion of the above quality assurance verification testing and receipt of the testing results, the CQA Organization will review all test results for compliance with the technical specifications. The CQA Organization will report any non-compliance of the test results to the Design Engineer.

Additional quality assurance verification testing or corrective action measures as the result of non-complying test results will be determined by the Design Engineer.

11.2.2 FIELD TESTING EQUIPMENT

Prior to geomembrane deployment, confirm the following with the Installer:

1. Verify Installer provides a field tensiometer capable of measuring seam strength for trial welds. Verify tensiometer has been calibrated within the last year and is accurate within 2 pounds.
2. Verify Installer provides a 1-inch (width) by 6-inch (length) cutting die and cutting press for cutting seam specimens from the trial welds.

11.3 EXECUTION

11.3.1 GENERAL CQA PREPARATION

Prior to geomembrane installations, perform the following CQA verification procedures:

1. Hold preparatory meeting for geomembrane installation in accordance with Section 4.4 of this CQA Plan.

11.3.2 EXAMINATION OF GEOMEMBRANE SUBGRADE

Prior to geomembrane installations, perform the following CQA verification procedures:

1. Verify liner subgrade surface that the geomembrane will be installed on is complete and in compliance with the technical specifications.
2. Verify Installer's daily acceptance of the liner subgrade surface. Document acceptance with the site superintendent's signature on the daily Geomembrane Deployment/Welding Log.

11.3.3 CQA INSTALLATION PREPARATION

Prior to welding operations verify trial welds are prepared for each welding machine that will be used during the day. Verify the following procedures are used during preparation of the trial welds:

1. Trial welds are prepared for both fusion welding machines and extrusion guns.
2. At a minimum, trial welds are prepared at the beginning of the shift (am) and at mid-shift (pm).
3. Trial weld samples for fusion welding machines are a minimum of 6-feet in length with the trial weld centered down the length of the sample.

4. Trial weld samples for extrusion guns are a minimum of 3-feet in length with the trial weld centered down the length of the sample.

Verify trial weld is allowed to cool to ambient conditions. After cooling, verify excessive material is cut from the beginning and the end of the trial weld sample (approximately 4-inches from each end).

Verify four 1-inch specimens are cut with the cutting die and are spaced evenly along the length of the trial weld. Observe and verify field testing of two specimens for peel adhesion (peel) and two specimens for bonded seam strength (shear) in accordance with the technical specifications. Each specimen must pass their respective peel or shear test.

Peel test specimens must meet the following criteria:

1. The break is a film-tearing bond (FTB) or exceeds 400% strain.
2. There is no more than 10 percent peel penetration into the weld.
3. The quantitative value for peel strength is 63 lb./in for fusion welds and 57 lb./in for extrusion welds.

Shear test specimens must meet the following criteria:

1. The quantitative value for elongation is a minimum of 50%.
2. The quantitative value for shear strength is 75 lb./in. for both fusion and extrusion welds.

If any test specimens fail either peel or shear testing, the entire trial weld is considered failing. Verify the above trial weld procedure and field testing is repeated if any of the four specimens fail in either peel or shear. If the trial weld repeats in failure, verify the failing welding machine or extrusion gun is not used until proper adjustments are made or the machine or gun is repaired. Verify repeat trial weld failures pass two consecutive peel and shear tests. If the welding machine or extrusion gun continually fails field testing, verify the machine or gun is tagged and completely removed from service.

11.3.4 DEPLOYMENT CQA

To verify compliance of geomembrane installation operations with the technical specifications, perform the following CQA verification procedures:

1. Record the following information on the Geomembrane Deployment/Welding Log. Abbreviations in parenthesis following each verification procedure are used on the Geomembrane Deployment/Welding Log:

- Subgrade Acceptance (SA). Physical description and approximate area of subgrade accepted by the Installer and approved by the CQA Organization for daily geomembrane installation.
- Temperature (T). Ambient and geomembrane surface temperatures with a description of the current weather conditions. Record every two hours and document dramatic changes in temperature and weather conditions.
- Trial Welds (TW). Time of trial weld, type of welding equipment, welding equipment number, welding operator, and results of field peel and shear testing.
- Panel (P). Assigned panel number, geomembrane roll number, panel dimensions, and area of panel.

2. Field sketch a panel layout drawing of the geomembrane panels deployed during the day. Attach this field sketch to the completed Geomembrane Deployment/Welding Log. These daily field sketches will be transferred to the master panel layout drawing.
3. Verify panels are deployed parallel to the slope, with the panels running down the entire length of the slope. Verify corrections or adjustments are made to panels that become askew to the parallel line of the slope.
4. Verify panels are overlapped to the proper length as required by the fusion welding machines. At a minimum the panels should be overlapped 4-inches. Verify the alignment of the overlap is consistent and overlap indicator points are marked approximately every 20-feet along the entire length of the panels.
5. Verify geomembrane is not damaged during handling, transport, or deployment operations. Verify damaged geomembrane is repaired or removed entirely.
6. Verify underlying subgrade is not damaged during deployment. Verify any detected damaged subgrade is completely repaired.
7. Verify excessive wrinkling of the geomembrane does not occur and compensation for stress bridging is added during deployment operations. Verify excessive wrinkles and stress bridging are repaired or removed entirely.
8. Verify Installer only deploys the quantity of geomembrane that can be completely welded and secured in one day.
9. Verify, immediately after panels running through ditches are welded, sandbags are placed end-to-end along the entire length of the flow line to prevent geomembrane stress bridging through the ditch lines.

11.3.5 FUSION WELDING CQA

To verify compliance of geomembrane fusion welding operations with the technical specifications, perform the following CQA verification procedures:

1. Record the following information on the Geomembrane Deployment/Welding Log.

- Seam (S). Assigned seam number, welding equipment number that welded the seam, welding operator, and length of the welded seam.
- End of Seam Test. (EST). If the Installer's quality control program requires that specimens be taken from the end of each welded seam and tested for peel adhesion, record these results using the same criteria as trial welds. If the Installer records these results, request a copy of the results and this verification procedure can be omitted from the Geomembrane Deployment/Welding Log.
- Destructive Sample (DS). Assigned sample number, seam number sample is located on, location of sample within the seam, welding equipment number that welded the seam, welding operator, and results of field peel adhesion test results.

2. Verify welding operations only take place when the ambient temperature is between 40°F and 110°F. Measure ambient and in-place geomembrane temperatures and record readings every two hours on the Geomembrane Deployment/Welding Log. Special weather welding plans must be submitted and approved by the Design Engineer to weld outside this range.
3. Verify fusion welding machines complete trial weld procedures as specified in Section 11.3.3 of this CQA Plan prior to welding operations.
4. Verify power source is capable of producing sufficient and constant voltage under the combined line load of multiple welders and other equipment.
5. Verify welding surfaces are thoroughly cleaned prior to and during welding operations.
6. Verify seams are welded at the same speed, temperature, roller pressure, and gauge settings used to prepare the trial weld. Verify operators record welding machine numbers, operators, machine settings, times, and dates on each seam welded.
7. Closely observe each fusion welding machine to verify the machine is not adversely affecting or damaging the parent geomembrane material outside the welding area.

11.3.6 EXTRUSION WELDING CQA

To verify compliance of geomembrane extrusion welding operations with the technical specifications, perform the following CQA verification procedures:

1. Verify extrusion welding is used for repair operations, where welding is inaccessible to fusion welding machines.
2. Verify extrusion guns complete trial weld procedures as specified in Section 11.3.3 of this CQA Plan prior to welding operations.

3. Verify geomembrane is overlapped a minimum of 4-inches for extrusion welding.
4. Verify repair patches are cut square with rounded corners and are large enough to extend a minimum of 4-inches in all directions over the repair area.
5. Verify geomembrane and repair patches are tack-welded in place to prevent movement during grinding and extrusion welding operations.
6. Verify the outer edge of repair patches and the adjacent underlying geomembrane are disc-ground to remove surface debris and oxidation. Verify grinding is not parallel to seam.
7. Verify nozzles of extrusion guns are purged to remove solidified extrudate.
8. Verify extrusion weld completely covers the entire width of the grind area and extrusion safety welds extend 4-inches up the intersecting fusion weld (if applicable).
9. Verify extrusion weld repair (safety) patches are welded over all fusion welded seam intersections.

11.3.7 REPAIR CQA

To verify geomembrane is completely repaired and tested, perform the following CQA verification procedures:

1. After geomembrane deployment, welding, seam analysis sampling, and QC procedures, inspect the geomembrane installation to locate, mark, identify, number, and record defective areas for repair. Include all installation repairs (e.g. safety patches, air pressure patches, destructive seam sample patches, and geomembrane boots). Record the following information on the Geomembrane Repair Log.
   - Repair Number
   - Repair Description
   - Repair Location
2. After the repair is completed, verify and record the following QC information on the Geomembrane Repair Log:
   - Repair Date
   - Vacuum Test Date
   - Vacuum Test Result

11.3.8 INSTALLER'S QUALITY CONTROL

The CQA program requires the verification of quality control procedures performed by the geomembrane Installer in accordance with the technical specifications and the Installer's own Geomembrane Installation Quality Control (QC) Manual. At a minimum, verify Installer is performing the following QC procedures in accordance with the technical specifications:

1. Maintaining a geomembrane panel layout drawing during the geomembrane installation. The drawing must include; a) roll and panel numbers; b) seam numbers; c) geomembrane limits; and d) seam analysis sample locations.
2. Performing all quality control procedures and testing in accordance with the Installer's Geomembrane Installation Quality Control Manual, except where amended or modified by the Design Engineer or in the technical specifications.
3. Maintaining daily deployment logs and panel layout drawings as the deployment progresses. Logs must be submitted to the CQA Organization daily and include; 1) panel and seam numbers, 2) panel dimensions, and 3) deployment quantities.
4. Maintaining daily welding logs. Logs must be submitted to the CQA Organization daily and include; 1) welding machine numbers, 2) operators, 3) machine settings, and 4) times and dates for each seam welded.
5. Air pressure testing each fusion welded seam.
6. Vacuum testing each extrusion welded repair and length of seam.

Air pressure testing of fusion welded seams.

1. Verify each fusion welded seam is air pressure tested by the Installer and is in accordance with the following procedures:
   - The air pump must be capable of generating and maintaining 40 psi of pressure and equipped with a regulator and pressure gauge. Pressure feed needles must have pressure gauges accurate to 1 psi.
   - Both ends of the fusion welded seam are sealed with vise-grip plate clamps or extrusion weld. Heat may be applied to the seam ends to aid in sealing the seam in conjunction with the clamps.
   - The air pressure needle is inserted into the fusion weld channel at one end of the seam.
   - The channel is pressurized to 30-35 psi and pressure is maintained for 5 minutes.
   - Air is released from the opposite end of the seam to verify that the entire length of the fusion weld channel was pressurized. If channel does not maintain pressure with a maximum allowable pressure loss of 2 psi over the

5-minute test period or does not stabilize at all, verify that the defective area is located and isolated. Repeat air pressure test procedures in both directions from the defective area.

2. Record the following air pressure testing information on the Geomembrane Deployment/Welding Log. Abbreviations in parenthesis following each verification procedure are used on the Geomembrane Deployment/Welding Log.

    - Air Pressure Test (AP). Seam number tested, start time of the air pressure test and initial air pressure (psi), termination time of the air pressure test and ending air pressure (psi), and length of seam or portion of seam successfully tested.

Vacuum testing of extrusion welded repairs.

1. Verify each extrusion welded seam and repair is vacuum tested by the Installer and is in accordance with the following procedures:

    - Vacuum pump is capable of generating and maintaining 30 inches of mercury and is equipped with a regulator and vacuum gauge. Vacuum boxes have clean view windows and vacuum gauges are accurate to 1 psi.
    - Extrusion welds are saturated with soap/water solution.
    - View-box is placed over the saturated weld, an airtight seal is created, and vacuum is applied to the weld.
    - Vacuum is maintained for 10 seconds and weld is examined for leaks. Leaks are detected by the presence of excessive bubbles. Detected leaks are marked for follow up extrusion welding repair. Detected leaks are re-vacuumed tested after repair operations to verify that the leaks were successfully repaired.

2. Record the following vacuum testing information on the Geomembrane Repair Log:

    - Assigned repair number, location and description of repair, vacuum test dates, and vacuum test results.

11.3.9 DESTRUCTIVE SEAM SAMPLING AND TESTING PROCEDURES

Determine seam analysis sample locations by the stratified random sampling (SRS) method. The SRS method allows random selection of a single sample location anywhere within the required sampling interval specified within the technical specifications. In coordination with the Geosynthetics Contractor, perform the following seam analysis sampling procedures.

1. Destructive seam samples will be a minimum of 12-inches wide by 36-inches long with the weld centered down the length of the sample. Sample sizes may be increased at the request of the CQA Organization and/or the Geosynthetics Contractor.

2. Divide the sample into equal sections. A minimum of one section for destructive testing and one section for archival storage.
3. The Geosynthetics Contractor may obtain and test any seam sample at its option.
4. If there is a failing test, follow the procedures described in Section 11.3.10 of this CQA Plan.
5. Repair sample locations in accordance with Section 11.3.7 of this CQA Plan and vacuum test repair in accordance with Section 11.3.8 of this CQA Plan.
6. Based on the destructive sampling method of attributes, the Design Engineer may increase or decrease the sampling interval based on the information in Table 7.

11.3.10 FAILED SEAM ANALYSIS PROCEDURES

In coordination with the Installer, perform the following CQA verification procedures in the event of a seam analysis sample failure determined by either field testing or laboratory seam analysis:

1. Track the welded seam 10-feet in both directions away from the failed seam analysis sample location. Cut a small 8-inch wide by 8-inch long sample from each location. Cut two 1-inch specimens from each end of the sample, and field test specimens for peel adhesion in accordance with Section 12.3.3 of this CQA Plan. If either of the specimens fail the field peel test at either location, continue tracking the welded seam at 10-foot intervals until specimens successfully pass the field peel tests. If specimens continually fail field peel tests at 10-foot intervals, the entire seam or portion of the welded seam will be repaired at the discretion of the CQA Organization.
2. Verify the failed length of seam is repaired with an 18-inch wide extrusion welded cap strip. Tack and extrusion welding the leading flap of the fusion welded seam is not permitted. Verify the extrusion welded cap strip is vacuum tested in accordance with Section 11.3.8 of this CQA Plan.
3. If the re-test sample fails laboratory seam analysis, repeat the above procedures.
4. Sample extrusion welded cap strips exceeding 100-feet in length for seam analysis.

11.3.11 WRINKLES

Temperature changes may cause wrinkles to develop in the geomembrane. Any wrinkles that can fold over will be repaired either by cutting out excess material or, if possible, by allowing the geomembrane to contract by temperature reduction. In no case will material be placed over the geomembrane that could result in the geomembrane folding. The CQA Organization will monitor geomembrane for wrinkles and notify the Geosynthetics Installer if wrinkles are forming. The CQA Organization is then responsible for documenting corrective action to remove the wrinkles on the Daily Progress Report form.

12.0 CLOSURETURF® CQA

12.1 GENERAL

12.1.1 SECTION SUMMARY

CQA procedures, guidelines, and testing to verify the turf component materials and installation methods are in compliance with the technical specifications.

12.1.2 SUBMITTAL REVIEW

The following geotextile submittals are required 14 days prior to ClosureTurf® installation in accordance with the technical specifications:

1. Sample, product data sheet, and complete description of ClosureTurf® that meet or exceed the product requirements of the technical specifications and Table 8.
2. Manufacturer's quality control testing reports for ClosureTurf® rolls delivered to the site. At a minimum, tests specified in the technical specifications must be included in the testing reports.
3. Instructions for storage, installation, and repair of ClosureTurf®.
4. Collect two copies of each submittal listed above and initiate submittal review process as outlined in Section 5.0 of this CQA Plan.

12.1.3 DELIVERY, STORAGE, AND HANDLING

Prior to delivery and storage of the ClosureTurf® rolls, observe and verify that an elevated surface is prepared to store the rolls.

During delivery of the ClosureTurf® rolls, perform the following CQA verification procedures:

1. Obtain a copy of the packing list accompanying the ClosureTurf® rolls.
2. Complete the Geosynthetics Delivery and Control Log for each shipment of ClosureTurf®. Attach a copy of the accompanying packing list to the completed Geosynthetics Delivery and Control Log. This log documents and controls the following:
   - Delivery dates.
   - ClosureTurf® roll numbers.

- ClosureTurf® roll batch/lot numbers or production dates.
- CQA personnel monitoring the delivery of the ClosureTurf® rolls.
- Total quantity of ClosureTurf® delivered with each shipment and the accumulated total quantity of ClosureTurf® delivered to the site.
- Receipt of manufacturer's quality control test reports for each roll of ClosureTurf®.
- Completion of quality assurance verification testing.
- Additional notes including rejection of materials, condition of delivered materials and other materials included with the shipments.

3. Verify ClosureTurf® rolls are delivered with opaque protective coverings.
4. Verify ClosureTurf® rolls are unloaded, handled, and transported with nylon or other cloth straps that do not damage the ClosureTurf® rolls or the protective coverings.
5. Verify ClosureTurf® rolls are stored and protected from damage and damaged protective coverings are replaced.
6. Verify ClosureTurf® rolls are stacked only five rolls high and a 3-foot wide access path is left between the stacked rows of ClosureTurf®.
7. Identify and separate damaged or rejected ClosureTurf® rolls.
8. Determine which ClosureTurf® rolls will be sampled for quality assurance verification testing by either individual roll numbers, batch/lot numbers, or production dates. Select one ClosureTurf® roll for sampling and testing for every 100,000 square feet of material delivered to the site. Identify selected rolls and separate the rolls so that the rolls are stored on the top row of the five-roll stack.
9. Sample the selected ClosureTurf® rolls for quality assurance verification testing using the following sampling procedure:
   - Cut and remove the first three feet of ClosureTurf® material from across the entire width of the roll. Store this first three feet of material near the stacked rolls of ClosureTurf® for later use by the Installer.
   - Cut and remove the next 18 inches of material from across the entire width of the roll. This 18-inch section of material is the quality assurance verification testing sample.
   - Assign a quality assurance verification test number to the sample and mark the following information directly on the sample with a white paint marker.
     - Machine direction of the sample.

- Manufacturer's ClosureTurf® roll number.
- Quality assurance verification test number.

10. Immediately re-wrap the sampled ClosureTurf® roll with its protective covering. Use additional impermeable plastic sheeting if needed to completely cover the roll.
11. Complete the Geosynthetics Test Request and Sample Custody Log and ship samples to the geosynthetics testing laboratory via overnight delivery.

12.2 PRODUCTS

12.2.1 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

The following quality assurance verification testing will be performed by the geosynthetics testing laboratory to verify compliance with the ClosureTurf® product requirements of the technical specifications which are provided in Table 8:

1. ClosureTurf®
   - Yarn Weight (ASTM D5261)
   - CBR Puncture (ASTM D6241)
   - Tensile Strength of Product (ASTM D4595)
   - Tensile Strength of Yarn (ASTM D2256)

Upon completion of the above quality assurance verification testing and receipt of the testing results, the CQA Organization will review all test results for compliance with the technical specifications. The CQA Organization will report non-compliance to the Design Engineer.

Additional quality assurance verification testing or correction action measures as the result of non-complying test results will be determined by the Design Engineer.

12.3 EXECUTION

12.3.1 CQA PREPARATION

Prior to ClosureTurf® installations, perform the following CQA verification procedures:

1. Hold preparatory meeting in accordance with Section 4.4 of this CQA Plan.
2. Verify geomembrane installation is complete and in accordance with the technical specifications.

3. The geomembrane surface is free of stones or debris that could damage the turf or geomembrane during the turf installation process.

12.3.2 CLOSURETURF® INSTALLATIONS CQA

1. In general, verify ClosureTurf® is installed in accordance with manufacturer's instructions.
2. Verify ClosureTurf® is deployed from the top of the slope in a manner where the leading edge of the roll stays at the top of the slope with the grass filaments pointing up the slope.
3. Verify installation equipment or methods do not damage underlying geomembrane by handling, traffic, leakage of hydrocarbons, or by other means. Verify small equipment such as generators are placed on rub sheets above geosynthetics materials.
4. Verify ClosureTurf® is adequately ballasted during placement operations and that ballast is left in place until geotextile is covered with the overlying cover sand layer.
5. Verify ClosureTurf® is installed with sufficient tension to prevent excessive overlapping, insufficient overlapping, wrinkles, and folds.
6. Verify ClosureTurf® panels are overlapped with sufficient material to create a thermal bond or prayer fold for sewing operations.
7. Verify the seaming operations use stitching or thermal bonding. Seaming must be performed using a 4-inch overlap. Stitched seams shall be fastened with a heavy-duty textile stitching machine or equivalent means. A prayer-type seam is constructed using a Nulong sewing machine or approved equivalent. Sewing shall use 207 polyester thread or equivalent.
8. Verify no horizontal seams are placed on side slopes greater than 10-percent, except when part of a patch.
9. Verify stitching operations do not expose woven geotextiles
10. Verify rocks, excessive dust, excessive moisture, or other materials that could hamper sewing operations are not entrapped under the ClosureTurf® or within the overlap.
11. Verify in-place ClosureTurf® is not left exposed and uncovered beyond the time limitations recommended by the Manufacturer.
12. Verify the ends of the ClosureTurf® panels are permanently anchored in the anchor trench and covered with a minimum of 2-feet of soil after seaming operations are completed and sand ballast has been placed.

13. Verify the ClosureTurf® and underlying geosynthetics are not damaged or displaced during placement of the sand ballast layer. Sand material shall be placed over the ClosureTurf® system with equipment ground pressure less than five pounds per square foot (psi). No equipment shall be left running and unattended over the constructed ClosureTurf® system.

12.3.3 CLOSURETURF® REPAIR CQA

Verify damaged ClosureTurf® is removed entirely or repaired in accordance with the following guidelines:

1. Sand shall be removed from the area surrounding the repair to prevent migration of sand into the SGN drainage layer. Sand removal shall be performed using a blower, vacuum, or other means that will not damage the underlying geomembrane.
2. Holes or tears in the turf shall be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
3. Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be cut out across the entire roll, and the two portions of the turf will be joined.
4. All artificial turf repairs will be completed using a heatbond seam, achieved with either a hand held Leister or a Varimat V2 leistering machine.

13.0 SAND BALLAST CQA

13.1 GENERAL

13.1.1 SECTION SUMMARY

CQA monitoring procedures to verify sand ballast materials and construction methods of the ClosureTurf® system are in compliance with the technical specifications.

13.2 PRODUCTS

The sand layer shall have a minimum thickness of ½ inch and a maximum thickness of ¾ inch. The sand shall be worked into the turf layer as in-fill between the synthetic yarn blades. The physical characteristics of the sand layer shall be evaluated through laboratory testing prior to construction and will be visually inspected during construction. The sand shall be tan or light brown in color. Additional materials testing during construction will be at the discretion of the CQA Consultant based on the variability of material observed by the CQA Consultant and/or if the sand source is changed.

13.2.1 PRODUCT QUALITY ASSURANCE VERIFICATION TESTING

Verify the sand ballast consists of a highly permeable sand with a Universal Soil Classification of SW or SP and meets the graduation requirements presented in Table 9 prior to delivery of the ballast material.

13.3 EXECUTION

13.3.1 CONSTRUCTION AND CQA PREPARATION

Prior to sand ballast placement, perform the following CQA verification procedures.

1. Hold a preparatory meeting in accordance with Section 4.4 of this CQA Plan.
2. Verify underlying geosynthetics and turf installation is complete and in accordance with the technical specifications.

13.3.2 SAND BALLAST CQA MONITORING

The Installer shall place the sand ballast in the geotextile artificial turf in accordance with the following:

1. The ½-inch to ¾-inch thick sand ballast layer shall be installed in two lifts of ¼inch to ½-inch thickness.

2. No equipment shall be allowed on slopes exceeding 15% until the sand ballast is in place. On flatter slopes, ATV and vehicles will be allowed prior to sand ballast placement if the tire pressure is less than 15 psi.
3. Precautions must be taken to ensure that the geosynthetics are not displaced as the sand ballast is being placed.
4. Placement of the sand ballast shall not occur with snow or ice on the artificial turf and must occur during dry weather conditions.

During construction, the CQA Organization will:

1. Verify that grade control is performed prior to work.
2. Verify that underlying geosynthetic installations are not damaged during placement operations. Identify and mark damaged geosynthetics and verify that damage is repaired.
3. Verify that a minimum thickness of ½ inch and a maximum thickness of ¾ inches of sand is placed on the synthetic turf. Frequency will be 10 measurements per acre of turf installed. Additional measurements shall be taken if the CQA Organization visually identifies areas that appear to have insufficient sand ballast.
4. Examine 12-inch by 12-inch grids, and verify that a minimum of 90% of the HDPE grass blades protrude through the ballast. The exposed blades shall be counted in a representative area and compared to the standard grass blade count of uncovered material. The percentage of protruding blades shall be calculated, and sand shall be adjusted accordingly. A minimum of 4 tests shall be conducted per acre, and any increased frequency shall be at the discretion of the CQA Organization.
5. Verify the sand ballast is spread using blower equipment, ATVs with oscillating brushes, golf type equipment, or a combination of these. Sand placement shall be monitored to verify that underlying geosynthetic installations are not damaged during sand placement, and to verify that a sufficient thickness of sand is applied. Proper embedment of the sand is essential to prevent migration of the sand during storm events. Special care shall be taken to ensure proper sand embedment and HDPE blade protrusion through the sand ballast.

TABLES

TABLE 1. NORTH HOLDING POND
SOIL TESTING STANDARDS

Number	Testing Standard	Description
1	AASHTO T11	Standard Method of Test for Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
2	ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
3	ASTM D 698	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort
4	ASTM D 2216	Standard Test Method for Laboratory Determination of Water Moisture Content of Soil and Rock
5	ASTM D 2434	Standard Test Method for Permeability of Granular Soils
6	ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods
7	ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
8	ASTM D 4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
9	ASTM D 5084	Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

TABLE 2. NORTH HOLDING POND
GEOSYNTHETICS TESTING STANDARDS

Number	Testing Standard	Description
1	ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement
2	ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
3	ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
4	ASTM D 1603	Standard Test Method for Carbon Black Content in Olefin Plastics
5	ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
6	ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane
7	ASTM D 7466	Standard Test Method for Measuring Asperity Height of Textured Geomembranes
8	ASTM D 4833	Standard Test Method for Index Puncture of Geotextiles, Geomembranes, and Related Products
9	ASTM D 6392	Standard Practice for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
10	ASTM D 4437	Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes

TABLE 3. NORTH HOLDING POND
EARTHWORKS SCHEDULE OF TESTING FREQUENCIES

MATERIAL	REQUIRED TESTING	MINIMUM SPECIFICATION	TESTING FREQUENCY
UNCLASSIFIED FILL - PRE-CONSTRUCTION TESTING			
Unclassified Fill	Moisture Density Relations ASTM D698		1 test per material type
			1 check point per 10,000 yd^3
	Visual Examination		Continuous during excavation operations
	Nuclear Density-Moisture ASTM D 6938	95% Max. Dry Density	1 test per 500 yd^3 of in-place material, or one test per 500 lf in backfilled trenches
	Drive-Cylinder Density ASTM D2937	+/- 3% Optimum Moisture	1 test per 30 Nuclear Density-Moisture tests
UNCLASSIFIED FILL - CONSTRUCTION TESTING			
Unclassified Fill	Moisture Density Relations ASTM D698		1 check point per 10,000 yd^3
	Visual Examination		Continuous during excavation operations
	Nuclear Density-Moisture ASTM D 6938	95% Max. Dry Density	1 test per 500 yd^3 of in-place material
	Drive-Cylinder Density ASTM D2937	+/- 3% Optimum Moisture	1 test per 30 Nuclear Density-Moisture tests
SUBGRADE - CONSTRUCTION TESTING			
Subgrade	Moisture Density Relations ASTM D698	95% Max. Dry Density +/- 3% Optimum Moisture	1 test per material type

TABLE 4. NORTH HOLDING POND
SOIL LINER SCHEDULE OF TESTING FREQUENCIES

REQUIRED TESTING	MINIMUM SPECIFICATION	TESTING FREQUENCY
PRE-CONSTRUCTION TESTING		
Visual Examination		Continuous during excavation from borrow area
Grain Size Distribution ASTM C136	> 30% Passing # 200 100% Passing 1-inch	1 test per source
Atterberg Limits ASTM D 4318	LL >= 30 PI > 15	1 test per source
Hydraulic Conductivity ASTM D 5084	K < = 1x10-7 cm/s	One per Moisture Density Relations
Moisture Density Relations ASTM D 698		1 test per material type
Oven Moisture Content ASTM D 2216		1 per nuclear density test until correlation is established (minimum 10)
CONSTRUCTION TESTING		
Grain Size Distribution ASTM C 136	> 30% Passing # 200 100% Passing 1-inch	1 test per 1,850 yd^3
Atterberg Limits ASTM D 4318	LL > 30 PI > 15	1 test per 1,850 yd^3
Hydraulic Conductivity ASTM D 5084	K < = 1x10-7 cm/s	1 per acre per 6-inch lift
Moisture Density Relations (check point) ASTM D 698		1 test per 6,500 yd^3
Drive Cylinder ASTM D 2937		1 per 20 nuclear tests
Oven Moisture Content ASTM D 2216		1 per nuclear density test until correlation is established (minimum 10)
Nuclear Density-Moisture ASTM D 6938		6 tests per lift per acre

TABLE 5. NORTH HOLDING POND
GCL SCHEDULE OF TESTING FREQUENCIES

MATERIAL	REQUIRED TESTING	MINIMUM SPECIFICATION	MANUFACTURER OR SUPPLIER	MQC TESTING FREQUENCY	CONFORMANCE TESTING FREQUENCY
GEOSYNTHETIC CLAY LINER (GRI - GCL3)					
GCL	Bentonite Mass Per Unit Area (ASTM D5993)	0.75 lb/ft2		1 per 40,000 ft^2	1 per 100,000 ft^2
	Bentonite Moisture Content (ASTM D2216)	<= 35%		1 per 40,000 ft^2	
	Tensile Strength (ASTM D6768)	23 lb/in		1 per 200,000 ft^2	
	Hydraulic Conductivity (ASTM 5084)	$5x10^{-9}$ cm/sec		1 per week/production line	1 per 100,000 ft^2
	Peel Strength (D6496)	2.1 lb/in		1 per 5,000 yd^2	
Bentonite	Free Swell Index (ASTM D5890)	24 ml	1 per 50 tons	1 per 50 tons	
	Fluid Loss (ASTM D5891)	18 ml	1 per 50 tons	1 per 50 tons	
Geotextile	Mass/Unit Area (ASTM D5261)	3 oz/yd^2	1 per 200,000 ft^2		
	Grab Tensile Strength (ASTM D4632)	90 lb	1 per 200,000 ft^2		

TABLE 6. NORTH HOLDING POND
LLDPE SCHEDULE OF TESTING FREQUENCIES

MATERIAL	REQUIRED TESTING	MINIMUM SPECIFICATION	TESTING FREQUENCY
GEOMEMBRANE PROPERTIES (GRI GM-17) & MQC TESTING FREQUENCY			
Geomembrane	Asperity Height (ASTM D 7466).	16	every 2nd roll
	Grab Tensile Strength (ASTM D4632)	0.939 g/cc	200,000 lb
	Tensile Properties (ASTM D 6693)		20,000 lb
	1. Break Strength	75 lb/in (min. avg)	
	2. Break Elongation	250% (min. avg)	
	2% Modulus (ASTM D5323)	3000	per formulation
	Tear Resistance (ASTM D1004)	27	45,000 lb
	Puncture Resistance (ASTM D 4833)	55 (min. avg)	45,000 lb
	Drainage Stud Height	0.13 inches	per roll
	Carbon Black Content (ASTM D 4218)	2%-3%	20,000 lb
	Carbon Black Dispersion (ASTM D 5596)	See Note 1	45,000 lb
	Oxidative Induction Time - Standard (ASTM D 3895)	100 hours	200,000 lb
	Oxidative Induction Time - High Pressure (ASTM D 5885)	400 Min.	200,000 lb
	Oven Aging @ 85°C (ASTM D 5721)		Per Each Formulation
	a. Standard OIT (min. ave. - % retained after 90 days) (ASTM D 3895)	35%	
	b. High Pressure OIT (min. ave. - % retained after 90 days) (ASTM D 5885)	60%	
	UV Resistance (ASTM D7238)		Per Each Formulation
	a. Standard OIT (min. ave.) (ASTM D 3895)	Not Recommended	
	b. High Pressure OIT (min. ave. - % retained after 1600 hrs) (ASTM D 5885)	35%	
Resin	Density (ASTM D 1505 or ASTM D 792 Method B	0.932 g/cm3	1 per Resin batch
	Melt Index (ASTM D 1238 Condition E)	< 1.0 g per 10 minutes	1 per Resin batch
	Oxidative Induction Time	100 hr.	1 per formulation
	Standard OIT or High Pressure OIT (ASTM D 3895 or ASTM D 5885)	400 min.	1 per formulation
Extrudate or Bead	Density (ASTM D 1505 or ASTM D 792 Method B	0.939 g/cm3	1 per resin lot or batch
	Carbon Black Content (ASTM D 1603)	2-3%	
	Melt Index (ASTM D 1238 Condition E)	< 1.0 g per 10 minutes	

TABLE 6. NORTH HOLDING POND
LLDPE SCHEDULE OF TESTING FREQUENCIES

MATERIAL	REQUIRED TESTING	MINIMUM SPECIFICATION	TESTING FREQUENCY
QUALITY ASSURANCE GEOMEMBRANE TESTING			
Geomembrane	Density (ASTM D 792 or 1505)	0.939 g/cc	1 test per 100,000 ft^2
	Tensile Properties (ASTM D 6693)		
	1. Break Strength	60 lb/in (min. avg)	
	2. Break Elongation	100% (min. avg)	
	Carbon Black Content (ASTM D 1603)	2%-3%	
	Carbon Black Dispersion (ASTM D 5596)	See Note 1	
	Thickness (ASTM D 5994)	47.5 mil (min avg)	
	Asperity Height (ASTM D 7466).	16	
	Puncture Resistance (ASTM D 4833)	55 (min. avg)	
Seam Analysis (ASTM D 6392)			
Peel	Peel Strength (ASTM D4437)	Fusion 63 lb/in Extrusion 57 lb/in	1 test per 500 linear feet of welded seam to start, then method of attributes
	Elongation	min. 50%[2]	
Shear	Shear (ASTM D4437)	75 lb/in	

Notes:
1. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   * 9 in Categories 1 or 2 and 1 in Category 3
2. Elongation measurements should be omitted for field testing.

TABLE 7. NORTH HOLDING POND
DESTRUCTIVE SAMPLING INTERVALS

Percent of Passing Seam Analysis	Sampling Modifications*
100	Decrease interval to 1000 LF
90-100	Decrease interval to 750 LF
60-90	Maintain interval at 500 LF
30-60	Increase interval to 250 LF

*Note that sampling modifications will not be considered until 20 percent of testing is completed.

TABLE 8. NORTH HOLDING POND
CLOSURE TURF SCHEDULE OF TESTING FREQUENCIES

REQUIRED TESTING	MINIMUM SPECIFICATION	MQC TESTING FREQUENCY	CONFORMANCE TESTING FREQUENCY
Yarn Weight (ASTM D5261)	>= 20 oz/sq yard	1 test per 100,000 ft^2	1 test per 50,000 ft^2
Tensile Strength of Yarn (ASTM D2256)	15 lb min.	1 test per 100,000 ft^2	1 test per 50,000 ft^2
CBR Puncture (ASTM D6241)	1500 lb. (MARV)	1 test per 100,000 ft^2	1 test per 50,000 ft^2
Tensile Product (MD/XD) (ASTM D4595)	2100 MD/ 1600 XD lb/ft MARV	1 test per 100,000 ft^2	1 test per 50,000 ft^2
Interface Friction (ASTM D5321)	21(d) Peak	1 test per 100,000 ft^2	None
Engineered Turf Fiber UV Stability (ASTM G147)	>60% retained @ 100 years	1 test per 100,000 ft^2	None
Backing System UV Stability (Exposed) (ASTM G154)	110 lb/ft retained at 6,500 hrs	1 test per 100,000 ft^2	None

TABLE 9. NORTH HOLDING POND
SAND BALLAST SCHEDULE OF TESTING FREQUENCIES

REQUIRED TESTING	MINIMUM SPECIFICATION	PRE-CONSTRUCTION TESTING	CONSTRUCTION TESTING
CONFORMANCE TESTING			
Visual Examination			Continuous during placement operations
Void Content - Method A (ASTM C1252)	>= 40%	1 test per source	1 test per 175 yd^3
Relative Density (ASTM C128)	>= 2.40	1 test per source	1 test per 175 yd^3
Sieve Analysis - (ASTM C 136)	See Specification	1 test per source	1 test per 175 yd^3

APPENDIX A

TECHNICAL SPECIFICATIONS

SECTION 01050
SURVEYING

PART 1 GENERAL

1.01 SECTION SUMMARY

A. Surveying requirements.

B. Submittals.

C. Surveying performed by OWNER.

D. Construction staking performed by CONTRACTOR to layout the Work.

E. Surveying performed by OWNER to determine measurement and payment quantities.

F. Surveying performed by OWNER to prepare as-built record drawings.

G. Surveying Accuracy and Tolerances.

1.02 SURVEYING REQUIREMENTS

A. Employ a Land Surveyor registered in the State of Texas and acceptable to OWNER, to perform survey work described in this Section.

1.03 SUBMITTALS

A. Submit with bid, name, address, and phone number of proposed Land Surveyor.

B. Submit before starting survey work, certificate of Land Surveyor's Errors and Omissions current insurance coverage.

C. Submit upon request, documentation verifying the accuracy of the survey work.

1.04 SURVEYS PERFORMED BY OWNER

A. OWNER has reference control points and benchmark elevations in the vicinity of the project. OWNER will provide drawing and/or coordinates of the reference control points prior to construction. All other necessary reference points to perform the Work will be established by CONTRACTOR. CONTRACTOR will replace any pins, hubs, benchmarks, or other survey markers destroyed or displaced by CONTRACTOR at CONTRACTOR's expense.

B. OWNER will perform surveying for Certification Surveys and As-Built Record Drawings.

C. OWNER may use line and grade points and markers established by the CONTRACTOR as part of the Work.

1.05 CONSTRUCTION STAKING TO LAYOUT AND PERFORM THE WORK

A. CONTRACTOR will provide initial construction staking necessary to commence construction. CONTRACTOR will provide grade staking as required to complete the work in accordance with the Drawings and Technical Specifications.

1.06 SURVEYING FOR AS-BUILT RECORD DRAWINGS

A. OWNER will perform the following as-built surveys and provide record drawings at 50-scale for the following items.

1. Limits, contours, and grade breaks of subgrade on 50-foot point-over-point grid (x,y,z).

2. Limits, contours, and grade breaks of soil liner on 50-foot point-over-point grid (x,y,z) for layer thickness verification.

3. Limits of landfill geomembrane installation at 50-foot stations (x,y,z) and angle points.

4. Alignment and grade of stormwater ditches and stormwater culvert pipes at 50-foot stations (x,y,z) and angle points.

5. Alignment, width and grade of all roadways at 50-foot stations (x,y,z) and angle points.

1.08 SURVEYING ACCURACY AND TOLERANCES

A. Perform control traverse field surveys and computations to an accuracy of 1:10,000.

B. Tolerances for setting survey stakes are as follows.

Type of Point	**Horizontal Position**	**Elevation**
Permanent reference points	1: 10,000	±0.01 foot
Earthwork	1: 2,000	±0.10 foot

C. Tolerances for thickness and elevations of the granular drainage layer and cover soil layer are as follows unless otherwise specified.

1. Soil Liner Layer Thickness - 0.0 / + 0.1 foot

2. Elevations ± 0.10 foot

3. Line ± 0.30 foot

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END SECTION 01050

SECTION 02220
EARTHWORK

PART 1 GENERAL

The directives outlined in this document apply to the WORK performed by the CONTRACTOR unless otherwise noted.

1.01 SECTION SUMMARY

A. Excavation

1. Excavation of suitable earth fill materials to construct the unclassified fill and compacted soil liner for the final cover system.

B. Unclassified Fill

1. Unclassified fill to achieve design grades in the landfill closure limits.

1.02 RELATED SECTIONS

A. Section 1050 – Surveying

B. Section 02250 – Soil Liner

1.03 REFERENCES

A. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

B. ASTM D6938 Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods.

C. ASTM D2937 Density of Soil in Place by the Drive-Cylinder Method.

1.04 QUALITY ASSURANCE VERIFICATION TESTING AND DESIGNATION OF MATERIAL TYPES

A. CQA ORGANIZATION will perform the following quality assurance verification testing prior to and during embankment operations.

1. Moisture-density relations (ASTM D698) to determine the maximum dry density and optimum moisture content for each different type of embankment material.

2. Nuclear density and moisture content (ASTM D 6938) to verify relative compaction.

3. In-place density by the drive-cylinder method (ASTM D2937) to verify that the nuclear density gauge is working properly and providing reliable test results

4. Visual examination and sampling to verify that embankment materials contain no organic, saturated, oversized, or other unsuitable materials.

B. The CONTRACTOR shall cooperate with CQA ORGANIZATION in the performance of quality assurance verification testing.

PART 2 PRODUCTS

2.01 TOPSOIL

A. Removed from on-site unclassified fill and soil liner borrow sources.

B. Topsoil and organic soil contain organic material (grassy vegetation, roots, etc.).

2.02 UNCLASSIFIED FILL

A. Obtained from on-site borrow sources.

B. Free of organic, saturated, oversized, or other unsuitable materials.

C. Maximum particle size of four (4) inches, unless otherwise approved by Engineer.

2.03 CONSTRUCTION WATER

A. Obtain from OWNER provided source.

PART 3 EXECUTION

3.01 PREPARATION AND EXAMINATION

A. Locate, identify, and protect all utilities and existing structures from damage (including overhead and suspended utilities).

B. Coordinate with utility company and OWNER to locate utilities, if applicable.

C. Provide dust control. Water haul roads several times each day and when requested by OWNER.

D. Coordinate traffic control and barricades with OWNER.

E. Coordinate operations and haul routes with site operations. Maintain OWNER's access to and from operating facilities.

F. CONTRACTOR will provide construction staking and grade control. Establish lines, grade, contours and datum. Protect temporary benchmarks and offset construction staking.

G. OWNER will perform topographic surveys and mapping prior to starting any excavation or fill for measurement and payment purposes.

H. Perform and provide as-built surveys in accordance with Section 01050.

3.02 TOPSOIL

A. Strip and remove surface of all vegetation, roots, and organic soil.

B. Stockpile topsoil at the direction of the OWNER and CQA ORGANIZATION.

C. Upon completion of borrow area grading, place topsoil uniformly over the borrow area.

3.03 EXCAVATION

A. Strip and remove surface of all vegetation, roots, and organic soil.

B. Excavate borrow source to the limits, lines, and grades at the direction of the OWNER and CQA ORGANIZATION.

C. Contractor responsible for stormwater control and will be required utilize best management practices (BMP)s to manage stormwater run-on/run-off.

D. Grade perimeter of excavation to prevent surface water run-off from entering the excavation.

E. Dewater excavation as necessary.

F. Notify OWNER of unexpected subsurface conditions. Discontinue work in affected area until notified to resume work by the OWNER or CQA ORGANIZATION.

G. If waste is encountered during grading activities or excavation activities, work will stop and the CQA Organization notified to determine action. Contractor may be required to remove waste and stockpile, unless adequate cover can be established to maintain design requirements.

3.04 UNCLASSIFIED FILL

A. Place unclassified fill to the limits, lines and grades as shown on the Drawings.

B. Place in loose lifts not exceeding 8-inches. Unclassified fill thickness will vary depending starting grade and design grade established.

C. Moisture condition each lift to ±3.0 percent of the optimum moisture content and compact to a minimum of 95 percent relative compaction as determined by ASTM D698. Unclassified fill compacted to densities lower than the specified minimum density (95%), or unclassified fill compacted at a moisture content outside the specified acceptable range shall be reworked in-place to meet the density and moisture requirements or removed and replaced by acceptable unclassified fill compacted to meet requirements by the CONTRACTOR. Sample quantities are listed in the CQA tables associated with these specifications. Locations not meeting required density and moisture content will be reworked at the contractor's expense, until verified passing by QCA Organization.

D. Scarify the top of each lift prior to placing subsequent lifts. Additional scarifying is not required if a sheep-foot or pad-foot compactor is used for compaction.

E. Maintain embankment lift surfaces to prevent moisture loss and desiccation cracking. Repair desiccated areas prior to placing subsequent lifts.

F. Do not place frozen unclassified fill material or place material over frost or snow impacted base layer.

3.05 FINAL SUBGRADE PREPARATION

A. Grade final subgrade surface to the limits, lines, and grades as shown on the Drawings. Fine grade to a tolerance of 0.0 to 0.10 feet below design grade.

B. Maintain subgrades to prevent moisture loss and desiccation cracking. Repair desiccated areas.

C. Remove all debris and rocks greater than 1-inch in diameter from the completed surface.

D. Roll the completed surface with a steel drum roller. *For clay liner subgrade, remove ridges, gouges and ruts greater than 1-inch.*

E. Moisture condition completed surface as necessary.

F. OWNER will perform as-built survey of completed borrow source and unclassified fill in accordance with Section 01050. As-built survey must be completed, submitted, and accepted prior to soil liner construction.

G. OWNER will perform and provide measurement and payment surveys in accordance with Sections 01050.

END SECTION 02220

SECTION 02223
TRENCHING AND BACKFILLING

PART 1 GENERAL

The directives outlined in this document apply to the WORK performed by the CONTRACTOR unless otherwise noted.

1.01 SECTION SUMMARY

A. Trenching and backfilling.

1.02 RELATED SECTIONS

A. Section 01050 - Surveying

B. Section 02220 - Earthworks

C. Section 02771-1 - LLDPE Geomembrane

PART 2 PRODUCTS

2.01 UNCLASSIFIED FILL

A. In accordance with Section 02220

PART 3 EXECUTION

3.01 PREPARATION

A. Provide alignment control staking at 50-foot stations for anchor trenches.

B. Locate, identify, and protect utilities and existing structures from damage.

3.04 ANCHOR TRENCHES

A. Excavate at locations and to dimensions shown on the Drawings.

B. Round inside edge of anchor trench or protect with 4-foot wide strip of geotextile cushion. Remove materials from trench that may damage geomembrane.

C. Backfill anchor trench with earthfill or material excavated from the trench (if material meets specifications outlined by Section 02220 – Earthworks) to dimensions shown on the Drawings and only after engineered turf layer placement operations are complete.

D. Place earthfill in loose 12-inch lifts.

E. Moisture condition and compact each lift with manual hand tampers or by wheel-rolling with rubber tired equipment to a minimum 95 percent relative compaction as determined by ASTM D698.

F. Repair damaged geomembrane if damage occurs during trenching and backfill operations. The CONTRACTOR shall be responsible for repairs to the geomembrane at no additional cost to the OWNER.

G. Remove geomembrane and closure turf tails so that material is adequately covered in the anchor trench and the terminal ends do not surface.

H. Receive approval from QCA Organization prior to backfilling anchor trenches.

END SECTION 02223

SECTION 02250
SOIL LINER

PART 1 GENERAL

The directives outlined in this document apply to the WORK performed by the CONTRACTOR unless otherwise noted.

1.01 SECTION SUMMARY

A. Quality assurance verification and testing.

B. Excavation and processing of liner material from on-site borrow source.

C. Construction of soil liner test pad.

D. Construction and maintenance of soil liner.

1.02 RELATED SECTIONS

A. Section 01050 - Surveying

B. Section 02220 - Earthwork

C. Section 02271-1 - LLDPE Geomembrane

D. Section 02774 - Geosynthetic Clay Liner

1.03 REFERENCES

A. ASSHTO T11 #200 Sieve Wash of Soils and Aggregates.

B. ASTM C136 Sieve Analysis of Fine and Coarse Aggregates

C. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

D. ASTM D2216 Laboratory Determination of Water (Moisture) Content of Soil and Rock.

E. ASTM D2937 Density of Soil in Place by the Drive-Cylinder Method.

F. ASTM D6938 In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods.

G. ASTM D4318 Determining Liquid Limit, Plastic Limit, and Plasticity Index for Soils.

H. ASTM D5084 Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

1.04 SUBMITTALS

A. Submit the following with the Contractor’s bid:

1. List of proposed equipment and description of construction methods to excavate, moisture condition, haul, place, compact, finish, maintain, and protect soil liner in accordance with this Section.

B. Submit the following information at least 5 days prior to delivery of bentonite amendment material (if used) used for mixing with soil liner material:

1. The type and origin of the bentonite component (natural sodium, sodium enriched bentonite, or calcium bentonite)

2. The montmorillonite content

3. Content of materials other than montmorillonite.

4. Presence or absence of polymers or additives.

1.05 QUALITY ASSURANCE VERIFICATION TESTING

A. CQA ORGANIZATION will perform the following quality assurance verification testing prior to and during soil liner operations.

1. Determine amount of bentonite addition required to be applied to borrow soils to achieve a hydraulic conductivity of $1x10^{-7}$ cm/s and meet the requirements set forth in the technical specifications 30-days prior to construction of the test pad.

2. Apply moisture-density relations to determine a “Zone of Acceptable Compaction” for each different type of soil liner material. The “Zone of Acceptable Compaction” will establish a relationship of in-place dry density and moisture content that achieve the specified permeability of the soil liner. The “Zone of Acceptable Compaction” is for guidance only; passing criteria for the in-place soil liner is <u>permeability</u>.

3. Nuclear density and moisture content.

4. In-place density by the drive-cylinder method used to verify nuclear density tests.

5. Oven-dried moisture content.

6. Atterberg Limits.

7. Particle size analysis and #200 washes.

8. Hydraulic conductivity.

9. Visual examination and sampling to verify soil liner materials contain no organic, saturated, oversized, or other unsuitable materials.

B. The CONTRACTOR shall cooperate with CQA ORGANIZATION in the performance of quality assurance verification testing.

C. Allow up to 10 days for hydraulic conductivity testing for any given area or lift.

PART 2 PRODUCTS

2.01 SOIL LINER

A. The CONTRACTOR shall obtain soil liner material from on-site borrow area. On-site soils must meet the following requirements:

1. Percent passing (by weight), of fine material passing the No. 200 sieve greater than 30 percent.

2. Percent passing (by weight), of fine material passing the one inch sieve equal to 100 percent.

3. Plasticity index (PI) greater than 15 percent.

4. Liquid Limit (LL) greater than or equal to 30.

5. Free of organic, saturated, oversized, or other unsuitable materials.

6. Hydraulic conductivity less than or equal to 1 x 10^{-7} when moisture conditioned, placed, and compacted in accordance with this Section.

B. Addition of bentonite amendment to on-site soils may be required to meet the specifications outlined in Section 2.01.A. Bentonite used for amendment shall be in granular or pulverized form.

C. Off-site borrow materials may be used if the material meets the requirements of these specifications without bentonite amendments. The proposed soil liner materials shall be approved by the OWNER and the DESIGN ENGINEER prior to use.

D. Required proportion of on-site soils and bentonite, and the suitability of the soil liner material shall be verified by the CQA ORGANIZATION by evaluation and testing conducted by the CQA ORGANIZATION prior to and as part of the test pad construction.

2.02 CONSTRUCTION WATER

A. Obtain from OWNER furnished source. Contractor required to haul water to the project location.

PART 3 EXECUTION

3.01 PREPARATION OF BENTONITE AMENDED SOIL LINER MATERIAL

A. If onsite soils require bentonite amendments to meet the specified soil liner requirements, the following procedures shall be implemented to prepare the bentonite amended soil liner material:

1. Use a soil liner material as determined by pre-construction testing and outlined in 2.01. The soil liner material shall be placed in measured loose lifts with a measured quantity of bentonite and blended using a rotary mixer (Caterpillar

RM300 or DESIGN ENGINEER approved equivalent). Care shall be taken to not incorporate subgrade soils into the bentonite/soil blend.

2. Do not apply water during the first three passes of the rotary mixer. Water may be added after the initial three passes.

3. Water shall be added in a uniform manner either with the rotary mixer and the materials moisture conditioned to within 2% of the optimum moisture content or slightly higher in extreme heat conditions to account for moisture loss due to evaporation. The material will be hydrated for a minimum of 24 hours prior to placement as liner. The remaining water required to reach the appropriate water content may be added to the soil in-place during liner placement and compaction.

B. Contractor shall blend the material in the mixing area prior to placement in the test pad. Samples will be obtained for hydraulic conductivity testing and tested prior to placement by the CQA ORGANIZATION. Samples will be remolded at the testing laboratory within the range specified in this section. Pre-construction tests shall be performed for hydraulic conductivity by the CQA ORGANIZATION to verify the blended material meets the hydraulic conductivity specification of $1x10^{-7}$ cm/sec or lower.

3.02 TEST PAD CONSTRUCTION

The intent of the test pad is to simulate construction of the actual soil liner in the landfill cell including processing, moisture conditioning, bentonite addition, lift thickness, placement, grading, compaction efforts, and finishing operations. The intent of the test pad is to also verify that requirements of this specification can be met.

A. Construct test pad a minimum of 14 days prior to actual soil liner construction.

B. Use equipment and construction methods used proposed to construct the soil liner to construct the test pad.

C. Test pad shall consist of a minimum 2-foot thick fill of soil liner material. Construct test pad with a top deck of 25-feet wide by 50-feet long. Provide 4H:1V ramps onto and off the pad along the width of the pad and a 2H:1V slope the length the pad. The DESIGN ENGINEER shall provide a drawing for the configuration of the test pad prior to construction.

D. Do not contaminate soil liner material with any other soil materials.

E. Construct test pad in accordance with Parts 3.03 and 3.04 of this Section.

F. CQA ORGANIZATION will document construction equipment and methods and perform quality assurance verification testing outlined in Part 1.05 of this Section. The DESIGN ENGINEER will review the results of test pad construction and may modify the construction requirements and testing criteria specified in Part 3.03.

3.02 PREPARATION AND EXAMINATION OF LANDFILL CLOSURE SITE

A. CQA ORGANIZATION shall verify landfill closure subgrade is complete and in accordance with Section 02220 Earthwork. Verification includes submission of as-built survey of completed subgrade by the OWNER and acceptance of as-built survey by the CQA ORGANIZATION.

B. Locate, identify and protect all utilities and existing structures from damage (including overhead and suspended utilities).

C. Provide dust control.

D. Coordinate traffic control and barricades with OWNER.

E. Coordinate operations and haul routes with landfill operations.

F. Provide construction staking and grade control stakes at 50-foot grid and grade breaks or utilize construction equipment equipped with GPS grade control.

G. Provide full-time grade checker during soil liner placement to control grade, lift thickness, and tolerances or provide equipment with GPS grade control.

H. Protect temporary benchmarks and construction staking from disturbance during construction.

3.03 SOIL LINER CONSTRUCTION

A. Place soil liner to the limits, lines, and grades as shown on the Drawings.

B. Process soil liner material to meet the project specifications in accordance with the specified blend and procedures identified during construction of the test pad.

C. Scarify liner subgrade areas to a depth of two inches to ensure adequate bonding.

D. Place initial soil line lift at 8-inches in depth to prevent contamination of soil liner with subgrade materials.

E. Place subsequent lifts of soil liner in loose lifts not exceeding 6-inches in thickness. Lift thickness may be adjusted (decreased) depending on permeability results. The final 1-foot thick soil liner shall consist of <u>a minimum of 2 separate compacted lifts</u> but may require 4 or more to achieve the required permeability. No loose lift shall be thicker than the pads of the compactor so complete bonding with the previous lift is achieved.

F. Compact the soil liner to at least 95% of the maximum dry density (ASTM D698) at a moisture content that falls within the "Acceptable Zone of Compaction," ` and as confirmed, or revised as applicable, based on final test results obtained from the soil liner test pad. The moisture content and density shall be uniform throughout the lift. The CONTRACTOR shall reduce the clod size of the soil liner to a size no greater than 1-inch or a size acceptable to the CQA ORGANIZATION, the method by which shall be approved by the CQA ORGANIZATION and OWNER prior to implementation.

G. Compact lifts with kneading pad-foot compactor and adjust moisture content to specified range.

H. Scarify, blend, and compact lifts together to prevent smooth zones and provide bonding between lifts.

I. Protect completed lifts from damage, desiccation, and moisture loss. Repair damaged lifts prior to placing succeeding lifts.

J. Schedule soil liner placement operations to facilitate quality assurance verification testing. Do not place succeeding lifts until passing results for compaction, moisture content, and permeability are achieved from the completed soil liner lift.

K. Ensure the in-place soil liner has a permeability less than or equal to 1 x 10^{-7} cm/sec as determined by ASTM D5084 (Method D). If soil liner does not meet the specified permeability, the CONTRACTOR shall rework areas, or remove and replace materials to meet the specified permeability. Rework to areas of failed permeability shall be completed are at no additional cost to the OWNER, even if materials were placed and compacted within the "Zone of Acceptable Compaction".

3.04 FINAL SURFACE PREPARATION

A. Remove all exposed rock protruding greater than 0.5-inch from the completed soil liner surface. In no case will sharp protrusions be allowed even if less than 0.5-inch.

B. Grade final surface to the lines and grades shown on the Drawings within the tolerances specified in Section 01050, Part 1.08. The absolute minimum thickness is 2.0 feet and maximum thickness is 2.1 feet. Do not over build soil liner thickness.

C. Shall use a steel drum roller to complete the surface. Remove abrupt edges, ridges, gouges, tire tracks, desiccation cracks, and ruts greater than 0.5 inches.

D. Compact corners and other areas not accessible by driven compaction equipment utilizing hand-operated 500-pound (minimum) vibratory plate or vibratory smooth-drum compaction equipment approved by CQA ORGANIZATION and OWNER.

E. Moisture condition completed surface as necessary to prevent desiccation.

F. Perform as-built surveys (thickness verification) of completed soil liner prior to geomembrane installation. As-built surveys shall be provided to the CQA ORGANIZATION.

3.05 MAINTENANCE AND REPAIR

A. Remove all hubs, grade control stakes, and survey stakes. Repair all holes with approved moisture conditioned soil liner material or bentonite/soil admixture. Compact with suitable device (e.g. jumping jack) to achieve required material compaction.

B. Maintain and protect soil liner moisture content and surface condition within specified moisture content range until covered by geomembrane. Protective measures may include covering the soil liner with temporary plastic sheeting.

C. Shall not allow completed surface to desiccate. If desiccation cracks are greater than 0.2 feet deep or 0.5 inches wide, excavate the full depth and along the full length of the crack, and repair with additional soil liner material. If desiccation cracks are less than 0.2 feet deep or 0.5 inches wide, moisture condition and compact with steel drum roller.

D. Repair all weather and erosion related damage to the soil liner not covered by geosynthetics at no additional cost to the OWNER. Do not allow water to run or collect under the geosynthetics installation. If water runs or collects under the geosynthetics, causing erosion and saturation, remove geosynthetics and then remove and replace soil liner material entirely. Depending on circumstances, the soil liner material may or moisture conditioned, re-compacted, and re-finished to the requirements of 3.03 and 3.04.

E. Repair soil liner surfaces found to be out-of-grade-tolerance as follows:

1. Scarify and moisture condition (water spray) surface.

2. Place additional moisture-conditioned soil liner material.

3. If surface is greater than 0.1 feet out-of-grade-tolerance, compact soil liner backfill with pad-foot compactor. If surface is less than 0.1 feet out-of-grade-tolerance, compact soil liner backfill with steel drum roller.

4. Grade or trim repaired surface within tolerance. Steel drum roll surface smooth.

F. Repair wheel ruts on soil liner surface caused by geomembrane deployment equipment.

3.06 SURVEY CONTROL

A. Surveys of soil liner shall be conducted by the OWNER to verify quantities for payment purposes and verify thickness on a 50-foot point over point grid.

END SECTION 02250

SECTION 02771-1
LINEAR LOW DENSITY POLYETHYLENE (LLDPE) GEOMEMBRANE

PART 1 GENERAL

The directives outlined in this document apply to the WORK performed by the CONTRACTOR unless otherwise noted.

1.01 SECTION SUMMARY

A. Furnishing and installing primary geomembrane.

1.02 RELATED SECTIONS

A. Section 02774 – Geosynthetic Clay Liner.

1.03 REFERENCES

A. ASTM D 792 - Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement

B. ASTM D 1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique

C. ASTM D 6693 - Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

D. ASTM D 1603 - Standard Test Method for Carbon Black Content in Olefin Plastics

E. ASTM D 5596 - Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

F. ASTM D 5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembrane

G. ASTM D 7466 - Standard Test Method for Measuring Asperity Height of Textured Geomembranes

H. ASTM D 4833 - Standard Test Method for Index Puncture of Geotextiles, Geomembranes, and Related Products

I. ASTM D 6392 - Standard Practice for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

J. ASTM D 4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes

K. GRI GM17 Standard Specification for Supply of LLDPE Geomembrane.

L. GRI GM19 Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.04 SUBMITTALS

A. Submit the following 21 days before geomembrane is shipped to the site.

1. A 2-foot by 10-foot sample of geomembrane material meeting the specifications outlined in Part 2.02 and containing a degree of texturization representative of the material that will be shipped to the site. Materials shipped to the site that do not contain a degree of texturization comparable to the samples will be rejected.

B. Submit the following 14 days prior geomembrane installations.

1. Geomembrane Resin.

   a. Certificate of Compliance with product requirements of Part 2.01 of this Section.

   b. Specific Gravity quality control test reports.

   c. Certification listing percentages of processing aids, antioxidants, and other additives other than carbon black added to the resin.

2. Geomembrane Rolls.

   a. Samples, product data sheets, and complete description of geomembranes that meet or exceed the product requirements of Part 2.02 of this Section.

   b. Manufacturer's quality control testing reports for geomembrane rolls delivered to the site. At a minimum, tests specified in Part 2.02 of this Section must be included in the testing reports.

   c. Certification stating that all geomembrane rolls are furnished by one supplier and that all rolls are manufactured from one resin type obtained from one resin supplier.

   d. Instructions for handling, storing, installing, and repairing geomembrane.

   e. Geomembrane Installation Quality Control Manual.

3. Extrusion Welding Beads and Rod.

   a. Certificate of Compliance with product requirements of Part 2.03 of this Section.

4. LLDPE Pipe Boots

   a. Shop drawings proposed pipe boot configuration and dimensions.

5. Proposed Geomembrane Panel Layout Drawings.

    a. Drawings showing the proposed primary and secondary geomembrane panel layouts and penetration details in compliance with Drawings and this Section.

6. Geomembrane INSTALLER Qualifications.

    a. Resumes must include number of lineal feet of seam welded.

    b. Resume of geomembrane installation superintendent.

    c. Resume of geomembrane master welder.

    d. Resume of welding and quality control crew.

C. Submit at the completion of the geomembrane installation.

1. Manufacturer’s warranty in compliance with Part 1.05 of this Section.

2. Installation warranty in compliance with Part 1.05 of this Section.

3. Completed geomembrane panel layout drawings.

1.05 WARRANTIES

A. Twenty year <u>prorata</u> manufacturer warranty for the primary geomembranes against deterioration due to exposure to the elements, either exposed or buried.

B. Two year <u>nonprorata</u> installation warranty for the primary geomembrane installations against defects.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Notify CQA ORGANIZATION of geomembrane shipment deliveries. Provide CQA ORGANIZATION with copy of packing list.

B. Unload, handle, transport geomembrane rolls with nylon or other cloth straps that do not damage the geomembrane rolls.

C. Prepare a bedding layer surface in an area indicated by CQA ORGANIZATION to store the geomembrane rolls.

D. Only stack the geomembrane rolls three high.

E. Leave a 3-foot wide access path between the stacked geomembrane rolls.

F. Separate damaged or rejected geomembrane rolls as directed by CQA ORGANIZATION.

1.07 QUALITY ASSURANCE VERIFICATION TESTING

A. CQA ORGANIZATION will sample geomembrane every 100,000 square feet of material delivered to the site or produced at the manufacturing plant and perform the following quality assurance verification testing to verify compliance with the product requirements of this Section.

1. Tensile Properties

2. Density

3. Carbon Black Content

4. Carbon Black Dispersion

5. Sheet Thickness

6. Asperity Height

7. Puncture Resistance

B. OWNER's acceptance of geomembrane will be based on results of quality assurance verification testing. Allow 7 days to complete testing.

C. Assist CQA ORGANIZATION with sampling procedures by separating selected rolls during unloading operations.

D. CQA ORGANIZATION will perform laboratory seam analysis approximately every 500 lineal feet of welded geomembrane seam in accordance with Part 3.07 of this Section. OWNER's acceptance of welded geomembrane seams will be based on results of the CQA ORGANIZATION'S seam analysis. Allow 2 days to complete seam analysis.

1. Based on the destructive sampling method of attributes, the DESIGN ENGINEER may increase or decrease the sampling interval based on information in Table 7 of the CQA Plan.

E. Assist CQA ORGANIZATION with seam analysis sampling procedures by cutting samples and repairing sample locations.

PART 2 PRODUCTS

2.01 GEOMEMBRANE RESIN

A. Linear low density polyethylene (LLDPE) new, first quality, compounded, and manufactured specifically for producing LLDPE geomembrane.

B. No mixing of different resin types during manufacturing.

C. No second run or recycled materials in manufacturing.

D. Having a Specific Gravity (ASTM D 792) of 0.939 gm/cm^3 measured after adding carbon black.

2.02 GEOMEMBRANE

A. Linear low density polyethylene (LLDPE).

B. Geomembrane shall have drainage studs on one side (up) and textured on the other (down). Texture cannot be sprayed on.

C. Non-textured edges along roll length.

D. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black or pigment. Identify percentage of processing aids, antioxidants, and other additives other than carbon black.

E. Do not exceed 3.5 percent by weight of finished geomembrane for total combined processing aids, antioxidants, carbon black, and other additives.

F. All additives for UV protection, thermal stability, color, or processing agents must not "bloom" to the surface over time or inhibit welding.

G. Materials produced in the United States or Canada.

H. Finished geomembrane rolls free from blemishes, holes, pin holes, bubbles, blisters, excessive gels, undispersed resins, undispersed carbon black, contamination by foreign materials, and nicks or cuts.

I. Meeting the following minimum average roll values (MARV) specified in **Table 02772-1A** for the proposed 50-mil textured LLDPE MicroDrain®.

TABLE 02771-1A
50-MIL TEXTURED LLDPE MICRODRAIN® PROPERTIES

TEST	MINIMUM AVERAGE ROLL VALUE	MQC[1] TEST FREQUENCY
Sheet Thickness (ASTM D 5994)	47.5[2]	per roll
Asperity Height (ASTM D 7466)	16 mils (min avg)	Every 2nd roll
Density with carbon black (ASTM D 792 or ASTM 1505)	0.939 gm/cm³	200,000 lbs
Drainage Stud Height	0.130 inches	Per roll
Tensile Properties		
Break Stress	75 ppi (min avg)	20,000 lbs
Break Elongation	250% (min. avg)	
Tear Resistance (ASTM D 1004)	27 lb. (min avg)	45,000 lbs
Puncture Resistance (ASTM D 4833)	55 lb. (min avg)	45,000 lbs
Carbon Black Content (ASTM D 1603)	2.0 to 3.0 %	45,000 lbs
Carbon Black Dispersion (ASTM D 5596)	Category 1 or 2	45,000 lbs
Oxidation Induction Time (ASTM D 5885)	400 hours (min avg)	200,000 lbs
2% Modulus (ASTM D 5323) Stress Crack Resistance (ASTM D 5397) Axi-Symmetric Break Resistance Strain (ASTM D 5617)	3000 lbs/in (max) 300 hours 30% min	Per formulation Per GRI-GM10 Per formulation

(1) Manufacturing Quality Control.
(2) The minimum average allowable thickness.

2.03 EXTRUSION WELDING BEADS OR ROD

A. Made from same resin as the geomembrane.

B. Thoroughly disperse additives throughout beads or rod.

C. Containing 2 to 3 percent carbon black.

D. Free of contamination by moisture or foreign materials.

2.04 FIELD TESTING EQUIPMENT

A. Field tensiometer capable of measuring seam strength for trial welds. Calibrated and accurate within 2 pounds.

B. One-inch (width) x six-inch (length) cutting die for cutting seam specimens for testing trial welds.

PART 3 EXECUTION

3.01 EXAMINATION OF GEOMEMBRANE SURFACE

A. Complete and sign Subgrade Acceptance form provided by CQA ORGANIZATION verifying that the surface the geomembrane will be installed on is acceptable. CQA ORGANIZATION will also verify subgrade acceptance.

3.02 PREPARATION

A. Prepare adequate number of sandbags to ballast the geomembrane during deployment operations. Use free-draining sand or gravel material to fill the sandbags.

B. Do not rely on anchor trenches shown on the Drawings to secure the geomembrane during construction. INSTALLER is responsible for temporary anchorage during construction.

C. Prior to welding operations, prepare trial welds for each welding machine that will be used during the day. Trial welds will be prepared for both fusion and extrusion welding machines. At a minimum, trial welds will be prepared the beginning of the shift and at mid-shift. Trial weld samples for fusion welding machines will be a minimum of 6-feet in length and samples for extrusion guns will be a minimum of 3-feet in length with the trial weld centered down the length of the sample.

D. Allow trial weld to cool to ambient conditions. After cooling, cut excessive material from the beginning and the end of the trial weld sample (approximately 4-inches from each end). Using the cutting die, cut four 1-inch specimens, spaced evenly along the length of the trial weld.

E. Using the field tensiometer, test the specimens for peel adhesion (peel) and bonded seam strength (shear). Alternate the specimens peel, shear, peel, shear. Peel test both sides of the weld for fusion welded samples. The rate of separation for both the peel and the shear test is 2-inch per minute. Test specimens only when the Engineer is present.

F. Each specimen must pass their respective test (peel or shear).

1. 50-mil LLDPE Geomembrane:

Peel test specimens must meet all three of the following criteria:

a. The break is a film tearing bond (FTB).

b. There is no more than 25 percent peel penetration into the weld.

c. The quantitative value for peel strength is a minimum of 57 ppi for extrusion welded seams.

d. The quantitative value for peel strength is a minimum of 63 ppi for fusion welded seams

2. Shear test specimens must meet both of the following criteria:

    a. The quantitative value for shear strength is a minimum of 75 ppi for extrusion welded seams.

    b. The quantitative value for shear strength is a minimum of 75 ppi for fusion welded seams.

G. If any of the four test specimens fail either peel or shear testing, the entire trial weld is considered failing. Repeat the above trial weld procedure and field testing if any of the four specimens fail in either peel or shear. If the trial weld repeats in failure, do not use the failing welding machine until proper adjustments are made or the machine is repaired. Repeat trial weld failures must pass two peel and shear test consecutively. If the welding machine continually fails field-testing, tag and completely remove the machine from service.

H. Conduct additional trial welds at mid-day, and whenever adjustments are made to the welding machines.

3.03 DEPLOYMENT

A. Deploy panels parallel to the slope, running the panels down the entire length of the slope. Correct or make adjustments to panels that become askew to the parallel line of the slope.

B. Overlap panels a minimum of 4-inches. Keep the alignment of the overlap consistent by marking overlap indicator points.

C. Do not damage geomembrane during handling, transport, or deployment operations. Remove or repair damaged geomembrane. Repairs to damaged geomembrane will be completed by the CONTRACTOR at no additional cost to the OWNER.

D. Do not damage the underlying soil layers or geotextile installation. Repair damaged soil layers or geotextile. Repairs to damaged soil layers or geotextile will be completed by the CONTRACTOR at no additional cost to the OWNER.

E. Only deploy the quantity of geomembrane that can be completely welded and secured in one day. Securely ballast (sandbag) the geomembrane at the end of the day. If wind conditions are high use geomembrane rolls as extra ballast. INSTALLER is responsible for temporary anchorage during construction.

F. Avoid excessive wrinkles and compensate for stress bridging during deployment operations. Remove and repair excessive wrinkles and stress bridging. Excessive wrinkles and stress bridging will be removed and repaired even if these conditions occur during placement operations of the succeeding soil or geosynthetic layer.

G. Immediately after panels running through ditch flow lines or slope toes are welded, place sandbags end-to-end along the entire length of the flow line to prevent geomembrane stress bridging through the ditch.

H. When deploying textured geomembrane above a geotextile, or a GCL, always use a slip sheet to avoid snagging and weakening the geotextile fibers, or damaging the bentonite surface.

3.04 FUSION WELDING

A. Welding operations will only take place when the ambient temperature is between 40°F and 110°F. Measure ambient temperature 6-inches above the in-place geomembrane. Special weather seaming plans must be submitted and approved by Engineer to weld outside this range.

B. Fusion weld all seams. Extrusion welding will only be used for repair and patching operations.

C. Fusion welding machines must complete trial weld procedures and pass field testing as specified in Part 3.02 of this Section prior to welding operations.

D. Use power source capable of producing sufficient and constant voltage under the combined line load of other welders and equipment.

E. Thoroughly clean welding surface.

F. Weld panels at the same speed, temperature, roller pressure, and gauge settings used to prepare the trial weld. Adjust the above settings as temperature conditions indicate. Record welding machine number, operator, machine settings, time, and date on each seam welded.

3.05 EXTRUSION WELDING

A. Extrusion guns must complete trial weld procedures and pass field testing as specified in Part 3.02 of this Section prior to welding operations.

B. Overlap geomembrane a minimum of 4-inches.

C. Cut square repair patches with rounded corners large enough to extend a minimum of 4-inches in all directions over the repair area.

D. Tack-weld geomembrane or repair patches in place to prevent movement during grinding and extrusion welding operations.

E. Disc-grind the outer edge of overlapped geomembrane or repair patches and the adjacent underlying geomembrane to remove surface debris and oxidation. Do not grind parallel to seam.

F. Purge nozzle of extrusion gun to remove solidified extrudate.

G. Completely cover the entire width of the grind area with extrusion weld. Extend extrusion safety welds 4-inches up the intersecting fusion weld (if applicable).

H. Extrusion weld repair (safety) patches at all fusion welded seam intersections.

3.06 QUALITY CONTROL

A. General Quality Control

1. Perform all quality control procedures and testing in accordance with the INSTALLER's Geomembrane Installation Quality Control Manual, except where amended or modified by the DESIGN ENGINEER or this Section.

2. Maintain a geomembrane panel layout drawing during the geomembrane installation. Include in the drawing; 1) roll and panel numbers; 2) seam numbers; 3) geomembrane limits; 4) anchor trench locations; and 5) seam analysis sample locations.

B. Deployment Quality Control

1. Coordinate with CQA ORGANIZATION in assigning panel identification and corresponding seam numbering system.

2. Maintain daily deployment logs and panel layout drawings as the deployment progresses. Record panel and seam numbers, panel dimensions, and deployment quantities. Submit daily deployment logs to Engineer.

C. Fusion Welding Quality Control

1. Maintain daily welding logs. Record welding machine number, operator, machine settings, time, and date for each seam welded. Submit daily welding logs to CQA ORGANIZATION.

2. Air pressure test each fusion-welded seam. Provide air pump capable of generating and maintaining 40 psi of pressure equipped with a regulator and pressure gauge. Provide pressure feed needles with pressure gauges accurate to 1 psi. Perform the following air pressure test procedure.

a. Seal both ends of the fusion-welded seam with vise-grip plate clamps or extrusion weld. Heat may be applied to the seam ends to aid in sealing the seam in conjunction with the clamps. Due to the potential hazard of igniting landfill gas, DO NOT use propane torches or any other flame-producing device.

b. At one end of the seam, insert air pressure needle into the fusion weld channel.

c. Pressurized channel to 30-35 psi. Maintain pressure for 5 minutes.

d. Release air from the opposite end of the seam to verified that the entire length of the fusion weld channel was pressurized. If channel does not maintain pressure with a maximum allowable pressure loss of 2 psi over the 5 minute test period or does not stabilize at all, locate defective area, isolate, and repeat air pressure test procedures in both directions from the defective area.

e. Maintain air pressure test logs. Record seam numbers, beginning and ending air pressures, beginning and ending test times, lengths of tested seam, and defective areas.

D. Extrusion Welding Quality Control

1. Maintain daily welding logs. Record welding machine number, operator, machine settings, time, and date. Submit daily welding logs to CQA ORGANIZATION.

2. Vacuum test each extrusion welded repair and length of seam. Provide vacuum pump capable of generating and maintaining 30 inches of mercury equipped with a regulator and vacuum gauge. Provide vacuum box with a clean view window, and vacuum gauge accurate to 1 psi. Perform the following vacuum test procedure.

   a. Saturate extrusion weld with soap/water solution.

   b. Place view box over the saturated weld, create an airtight seal, and apply vacuum to the weld.

   c. Maintain vacuum for 10 seconds and examine weld for leaks. Leaks are detected by the presence of excessive bubbles. Mark detected leaks for follow up extrusion weld repair. Re-vacuum test detected leaks after repair operations to verify that the leaks were successfully repaired.

   d. Maintain repair logs. Assign and record repair numbers, vacuum test dates, and vacuum test results.

E. Seam Analysis Sampling Procedures

1. CQA ORGANIZATION will determine seam analysis sample locations at minimum intervals of 500 lineal feet of welded seam. CQA ORGANIZATION OR DESIGN ENGINEER may decrease or increase this frequency based on previous seam analysis results. INSTALLER will cut samples at its discretion.

2. Repair sample holes in accordance with Part 3.05 of this Section. Vacuum test repair in accordance with Part 3.06 of this Section.

3. Seam analysis samples will be 12-inches wide by 36-inches long with the weld centered down the length of the sample. Samples sizes may be modified at the request of the INSTALLER or CQA ORGANIZATION. Cut one 1-inch specimen from each end of the sample, and field test specimens for peel adhesion in accordance with Part 3.02 of this Section. If these specimens pass the field peel test, submit sample for laboratory seam analysis. If either of the specimens fail the field peel test, perform Failed Seam Analysis Procedures in accordance with Part 3.08 of this Section.

4. Divide the remaining sample into equal two sections and submit to CQA ORGANIZATION for quality assurance seam analysis and archive storage.

5. INSTALLER may take and test any sample at its option.

3.07 LABORATORY SEAM ANALYSIS

A. CQA ORGANIZATION will perform seam analysis in accordance with the following procedures.

1. Seam analysis will be performed at qualified geosynthetics testing laboratory independent of the geomembrane manufacturer and INSTALLER.

2. Seam analysis includes peel adhesion and bonded seam strength (ASTM D4437). Five specimens will be tested for each method.

3. All five of the specimens must meet the criteria specified in paragraph E, Part 3.02 of this Section.

4. Both sides of fusion-welded seams will be tested for peel adhesion.

B. OWNER's acceptance of the welded geomembrane seams will be based on the results of laboratory seam analysis.

C. Allow 24 hours to complete seam analysis after submission of the samples.

3.08 FAILED SEAM ANALYSIS PROCEDURES

A. Perform the following procedures in the event of a seam analysis sample failure determined by field-testing or laboratory seam analysis.

1. Track the welded seam 10-feet in both directions away from the failed seam analysis sample location. Cut a small 8-inch wide by 8-inch long sample from each location. Cut one 1-inch specimen from each end of the sample, and field test specimens for peel adhesion in accordance with Part 3.02 of this Section. If these specimens pass the field peel test, submit a 12-inch wide by 18-inch long re-test sample from both locations for laboratory seam analysis. If either of the specimens fail the field peel test at either location, continue tracking the welded seam at 10-foot intervals until specimens successfully pass the field peel tests and a sample can be submitted for laboratory seam analysis. If specimens continually fail field peel tests at 10-foot intervals, the entire seam or portion of the welded seam will be repaired at the discretion of the CQA ORGANIZATION.

2. Repair the failed length of seam determined by field peel testing with an 18-inch wide cap strip. Extrusion weld the cap strip in accordance with Part 3.04 of this Section. Tack and extrusion welding the leading flap of the fusion-welded seam is not permitted. Vacuum test extrusion welded cap strip in accordance with Part 3.05 of this Section.

3. If the re-test sample fails laboratory seam analysis, repeat the above procedures.

B. Seam analysis samples will be taken from extrusion welded cap strips exceeding 100-feet in length, at the CQA ORGANIZATION'S discretion.

3.09 REPAIRS

A. Available repair procedures include:

1. Patching: Extrusion welding a patch of geomembrane over seam intersections and defects.

2. Spot welding: A bead of molten extrudate placed on a flaw up to ¼-inch wide.

3. Capping: A strip of geomembrane extrusion welded over a defective area.

4. Removal and replacement.

B. All repairs must be thoroughly checked with a vacuum box.

END SECTION 02771-1

SECTION 02771-2
CLOSURETURF®

PART 1 GENERAL

1.01 SECTION SUMMARY

A. Product specifications for ClosureTurf®

B. Furnishing and installing ClosureTurf® synthetic turf component.

1.02 RELATED SECTIONS

A. Section 02771-1 – Linear Low Density Polyethylene (LLDPE) Liner

B. Section 02771-3 – Sand Infill

1.03 REFERENCES

A. ASTM D 5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles

B. ASTM D 2256 – Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method

C. ASTM D 6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

D. ASTM D 4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

E. ASTM D 5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

F. ASTM G 147 – Standard Practice for Conditioning and Handling of Nonmetallic materials for Natural and Artificial Weathering Tests

G. ASTM G 154 – Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

H. Aerospace, Transportation and Advanced Systems Laboratory, Georgia Tech Research Institute – Aerodynamic Evaluations of ClosureTurf™ Ground Cover. 2010.

I. WatershedGeo – ClosureTurf® Design Guidelines Manual v05.19

1.04 SUBMITTALS

A. Manufacturer

1. Provide the following Manufacturer's Quality Control (MQC) testing data:

a. Provide inspection records of the tufting procedures for every 100,000 square feet of engineered turf.

b. Inspection records that indicates the following properties as they relate to the product specifications described in Part 2.01 of this specification including:

(1) Tufting gauge

(2) Pile height

(3) Total product weight

(4) CBR Puncture (ASTM D6241)

(5) Tensile Strength Product (ASTM D4595)

(6) Tensile Strength of Yarn (ASTM D2256)

B. Submit the following 14 days prior geomembrane installations.

1. Engineered Turf

a. Certificate of Compliance with product requirements of Part 2.01 of this Section.

2. Proposed Panel Layout Drawings.

a. Drawings indicating the panel layout and field seams

3. INSTALLER Qualifications.

a. Documentation that the INSTALLER is an approved ClosureTurf® INSTALLER.

b. ClosureTurf® Installation Schedule

c. Installation capabilities, including:

(1) Information on seaming, testing, and deployment equipment proposed for this project.

(2) Average daily production anticipated for this project; and,

(3) Construction Quality Control (CQC) procedures.

d. Resumes of:

(1) Project designated turf seaming supervisor

(2) CQA supervisor

(3) All personnel who will perform seaming operations including:

(a) Date hired and duration of employment

(b) Installed at least 5,000,000 square feet of geomembrane materials

(c) Engineered turf fusion seamers shall be factory trained by DemTech

e. Geosynthetics INSTALLER personnel shall attend ClosureTurf® orientation prior to the job beginning if this is their first ClosureTurf® installation.

C. Submit at the completion of the engineered turf installation.

1. Completed geomembrane panel layout drawings.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Notify CQA ORGANIZATION of engineered turf shipment deliveries. Provide CQA ORGANIZATION with copy of packing list which includes the manufacturer's name, product identification, lot number, roll number, and roll dimensions.

B. Unload, handle, transport engineered turf rolls with nylon or other cloth straps that do not damage the geomembrane rolls and preserve the integrity of the protective covering

C. Store on a level surface graded to drain away from engineered turf rolls.

D. Only stack the geomembrane rolls three high.

E. Leave a 3-foot wide access path between the stacked geomembrane rolls.

F. Separate damaged or rejected geomembrane rolls as directed by CQA ORGANIZTION.

1.06 QUALITY ASSURANCE VERIFICATION TESTING

A. CQA ORGANIZATION will sample engineered turf every 50,000 square feet of material delivered to the site or produced at the manufacturing plant and perform the following quality assurance verification testing to verify compliance with the product requirements of this Section.

1. Total Product Weight

2. CBR Puncture (ASTM D6241)

3. Tensile Strength of Product (ASTM D4595)

4. Tensile Strength of Yarn (ASTM D2256)

B. Owner's acceptance of geomembrane will be based on results of quality assurance verification testing. Allow 7 days to complete testing.

C. Assist CQA ORGANIZATION with sampling procedures by separating selected rolls during unloading operations.

PART 2 PRODUCTS

2.01 CLOSURETURF® ENGINEERED TURF COMPONENT

A. Engineered turf manufactured by Watershed Geo

B. Meeting the following minimum average roll values (MARV) specified in **Table 02772-2A** for the proposed engineered turf product.

TABLE 02771-2A
CLOSURE TURF® ENGINEERED TURF PROPERTIES

TEST	MINIMUM AVERAGE ROLL VALUE	MQC[(1)] TEST FREQUENCY
CBR Puncture (ASMT D6241)	1500 lb.	100,000 ft^2
Tensile Strength Product (MD/XD) (ASTM D4595)	2,100 MD/1,600 XD lb./ft.	100,000 ft^2
Aerodynamic Evaluation (GTRI Wind Tunnel)	120 mph w/ max. uplift of 0.12 lb/ft^2	
Engineered Turf Fiber Stability (ASTM G147)	>60% retained tensile strength at 100 yrs (projected)	
Backing System UV Stability Index Test (ASTM G1545 Modified Cycle 1.UVA340)	110 lbs/ft retained tensile strength at 6500 hrs. (projected)	
Internal Friction of Combined Components (ASTM D5321)	35°, min	
Yarn Weight (Total Product Weight) (ASTM D5261)	>= 20 oz/sq. yard	100,000 ft^2
Tensile Strength of Yarn (ASTM D2256)	15 lbs. min.	100,000 ft^2

(1) Manufacturing Quality Control.

2.02 SEWING THREAD

A. Sewing thread shall be 207 Polyester or equivalent.

2.03 FIELD TESTING EQUIPMENT

A. Field tensiometer capable of measuring seam strength for trial welds. Calibrated and accurate within 2 pounds.

B. One-inch (width) x six-inch (length) cutting die for cutting seam specimens for testing trial welds.

PART 3 EXECUTION

3.01 EXAMINATION OF ENGINEERED TURF SURFACE

A. Complete and sign Subgrade Acceptance form provided by CQA ORGANIZATION verifying that the surface the engineered turf will be installed on is acceptable. CQA ORGANIZATION will also verify engineered turf acceptance.

3.02 PREPARATION

A. Prepare adequate number of sandbags to ballast the engineered turf during deployment operations. Use free-draining sand or gravel material to fill the sandbags.

B. Coordinate anchor trench excavation with Earthwork Contractor. Do not rely on anchor trenches shown on the Drawings to secure the engineered turf during construction. INSTALLER is responsible for temporary anchorage during construction.

C. Prior to welding operations, prepare trial welds for each welding machine that will be used during the day. Trial welds will be prepared fusion welding machines. At a minimum, trial welds will be prepared the beginning of the shift, after any break, or any time after the machine is turned off for more than 30 minutes. The CQA Organization may request a trial weld seam if they believe the operator or fusion welding apparatus is not functioning properly. Trial weld samples for fusion welding machines will be a minimum of 3-feet in length and 12 inches in width with the trial weld centered down the length of the sample.

D. Allow trial weld to cool to ambient conditions before seam snapping or panel adjustments are applied.

E. A manual peal/pull test is performed and a passing seam is based on visual criteria.

F. The criterial for a passing trial weld includes:

1. A passing trial weld is achieved when approximately 75% of the top turf panel tufts transfer to the bottom turf panel.

2. Two consecutive trial welds meet the visual passing criteria.

G. If any of the two test specimens fail, both trial welds are considered failing. Repeat the above trial weld procedure and field testing if any of the two specimens fail. If the trial weld repeats in failure, do not use the failing welding machine until proper adjustments are made or the machine is repaired. Repeat trial weld failures must pass two visual inspections consecutively. If the welding machine continually fails field-testing, tag and completely remove the machine from service.

H. Conduct additional trial welds at mid-day, and whenever adjustments are made to the welding machines.

3.03 DEPLOYMENT

A. Deploy panels from the top of the slope in a way that the engineered turf filaments are pointing upslope after deployment is complete.

B. Overlap panels a minimum of 5-inches. Keep the alignment of the overlap consistent by marking overlap indicator points.

C. Do not damage engineered turf during handling, transport, or deployment operations. Remove or repair damaged engineered turf.

D. Do not damage the underlying geomembrane. Repair damaged geomembrane.

E. Only deploy the quantity of engineered turf that can be completely welded and secured in one day. Securely ballast (sandbag) the geomembrane at the end of the day. If wind conditions are high use engineered turf rolls as extra ballast. INSTALLER is responsible for temporary anchorage during construction.

F. Avoid excessive wrinkles and compensate for stress bridging during deployment operations. Remove and repair excessive wrinkles and stress bridging. Excessive wrinkles and stress bridging will be removed and repaired even if these conditions occur during placement operations of the succeeding sand ballast layer.

3.04 SEWN SEAMS

A. Sew all longitudinal and transverse seams.

B. Deploy first panel with turf filaments facing up.

C. Deploy subsequent panels turf side down, on top of the previous panel.

D. After each panel is seamed, flip onto the geomembrane component with care to avoid pulling of tufts in the drainage studs.

E. Sewn seams shall consist of a prayer type seam installed with a Newlong sewing machine or equivalent.

F. Sewing will occur between the first and second row of tufts on the both sides of panel.

3.05 FUSION WELDING (FOR REFERENCE ONLY)

A. Welding operations will only take place when the ambient temperature is between 40°F and 110°F. Measure ambient temperature 6-inches above the in-place geomembrane. Special weather seaming plans must be submitted and approved by CQA ORGANIZATION to weld outside this range.

B. Fusion welding machines must consist of a DemTech VM20/4/A fusion welder only.

C. Use power source capable of producing sufficient and constant voltage under the combined line load of other welders and equipment.

D. Thoroughly clean welding surface.

E. Fusion welded seams require a minimum of 5-inches of overlap.

F. Frayed or loose geotextile strands will be cut off or removed.

G. Prior to starting the production fusion seaming, trial seams must be performed as outlined in Section 3.02.

H. Demonstrate the preparation methods and equipment utilized for removal of the selvage from the outside edge of the rolls of turf (i.e. trimming and cutting devices).

I. Mechanical or hot knife trimming and cutting devices will be utilized for salvage trimming.

J. Demonstrate and control the fraying of geotextile strands when performing the removal of selvage.

K. Any damage that occurs due to production seaming will be repaired as outlined in the WG Installation guidance Documents.

L. Any defects will be repaired as outlined in Section 3.06

M. Weld panels at the same speed, temperature, roller pressure, and gauge settings used to prepare the trial weld. Adjust the above settings as temperature conditions indicate. Record welding machine number, operator, machine settings, time, and date on each seam welded.

3.06 EQUIPMENT ON THE TURF

A. During Construction

1. On slopes exceeding 15% no equipment will be allowed until sand infill is in place.

2. On Slopes less than 15% ATV type vehicles will be allowed prior to infill placement if the tire/track ground contact pressure is less than 5 psi.

B. Post Construction (full specified sand infill thickness)

1. On slopes exceeding 15%

a. Temporary or transient loads, allowable tire/track ground contact pressure will be limited to 35 psi.

b. Regularly trafficked areas will be designed and approved by the DESIGN ENGINEER.

2. On Slopes less than 15%

a. Temporary or transient loads, allowable tire/track ground contact pressure will be limited to 85 psi.

b. Regularly trafficked areas will be designed and approved by the DESIGN ENGINEER.

c. Allowable tire/track ground contact pressures may be increased with the written approval of the DESIGN ENGINEER.

C. Any activity that may be identified during construction by the Owner, CQA Organization as being a possible danger to the integrity of the ClosureTurf® system will be prohibited regardless of any prior approval.

3.07 REPAIRS

A. When repairs to engineered turf occur, the CQA Organization must observe the following:

1. Repairs are completed by using a heat-bonded seam.

2. All tie-in seams along flatter slopes (i.e. less than 15%) with length greater than 25 feet will use an approved heat bonded seam so as consistent pressure is achieved throughout the seam.

3. A handheld heat gun with a pressure wheel will be used in small areas.

3.08 QUALITY CONTROL

A. General Quality Control

1. Perform all quality control procedures and testing in accordance with the INSTALLER's Installation Quality Control Manual, except where amended or modified by the Engineer or this Section.

2. Maintain a engineered turf panel layout drawing during the engineered turf installation. Include in the drawing; 1) roll and panel numbers; 2) seam numbers; 3) geomembrane limits; 4) anchor trench locations; and 5) seam analysis sample locations.

B. Deployment Quality Control

1. Coordinate with CQA ORGANIZATION in assigning panel identification and corresponding seam numbering system.

2. Maintain daily deployment logs and panel layout drawings as the deployment progresses. Record panel and seam numbers, panel dimensions, and deployment quantities. Submit daily deployment logs to CQA ORGANIZATION.

C. Sewn Seam Quality Control

1. Verify engineered turf tufts are not excessively pulled out by the installation process.

D. Fusion Welding Quality Control

1. Maintain daily welding logs. Record welding machine number, operator, machine settings, time, and date for each seam welded. Submit daily welding logs to CQA ORGANIZATION.

END SECTION 02771-2

SECTION 02771-3
SAND INFILL

PART 1 GENERAL

1.01 SECTION SUMMARY

The directives outlined in this document apply to the WORK performed by the CONTRACTOR unless otherwise noted.

A. This section describes product requirements and installation requirements for the sand infill component of the ClosureTurf® final cover system.

1.02 RELATED SECTIONS

A. Section 02771-1 – Linear Low Density Polyethylene (LLDPE) Liner

B. Section 02771-2 – ClosureTurf®

1.03 REFERENCES

A. ASTM C1252 Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influence by Particle Shape, Surface Texture, and Grading) Method A.

B. ASTM C128 Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate.

C. ASTM C136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

1.05 SUBMITTALS

A. Submit the following 14 days before sand infill material is shipped to site:

1. Product data sheets and complete description of sand material that meet or exceed the product requirements of Part 2.01 of this Section.

2. Suppliers quality control testing demonstrating the proposed material's void content, relative density, and gradation meet the product requirements of Part 2.01 of this Section.

B. Submit written description of sand infill placement methods describing equipment and application methods 14 days prior to sand infill installation.

1.04 QUALITY ASSURANCE VERIFICATION TESTING

A. CQA ORGANIZATION will perform the following quality assurance verification testing prior to and during sand infill placement operations.

1. Uncompacted void content of sand infill (ASTM C1252)

2. Relative density of sand infill (ASTM C128)

3. Sieve analysis of sand infill (ASTM C136)

4. Visual examination and sampling to verify that sand materials contain no organic, saturated, oversized, or other unsuitable materials.

B. Cooperate with CQA ORGANIZATION in the performance of quality assurance verification testing.

PART 2 PRODUCTS

2.01 SAND INFILL

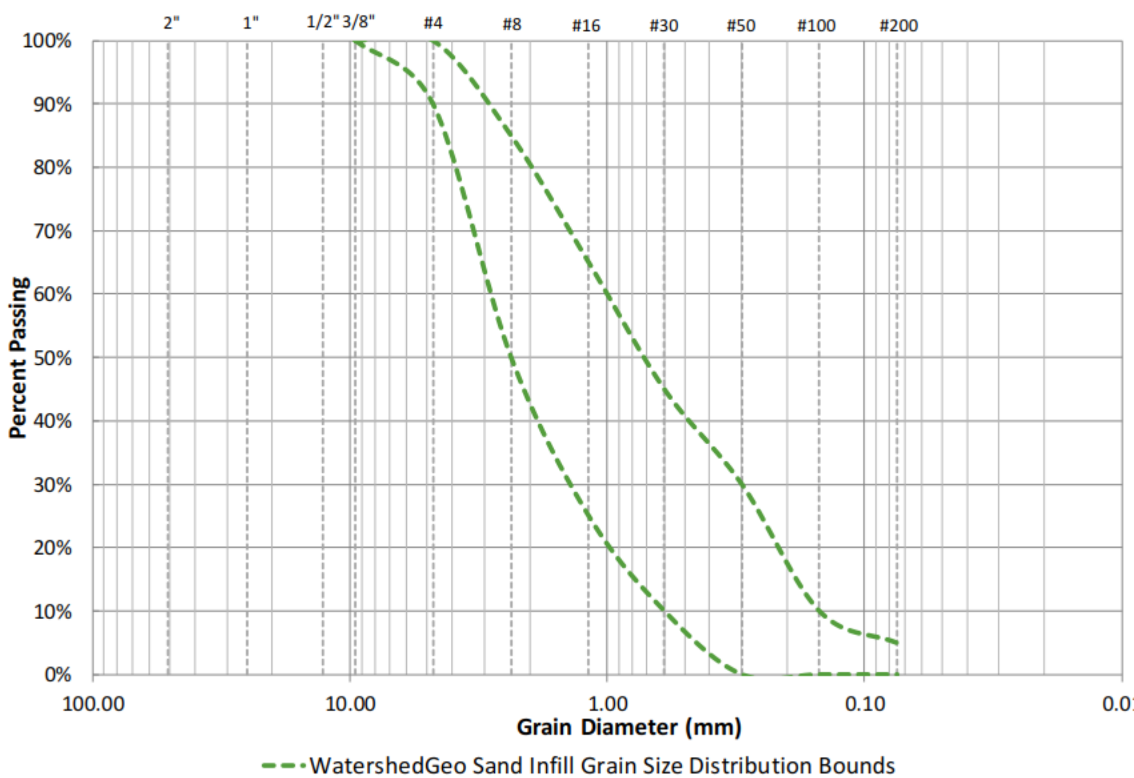
A. Uncompacted Void Content (ASTM C1242) >= 40%

B. Specific Gravity (ASTM C128) >= 2.40

C. Grain Size Distribution (ASTM C136)

TABLE 02771-3A
SAND INFILL GRAIN SIZE DISTRIBUTION

		3/8" (9.5 mm)	<	100%
90%	<	#4 (4.75 mm)	<	100%
50%	<	#8 (2.36 mm)	<	85%
25%	<	#16 (1.18 mm)	<	65%
10%	<	#30 (0.60 mm)	<	45%
0	<	#50 (0.30 mm)	<	30%
0	<	#100 (0.15 mm)	<	10%
0	<	#200 (0.075 mm)	<	5%



PART 3 EXECUTION

3.01 EQUIPMENT ON THE TURF

A. During Construction

1. On slopes exceeding 15% no equipment will be allowed until sand infill is in place.

2. On Slopes less than 15% ATV type vehicles will be allowed prior to infill placement if the tire/track ground contact pressure is less than 5 psi.

B. Post Construction (full specified sand infill thickness)

1. On slopes exceeding 15%

a. Temporary or transient loads, allowable tire/track ground contact pressure will be limited to 35 psi.

b. Regularly trafficked areas will be designed and approved by the DESIGN ENGINEER.

2. On Slopes less than 15%

a. Temporary or transient loads, allowable tire/track ground contact pressure will be limited to 85 psi.

b. Regularly trafficked areas will be designed and approved by the DESIGN ENGINEER.

c. Allowable tire/track ground contact pressures may be increased with the written approval of the DESIGN ENGINEER.

C. Any activity that may be identified during the course of construction by the Owner, CQA ORGANIZATION as being a possible danger to the integrity of the ClosureTurf® system will be prohibited regardless of any prior approval.

3.02 SAND BALLAST INFILL PLACEMENT

A. Sand infill that is placed between the tufts of the engineered turf component:

1. The sand infill layer will be placed to a ½ inch minimum thickness not to exceed ¾ inch thick.

2. Will consist wholly of sand meeting Part 2 of this specification.

3. The CQA ORGANIZATION shall check final thickness of sand infill at a rate of approximately 20 times per acre.

B. ClosureTurf® Sand Infill Grain Size Parameters are shown in Section 2.01, Table 1.

1. The CQA ORGANIZATION shall observe that the following requirements regarding Sand Infill are met:

a. Installation of sand infill will only be performed by a Watershed Geosynthetics' licensed and approved installer.

b. Areas that are to receive sand infill must be accepted by the CQA Organization before placement of sand infill takes place.

C. SAND INFILL INSTALLATION

1. Prior to installation, the Sand Infill Installer will explain with detail the method of sand infill deployment to be used during the pre-construction meeting. The contactor shall take into account recent OSHA requirements for silica exposure for sand placement methods.

2. The sand infill is worked into the Engineered Turf between the synthetic yarn blades.

3. Conveyor systems and/or Express Blowers will be used to spread and place the sand infill.

4. That sand infill placement does not occur with snow or ice on the Engineered Turf component.

5. That previously installed ClosureTurf® components are not displaced or damaged as a result of the sand infill component installation.

D. CQA ORGANIZATION shall observe and/or verify:

1. The sand infill is worked into the Engineered Turf between the synthetic yarn blades with a brush.

2. Conveyor systems and/or Express Blowers will be used to spread and place the sand infill.

3. The method for measuring the sand infill thickness will be performed utilizing a digital caliper, or a DESIGN ENGINEER approved alternate measuring device.

D. OWNER will perform surveys in accordance with Section01050.

END SECTION 02221-3

SECTION 02774
GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

The directives outlined in this document apply to the WORK performed by the CONTRACTOR unless otherwise noted.

1.01 SECTION SUMMARY

A. Furnishing and installing geosynthetic clay liner (GCL) at locations shown on the Drawings.

1.02 RELATED SECTIONS

A. Section 02250 – Soil Liner

B. Section 02771-1 – Linear Low Density Polyethylene (LLDPE) Geomembrane.

1.03 REFERENCES

A. ASTM D 4632 Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).

B. ASTM D 5084 Standard Test Method of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

C. ASTM D 5261 Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.

D. ASTM D 5888 Standard Guide for Storage and Handling of GCLs.

E. ASTM D 5890 Standard Test Method for Swell Index of Clay Mineral Component of GCLs.

F. ASTM D 5891 Standard Test Method for Fluid Loss of Clay Mineral Component of GCLs.

G. ASTM D 5993 Standard Test Method for Mass Per Unit Area of GCLs.

H. ASTM D 6072 Standard Guide for Installation of GCLs.

I. GRI GCL-3 Standard Test Method for "GCL Overlap Seam Permeability".

1.04 SUBMITTALS

A. Submit the following before the GCL is shipped from the point of manufacture to the site:

1. Two 1-foot by 1-foot samples representative of the GCL material meeting these specifications of the material that will be shipped to the site.

2. Product data sheet, and complete description of GCL that meet or exceed the product requirements of Part 2.03 of this Section.

3. Manufacturer's quality control testing reports for GCL rolls delivered to the site. At a minimum, GCL tests specified in Table 02774-1 of this Section must be included in the testing reports.

B. DESIGN ENGNEER's acceptance of GCL will be based on submittal documents meeting the product requirements of this Section.

1.05 SHIPMENT, DELIVERY, STORAGE, AND HANDLING

A. Follow guidance from ASTM D 5888: Standard Guide for Storage and Handling of GCLs.

B. Ship GCL rolls with waterproof opaque protective coverings on flatbed trailer.

C. Notify CQA ORGANIZATION of GCL shipment deliveries and provide copy of packing list.

D. Unload, handle and transport rolls with nylon or other cloth straps that do not damage the GCL or the protective coverings.

E. Protect rolls from damage. Replace damaged protective coverings.

F. Separate damaged GCL rolls.

1.06 QUALITY ASSURANCE VERIFICATION TESTING

A. Engineer will sample GCL every 100,000 square feet of material delivered to the site or produced at the manufacturing plant and perform the following quality assurance verification testing to verify compliance with the product requirements of this Section.

1. Bentonite Mass per Unit Area

2. Permeability

PART 2 PRODUCTS

2.01 GCL BASE BENTONITE

A. Greater than 80 percent sodium montmorillonite clay.

B. Granular form.

C. Meeting the product requirements specified in Table 02774-1.

2.02 TOP (CAP) GEOTEXTILE

A. Non-woven, continuous or staple-filament, needle punched, polypropylene or polyester fabric; yarn oriented into a stable network that maintains its structure during handling, placement, and long term service.

B. Resistant to soil chemicals.

C. No recycled materials.

D. Meeting the minimum average roll values (MARV) specified in Table 02774-1.

2.03 BOTTOM (CARRIER) GEOTEXTILE

A. Woven monofilament polypropylene fabric.

B. Resistant to soil chemicals.

C. No recycled materials.

D. Meeting the minimum average roll values (MARV) specified in Table 02774-1.

2.04 GCL

A. Bentonite granules, containing no adhesives, supported by individual geotextiles on the upper and lower surfaces that are needle punched throughout or stitch-bonded to form a stable composite.

B. Needled surface to receive heat-bonding to resist fiber pullout.

C. Rolls marked with continuous, water-proof laplines and matchlines offset 6 and 9 inches from the edge of the rolls.

D. Supplied on center-cores that can fully support the weight of the GCL without bending or buckling.

E. Meeting the minimum average roll values (MARV) specified in Table 02774-1.

TABLE 02774-1
GCL PROPERTIES

Material Property	Test Method	Minimum Requirement	MQC(1) Testing Frequency
Base Bentonite			
Free Swell	ASTM D 5890	24 ml/2g (min.)	1 per 50 tons
Fluid Loss	ASTM D 5891	18 ml (max.)	1 per 50 tons
Top (Cap) (2) Geotextile			
Mass Per Unit Area	ASTM D 5261	3.0 oz/SY	1 per 200,000 sqft
Bottom (Carrier)(2) Geotextile		3.0 oz/SY	1 per 200,000 sqft
Mass Per Unit Area	ASTM D 5261		
GCL(2)			
Grab Strength	ASTM D 4632	90 lb	1 per 200,000 sqft
MD Peel Strength	ASTM D 4632 MOD.	1 lb/inch	1 per 50,000 sqft
Bentonite Mass Per Unit Area	ASTM D 5993 @ 0% moisture content	0.81 lb/sqft	1 per 40,000 sqft
Bentonite Moisture	ASTM D 5993	<35% delivered	1 per 40,000 sqft
Lap Joint Permeability	GRI GCL-3		1 per material and lap type

(1) Manufacturing Quality Control.
(2) Minimum valves for geotextiles and GCL are Minimum Average Roll Valves (MARV).

PART 3 EXECUTION

3.01 DEPLOYMENT

A. Follow guidance given in ASTM D 6072 - Standard Guide for Installation of GCLs.

B. Use slip sheet when deploying over textured geomembrane. Do not snag and pull geotextile fibers on textured geomembrane when positioning.

C. Overlap panels a minimum of 12-inches along the length (sides) and a minimum of 18-inches along the width (ends) of the panels. Overlap panels placed in drainage troughs a minimum of 12-inches in all directions. Keep the alignment of the overlap consistent against the lapline printed on the GCL.

D. Do not damage GCL during handling, transport, or deployment operations. Remove or repair damaged GCL.

E. Do not damage the underlying geosynthetic installations. Repair damaged geosynthetic installations.

F. Do not drive on GCL with any equipment. Driving on GCL with specialized equipment for purposes of deploying geosynthetics can only be done with CQA ORGANIZATION'S and DESIGN ENGINEER'S approval.

G. Avoid wrinkles during deployment operations. Remove and repair wrinkles. Wrinkles will be removed and repaired even if these conditions occur during placement operations of succeeding geosynthetic layers.

H. Protect GCL from becoming excessively hydrated (rain). GCL with moisture content greater than 100 percent may be required to be removed at INSTALLER's expense.

I. Only deploy the quantity of GCL that can be completely covered by the overlying primary geomembrane and secured in one day. Securely anchor the GCL and primary geomembrane at the end of the day. If wind conditions are high use geomembrane rolls as extra ballast during deployment. INSTALLER is responsible for temporary anchorage during construction.

J. Coordinate backfill and compaction of anchor trench with CONTRACTOR after installation of GCL, primary geomembrane, and engineered turf.

3.02 SEAMING

A. All overlapped panels shall be augmented with seaming bentonite.

B. Clean overlaps.

C. Place seaming bentonite within the overlapped panel zone at a rate of 4 ounces per lineal foot.

3.03 REPAIRS

A. Repair holes or tears by patching.

B. Extend patch 12-inches beyond the edges of the hole or tear.

C. Place seaming bentonite within the overlapped patch at a rate of 4 ounces per lineal foot. All overlapped patches must be augmented with seaming bentonite.

END SECTION 02774

APPENDIX B

HELP MODELING MEMO

memorandum

To:	Project File
From:	Ms. Melissa Hinman
Date:	May 18, 2020
Re:	North Holding Pond – HELP Model Design Calculations

BACKGROUND

Phillips 66 Company (Phillips 66, CN601491608) operates the Borger Refinery (RN102495884), which is owned by a joint venture between Phillips 66 (P66) and Cenovus called WRB Refining LP (WRB, CN603215997). This memo has been prepared to evaluate the proposed cover system design to close the North Holding Pond (NOR#036).

The North Holding Pond (NHP) is a 3.4-acre surface impoundment with a liner system consisting of 3-feet of bentonite amended clay, leak detection system, and 100-mil high-density polyethylene (HDPE) liner. The North Holding Pond is in partial closure in accordance with the 1998 closure plan. The free liquid has been removed and the sludge has been stabilized. The impoundment is now being filled with non-hazardous waste. The partial closure permit modification was approved by the Texas Commission of Environmental Quality (TCEQ) on April 21, 2004.

OBJECTIVE

The following calculations will demonstrate the performance of the proposed final cover system is superior or equivalent to the previously permitted cover system for the North Holding Pond during the 30-year post closure period. The calculations for the hydrologic evaluation of the cover systems presented below were modeled using the Hydrologic Evaluation of Landfill Performance (HELP) software, Version 3.07. The proposed cover system and previously permitted cover system elements are summarized in **TABLE 1**.

TABLE 1. COVER SYSTEM ELEMENTS

Proposed Cover System	Previously Permitted Cover System
Engineered Turf with ½" sand ballast	18" Vegetative Support and Protective Cover Layer
	Non-woven fabric
130-mil Linear Low-Density Polyethylene (LLDPE) MicroDrain® (integrated in to geomembrane)	3" Sand or gravel drainage layer
50-mil LLDPE Geomembrane	40-mil HDPE geomembrane liner layer
0.24" Geosynthetic Clay Liner and 12" Compacted Clay	24" Compacted clay

MODELING ASSUMPTIONS

Weather Data

Precipitation and mean temperature data were synthetically generated utilizing average monthly values for Borger, Texas from the National Oceanic and Atmospheric Administration (NOAA) Climate Data Online, Data Tools 1981-2010 Normals. Solar radiation data were synthetically generated utilizing

coefficients for Amarillo, Texas modified to the site's latitude of 35.71 degrees. The precipitation data for the 100-year, 24-hour rainfall event for Borger was 3.88 in.
Relative humidity and evapotranspiration data used in the model reflect the default HELP data for Amarillo, Texas modified to the site's latitude of 35.71 degrees.

For the proposed cover the evaporative zone depth assumed was 0.63 in. (0.5 in. sand ballast and 0.13 in. studded drainage layer that is part of the LLDPE geomembrane). A leaf index of 0 was utilized as the synthetic turf is constructed of HDPE and will not transpire.

For the previously permitted cover the evaporative zone depth assumed was 18 in. and a leaf index of 2 was utilized based on the assumption a fair stand of grass will be established on the final cover.

100% of the area will have runoff.

Initial Soil Moisture Content

The initial soil moisture content for the soil layers and snow water were computed as nearly steady-state values by the HELP Model program.

Runoff Curve Number

The runoff curve number (88.4) was computed by the HELP Model using soil texture #13 with a fair stand of grass, a surface slope of 3% and a slope length of 260 feet for the previously permitted cover.

A runoff curve number of 92 was manually input based on data provided by WatershedGeo, the ClosureTurf® manufacturer.

Final Cover Section Input

The final cover cross section for the proposed (**TABLE 2**) and previously permitted cover (**TABLE 3**) systems were modeled using the HELP Model and included layers described in the following tables.

TABLE 2. PROPOSED COVER SYSTEM

MATERIAL	LAYER TYPE	HELP MODEL MATERIAL TEXTURE NO.	ASSUMPTIONS
Engineered Turf with ½" sand ballast	1-Vertical Percolation Layer	2	Default HELP values for hydraulic conductivity and porosity were utilized.
130-mil LLDPE MicroDrain®	2-Lateral Drainage Layer	0	Hydraulic conductivity of 31.57 cm/s represent the long-term hydraulic conductivities with a performance reduction factor of 2.4 applied.[1]

MATERIAL	LAYER TYPE	HELP MODEL MATERIAL TEXTURE NO.	ASSUMPTIONS
50-mil LLDPE Geomembrane	4-Geomembrane Liner	36	Default HELP values for hydraulic conductivity and porosity were utilized. Assume 1 pinhole per acre and a “good” placement quality, which is conservative based on Construction Quality Assurance (CQA) requirements.
0.24” Geosynthetic Clay Liner and 12” Compacted Clay	3-Barrier Soil Liner	0	Hydraulic Conductivity of 3.435 x 10^{-8} cm/s is the calculated effective saturated hydraulic conductivity of the GCL and the compacted clay.[2]

Notes:
[1] MicroDrain® hydraulic conductivity value and reduction factor from “Hydrologic Performance of Synthetic Turf Cover Systems and Their Equivalency to Prescriptive Cover Systems” (Carlson et al. 2019)
[2] The EPA’s user guide for the HELP model was followed to calculate the effective saturated hydraulic conductivity of the barrier soil liner.

TABLE 3. PREVIOUSLY PERMITTED COVER SYSTEM

MATERIAL	LAYER TYPE	HELP MODEL MATERIAL TEXTURE NO. (1)	ASSUMPTIONS
18” Vegetative Support and Protective Cover Layer	1-Vertical Percolation Layer	13	Utilized soil type with a hydraulic conductivity (3.3 x 10^{-5} cm/s) similar to site soils (1 x 10^{-8} to 5 x 10^{-5} cm/sec)
Non-woven fabric	Not modeled	Not modeled	
3” Sand and gravel drainage layer	2-Lateral Drainage Layer	0	User input hydraulic conductivity of 3.3 x 10^{-2} cm/sec selected as 3 orders of magnitude greater than topsoil as specified in permitted closure plan.
40-mil high density polyethylene (HDPE) geomembrane liner layer	4-Geomembrane Liner	35	Default HELP values for hydraulic conductivity and porosity were utilized. Assume 1 pinhole per acre and a “good” placement quality, which is conservative based on CQA requirements.
24” Compacted clay	3-Barrier Soil Liner	16	Utilized a soil type with a hydraulic conductivity matching the permitted hydraulic conductivity for the compacted clay liner of 1 x 10^{-7} cm/sec.

Note:
(1) Total porosity, field capacity, and wilting point used in the model were the default values for the selected HELP material texture number.

MODELING RESULTS

The results of the modeling are presented in Attachment A and summarized in **TABLE 4** below. HELP modeling was conducted over a 100-year period.

TABLE 4. HELP MODELING RESULTS

HELP RESULTS	PROPOSED COVER		PREVIOUSLY PERMITTED COVER	
	INCHES	MM	INCHES	MM
Average Annual Precipitation	22.97	583.44	22.97	583.44
Average Runoff	2.972	75.49	1.439	36.55
Average Annual Evapotranspiration	4.665	118.49	20.655	524.64
Average Annual Percolation through Barrier Layer	0.00000	0.00000	0.00006	0.001524

CONCLUSION

The average annual percolation of 0.00000 inches through the barrier layer of the proposed cover is less than the average annual percolation of 0.00006 inches through the previously permitted cover, is based on the conservative calculations by the HELP Model. The lower annual average percolation of the proposed final cover demonstrates it will perform which exceeds or is equivalent to the previously permitted cover system.

REFERENCES

Carlson, C., Zhu, M., Ebrahimi, A. 2019. Hydrologic Performance of Synthetic Turf Cover Systems and Their Equivalency to Prescriptive Cover Systems. February 10-13, 2019; Houston, TX: Geosynthetics Conference.

QUALITY CONTROL	
Calculations By:	TE
Calculations Checked By:	MH
Calculations Reviewed By:	CT

42M-002-008

ATTACHMENT A

PROPOSED COVER HELP MODEL OUTPUT

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↑
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    C:\NHP\DATA4.D4
TEMPERATURE DATA FILE:      C:\NHP\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\NHP\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\NHP\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\NHP\opt2.D10
OUTPUT DATA FILE:           C:\NHP\opt2.OUT


TIME:  16:32     DATE:   5/ 8/2020


******************************************************************************

     TITLE:  NORTH HOLDING POND - OPTION 2

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     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   0
           THICKNESS                       =      0.50   INCHES
```

```
POROSITY                      =      0.4370 VOL/VOL
FIELD CAPACITY                =      0.0620 VOL/VOL
WILTING POINT                 =      0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0241 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.250000004000E-01 CM/SEC


                        LAYER  2
                        --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.13   INCHES
POROSITY                      =      0.8500 VOL/VOL
FIELD CAPACITY                =      0.0100 VOL/VOL
WILTING POINT                 =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0061 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   31.5699997000     CM/SEC
SLOPE                         =      3.00   PERCENT
DRAINAGE LENGTH               =    260.0    FEET


                        LAYER  3
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
THICKNESS                     =      0.05   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      =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                        LAYER  4
                        --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     12.24   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.	=	0.343499984000E-07 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	92.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	0.6	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.013	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	0.304	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.013	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.193	INCHES
TOTAL INITIAL WATER	=	9.193	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AMARILLO TEXAS

STATION LATITUDE	=	35.71	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	95	
END OF GROWING SEASON (JULIAN DATE)	=	303	
EVAPORATIVE ZONE DEPTH	=	0.6	INCHES
AVERAGE ANNUAL WIND SPEED	=	13.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	55.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	52.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	57.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	57.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING

COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.71	0.69	1.54	1.79	2.68	3.28
2.68	3.56	2.09	1.94	1.03	0.86

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
38.50	41.90	49.30	58.10	67.30	76.20
80.60	79.40	71.80	60.60	48.20	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS
AND STATION LATITUDE = 35.71 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.15	69514.516	100.00
RUNOFF	1.217	4417.716	6.36
EVAPOTRANSPIRATION	4.661	16919.994	24.34
DRAINAGE COLLECTED FROM LAYER 2	13.2718	48176.629	69.30
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	0.000	0.142	0.00

```
  SOIL WATER AT START OF YEAR                 9.193         33370.086

  SOIL WATER AT END OF YEAR                   9.193         33370.230

  SNOW WATER AT START OF YEAR                 0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                   0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE                 0.0000            0.033      0.00

******************************************************************************


******************************************************************************

                          ANNUAL TOTALS FOR YEAR    2
------------------------------------------------------------------------------
                                            INCHES          CU. FEET     PERCENT
                                           --------        ----------   -------
  PRECIPITATION                             27.94          101422.203   100.00

  RUNOFF                                     3.968          14404.554    14.20

  EVAPOTRANSPIRATION                         5.072          18409.941    18.15

  DRAINAGE COLLECTED FROM LAYER  2          18.9003         68608.070    67.65

  PERC./LEAKAGE THROUGH LAYER  4             0.000002           0.007     0.00

  AVG. HEAD ON TOP OF LAYER  3               0.0025

  CHANGE IN WATER STORAGE                    0.000             -0.370     0.00

  SOIL WATER AT START OF YEAR                9.193          33370.230

  SOIL WATER AT END OF YEAR                  9.193          33369.859

  SNOW WATER AT START OF YEAR                0.000              0.000     0.00

  SNOW WATER AT END OF YEAR                  0.000              0.000     0.00

  ANNUAL WATER BUDGET BALANCE                0.0000            -0.001     0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.10	76593.000	100.00
RUNOFF	2.536	9205.100	12.02
EVAPOTRANSPIRATION	5.478	19886.479	25.96
DRAINAGE COLLECTED FROM LAYER 2	13.0858	47501.402	62.02
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.58	78335.430	100.00
RUNOFF	2.059	7475.807	9.54
EVAPOTRANSPIRATION	3.682	13364.661	17.06
DRAINAGE COLLECTED FROM LAYER 2	15.8388	57494.937	73.40
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.77	75395.094	100.00
RUNOFF	1.002	3635.646	4.82
EVAPOTRANSPIRATION	5.201	18879.016	25.04
DRAINAGE COLLECTED FROM LAYER 2	14.5676	52880.437	70.14
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.012	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.15	87664.516	100.00
RUNOFF	4.089	14842.455	16.93
EVAPOTRANSPIRATION	5.151	18698.168	21.33
DRAINAGE COLLECTED FROM LAYER 2	14.9102	54123.863	61.74
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.44	74197.195	100.00
RUNOFF	1.911	6935.774	9.35

EVAPOTRANSPIRATION	4.058	14729.002	19.85
DRAINAGE COLLECTED FROM LAYER 2	14.3346	52034.535	70.13
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	0.137	497.878	0.67
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.330	33867.738	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.28	91766.406	100.00
RUNOFF	3.812	13836.615	15.08
EVAPOTRANSPIRATION	5.207	18899.994	20.60
DRAINAGE COLLECTED FROM LAYER 2	16.1120	58486.543	63.73
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.150	543.245	0.59
SOIL WATER AT START OF YEAR	9.330	33867.738	
SOIL WATER AT END OF YEAR	9.480	34410.984	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.33	70167.898	100.00
RUNOFF	2.624	9524.913	13.57
EVAPOTRANSPIRATION	2.831	10277.644	14.65
DRAINAGE COLLECTED FROM LAYER 2	14.1616	51406.465	73.26
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	-0.287	-1041.124	-1.48
SOIL WATER AT START OF YEAR	9.480	34410.984	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	22.40	81312.016	100.00
RUNOFF	2.052	7448.376	9.16
EVAPOTRANSPIRATION	4.368	15856.794	19.50
DRAINAGE COLLECTED FROM LAYER 2	15.8960	57702.598	70.96
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.084	304.212	0.37
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.277	33674.070	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.033	0.00

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	29.18	105923.406	100.00
RUNOFF	2.848	10339.919	9.76
EVAPOTRANSPIRATION	7.125	25865.432	24.42
DRAINAGE COLLECTED FROM LAYER 2	18.1735	65969.680	62.28
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	1.033	3748.354	3.54

SOIL WATER AT START OF YEAR	9.277	33674.070	
SOIL WATER AT END OF YEAR	9.248	33570.949	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.061	3851.475	3.64
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.82	71946.602	100.00
RUNOFF	2.283	8288.470	11.52
EVAPOTRANSPIRATION	3.951	14343.427	19.94
DRAINAGE COLLECTED FROM LAYER 2	14.7017	53367.262	74.18
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	-1.116	-4052.567	-5.63
SOIL WATER AT START OF YEAR	9.248	33570.949	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	1.061	3851.475	5.35
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.09	91076.711	100.00
RUNOFF	2.848	10338.269	11.35
EVAPOTRANSPIRATION	6.267	22751.021	24.98
DRAINAGE COLLECTED FROM LAYER 2	15.9745	57987.402	63.67
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.15	54994.516	100.00
RUNOFF	1.631	5920.577	10.77
EVAPOTRANSPIRATION	3.094	11229.421	20.42
DRAINAGE COLLECTED FROM LAYER 2	10.4255	37844.504	68.82
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0014		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.42	66864.609	100.00
RUNOFF	1.200	4356.324	6.52
EVAPOTRANSPIRATION	4.814	17474.369	26.13
DRAINAGE COLLECTED FROM LAYER 2	12.4060	45033.906	67.35
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.01	79896.305	100.00
RUNOFF	3.641	13215.442	16.54
EVAPOTRANSPIRATION	3.931	14268.033	17.86
DRAINAGE COLLECTED FROM LAYER 2	14.4388	52412.820	65.60
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.31	55575.305	100.00
RUNOFF	1.486	5393.886	9.71

EVAPOTRANSPIRATION	3.069	11140.818	20.05
DRAINAGE COLLECTED FROM LAYER 2	10.7550	39040.586	70.25
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.27	77210.102	100.00
RUNOFF	2.389	8672.902	11.23
EVAPOTRANSPIRATION	5.451	19787.137	25.63
DRAINAGE COLLECTED FROM LAYER 2	13.4298	48750.051	63.14
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.00	98010.016	100.00
RUNOFF	5.556	20168.148	20.58
EVAPOTRANSPIRATION	3.918	14221.061	14.51
DRAINAGE COLLECTED FROM LAYER 2	17.5264	63620.781	64.91
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.09	54776.699	100.00
RUNOFF	1.264	4587.510	8.37
EVAPOTRANSPIRATION	3.109	11284.935	20.60
DRAINAGE COLLECTED FROM LAYER 2	10.7174	38904.258	71.02
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.54	67300.219	100.00
RUNOFF	3.345	12140.685	18.04
EVAPOTRANSPIRATION	2.861	10383.902	15.43
DRAINAGE COLLECTED FROM LAYER 2	12.3173	44711.848	66.44
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	0.018	63.757	0.09

SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.210	33433.617	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.020	0.00

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.25	95287.508	100.00
RUNOFF	3.223	11698.722	12.28
EVAPOTRANSPIRATION	4.935	17915.662	18.80
DRAINAGE COLLECTED FROM LAYER 2	18.0980	65695.617	68.94
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	-0.006	-22.502	-0.02
SOIL WATER AT START OF YEAR	9.210	33433.617	
SOIL WATER AT END OF YEAR	9.204	33411.113	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.73	75249.898	100.00
RUNOFF	2.908	10557.721	14.03
EVAPOTRANSPIRATION	3.593	13043.321	17.33
DRAINAGE COLLECTED FROM LAYER 2	14.2397	51690.117	68.69
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	-0.011	-41.255	-0.05
SOIL WATER AT START OF YEAR	9.204	33411.113	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.92	83199.617	100.00
RUNOFF	2.271	8245.218	9.91
EVAPOTRANSPIRATION	4.068	14765.494	17.75
DRAINAGE COLLECTED FROM LAYER 2	16.4976	59886.422	71.98
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0022		
CHANGE IN WATER STORAGE	0.083	302.450	0.36
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.276	33672.309	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.023	0.00

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.80	86394.008	100.00
RUNOFF	2.237	8119.025	9.40
EVAPOTRANSPIRATION	6.850	24866.164	28.78
DRAINAGE COLLECTED FROM LAYER 2	14.7965	53711.250	62.17
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	-0.083	-302.450	-0.35
SOIL WATER AT START OF YEAR	9.276	33672.309	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.41	70458.312	100.00
RUNOFF	1.780	6462.535	9.17
EVAPOTRANSPIRATION	4.776	17336.844	24.61
DRAINAGE COLLECTED FROM LAYER 2	12.8447	46626.211	66.18
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.009	32.683	0.05
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.202	33402.543	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.034	0.00

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.64	85813.219	100.00
RUNOFF	1.865	6768.195	7.89

EVAPOTRANSPIRATION	5.109	18546.631	21.61
DRAINAGE COLLECTED FROM LAYER 2	16.6752	60531.070	70.54
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0022		
CHANGE IN WATER STORAGE	-0.009	-32.683	-0.04
SOIL WATER AT START OF YEAR	9.202	33402.543	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.17	76847.117	100.00
RUNOFF	1.709	6202.729	8.07
EVAPOTRANSPIRATION	4.946	17952.709	23.36
DRAINAGE COLLECTED FROM LAYER 2	14.3411	52058.305	67.74
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	0.174	633.357	0.82
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.367	34003.215	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.90	97646.984	100.00
RUNOFF	4.052	14707.945	15.06
EVAPOTRANSPIRATION	4.803	17433.322	17.85
DRAINAGE COLLECTED FROM LAYER 2	18.2201	66139.086	67.73
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	-0.174	-633.357	-0.65
SOIL WATER AT START OF YEAR	9.367	34003.215	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.88	93944.398	100.00
RUNOFF	3.616	13125.238	13.97
EVAPOTRANSPIRATION	5.742	20842.186	22.19
DRAINAGE COLLECTED FROM LAYER 2	16.5224	59976.312	63.84
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0022		
CHANGE IN WATER STORAGE	0.000	0.661	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33370.520	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.006	0.00

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ANNUAL TOTALS FOR YEAR 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.80	90024.008	100.00
RUNOFF	2.803	10174.625	11.30
EVAPOTRANSPIRATION	6.036	21911.082	24.34
DRAINAGE COLLECTED FROM LAYER 2	15.9611	57938.941	64.36
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.000	-0.661	0.00

SOIL WATER AT START OF YEAR	9.193	33370.520	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 32

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.36	92056.812	100.00
RUNOFF	2.723	9883.026	10.74
EVAPOTRANSPIRATION	4.733	17182.592	18.67
DRAINAGE COLLECTED FROM LAYER 2	17.8425	64768.320	70.36
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	0.061	222.856	0.24
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.254	33592.715	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

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ANNUAL TOTALS FOR YEAR 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.27	62690.117	100.00
RUNOFF	0.719	2610.606	4.16
EVAPOTRANSPIRATION	4.696	17044.965	27.19
DRAINAGE COLLECTED FROM LAYER 2	11.8491	43012.168	68.61
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	0.006	22.357	0.04
SOIL WATER AT START OF YEAR	9.254	33592.715	
SOIL WATER AT END OF YEAR	9.260	33615.070	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 34

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.87	101168.094	100.00
RUNOFF	5.569	20216.410	19.98
EVAPOTRANSPIRATION	4.217	15306.130	15.13
DRAINAGE COLLECTED FROM LAYER 2	18.1517	65890.758	65.13
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	-0.068	-245.212	-0.24
SOIL WATER AT START OF YEAR	9.260	33615.070	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 35

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.38	70349.398	100.00
RUNOFF	0.724	2628.988	3.74
EVAPOTRANSPIRATION	5.414	19653.125	27.94
DRAINAGE COLLECTED FROM LAYER 2	13.2412	48065.699	68.32
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	1.579	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33371.437	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.001	0.00

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ANNUAL TOTALS FOR YEAR 36

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.52	74487.617	100.00
RUNOFF	3.230	11723.593	15.74
EVAPOTRANSPIRATION	3.273	11880.292	15.95
DRAINAGE COLLECTED FROM LAYER 2	13.9733	50723.223	68.10
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	0.044	160.487	0.22
SOIL WATER AT START OF YEAR	9.193	33371.437	
SOIL WATER AT END OF YEAR	9.237	33531.926	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.018	0.00

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ANNUAL TOTALS FOR YEAR 37

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.59	67481.711	100.00
RUNOFF	2.454	8909.412	13.20

EVAPOTRANSPIRATION	3.344	12140.296	17.99
DRAINAGE COLLECTED FROM LAYER 2	12.8358	46594.059	69.05
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	-0.045	-162.066	-0.24
SOIL WATER AT START OF YEAR	9.237	33531.926	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 38

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.07	61964.105	100.00
RUNOFF	0.859	3117.153	5.03
EVAPOTRANSPIRATION	3.736	13562.092	21.89
DRAINAGE COLLECTED FROM LAYER 2	12.4752	45284.824	73.08
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.033	0.00

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ANNUAL TOTALS FOR YEAR 39

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.27	88100.109	100.00
RUNOFF	4.066	14758.231	16.75
EVAPOTRANSPIRATION	4.760	17279.980	19.61
DRAINAGE COLLECTED FROM LAYER 2	15.4440	56061.871	63.63
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.020	0.00

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ANNUAL TOTALS FOR YEAR 40

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.65	89479.516	100.00
RUNOFF	1.694	6150.279	6.87
EVAPOTRANSPIRATION	5.869	21305.996	23.81
DRAINAGE COLLECTED FROM LAYER 2	17.0762	61986.504	69.27
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	0.010	36.727	0.04
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.203	33406.586	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.001	0.00

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ANNUAL TOTALS FOR YEAR 41

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.48	70712.414	100.00
RUNOFF	2.100	7622.201	10.78
EVAPOTRANSPIRATION	4.862	17647.461	24.96
DRAINAGE COLLECTED FROM LAYER 2	12.5288	45479.453	64.32
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	-0.010	-36.727	-0.05

SOIL WATER AT START OF YEAR	9.203	33406.586	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 42

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.16	91330.805	100.00
RUNOFF	2.277	8266.765	9.05
EVAPOTRANSPIRATION	4.680	16987.361	18.60
DRAINAGE COLLECTED FROM LAYER 2	18.2029	66076.672	72.35
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

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ANNUAL TOTALS FOR YEAR 43

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.81	100950.336	100.00
RUNOFF	3.588	13023.431	12.90
EVAPOTRANSPIRATION	5.806	21075.201	20.88
DRAINAGE COLLECTED FROM LAYER 2	18.1671	65946.492	65.33
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	0.249	905.135	0.90
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.232	33512.770	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.210	762.223	0.76
ANNUAL WATER BUDGET BALANCE	0.0000	0.072	0.00

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ANNUAL TOTALS FOR YEAR 44

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.59	89261.711	100.00
RUNOFF	3.716	13489.295	15.11
EVAPOTRANSPIRATION	5.246	19043.187	21.33
DRAINAGE COLLECTED FROM LAYER 2	15.8672	57597.828	64.53
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	-0.239	-868.613	-0.97
SOIL WATER AT START OF YEAR	9.232	33512.770	
SOIL WATER AT END OF YEAR	9.203	33406.383	
SNOW WATER AT START OF YEAR	0.210	762.223	0.85
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 45

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.39	77645.703	100.00
RUNOFF	1.217	4417.427	5.69
EVAPOTRANSPIRATION	4.116	14942.576	19.24
DRAINAGE COLLECTED FROM LAYER 2	16.0597	58296.773	75.08
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	-0.003	-11.078	-0.01
SOIL WATER AT START OF YEAR	9.203	33406.383	
SOIL WATER AT END OF YEAR	9.200	33395.305	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.001	0.00

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ANNUAL TOTALS FOR YEAR 46

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.33	59277.906	100.00
RUNOFF	1.891	6863.788	11.58
EVAPOTRANSPIRATION	4.591	16663.893	28.11
DRAINAGE COLLECTED FROM LAYER 2	9.8556	35775.668	60.35
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0013		
CHANGE IN WATER STORAGE	-0.007	-25.445	-0.04
SOIL WATER AT START OF YEAR	9.200	33395.305	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.001	0.00

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ANNUAL TOTALS FOR YEAR 47

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.05	98191.508	100.00
RUNOFF	3.362	12205.005	12.43

EVAPOTRANSPIRATION	5.940	21563.570	21.96
DRAINAGE COLLECTED FROM LAYER 2	17.7474	64422.926	65.61
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 48

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.27	77210.109	100.00
RUNOFF	2.665	9674.837	12.53
EVAPOTRANSPIRATION	4.857	17632.289	22.84
DRAINAGE COLLECTED FROM LAYER 2	13.7474	49902.957	64.63
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 49

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.01	94416.305	100.00
RUNOFF	4.101	14884.872	15.77
EVAPOTRANSPIRATION	4.020	14591.031	15.45
DRAINAGE COLLECTED FROM LAYER 2	17.8899	64940.379	68.78
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.018	0.00

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ANNUAL TOTALS FOR YEAR 50

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.28	91766.406	100.00
RUNOFF	1.861	6756.082	7.36
EVAPOTRANSPIRATION	6.039	21922.135	23.89
DRAINAGE COLLECTED FROM LAYER 2	17.3797	63088.156	68.75
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 51

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.42	95904.602	100.00
RUNOFF	4.954	17982.834	18.75
EVAPOTRANSPIRATION	5.130	18622.783	19.42
DRAINAGE COLLECTED FROM LAYER 2	16.3289	59273.793	61.80
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0022		
CHANGE IN WATER STORAGE	0.007	25.188	0.03

SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.200	33395.047	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 52

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.56	60112.805	100.00
RUNOFF	1.293	4694.248	7.81
EVAPOTRANSPIRATION	3.010	10927.794	18.18
DRAINAGE COLLECTED FROM LAYER 2	12.2633	44515.941	74.05
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	-0.007	-25.188	-0.04
SOIL WATER AT START OF YEAR	9.200	33395.047	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

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ANNUAL TOTALS FOR YEAR 53

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.78	86321.414	100.00
RUNOFF	3.760	13650.543	15.81
EVAPOTRANSPIRATION	4.256	15448.106	17.90
DRAINAGE COLLECTED FROM LAYER 2	14.9290	54192.090	62.78
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	0.835	3030.652	3.51
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.248	33571.020	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.779	2829.491	3.28
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 54

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.58	107375.430	100.00
RUNOFF	3.767	13675.795	12.74
EVAPOTRANSPIRATION	6.154	22340.418	20.81
DRAINAGE COLLECTED FROM LAYER 2	20.3529	73881.117	68.81
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0027		
CHANGE IN WATER STORAGE	-0.695	-2521.941	-2.35
SOIL WATER AT START OF YEAR	9.248	33571.020	
SOIL WATER AT END OF YEAR	9.232	33512.770	
SNOW WATER AT START OF YEAR	0.779	2829.491	2.64
SNOW WATER AT END OF YEAR	0.101	365.800	0.34
ANNUAL WATER BUDGET BALANCE	0.0000	0.032	0.00

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ANNUAL TOTALS FOR YEAR 55

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.93	68715.930	100.00
RUNOFF	2.804	10177.842	14.81
EVAPOTRANSPIRATION	3.796	13780.195	20.05
DRAINAGE COLLECTED FROM LAYER 2	12.4516	45199.152	65.78
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	-0.122	-441.295	-0.64
SOIL WATER AT START OF YEAR	9.232	33512.770	
SOIL WATER AT END OF YEAR	9.211	33437.273	
SNOW WATER AT START OF YEAR	0.101	365.800	0.53
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.028	0.00

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ANNUAL TOTALS FOR YEAR 56

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.11	98409.312	100.00
RUNOFF	2.933	10645.314	10.82
EVAPOTRANSPIRATION	5.159	18727.936	19.03
DRAINAGE COLLECTED FROM LAYER 2	19.0368	69103.469	70.22
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0025		
CHANGE IN WATER STORAGE	-0.019	-67.416	-0.07
SOIL WATER AT START OF YEAR	9.211	33437.273	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 57

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.52	85377.625	100.00
RUNOFF	4.602	16707.043	19.57

EVAPOTRANSPIRATION	4.904	17799.971	20.85
DRAINAGE COLLECTED FROM LAYER 2	14.0139	50870.566	59.58
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.035	0.00

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ANNUAL TOTALS FOR YEAR 58

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.77	64505.109	100.00
RUNOFF	2.060	7478.300	11.59
EVAPOTRANSPIRATION	2.978	10809.291	16.76
DRAINAGE COLLECTED FROM LAYER 2	12.7321	46217.500	71.65
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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ANNUAL TOTALS FOR YEAR 59

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.77	64505.102	100.00
RUNOFF	2.524	9163.584	14.21
EVAPOTRANSPIRATION	3.610	13103.770	20.31
DRAINAGE COLLECTED FROM LAYER 2	11.4187	41449.902	64.26
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0015		
CHANGE IN WATER STORAGE	0.217	787.823	1.22
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.248	33571.074	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.162	586.607	0.91
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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ANNUAL TOTALS FOR YEAR 60

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.41	110388.305	100.00
RUNOFF	4.356	15810.556	14.32
EVAPOTRANSPIRATION	5.182	18812.145	17.04
DRAINAGE COLLECTED FROM LAYER 2	20.4366	74185.016	67.20
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0027		
CHANGE IN WATER STORAGE	0.435	1580.564	1.43
SOIL WATER AT START OF YEAR	9.248	33571.074	
SOIL WATER AT END OF YEAR	9.232	33512.770	
SNOW WATER AT START OF YEAR	0.162	586.607	0.53
SNOW WATER AT END OF YEAR	0.613	2225.476	2.02
ANNUAL WATER BUDGET BALANCE	0.0000	0.018	0.00

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ANNUAL TOTALS FOR YEAR 61

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.01	105306.320	100.00
RUNOFF	5.882	21351.617	20.28
EVAPOTRANSPIRATION	6.375	23140.701	21.97
DRAINAGE COLLECTED FROM LAYER 2	17.4056	63182.348	60.00
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	-0.652	-2368.387	-2.25

SOIL WATER AT START OF YEAR	9.232	33512.770	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.613	2225.476	2.11
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.036	0.00

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ANNUAL TOTALS FOR YEAR 62

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.48	67082.406	100.00
RUNOFF	1.504	5459.158	8.14
EVAPOTRANSPIRATION	3.119	11322.083	16.88
DRAINAGE COLLECTED FROM LAYER 2	13.8571	50301.148	74.98
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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ANNUAL TOTALS FOR YEAR 63

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.00	98010.008	100.00
RUNOFF	3.233	11734.974	11.97
EVAPOTRANSPIRATION	5.856	21256.482	21.69
DRAINAGE COLLECTED FROM LAYER 2	17.9055	64997.062	66.32
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	0.006	21.477	0.02
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.199	33391.336	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 64

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.90	86756.992	100.00
RUNOFF	3.462	12566.325	14.48
EVAPOTRANSPIRATION	4.524	16422.404	18.93
DRAINAGE COLLECTED FROM LAYER 2	15.8446	57516.023	66.30
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.069	252.243	0.29
SOIL WATER AT START OF YEAR	9.199	33391.336	
SOIL WATER AT END OF YEAR	9.268	33643.578	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.008	0.00

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ANNUAL TOTALS FOR YEAR 65

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.89	83090.687	100.00
RUNOFF	3.755	13630.556	16.40
EVAPOTRANSPIRATION	4.219	15313.666	18.43
DRAINAGE COLLECTED FROM LAYER 2	14.9802	54378.168	65.44
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	-0.064	-231.697	-0.28
SOIL WATER AT START OF YEAR	9.268	33643.578	
SOIL WATER AT END OF YEAR	9.204	33411.883	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 66

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.38	99389.422	100.00
RUNOFF	4.144	15042.011	15.13
EVAPOTRANSPIRATION	5.793	21029.807	21.16
DRAINAGE COLLECTED FROM LAYER 2	17.4544	63359.613	63.75
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	-0.012	-42.023	-0.04
SOIL WATER AT START OF YEAR	9.204	33411.883	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 67

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.82	100986.609	100.00
RUNOFF	5.536	20096.037	19.90

EVAPOTRANSPIRATION	5.476	19876.941	19.68
DRAINAGE COLLECTED FROM LAYER 2	16.8082	61013.609	60.42
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0022		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 68

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.45	117793.500	100.00
RUNOFF	6.685	24266.686	20.60
EVAPOTRANSPIRATION	6.785	24631.121	20.91
DRAINAGE COLLECTED FROM LAYER 2	18.8847	68551.500	58.20
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0025		
CHANGE IN WATER STORAGE	0.095	344.187	0.29
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.248	33571.031	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.039	143.016	0.12
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

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ANNUAL TOTALS FOR YEAR 69

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.24	84361.203	100.00
RUNOFF	3.148	11428.249	13.55
EVAPOTRANSPIRATION	4.351	15793.733	18.72
DRAINAGE COLLECTED FROM LAYER 2	15.8356	57483.402	68.14
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	-0.095	-344.187	-0.41
SOIL WATER AT START OF YEAR	9.248	33571.031	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.039	143.016	0.17
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 70

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.52	78117.602	100.00
RUNOFF	4.217	15309.391	19.60
EVAPOTRANSPIRATION	4.173	15149.753	19.39
DRAINAGE COLLECTED FROM LAYER 2	13.1291	47658.461	61.01
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.010	0.00

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ANNUAL TOTALS FOR YEAR 71

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.47	85196.102	100.00
RUNOFF	2.345	8514.038	9.99
EVAPOTRANSPIRATION	5.181	18807.637	22.08
DRAINAGE COLLECTED FROM LAYER 2	15.7159	57048.621	66.96
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.227	825.795	0.97

SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.212	33441.316	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.208	754.339	0.89
ANNUAL WATER BUDGET BALANCE	0.0000	0.006	0.00

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ANNUAL TOTALS FOR YEAR 72

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.65	74959.516	100.00
RUNOFF	1.576	5719.453	7.63
EVAPOTRANSPIRATION	4.017	14580.358	19.45
DRAINAGE COLLECTED FROM LAYER 2	15.2853	55485.465	74.02
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	-0.227	-825.795	-1.10
SOIL WATER AT START OF YEAR	9.212	33441.316	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.208	754.339	1.01
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.025	0.00

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ANNUAL TOTALS FOR YEAR 73

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.09	98336.711	100.00
RUNOFF	4.593	16673.887	16.96
EVAPOTRANSPIRATION	5.217	18937.145	19.26
DRAINAGE COLLECTED FROM LAYER 2	17.2798	62725.656	63.79
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 74

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.84	108319.211	100.00
RUNOFF	3.470	12594.602	11.63
EVAPOTRANSPIRATION	6.420	23305.164	21.52
DRAINAGE COLLECTED FROM LAYER 2	19.9503	72419.422	66.86
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0027		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 75

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.99	119753.703	100.00
RUNOFF	8.015	29095.840	24.30
EVAPOTRANSPIRATION	5.358	19447.785	16.24
DRAINAGE COLLECTED FROM LAYER 2	19.6171	71210.047	59.46
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0026		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.029	0.00

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ANNUAL TOTALS FOR YEAR 76

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.32	106431.609	100.00
RUNOFF	5.712	20734.414	19.48
EVAPOTRANSPIRATION	4.524	16420.311	15.43
DRAINAGE COLLECTED FROM LAYER 2	18.9347	68733.078	64.58
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0025		
CHANGE IN WATER STORAGE	0.150	543.779	0.51
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.343	33913.637	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.024	0.00

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ANNUAL TOTALS FOR YEAR 77

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.50	67155.008	100.00
RUNOFF	2.434	8834.682	13.16

EVAPOTRANSPIRATION	2.948	10700.844	15.93
DRAINAGE COLLECTED FROM LAYER 2	13.2681	48163.238	71.72
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	-0.150	-543.779	-0.81
SOIL WATER AT START OF YEAR	9.343	33913.637	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 78

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.92	90459.594	100.00
RUNOFF	3.997	14509.966	16.04
EVAPOTRANSPIRATION	5.027	18249.689	20.17
DRAINAGE COLLECTED FROM LAYER 2	15.8851	57662.992	63.74
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.010	36.931	0.04
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.203	33406.789	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 79

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.33	81057.906	100.00
RUNOFF	3.399	12338.158	15.22
EVAPOTRANSPIRATION	4.046	14687.855	18.12
DRAINAGE COLLECTED FROM LAYER 2	14.8950	54068.809	66.70
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	-0.010	-36.931	-0.05
SOIL WATER AT START OF YEAR	9.203	33406.789	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 80

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.86	64831.801	100.00
RUNOFF	0.842	3055.621	4.71
EVAPOTRANSPIRATION	4.384	15915.661	24.55
DRAINAGE COLLECTED FROM LAYER 2	11.6668	42350.449	65.32
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0015		
CHANGE IN WATER STORAGE	0.967	3510.073	5.41
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.248	33570.902	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.912	3309.030	5.10
ANNUAL WATER BUDGET BALANCE	0.0000	-0.006	0.00

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ANNUAL TOTALS FOR YEAR 81

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.52	70857.617	100.00
RUNOFF	2.569	9324.905	13.16
EVAPOTRANSPIRATION	4.117	14946.244	21.09
DRAINAGE COLLECTED FROM LAYER 2	13.8007	50096.512	70.70
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
CHANGE IN WATER STORAGE	-0.967	-3510.073	-4.95

SOIL WATER AT START OF YEAR	9.248	33570.902	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.912	3309.030	4.67
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

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ANNUAL TOTALS FOR YEAR 82

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.45	88753.516	100.00
RUNOFF	2.469	8961.838	10.10
EVAPOTRANSPIRATION	6.352	23058.756	25.98
DRAINAGE COLLECTED FROM LAYER 2	15.6289	56732.902	63.92
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 83

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.87	79388.102	100.00
RUNOFF	2.094	7601.854	9.58
EVAPOTRANSPIRATION	4.795	17405.955	21.93
DRAINAGE COLLECTED FROM LAYER 2	14.9808	54380.277	68.50
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 84

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.64	71293.203	100.00
RUNOFF	2.731	9912.791	13.90
EVAPOTRANSPIRATION	4.499	16329.606	22.90
DRAINAGE COLLECTED FROM LAYER 2	12.4074	45038.918	63.17
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	0.003	11.878	0.02
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.196	33381.738	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.006	0.00

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ANNUAL TOTALS FOR YEAR 85

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.23	55284.906	100.00
RUNOFF	1.702	6178.006	11.17
EVAPOTRANSPIRATION	3.133	11371.894	20.57
DRAINAGE COLLECTED FROM LAYER 2	10.3657	37627.473	68.06
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
CHANGE IN WATER STORAGE	0.030	107.528	0.19
SOIL WATER AT START OF YEAR	9.196	33381.738	
SOIL WATER AT END OF YEAR	9.226	33489.266	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.002	0.00

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ANNUAL TOTALS FOR YEAR 86

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.49	74378.703	100.00
RUNOFF	0.947	3437.951	4.62
EVAPOTRANSPIRATION	5.168	18761.303	25.22
DRAINAGE COLLECTED FROM LAYER 2	14.4074	52298.852	70.31
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	-0.033	-119.406	-0.16
SOIL WATER AT START OF YEAR	9.226	33489.266	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.002	0.00

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ANNUAL TOTALS FOR YEAR 87

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.38	99389.414	100.00
RUNOFF	4.987	18103.678	18.21

EVAPOTRANSPIRATION	5.248	19051.357	19.17
DRAINAGE COLLECTED FROM LAYER 2	17.1445	62234.359	62.62
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0023		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.018	0.00

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ANNUAL TOTALS FOR YEAR 88

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.19	58769.703	100.00
RUNOFF	0.821	2980.050	5.07
EVAPOTRANSPIRATION	3.899	14155.031	24.09
DRAINAGE COLLECTED FROM LAYER 2	11.4696	41634.613	70.84
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0015		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 89

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.12	65775.602	100.00
RUNOFF	1.694	6148.832	9.35
EVAPOTRANSPIRATION	3.339	12121.479	18.43
DRAINAGE COLLECTED FROM LAYER 2	13.0869	47505.270	72.22
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 90

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.58	71075.406	100.00
RUNOFF	2.606	9460.654	13.31
EVAPOTRANSPIRATION	3.906	14177.209	19.95
DRAINAGE COLLECTED FROM LAYER 2	13.0682	47437.520	66.74
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 91

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.14	113038.219	100.00
RUNOFF	5.132	18628.561	16.48
EVAPOTRANSPIRATION	6.577	23876.123	21.12
DRAINAGE COLLECTED FROM LAYER 2	19.4307	70533.508	62.40
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0026		
CHANGE IN WATER STORAGE	0.000	0.000	0.00

SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 92

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.22	58878.605	100.00
RUNOFF	1.551	5629.874	9.56
EVAPOTRANSPIRATION	2.742	9952.341	16.90
DRAINAGE COLLECTED FROM LAYER 2	11.9274	43296.383	73.53
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0016		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 93

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.88	101204.414	100.00
RUNOFF	4.277	15526.429	15.34
EVAPOTRANSPIRATION	5.011	18190.832	17.97
DRAINAGE COLLECTED FROM LAYER 2	18.5915	67487.125	66.68
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0025		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 94

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.00	54450.000	100.00
RUNOFF	1.449	5258.681	9.66
EVAPOTRANSPIRATION	2.602	9443.602	17.34
DRAINAGE COLLECTED FROM LAYER 2	10.9498	39747.727	73.00
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0014		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 95

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.27	77210.125	100.00
RUNOFF	3.286	11927.324	15.45
EVAPOTRANSPIRATION	3.052	11077.056	14.35
DRAINAGE COLLECTED FROM LAYER 2	14.9327	54205.727	70.21
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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ANNUAL TOTALS FOR YEAR 96

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.96	108754.820	100.00
RUNOFF	2.874	10434.272	9.59
EVAPOTRANSPIRATION	7.128	25873.336	23.79
DRAINAGE COLLECTED FROM LAYER 2	19.9579	72447.172	66.62
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0026		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.027	0.00

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ANNUAL TOTALS FOR YEAR 97

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.47	114236.102	100.00
RUNOFF	5.082	18446.670	16.15

EVAPOTRANSPIRATION	5.998	21772.734	19.06
DRAINAGE COLLECTED FROM LAYER 2	20.3903	74016.664	64.79
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0027		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.023	0.00

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ANNUAL TOTALS FOR YEAR 98

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.32	73761.609	100.00
RUNOFF	1.646	5973.335	8.10
EVAPOTRANSPIRATION	3.649	13247.470	17.96
DRAINAGE COLLECTED FROM LAYER 2	15.0250	54540.785	73.94
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0020		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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ANNUAL TOTALS FOR YEAR 99

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.78	97211.430	100.00
RUNOFF	4.041	14667.964	15.09
EVAPOTRANSPIRATION	4.895	17767.855	18.28
DRAINAGE COLLECTED FROM LAYER 2	17.8445	64775.582	66.63
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0024		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33369.859	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 100

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	28.58	103745.414	100.00
RUNOFF	5.197	18866.279	18.19
EVAPOTRANSPIRATION	4.061	14742.487	14.21
DRAINAGE COLLECTED FROM LAYER 2	19.3213	70136.281	67.60
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0026		
CHANGE IN WATER STORAGE	0.000	0.343	0.00
SOIL WATER AT START OF YEAR	9.193	33369.859	
SOIL WATER AT END OF YEAR	9.193	33370.203	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

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

TOTALS	0.69	0.72	1.51	1.73	2.79	3.15
	2.67	3.49	2.08	2.23	1.05	0.85
STD. DEVIATIONS	0.60	0.54	1.09	1.30	1.53	1.54
	1.36	2.16	1.39	1.91	1.07	0.84
RUNOFF						

TOTALS	0.018	0.013	0.139	0.204	0.309	0.496

```
                         0.246    0.657    0.320    0.421    0.093    0.057

  STD. DEVIATIONS        0.054    0.043    0.244    0.344    0.400    0.567
                         0.309    0.829    0.421    0.653    0.182    0.208

EVAPOTRANSPIRATION
------------------
  TOTALS                 0.239    0.231    0.287    0.326    0.630    0.623
                         0.622    0.589    0.338    0.334    0.183    0.263

  STD. DEVIATIONS        0.208    0.202    0.250    0.300    0.429    0.420
                         0.419    0.429    0.275    0.299    0.210    0.237

LATERAL DRAINAGE COLLECTED FROM LAYER  2
----------------------------------------
  TOTALS                 0.4844   0.4789   1.0826   1.1954   1.8461   2.0366
                         1.7988   2.2371   1.4385   1.4764   0.7646   0.4982

  STD. DEVIATIONS        0.4514   0.3925   0.7484   0.8132   0.8883   0.8537
                         0.8540   1.1433   0.8513   1.1462   0.7561   0.5186

PERCOLATION/LEAKAGE THROUGH LAYER  4
------------------------------------
  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  3
-------------------------------------
  AVERAGES               0.0008   0.0008   0.0017   0.0019   0.0029   0.0033
                         0.0028   0.0035   0.0023   0.0023   0.0012   0.0008

  STD. DEVIATIONS        0.0007   0.0007   0.0012   0.0013   0.0014   0.0014
                         0.0013   0.0018   0.0014   0.0018   0.0012   0.0008

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   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
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	INCHES		CU. FEET	PERCENT
PRECIPITATION	22.97	(4.466)	83398.2	100.00
RUNOFF	2.972	(1.4395)	10788.24	12.936
EVAPOTRANSPIRATION	4.665	(1.0804)	16933.93	20.305
LATERAL DRAINAGE COLLECTED FROM LAYER 2	15.33773	(2.64988)	55675.969	66.75923
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.007	0.00001
AVERAGE HEAD ON TOP OF LAYER 3	0.002	(0.000)		
CHANGE IN WATER STORAGE	0.000	(0.2573)	0.00	0.000

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	3.88	14084.400
RUNOFF	2.466	8950.0703
DRAINAGE COLLECTED FROM LAYER 2	1.59852	5802.63867
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00023
AVERAGE HEAD ON TOP OF LAYER 3	0.080	
MAXIMUM HEAD ON TOP OF LAYER 3	0.153	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	2.6 FEET	
SNOW WATER	1.87	6789.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4989

```
      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.0208


       ***  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.

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                   FINAL WATER STORAGE AT END OF YEAR  100
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            0.0121         0.0242

                      2            0.0008         0.0062

                      3            0.0000         0.0000

                      4            9.1800         0.7500

                   SNOW WATER      0.000

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ATTACHMENT B

PREVIOUSLY PERMITTED COVER HELP MODEL OUTPUT

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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             **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:     C:\NHP\DATA4.D4
TEMPERATURE DATA FILE:       C:\NHP\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\NHP\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\NHP\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\NHP\data10.D10
OUTPUT DATA FILE:            C:\NHP\permitUD.OUT


TIME:  12:14     DATE:   5/ 7/2020


******************************************************************************

     TITLE:  North Holding Pond - Permitted Final Cover System

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     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  13
           THICKNESS                   =     18.00   INCHES
```

```
  POROSITY                     =     0.4300 VOL/VOL
  FIELD CAPACITY               =     0.3210 VOL/VOL
  WILTING POINT                =     0.2210 VOL/VOL
  INITIAL SOIL WATER CONTENT   =     0.2725 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.330000003000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.




                        LAYER  2
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =     3.00   INCHES
  POROSITY                     =     0.3970 VOL/VOL
  FIELD CAPACITY               =     0.0320 VOL/VOL
  WILTING POINT                =     0.0130 VOL/VOL
  INITIAL SOIL WATER CONTENT   =     0.0323 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.329999998000E-01 CM/SEC
  SLOPE                        =     3.00   PERCENT
  DRAINAGE LENGTH              =   260.0    FEET




                        LAYER  3
                        --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
  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.    =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY          =     1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =     1.00   HOLES/ACRE
  FML PLACEMENT QUALITY        =  3 - GOOD




                        LAYER  4
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               TYPE 3 - BARRIER SOIL LINER
```

MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #13 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 260. FEET.

SCS RUNOFF CURVE NUMBER	=	88.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.906	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.740	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.978	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	15.251	INCHES
TOTAL INITIAL WATER	=	15.251	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AMARILLO TEXAS

STATION LATITUDE	=	35.71 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	95
END OF GROWING SEASON (JULIAN DATE)	=	303
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	13.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	55.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	52.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	57.00 %

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 57.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.71	0.69	1.54	1.79	2.68	3.28
2.68	3.56	2.09	1.94	1.03	0.86

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
38.50	41.90	49.30	58.10	67.30	76.20
80.60	79.40	71.80	60.60	48.20	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS
AND STATION LATITUDE = 35.71 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.15	69514.516	100.00
RUNOFF	0.465	1686.935	2.43
EVAPOTRANSPIRATION	18.392	66761.250	96.04
DRAINAGE COLLECTED FROM LAYER 2	0.2355	854.972	1.23
PERC./LEAKAGE THROUGH LAYER 4	0.000016	0.058	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0299		
CHANGE IN WATER STORAGE	0.058	211.276	0.30
SOIL WATER AT START OF YEAR	15.251	55360.180	
SOIL WATER AT END OF YEAR	15.309	55571.457	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.028	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.94	101422.203	100.00
RUNOFF	1.753	6361.691	6.27
EVAPOTRANSPIRATION	25.817	93716.367	92.40
DRAINAGE COLLECTED FROM LAYER 2	0.9151	3321.664	3.28
PERC./LEAKAGE THROUGH LAYER 4	0.000051	0.187	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1159		
CHANGE IN WATER STORAGE	-0.545	-1977.720	-1.95
SOIL WATER AT START OF YEAR	15.309	55571.457	
SOIL WATER AT END OF YEAR	14.764	53593.734	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.10	76593.000	100.00
RUNOFF	1.241	4504.747	5.88
EVAPOTRANSPIRATION	18.334	66551.187	86.89
DRAINAGE COLLECTED FROM LAYER 2	1.9563	7101.415	9.27
PERC./LEAKAGE THROUGH LAYER 4	0.000130	0.473	0.00
AVG. HEAD ON TOP OF LAYER 3	0.3467		
CHANGE IN WATER STORAGE	-0.431	-1564.813	-2.04
SOIL WATER AT START OF YEAR	14.764	53593.734	
SOIL WATER AT END OF YEAR	14.333	52028.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.006	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.58	78335.430	100.00
RUNOFF	0.754	2737.023	3.49

EVAPOTRANSPIRATION	19.529	70891.773	90.50
DRAINAGE COLLECTED FROM LAYER 2	0.5990	2174.518	2.78
PERC./LEAKAGE THROUGH LAYER 4	0.000036	0.130	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0764		
CHANGE IN WATER STORAGE	0.698	2531.926	3.23
SOIL WATER AT START OF YEAR	14.333	52028.922	
SOIL WATER AT END OF YEAR	15.031	54560.848	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.054	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.77	75395.094	100.00
RUNOFF	0.300	1088.535	1.44
EVAPOTRANSPIRATION	20.678	75060.227	99.56
DRAINAGE COLLECTED FROM LAYER 2	0.0048	17.335	0.02
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
CHANGE IN WATER STORAGE	-0.212	-770.934	-1.02
SOIL WATER AT START OF YEAR	15.031	54560.848	
SOIL WATER AT END OF YEAR	14.818	53789.914	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.076	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.15	87664.516	100.00
RUNOFF	1.754	6366.597	7.26
EVAPOTRANSPIRATION	22.057	80065.641	91.33
DRAINAGE COLLECTED FROM LAYER 2	0.4740	1720.626	1.96
PERC./LEAKAGE THROUGH LAYER 4	0.000027	0.098	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0598		
CHANGE IN WATER STORAGE	-0.135	-488.493	-0.56
SOIL WATER AT START OF YEAR	14.818	53789.914	
SOIL WATER AT END OF YEAR	14.684	53301.422	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.044	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.44	74197.195	100.00
RUNOFF	0.795	2887.581	3.89
EVAPOTRANSPIRATION	16.370	59422.160	80.09
DRAINAGE COLLECTED FROM LAYER 2	1.3027	4728.766	6.37
PERC./LEAKAGE THROUGH LAYER 4	0.000068	0.248	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1648		
CHANGE IN WATER STORAGE	1.972	7158.454	9.65
SOIL WATER AT START OF YEAR	14.684	53301.422	
SOIL WATER AT END OF YEAR	16.656	60459.875	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.28	91766.406	100.00
RUNOFF	1.821	6611.068	7.20
EVAPOTRANSPIRATION	23.378	84862.039	92.48
DRAINAGE COLLECTED FROM LAYER 2	0.4656	1690.212	1.84
PERC./LEAKAGE THROUGH LAYER 4	0.000028	0.100	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0588		
CHANGE IN WATER STORAGE	-0.385	-1397.059	-1.52

SOIL WATER AT START OF YEAR	16.656	60459.875	
SOIL WATER AT END OF YEAR	16.271	59062.816	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.051	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.33	70167.898	100.00
RUNOFF	1.424	5170.198	7.37
EVAPOTRANSPIRATION	18.812	68288.875	97.32
DRAINAGE COLLECTED FROM LAYER 2	0.5249	1905.512	2.72
PERC./LEAKAGE THROUGH LAYER 4	0.000032	0.115	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0664		
CHANGE IN WATER STORAGE	-1.432	-5196.821	-7.41
SOIL WATER AT START OF YEAR	16.271	59062.816	
SOIL WATER AT END OF YEAR	14.839	53865.996	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.40	81312.016	100.00
RUNOFF	0.841	3053.951	3.76
EVAPOTRANSPIRATION	19.529	70891.687	87.18
DRAINAGE COLLECTED FROM LAYER 2	0.2360	856.712	1.05
PERC./LEAKAGE THROUGH LAYER 4	0.000016	0.057	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0301		
CHANGE IN WATER STORAGE	1.793	6509.598	8.01
SOIL WATER AT START OF YEAR	14.839	53865.996	
SOIL WATER AT END OF YEAR	16.632	60375.594	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.18	105923.406	100.00
RUNOFF	1.239	4499.068	4.25
EVAPOTRANSPIRATION	25.849	93831.141	88.58
DRAINAGE COLLECTED FROM LAYER 2	2.1398	7767.571	7.33
PERC./LEAKAGE THROUGH LAYER 4	0.000115	0.418	0.00

AVG. HEAD ON TOP OF LAYER 3	0.2723		
CHANGE IN WATER STORAGE	-0.048	-174.808	-0.17
SOIL WATER AT START OF YEAR	16.632	60375.594	
SOIL WATER AT END OF YEAR	15.523	56349.309	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.061	3851.475	3.64
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.82	71946.602	100.00
RUNOFF	0.974	3535.443	4.91
EVAPOTRANSPIRATION	19.661	71370.586	99.20
DRAINAGE COLLECTED FROM LAYER 2	0.6937	2518.108	3.50
PERC./LEAKAGE THROUGH LAYER 4	0.000040	0.144	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0875		
CHANGE IN WATER STORAGE	-1.509	-5477.653	-7.61
SOIL WATER AT START OF YEAR	15.523	56349.309	
SOIL WATER AT END OF YEAR	15.075	54723.133	
SNOW WATER AT START OF YEAR	1.061	3851.475	5.35
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.027	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.09	91076.711	100.00
RUNOFF	1.715	6223.742	6.83
EVAPOTRANSPIRATION	22.191	80552.312	88.44
DRAINAGE COLLECTED FROM LAYER 2	1.1575	4201.882	4.61
PERC./LEAKAGE THROUGH LAYER 4	0.000061	0.222	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1473		
CHANGE IN WATER STORAGE	0.027	98.493	0.11
SOIL WATER AT START OF YEAR	15.075	54723.133	
SOIL WATER AT END OF YEAR	15.102	54821.625	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.064	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.15	54994.516	100.00
RUNOFF	0.686	2490.765	4.53

EVAPOTRANSPIRATION	14.679	53283.348	96.89
DRAINAGE COLLECTED FROM LAYER 2	0.1594	578.507	1.05
PERC./LEAKAGE THROUGH LAYER 4	0.000012	0.043	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0203		
CHANGE IN WATER STORAGE	-0.374	-1358.152	-2.47
SOIL WATER AT START OF YEAR	15.102	54821.625	
SOIL WATER AT END OF YEAR	14.728	53463.473	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.006	0.00

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.42	66864.609	100.00
RUNOFF	0.425	1544.556	2.31
EVAPOTRANSPIRATION	16.562	60121.258	89.91
DRAINAGE COLLECTED FROM LAYER 2	0.4000	1451.961	2.17
PERC./LEAKAGE THROUGH LAYER 4	0.000024	0.088	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0504		
CHANGE IN WATER STORAGE	1.032	3746.712	5.60
SOIL WATER AT START OF YEAR	14.728	53463.473	
SOIL WATER AT END OF YEAR	15.760	57210.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.031	0.00

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.01	79896.305	100.00
RUNOFF	1.922	6976.539	8.73
EVAPOTRANSPIRATION	20.792	75474.398	94.47
DRAINAGE COLLECTED FROM LAYER 2	0.4789	1738.268	2.18
PERC./LEAKAGE THROUGH LAYER 4	0.000028	0.103	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0611		
CHANGE IN WATER STORAGE	-1.183	-4293.004	-5.37
SOIL WATER AT START OF YEAR	15.760	57210.187	
SOIL WATER AT END OF YEAR	14.578	52917.180	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.004	0.00

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.31	55575.305	100.00
RUNOFF	0.539	1956.215	3.52
EVAPOTRANSPIRATION	14.495	52617.676	94.68
DRAINAGE COLLECTED FROM LAYER 2	0.0385	139.768	0.25
PERC./LEAKAGE THROUGH LAYER 4	0.000005	0.018	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0049		
CHANGE IN WATER STORAGE	0.237	861.610	1.55
SOIL WATER AT START OF YEAR	14.578	52917.180	
SOIL WATER AT END OF YEAR	14.815	53778.793	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.27	77210.102	100.00
RUNOFF	1.038	3766.968	4.88
EVAPOTRANSPIRATION	19.065	69206.937	89.63
DRAINAGE COLLECTED FROM LAYER 2	1.0045	3646.441	4.72
PERC./LEAKAGE THROUGH LAYER 4	0.000055	0.199	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1266		
CHANGE IN WATER STORAGE	0.162	589.544	0.76

SOIL WATER AT START OF YEAR	14.815	53778.793	
SOIL WATER AT END OF YEAR	14.978	54368.336	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.00	98010.016	100.00
RUNOFF	3.320	12051.882	12.30
EVAPOTRANSPIRATION	22.686	82351.617	84.02
DRAINAGE COLLECTED FROM LAYER 2	0.8709	3161.365	3.23
PERC./LEAKAGE THROUGH LAYER 4	0.000051	0.185	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1110		
CHANGE IN WATER STORAGE	0.123	444.912	0.45
SOIL WATER AT START OF YEAR	14.978	54368.336	
SOIL WATER AT END OF YEAR	15.100	54813.246	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.054	0.00

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.09	54776.699	100.00
RUNOFF	0.431	1562.987	2.85
EVAPOTRANSPIRATION	14.890	54050.605	98.67
DRAINAGE COLLECTED FROM LAYER 2	0.1121	406.878	0.74
PERC./LEAKAGE THROUGH LAYER 4	0.000009	0.033	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0143		
CHANGE IN WATER STORAGE	-0.343	-1243.800	-2.27
SOIL WATER AT START OF YEAR	15.100	54813.246	
SOIL WATER AT END OF YEAR	14.757	53569.445	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.54	67300.219	100.00
RUNOFF	2.266	8226.578	12.22
EVAPOTRANSPIRATION	15.241	55323.559	82.20
DRAINAGE COLLECTED FROM LAYER 2	0.5519	2003.248	2.98
PERC./LEAKAGE THROUGH LAYER 4	0.000032	0.117	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0694		
CHANGE IN WATER STORAGE	0.481	1746.684	2.60
SOIL WATER AT START OF YEAR	14.757	53569.445	
SOIL WATER AT END OF YEAR	15.239	55316.133	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.030	0.00

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.25	95287.508	100.00
RUNOFF	2.255	8185.246	8.59
EVAPOTRANSPIRATION	20.259	73539.992	77.18
DRAINAGE COLLECTED FROM LAYER 2	3.8305	13904.696	14.59
PERC./LEAKAGE THROUGH LAYER 4	0.000378	1.373	0.00
AVG. HEAD ON TOP OF LAYER 3	1.0833		
CHANGE IN WATER STORAGE	-0.095	-343.833	-0.36
SOIL WATER AT START OF YEAR	15.239	55316.133	
SOIL WATER AT END OF YEAR	15.144	54972.297	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.031	0.00

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.73	75249.898	100.00
RUNOFF	1.587	5762.624	7.66
EVAPOTRANSPIRATION	19.352	70249.406	93.35
DRAINAGE COLLECTED FROM LAYER 2	0.1514	549.427	0.73
PERC./LEAKAGE THROUGH LAYER 4	0.000011	0.041	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0191		
CHANGE IN WATER STORAGE	-0.361	-1311.590	-1.74
SOIL WATER AT START OF YEAR	15.144	54972.297	
SOIL WATER AT END OF YEAR	14.783	53660.707	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.009	0.00

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.92	83199.617	100.00
RUNOFF	0.992	3602.497	4.33

EVAPOTRANSPIRATION	19.613	71194.609	85.57
DRAINAGE COLLECTED FROM LAYER 2	1.8919	6867.448	8.25
PERC./LEAKAGE THROUGH LAYER 4	0.000097	0.350	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2394		
CHANGE IN WATER STORAGE	0.423	1534.709	1.84
SOIL WATER AT START OF YEAR	14.783	53660.707	
SOIL WATER AT END OF YEAR	15.205	55195.418	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.002	0.00

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.80	86394.008	100.00
RUNOFF	0.749	2718.973	3.15
EVAPOTRANSPIRATION	21.928	79597.711	92.13
DRAINAGE COLLECTED FROM LAYER 2	0.5930	2152.558	2.49
PERC./LEAKAGE THROUGH LAYER 4	0.000035	0.128	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0753		
CHANGE IN WATER STORAGE	0.530	1924.626	2.23
SOIL WATER AT START OF YEAR	15.205	55195.418	
SOIL WATER AT END OF YEAR	15.736	57120.043	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.41	70458.312	100.00
RUNOFF	0.518	1879.630	2.67
EVAPOTRANSPIRATION	19.609	71181.133	101.03
DRAINAGE COLLECTED FROM LAYER 2	0.1202	436.473	0.62
PERC./LEAKAGE THROUGH LAYER 4	0.000010	0.035	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0153		
CHANGE IN WATER STORAGE	-0.837	-3038.971	-4.31
SOIL WATER AT START OF YEAR	15.736	57120.043	
SOIL WATER AT END OF YEAR	14.898	54081.070	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	23.64	85813.219	100.00
RUNOFF	0.705	2558.708	2.98
EVAPOTRANSPIRATION	22.899	83124.016	96.87
DRAINAGE COLLECTED FROM LAYER 2	0.5035	1827.730	2.13
PERC./LEAKAGE THROUGH LAYER 4	0.000031	0.112	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0639		
CHANGE IN WATER STORAGE	-0.468	-1697.415	-1.98
SOIL WATER AT START OF YEAR	14.898	54081.070	
SOIL WATER AT END OF YEAR	14.431	52383.656	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.070	0.00

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	21.17	76847.117	100.00
RUNOFF	0.686	2490.276	3.24
EVAPOTRANSPIRATION	19.458	70633.258	91.91
DRAINAGE COLLECTED FROM LAYER 2	0.0324	117.615	0.15
PERC./LEAKAGE THROUGH LAYER 4	0.000005	0.017	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0041		
CHANGE IN WATER STORAGE	0.993	3605.926	4.69

SOIL WATER AT START OF YEAR	14.431	52383.656	
SOIL WATER AT END OF YEAR	15.424	55989.582	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.027	0.00

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.90	97646.984	100.00
RUNOFF	1.587	5760.464	5.90
EVAPOTRANSPIRATION	24.492	88907.719	91.05
DRAINAGE COLLECTED FROM LAYER 2	1.3152	4774.003	4.89
PERC./LEAKAGE THROUGH LAYER 4	0.000069	0.252	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1672		
CHANGE IN WATER STORAGE	-0.495	-1795.461	-1.84
SOIL WATER AT START OF YEAR	15.424	55989.582	
SOIL WATER AT END OF YEAR	14.930	54194.121	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.006	0.00

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.88	93944.398	100.00
RUNOFF	1.714	6223.134	6.62
EVAPOTRANSPIRATION	23.351	84764.484	90.23
DRAINAGE COLLECTED FROM LAYER 2	0.6987	2536.220	2.70
PERC./LEAKAGE THROUGH LAYER 4	0.000040	0.145	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0892		
CHANGE IN WATER STORAGE	0.116	420.378	0.45
SOIL WATER AT START OF YEAR	14.930	54194.121	
SOIL WATER AT END OF YEAR	15.045	54614.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.038	0.00

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ANNUAL TOTALS FOR YEAR 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.80	90024.008	100.00
RUNOFF	1.248	4532.006	5.03
EVAPOTRANSPIRATION	23.581	85599.172	95.08
DRAINAGE COLLECTED FROM LAYER 2	0.5548	2013.919	2.24
PERC./LEAKAGE THROUGH LAYER 4	0.000032	0.118	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0708		
CHANGE IN WATER STORAGE	-0.584	-2121.220	-2.36
SOIL WATER AT START OF YEAR	15.045	54614.500	
SOIL WATER AT END OF YEAR	14.461	52493.277	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 32

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.36	92056.812	100.00
RUNOFF	1.365	4955.005	5.38
EVAPOTRANSPIRATION	22.217	80646.031	87.60
DRAINAGE COLLECTED FROM LAYER 2	0.7714	2800.296	3.04
PERC./LEAKAGE THROUGH LAYER 4	0.000045	0.163	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0985		
CHANGE IN WATER STORAGE	1.007	3655.296	3.97
SOIL WATER AT START OF YEAR	14.461	52493.277	
SOIL WATER AT END OF YEAR	15.468	56148.574	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.27	62690.117	100.00
RUNOFF	0.123	447.823	0.71
EVAPOTRANSPIRATION	17.252	62623.336	99.89
DRAINAGE COLLECTED FROM LAYER 2	0.0233	84.477	0.13
PERC./LEAKAGE THROUGH LAYER 4	0.000004	0.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0029		
CHANGE IN WATER STORAGE	-0.128	-465.544	-0.74
SOIL WATER AT START OF YEAR	15.468	56148.574	
SOIL WATER AT END OF YEAR	15.340	55683.031	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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ANNUAL TOTALS FOR YEAR 34

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.87	101168.094	100.00
RUNOFF	2.676	9715.480	9.60

EVAPOTRANSPIRATION	25.010	90784.484	89.74
DRAINAGE COLLECTED FROM LAYER 2	1.2011	4359.915	4.31
PERC./LEAKAGE THROUGH LAYER 4	0.000065	0.236	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1521		
CHANGE IN WATER STORAGE	-1.017	-3692.043	-3.65
SOIL WATER AT START OF YEAR	15.340	55683.031	
SOIL WATER AT END OF YEAR	14.323	51990.988	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 35

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.38	70349.398	100.00
RUNOFF	0.117	423.129	0.60
EVAPOTRANSPIRATION	18.751	68066.234	96.75
DRAINAGE COLLECTED FROM LAYER 2	0.1412	512.466	0.73
PERC./LEAKAGE THROUGH LAYER 4	0.000011	0.039	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0178		
CHANGE IN WATER STORAGE	0.371	1347.545	1.92
SOIL WATER AT START OF YEAR	14.323	51990.988	
SOIL WATER AT END OF YEAR	14.694	53338.531	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

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ANNUAL TOTALS FOR YEAR 36

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.52	74487.617	100.00
RUNOFF	1.295	4701.770	6.31
EVAPOTRANSPIRATION	17.406	63182.965	84.82
DRAINAGE COLLECTED FROM LAYER 2	0.2488	903.232	1.21
PERC./LEAKAGE THROUGH LAYER 4	0.000016	0.060	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0313		
CHANGE IN WATER STORAGE	1.570	5699.573	7.65
SOIL WATER AT START OF YEAR	14.694	53338.531	
SOIL WATER AT END OF YEAR	16.264	59038.105	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.018	0.00

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ANNUAL TOTALS FOR YEAR 37

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.59	67481.711	100.00
RUNOFF	1.056	3834.298	5.68
EVAPOTRANSPIRATION	18.331	66543.234	98.61
DRAINAGE COLLECTED FROM LAYER 2	0.7021	2548.781	3.78
PERC./LEAKAGE THROUGH LAYER 4	0.000041	0.149	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0905		
CHANGE IN WATER STORAGE	-1.500	-5444.785	-8.07
SOIL WATER AT START OF YEAR	16.264	59038.105	
SOIL WATER AT END OF YEAR	14.764	53593.320	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.034	0.00

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ANNUAL TOTALS FOR YEAR 38

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.07	61964.105	100.00
RUNOFF	0.193	702.388	1.13
EVAPOTRANSPIRATION	16.551	60080.508	96.96
DRAINAGE COLLECTED FROM LAYER 2	0.3711	1347.214	2.17
PERC./LEAKAGE THROUGH LAYER 4	0.000024	0.085	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0469		
CHANGE IN WATER STORAGE	-0.046	-166.113	-0.27

SOIL WATER AT START OF YEAR	14.764	53593.320	
SOIL WATER AT END OF YEAR	14.718	53427.207	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.025	0.00

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ANNUAL TOTALS FOR YEAR 39

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.27	88100.109	100.00
RUNOFF	2.436	8843.934	10.04
EVAPOTRANSPIRATION	19.356	70260.562	79.75
DRAINAGE COLLECTED FROM LAYER 2	2.1466	7792.272	8.84
PERC./LEAKAGE THROUGH LAYER 4	0.000112	0.407	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2707		
CHANGE IN WATER STORAGE	0.331	1202.944	1.37
SOIL WATER AT START OF YEAR	14.718	53427.207	
SOIL WATER AT END OF YEAR	15.050	54630.152	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.65	89479.516	100.00
RUNOFF	0.606	2200.535	2.46
EVAPOTRANSPIRATION	24.058	87330.648	97.60
DRAINAGE COLLECTED FROM LAYER 2	0.0148	53.638	0.06
PERC./LEAKAGE THROUGH LAYER 4	0.000004	0.013	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
CHANGE IN WATER STORAGE	-0.029	-105.323	-0.12
SOIL WATER AT START OF YEAR	15.050	54630.152	
SOIL WATER AT END OF YEAR	15.021	54524.828	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 41

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.48	70712.414	100.00
RUNOFF	0.926	3360.398	4.75
EVAPOTRANSPIRATION	18.133	65824.414	93.09
DRAINAGE COLLECTED FROM LAYER 2	0.8394	3046.924	4.31
PERC./LEAKAGE THROUGH LAYER 4	0.000046	0.166	0.00

AVG. HEAD ON TOP OF LAYER 3	0.1056		
CHANGE IN WATER STORAGE	-0.419	-1519.515	-2.15
SOIL WATER AT START OF YEAR	15.021	54524.828	
SOIL WATER AT END OF YEAR	14.602	53005.312	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.025	0.00

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ANNUAL TOTALS FOR YEAR 42

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.16	91330.805	100.00
RUNOFF	0.711	2579.278	2.82
EVAPOTRANSPIRATION	22.599	82032.742	89.82
DRAINAGE COLLECTED FROM LAYER 2	0.1419	515.131	0.56
PERC./LEAKAGE THROUGH LAYER 4	0.000011	0.039	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0178		
CHANGE IN WATER STORAGE	1.709	6203.606	6.79
SOIL WATER AT START OF YEAR	14.602	53005.312	
SOIL WATER AT END OF YEAR	16.311	59208.918	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 43

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.81	100950.336	100.00
RUNOFF	1.484	5387.473	5.34
EVAPOTRANSPIRATION	27.061	98232.898	97.31
DRAINAGE COLLECTED FROM LAYER 2	0.5614	2037.791	2.02
PERC./LEAKAGE THROUGH LAYER 4	0.000034	0.122	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0712		
CHANGE IN WATER STORAGE	-1.297	-4707.993	-4.66
SOIL WATER AT START OF YEAR	16.311	59208.918	
SOIL WATER AT END OF YEAR	14.804	53738.703	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.210	762.223	0.76
ANNUAL WATER BUDGET BALANCE	0.0000	0.045	0.00

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ANNUAL TOTALS FOR YEAR 44

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.59	89261.711	100.00
RUNOFF	1.650	5988.414	6.71

EVAPOTRANSPIRATION	22.362	81175.570	90.94
DRAINAGE COLLECTED FROM LAYER 2	0.9305	3377.716	3.78
PERC./LEAKAGE THROUGH LAYER 4	0.000050	0.183	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1187		
CHANGE IN WATER STORAGE	-0.353	-1280.156	-1.43
SOIL WATER AT START OF YEAR	14.804	53738.703	
SOIL WATER AT END OF YEAR	14.661	53220.770	
SNOW WATER AT START OF YEAR	0.210	762.223	0.85
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.010	0.00

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ANNUAL TOTALS FOR YEAR 45

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.39	77645.703	100.00
RUNOFF	0.331	1200.023	1.55
EVAPOTRANSPIRATION	20.735	75266.594	96.94
DRAINAGE COLLECTED FROM LAYER 2	0.0279	101.352	0.13
PERC./LEAKAGE THROUGH LAYER 4	0.000004	0.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0035		
CHANGE IN WATER STORAGE	0.297	1077.746	1.39
SOIL WATER AT START OF YEAR	14.661	53220.770	
SOIL WATER AT END OF YEAR	14.958	54298.516	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.023	0.00

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ANNUAL TOTALS FOR YEAR 46

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.33	59277.906	100.00
RUNOFF	0.845	3068.953	5.18
EVAPOTRANSPIRATION	15.780	57282.441	96.63
DRAINAGE COLLECTED FROM LAYER 2	0.3112	1129.682	1.91
PERC./LEAKAGE THROUGH LAYER 4	0.000019	0.070	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0398		
CHANGE IN WATER STORAGE	-0.607	-2203.242	-3.72
SOIL WATER AT START OF YEAR	14.958	54298.516	
SOIL WATER AT END OF YEAR	14.351	52095.273	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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ANNUAL TOTALS FOR YEAR 47

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.05	98191.508	100.00
RUNOFF	1.175	4266.221	4.34
EVAPOTRANSPIRATION	25.016	90806.672	92.48
DRAINAGE COLLECTED FROM LAYER 2	0.7386	2681.140	2.73
PERC./LEAKAGE THROUGH LAYER 4	0.000041	0.151	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0943		
CHANGE IN WATER STORAGE	0.120	437.303	0.45
SOIL WATER AT START OF YEAR	14.351	52095.273	
SOIL WATER AT END OF YEAR	14.472	52532.578	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.027	0.00

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ANNUAL TOTALS FOR YEAR 48

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.27	77210.109	100.00
RUNOFF	1.124	4079.457	5.28
EVAPOTRANSPIRATION	19.272	69958.836	90.61
DRAINAGE COLLECTED FROM LAYER 2	1.0225	3711.501	4.81
PERC./LEAKAGE THROUGH LAYER 4	0.000056	0.202	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1290		
CHANGE IN WATER STORAGE	-0.149	-539.894	-0.70

SOIL WATER AT START OF YEAR	14.472	52532.578	
SOIL WATER AT END OF YEAR	14.323	51992.684	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 49

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.01	94416.305	100.00
RUNOFF	2.385	8658.673	9.17
EVAPOTRANSPIRATION	22.293	80922.594	85.71
DRAINAGE COLLECTED FROM LAYER 2	1.3314	4832.906	5.12
PERC./LEAKAGE THROUGH LAYER 4	0.000070	0.256	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1682		
CHANGE IN WATER STORAGE	0.001	1.876	0.00
SOIL WATER AT START OF YEAR	14.323	51992.684	
SOIL WATER AT END OF YEAR	14.324	51994.559	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.28	91766.406	100.00
RUNOFF	0.808	2934.781	3.20
EVAPOTRANSPIRATION	22.683	82337.766	89.73
DRAINAGE COLLECTED FROM LAYER 2	0.7979	2896.224	3.16
PERC./LEAKAGE THROUGH LAYER 4	0.000046	0.166	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1023		
CHANGE IN WATER STORAGE	0.991	3597.445	3.92
SOIL WATER AT START OF YEAR	14.324	51994.559	
SOIL WATER AT END OF YEAR	15.315	55592.004	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 51

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.42	95904.602	100.00
RUNOFF	3.047	11061.996	11.53
EVAPOTRANSPIRATION	20.568	74662.898	77.85
DRAINAGE COLLECTED FROM LAYER 2	2.8481	10338.757	10.78
PERC./LEAKAGE THROUGH LAYER 4	0.000169	0.614	0.00

AVG. HEAD ON TOP OF LAYER 3	0.4550		
CHANGE IN WATER STORAGE	-0.044	-159.688	-0.17
SOIL WATER AT START OF YEAR	15.315	55592.004	
SOIL WATER AT END OF YEAR	15.271	55432.316	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 52

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.56	60112.805	100.00
RUNOFF	0.598	2169.912	3.61
EVAPOTRANSPIRATION	15.920	57789.215	96.13
DRAINAGE COLLECTED FROM LAYER 2	0.1513	549.151	0.91
PERC./LEAKAGE THROUGH LAYER 4	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0190		
CHANGE IN WATER STORAGE	-0.109	-395.498	-0.66
SOIL WATER AT START OF YEAR	15.271	55432.316	
SOIL WATER AT END OF YEAR	15.162	55036.820	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.016	0.00

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ANNUAL TOTALS FOR YEAR 53

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.78	86321.414	100.00
RUNOFF	2.210	8021.332	9.29
EVAPOTRANSPIRATION	19.381	70353.023	81.50
DRAINAGE COLLECTED FROM LAYER 2	1.8903	6861.704	7.95
PERC./LEAKAGE THROUGH LAYER 4	0.000114	0.415	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2987		
CHANGE IN WATER STORAGE	0.299	1084.919	1.26
SOIL WATER AT START OF YEAR	15.162	55036.820	
SOIL WATER AT END OF YEAR	14.681	53292.246	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.779	2829.491	3.28
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

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ANNUAL TOTALS FOR YEAR 54

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.58	107375.430	100.00
RUNOFF	1.764	6402.517	5.96

EVAPOTRANSPIRATION	27.125	98463.898	91.70
DRAINAGE COLLECTED FROM LAYER 2	1.2417	4507.262	4.20
PERC./LEAKAGE THROUGH LAYER 4	0.000065	0.235	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1587		
CHANGE IN WATER STORAGE	-0.551	-1998.563	-1.86
SOIL WATER AT START OF YEAR	14.681	53292.246	
SOIL WATER AT END OF YEAR	14.809	53757.375	
SNOW WATER AT START OF YEAR	0.779	2829.491	2.64
SNOW WATER AT END OF YEAR	0.101	365.800	0.34
ANNUAL WATER BUDGET BALANCE	0.0000	0.082	0.00

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ANNUAL TOTALS FOR YEAR 55

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.93	68715.930	100.00
RUNOFF	1.395	5063.564	7.37
EVAPOTRANSPIRATION	16.499	59890.977	87.16
DRAINAGE COLLECTED FROM LAYER 2	1.0963	3979.693	5.79
PERC./LEAKAGE THROUGH LAYER 4	0.000061	0.222	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1419		
CHANGE IN WATER STORAGE	-0.060	-218.543	-0.32
SOIL WATER AT START OF YEAR	14.809	53757.375	
SOIL WATER AT END OF YEAR	14.850	53904.633	
SNOW WATER AT START OF YEAR	0.101	365.800	0.53

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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ANNUAL TOTALS FOR YEAR 56

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.11	98409.312	100.00
RUNOFF	1.110	4030.939	4.10
EVAPOTRANSPIRATION	23.885	86703.758	88.11
DRAINAGE COLLECTED FROM LAYER 2	1.7832	6473.026	6.58
PERC./LEAKAGE THROUGH LAYER 4	0.000095	0.345	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2258		
CHANGE IN WATER STORAGE	0.331	1201.234	1.22
SOIL WATER AT START OF YEAR	14.850	53904.633	
SOIL WATER AT END OF YEAR	15.181	55105.867	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 57

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	23.52	85377.625	100.00
RUNOFF	2.780	10090.044	11.82
EVAPOTRANSPIRATION	21.008	76257.641	89.32
DRAINAGE COLLECTED FROM LAYER 2	0.5454	1979.861	2.32
PERC./LEAKAGE THROUGH LAYER 4	0.000032	0.116	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0699		
CHANGE IN WATER STORAGE	-0.813	-2950.095	-3.46
SOIL WATER AT START OF YEAR	15.181	55105.867	
SOIL WATER AT END OF YEAR	14.368	52155.770	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.058	0.00

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ANNUAL TOTALS FOR YEAR 58

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	17.77	64505.109	100.00
RUNOFF	0.830	3014.282	4.67
EVAPOTRANSPIRATION	16.652	60447.566	93.71
DRAINAGE COLLECTED FROM LAYER 2	0.0080	29.209	0.05
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.011	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0010		
CHANGE IN WATER STORAGE	0.279	1014.021	1.57

SOIL WATER AT START OF YEAR	14.368	52155.770	
SOIL WATER AT END OF YEAR	14.647	53169.793	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 59

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.77	64505.102	100.00
RUNOFF	1.469	5333.382	8.27
EVAPOTRANSPIRATION	15.630	56736.152	87.96
DRAINAGE COLLECTED FROM LAYER 2	0.4186	1519.433	2.36
PERC./LEAKAGE THROUGH LAYER 4	0.000024	0.089	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0525		
CHANGE IN WATER STORAGE	0.252	916.057	1.42
SOIL WATER AT START OF YEAR	14.647	53169.793	
SOIL WATER AT END OF YEAR	14.738	53499.242	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.162	586.607	0.91
ANNUAL WATER BUDGET BALANCE	0.0000	-0.012	0.00

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ANNUAL TOTALS FOR YEAR 60

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.41	110388.305	100.00
RUNOFF	2.321	8424.145	7.63
EVAPOTRANSPIRATION	25.324	91927.500	83.28
DRAINAGE COLLECTED FROM LAYER 2	1.9564	7101.659	6.43
PERC./LEAKAGE THROUGH LAYER 4	0.000102	0.371	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2475		
CHANGE IN WATER STORAGE	0.808	2934.614	2.66
SOIL WATER AT START OF YEAR	14.738	53499.242	
SOIL WATER AT END OF YEAR	15.095	54794.984	
SNOW WATER AT START OF YEAR	0.162	586.607	0.53
SNOW WATER AT END OF YEAR	0.613	2225.476	2.02
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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ANNUAL TOTALS FOR YEAR 61

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.01	105306.320	100.00
RUNOFF	3.198	11608.200	11.02
EVAPOTRANSPIRATION	24.712	89702.773	85.18
DRAINAGE COLLECTED FROM LAYER 2	1.7777	6453.181	6.13
PERC./LEAKAGE THROUGH LAYER 4	0.000094	0.343	0.00

AVG. HEAD ON TOP OF LAYER 3	0.2259		
CHANGE IN WATER STORAGE	-0.677	-2458.229	-2.33
SOIL WATER AT START OF YEAR	15.095	54794.984	
SOIL WATER AT END OF YEAR	15.031	54562.234	
SNOW WATER AT START OF YEAR	0.613	2225.476	2.11
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.054	0.00

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ANNUAL TOTALS FOR YEAR 62

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.48	67082.406	100.00
RUNOFF	0.637	2310.762	3.44
EVAPOTRANSPIRATION	17.647	64057.215	95.49
DRAINAGE COLLECTED FROM LAYER 2	0.0064	23.413	0.03
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.011	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
CHANGE IN WATER STORAGE	0.190	691.004	1.03
SOIL WATER AT START OF YEAR	15.031	54562.234	
SOIL WATER AT END OF YEAR	15.221	55253.238	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 63

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.00	98010.008	100.00
RUNOFF	1.250	4537.256	4.63
EVAPOTRANSPIRATION	26.030	94490.367	96.41
DRAINAGE COLLECTED FROM LAYER 2	0.1772	643.337	0.66
PERC./LEAKAGE THROUGH LAYER 4	0.000013	0.046	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0224		
CHANGE IN WATER STORAGE	-0.458	-1661.045	-1.69
SOIL WATER AT START OF YEAR	15.221	55253.238	
SOIL WATER AT END OF YEAR	14.764	53592.191	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.042	0.00

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ANNUAL TOTALS FOR YEAR 64

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.90	86756.992	100.00
RUNOFF	1.687	6122.974	7.06

EVAPOTRANSPIRATION	22.436	81441.398	93.87
DRAINAGE COLLECTED FROM LAYER 2	0.0275	99.673	0.11
PERC./LEAKAGE THROUGH LAYER 4	0.000004	0.016	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0035		
CHANGE IN WATER STORAGE	-0.250	-907.088	-1.05
SOIL WATER AT START OF YEAR	14.764	53592.191	
SOIL WATER AT END OF YEAR	14.514	52685.102	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

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ANNUAL TOTALS FOR YEAR 65

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.89	83090.687	100.00
RUNOFF	2.227	8084.180	9.73
EVAPOTRANSPIRATION	19.311	70098.625	84.36
DRAINAGE COLLECTED FROM LAYER 2	1.2950	4700.750	5.66
PERC./LEAKAGE THROUGH LAYER 4	0.000070	0.254	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1636		
CHANGE IN WATER STORAGE	0.057	206.872	0.25
SOIL WATER AT START OF YEAR	14.514	52685.102	
SOIL WATER AT END OF YEAR	14.571	52891.977	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 66

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.38	99389.422	100.00
RUNOFF	2.094	7602.431	7.65
EVAPOTRANSPIRATION	24.416	88630.086	89.17
DRAINAGE COLLECTED FROM LAYER 2	0.9863	3580.199	3.60
PERC./LEAKAGE THROUGH LAYER 4	0.000056	0.202	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1245		
CHANGE IN WATER STORAGE	-0.117	-423.545	-0.43
SOIL WATER AT START OF YEAR	14.571	52891.977	
SOIL WATER AT END OF YEAR	14.454	52468.430	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.050	0.00

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ANNUAL TOTALS FOR YEAR 67

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	27.82	100986.609	100.00
RUNOFF	3.430	12451.944	12.33
EVAPOTRANSPIRATION	21.333	77439.250	76.68
DRAINAGE COLLECTED FROM LAYER 2	2.6674	9682.739	9.59
PERC./LEAKAGE THROUGH LAYER 4	0.000138	0.499	0.00
AVG. HEAD ON TOP OF LAYER 3	0.3394		
CHANGE IN WATER STORAGE	0.389	1412.139	1.40
SOIL WATER AT START OF YEAR	14.454	52468.430	
SOIL WATER AT END OF YEAR	14.843	53880.570	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.043	0.00

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ANNUAL TOTALS FOR YEAR 68

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	32.45	117793.500	100.00
RUNOFF	3.462	12567.119	10.67
EVAPOTRANSPIRATION	27.840	101059.281	85.79
DRAINAGE COLLECTED FROM LAYER 2	0.6491	2356.292	2.00
PERC./LEAKAGE THROUGH LAYER 4	0.000038	0.136	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0823		
CHANGE IN WATER STORAGE	0.499	1810.680	1.54

SOIL WATER AT START OF YEAR	14.843	53880.570	
SOIL WATER AT END OF YEAR	15.303	55548.234	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.039	143.016	0.12
ANNUAL WATER BUDGET BALANCE	0.0000	-0.009	0.00

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ANNUAL TOTALS FOR YEAR 69

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.24	84361.203	100.00
RUNOFF	1.172	4254.585	5.04
EVAPOTRANSPIRATION	20.981	76160.156	90.28
DRAINAGE COLLECTED FROM LAYER 2	0.6299	2286.522	2.71
PERC./LEAKAGE THROUGH LAYER 4	0.000036	0.132	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0800		
CHANGE IN WATER STORAGE	0.457	1659.816	1.97
SOIL WATER AT START OF YEAR	15.303	55548.234	
SOIL WATER AT END OF YEAR	15.799	57351.066	
SNOW WATER AT START OF YEAR	0.039	143.016	0.17
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

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ANNUAL TOTALS FOR YEAR 70

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.52	78117.602	100.00
RUNOFF	2.069	7510.305	9.61
EVAPOTRANSPIRATION	19.824	71961.687	92.12
DRAINAGE COLLECTED FROM LAYER 2	1.1019	3999.924	5.12
PERC./LEAKAGE THROUGH LAYER 4	0.000059	0.214	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1391		
CHANGE IN WATER STORAGE	-1.475	-5354.504	-6.85
SOIL WATER AT START OF YEAR	15.799	57351.066	
SOIL WATER AT END OF YEAR	14.324	51996.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.022	0.00

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ANNUAL TOTALS FOR YEAR 71

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.47	85196.102	100.00
RUNOFF	0.996	3614.864	4.24
EVAPOTRANSPIRATION	20.042	72753.977	85.40
DRAINAGE COLLECTED FROM LAYER 2	1.0142	3681.612	4.32
PERC./LEAKAGE THROUGH LAYER 4	0.000056	0.204	0.00

AVG. HEAD ON TOP OF LAYER 3	0.1272		
CHANGE IN WATER STORAGE	1.417	5145.418	6.04
SOIL WATER AT START OF YEAR	14.324	51996.562	
SOIL WATER AT END OF YEAR	15.534	56387.641	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.208	754.339	0.89
ANNUAL WATER BUDGET BALANCE	0.0000	0.032	0.00

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ANNUAL TOTALS FOR YEAR 72

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.65	74959.516	100.00
RUNOFF	0.596	2164.540	2.89
EVAPOTRANSPIRATION	20.225	73416.648	97.94
DRAINAGE COLLECTED FROM LAYER 2	0.5123	1859.728	2.48
PERC./LEAKAGE THROUGH LAYER 4	0.000031	0.113	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0647		
CHANGE IN WATER STORAGE	-0.684	-2481.520	-3.31
SOIL WATER AT START OF YEAR	15.534	56387.641	
SOIL WATER AT END OF YEAR	15.058	54660.457	
SNOW WATER AT START OF YEAR	0.208	754.339	1.01
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 73

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.09	98336.711	100.00
RUNOFF	2.354	8545.519	8.69
EVAPOTRANSPIRATION	23.552	85495.266	86.94
DRAINAGE COLLECTED FROM LAYER 2	1.1928	4330.027	4.40
PERC./LEAKAGE THROUGH LAYER 4	0.000063	0.228	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1521		
CHANGE IN WATER STORAGE	-0.009	-34.362	-0.03
SOIL WATER AT START OF YEAR	15.058	54660.457	
SOIL WATER AT END OF YEAR	15.049	54626.098	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.033	0.00

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ANNUAL TOTALS FOR YEAR 74

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.84	108319.211	100.00
RUNOFF	1.809	6565.681	6.06

EVAPOTRANSPIRATION	25.614	92979.398	85.84
DRAINAGE COLLECTED FROM LAYER 2	1.6583	6019.551	5.56
PERC./LEAKAGE THROUGH LAYER 4	0.000089	0.321	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2102		
CHANGE IN WATER STORAGE	0.759	2754.245	2.54
SOIL WATER AT START OF YEAR	15.049	54626.098	
SOIL WATER AT END OF YEAR	15.807	57380.344	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.020	0.00

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ANNUAL TOTALS FOR YEAR 75

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.99	119753.703	100.00
RUNOFF	5.047	18320.113	15.30
EVAPOTRANSPIRATION	25.204	91492.180	76.40
DRAINAGE COLLECTED FROM LAYER 2	3.6528	13259.784	11.07
PERC./LEAKAGE THROUGH LAYER 4	0.000235	0.854	0.00
AVG. HEAD ON TOP OF LAYER 3	0.6251		
CHANGE IN WATER STORAGE	-0.914	-3319.286	-2.77
SOIL WATER AT START OF YEAR	15.807	57380.344	
SOIL WATER AT END OF YEAR	14.893	54061.055	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.057	0.00

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ANNUAL TOTALS FOR YEAR 76

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.32	106431.609	100.00
RUNOFF	3.660	13285.941	12.48
EVAPOTRANSPIRATION	19.608	71178.242	66.88
DRAINAGE COLLECTED FROM LAYER 2	3.9499	14338.006	13.47
PERC./LEAKAGE THROUGH LAYER 4	0.000567	2.056	0.00
AVG. HEAD ON TOP OF LAYER 3	1.6738		
CHANGE IN WATER STORAGE	2.101	7627.343	7.17
SOIL WATER AT START OF YEAR	14.893	54061.055	
SOIL WATER AT END OF YEAR	16.994	61688.398	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

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ANNUAL TOTALS FOR YEAR 77

	INCHES	CU. FEET	PERCENT

PRECIPITATION	18.50	67155.008	100.00
RUNOFF	1.029	3734.817	5.56
EVAPOTRANSPIRATION	19.288	70016.570	104.26
DRAINAGE COLLECTED FROM LAYER 2	0.8548	3102.942	4.62
PERC./LEAKAGE THROUGH LAYER 4	0.000047	0.170	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1084		
CHANGE IN WATER STORAGE	-2.672	-9699.543	-14.44
SOIL WATER AT START OF YEAR	16.994	61688.398	
SOIL WATER AT END OF YEAR	14.322	51988.855	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.052	0.00

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ANNUAL TOTALS FOR YEAR 78

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.92	90459.594	100.00
RUNOFF	1.893	6870.896	7.60
EVAPOTRANSPIRATION	21.475	77952.609	86.17
DRAINAGE COLLECTED FROM LAYER 2	1.3031	4730.374	5.23
PERC./LEAKAGE THROUGH LAYER 4	0.000068	0.245	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1646		
CHANGE IN WATER STORAGE	0.249	905.492	1.00

SOIL WATER AT START OF YEAR	14.322	51988.855	
SOIL WATER AT END OF YEAR	14.571	52894.348	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.025	0.00

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ANNUAL TOTALS FOR YEAR 79

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.33	81057.906	100.00
RUNOFF	1.771	6429.615	7.93
EVAPOTRANSPIRATION	20.500	74416.461	91.81
DRAINAGE COLLECTED FROM LAYER 2	0.0029	10.688	0.01
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
CHANGE IN WATER STORAGE	0.055	201.095	0.25
SOIL WATER AT START OF YEAR	14.571	52894.348	
SOIL WATER AT END OF YEAR	14.627	53095.441	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.037	0.00

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ANNUAL TOTALS FOR YEAR 80

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.86	64831.801	100.00
RUNOFF	0.237	860.922	1.33
EVAPOTRANSPIRATION	16.147	58613.531	90.41
DRAINAGE COLLECTED FROM LAYER 2	0.0098	35.556	0.05
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.012	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0012		
CHANGE IN WATER STORAGE	1.466	5321.801	8.21
SOIL WATER AT START OF YEAR	14.627	53095.441	
SOIL WATER AT END OF YEAR	15.181	55108.215	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.912	3309.030	5.10
ANNUAL WATER BUDGET BALANCE	0.0000	-0.020	0.00

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ANNUAL TOTALS FOR YEAR 81

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.52	70857.617	100.00
RUNOFF	1.262	4579.860	6.46
EVAPOTRANSPIRATION	18.159	65916.461	93.03
DRAINAGE COLLECTED FROM LAYER 2	1.3286	4822.966	6.81
PERC./LEAKAGE THROUGH LAYER 4	0.000070	0.253	0.00

AVG. HEAD ON TOP OF LAYER 3	0.1675		
CHANGE IN WATER STORAGE	-1.229	-4461.957	-6.30
SOIL WATER AT START OF YEAR	15.181	55108.215	
SOIL WATER AT END OF YEAR	14.864	53955.285	
SNOW WATER AT START OF YEAR	0.912	3309.030	4.67
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.034	0.00

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ANNUAL TOTALS FOR YEAR 82

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.45	88753.516	100.00
RUNOFF	0.772	2800.682	3.16
EVAPOTRANSPIRATION	22.619	82108.516	92.51
DRAINAGE COLLECTED FROM LAYER 2	1.1941	4334.654	4.88
PERC./LEAKAGE THROUGH LAYER 4	0.000066	0.238	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1510		
CHANGE IN WATER STORAGE	-0.135	-490.650	-0.55
SOIL WATER AT START OF YEAR	14.864	53955.285	
SOIL WATER AT END OF YEAR	14.729	53464.637	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.080	0.00

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ANNUAL TOTALS FOR YEAR 83

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.87	79388.102	100.00
RUNOFF	0.800	2904.345	3.66
EVAPOTRANSPIRATION	21.361	77540.289	97.67
DRAINAGE COLLECTED FROM LAYER 2	0.1144	415.126	0.52
PERC./LEAKAGE THROUGH LAYER 4	0.000009	0.034	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0146		
CHANGE IN WATER STORAGE	-0.405	-1471.717	-1.85
SOIL WATER AT START OF YEAR	14.729	53464.637	
SOIL WATER AT END OF YEAR	14.323	51992.918	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

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ANNUAL TOTALS FOR YEAR 84

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.64	71293.203	100.00
RUNOFF	1.188	4311.919	6.05

EVAPOTRANSPIRATION	17.388	63119.785	88.54
DRAINAGE COLLECTED FROM LAYER 2	0.9180	3332.277	4.67
PERC./LEAKAGE THROUGH LAYER 4	0.000050	0.181	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1172		
CHANGE IN WATER STORAGE	0.146	529.031	0.74
SOIL WATER AT START OF YEAR	14.323	51992.918	
SOIL WATER AT END OF YEAR	14.469	52521.949	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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ANNUAL TOTALS FOR YEAR 85

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.23	55284.906	100.00
RUNOFF	1.036	3760.969	6.80
EVAPOTRANSPIRATION	14.049	50997.418	92.24
DRAINAGE COLLECTED FROM LAYER 2	0.1049	380.739	0.69
PERC./LEAKAGE THROUGH LAYER 4	0.000009	0.031	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0132		
CHANGE IN WATER STORAGE	0.040	145.743	0.26
SOIL WATER AT START OF YEAR	14.469	52521.949	
SOIL WATER AT END OF YEAR	14.509	52667.695	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 86

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.49	74378.703	100.00
RUNOFF	0.196	710.755	0.96
EVAPOTRANSPIRATION	19.880	72163.039	97.02
DRAINAGE COLLECTED FROM LAYER 2	0.0011	4.014	0.01
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0001		
CHANGE IN WATER STORAGE	0.413	1500.852	2.02
SOIL WATER AT START OF YEAR	14.509	52667.695	
SOIL WATER AT END OF YEAR	14.922	54168.547	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.037	0.00

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ANNUAL TOTALS FOR YEAR 87

	INCHES	CU. FEET	PERCENT

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.38	99389.414	100.00
RUNOFF	2.625	9529.044	9.59
EVAPOTRANSPIRATION	22.667	82282.477	82.79
DRAINAGE COLLECTED FROM LAYER 2	1.9784	7181.753	7.23
PERC./LEAKAGE THROUGH LAYER 4	0.000103	0.375	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2518		
CHANGE IN WATER STORAGE	0.109	395.743	0.40
SOIL WATER AT START OF YEAR	14.922	54168.547	
SOIL WATER AT END OF YEAR	15.031	54564.289	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.025	0.00

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ANNUAL TOTALS FOR YEAR 88

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.19	58769.703	100.00
RUNOFF	0.205	745.279	1.27
EVAPOTRANSPIRATION	16.580	60187.008	102.41
DRAINAGE COLLECTED FROM LAYER 2	0.0729	264.643	0.45
PERC./LEAKAGE THROUGH LAYER 4	0.000007	0.025	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0093		
CHANGE IN WATER STORAGE	-0.669	-2427.261	-4.13

SOIL WATER AT START OF YEAR	15.031	54564.289	
SOIL WATER AT END OF YEAR	14.363	52137.027	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 89

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.12	65775.602	100.00
RUNOFF	0.527	1912.907	2.91
EVAPOTRANSPIRATION	16.800	60984.750	92.72
DRAINAGE COLLECTED FROM LAYER 2	0.2275	825.680	1.26
PERC./LEAKAGE THROUGH LAYER 4	0.000015	0.056	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0284		
CHANGE IN WATER STORAGE	0.565	2052.191	3.12
SOIL WATER AT START OF YEAR	14.363	52137.027	
SOIL WATER AT END OF YEAR	14.928	54189.219	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.018	0.00

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ANNUAL TOTALS FOR YEAR 90

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.58	71075.406	100.00
RUNOFF	1.038	3767.526	5.30
EVAPOTRANSPIRATION	18.674	67788.148	95.37
DRAINAGE COLLECTED FROM LAYER 2	0.0870	315.850	0.44
PERC./LEAKAGE THROUGH LAYER 4	0.000008	0.029	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0110		
CHANGE IN WATER STORAGE	-0.219	-796.174	-1.12
SOIL WATER AT START OF YEAR	14.928	54189.219	
SOIL WATER AT END OF YEAR	14.709	53393.047	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.027	0.00

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ANNUAL TOTALS FOR YEAR 91

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.14	113038.219	100.00
RUNOFF	2.546	9240.598	8.17
EVAPOTRANSPIRATION	27.187	98688.820	87.31
DRAINAGE COLLECTED FROM LAYER 2	0.9277	3367.520	2.98
PERC./LEAKAGE THROUGH LAYER 4	0.000052	0.190	0.00

AVG. HEAD ON TOP OF LAYER 3	0.1175		
CHANGE IN WATER STORAGE	0.480	1741.083	1.54
SOIL WATER AT START OF YEAR	14.709	53393.047	
SOIL WATER AT END OF YEAR	15.188	55134.129	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 92

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.22	58878.605	100.00
RUNOFF	0.634	2300.995	3.91
EVAPOTRANSPIRATION	16.183	58743.496	99.77
DRAINAGE COLLECTED FROM LAYER 2	0.2698	979.341	1.66
PERC./LEAKAGE THROUGH LAYER 4	0.000018	0.064	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0342		
CHANGE IN WATER STORAGE	-0.866	-3145.294	-5.34
SOIL WATER AT START OF YEAR	15.188	55134.129	
SOIL WATER AT END OF YEAR	14.322	51988.836	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 93

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.88	101204.414	100.00
RUNOFF	1.946	7065.454	6.98
EVAPOTRANSPIRATION	24.623	89380.297	88.32
DRAINAGE COLLECTED FROM LAYER 2	0.7988	2899.590	2.87
PERC./LEAKAGE THROUGH LAYER 4	0.000046	0.168	0.00
AVG. HEAD ON TOP OF LAYER 3	0.1012		
CHANGE IN WATER STORAGE	0.512	1858.865	1.84
SOIL WATER AT START OF YEAR	14.322	51988.836	
SOIL WATER AT END OF YEAR	14.834	53847.699	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.038	0.00

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ANNUAL TOTALS FOR YEAR 94

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.00	54450.000	100.00
RUNOFF	0.673	2441.413	4.48

EVAPOTRANSPIRATION	14.268	51793.379	95.12
DRAINAGE COLLECTED FROM LAYER 2	0.0284	102.987	0.19
PERC./LEAKAGE THROUGH LAYER 4	0.000004	0.016	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0036		
CHANGE IN WATER STORAGE	0.031	112.195	0.21
SOIL WATER AT START OF YEAR	14.834	53847.699	
SOIL WATER AT END OF YEAR	14.865	53959.895	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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ANNUAL TOTALS FOR YEAR 95

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.27	77210.125	100.00
RUNOFF	1.660	6025.019	7.80
EVAPOTRANSPIRATION	18.538	67292.414	87.15
DRAINAGE COLLECTED FROM LAYER 2	0.6192	2247.793	2.91
PERC./LEAKAGE THROUGH LAYER 4	0.000036	0.130	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0780		
CHANGE IN WATER STORAGE	0.453	1644.747	2.13
SOIL WATER AT START OF YEAR	14.865	53959.895	
SOIL WATER AT END OF YEAR	15.318	55604.641	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 96

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.96	108754.820	100.00
RUNOFF	1.433	5203.594	4.78
EVAPOTRANSPIRATION	25.468	92449.094	85.01
DRAINAGE COLLECTED FROM LAYER 2	2.8669	10406.967	9.57
PERC./LEAKAGE THROUGH LAYER 4	0.000204	0.741	0.00
AVG. HEAD ON TOP OF LAYER 3	0.5486		
CHANGE IN WATER STORAGE	0.191	694.368	0.64
SOIL WATER AT START OF YEAR	15.318	55604.641	
SOIL WATER AT END OF YEAR	15.509	56299.008	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.056	0.00

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ANNUAL TOTALS FOR YEAR 97

	INCHES	CU. FEET	PERCENT

PRECIPITATION	31.47	114236.102	100.00
RUNOFF	2.619	9506.340	8.32
EVAPOTRANSPIRATION	27.422	99541.352	87.14
DRAINAGE COLLECTED FROM LAYER 2	1.6978	6163.127	5.40
PERC./LEAKAGE THROUGH LAYER 4	0.000092	0.334	0.00
AVG. HEAD ON TOP OF LAYER 3	0.2142		
CHANGE IN WATER STORAGE	-0.269	-975.065	-0.85
SOIL WATER AT START OF YEAR	15.509	56299.008	
SOIL WATER AT END OF YEAR	15.241	55323.945	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 98

	INCHES	CU. FEET	PERCENT
PRECIPITATION	20.32	73761.609	100.00
RUNOFF	0.557	2023.709	2.74
EVAPOTRANSPIRATION	19.808	71901.711	97.48
DRAINAGE COLLECTED FROM LAYER 2	0.2077	753.896	1.02
PERC./LEAKAGE THROUGH LAYER 4	0.000015	0.053	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0264		
CHANGE IN WATER STORAGE	-0.253	-917.750	-1.24

SOIL WATER AT START OF YEAR	15.241	55323.945	
SOIL WATER AT END OF YEAR	14.988	54406.195	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 99

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.78	97211.430	100.00
RUNOFF	1.820	6607.295	6.80
EVAPOTRANSPIRATION	24.792	89994.305	92.58
DRAINAGE COLLECTED FROM LAYER 2	0.4114	1493.321	1.54
PERC./LEAKAGE THROUGH LAYER 4	0.000026	0.093	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0523		
CHANGE IN WATER STORAGE	-0.243	-883.620	-0.91
SOIL WATER AT START OF YEAR	14.988	54406.195	
SOIL WATER AT END OF YEAR	14.745	53522.574	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.040	0.00

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ANNUAL TOTALS FOR YEAR 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.58	103745.414	100.00
RUNOFF	3.146	11418.242	11.01
EVAPOTRANSPIRATION	22.448	81486.633	78.54
DRAINAGE COLLECTED FROM LAYER 2	2.3334	8470.373	8.16
PERC./LEAKAGE THROUGH LAYER 4	0.000157	0.571	0.00
AVG. HEAD ON TOP OF LAYER 3	0.4188		
CHANGE IN WATER STORAGE	0.653	2369.586	2.28
SOIL WATER AT START OF YEAR	14.745	53522.574	
SOIL WATER AT END OF YEAR	15.397	55892.160	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.69	0.72	1.51	1.73	2.79	3.15
	2.67	3.49	2.08	2.23	1.05	0.85
STD. DEVIATIONS	0.60	0.54	1.09	1.30	1.53	1.54

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                         1.36     2.16     1.39     1.91     1.07     0.84

  RUNOFF
  ------
    TOTALS               0.004    0.003    0.063    0.105    0.138    0.244
                         0.090    0.332    0.145    0.240    0.048    0.026

    STD. DEVIATIONS      0.019    0.016    0.137    0.242    0.245    0.367
                         0.149    0.518    0.246    0.469    0.123    0.119

  EVAPOTRANSPIRATION
  ------------------
    TOTALS               0.744    0.667    1.211    1.558    3.005    3.002
                         2.643    2.853    1.871    1.270    1.053    0.779

    STD. DEVIATIONS      0.500    0.430    0.811    0.910    1.168    1.149
                         1.264    1.517    1.120    0.839    0.625    0.470

  LATERAL DRAINAGE COLLECTED FROM LAYER  2
  ----------------------------------------
    TOTALS               0.0368   0.0141   0.0293   0.1073   0.1058   0.0655
                         0.0199   0.0373   0.0436   0.1144   0.2014   0.1041

    STD. DEVIATIONS      0.0946   0.0429   0.0926   0.2336   0.1844   0.1300
                         0.0467   0.1157   0.1154   0.2480   0.3974   0.2590

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    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)
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  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES             0.0550   0.0231   0.0540   0.1886   0.1582   0.1013
                         0.0298   0.0558   0.0674   0.2304   0.4784   0.1952

    STD. DEVIATIONS      0.1415   0.0710   0.2009   0.4661   0.2758   0.2010
                         0.0698   0.1731   0.1783   0.6340   1.5689   0.6694

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	22.97	(4.466)	83398.2	100.00
RUNOFF	1.439	(0.9255)	5222.75	6.262
EVAPOTRANSPIRATION	20.655	(3.4404)	74977.91	89.904
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.87933	(0.86703)	3191.952	3.82736
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00006	(0.00008)	0.203	0.00024
AVERAGE HEAD ON TOP OF LAYER 3	0.136	(0.217)		
CHANGE IN WATER STORAGE	0.001	(0.7798)	5.32	0.006

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	3.88	14084.400
RUNOFF	2.066	7497.9219
DRAINAGE COLLECTED FROM LAYER 2	0.06526	236.87787
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000016	0.05776
AVERAGE HEAD ON TOP OF LAYER 3	17.637	
MAXIMUM HEAD ON TOP OF LAYER 3	24.104	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	82.2 FEET	

SNOW WATER	1.87	6789.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4140
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2210

*** 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 100

LAYER	(INCHES)	(VOL/VOL)
1	4.7372	0.2632
2	0.4121	0.1374
3	0.0000	0.0000
4	10.2480	0.4270
SNOW WATER	0.000	

****
****

APPENDIX C

STORMWATER CALCULATIONS MEMO

Trihydro CORPORATION

memorandum

To:	Project File
From:	Mr. Nathan Ewert, P.E.
Date:	May 18, 2020
Re:	North Holding Pond – Stormwater Channel Design Model Calculations

BACKGROUND

Phillips 66 Company (Phillips 66, CN601491608) operates the Borger Refinery (RN102495884), which is owned by a joint venture between Phillips 66 (P66) and Cenovus called WRB Refining LP (WRB, CN603215997). This memo has been prepared to evaluate the proposed stormwater channel design to close the North Holding Pond (NOR#036).

The North Holding Pond (NHP) is a 3.4-acre surface impoundment with a liner system consisting of 3-feet of bentonite amended clay, leak detection system, and 100-mil high-density polyethylene (HDPE) liner. The North Holding Pond is in partial closure in accordance with the 1998 closure plan. The free liquid has been removed and the sludge has been stabilized. The impoundment is now being filled with non-hazardous waste. The partial closure permit modification was approved by the Texas Commission of Environmental Quality (TCEQ) on April 21, 2004.

OBJECTIVE

The following memorandum describes the evaluation and design of the proposed stormwater channels, existing detention pond, and outfall system which will capture and convey runoff from the North Holding Pond, once the final cap is in place, as shown on the attached Figure 1. The calculations for the evaluation of the channels, detention pond, and outlet system are presented below. Evaluation of the entire system was completed using the United States Army Corp Hydrologic Modeling System (HEC-HMS) software (Ver. 4.2.1) and Manning's open channel and pipe flow equations.

HYDROLOGIC MODELING

The North Holding Pond Cap (Cap) was subdivided into five sub-basins. The runoff from the sub-basins is collected and conveyed to the detention pond via the stormwater channels which run along the east and west side of the cap. The Soil Conservation Service (SCS) Curve Number method was used to calculate runoff from each sub-basin using the HEC-HMS software. Area weighted curve numbers for each sub-basin were calculated based on final cap surfacing conditions. Rainfall information from United States Geological Survey (USGS) Depth Duration Frequency of Precipitation for Texas were used to determine runoff amounts for the 10, 25, 50 and 100-year 24-hour events. Only the 100-year 24-hour event was used for sizing the channels and structures. Input parameters and peak runoff values for each sub-basin are summarized in Table 1.

HYDRAULIC MODELING

Hydraulic modeling for the main components of the stormwater channels, detention pond and outlet system were completed using HEC-HMS modeling software. HEC-HMS was used to route the runoff hydrographs through the system. Peak flows through each of the components of the system were used to confirm channel and pipe sizes using Manning's Equation for open channel and circular (pipe) flow.

East Stormwater Channel

The east stormwater channel (east channel) was divided into five segments along the east side of the cap and collects runoff from sub-basins 1, 2, and 3 (See Figure 1). The divisions within the east channel were based on changes in slope of the channel. Capacity calculations for each segment were completed using the specific slope of that segment along with the peak flow from HEC-HMS. The typical section for the east channel generally consisted of a "v section" with depth ranging from 3 feet to 4 feet and sides slopes of 1.5 ft to 1 ft (horizontal to vertical). The east channel was lined with angular rock riprap or recycled concrete with a D_{50} of 6 inches and a manning's n value of 0.036, which was used in the calculations. East channel capacity calculations are summarized in Table 2.

The East Stormwater Channel discharges into the detention pond through a 30-inch corrugated metal pipe (CMP) culvert. Culvert capacity was analyzed using the Federal Highway Administration HY-8 culvert design software version 7.5. The CMP is approximately 83 feet long with a slope of 3.0 percent. At the peak flow for the east channel of 34 cubic feet per second (cfs) the culvert has a headwater elevation of 2,951.0 feet. The culvert overtopping elevation is 2,952 feet. Outlet velocity from the culvert is 8.7 feet per second (ft/s). The culvert outlet is protected by riprap with a D_{50} of 6 inches.

West Stormwater Channel

The west stormwater channel (west channel) runs along the west side of the cap collecting runoff from sub-basins 4 and 5. The same capacity calculation method of dividing the channel into segments based on the varying slope and using the peak runoff values from HEC-HMS was used to confirm channel sizing. The typical section for the west channel consists of a two feet deep trapezoidal section with a two-foot bottom width and 2:1 side slopes. Due to minimal slopes and velocities, there is no riprap lining along these channels, so a Manning's n value of 0.025 is used. West channel capacity calculations are summarized in Table 2.

Detention Pond

The existing detention pond that the stormwater channels discharge into has a storage volume of 2.63-acre feet at a maximum elevation of 2,950 feet and bottom elevation of 2,941 feet. Storage within the pond was modeled in HEC-HMS using a stage storage curve developed from survey of the pond. The maximum storage within the pond during the 100-year event is 0.7 ac-ft corresponding to an elevation of

2,946.6 feet. Peak inflow into the pond is approximately 100cfs, the peak discharge from the pond is approximately 45 cfs.

Discharge from the pond is controlled by a two-foot diameter smooth polyethylene (PE 4710 DR11) outlet pipe which is projecting from fill at an invert elevation of 2,941 feet. The detention pond outlet pipe system hydraulics are further discussed in the Outfall Pipe section.

Outfall Pipe

The outfall pipe conveys stormwater runoff from the detention pond to the new outfall location within an existing drainage channel. The outfall pipe consists of approximately 350 feet of 30-inch PE 4710 DR11 pipe broken into six segments with slopes ranging from 3.1 percent to 21 percent. The outfall pipe discharges to a 43 foot by 14 foot by 2.9-foot riprap and angular concrete pad with a D_{50} of 1.4 feet. Peak discharge through the outfall pipe is 45 cfs.

SUMMARY

Calculations summarized within this memorandum were used for the design of the Refinery Stormwater Improvement Project dated 5/24/2018.

QUALITY CONTROL	
Calculations By:	RJ/NE
Calculations Checked By:	JY
Calculations Reviewed By:	CT

42M-002-008

TABLES

TABLE 1. SUB-BASIN SUMMARY
BORGER REFINERY, HUTCHINSON COUNTY, TEXAS

Basin ID	Area (sq. mi.)	Area Weighted Curve Number	Percent Impervious	100-Year Peak Discharge (cfs)
Sub-Basin-1	0.00102	90	47	9
Sub-Basin-2	0.00257	89	0	21
Sub-Basin-3	0.00117	88	3	10
Sub-Basin-4	0.00292	89	0	25
Sub-Basin-5	0.00525	90	7	47

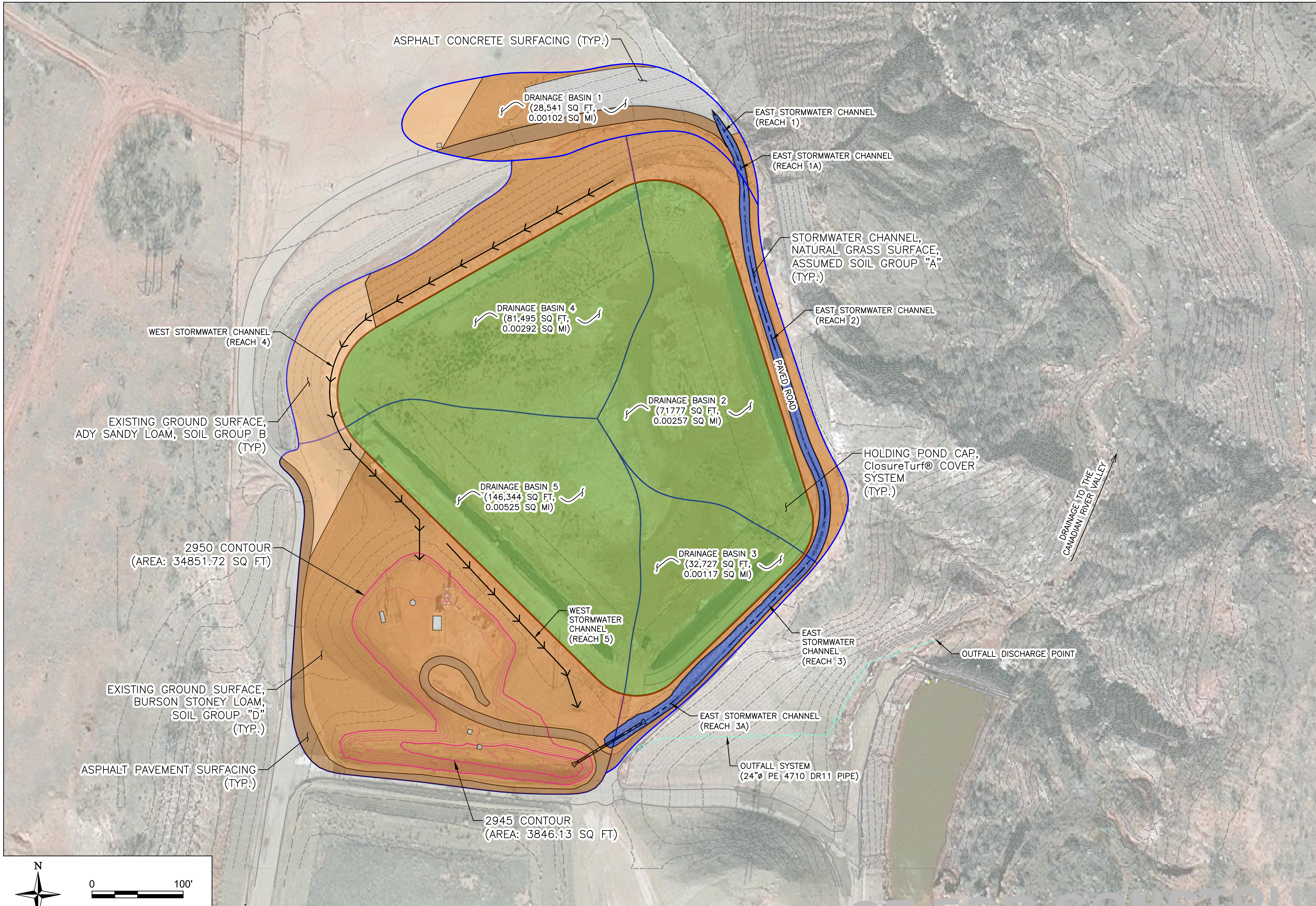
Notes:
cfs - cubic feet per second
sq. mi. - square miles

TABLE 2. CHANNEL DESIGN SUMMARY
BORGER REFINERY, HUTCHINSON COUNTY, TEXAS

Stormwater Channel	Channel Section[1,2]	Channel Slope (ft/ft)	Length (ft)	Manning's n	Velocity (ft/s)	100-Year Normal Depth (ft)	100-Year Design Capacity (ft)
East Channel Reach 1	V-Ditch	0.140	38	0.036	13.7	0.9	3.0
East Channel Reach 1A	V-Ditch	0.070	70	0.036	9.7	1.0	3.0
East Channel Reach 2	V-Ditch	0.005	398	0.036	3.0	2.4	3.0
East Channel Reach 3	V-Ditch	0.025	201	0.036	6.7	2.0	3.5
East Channel Reach 3A	V-Ditch	0.015	108	0.036	5.2	2.2	3.5
West Channel Reach 4	Trapezoidal Channel	0.006	500	0.025	4.9	1.8	2.0
West Channel Reach 5	Trapezoidal Channel	0.005	200	0.025	4.5	1.8	2.0

Notes:
1 - V-Ditch section consist on varying depth and 1.5ft:1ft side slopes
2 - Trapezoidal Channel consists of 2ft depth, 2ft bottom width and 2ft:1ft side slopes
ft - feet
ft/s - feet per second
ft/ft - foot per foot

FIGURE



REV.	DATE	DESCRIPTION	BY	CHK'D
A	5/12/2020	FOR INTERNAL REVIEW	RJ	TH

REVISIONS

DRAWN BY: RJ
CHECKED BY: NE
DATE: 5/13/2020
SCALE: 1" = 100'
FILE: 42M-NHPE-S_DRAINAGEBASINS-WITHMAINCAPDESIGN

Trihydro CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

APPROXIMATE DRAINAGE BASINS WITH SURFACE MATERIAL DELINEATIONS

NORTH HOLDING POND STORMWATER IMPROVEMENT PROJECT BORGER, TEXAS

SHEET 1
1 OF 1
REV: A

NOT FOR CONSTRUCTION

\\TRIHYDRO.COM\CLIENTS\OTOR\PHILLIPS66\PROJECTS\BORGERREFINERY\CADD\NORTHHOLDINGPONDEVAL\STORMWATER\ENGINEERINGDEV\42M-NHPE-S_DRAINAGEBASINS-WITHMAINCAPDESIGN

Attachment B.VII.C.1
Post-Closure Care Plan

Table of Contents

1.0 General Information

This post-closure care plan has been prepared to provide guidance to Phillips 66 (P66) for post-closure care of the Hazardous Waste Landfill; Surface Impoundment 302; North Holding Pond (NHP); Pitch Pits 11, 12 & 14; Old Caustic Pond; Filter Slurry Pond; New Caustic Pond; Surge Pond; Off Test Pond; Class I Landfill; and New Evaporation Pond for Hazardous Waste Permit No. 50078. This post-closure care plan is prepared in accordance with Federal (40 CFR §264 Subpart G and 40 CFR §264.144) and State (30 TAC §335.169) requirements.

Phillips 66 Company (Phillips 66, CN601491608) operates the Borger Refinery (RN102495884), which is owned by a joint venture between Phillips 66 (P66) and Cenovus called WRB Refining LP (WRB, CN603215997).The mailing address to the facility is P.O. Box 271, Borger, Texas 79008. The physical address for the facility is State Highway Spur 119 North, Borger, Texas 79007. P66 has been assigned a hazardous waste generator number by the U.S. Environmental Protection Agency (EPA) TXD980626774 and a Texas Commission on Environmental Quality (TCEQ) Solid Waste Notice of Registration Number 30111. The units listed above were closed and will be maintained in the post-closure period in a manner that minimizes the need for maintenance, and minimizes or eliminates the potential for hazardous waste and hazardous constituents to contaminate the ground or surface waters or the atmosphere. The hazardous waste units are deed recorded for commercial and industrial use only. No future changes in land use are expected.

Surface Impoundment 301 has never received hazardous waste, will be closed as such, and so does not require post-closure care.

Copies of engineering reports and figures for the surface impoundments closed as landfills and closed landfills are presented in Appendix A.

2.0 Post-Closure Period

The post-closure period for units will extend for at least 30 years after final closure as specified in the permit, or as modified by the TCEQ. Closure dates are presented below. Closure letters and deed recordation are presented in Appendix B.

Closure Dates and Schedules

Unit Name (NOR #)	Date Closed	Registration #	Anticipated End of Post-Closure Care Period
Hazardous Waste Landfill	N/A	536-589	-
Surface Impoundment 301	N/A	564-967	-
Surface Impoundment 302	N/A	564-967	-
North Holding Pond (36)[a]	3/15/1991 (reopened)	585-875	-
Pitch Pit 11 (5)	7/05/1995	75220	7/2025
Pitch Pits 12/14 (6)	7/05/1995	75220	7/2025
Old Caustic Pond (8)	1/17/1990	176-433	1/2020
Filter Slurry Pond (10)	11/15/1994	72317	11/2024
New Caustic Pond (11)	4/13/1993	642141	4/2023
Surge Pond (37)	12/03/1998	0290260/0296785	12/2030
Off Test Pond (39)	12/03/1998	0290261/0296785	12/2030
Class I Landfill	4/09/1990	0291953	9/2020
New Evaporation Pond	4/09/1990	0291955	9/2020

[a]Although the North Holding Pond stopped receiving hazardous waste in 1991, it is still open as a non-hazardous landfill.

A groundwater detection monitoring program is in place for the regulated units listed in the above table. The Old Caustic Pond and New Caustic Pond are in Corrective Action; the Class I Landfill and New Evaporation Pond are in Compliance Monitoring. Post-closure costs for the Class 1 Landfill, New Evaporation Pond, Old Caustic Pond, and New Caustic Pond were previously included in the Compliance Plan Financial Assurance costs. The costs for Post-Closure maintenance, inspection, closure certification, etc. (i.e. above-ground post-closure items) for these units have now been separated from the Compliance Plan and are included in Table 1 of the Post-Closure Plan. The corrective action and groundwater monitoring post-closure costs for these units are included in the Compliance Plan.

3.0 Post-Closure Monitoring

3.1 Groundwater Detection Monitoring Program

A groundwater detection monitoring program has been in place since the initial operation of the units. Details of the program are presented in Section VI of the RCRA Permit Renewal Application, Geology Section.

3.2 Leachate Collection and Leak Detection System

Leachate collection and/or leak detection systems exist for the Hazardous Waste Landfill, the surface impoundments, the N H P, and the Filter Slurry Pond. The leachate collection and leak detection systems are described below:

Surface Impoundments

The leak detection system of each impoundment consists of a geogrid, installed between the primary and secondary liners, which drains to a perforated central drain pipe along the bottom of each pond. The geogrid consists of a HDPE mesh material designed to drain moisture which penetrates the primary liner. The central drain pipe is enclosed in a geotextile sleeve and embedded in coarse sand within a geotextile envelope to prevent clogging of the perforations. The drain pipe accepts drainage from the geogrid and conveys the liquid to a Driscopipe sump. Each sump was constructed in a mechanically stable and watertight manner to enable the sump to retain any moisture which drains from the geogrid drainage layer.

North Holding Pond

A three-foot thick soil/bentonite liner was constructed on the pond bottom and interior side wails, with a pipe and gravel leak detection system constructed on top of the liner. Construction details are included in Section V of the 1997 Part B permit application. Since the NHP no longer receives hazardous waste, construction details have not been reproduced in this report.

Hazardous Waste Landfill

A leachate collection system was installed above the primary liner. The leachate collection system consists of a network of 4-6 inch perforated Driscopipes packed in a 12-inch layer of coarse sand. The piping directs leachate to a sump located at the east end of the landfill. The sump also receives run-off from within the landfill. The pumping system has a capacity of 100 gallons per minute. A leak detection system was installed between the primary and secondary liners.

Filter Slurry Pond

The Filter Slurry Pond was constructed with a primary liner of 45 mil reinforced Hypalon above a 3-foot bentonite-stabilized clay secondary liner. A leak detection system of three, 3-inch perforated PVC pipes within a 6-inch layer of granular material that separates the two liners. The PVC pipes drain by gravity into three concrete leak detection drain boxes located at the toe of the eastern embankment.

4.0 Post-Closure Inspections

The units will be inspected semi-annually during the post-closure care period. Post-closure inspections will evaluate the condition of the system components. Post-closure inspections include the following activities:

< Clay-rich soil structures, including covers and caps, will be inspected to verify that no cracks or deep erosions have developed, that deleterious settlement has not occurred, and that deep-rooted vegetation or burrowing animals have not penetrated the cap;

< Synthetic covers and caps will be inspected to verify that no damage has occurred, and that deleterious settlement has not occurred.

  - Samples of engineered turf material will be collected annually at a rate of 1 sample per acre and tested for tensile strength in accordance with ASTM D2256.
  - Condition of sand ballast will be inspected to determine if appropriate cover of turf remains in sufficient quantity to meet manufacturers specifications.

< Signage (e.g., “TCEQ Permit Unit No.”, “Danger Hazardous Waste”), or other markers will be observed to ensure they are intact and legible; and

< Benchmark surveys will be conducted annually to evaluate cap subsidence potential.

5.0 Post-Closure Maintenance

Because of the design of the closure caps, only routine post-closure maintenance is usually required (e.g., maintaining cover after storms, etc.). These and other less routine maintenance are evaluated as part of the routine inspections. Based on the results of these inspections, the following maintenance activities are performed as required:

< Stormwater conveyances will be maintained in good functional condition to avoid erosional features such as rills or other erosional damage to cover integrity;

< If evidence of ponding, settling, subsidence or disruption of established drainage patterns is observed, or discovered using the annual benchmark survey data, additional cover materials or vegetation, if applicable, will be applied to maintain proper slope and cover integrity;

< If damage to a synthetic cover or cap is discovered, it will be repaired;

< If annual test results indicate the engineered turf material has lost 50% or more in tensile strength the engineered turf material and sand ballast will be replaced;

< If subsidence or damage to a benchmark is observed during the annual benchmark survey, repairs will be made and the benchmark will be returned to its original elevation;

< Missing or illegible signage will be replaced;

< Animal burrows will be addressed by removal of the animal if possible and backfilling the burrow to avoid animals from encountering waste material; and

< Routine and other maintenance activities are performed as needed. If an inspection reveals that a maintenance activity is required to correct a problem, that action is implemented as soon as practicable.

Because the Borger, Texas area is semi-arid, minimal vegetative maintenance will be performed. The units are initially seeded with native species; however, no routine watering or mowing will take place.

6.0 Amendment of Plan

The post-closure plan will be maintained and updated as necessary by the Site Environmental Specialist.

The post-closure care contact is:

Site Environmental Specialist
Phillips 66, Borger Refinery
P.O. Box 271
Borger, Texas 79008-0271
806-275-1815

7.0 Post-Closure Cost Estimates

This information is provided for each hazardous waste land-based unit included in this plan. These closure costs were developed using a combination of EPA's preferred software, Costpro 6.0 and using 2019 cost estimates from material vendors and contractors. Estimates from Costpro are based upon 2007 unit costs; these costs were updated using standard inflation factors to give 2019 costs.

Detailed costs are presented in Tables VII.C.1-1 through VII.C.1-8. Post-closure costs for the Class 1 Landfill, New Evaporation Pond, Old Caustic Pond, and New Caustic Pond were previously included in the Compliance Plan Financial Assurance costs. The costs for Post-Closure maintenance, inspection, closure certification, etc. (i.e. above-ground post-closure items) for these units have now been separated from the Compliance Plan and are included in Table 1 of the Post-Closure Plan. The corrective action and groundwater monitoring post-closure costs for these units are included in the Compliance Plan.

8.0 Reporting

Reports and documentation required by the Part B Permit will be provided to TCEQ as indicated in the permit.

Additionally, post-closure care notices and certifications required by 40 CFR §264.119 through §264.120 will be performed. Within 60 days of completing the post-closure care period, P66 will provide the TCEQ with a certification that the post-closure care period was performed and completed in accordance with the specifications in the approved post-closure plan.

Tables/Figures/Drawings for Post-Closure Care Plan

Tables

Table 1 – Unit Post-Closure Cost Estimate

Figures

None

Drawings

None

Table 1. Unit Post-Closure Cost Estimate

Task	Cost
Hazardous Waste Landfill	
Maintenance and Inspection	$930
Groundwater Monitoring (5 wells x 2 events)	$11,597
Subtotal of Post-closure Costs	*$12,526*
Engineering Expenses (10%)	$1,253
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$13,779
Contingency (10% minimum)	$1,378
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$466,471 (2009)**
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$481,398 (2011)**
	$497,414 (2013)
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$547,000 (2019)**

Table 1. Unit Post-Closure Cost Estimate (Continued)

Task	Cost
Surface Impoundments 301 and 302	
SI 301	
Maintenance and Inspection	$642
Groundwater Monitoring	$0[a]
Subtotal of Post-closure Costs	$642
Engineering Expenses (10%)	$64
Subtotal of Annual Post-Closure Costs	$706
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
SI 302	
Maintenance and Inspection	$549
Groundwater Monitoring (7 wells x 2 events)	$15,512
Subtotal of Post-closure Costs	*$16,061*
Engineering Expenses (10%)	$1,606
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$18,373
Contingency (10% minimum)	$1,837
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$606,300 (2009)**
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$625,702 (2011)**
	$646,519 (2013)
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$711,000 (2019)**

[a]Groundwater monitoring is priced in the SI 302 Closure Costs. The units are too close together to separate.

Table 1. Unit Post-Closure Cost Estimate (Continued)

Task[1]	Cost
North Holding Pond	
Site Security (one-time only)	$25,000
Site Security (annual)	$500
Maintenance and Inspection	$1,000
Groundwater Monitoring (6 wells x 2 events)	$13,000
Non-destructive engineered turf testing (annual)	$500
Engineered turf replacement (one-time if needed)	$200,000
Subtotal of Annual Post-closure Costs	*$15,000*
Engineering Expenses (10%)	$1,500
Deed Notation	$7,000
Final Certification of Post-Closure Care	$10,000
subtotal	$16,500
Contingency (10% minimum)	$1,650
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$952,000 (2019)**

[1]The cost basis for line items in the above table are based on a mixture of 2007 and 2019 costs; these items were adjusted to a common 2019 cost basis in the total post closure cost.

Task	Cost
Pitch Pits 11, 12 &14	
Maintenance and Inspection	$2,440
Groundwater Monitoring (7 wells x 2 events)	$16,292
Subtotal of Annual Post-closure Costs	*$19,217*
Engineering Expenses (10%)	$1,922
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$21,139
Contingency (10% minimum)	$2,114
TOTAL UNIT POST-CLOSURE CARE COST x 14 yrs. (or other post-closure care period)	**$337,295 (2009)**
TOTAL UNIT POST-CLOSURE CARE COST x 14 yrs. (or other post-closure care period)	**$348,088 (2011)**
	$359,669 (2013)
TOTAL UNIT POST-CLOSURE CARE COST x 14 yrs. (or other post-closure care period)	**$395,000 (2019)**

Table 1. Unit Post-Closure Cost Estimate (Continued)

Task	Cost
Filter Slurry Pond	
Maintenance and Inspection	$2,627
Groundwater Monitoring (5 wells x 2 events)	$17,326
Subtotal of Post-closure Costs	*$20,476*
Engineering Expenses (10%)	$2,048
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$22,524
Contingency (10% minimum)	$2,252
TOTAL UNIT POST-CLOSURE CARE COST x 13 yrs. (or other post-closure care period)	**$333,854 (2009)**
TOTAL UNIT POST-CLOSURE CARE COST x 13 yrs. (or other post-closure care period)	**$346,601 (2011)**
	$358,132 (2013)
TOTAL UNIT POST-CLOSURE CARE COST x 13 yrs. (or other post-closure care period)	**$394,000 (2019)**

Task	Cost
New Caustic Pond (Post-closure groundwater and corrective action costs for NCP in Compliance Plan)	
Maintenance and Inspection	$1,363
Subtotal of Post-closure Costs	*$1,363*
Engineering Expenses (10%)	$136
Deed Notation	$6,800
Final Certification of Post-Closure Care	$10,000
subtotal	$1,499
Contingency (10% minimum)	$150
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$84,000 (2019)**

Table 1. Unit Post-Closure Cost Estimate (Continued)

Task	Cost
Surge Pond	
Maintenance and Inspection	$1,908
Groundwater Monitoring (5 wells x 2 events)	$14,838
Subtotal of Post-closure Costs	*$17,105*
Engineering Expenses (10%)	$1,710
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$18,815
Contingency (10% minimum)	$1,882
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$398,689 (2009)**
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$424,613 (2011)**
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$438,740 (2013)**
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$483,000 (2019)**

Task	Cost
Off-Test Pond	
Maintenance and Inspection	$1,908
Groundwater Monitoring (5 wells x 2 events)	$12,377
Subtotal of Post-closure Costs	*$14,643*
Engineering Expenses (10%)	$1,464
Deed Notation	$6,880
Final Certification of Post-Closure Care	$4,960
subtotal	$16,107
Contingency (10% minimum)	$1,611
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$348,400 (2009)**
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$359,549 (2011)**
	$371,511 (2013)
TOTAL UNIT POST-CLOSURE CARE COST x 19 yrs. (or other post-closure care period)	**$408,000 (2019)**

Task	Cost
Old Caustic Pond (Post-closure groundwater and corrective action costs for OCP in Compliance Plan)	
Maintenance and Inspection	$1,363
Subtotal of Post-closure Costs	*$1,363*
Engineering Expenses (10%)	$136
Deed Notation	$6,800
Final Certification of Post-Closure Care	$10,000
subtotal	$1,499
Contingency (10% minimum)	$150
TOTAL UNIT POST-CLOSURE CARE COST x 30 yrs. (or other post-closure care period)	**$84,000 (2019)**

Task	Cost
Class I Landfill (Post-closure groundwater costs for this unit in Compliance Plan)	
Maintenance and Inspection	$913
Subtotal of Post-closure Costs	$913
Engineering Expenses (10%)	$91
Subtotal of Annual Post-Closure Costs	$1,004
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$1,004
Contingency (10% minimum)	$100
TOTAL UNIT POST-CLOSURE CARE COST x 9 yrs. (or other post-closure care period)	**$29,000 (2019)**

Task	Cost
New Evaporation Pond (Post-closure groundwater costs for this unit in Compliance Plan)	
Maintenance and Inspection	$1,567
Subtotal of Post-closure Costs	$1,567
Engineering Expenses (10%)	$157
Subtotal of Annual Post-Closure Costs	$1,723
Deed Notation	$6,800
Final Certification of Post-Closure Care	$4,960
subtotal	$1,724
Contingency (10% minimum)	$172
TOTAL UNIT POST-CLOSURE CARE COST x 10 yrs. (or other post-closure care period)	**$40,000 (2019)**

TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$3,344,299 (2009)**
TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$3,442,273 (2011)**
TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined	**$3,556,800 (2013)**
TOTAL PERMITTED FACILITY POST-CLOSURE COST (all unit costs combined)	**$4,127,000 (2019)**

One-time only costs such as Deed Notation and Fencing have not been multiplied by the number of years left in post-closure care but added to the total cost.

Appendices to Post-Closure Care Plan

Appendix A – Engineering Reports and Drawings for Closed Surface Impoundments and Landfills

Appendix B – Closure Notices and Deed Recordation