Stantec

Basis of Design Report

Johnsonville Fossil Plant
Existing Spillway Closure Project
Ash Disposal Area No. 2
Work Plan 4
(JOF-100407-WP-4)
Humphreys County, Tennessee

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Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

May 31, 2011

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May 31, 2011 rpt_02_175559008

Mr. Ronald D. Skelton
Tennessee Valley Authority
1101 Market Street, LP 5E-C
Chattanooga, Tennessee 37402

Re: Basis of Design Report
Johnsonville Fossil Plant
Existing Spillway Closure Project
Ash Disposal Area No. 2
Work Plan 4 (JOF-100407-WP-4)
Humphreys County, Tennessee

Dear Mr. Skelton:

The enclosed report summarizes Stantec's design for the abandonment of the inactive spillways at Johnsonville Fossil Plant's Ash Disposal Area No. 2. The report contains a description of the project, design narrative, construction drawings, and calculation documentation.

We appreciate the opportunity to assist the Tennessee Valley Authority on this project. If there are any questions regarding the enclosed report please call our office.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Stephen H. Bickel, PE
Senior Principal

Joshua Kopp
Project Engineer

Enclosures

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Johnsonville Fossil Plant
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Humphreys County, Tennessee

1. Project Description

Stantec Consulting Services Inc. (Stantec) was retained to design methods to permanently close and abandon nine (9) inactive spillways in Ash Disposal Area No. 2 (Active Ash Disposal Area) at the Tennessee Valley Authority (TVA) Johnsonville Fossil Plant (JOF). This report contains pertinent information utilized as the basis of design. In general, guidelines presented in the *TVA Coal Combustion Products Management Program, Master Programmatic Document, Volume 2, Section 2.1* were followed in preparing this report.

The Johnsonville Fossil Plant (JOF) is located on a 748-acre reservation owned by TVA in west-central Tennessee. The plant site is in the community of New Johnsonville, which is in Humphreys County and along the east bank of the Kentucky Lake reservoir. Ash Disposal Area No. 2 is the second disposal area constructed at JOF. It is located on a 125-acre constructed island centered approximately 2,000 feet west of the JOF powerhouse. Access onto the island is via a 1,000 foot causeway embankment. The island is surrounded by Kentucky Lake to the west and two dredged channels (the Boat Harbor and Condenser Water Inlet channels) to the east. Ash Disposal Area No. 2 is 87 acres in area, as measured within the dike. The crest is at Elevation 390 feet mean sea level (msl), or about 30 feet higher than Kentucky Lake summer pool. The dike is from 25 to 30 feet in height, and was constructed with outslopes that varied from 1.5H:1V on the east side to 2.5H:1V along the west side.

Ash Disposal Area No. 2 at Johnsonville contains three sets of spillways, each consisting of three separate riser/outlet pipe structures (nine separate spillway structures). They are located on the southwest (South Spillways), northwest (North Spillways) and southeast (East Spillways) dikes (Figure 1).

Based on TVA's and Stantec's prioritization of spillways to be replaced, the Johnsonville spillways were considered to be of highest priority due to the height of the structures, past history of damage, surging within the active South Spillways, and their location on an island in Kentucky Lake. The Existing Spillway Closure Project was the second phase of the Johnsonville spillway project. The first phase included replacement of the active spillways (South Spillways) which allowed the stilling ponds to operate with a 2.5 feet lower pool elevation.

The nine inactive spillways were permanently abandoned by filling them with grout to prevent the possibility of seepage and soil migration through pipe joints. Cofferdams were constructed near the pipe outlets to expose the pipes. Each pipe was cleaned, inspected, and pumped full of grout.

2. Site Conditions

2.1. Existing Site Conditions

Each spillway riser consists of 48-inch inside diameter (ID) stacked concrete pipe sections constructed on a precast concrete junction box. The spillway outlet consists of 36-inch ID reinforced concrete pipe placed horizontally in a trench beneath the perimeter dike to discharge into Kentucky Lake (South and North spillways) or into the plant Condenser Water Inlet Channel (East Spillways). The ends of the outlet pipes are submerged below the winter pool water level for Kentucky Lake. Headwalls were not constructed at the outlet pipe ends.

The spillway risers are vertically stacked concrete pipe sections, approximately 35 feet in height, and are laterally supported by settled ash only (they are not structurally connected, but held together by gravity). Several risers display a slight tilt that may have been caused by impacts during a dredging operation. This created a concern for structural stability and potential for loss of pool, or complete dike breach should the riser topple or separate at depth.

Additionally, the spillway outlet pipes were not constructed using restrained joints or gaskets. According to past inspection reports, some of the pipes along the South Spillways experienced joint separations that resulted in internal erosion of downstream dike material and formation of sinkholes in the fall of 1992 and spring of 1993. Up to 20 feet in diameter and 15 feet deep, the sinkholes created concern about the integrity of the dike and whether the repairs (slip lining) adequately addressed issue of internal erosion. It was noted that one of the pipes could not be slip-lined for an unknown reason.

The North Spillway risers were inspected and videotaped on September 13, 2003 and then filled with concrete. Concrete is visible in the exposed tops of the risers; however, there is no available documentation on the method of execution of this work.

2.2. Proposed Site Improvements

The proposed improvements included completely filling the inactive horizontal spillway pipes and a portion of the vertical risers with grout. This was performed to stabilize the riser structures thus reducing the possibility of toppling and also preventing seepage and soil migration through misaligned pipe joints. Prior to grouting, the spillway pipes were inspected by closed circuit television camera and cleaned using high pressure washing equipment. After grouting was complete, a graded filter was constructed over the exposed outlet pipe to control potential seepage along the outside of the pipes.

Appendix A contains reduced-size Plans for Construction (“Issued for Construction”). The revision number of each drawing varies and only the version of each sheet actually used for construction is provided.

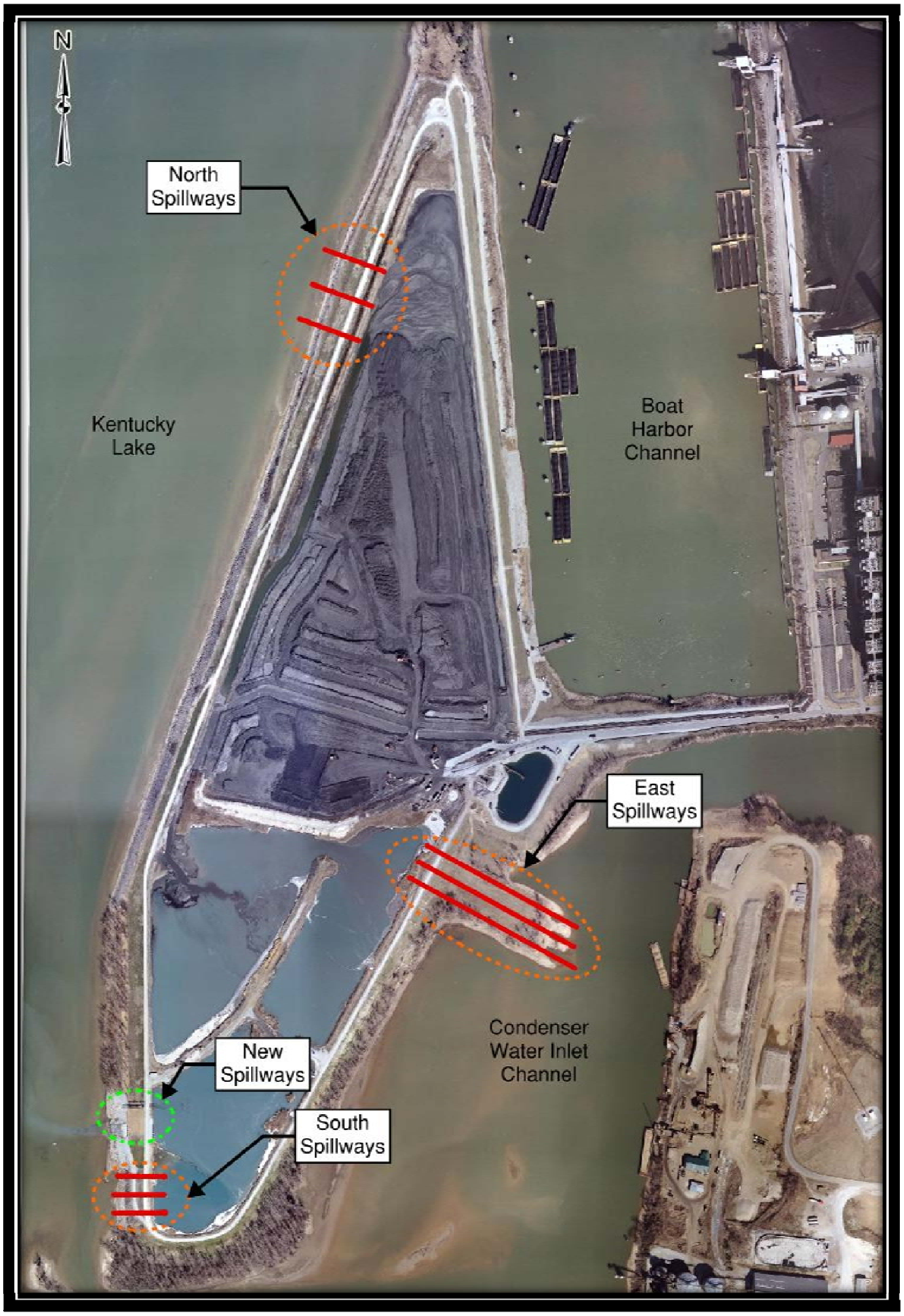


Figure 1. Overview of inactive existing spillways at the JOF Ash Disposal Area No. 2

3. Design

The TVA Fossil Group Management desired that this project be completed without delays due to Kentucky Lake operations (i.e. elevated lake levels). Therefore it was decided that the closure plan would be designed to allow work when Kentucky Lake was at maximum (summer) pool. Other key design considerations included:

- Pipes must be cleaned and inspected by CCTV cameras.
- A graded filter must be installed around the end of each pipe
- A contingency plan against ash release during "the critical period" must be implemented
- The grout mix must retain fluidity during pumping and develop enough short term strength for early form removal.
- Grout was pumped until the grout level measured in the riser rose to ten feet above the invert, or the pressure recorded at the bulkhead reached 25 psi.

The following narrative describes the design, constraints, evaluations, material selections, and/or analyses of the main project components required to achieve the key design considerations listed above. Appendix B contains the TVA Calculation Package associated with this project. Design criteria followed the guidelines outlined in: "TVA Coal Combustion Products Management Program, Master Programmatic Document, Volume 2 (Facilities Design and Construction Requirements)", as applicable. Where specific guidelines were not included therein, Stantec followed recognized design guidelines developed by the U.S. Army Corps of Engineers (USACE) and the Naval Facilities Engineering Command (NAVFAC).

3.1. Cofferdams

Two different types of cofferdams were utilized to gain access to the spillway pipes. Cofferdams were selected to minimize the amount of excavation required and to control seepage. Steel sheet pile cofferdams were designed to gain access to the East Spillways. Rock cofferdams combined with heavy plastic sheeting were designed to gain access to the South and North Spillway outlets.

3.1.1. Steel Sheet Pile Cofferdams

Steel sheet piles were used to form the cofferdams for the East Spillways. Earth pressure loads were determined by using methods found in the Naval Facilities (NAVFAC) Engineering Command, 'Foundations and Earth Pressures Design Manual, 7.02". Subsurface parameters for the analysis were obtained from boring data gathered by Stantec. The ground water level was conservatively assumed to be at the ground surface.

The sheet pile size was pre-selected to be PZ-27 at the request of the Contractor. This sheet pile size was analyzed for final and construction (without shoring system) loading conditions, basal heave, and embedment depth required to control seepage. The PZ-27 sections also provided extra durability to allow the Contractor to remove and reuse the sheets at all three spillway locations. Standard pumping methods were used to control groundwater seepage inside the cofferdam. Methods found in USACE "Engineering and Design – Design of Sheet Pile Cellular Structures, Cofferdams, and Retaining Structures (EM 1110-2-2-2503)", NAVFAC Design Manual 7.02, and the American Institute of Steel Design

“Manual of Steel Construction – Load and Resistance Factor Design” were used to analyze the sheet pile selection.

A shoring system was attached to the sheet piling to reduce the driving depth required. The wales used in the system consisted of HP14x102 steel sections that were welded together at the corners. They were installed at three feet below the groundline. Stadd.Pro computer software was utilized to design the wale size and connections.

3.1.2. Rock Cofferdams

The working area for the South and North Spillways is at the edge of Kentucky Lake. It was determined that driving sheet piles to form a cofferdam would be too difficult (this determination was made after construction of the East Spillway cofferdams). Constructing cofferdams of riprap and crushed stone was selected as an alternative. These materials were combined with a layer of heavy plastic liner to minimize seepage from Kentucky Lake into the excavations.

Seepage and slope stability analyses were performed to determine the seepage and slope stability factors of safety for the cofferdam configuration. Seepage analysis was performed to evaluate piping and to determine if seepage from the ash pond into the excavation would lead to instability in the slope. Total stress slope stability analysis was performed to determine the short-term slope stability factor of safety. Parameters for each analysis was taken from laboratory testing included in Stantec’s “Report of Geotechnical Exploration and Slope Stability Evaluation”, dated April 13, 2010.

The numerical seepage models were developed using SEEP/W 2007 (Version 7.17), a finite element code tailored for modeling groundwater seepage in soil and rock. SEEP/W is distributed by GEO-SLOPE International, Ltd, of Calgary, Alberta, Canada (www.geo-slope.com). Water levels within Kentucky Lake were modeled at Elevation 354 ft msl (normal winter pool) and Elevation 356 ft msl (water level at time of modeling). Ash Pond water levels were modeled at Elevation 384.5 ft msl, near normal pool for the ash pond. Water levels within the excavation were modeled near the bottom of the proposed excavation (Elevation 348 ft). A seepage blanket was designed at the bottom of the excavation consisting of No. 3 crushed stone and sand.

The factors of safety against piping ranged from 2.0 (for Lake Elevation 356 ft msl) to 2.5 (Elevation 354 ft msl). These factors of safety against piping were lower than those presented in TVA’s Programmatic Document. Stantec determined that the lower factors of safety can be tolerated since the rock cofferdams were a temporary structure. Stantec also provided onsite personnel that can address any concerns and problems which may develop during the construction. Stantec developed a contingency plan for the construction project that addressed potential problems that could occur from excessive seepage.

The SLOPE/W software is also available from GEO-SLOPE. SLOPE/W is a special-purpose computer code designed to analyze the stability of earth slopes using two-dimensional, limit equilibrium methods. For the slope stability analysis, the phreatic conditions/steady-state pore pressures obtained from the SEEP/W model were used. The slope stability factors of safety met the target value of 1.5.

Details of these analyses are included in the calculation package in appendix B.

3.2. Bulkhead

A steel bulkhead was designed equipped with two grout injection ports, air/water release port (for North Spillways only), valves and pressure gauges, and the struts and screw jacks to hold the bulkhead securely against the outlet pipe. The bulkhead was 5/8-inch thick steel plate. Four-inch diameter Schedule 40 black steel will be used for grout pipes, and bronze ball valves were used to block flow at completion of grouting. The steel struts extended from the bulkhead to the backside of the cofferdam and consisted of 5 inch diameter, Schedule 40 black steel pipe.

The bulkhead system was sized based on the maximum grout pressures. This was based on the maximum elevation of grout placed in the riser and the maximum allowable pressure at the bulkhead. The struts were analyzed as columns. Sizing of the struts and bulkhead were determined based on the American Institute of Steel Design “Manual of Steel Construction – Load and Resistance Factor Design”.

3.3. Graded Filter

The purpose of the graded filter was to control potential future seepage flowing along the outside of the spillway pipes and to prevent migration of soil particles. The design criteria used for the filter were taken from the U.S. Army Corps of Engineer (USACE) Engineering Manual EM1110-2-2300, Appendix B. The material uses a step approach in designing the filter materials. The results indicated that concrete sand, overlain by No. 57 stone, overlain by No. 3 stone would provide an adequate filter.

3.4. Pipe Plug

As part of the contingency plan, an inflatable plug was inserted into the riser base at the beginning of a defined “critical period”. The plugs were inserted into the vertical risers of the East and South Spillways (these are located in the active ash ponds). The intent of the plug was to prevent an accidental release of ash or water into Kentucky Lake if the risers toppled over during construction when the outlet pipes were exposed.

The worst case condition was assumed in the analysis to be the maximum pressure on the plug if the entire riser falling over and an ash/water slurry covered the pipe plug up to the pool elevation. This maximum pressure was compared to the manufacturer’s specifications to select the pipe plug to be used.

3.5. Grout

It was imperative that the grout mix design selected be flowable such that the entire pipe and section of riser could be filled prior to the grout setting. Specifications for shrinkage and strength were also provided. However, the original specification for shrinkage was relaxed after it was deemed too difficult to obtain while preserving the fluidity requirement.

The design team worked with the local ready mix company to develop a mix design. After testing several trial batches, the team selected a mix design with the following proportions (per Cu. Yd.):

525 lbs	Cement
130 lbs	Fly Ash
1850 lbs	Concrete Sand
1000 lbs	Pea Gravel
32 oz	High Range Water Reducer (Glenium 7500)
20 oz	Set Retarding Admixture (Pozzolith 300R)
40 gal	Water

4. Permits

TVA was responsible for securing the necessary permits for this project. The following permits were required for this project.

- United States Army Corps of Engineers (USACE) 404 Permit.

- Tennessee Department of Conservation (TDEC), Aquatic Resource Alteration Permit (ARAP) 401 Blanket Permit.

- TVA Excavation Permit.

5. Construction

5.1. Cost Estimate

The cost estimate for the project was provided by the Contractor. TVA contracted with the Environment and Technology Group for this project.

5.2. Schedule

Based on the construction schedule, the Contractor completed construction of the project in approximately 34 weeks.

5.3. Implementation

The main construction components for abandonment of the spillways consisted of:

- Construction of Sheet Pile Cofferdams (East Spillways) – This consisted of driving sheet piles with vibratory hammers. After the sheet piles were installed, a partial excavation was completed to allow installation of the shoring system. The primary excavation was then executed.

- Construction of Rock Cofferdams (North and South Spillways) – This involved placing crushed stone, riprap, and heavy plastic liner to control seepage. After these materials were in place, the inside of the cofferdam was excavated to expose the spillway pipe. Continuous pumping was required to keep the cofferdam from filling with water.

- CCTV Inspection and Pipe Cleaning – Prior to grouting, the inside of each spillway pipe was inspected with a CCTV camera to identify major defects in the pipes or at the joints and to look for seepage. No major defects were found. The pipe was cleaned with high pressure nozzles to remove all dirt and sediment buildup. A final inspection will be performed to verify that the cleaning process did not cause any damage to the pipe.

- Bulkhead Installation – A steel bulkhead was installed over each spillway pipe. This bulkhead was held in place by steel struts that were braced against sheet piles.

- Grouting – A fluid grout was pumped through the bulkheads and into the spillway pipes to the specified elevation and/or pressure.

- Graded Filter – After grouting was complete, a graded filter was installed over the spillway pipe. The excavations were then backfilled according to the method specified.

The Contractor developed his/her own means, methods, sequencing and schedule for construction of the improvements.

Stantec issued a Construction Certification Report and Record Drawings at the conclusion of construction.

6. Operational and Maintenance Features

No operation or maintenance features are required for this project.

7. Closure

This report was prepared to present pertinent information to document design activities for the Existing Spillway Closure Project at JOF's Ash Disposal Area No. 2. In general, guidelines presented in the *TVA Coal Combustion Products Management Program, Master Programmatic Document, Volume 2, Section 2.1* were followed in preparing this report.

Appendix A

Plans for Construction

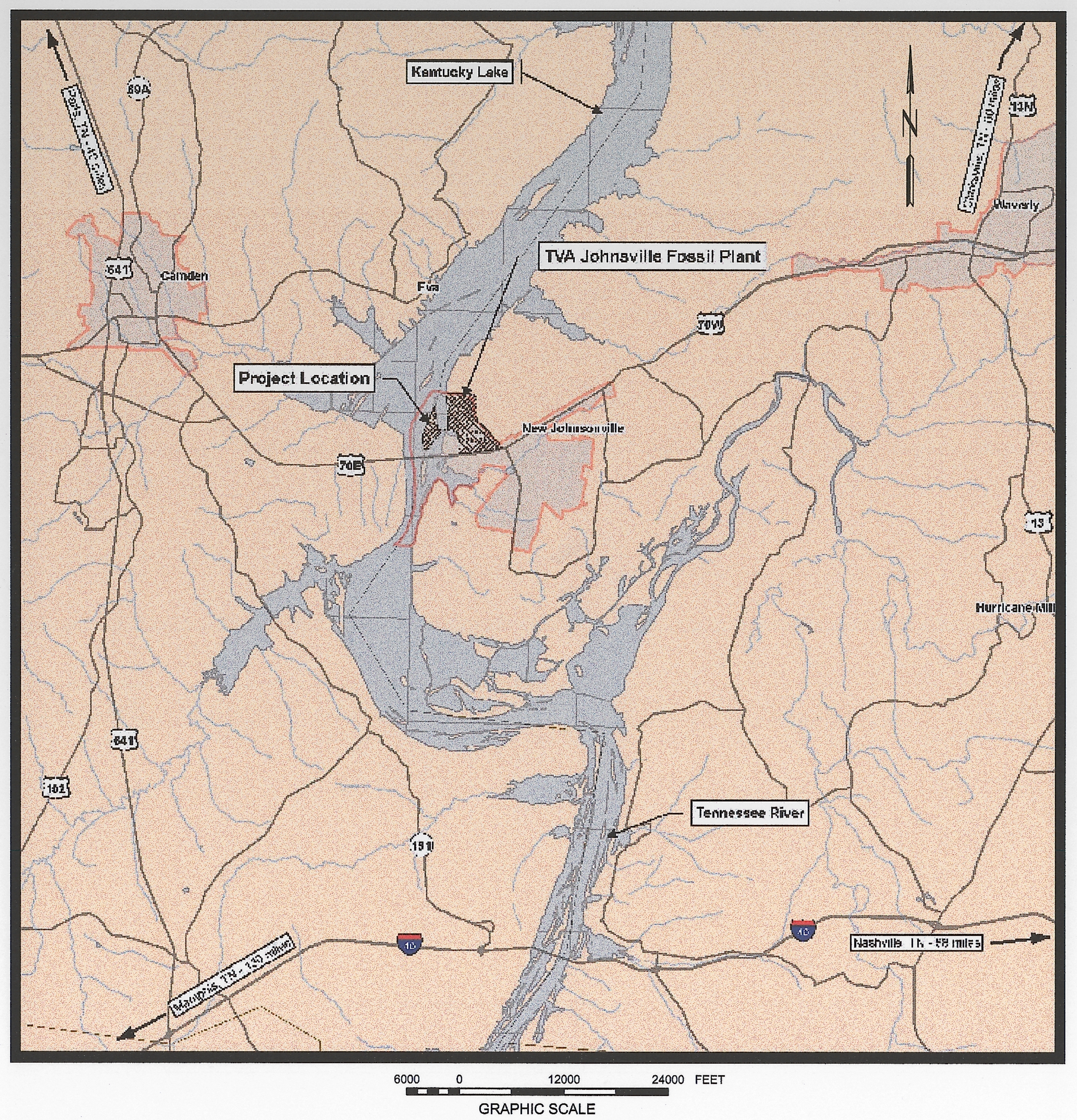
PLANS FOR CONSTRUCTION

ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
WORK PLAN 4 (JOF-100407-WP-4)
JOHNSONVILLE FOSSIL PLANT

NEW JOHNSONVILLE, HUMPHREYS COUNTY, TENNESSEE

PREPARED FOR

TENNESSEE VALLEY AUTHORITY



VICINITY MAP

PREPARED BY

Stantec

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INDEX OF SHEETS

ISSUED FOR CONSTRUCTION

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R –	–	–	–	–	–	–	–	–	–	–	–
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	–	–	–

ISSUED FOR CONSTRUCTION

DISCIPLINE INTERFACE 1 2 3 4

SCALE: AS SHOWN EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2

EXISTING SPILLWAY CLOSURE PROJECT
COVER SHEET
WORK PLAN 4 (JOF-100407-WP-4)

STEPHEN H. BICKEL REGISTERED ENGINEER AGRICULTURE COMMERCE No. 113134 STATE OF TENNESSEE

4/7/10

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	S. BICKEL	J. MONTGOMERY	T. JOHNSON

JOHNSONVILLE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000	DATE 04/07/10	30	C	10W505-01	R 0

STANTEC	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

TECHNICAL SPECIFICATIONS

GENERAL PROVISIONS

1. The proposed project is part of the Closure Plan for the TVA Johnsonville Fossil Plant Ash Disposal Area No. 2 (Active Ash Disposal Area). The purpose of the project is to abandon nine inactive spillway outlet pipes at the Ash Disposal Area. The pipes will be abandoned by cleaning, inspecting and filling pipe sections beneath the perimeter dike using flowable sand-cement grout. Additionally, a graded filter will be constructed at each pipe.

2. These drawings were prepared by Stantec Consulting Services, Inc. (Engineer) using topographic information provided by TVA (Owner) dated March 25, 2009, existing TVA design drawings 10W527-R11, 10W527-R15 and 10N529-R06, and information gathered from the TVA diving reconnaissance on December 9, 2009. The information is thought to be the best available; however, the Contractor shall expect that deviations from locations, dimensions, depths, etc. shown on the drawings will be required to achieve the purpose of the project. It will be the Contractor's responsibility to locate the outlet pipes and position sheet pile cofferdams as needed to accomplish the Work.

3. The Contractor shall conduct the Work in such manner so as to prevent any damage to crest or slopes of the Active Ash Disposal Area dikes. If equipment or material hauling causes damage, it shall be immediately repaired by the Contractor, and the activities causing damage shall cease or be altered to prevent additional damage. Except as shown on these drawings, the Contractor shall avoid making excavations in the dikes without the prior approval of the Engineer. The Contractor is also responsible for protecting the integrity of spillways, siphons, and any other appurtenances needed for the safe operation of the Active Ash Disposal Area, from damage due to the Contractor's operations.

4. The Contractor shall improve proposed haul and access roads to support hauling and construction equipment as needed. Stabilization materials (crushed stone, geogrid, geotextile) shall be used as necessary. The Engineer's approval shall be obtained wherever widening or regrading will result in excavations in the dike.

5. Proposed staging and stockpile storage areas are shown on the drawings. The Contractor shall coordinate with the Owner (TVA) regarding use of these areas, and of any other locations proposed by the Contractor. Staging and stockpile storage areas shall be approved by the Owner.

6. Whenever reference is made to Tennessee Department of Transportation (TDOT) Standard Specifications, the American Society of Testing and Materials (ASTM), American Concrete Institute (ACI), or other published standards or specifications, it shall mean the latest version in its entirety.

7. The Contractor shall keep a record of all deviations in location, elevation, method, or material used from that shown on these plans. At completion of the project a plan set of final record drawings shall be prepared by the Engineer to ensure that TVA has a permanent record of the project as it was constructed. The Contractor shall cooperate fully by providing his record of deviations, and shall assist with preparation of the Final Record Drawings.

EROSION PREVENTION AND SEDIMENT CONTROL (EPSC)

1. The Contractor shall exercise every reasonable precaution at all times to minimize soil erosion and prevent water pollution by deposition of sediment into Kentucky Lake. Soil erosion and sediment controls must be used and maintained in effective operating condition during construction, and exposed soil and other fill must be permanently stabilized at the earliest practicable date.

2. Silt fences shall be installed by the Contractor prior to the commencement of construction activities in any area where they are shown on the drawings. The Contractor shall inspect the silt fence for damage and sediment buildup every 7 days and within 24 hours of a precipitation event that produces 1/2-inch or more of rainfall. If the fence fabric is undermined, torn, or in any way becomes ineffective, it shall be immediately repaired or replaced by the Contractor. Silt fences removed to provide access for equipment and vehicles shall be replaced at the end of the work day.

3. Rock berms shall be constructed of quarried crushed stone prior to performing any excavation or pipe removal activities below the water level of Kentucky Lake. Rock berms are considered temporary fills and shall be removed to the approximate pre-construction elevations.

4. Water and sediment from pipe during pipe cleaning operations shall be removed from cofferdams and disposed of by pumping or hauling to the ash pond complex. The location of disposal shall be approved by the Owner.

5. The Contractor shall also exercise every precaution at all times to prevent water pollution by non-stormwater discharges, including spills or releases of hazardous materials.

LOWERING POOL LEVEL IN ASH POND COMPLEX

1. Prior to beginning work on East or South Spillways, the Contractor shall use the existing siphon system and lower the ash pond complex pool level to approximate elevation 378 feet. The siphons shall be operated in a manner such that the pool is not reduced more than one foot during a 24 hour period.

2. The Contractor shall immediately stop lowering the pool if any sign of dike instability is observed, or if there is any indication of non-compliance with the NPDES permit. At all times the Contractor shall coordinate his activities with Trans Ash and the Johnsonville Fossil Plant Environmental Staff to ensure that the Work does not impact the routine ash handling, or violate Total Suspended Solids permit limits.

3. The pool shall remain at the lowered elevation until grouting of the East and South Spillway pipes are complete. Before the pool is raised to the normal operating level, the Contractor shall ensure that there are no cenospheres between the spillway skimmers and outlet structures. The Contractor shall exercise caution to prevent the loss of cenospheres from the ash pond complex into Kentucky Lake.

PIPE PLUGS IN RISERS

1. A pipe plug shall be installed in each East and South Spillway riser prior to excavation at end of the outlet pipe. The Contractor shall lower the plug into the riser and secure at the top of the riser to ensure that the plug can be retrieved after the steel bulkhead is in place.

2. A CCTV inspection of the riser shall be performed before the plug is installed to look for sharp objects, protrusions, or anything that may puncture the plug.

3. The plug shall initially be inflated with air to obtain the proper shape. Water shall then be pumped into the plug to displace the air. All inflation procedures shall be in accordance with manufacturer's recommendations.

4. A compressed air and regulator shall be attached to the plug to ensure that it maintains the proper pressure.

5. The plug shall remain in place until the steel bulkhead is installed. Any water that has accumulated above the plug shall be pumped out before the plug is deflated and removed.

6. Prior to beginning any excavation and outlet pipe removal, the Contractor shall have stockpiles of rock and clay on-site nearby which can be quickly moved and placed into the excavation in the event of an ash discharge through the spillway pipe.

7. During the period beginning with work at the end of the outlet pipe and continuing until the steel bulkhead is in place, the Contractor shall provide equipment operators on-site 24 hours a day, 7 days a week. These operators shall be aware of procedures to follow in the event of loss of ash material and shall be capable of operating all equipment required to move stockpiled material and fill the excavation.

8. All supplementary equipment (lights, road markers, etc.) that may be required for backfilling operations to occur at night shall be on-site and workers shall be familiar with the location and use of this equipment before any excavations take place.

SHEET PILES AND STRUCTURAL STEEL FOR COFFERDAMS

1. The Contractor shall submit to the Owner and Engineer a cofferdam construction plan, which includes the dewatering plan, safety procedures, and sequence of construction, prior to beginning such operations.

2. Sheet piles and wales shall be handled and stored in such a manner as to avoid damage.

3. W 14x109 sections, connections, and stiffener plates shall meet the requirements of ASTM A992 Grade 50.

4. Bolts shall conform to ASTM A325.

5. Preparation of base metal prior to welding shall be performed in accordance with the American Welding Society (AWS) D1.1 Structural Welding Code.

6. All welding shall be done by the Shielded Metal Arc Welding (SMAW) process.

7. Welding operators shall be qualified in accordance with the AWS Standard Qualification Procedures. Certifications showing that welders employed in the work have satisfactorily passed AWS qualification test within the previous 12 months shall be provided.

8. Sheet piles shall be PZ 27 sections, and shall conform to ASTM A328 (fy=39 ksi).

9. The steel sheet piles shall be driven with a vibratory, impact, or gravity hammer specifically designed for pile driving. In order to maintain satisfactory alignment, the sheet pile shall be driven in such increments of penetration as necessary to prevent distortion, twisting, out of position or pulling apart at the interlocks. Driving operations shall be continuous except when interrupted by an emergency. If the installed sheet piles are appreciably distorted or otherwise damaged, the damaged piles shall be removed and replaced.

10. The rock berms around the North and South Spillways are to provide a working base for pile driving and excavation equipment, and to prevent sediment from below water level excavation/pipe removal activities from leaving the immediate work site. TDOT No. 2 or No. 3 stone shall be used to construct the berms.

11. After completion of the graded filter and removal of the sheet piles, remove the stone from the lake bank and haul to the stockpile area near the East Spillways shown on Sheet 3. This material shall be used in the future Southeast Dike Stability Improvement Project. Install silt fence around the stockpile as shown on Sheet 3.

CLEANING PIPE

1. Before grouting, each spillway pipe shall be cleaned of sand, dirt, and other solid or semi-solid materials. The term "clean" shall mean removing all solid or semi-solid materials from the pipe so that a closed circuit television camera can be used in the internal pipe inspection for the purpose of discerning structural defects, misalignments, separations at joints, etc.

2. Cleaning will be accomplished utilizing a high pressure, hydraulic sewer pipeline cleaner. Pressure jetting equipment used shall be sufficient for the purposes of attaining the degree of cleanliness as specified. At least three passes of the pressure jetting equipment shall be performed in each pipe.

3. Cleaning shall include the trapping and removal of all sediments and residual wastes including rinse water from the spillway pipes. The Contractor shall dispose of residual wastes in the Ash Pond complex at a location designated by the Owner.

4. Potable water required for cleaning will be the responsibility of the Contractor.

TV INSPECTION

1. After cleaning and prior to filling the pipes with grout, the spillway pipes are to be inspected via a closed circuit television (CCTV). The inspection shall be conducted in such a manner as to determine that the line is clean and to locate all leaking joints, breaks, and faults in the pipes. Television camera movement shall be temporarily halted at each visible point source of infiltration/inflow.

2. If at any time, the pipe is found not to be cleaned, the CCTV will be removed and the Contractor shall re-clean the pipe until video footage

3. Maximum CCTV speed shall be 30 feet per minute.

4. The CCTV truck shall have certified Pipeline Assessment and Certification Program (PACP) software (current version is 4.4 or newer). The camera operator shall also be PACP certified.

5. All pipe inspections performed shall be captured and submitted to TVA in a Moving Pictures Expert Group (MPEG) format. A separate MPEG file shall be produced for each pipe inspected. MPEG file names shall be the same as the spillway pipe names on these drawings (i.e. Spillway Pipe 4, etc.). The MPEG files shall be delivered to TVA on DVD discs or an external hard drive (USB 2.0).

6. During the entire video of the pipeline, the following information shall be continuously displayed:
   i. Automatic update of the camera's footage position in the pipeline from adjusted zero (zero being the point of entry of the pipe).
   ii. Pipe dimension in inches.
   iii. Spillway pipe name.
   iv. Date and time of video.

7. The size and position of the data display shall be such as not to interfere with the main subject of the picture.

8. The Engineer shall be present during the internal television inspection and shall monitor the live video feed during the inspection.

GROUTING

1. Grout shall be composed of Portland cement, fine aggregate (sand), water, and admixtures to provide fluidity, retard setting time, and prevent shrinkage. The design of the grout mixture shall be based on a water-cement ratio necessary to secure (1) a plastic, flowable mixture suitable for the specific condition of placement, (2) provide less than one-half percent shrinkage, and (3) retard the setting time to at least the time required by the Contractor to complete filling of the pipe in a single uninterrupted operation. Additionally, the grout mixture shall be designed so that it will produce a minimum laboratory compressive strength of 1000 psi at 28 days. Prior to beginning the Work, the grout mix design shall be submitted to the Engineer for approval.

2. Portland cement shall meet the requirements of ASTM C-150 Type I cement. Cement shall be properly stored and protected from weather, dampness, or other destructive agents. Any cement which is damaged will be rejected and not permitted to be used in the Work. Portland cement shall be subject to sampling and testing in accordance with ASTM C-150.

3. Sand shall meet the requirements of TDOT 903.02 - Fine Aggregate for Mortar. It shall be uniformly graded and 100% shall pass the No. 8 sieve.

4. Water for mixing grout shall be potable water in accordance with ASTM C-94.

5. The materials shall be mixed and delivered to the jobsite in equipment of sufficient size and capacity to provide the desired amount of grout material for each spillway pipe to be completely filled in a single operation. The Contractor shall provide a stand-by grout pump, dewatering pump and hoses for 100 percent backup capacity to ensure an uninterrupted pipe grouting operation once grout placement begins.

6. At least 20 working days prior to the start of the grouting operation, the Contractor shall submit a grouting plan to the Engineer for review. The Plan shall include the equipment and procedure/method that the Contractor proposes for the Work. The Plan shall also include the Contractor's proposed grout mix design (materials, proportions, admixtures, etc.), initial set time for the grout, maximum injection pressure, 24 hour and 28 day minimum compressive strength, and pressure gauge certification.

7. In addition, the Contractor shall be required to perform an above-ground test of the grout batching operation, whereby a sample truckload of the grout is delivered to the jobsite. The grout shall be sampled and tested by the Engineer to ensure that it exhibits adequate fluidity, shrinkage, and strength characteristics, and the initial set time is retarded sufficiently for placement.

8. Grouting shall commence using the primary pipe. Gauges to monitor grout pressure shall be installed into the injection piping and immediately adjacent to the bulkhead. The gauges shall conform to an accuracy of no more than one-half percent error over the full range, and the full range shall not be more than 100 percent greater than the maximum design pressure. Pressure gauges shall be instrument oil- filled, and attached to a saddle-type diaphragm seal (gauge saver) to prevent clogging with grout. Gauges shall be certified and calibrated in accordance with ANSI B40, Grade 2A.

9. Grout shall be injected through the primary port, which discharges into the spillway pipe at the bulkhead. In this manner grout will fill the lower end of the pipe first and displace air/seepage water in an upstream direction. During grout injection the grout pressure shall be monitored. If elevated pressures are detected indicating that the primary port has clogged, then the grout injection shall be diverted and continued through the secondary pipe. Grout pressure at the bulkhead shall not exceed 25 psi to avoid overstressing bulkhead struts. For the East and South spillway pipes, grout injection shall be terminated when grout fills the riser at least 10 feet above the invert of the riser pipe. For the North spillway pipes, grout injection shall be terminated when grout is observed from the air relief pipe, or the grout pressure at the bulkhead achieves 25 psi.

10. The Contractor shall monitor the dike slopes around and above the spillway pipe and be alert for ground heave. If ground heave is noted, grout injection shall be diverted and continued through the secondary pipe.

11. The Contractor shall record the grout take for each spillway pipe and the pressures developed during the operation and report results to the Engineer.

FILTER CONSTRUCTION

1. Filters shall be installed as soon as practicable following grouting operations, and as described using construction sequence outlined on these Drawings.

2. Sand shall conform to the gradation set forth in TDOT Standard Specifications Section 903.01 'Fine Aggregate for Concrete'. The sand shall be placed to a minimum thickness as shown on the drawings.

3. Coarse aggregate (Size No. 3 and No. 57) shall consist of quarried stone meeting the requirements of TDOT Standard Specifications Section 903. The gradation shall conform to Table 1 (AASHTO M43) in section 903.22 of the Standard Specifications. Stone shall be placed to the minimum thickness indicated on the drawings.

4. Riprap stone shall consist of quarried stone meeting the requirements of Section 709 of the TDOT Standard Specifications. Machined riprap (Class B) shall vary in size from 3 inches to 2.25 feet (from 75 to 675 mm) with no more than 20% by weight being less than 6 inches in size (150 mm).

5. Riprap shall be placed by mechanical means using an excavator or loader. The maximum allowable drop height for riprap placement is 2 feet. The rock shall be placed to the depths and extents shown in the drawings. The surface of the lining, upon completion, shall be graded as practicable into final position to ensure proper thickness and a uniform surface. Larger rocks shall be uniformly distributed with the small rocks and spalls filling the voids between the larger rocks.

6. Coarse aggregate (No. 3 stone) removed from the rock berms around the North and South Spillways can be used in the filters. Material used shall be clean and relative free from fines.

BACKFILLING AND RESTORATION

1. Disturbed ground, including backfilled excavations shall be finish graded to a relatively smooth surface. Seedbed preparation, fertilizing, seeding, mulching and seedbed preparation shall be performed in accordance with the applicable subsections of sections 801 and 918 or the TDOT Standard Specifications. Group "C" seed mixture shall be used.

QUALITY CONTROL TESTING

1. At least 10 working days prior to start of work, supplier certifications shall be submitted to the Engineer. The certifications shall state that materials meet the specifications listed in these drawings. Certifications will be required for: structural steel, steel sheet piling, sand, crushed stone, and riprap.

2. The Engineer shall be responsible for QC testing as follows:
   a. Grout
      i. Fluidity
         1. Method: ASTM C 939 (standard) test
         2. Frequency: Every 10 cubic yards, sample and test at time of delivery, retest at one hour intervals.
         3. Specification: Efflux time from 10 to 30 seconds.
      ii. Compressive Strength
         1. Method: ASTM C 109
         2. Frequency: Sample every 50 cubic yards of grout placed; 3 molds formed per sample, two broken at twenty-eight days (28) and one held for spare.
         3. Specification: 1,000 psi at 28 days.
      iii. Shrinkage
         1. Method: ASTM C 1090
         2. Frequency: Sample every 25 cubic yards of grout placed.
   b. Filter Sand
      i. Gradation
         1. Method: Sampled per ASTM D 75 and tested per C 136
         2. Frequency: One test per 200 tons
         3. Specification: Gradation requirements of TDOT Section 903.01.
   c. Filter Stone
      i. Gradation
         1. Method: Sampled per ASTM D 75 and tested per C136
         2. Frequency: One test per 200 tons
         3. Specification: Gradation requirements of TDOT Section 903.22.

3. Soil used to backfill excavations shall be placed in lifts (12 inches loose thickness) and compacted to at least 95% of the standard proctor dry density at moisture contents within plus or minus 2 percent of the optimum moisture content as determined by ASTM D-698. Samples of the proposed fill shall be submitted to the Engineer for review, testing and approval prior to placement. A Stantec engineering technician shall be on site to observe construction and test backfill.

ISSUED FOR CONSTRUCTION

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT	AS CONST
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	-	-
ISSUED FOR CONSTRUCTION										

SCALE: NONE — EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
TECHNICAL SPECIFICATIONS
WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	S. BICKEL	J. MONTGOMERY	T. JOHNSON

Stephen H. Bickel, Registered Engineer, Agriculture/Commerce, No. 113724, State of Tennessee — 4/7/10

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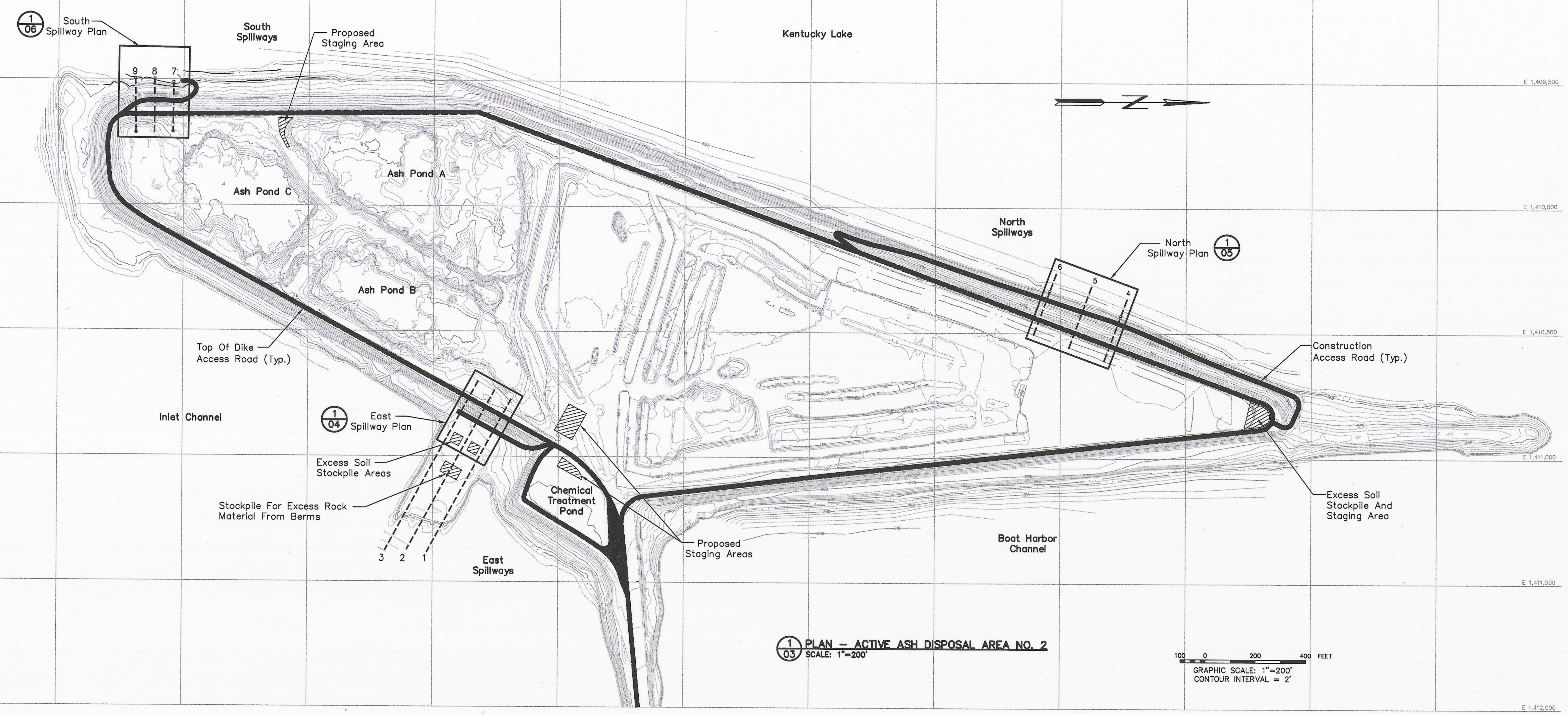
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000 | DATE 04/07/10 | 30 | C | 10W505-02 | R 0

STANTEC | 0
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

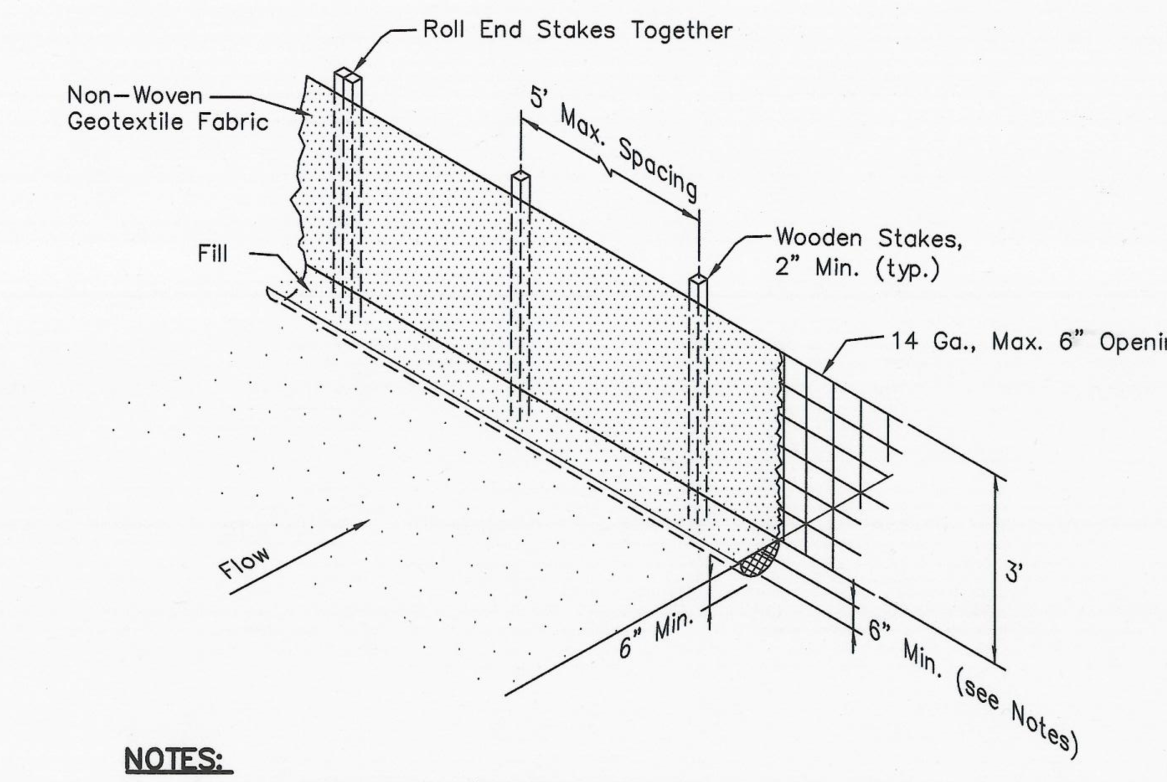
C.A.D. DRAWING DO NOT ALTER MANUALLY



1/03 PLAN – ACTIVE ASH DISPOSAL AREA NO. 2
SCALE: 1"=200'

NOTE:

Survey Coordinates Are Referenced To Tennesee State Plane Coordinate System (Lambert), NAD 27, Elevations Are Based On NGVD 29.



NOTES:

1. All Earthwork Activity Shall Be Located Uphill Of Silt Fence.
2. Silt Fence Shall Be Installed Across Slopes On The Contour Line.
3. Attach Filter Fabric To Wooden Stakes With Staples, Hogrings Or Other Materials Approved By The Engineer.
4. Wooden Stakes Shall Be Installed On The Downhill Side Of Filter Fabric.
5. Bury The Bottom 12 Inches Of Filter Fabric In A 6"x6" Trench (to Prevent Sediment From Escaping Under The Fence) And Back Fill With Soil.
6. Join Silt Fence Sections By Rolling End Stakes Together To Create An Unbroken Sediment Barrier.

2/03 DETAIL – REINFORCED SILT FENCE
Scale: N.T.S.

Summary – Spillway Outlet Pipes To Be Closed

Pipe	Description	TVA Spillway Inventory Pipe ID	End Of Outlet Pipe		Center Of Riser		Riser Invert Elevation (ft)	Outlet Pipe Invert Elevation (ft)	Weir Elevation (ft)	Riser Height (ft)	Pipe Length (ft)	Approximate Length Grouted (ft)	Estimated Volume Of Grout (cy)
			Northing[1]	Easting[1]	Northing[1]	Easting[1]							
1	East Spillways – North	JOF–APB–I–MG–001	599,976	1,411,383	600,309	1,410,773	357	344	Unknown	Unknown	690	160	47
2	East Spillways – Middle	JOF–APB–I–MG–002	599,895	1,411,373	600,243	1,410,737	357	344	Unknown	Unknown	720	160	47
3	East Spillways – South	JOF–APB–I–MG–003	599,806	1,411,381	600,178	1,410,701	357	344	Unknown	Unknown	770	160	47
4	North Spillways – North	JOF–APA–I–MG–004	602,656	1,410,332	602,674	1,41,608	351	349	Unknown	Unknown	258	165	44
5	North Spillways – Middle	JOF–APA–I–MG–005	602,515	1,410,280	602,533	1,410,556	351	349	Unknown	Unknown	258	165	44
6	North Spillways – South	JOF–APA–I–MG–006	602,374	1,410,228	602,392	1,410,504	351	349	Unknown	Unknown	258	165	44
7	South Spillways – North	JOF–ASPC–I–MG–007	598,968	1,409,461	598,957	1,409,708	351	349	386.49	35	189	189	54
8	South Spillways – Middle	JOF–ASPC–I–MG–008	598,894	1,409,462	598,883	1,409,710	351	349	387.60	36	207	207	59
9	South Spillways – South	JOF–ASPC–I–MG–009	598,820	1,409,464	598,809	1,409,711	351	349	386.49	35	205	205	58

1 Northing And Easting Coordinates Are Approximate.

ISSUED FOR CONSTRUCTION

Section or Detail No.
Sheet Where Shown
REFERENCE KEY

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R –	–	–	–	–	–	–	–	–	–	–	–
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	–	–	–

ISSUED FOR CONSTRUCTION

DISCIPLINE INTERFACE 1 2 3 4

SCALE: 1"=200' EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2

EXISTING SPILLWAY CLOSURE PROJECT
PLAN VIEW
WORK PLAN 4 (JOF–100407–WP–4)

STEPHEN H. BICKEL REGISTERED ENGINEER AGRICULTURE COMMERCE No. 113134 STATE OF TENNESSEE
4/7/10

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	S. BICKEL	J. MONTGOMERY	T. JOHNSON

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JOHNSONVILLE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

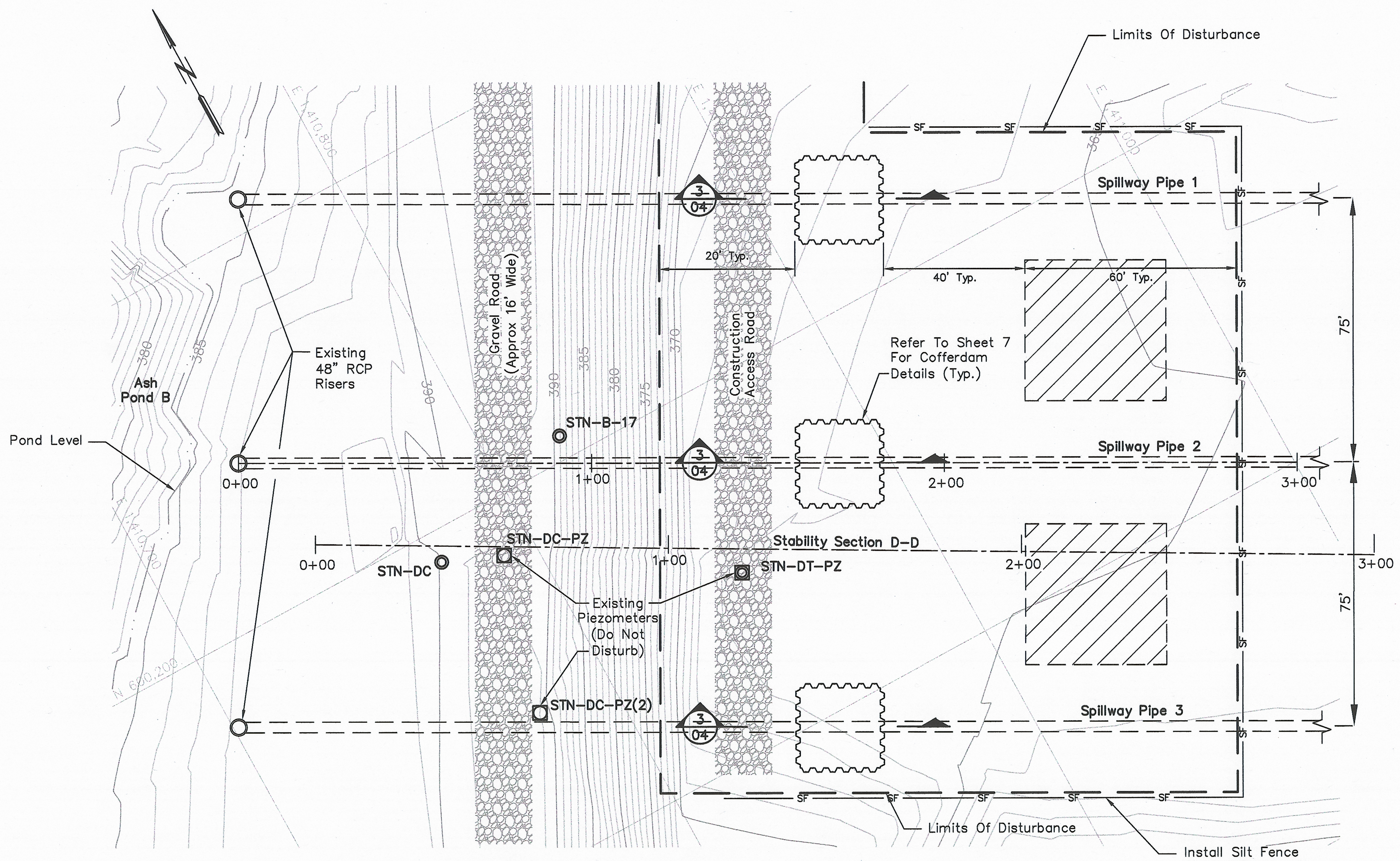
AUTOCAD R 2000 | DATE 04/07/10 | 30 | C | 10W505–03 | R 0

STANTEC | 0
TASK COMPLETED BY: | REV NO.

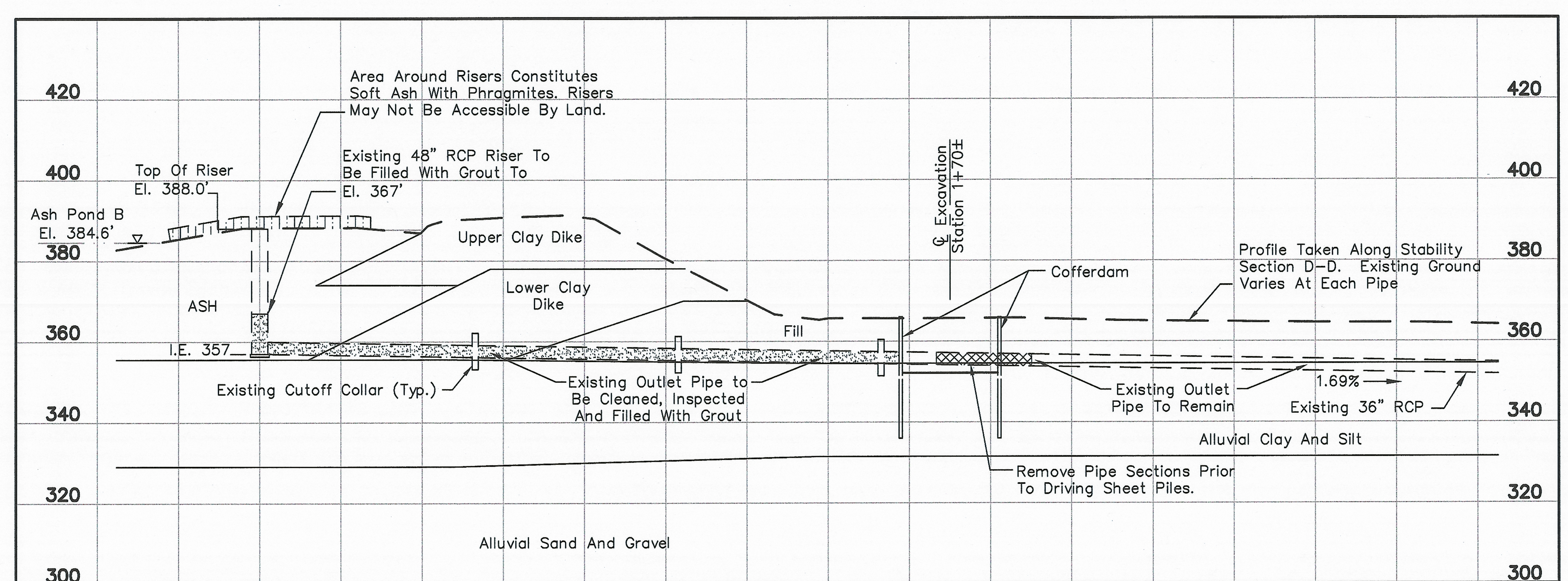
PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

PLOT DATE: 04/07/2010

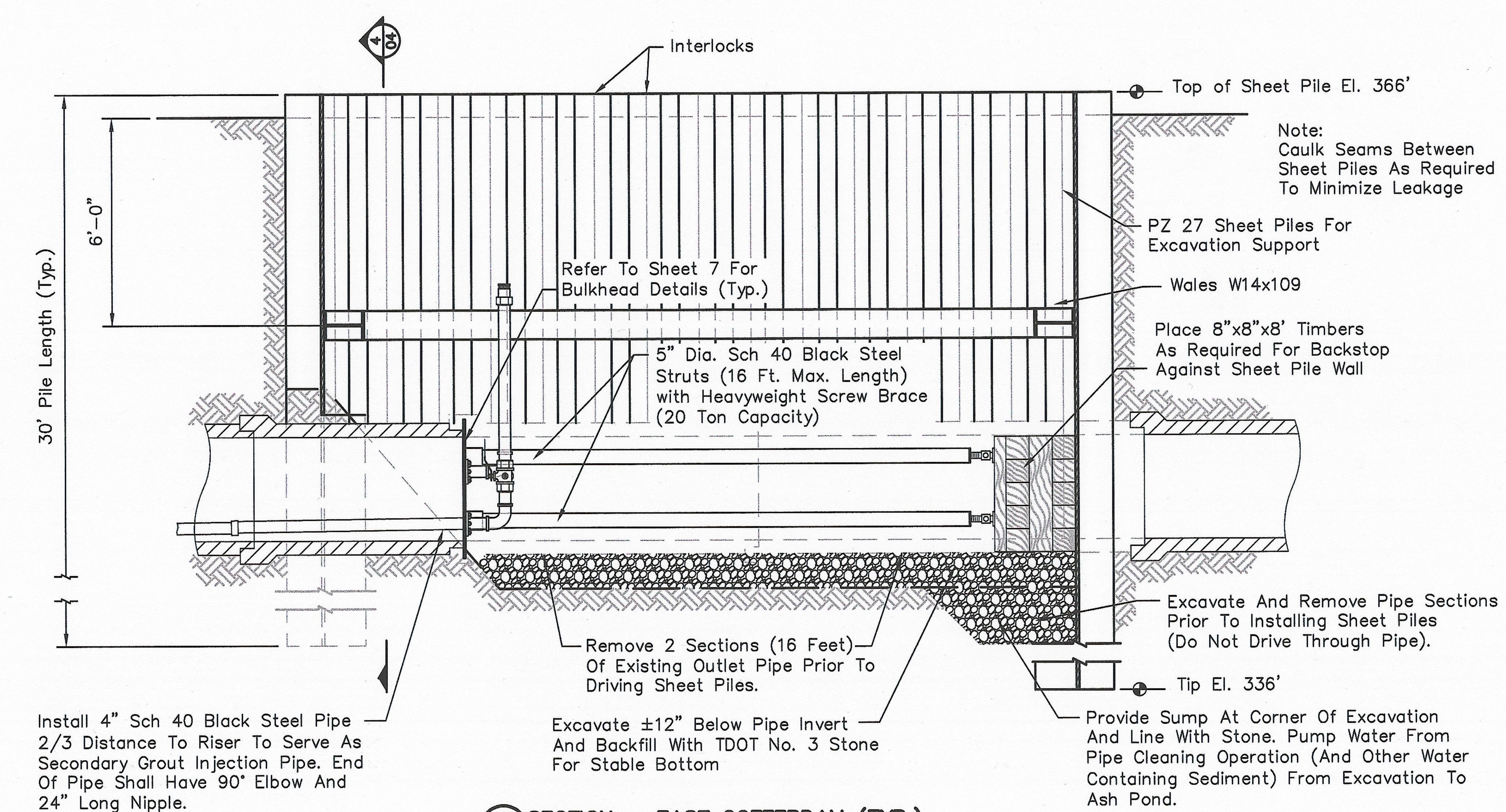


1 04 PLAN – EAST SPILLWAYS
SCALE: 1"=20'

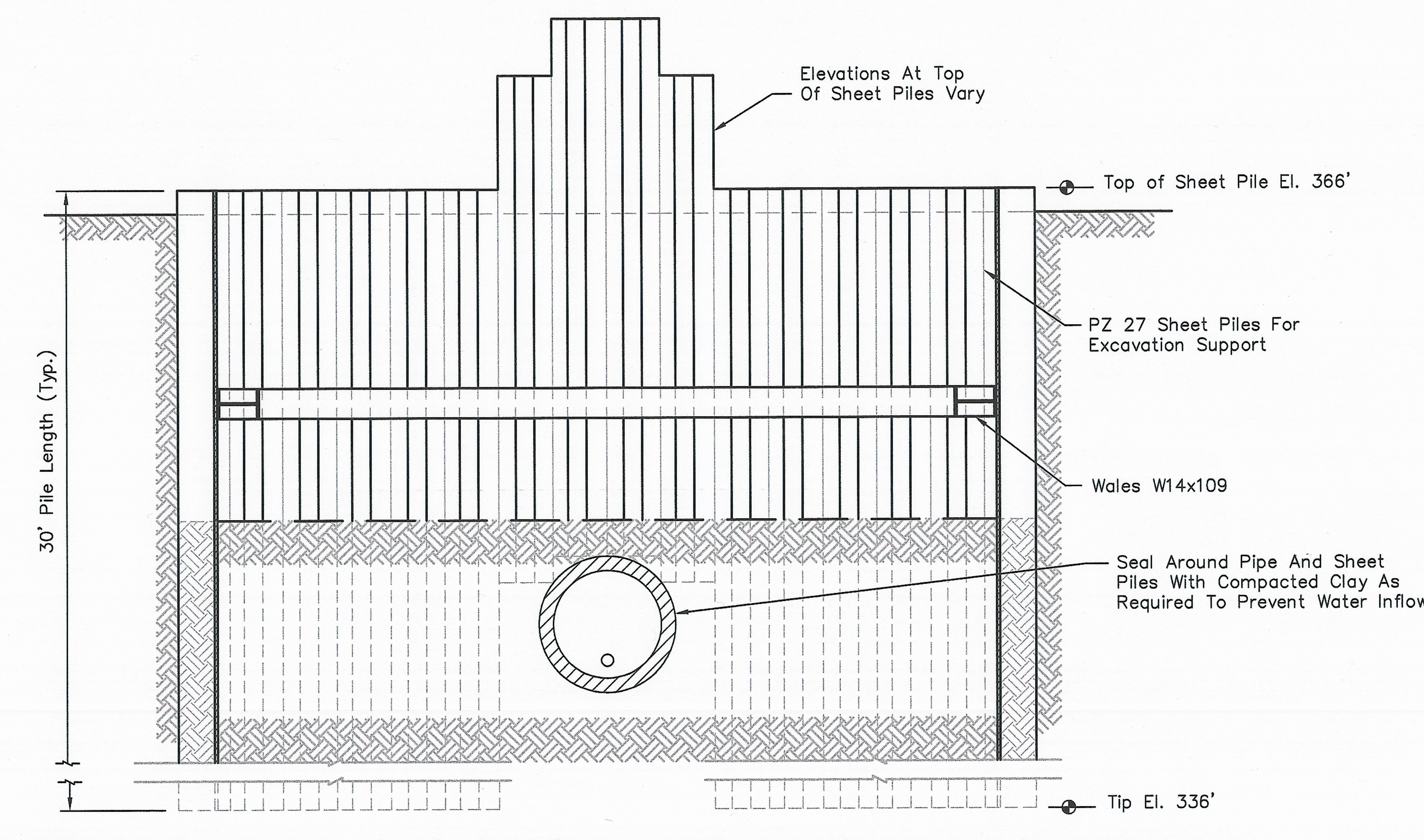


2 04 PROFILE – EAST SPILLWAY
SCALE: 1"=20'

10 0 20 40 FEET
GRAPHIC SCALE: 1"=20'



3 04 SECTION – EAST COFFERDAM (TYP.)
SCALE: 3/8"=1'-0"



4 04 SECTION – EAST COFFERDAM (TYP.)
SCALE: 3/8"=1'-0"

Note:
Graded Filter Shall Be Installed After Grouting Is Complete. See Sheet 8 For Details.

ISSUED FOR CONSTRUCTION

Section or Detail No.
Sheet Where Shown
REFERENCE KEY

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT	AS CONST
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ		
ISSUED FOR CONSTRUCTION										

SCALE: AS SHOWN EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
EAST SPILLWAYS
WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
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STEPHEN H. BICKEL REGISTERED ENGINEER AGRICULTURE No. 113134 STATE OF TENNESSEE
4/7/10

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AUTOCAD R 2000 | DATE 04/07/10 | 30 | C | 10W505-04 | R 0

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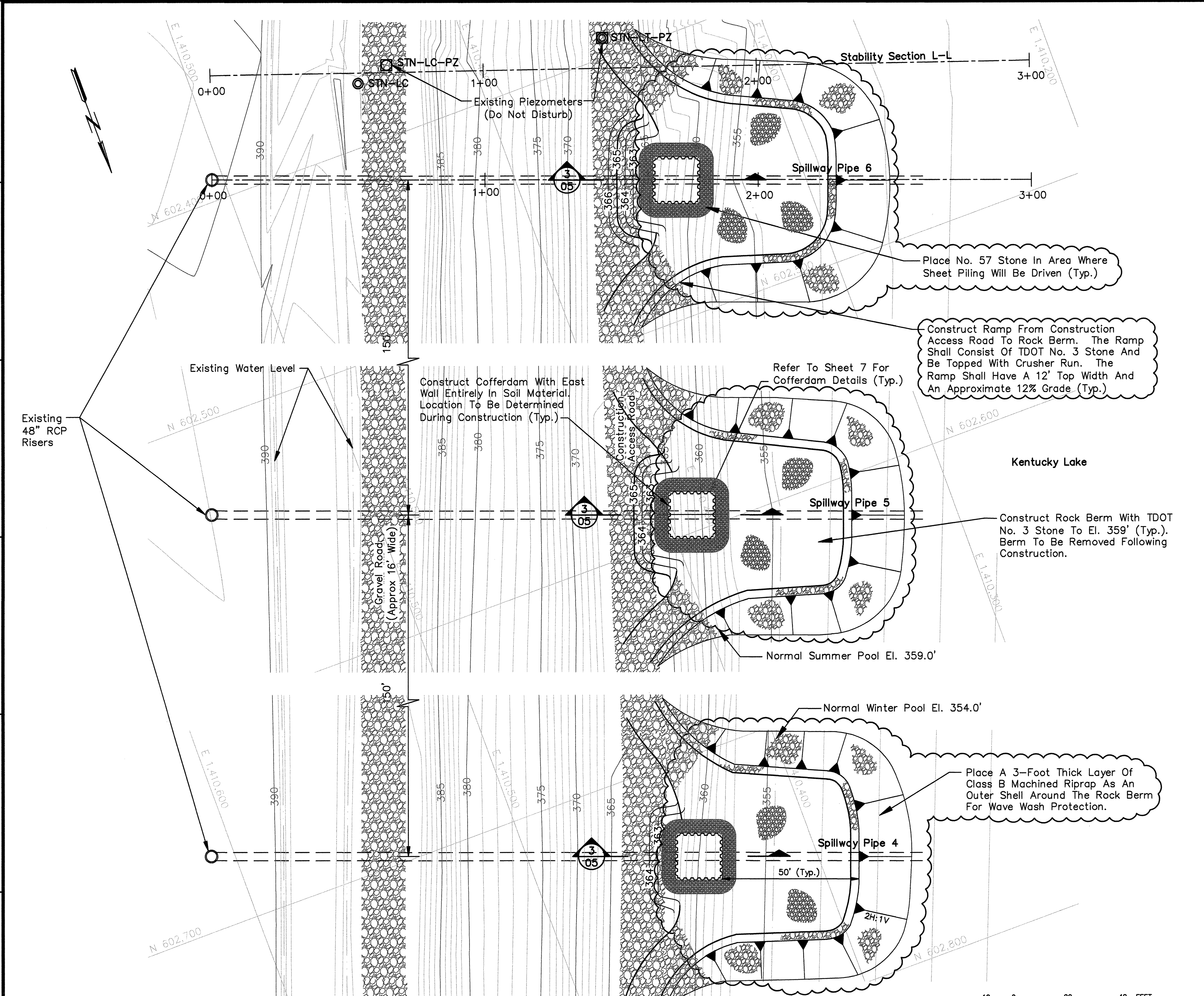
TASK COMPLETED BY: | REV NO.

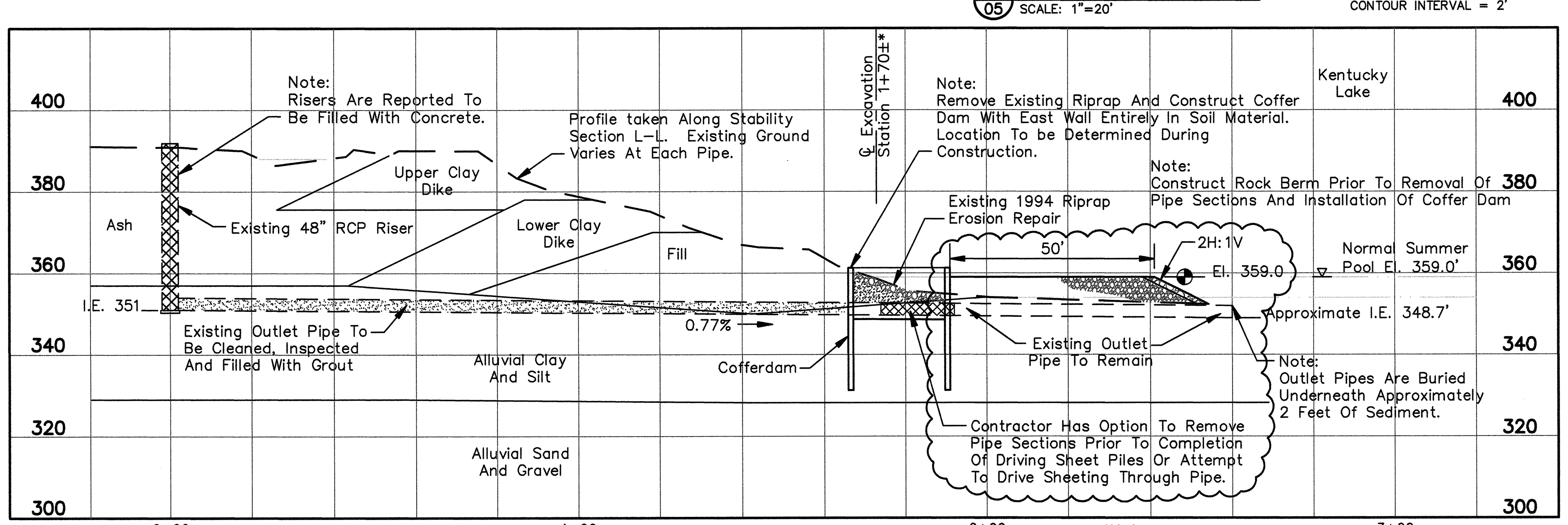
PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY



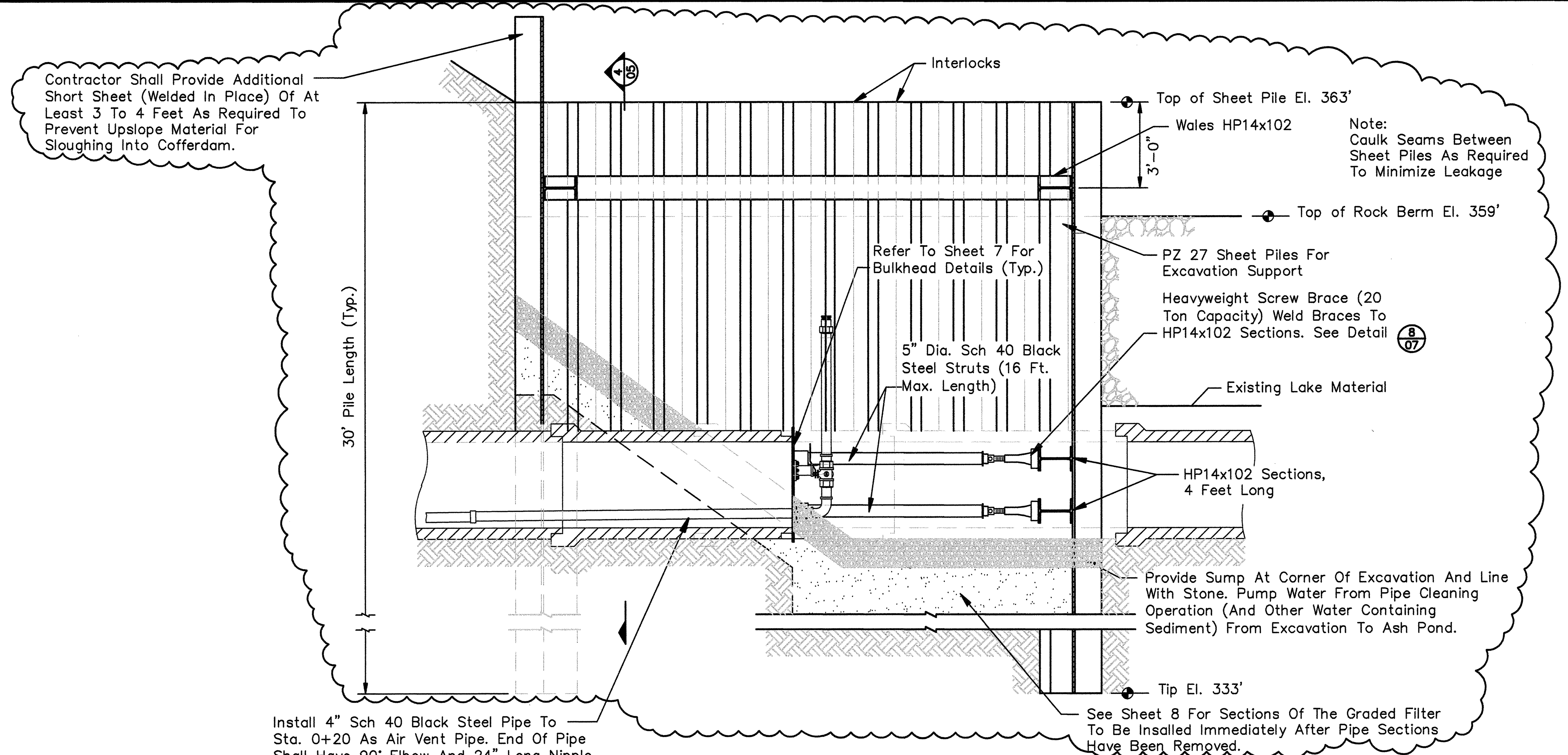
1 / 05 PLAN – NORTH SPILLWAYS
SCALE: 1"=20'

GRAPHIC SCALE: 1"=20'
CONTOUR INTERVAL = 2'

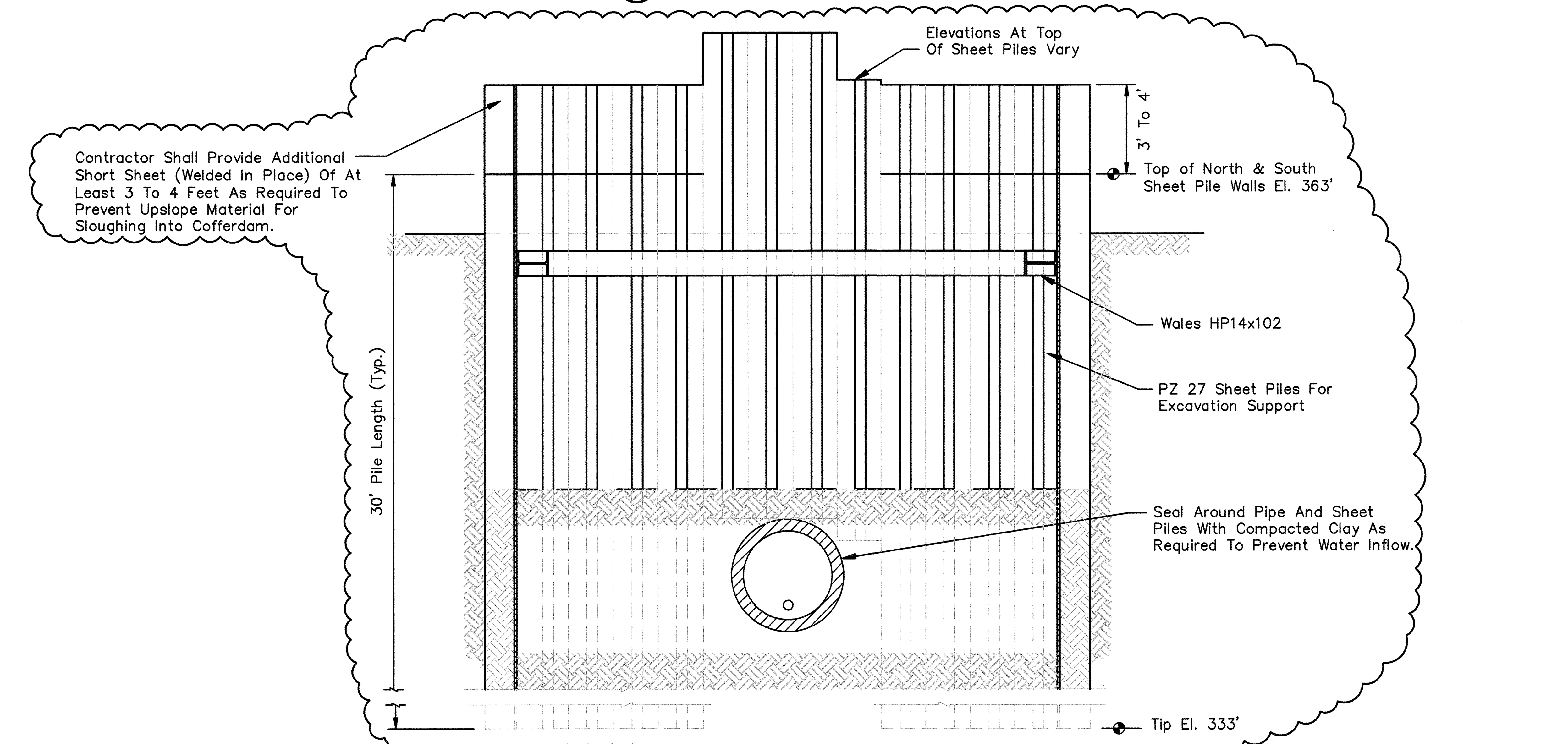


2 / 05 PROFILE – NORTH SPILLWAY
SCALE: 1"=20'

*Note:
Final Location Of Cofferdam To be Determined During Construction Following Excavation To Remove Riprap And Survey To Determine Slope Of Clay Dike And Location Of Soil.

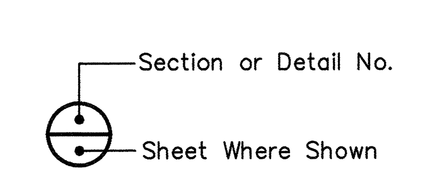


3 / 05 SECTION – NORTH COFFERDAM (TYP.)
SCALE: 3/8"=1'-0"



4 / 05 SECTION – NORTH COFFERDAM (TYP.)
SCALE: 3/8"=1'-0"

ISSUED FOR CONSTRUCTION



REFERENCE KEY

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT	AS CONST
R 1	10/05/10	JK	RP	SHB	SHB	SHB	SHB	TJ	–	–
	MOVE ROCK BERM, REDUCE TYPICAL SIZE OF COFFER DAM, UPDATE PROFILE									
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	–	–
	ISSUED FOR REVIEW									

SCALE: AS SHOWN — EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2

EXISTING SPILLWAY CLOSURE PROJECT
NORTH SPILLWAYS
WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	S. BICKEL	J. MONTGOMERY	T. JOHNSON

STEPHEN H. BICKEL, REGISTERED ENGINEER, AGRICULTURE, COMMERCE, No. 113134, STATE OF TENNESSEE — 10/5/2010

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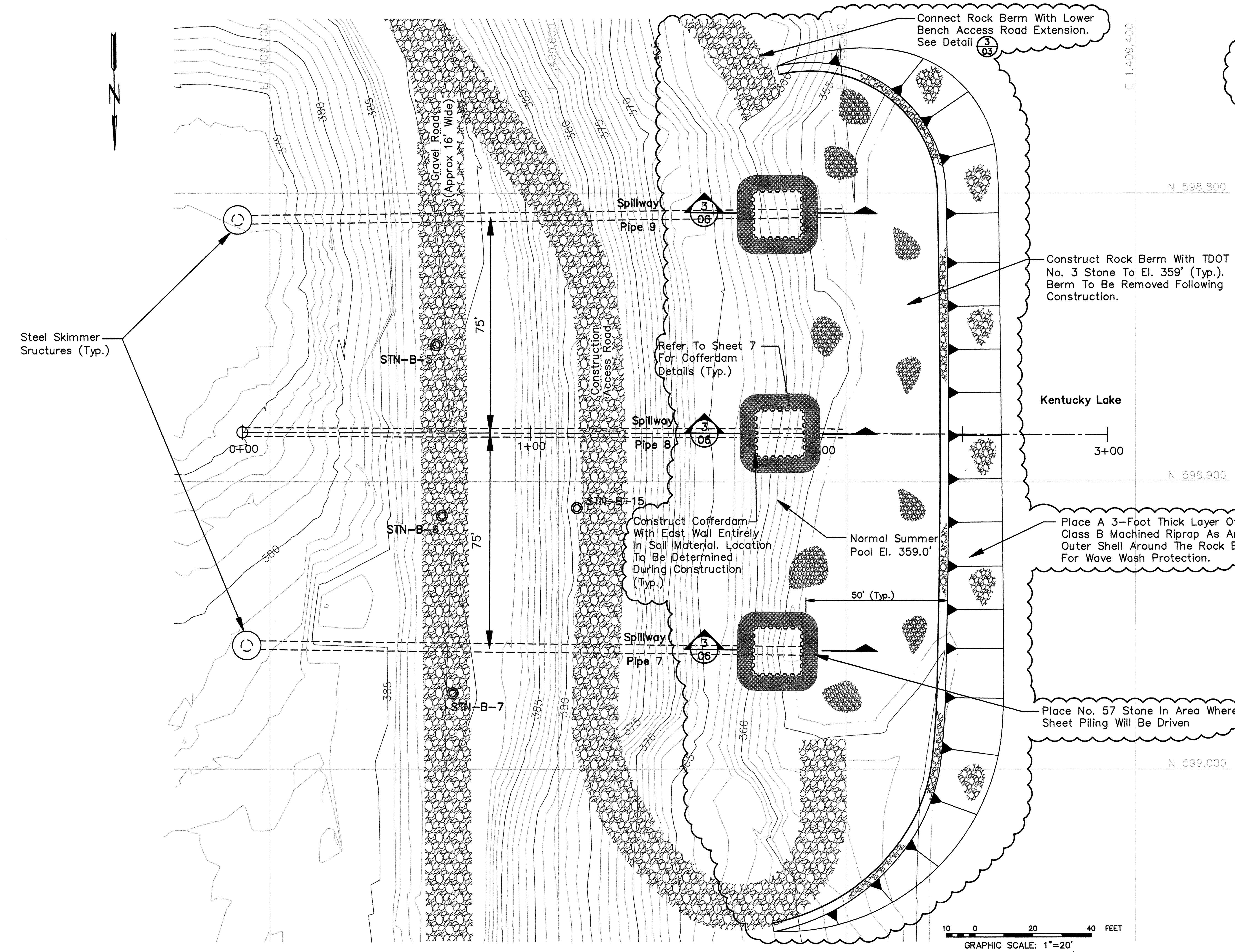
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000 | DATE 04/07/10 | 30 | C | 10W505-05 | R 1

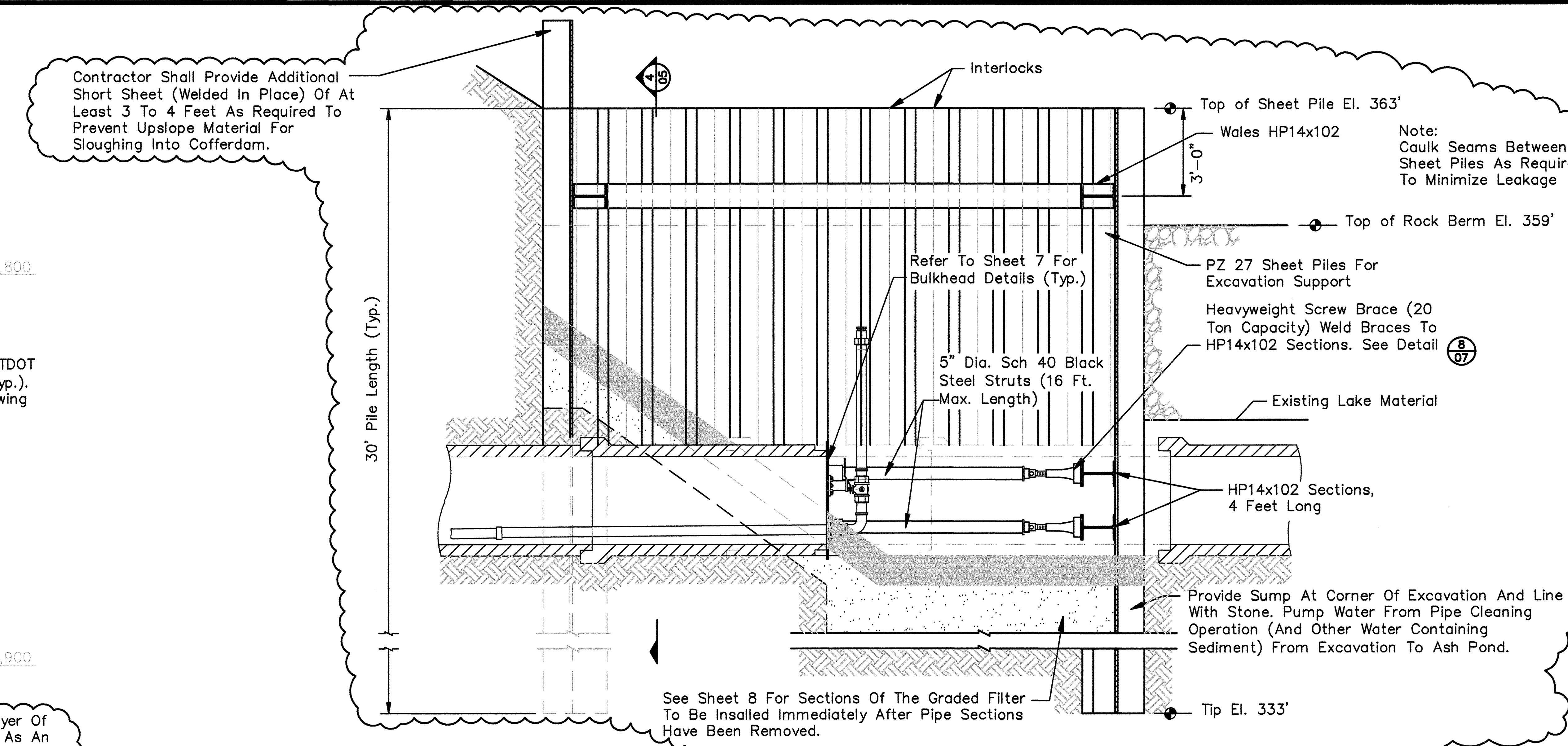
STANTEC | 1
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

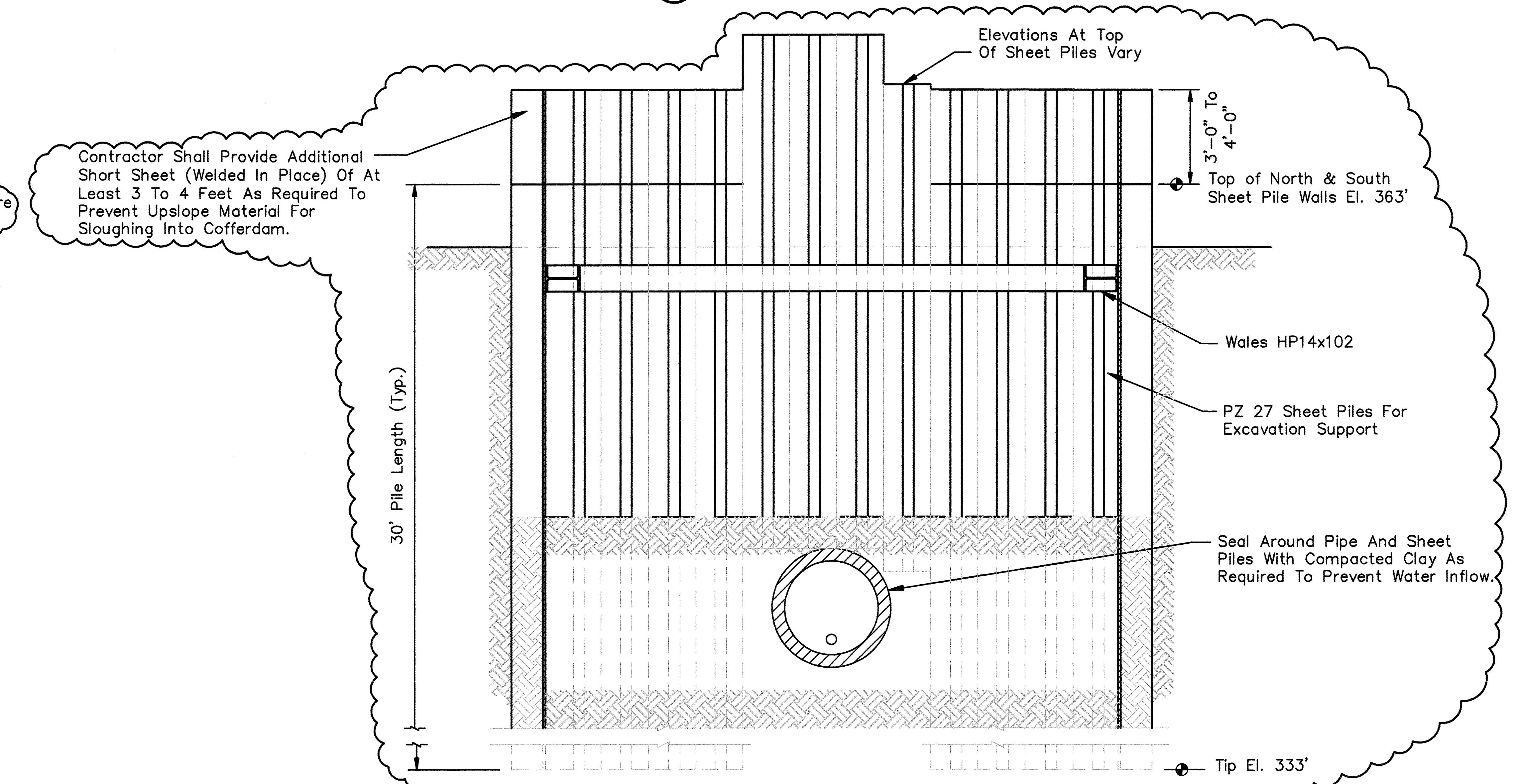
C.A.D. DRAWING
DO NOT ALTER MANUALLY



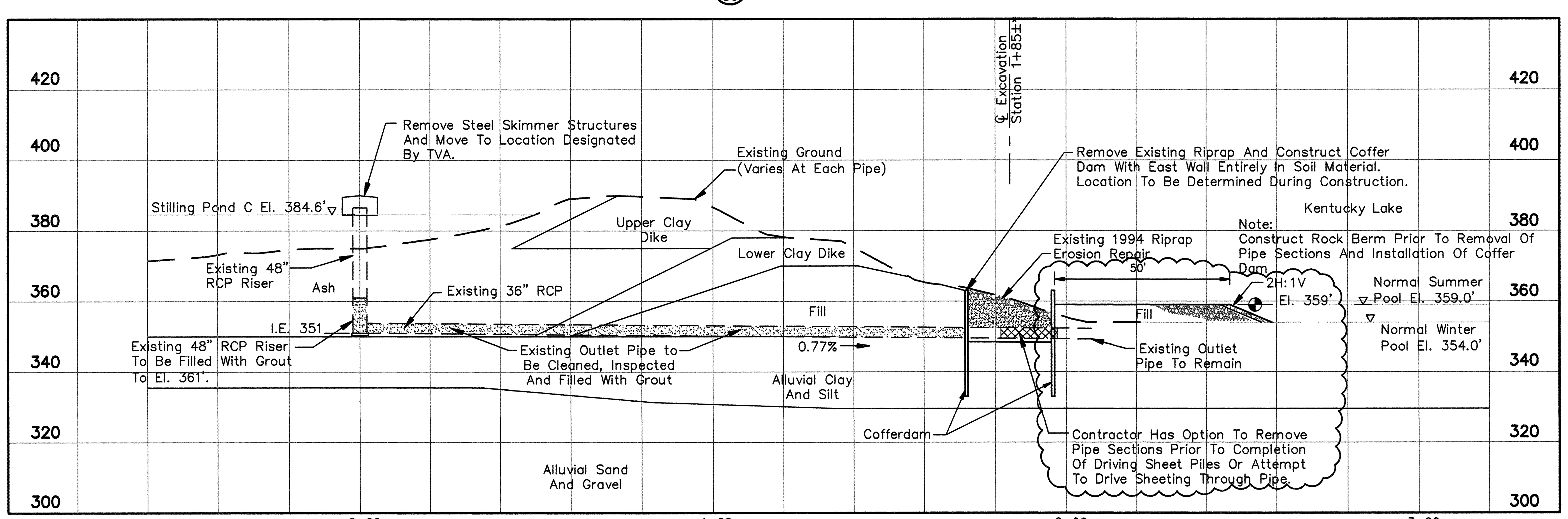
1/06 PLAN – SOUTH SPILLWAYS
SCALE: 1"=20'



3/06 SECTION – SOUTH COFFERDAM (TYP.)
SCALE: 3/8"=1'-0"



4/06 SECTION – SOUTH COFFERDAM (TYP.)
SCALE: 3/8"=1'-0"



2/06 PROFILE – SOUTH SPILLWAY (PIPE 8)
SCALE: 1"=20'

*Note:
Final Location To be Determined by Excavation And Location Of Soil

ISSUED FOR CONSTRUCTION

Section or Detail No.
Sheet Where Shown
REFERENCE KEY

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 1	10/05/10	JK	RP	SHB	SHB	SHB	SHB	TJ	–	–	–
MOVE ROCK BERM, REDUCE TYPICAL SIZE OF COFFER DAM, UPDATE PROFILE											
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	–	–	–
ISSUED FOR REVIEW											

SCALE: AS SHOWN EXCEPT AS NOTED

STEPHEN H. BICKEL REGISTERED ENGINEER AGRICULTURE COMMERCE No. 113134 STATE OF TENNESSEE 10/5/2010

YARD
ASH DISPOSAL AREA NO. 2

EXISTING SPILLWAY CLOSURE PROJECT SOUTH SPILLWAYS WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
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AUTOCAD R 2000 | DATE 04/07/10 | 30 | C | 10W505-06 | R 1

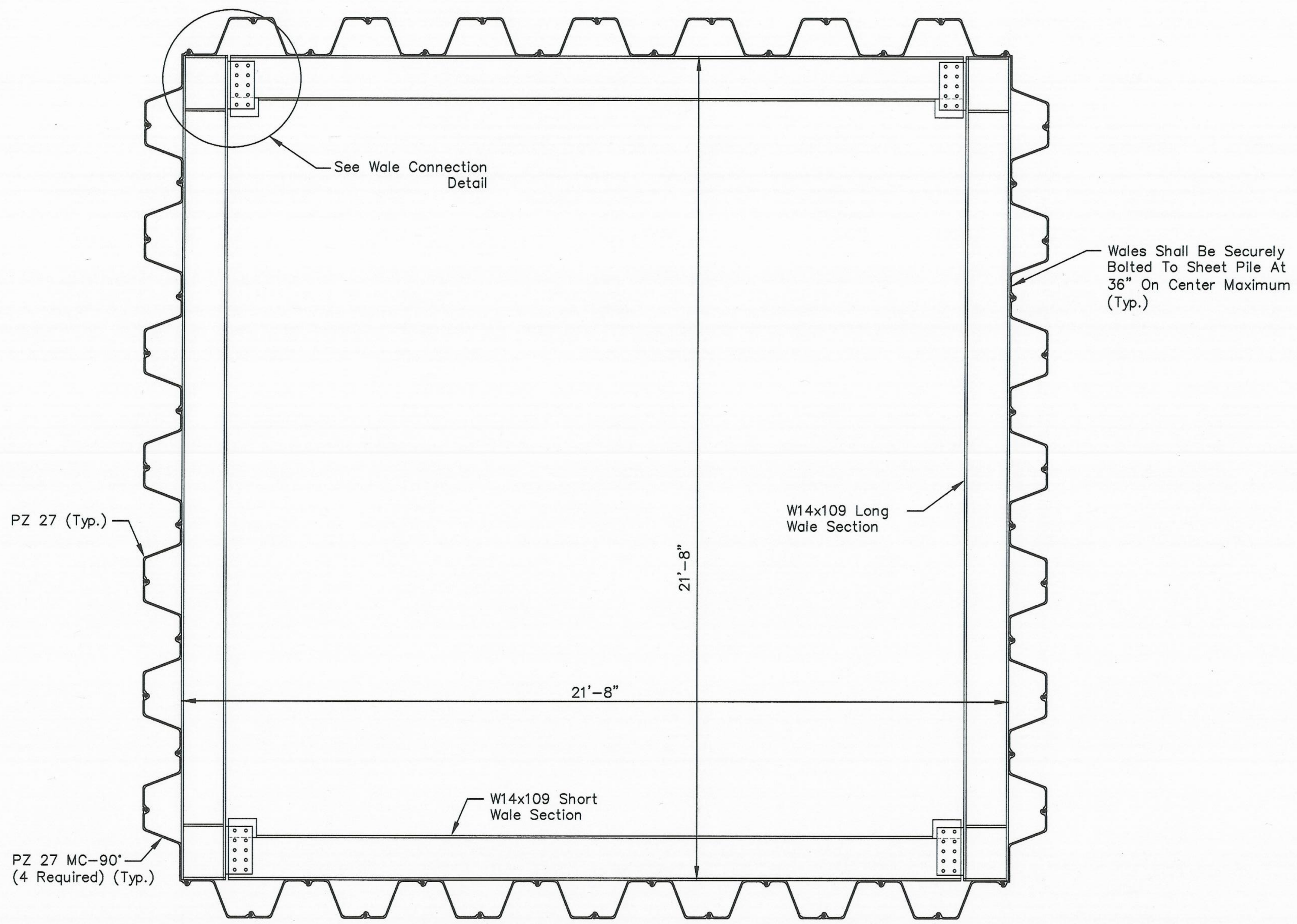
DISCIPLINE INTERFACE

PLOT DATE: 10/06/2010

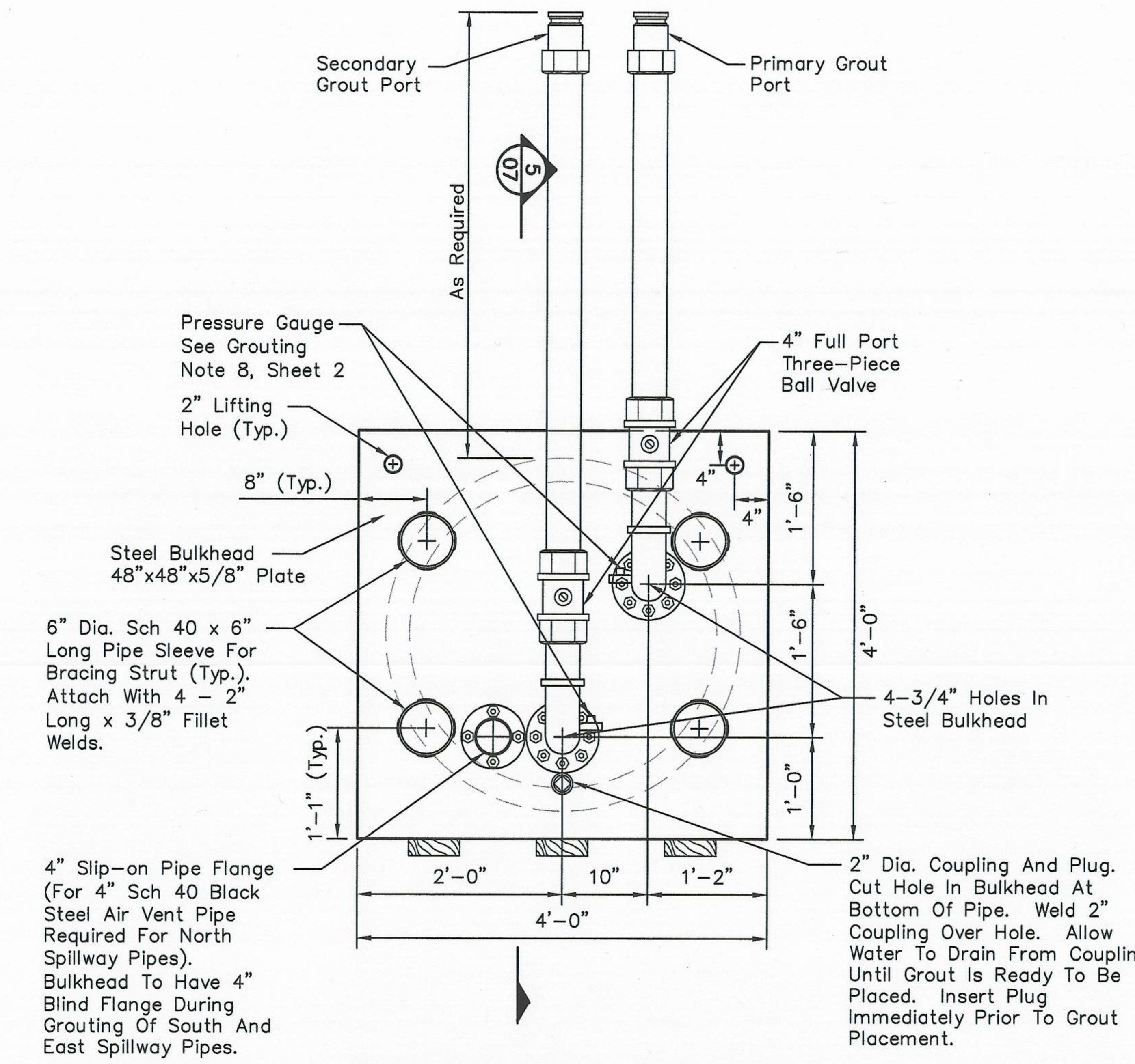
STANTEC | 1
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

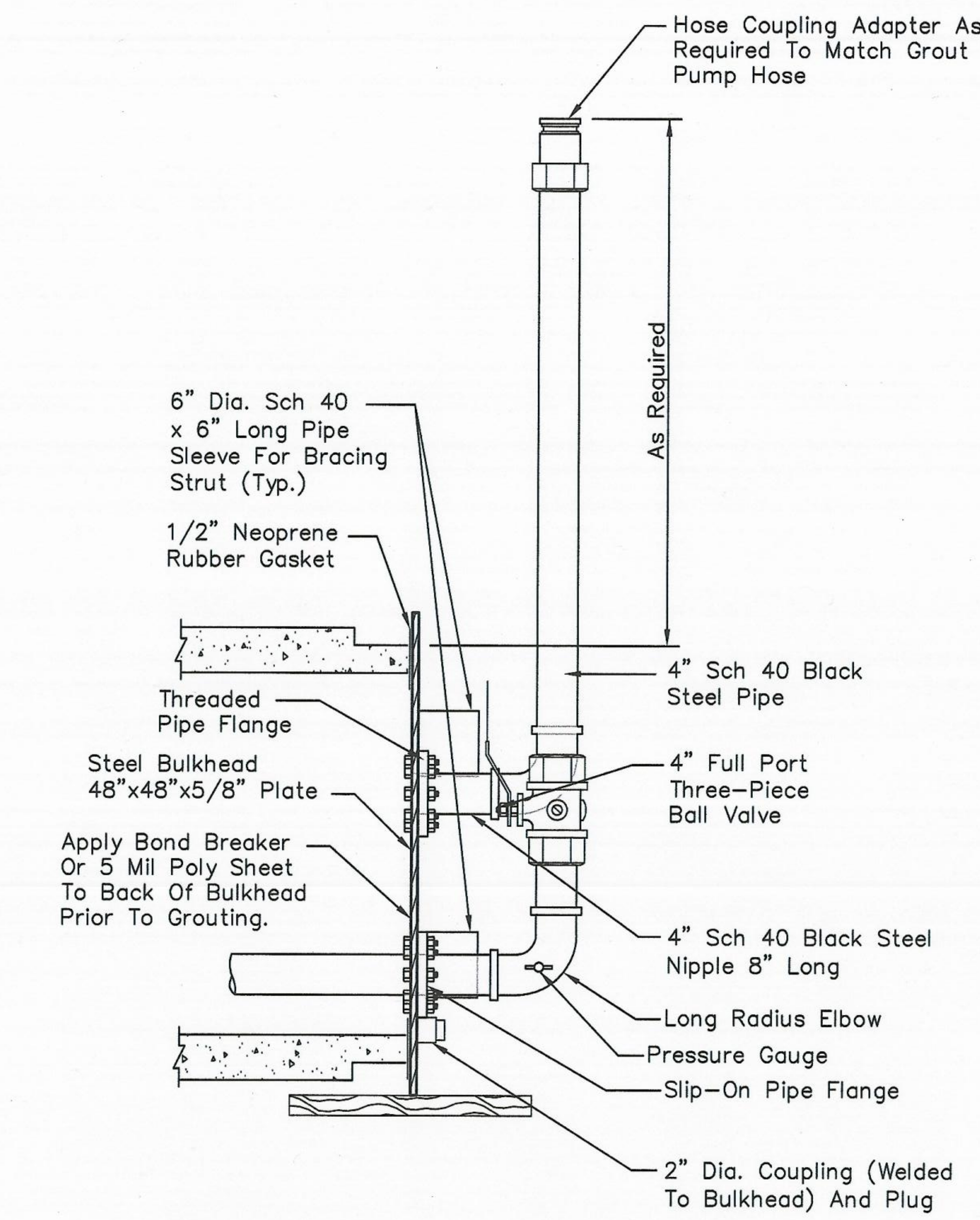
C.A.D. DRAWING
DO NOT ALTER MANUALLY



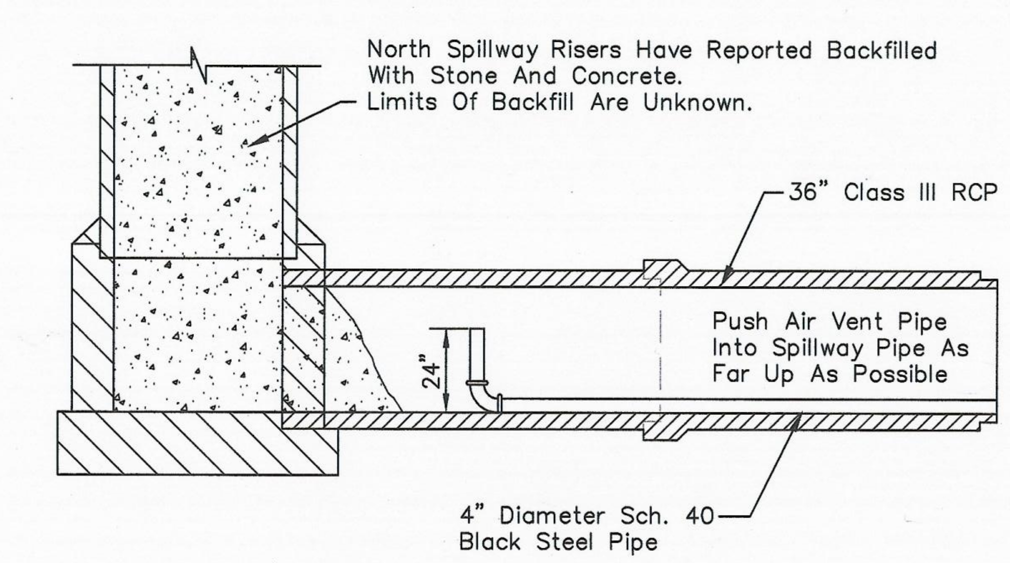
1/07 PLAN – SHEET PILE COFFERDAM
SCALE: 1/2"=1'-0"



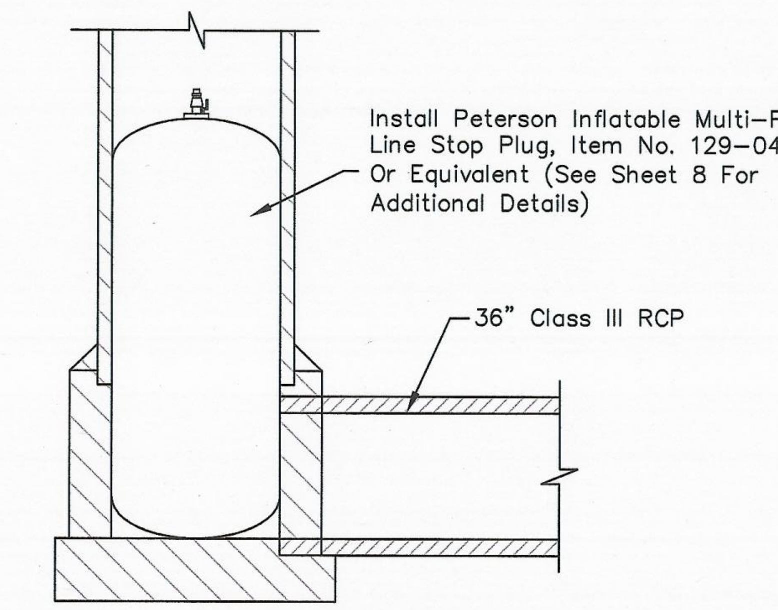
4/07 ELEVATION (TYP.)– STEEL BULKHEAD
SCALE: 1"=1'-0"



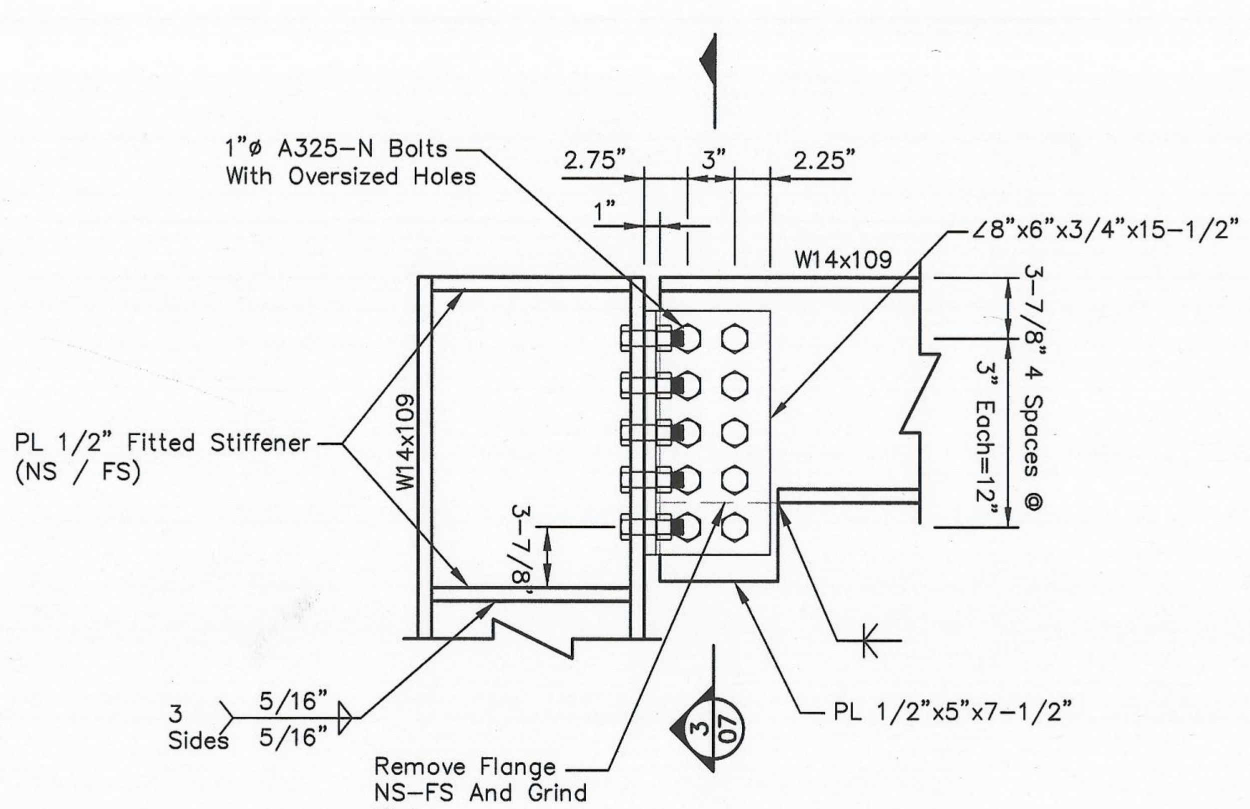
5/07 SECTION (TYP.) – STEEL BULKHEAD
SCALE: 1"=1'-0"



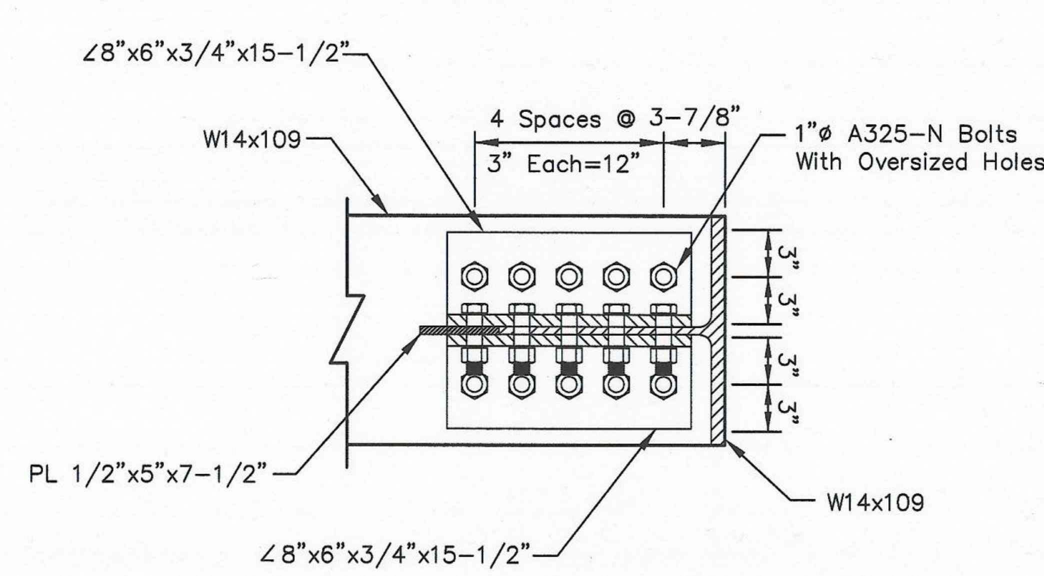
6/07 DETAIL – AIR VENT PIPE
SCALE: 1"=3'-0"



7/07 DETAIL – PIPE PLUG
SCALE: 1"=3'-0"



2/07 DETAIL – WALE CONNECTION
SCALE: 1/8"=1"



Notes:
1. Do Not Reuse Bolts.
2. Clip Angle Material To Be A36.

3/07 SECTION – WALE CONNECTION
SCALE: 1/8"=1"

ISSUED FOR CONSTRUCTION

REFERENCE KEY
- Section or Detail No.
- Sheet Where Shown

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

Stephen H. Bickel, Registered Engineer, Agricultural, No. 113136, State of Tennessee (seal) — signed 4/7/10

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT	AS CONST
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	–	–

ISSUED FOR CONSTRUCTION

SCALE: AS SHOWN — EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
STRUCTURAL & BULKHEAD DETAILS
WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	S. BICKEL	J. MONTGOMERY	T. JOHNSON

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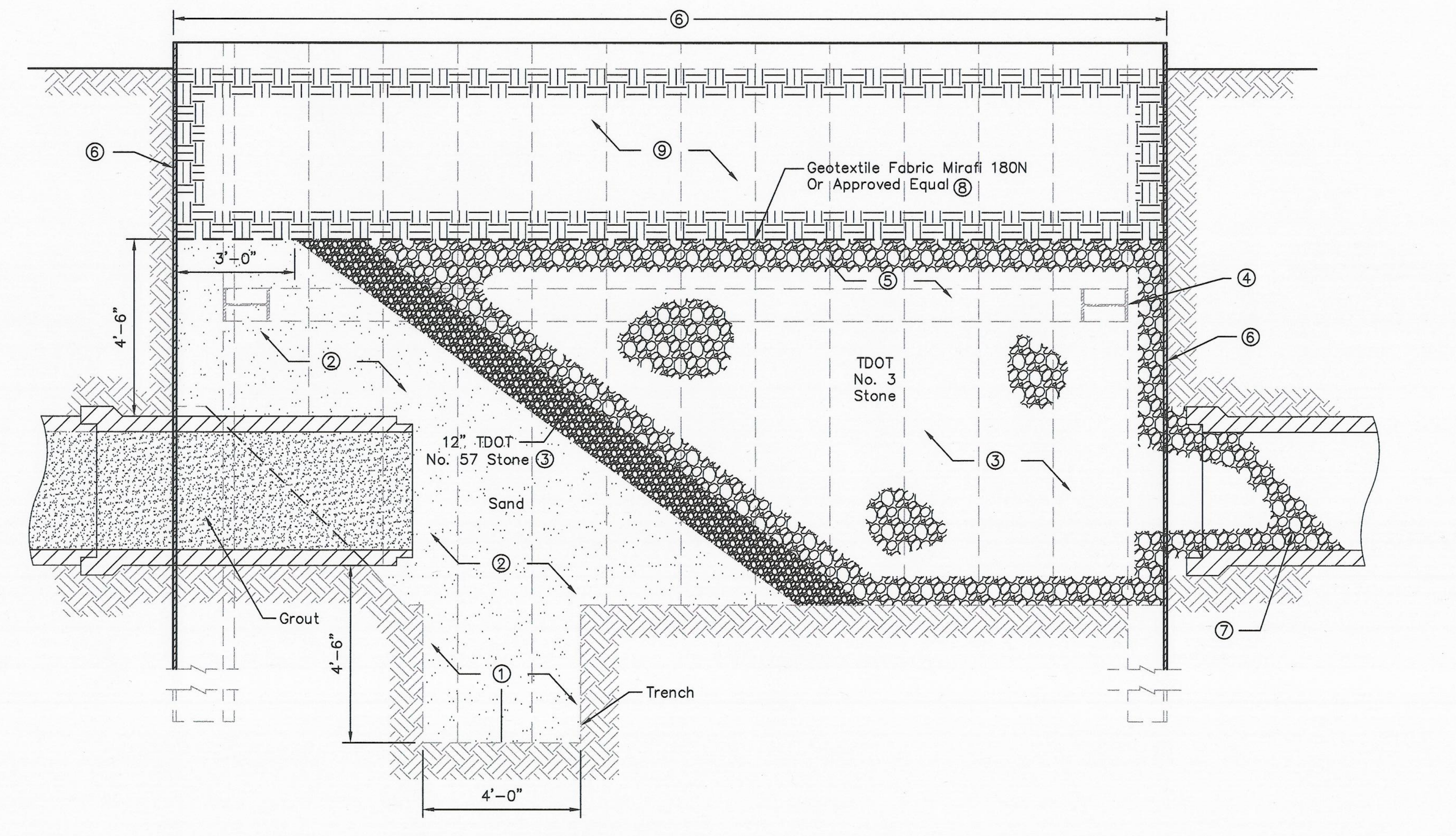
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000 | DATE 04/07/10 | 30 | C | 10W505-07 | R 0

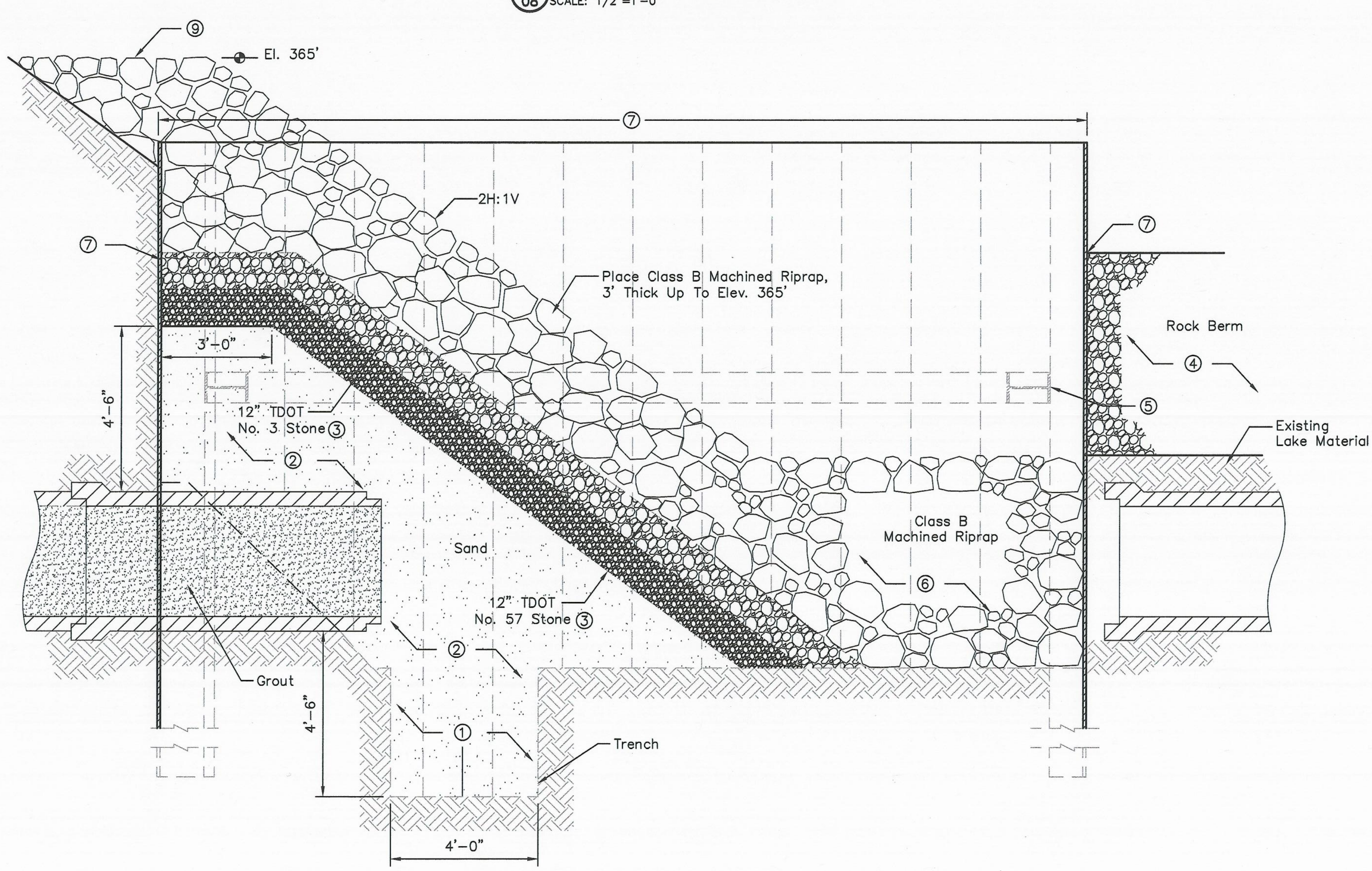
PLOT FACTOR:XX
W_TVA

STANTEC | 0
TASK COMPLETED BY: | REV NO.

C.A.D. DRAWING DO NOT ALTER MANUALLY



1/08 FILTER DETAIL – EAST SPILLWAYS
SCALE: 1/2"=1'-0"



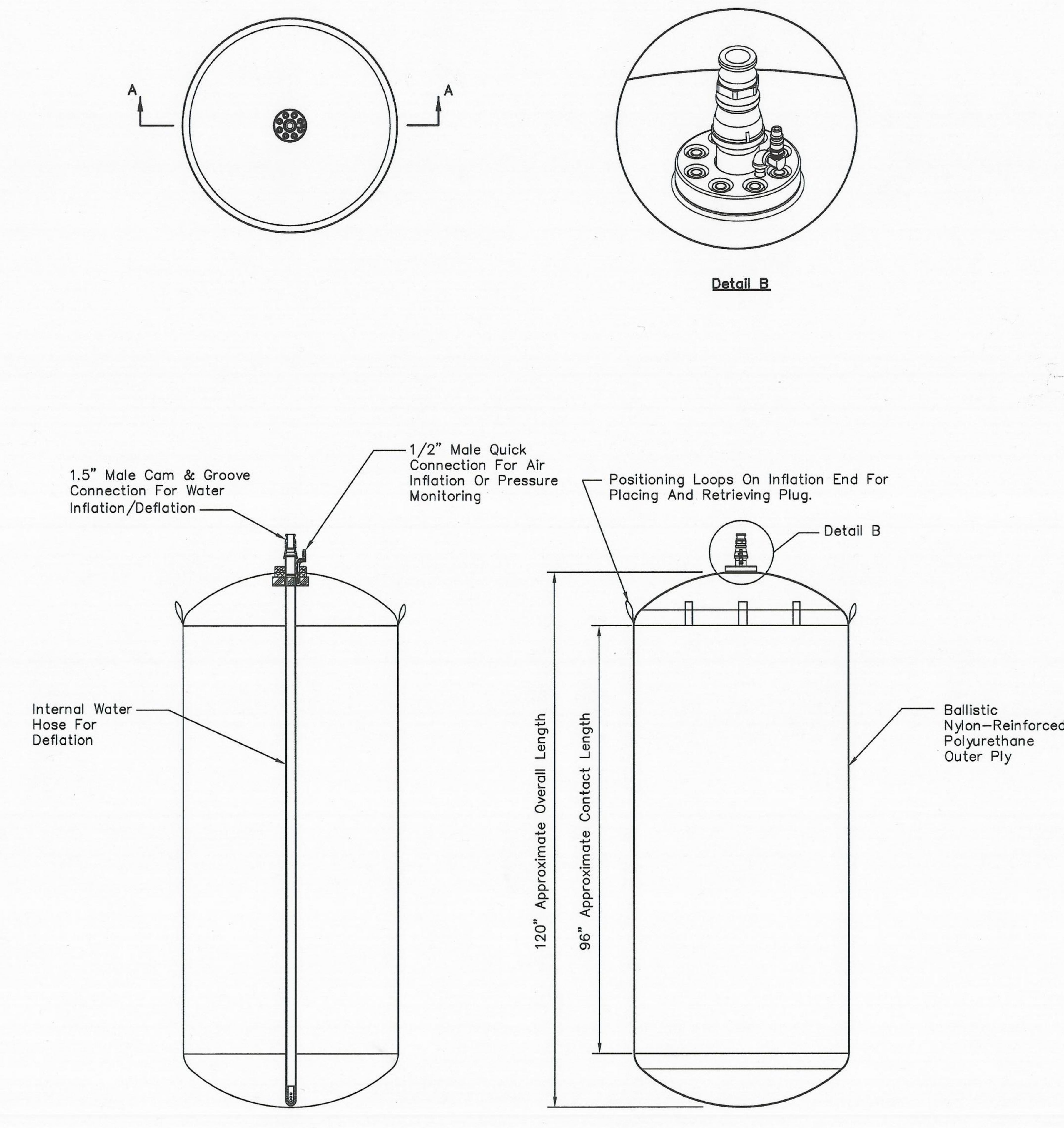
2/08 FILTER DETAIL – NORTH AND SOUTH SPILLWAYS
SCALE: 1/2"=1'-0"

Filter Installation And Excavation Backfill Notes For East Spillways

1. Excavate trench full width between North and South sides.
2. Place sand to fill trench and upwards to just below level of wales. Sand shall be placed in 2 foot lifts, spread, and compacted using 3 passes of a vibratory plate compactor.
3. As sand is brought up, place TDOT No. 57 and No. 2 stone in excavation as shown. Spread and compact stone using excavator bucket.
4. Remove wales.
5. Continue backfilling excavation to 4.5 feet above pipe with sand and gravel.
6. Remove sheet piling.
7. Use excavator bucket to and fill end of pipe to greatest extent practicable.
8. Place geotextile fabric over granular material.
9. Fill remaining excavation with stockpiled soil. Place in 1 foot lifts and compact to 95% Standard Proctor Density.
10. Excess stockpiled soil to be graded to drain.
11. Seed and straw all disturbed areas.

Filter Installation And Excavation Backfill Notes For North And South Spillways

1. Excavate trench full width between North and South sides. Contractor shall pump all water from trench immediately before sand placement.
2. Place sand to fill trench and upwards to just below level of wales. Sand shall be placed in 2 foot lifts, spread, and compacted using 3 passes of a vibratory plate compactor.
3. As sand is brought up, place TDOT No. 57 and No. 3 stone as shown to just below level of wales. Spread and compact stone using excavator bucket.
4. Remove rock berm. Haul stone to stockpile area shown on Sheet 3.
5. Remove wales.
6. Continue to place sand, No. 57 stone, and No. 3 stone up to the levels shown. Place 3 foot thick layer of Class B Machined riprap as shown and up to just below top of sheet piles.
7. Remove sheet piling. Replace any riprap that may have slid into un–abandoned section of pipe
8. Place additional stone and riprap as required to ensure sand has proper cover.
9. Place riprap to elevation 365 and match existing riprap slope.



Note:
Plug Shall Be Petersen Multi–Flex Line Stop Plug Item No. 129–048 With A Maximum Inflation Pressure At The Invert Of 50 Psi.

3/08 DETAIL – INFLATABLE PIPE PLUG
NOT TO SCALE

ISSUED FOR CONSTRUCTION

REFERENCE KEY
Section or Detail No.
Sheet Where Shown

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R –	–	–	–	–	–	–	–	–	–	–	–
R 0	04/07/10	JK	RP	SHB	SHB	SHB	JBM	TJ	–	–	–
ISSUED FOR CONSTRUCTION											

DISCIPLINE INTERFACE 1 2 3 4

SCALE: AS SHOWN EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2

EXISTING SPILLWAY CLOSURE PROJECT
FILTER DETAILS
WORK PLAN 4 (JOF–100407–WP–4)

STEPHEN H. BICKEL REGISTERED ENGINEER AGRICULTURE COMMERCE No. 113134 STATE OF TENNESSEE
[signature] 4/7/10

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	S. BICKEL	J. MONTGOMERY	T. JOHNSON

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40223-2177
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Fax 502.212.5055
www.stantec.com

JOHNSONVILLE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000	DATE 04/07/10	30	C	10W505–08	R 0

PLOT DATE: 04/07/2010

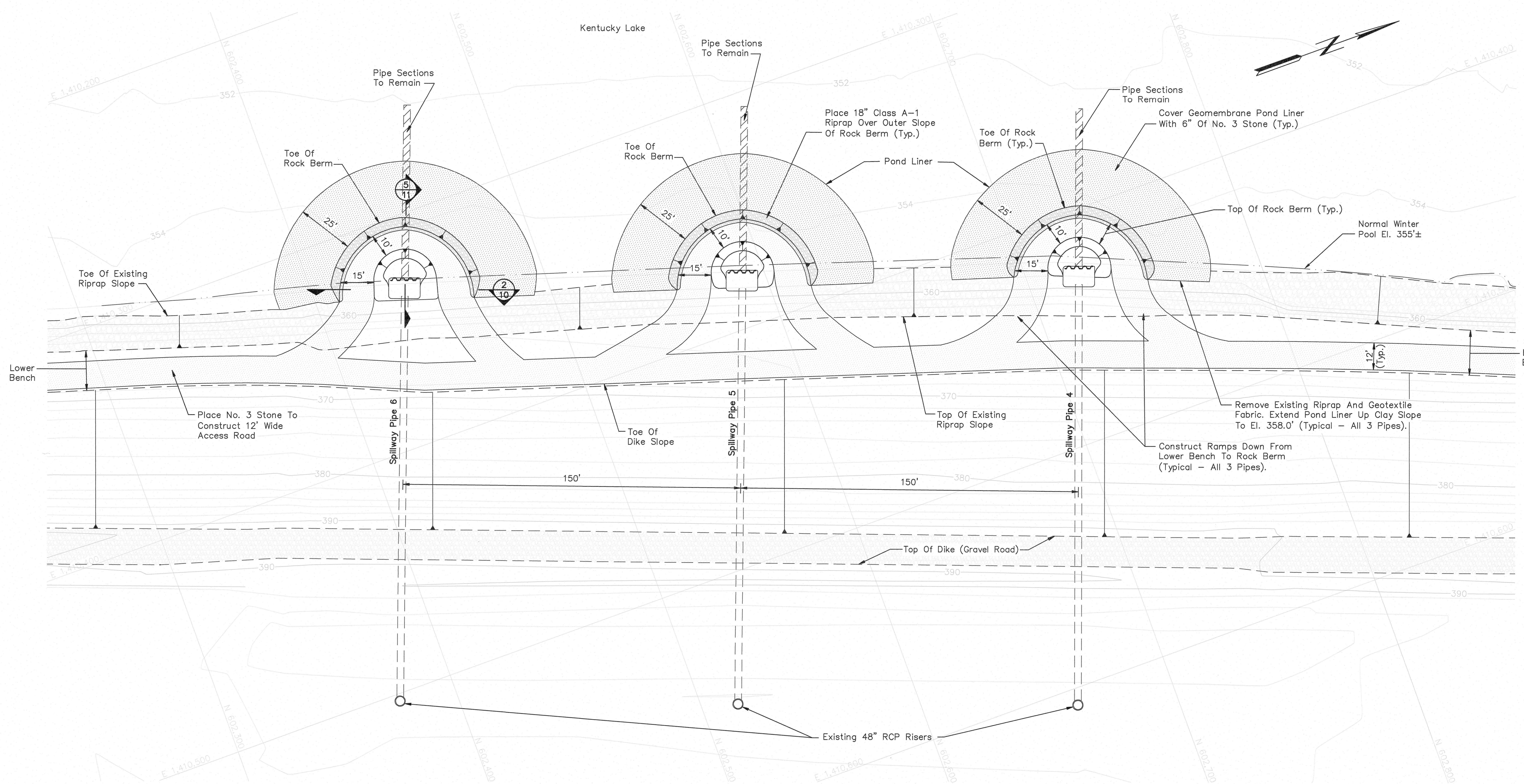
PLOT FACTOR:XX
W_TVA

STANTEC	0
TASK COMPLETED BY:	REV NO.

C.A.D. DRAWING
DO NOT ALTER MANUALLY


30 C 10W505-09
Remove Steel Skimmer Structures And Move To Location Designated By TVA.
Spillway Pipe 9
Spillway Pipe 8
Spillway Pipe 7
0+00
1+00
2+00
3+00
75'
75'
25'
Top Of Dike Gravel Road
Construction Access Road
Top Of Rock Berm
Intermediate Sump For Pumping To Ash Pond A
Construction Pool El. 383.0'
End Geomembrane Pond Liner At Ground El. 357.0' (Or Higher)
Limits Of Geomembrane Pond Liner
Place 18" Class A Riprap Over Outer Slope Rock Berm
Toe Of Rock Berm
Kentucky Lake
Cover Geomembrane Pond Liner With 6" Of No. 3 Stone
Provide 24" Lap (Minimum) At All Seams
Toe Of Rock Berm
Normal Winter Pool El. 354.0'
End Geomembrane Pond Liner At Ground El. 357.0' (Or Higher)
NOTE: Locations of pond liner sheets, seams and laps shown to convey design intent. Actual locations may vary to conform with field conditions.
1/09 PLAN – SOUTH SPILLWAYS SCALE: 1"=20'
GRAPHIC SCALE: 1"=20' CONTOUR INTERVAL = 2'
Existing Ground (Dike)
Remove Existing Riprap As Required To Expose Clay Around Pipe (4 Feet Each Side And 2 Feet Below)
Refer To Details 4/07, 5/07 And 6/07 For Steel Bulkhead And Struts
Drive Sheet Piles As Required For Anchorages. Fill Behind Sheet Piles With Crushed Stone
6" No. 3 Stone Over Anchor Trench
18" Class A Riprap
6" No. 3 Stone
20 Mil Geomembrane Pond Liner Raven Industries Rufco 2010B Polyethylene (Or Approved Equal)
Normal Winter Pool El. 354.0'
Existing Rock Berm
6" No. 3 Stone
Construct Filter See Detail 6/09
Sheet Piles For Strut Backstops
Estimated Bottom Of Lake (Primarily Alluvial Silt And Clay)
25' Limit Of Geomembrane Pond Liner From Toe Of Rock Berm
3/09 SECTION – SPILLWAY PIPE 9 SCALE: 1"=5'
NOTE: Typical Notes Shown On Section 3/09 Apply On Sections 4/09 And 5/09
Existing Ground (Dike)
Existing Rock Berm
Normal Winter Pool El. 354.0'
4/09 SECTION – SPILLWAY PIPE 8 SCALE: 1"=5'
Existing Ground (Dike)
Existing Rock Berm
5/09 SECTION – SPILLWAY PIPE 7 SCALE: 1"=5'
Restore Existing Ground And Replace Riprap Removed During Spillway Closure Project
Class B Rirap
Construct Filter, Then Remove Sheet Piles
Match Existing Ground Bottom Of Lake
3'
4'
Grout
12" No. 3
12" No. 57
12" Sand
NOTE: Graded Filter To Be Constructed 4' Each Side Of Pipe
6/09 DETAIL – GRADED FILTER SCALE: 1"=5'
420 400 380 360 340 320 300
Stilling Pond (Pond C)
Normal Pool El. 384.5'
Construction Pool El. 383.0'
Existing 48" RCP Riser
Ash
I.E. 351
Existing 48" RCP Riser To Be Filled With Grout To El. 367'.
Existing 36" RCP
Existing Ground (Varies At Each Pipe)
Upper Clay Dike
Lower Clay Dike
Fill
Existing Outlet Pipe to Be Cleaned, Inspected And Filled With Grout
0.79% (Per TVA Drawing 10N529)
Alluvial Clay And Silt
Alluvial Sand And Gravel
Kentucky Lake
Existing Rock Berm
Normal Winter Pool El. 354.0'
End Of Pipe Per TVA Diver Survey
End Of Pipe Per TVA Drawing 10N529
2/09 PROFILE – SOUTH SPILLWAY (PIPE 8) SCALE: 1"=20'
ISSUED FOR CONSTRUCTION
SURVEY CONTROL NOTE:
A Global Positioning System (GPS) Base Station has been established and transformation parameters determined by TVA using selected survey control monuments. Contact with TVA Surveying Department (423) 751-8416 or (423) 751-2571 shall be made before any survey or construction work is commenced. Base station frequencies and transformation parameters will be provided to the Contractor for use in construction activities at the site. Previously used or established control points and monuments shall not be used by the contractor without prior approval by TVA Surveying Department.
Section or Detail No.
Sheet Where Shown
REFERENCE KEY
For Supporting Design Calculations see FPGJOFFESCDX00000020100004
R0 12/08/10 JK RP SHB SHB RLS MST JCK ISSUED FOR CONSTRUCTION
SCALE: AS SHOWN EXCEPT AS NOTED
YARD
ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
SOUTH SPILLWAYS (REVISION)
WORK PLAN 4 (JOF-100407-WP-4)
DESIGNED BY: J. KOPP DRAWN BY: R. PETTY CHECKED BY: S. BICKEL SUPERVISED BY: S. BICKEL REVIEWED BY: R.L. SANCHEZ APPROVED BY: M.S. TURNBOW ISSUED BY: J.C. KAMMEYER
Stantec Consulting Services Inc. 1901 Nelson Miller Pky. Louisville, Kentucky 40223-2177 Tel. 502.212.5000 Fax 502.212.5055 www.stantec.com
JOHNSONVILLE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
AUTOCAD R 2000 DATE 12/08/10 30 C 10W505-09 R 0
12/8/2010
STANTEC 0
TASK COMPLETED BY: REV NO.
PLOT FACTOR:20 W_TVA
C.A.D. DRAWING DO NOT ALTER MANUALLY

30 | C | 10W505-10

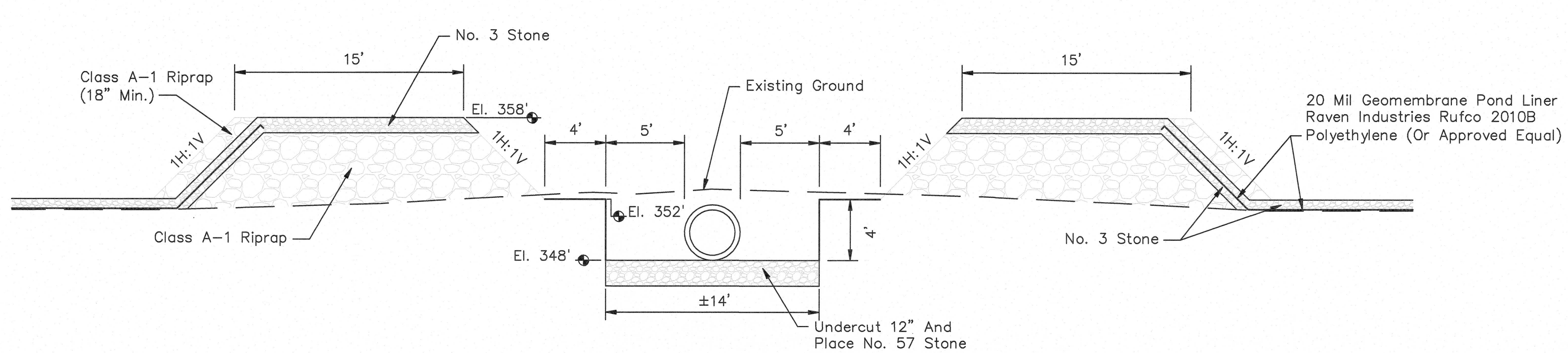


1/10 PLAN – NORTH SPILLWAYS
SCALE: 1"=20'

10 0 20 40 FEET
GRAPHIC SCALE: 1"=20'
CONTOUR INTERVAL = 2'

NOTE:

Limits Of Pond Liner As Shown. Provide 24" Overlap At Each Seam.



2/10 SECTION – ROCK BERM
SCALE: 1"=5'

ISSUED FOR CONSTRUCTION

SURVEY CONTROL NOTE:

A Global Positioning System (GPS) Base Station has been established and transformation parameters determined by TVA using selected survey control monuments. Contact with TVA Surveying Department (423) 751-8416 or (423) 751-2571 shall be made before any survey or construction work is commenced. Base station frequencies and transformation parameters will be provided to the Contractor for use in construction activities at the site. Previously used or established control points and monuments shall not be used by the Contractor without prior approval by TVA Surveying Department.

Section or Detail No.
Sheet Where Shown
REFERENCE KEY

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	01/31/11	JK	RP	SHB	SHB	RLS	MST	JCK	–	–	–
ISSUED FOR CONSTRUCTION											

SCALE: AS SHOWN EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
NORTH SPILLWAYS (REVISION)
WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	R.L. SANCHEZ	M.S. TURNBOW	J.C. KAMMEYER

Stephen H. Bickel, Registered Engineer, Agriculture / Commerce, No. 112990, State of Tennessee — 1/31/2011

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JOHNSONVILLE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
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AUTOCAD R 2000 | DATE 01/31/11 | 30 | C | 10W505-10 | R 0

STANTEC | 0
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:20
W_TVA

C.A.D. DRAWING
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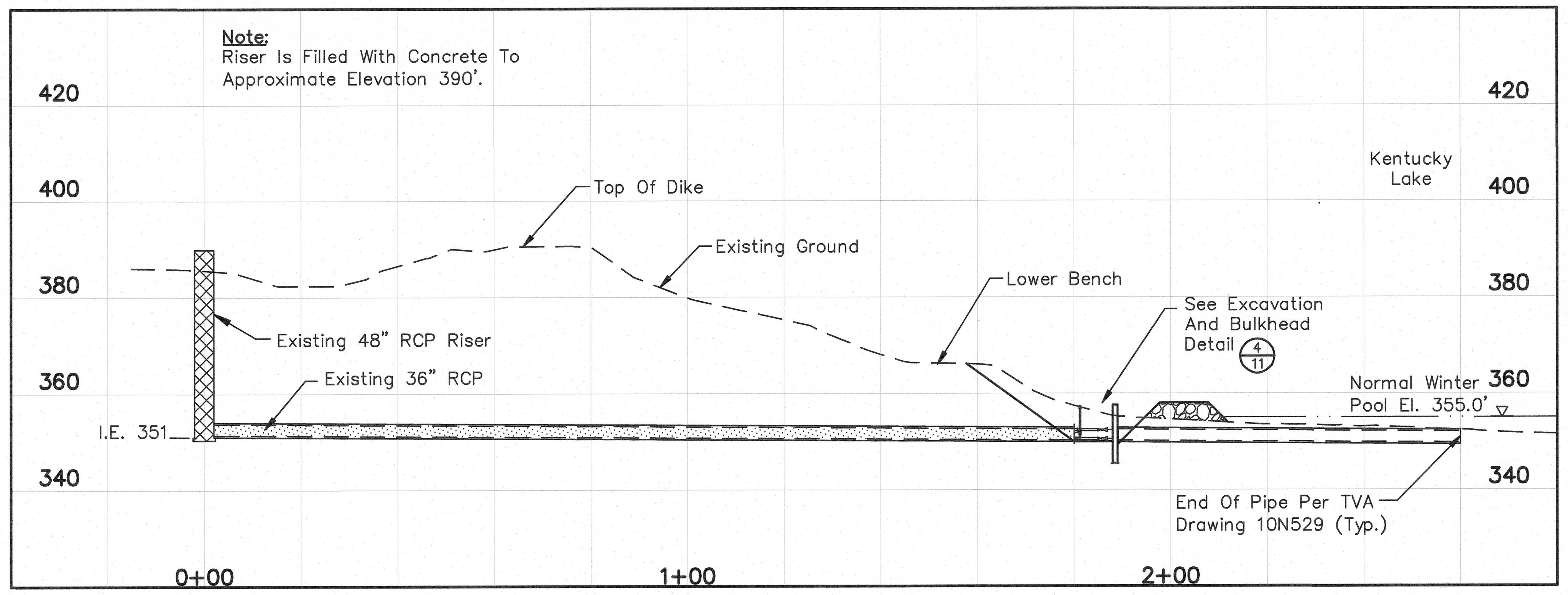
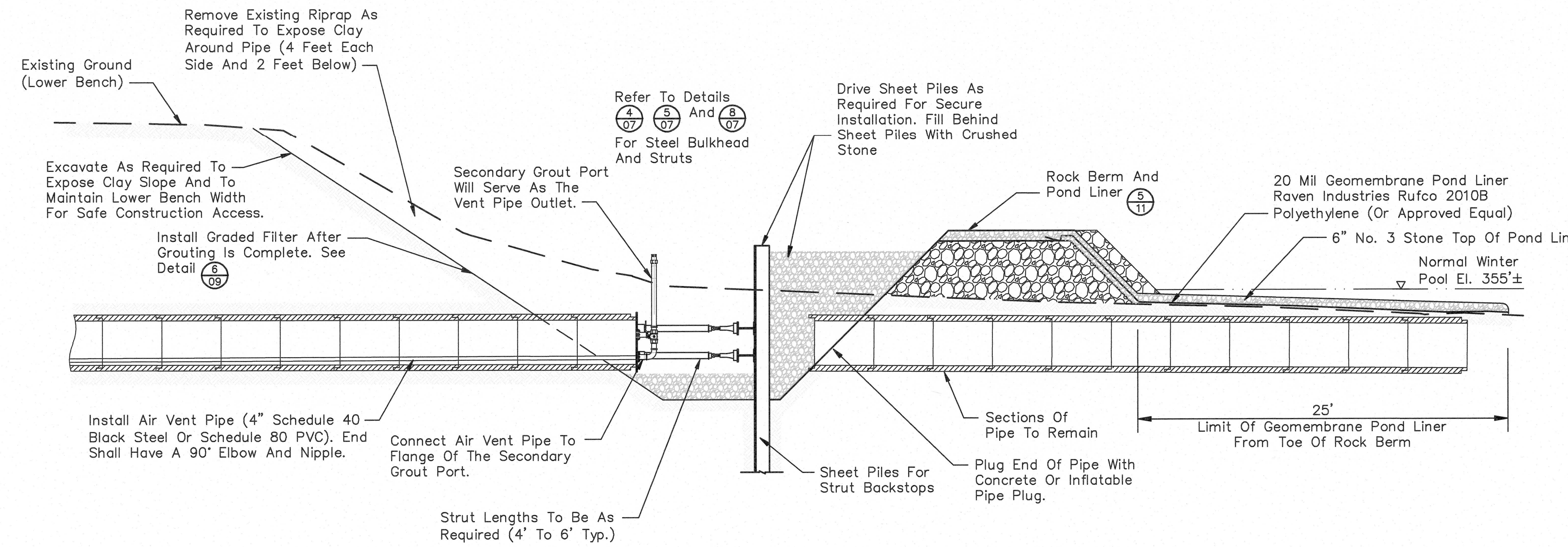
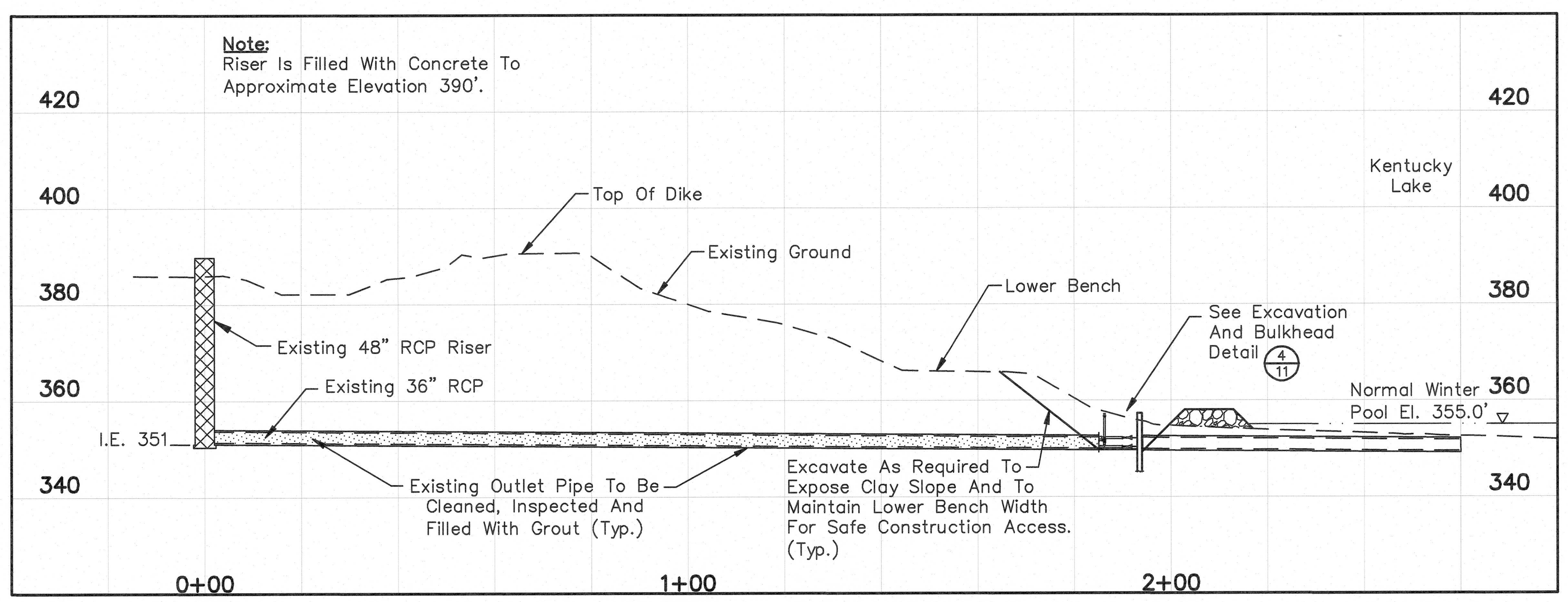


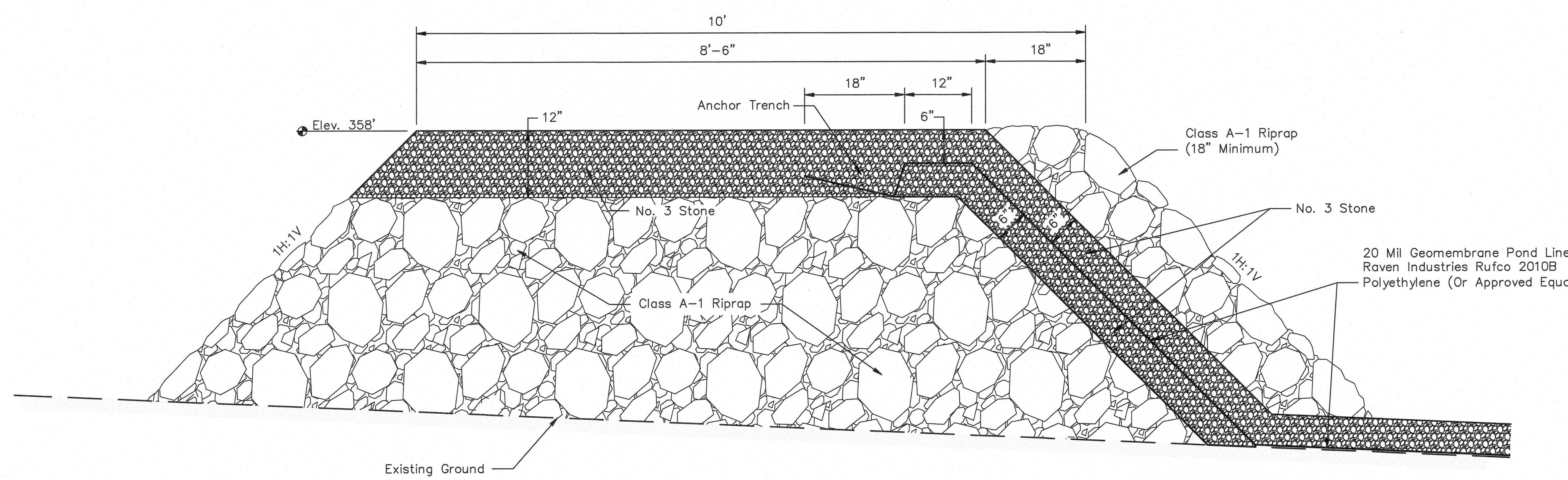
3/11 PROFILE – SPILLWAY PIPE 6
SCALE: 1"=20'



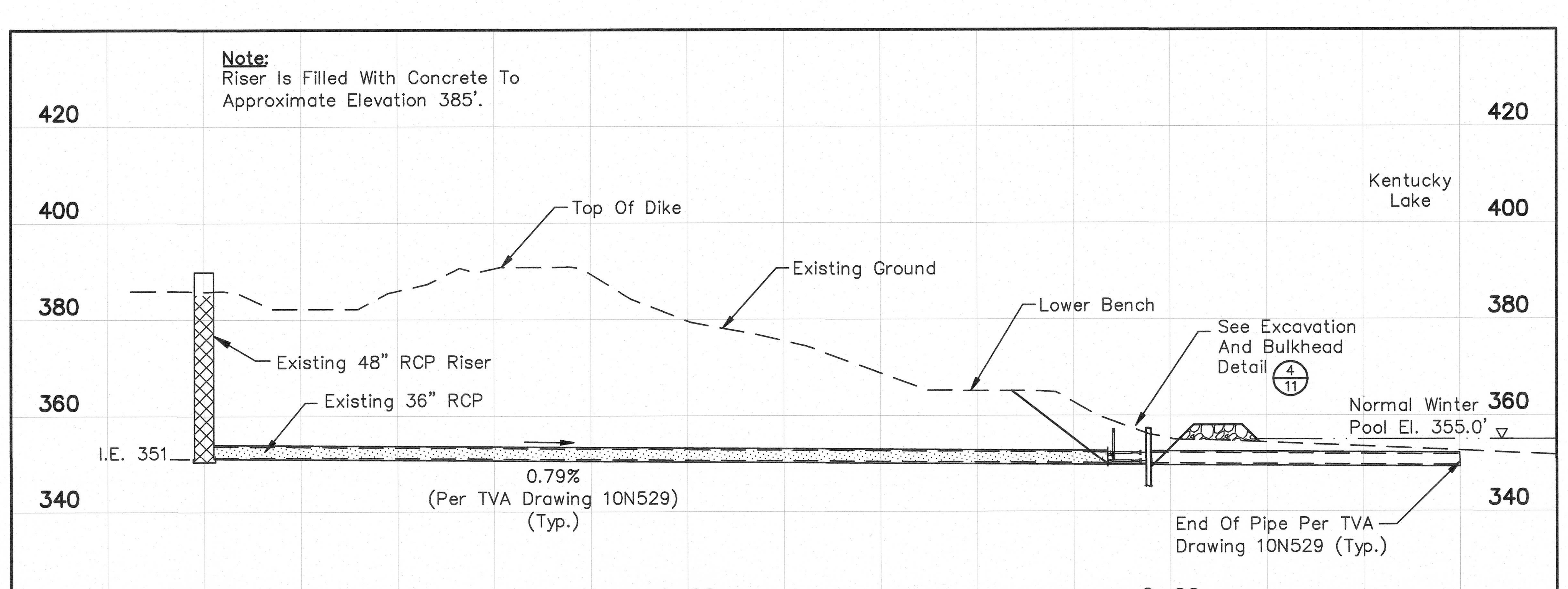
4/11 DETAIL – EXCAVATION AND BULKHEAD
SCALE: 1"=5'



2/11 PROFILE – SPILLWAY PIPE 5
SCALE: 1"=20'



5/11 DETAIL – ROCK BERM AND POND LINER
SCALE: 1"=1'



1/11 PROFILE – SPILLWAY PIPE 4
SCALE: 1"=20'

10 0 20 40 FEET
GRAPHIC SCALE: 1"=20'

POST-GROUT NOTES:

1. Remove bulkhead and struts.
2. Install graded filter per Detail 6/09.
3. Remove sheet piles.
4. Remove plastic liner and crushed stone materials from the lake.

RESTORATION NOTES:

1. Remove all crushed stone materials from the disturbed areas of the lower slope. Prepare the slope to a smooth surface.
2. Place geotextile fabric over the cleared slope.
3. Place Class A-1 riprap over the geotextile fabric. Final riprap slope shall match existing grades.

ISSUED FOR CONSTRUCTION

REFERENCE KEY
- Section or Detail No.
- Sheet Where Shown

For Supporting Design Calculations see FPGJOFFESCDX00000020100004

Stephen H. Bickel, Registered Engineer, State of Tennessee, No. 113735 — 1/31/2011

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REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R 0	01/31/11	JK	RP	SHB	SHB	RLS	MST	JCK	–	–
	ISSUED FOR CONSTRUCTION									

SCALE: AS SHOWN — EXCEPT AS NOTED

YARD
ASH DISPOSAL AREA NO. 2
EXISTING SPILLWAY CLOSURE PROJECT
NORTH SPILLWAYS (REVISION)
WORK PLAN 4 (JOF-100407-WP-4)

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
J. KOPP	R. PETTY	S. BICKEL	S. BICKEL	R.L. SANCHEZ	M.S. TURNBOW	J.C. KAMMEYER

JOHNSONVILLE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000 | DATE 01/31/11 | 30 | C | 10W505-11 | R 0

STANTEC 0
TASK COMPLETED BY: REV NO.

PLOT FACTOR:20
W_TVA

C.A.D. DRAWING
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Appendix B

Design Calculations (TVA Calculation Package)

TVA Calculation Package

Title JOF - Existing Spillway Closure Project

Location Description: *(Optional)* JOF Ash Disposal Area No. 2	**Total Pages:** *(including appendices & attachments)* 63

Calculation ID *(All parts required to form a unique ID)*:

Org Code	Location/ Plant Code	Branch Code	**Alphanumeric Part** = Discipline Code (1) + Type Code (1) + "X" + Unit Field (3) + Sys Code (3) + Year (4) + Sequence No. (4)
FPG	JOF	FES	CDX00000020100004

NOTE: When referencing the calculation ID, include all parts without spaces or dashes between them.

Unit(s), Spill gate(s), or Voltages (PSO):	**Key Nouns (For CTS/CCRIS):**

Applicable Design Document(s):	**Rev**	**RIMS/EDMS Accession Number** *(Optional)*
	R0	
	R	
UNID System(s):	**R**	
	R	

	R0	**R**	**R**	**R**
DCN, PCN, NA	NA-WP			
Prepared: Sign➔				
Print Name	Joshua Kopp			
Checked: Sign➔				
Print Name	Stephen Bickel			
	These calculations contain unverified assumption(s) that must be verified later? ☐ Yes ☒ No These calculations contain special requirements and/or limiting conditions? ☐ Yes ☒ No			
Approved: Sign➔				
Print Name	Stephen Bickel			
Approval Date	12/08/2010			
	These calculations contain a design output attachment? ☐ Yes ☒ No			
Revision Applicability	☒ Entire calc	☐ Entire calc ☐ Selected pgs	☐ Entire calc ☐ Selected pgs	☐ Entire calc ☐ Selected pgs
	Computer output Microfiche generated? ☐ Yes ☒ No Number: ______			

Purpose of the Calculation: These calculations determine the size of steel sheet piles and wales required for the braced excavation. Steel struts to brace a bulkhead and a graded filter are also designed.

Abstract: The nine (9) inactive spillways at the JOF Active Ash Disposal Area are to be permanently abandoned by filling them with grout. Since these outlets are submerged, a cofferdam must be installed to allow workers access to the outlets. Refer to 'Basis of Design Report, Johnsonville Fossil Plant, Existing Spillway Closur e Project, Ash Disposal Area No. 2, Work Plan 4 (May 31, 2011)' for additional information.

☒ Electronically file and return calculation to Calculation Library.

☐ Electronically file and return calculation ______________ Address: ______________

TVA Calculation Coversheet
CTS Input Form

Preparer	**Preparer Login ID**	**Date**
Checker	**Checker Login ID**	**Date**

Update Code: ☒ Add ☐ Change ☐ Delete ☐ Rename ☐ Supersede ☐ Duplicate ☐ Verify

The following section applies if a calculation is being renamed, superseded, or has a duplicate.

	Org Code	Plant	Branch	Number	Cur Rev	New Rev
Current Calc ID:						

The following section applies to all calculations.

Calc ID:	FPG	JOF	FES	CDX00000020100004	000	

Firm: *(TVA or Contractor)* Contractor - Stantec

Cross-References

A/C/D	Xref Code	Type	Org Code	Plant	Branch	Number	Rev

TVA Calculation Record of Revision

Calculation Identifier: FPGJOFFESCDX00000020100004

Title JOF - Existing Spillway Closure Project

Revision No.	Description of Revision
000	Original calculations and documentation.

TVA Computer File Storage Information Sheet

Calculation Identifier: FPGJOFFESCDX00000020100004 **Rev.** 000 **Plant:** JOF

Subject: This software was utilized to determine the required size of the wales used in the shoring system.

Software Name: STADD.Pro **Revision Level:** V8i

Vendor Name: Bentley Systems, Inc.

Address: 22700 Savi Ranch Parkway

Yorba Linda, CA 92887-4608

Executable Files

☒ No TVA developed **executable files** were used in this calculation.

Comments:

☐ TVA developed **executable files** used in this calculation have been stored electronically and sufficient identifying information is provided below for each executable file. *(Any retrieved file requires re-verification of its contents before use.)*

Input Files

☒ Electronic storage of the **input files** for this calculation is not required.

Comments:

☐ **Input files** for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. *(Any retrieved file requires re-verification of its contents before use.)*

TVA Computer File Storage Information Sheet

Calculation Identifier: FPGJOFFESCDX00000020100004 **Rev.** 000 **Plant:** JOF

Subject: This software was used in conjuction with SLOPE/W to determine the seepage and slope stability factors for the rock cofferdam configuration.

Software Name: SEEP/W 2007 **Revision Level:** 7.17

Vendor Name: GEO-SLOPE International, Ltd,

Address: 1400, 633 - 6th Avenue S.W.

Calgary, Alberta, T2P 2Y5, Canada

Executable Files

☒ No TVA developed **executable files** were used in this calculation.

Comments:

☐ TVA developed **executable files** used in this calculation have been stored electronically and sufficient identifying information is provided below for each executable file. *(Any retrieved file requires re-verification of its contents before use.)*

Input Files

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Comments:

☐ **Input files** for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. *(Any retrieved file requires re-verification of its contents before use.)*

TVA Calculation Table of Contents

Calculation Identifier: FPGJOFFESCDX00000020100004 **Revision:** 000

Table of Contents

Stantec

JOF Existing Spillway Closure Project
Cofferdam Design

NOTE: WALE DESIGN CALC'S ATTACHED PAGES 1 THRU 10

Background

Nine (9) existing spillway pipes will be permonently abandoned at the Johnsonville Fossil Plant (JOF), Ash Disposal Area No. 2 (Active Ash Disposal Area). There are three spillway areas (North, South, + East), with each area consisting of three spillway pipes. Abandonment will consist of filling the horizontal pipes and a portion of the vertical risers of each spillway with grout. This work must be performed from the outlets of each pipe which are submerged. A braced excavation will be used to allow the contractor to gain access to these outlets.

Steel sheet piling will be used for the walls of the excavation and structural steel will be used for the bracing. It is assumed that the excavation will be approximately 21'x21'.

Designed by: Joshua Kopp / Nathan Bader

Checked by: MICHAEL M LePAGE ML 3/24/10

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References

1) Naval Facilities (NAVFAC) Engineering Command, "Foundations and Earth Pressures, Design Manual 7.02", September 1986.

2) United States Army Corps of Engineers (USACE), "Engineering and Design - Design of Shee Pile Cellular Structures, Cofferdams, and Retaining Structures (EM 1110-2-2503), June 1990.

3) American Institute of Steel Design, "Manual of Steel Construction - Load + Resistance Factor Design Volumes I + II, 2nd Edition, 1994.

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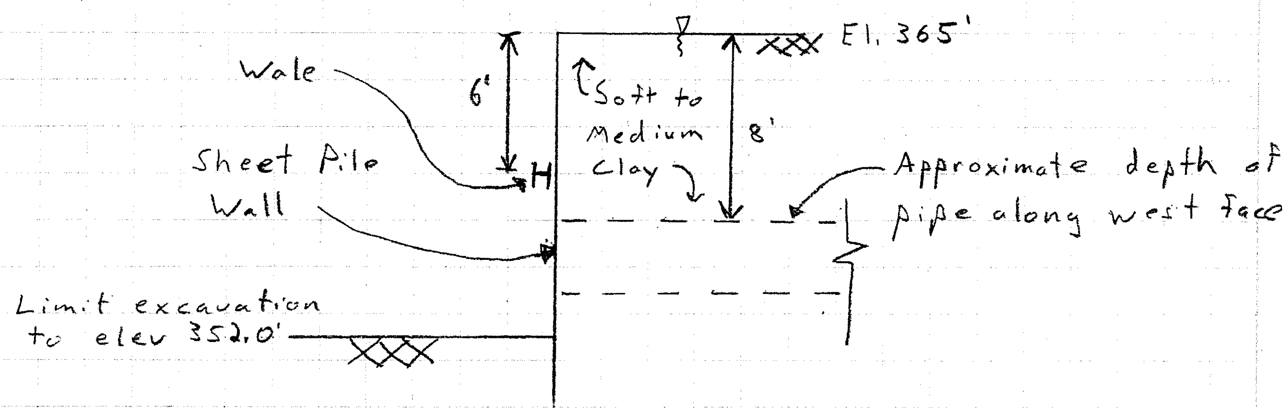
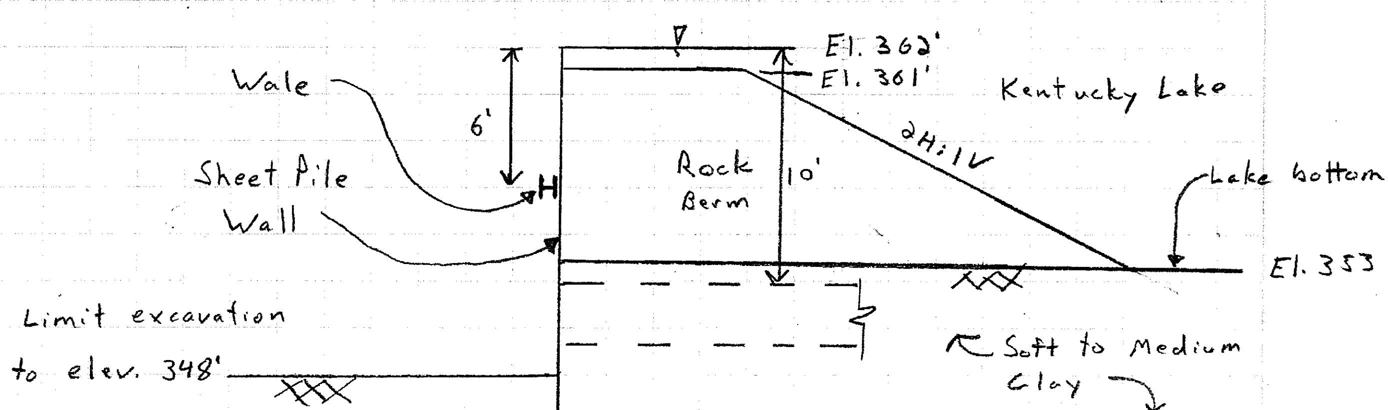
Design of Braced Excavation

The cross-sections below represent typical conditions at each of the three spillway areas. For purposes of this analysis, it is assumed that the sheet piles will be re-used, the wales will be bolted to allow for easy removal, and the soil conditions representing the worst case will be used.



East Spillway Cross-Section



North and South Spillway Cross-Section

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By inspection, the east spillway which consists of ~~soft~~ soft to medium stiff clay to a depth of 30 feet or more represents the greatest loading condition for the excavation.

From Boring Logs STN-DT, STN-HT, STN-LT, and STN-B-14 (which are the borings closest to the excavations in these areas), the lowest N-value observed was N=5.

Calculate S_u Using Lowest N-value

$$\frac{N}{8} \times 2000 \times \frac{1}{2} = S_u \text{ (psf)}$$

$$\frac{5}{8} \times 2000 \times \frac{1}{2} = 625 \text{ psf} \Rightarrow \text{Use } S_u = 500 \text{ psf (conservative)}$$

From recovered Shelby tube samples, Average $\gamma_w = 124$ pcf

Earth Pressure Selection

From NAVFAC 7.2, pg 100, determine pressure diagram for use in wall load calculation

$$N_o = \gamma H / c = 124 \text{ pcf} (14 \text{ ft}) / 500 \text{ psf}$$

$$= 3.47$$

Use $\sigma_h = 0.4\,\gamma H$

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Check Stability of Cut (Basal Heave)

Minimum safety factor required is 1.5. Check both cases.

$$F.S. = \frac{N_c S_u}{\gamma H} \quad (NAVFAC\ 7.2\text{-}104\ \&\ 7.2\text{-}196)$$

$N_c \Rightarrow \frac{B}{L} = \frac{22}{22} = 1.0$, $\frac{H}{B} = \frac{13}{22} = 0.60$ for East Spillway

$= \frac{14}{22} = 0.64$ for North + South Spillway

$N_{cc} \approx 6.1$ for East Spillways

$N_{cc} \approx 6.1$ for North + South Spillways

$N_{cR} = N_c\left(1 + 0.2\frac{B}{L}\right) = 6.1(1 + 0.2(1.0)) = 7.3$ for East Spillway

$N_{cR} = 6.1(1 + 0.2(1.0)) = 7.3$ for North + South Spillways

$F.S = \frac{(7.3)(500)}{(124)(13')} = 2.26$ for East Spillways > 1.5 OK

$F.S. = \frac{(7.3)(500)}{(124)(14)} = 2.1$ for North + South Spillways > 1.5 OK

These factors of safety are based on the assumption the there will be no embedment depth. Based on seepage analysis, an embedment depth of 15' will be required, thus increasing these factors of safety.

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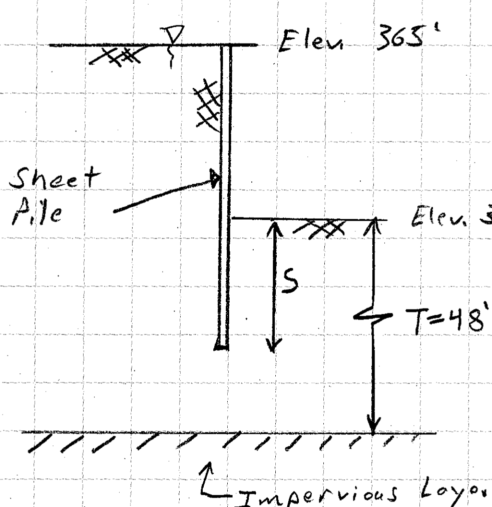
Determine Depth of Wall Below Excavation Required for Seepage

The Contractor is having difficulty driving the sheet piles to the elevation shown on the original Plans for Construction. They have requested that Stantec review the required depth of the sheet piles to determine if it can be reduced by two feet.

Sheet piles are being driven for the East Spillway site. This analysis is only for this area.



The factor of safety against piping, the exit gradient will be calculated using the Method of Fragments from Holtz Kovacs, pg. 258.

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From Table 7.2, Cofferdam is Fragment Type II

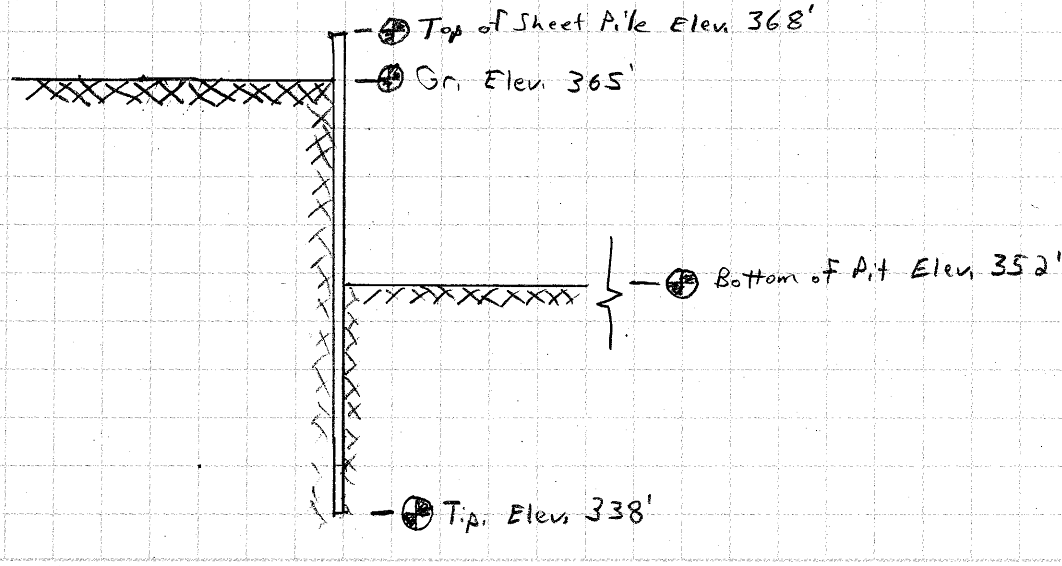
headloss over each fragment, $h_m = \frac{13\text{ ft}}{2} = 6.5\text{ ft}$

$m = \sin\frac{\pi s}{2T}$, $i_e = \frac{h_m \pi}{2KTm}$, $i_{crit} = 1.0$ (from dike seepage analysis)

s	m^2	K	i_e	F.S.
16	0.25	1.686	0.252	3.96
15	0.22	1.670	0.272	3.68
14	0.195	1.658	0.290	3.45
13	0.170	1.645	0.313	3.19
12	0.146	1.633	0.341	2.93

Factor of Safety against piping/seepage must be ≥ 3 (or $i_e \leq 0.33$) per EM 1110-2-2503.

Depth of sheetpile below bottom of pit must be at least 14 feet. This is a 2 foot reduction in driving depth.



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The pressure head at point A, at the base of the dam and just to the right of the left sheet pile is found this way: the percentage of the head loss is proportional to the number of equipotential drops. Of the total of 10.4 drops for the entire flow net, only 3.5 have occurred by point A. Thus the pressure head at point A is

$$h_A = 12\text{ m} - 12\text{ m} \times \frac{3.5}{10.4} + 2\text{ m}$$
$$= 12 - 4.04 + 2 = 9.96\text{ m}$$

The extra 2 m brings the head from the water-soil interface down to the base of the dam.

In a similar manner, we can calculate the head at point D:

$$h_D = 12 - 12 \times \frac{5.4}{10.4} + 2 = 7.77\text{ m}$$

The heads at all the points under the dam are as follows:

Location	Head (m)	Pressure (kPa)
A	9.96	97.7
B	9.38	92.0
C	8.23	80.7
D	7.77	76.2
E	6.62	64.9
F	6.04	59.2

These values of head are plotted in Fig. Ex. 7.19. To compute the *uplift pressures* on the base of the dam, we multiply the head times the product $\rho_w g$. The pressures are given above. If the density of concrete is 2.4 Mg/m^3, then the pressure exerted by 2 m of concrete is

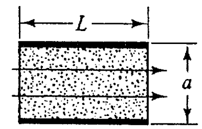
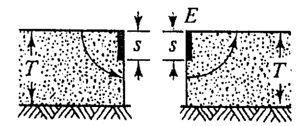
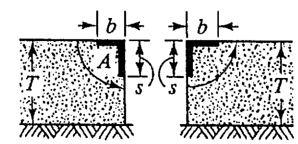
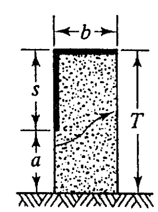
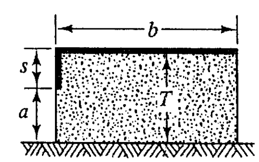
$$2.4\text{ Mg/m}^3 \times 9.81\text{ m/s}^2 \times 2\text{ m} = 47\text{ kPa}$$

Thus at any point along the base of the dam from point C through F the uplift force exceeds the weight of the dam so the dam is *unstable* with this design.

7.10 THE METHOD OF FRAGMENTS

The *method of fragments* presents a useful, rapid, although approximate, analytical design method for the solution of confined flow problems. After you learn the procedure, many cases may be investigated in little more than the time it usually takes to assemble paper, pencils and erasers for drawing flow nets. The method originated with Pavlovsky (1956) and was brought to the attention of the western world by Harr (1962). The

TABLE 7-2 Summary of Fragment Types and Form Factors*

Fragment Type	Illustration	Form Factor, Φ (h is head loss through fragment)
I		$\Phi = \frac{L}{a}$
II		$\Phi = \frac{K}{K'}$; $m = \sin \frac{\pi s}{2T}$ $i_E = \frac{h_m \pi}{2KTm}$
III		$\Phi = \frac{K}{K'}$ $m = \cos \frac{\pi s}{2T} \sqrt{\tanh^2 \frac{\pi b}{2T} + \tan^2 \frac{\pi s}{2T}}$
IV	 	*Exact solution:* $\frac{\Lambda}{\Lambda'} = \frac{T}{b}$; modulus = λ $\Phi = \frac{K'(m)}{K(m)}$; $m = \lambda \,\text{sn}\left(\frac{a}{T}\Lambda, \lambda\right)$ *Approximate solution:* $s \geq b$: $\Phi = \ln\left(1 + \frac{b}{a}\right)$ $b \geq s$: $\Phi = \ln\left(1 + \frac{s}{a}\right) + \frac{b-s}{T}$

*After *Groundwater and Seepage* by M. E. Harr. Copyright© 1962 McGraw-Hill Book Company. Used with permission.

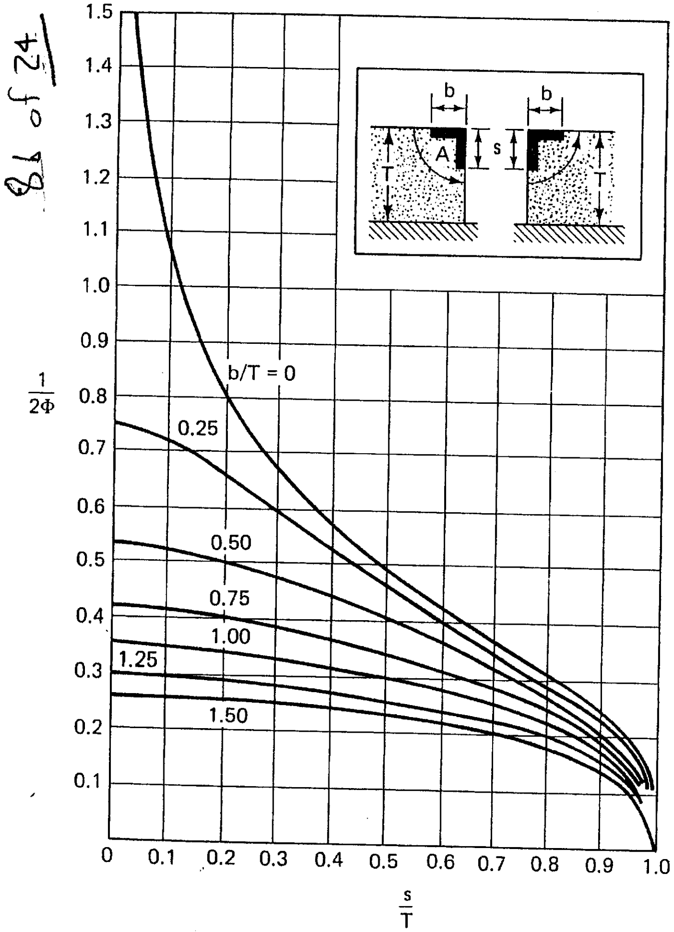


Fig. 7.19 Relationship between form factor Φ and s/T ratio for type II and type III fragments. (After Harr, 1977, © copyright McGraw-Hill Book Company. Used with permission.)

7-2, fragment type II, we find the formula for the exit gradient is

$$i_E = \frac{h\pi}{2KTm} \qquad (7\text{-}32)$$

the value of m is from Eq. 7-31 and equals 0.588; the value of h is ad loss in the third (exit) fragment. The value of K is found in Table r $m^2 = 0.345$; interpolating, $K = 1.741$. The value of h to use in Eq. ; the head loss in the *third fragment*, where the water exits, and it is

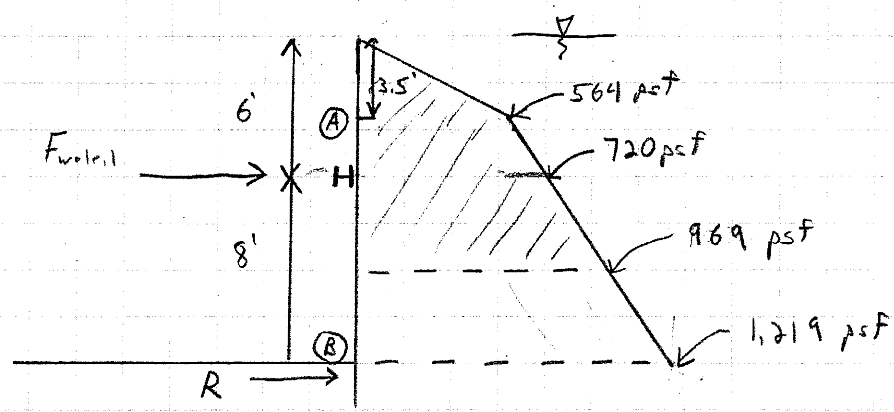
TABLE 7-3 Values of Parameters Used for Types II and III Fragments Described in Table 7-2*

m^2	K	K'	$\frac{K}{K'}$	$\frac{K'}{K}$	m'^2	m^2	K	K'	$\frac{K}{K'}$	$\frac{K'}{K}$	m'^2
0.000	1.571	∞	0.000	∞	1.000	0.21	1.665	2.235	0.745	1.34	0.79
0.001	1.571	4.841	0.325	3.08	0.999	0.22	1.670	2.214	0.754	1.33	0.78
0.002	1.572	4.495	0.349	2.86	0.998	0.23	1.675	2.194	0.763	1.31	0.77
0.003	1.572	4.293	0.366	2.73	0.997	0.24	1.680	2.175	0.773	1.29	0.76
0.004	1.572	4.150	0.379	2.64	0.996	0.25	1.686	2.157	0.782	1.28	0.75
0.005	1.573	4.039	0.389	2.57	0.995	0.26	1.691	2.139	0.791	1.26	0.74
0.006	1.573	3.949	0.398	2.51	0.994	0.27	1.697	2.122	0.800	1.25	0.73
0.007	1.574	3.872	0.406	2.46	0.993	0.28	1.702	2.106	0.808	1.24	0.72
0.008	1.574	3.806	0.413	2.42	0.992	0.29	1.708	2.090	0.817	1.22	0.71
0.009	1.574	3.748	0.420	2.38	0.991	0.30	1.714	2.075	0.826	1.21	0.70
0.01	1.575	3.696	0.426	2.35	0.99	0.31	1.720	2.061	0.834	1.20	0.69
0.02	1.579	3.354	0.471	2.12	0.98	0.32	1.726	2.047	0.843	1.19	0.68
0.03	1.583	3.156	0.502	1.99	0.97	0.33	1.732	2.033	0.852	1.17	0.67
0.04	1.587	3.016	0.526	1.90	0.96	0.34	1.738	2.020	0.860	1.16	0.66
0.05	1.591	2.908	0.547	1.83	0.95	0.35	1.744	2.008	0.869	1.15	0.65
0.06	1.595	2.821	0.565	1.77	0.94	0.36	1.751	1.995	0.877	1.14	0.64
0.07	1.599	2.747	0.582	1.72	0.93	0.37	1.757	1.983	0.886	1.13	0.63
0.08	1.604	2.684	0.598	1.67	0.92	0.38	1.764	1.972	0.895	1.12	0.62
0.09	1.608	2.628	0.612	1.63	0.91	0.39	1.771	1.961	0.903	1.11	0.61
0.10	1.612	2.578	0.625	1.60	0.90	0.40	1.778	1.950	0.911	1.10	0.60
0.11	1.617	2.533	0.638	1.57	0.89	0.41	1.785	1.939	0.920	1.09	0.59
0.12	1.621	2.493	0.650	1.54	0.88	0.42	1.792	1.929	0.929	1.08	0.58
0.13	1.626	2.455	0.662	1.51	0.87	0.43	1.799	1.918	0.938	1.07	0.57
0.14	1.631	2.421	0.674	1.48	0.86	0.44	1.806	1.909	0.946	1.06	0.56
0.15	1.635	2.389	0.684	1.46	0.85	0.45	1.814	1.899	0.955	1.05	0.55
0.16	1.640	2.359	0.695	1.44	0.84	0.46	1.822	1.890	0.964	1.04	0.54
0.17	1.645	2.331	0.706	1.42	0.83	0.47	1.829	1.880	0.973	1.03	0.53
0.18	1.650	2.305	0.716	1.40	0.82	0.48	1.837	1.871	0.982	1.02	0.52
0.19	1.655	2.281	0.726	1.38	0.81	0.49	1.846	1.863	0.991	1.01	0.51
0.20	1.660	2.257	0.735	1.36	0.80	0.50	1.854	1.854	1.000	1.00	0.50
m'^2	K'	K	$\frac{K'}{K}$	$\frac{K}{K'}$	m^2	m'^2	K'	K	$\frac{K'}{K}$	$\frac{K}{K'}$	m^2

*After Aravin and Numerov (1955).

Pressure Distributions

Assume one wale will be used set six feet below the top of the sheetpiles. The largest pressure distribution will be from the North & South Spillway cross-section (14' deep).



$\sigma_A = 0.4\gamma' H + \gamma_w (0.25) H$
$= (0.4)(61.6 \frac{lb}{ft^3})(14) + (62.4)(0.25)(14)$
$= 564$ psf

$\sigma_B = 0.4\gamma' H + \gamma_w H$
$= (0.4)(61.6)(14) + (62.4)(14)$
$= 1{,}219$ psf

Forces

$F_{wale,1} = (\frac{1}{2})(564)(3.5) + (\frac{564 + 969}{2})(6.5) = 5{,}970$ lb/ft

$R = (\frac{969 + 1{,}219}{2})(4) = 4{,}376$ lb/ft

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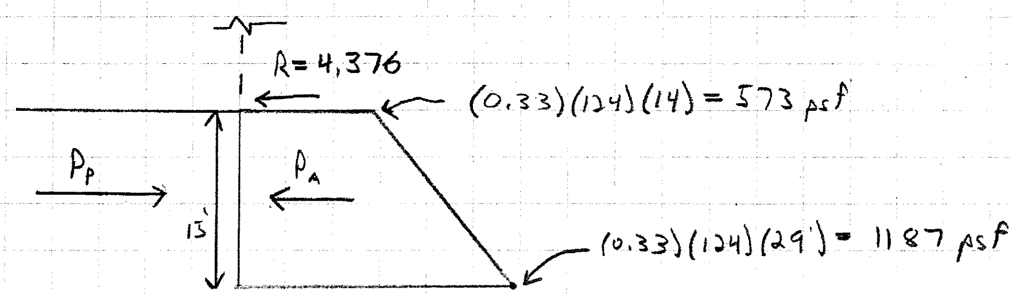
Check D Required to Resist R

From seepage analysis, D = 15 to obtain F.S = 3 against piping.



$\sigma_p = k_p \gamma D$ where $k_p = 3.0$
$= (3.0)(124)(15')$
$= 5,580$ psf

$P_p = (\frac{1}{2})(5,580)(15')$
$= 41,850$ lb/ft

$P_A = \left(\frac{573 + 1187}{2}\right)(15') = 13,200$ lb/ft

$F.S. = \frac{P_p}{P_A + R} = \frac{41,850}{13,200 + 4376} = 2.38$ OK

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Check M_{max} in Wall

Assume portion of wall above wale acts as a cantilever section with uniformly distributed load. (Assume w = 720 psf to be conservative.)

$$M_1 = \frac{wl^2}{2} = \frac{(720\ \frac{lbs}{ft})(6')^2}{2} \quad \text{(LRFD 4-196)}$$

$$= 12{,}960 \text{ ft}\cdot\text{lbs} \checkmark$$

Assume lower portion of wall acts as a simply supported beam with a uniformly distributed load. (Assume w = 1,219 psf to be conservative.)

$$M_2 = \frac{wl^2}{8} = \frac{(1{,}219)(8)^2}{8} = 9{,}752 \text{ ft}\cdot\text{lbs}$$

$$M_{max} = M_1 = 12{,}960 \text{ ft}\cdot\text{lbs}$$

$$M_{max\ (factored)} = M'_{max} = 12{,}960(1.4) = 18{,}144 \text{ ft}\cdot\text{lbs}$$

Determine S_{req}

$$S_{req} = \frac{M_{max}}{0.9 f_y} \quad \text{where } f_y = 39{,}000 \text{ psi}$$

$$= \frac{(18{,}144 \text{ ft}\cdot\text{lbs})(12 \frac{in}{ft})}{(0.9)(39{,}000 \text{ psi})}$$

$$S_{req} = 6.20 \text{ in}^3$$

Contractor requested to use PZ 27 with $S = 30.2 \text{ in}^3 > 6.20 \text{ in}^3$

OK

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Check Wall Under Construction Loading

During construction, assume the excavation will be dug 2 feet lower than the wale elevation to allow for installation of the wales. Assume wall acts as a cantilever section with a uniformly distributed load and length of 8 feet (6 feet to wale elevation plus 2 feet to allow installation).

$$w = 0.4\gamma' H + \gamma_w (8')$$
$$= (0.4)(61.6 \,\text{lb/ft}^3)(14') + (62.4)(8')$$
$$= 845 \text{ psf}$$

$$M_{max} = \frac{w l^2}{2} = \frac{(845 \,\text{lb/ft})(8')^2}{2}$$ (LRFD 4-196)

$$= 27{,}040 \text{ ft}\cdot\text{lbs}$$

$$M_{max(factored)} = 27{,}040\,(1.4) = 37{,}900 \text{ ft}\cdot\text{lbs}$$

$$S_{req} = \frac{(37{,}900 \text{ ft}\cdot\text{lbs})(12 \,\frac{\text{in}}{\text{ft}})}{(0.9)(39{,}000 \text{ psi})}$$

$$= 13.0 \text{ in}^3 < 30.2 \text{ in}^3$$, PZ 27 will work. OK

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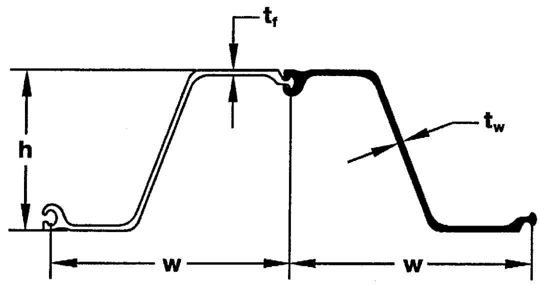
PZ/PS

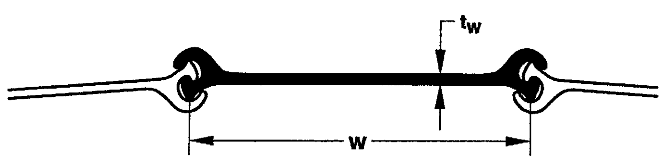
PZ/PS Hot Rolled Steel Sheet Piling

ArcelorMittal | skylinesteel



PZ

SECTION	Width (w) in (mm)	Height (h) in (mm)	THICKNESS: Flange (t_f) in (mm)	THICKNESS: Wall (t_w) in (mm)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT: Pile lb/ft (kg/m)	WEIGHT: Wall lb/ft² (kg/m²)	SECTION MODULUS: Elastic in³/ft (cm³/m)	SECTION MODULUS: Plastic in³/ft (cm³/m)	Moment of Inertia in⁴/ft (cm⁴/m)	COATING AREA: Both Sides ft²/ft of single (m²/m)	COATING AREA: Wall Surface ft²/ft² of wall (m²/m²)
PZ 22	22.0 559	9.0 229	0.375 9.50	0.375 9.50	6.47 136.9	40.3 60.0	22.0 107.4	18.1 973	21.79 1171.4	84.38 11500	4.48 1.37	1.22 1.22
PZ 27	18.0 457	12.0 305	0.375 9.50	0.375 9.50	7.94 168.1	40.5 60.3	27.0 131.8	30.2 1620	36.49 1961.9	184.20 25200	4.48 1.37	1.49 1.49
PZ 35	22.6 575	14.9 378	0.600 15.21	0.500 12.67	10.29 217.8	66.0 98.2	35.0 170.9	48.5 2608	57.17 3073.5	361.22 49300	5.37 1.64	1.42 1.42
PZ 40	19.7 500	16.1 409	0.600 15.21	0.500 12.67	11.77 249.1	65.6 97.6	40.0 195.3	60.7 3263	71.92 3866.7	490.85 67000	5.37 1.64	1.64 1.64



PS

SECTION	Width (w) in (mm)	Web (t_w) in (mm)	Maximum Interlock Strength k/in (kN/m)	Minimum Cell Diameter* ft (m)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT: Pile lb/ft (kg/m)	WEIGHT: Wall lb/ft² (kg/m²)	Elastic Section Modulus in³/sheet (cm³/sheet)	Moment of Inertia in⁴/sheet (cm⁴/sheet)	COATING AREA: Both Sides ft²/ft of single (m²/m)	COATING AREA: Wall Surface ft²/ft² of wall (m²/m²)
PS 27.5	19.69 500	0.4 10.2	24 4800	30 9.14	8.09 171.2	45.1 67.1	27.5 134.3	3.3 54	5.3 221	3.65 1.11	1.11 1.11
PS 31	19.69 500	0.5 12.7	24 4800	30 9.14	9.12 193.0	50.9 75.7	31.0 151.4	3.3 54	5.3 221	3.65 1.11	1.11 1.11

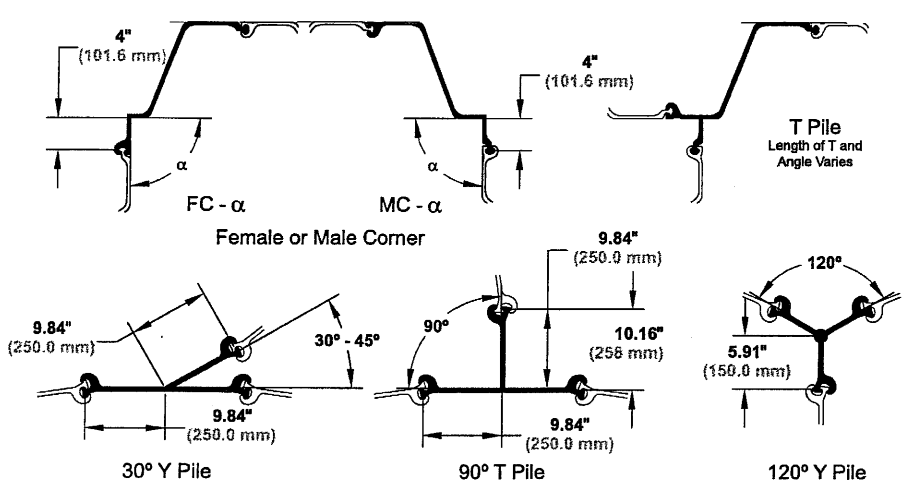
* Minimum cell diameter cannot be guaranteed for piles over 65 feet (19.81 m) in length.
* Minimum cell diameter cannot be guaranteed if piles are spliced.
* 58 Piles are needed to make a 30 foot diameter cell.

PZ/PS

PZ/PS Hot Rolled Steel Sheet Piling

Available Steel Grades							
PZ's			PS's				
ASTM	YIELD STRENGTH		ASTM	YIELD STRENGTH		INTERLOCK STRENGTH	
	(ksi)	(MPa)		(ksi)	(MPa)	(k/in)	(kN/m)
A 328	39	270	A 328	39	270	16	2800
A 572 Grade 50	50	345	A 572 Grade 50	50	345	20	3500
A 572 Grade 60	60	415	A 572 Grade 60	60	415	24	4200
A 572 Grade 65	65	450	A 572 Grade 65	65	450	24	4200
A 588	50	345	A 588	50	345	20	3500
A 690	50	345	A 690	50	345	20	3500

Corner and Junction Piles



Delivery Conditions & Tolerances

	ASTM A 6	
Mass	± 2.5%	
Length	+ 5 inches	− 0 inches

Maximum Rolled Lengths*

PZ	85 feet for singles, 70 feet for pairs	(25.9 m, 21.3 m)
PS	65 feet	(19.8 m)

* Longer lengths may be possible upon request.

Determine Length of Wale

Based on dimensions of selected sheet pile size, the maximum inside dimension of the trench is:

$$\# \text{ of piles} = \frac{(12'')(20')}{18''} = 13.3 \text{ piles} \Rightarrow 14$$ (round to nearest even number)

Add 8" for corner pile sections (4" per corner)

$$\text{Total length} = \frac{14(18'')}{12''} + \frac{8''}{12''} = 21.67'$$

Determine Wale Size

The wale size was determined using the program STAAD.Pro. The following pages include the input and output files.

Designed by: Joshua Kopp / Nathan Bader

Checked by: ML 3/24/10

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SUBSURFACE LOG

Project No.	175559008	Location	N 600147.64, E 1410847.53 (NAD27)
Project Name	Johnsonville Fossil Plant -- TVA	Boring No.	STN-DT Total Depth 56.5 ft
Location	Humphreys County, Tennessee	Surface Elevation	365.3 ft. (NGVD29)
Project Type	Geotechnical Exploration	Date Started	3/10/09 Completed 3/10/09
Supervisor	Russ Mehnert Driller G. Thompson	Depth to Water	18.0 ft Date/Time 3/10/09
Logged By	Russ Mehnert	Automatic Hammer ☒	Safety Hammer ☐ Other ☐

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
365.3'	0.0'	Top of Hole							
		LEAN CLAY with Gravel, brown, tan, and gray, moist, soft to stiff		SPT-1	0.0 - 1.5	1.0	3-3-5	18	Boring advanced using 3 1/4" Hollow Stem Augers
				SPT-2	1.5 - 3.0	1.2	4-6-7	17	
				SPT-3	3.0 - 4.5	1.1	3-4-5	19	
		$\frac{N}{8} \times 2000 = 1{,}250\,psf$		SPT-4	4.5 - 6.0	1.3	3-2-6	20	
				SPT-5	6.0 - 7.5	1.5	5-7-9	20	
		$S_u = 625\,psf$		SPT-6	7.5 - 9.0	1.5	5-5-8	18	
				SPT-7	9.0 - 10.5	1.5	3-3-8	23	
				SPT-8	10.5 - 12.0	1.0	2-3-2	38	N = 5
				SPT-9	12.0 - 13.5	1.5	2-3-4	29	
				SPT-10	13.5 - 15.0	1.5	2-2-4	28	
				SPT-11	15.0 - 16.5	1.5	2-3-4	25	
				SPT-12	16.5 - 18.0	1.0	3-2-4	26	Began using drilling fluid at 18.0 feet
				ST-1	18.0 - 20.0	2.0		25	
				SPT-13	20.0 - 21.5	1.5	3-4-6	25	
				SPT-14	22.5 - 24.0	1.5	4-5-8	21	
				SPT-15	25.0 - 26.5	1.5	3-6-8	21	
				SPT-16	27.5 - 29.0	1.5	6-6-7	22	
				SPT-17	30.0 - 31.5	1.5	2-4-5	22	
331.5'	33.8'			SPT-18	32.5 - 34.0	1.5	4-6-10	24	
		POORLY GRADED SAND, dark brown, brown, tan, and gray, wet, loose to dense		SPT-19	35.0 - 36.5	0.9	3-5-7	23	

FMRN_LEGACY 17145 6118 BORINGS.GPJ FMSIA.GDT 6/23/09

6/23/09

Project No.	175559008	Location	N 600147.64, E 1410847.53 (NAD27)
Project Name	Johnsonville Fossil Plant – TVA	Boring No.	STN-DT Total Depth 56.5 ft

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
		POORLY GRADED SAND, dark brown, brown, tan, and gray, wet, loose to dense *(Continued)*		SPT-20	37.5 - 39.0	1.1	8-11-13	21	
				SPT-21	40.0 - 41.5	1.5	12-20-19	17	
				SPT-22	42.5 - 44.0	1.5	4-2-4	22	
				SPT-23	45.0 - 46.5	1.5	4-8-6	21	
				SPT-24	47.5 - 49.0	1.5	2-2-2	34	
				SPT-25	50.0 - 51.5	1.2	11-11-11	24	
				SPT-26	52.5 - 54.0	1.0	7-9-10	20	Boring backfilled with bentonite grout from 0.0 ft to 56.5 ft.
308.8'	56.5'			SPT-27	55.0 - 56.5	1.4	7-10-12	24	

No Refusal /
Bottom of Hole

FMSM_LEGACY 171495110 BORINGS.GPJ FMSM.GDT 6/23/09

6/23/09

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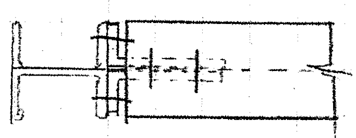
CONNECTION BACKGROUND

LOAD

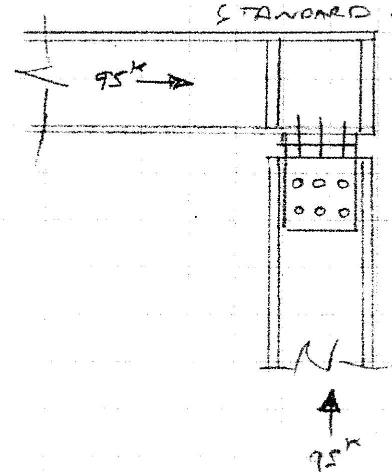
- 95 kips TRANSFERRED BETWEEN WALE SECTIONS
- EXISTING WALE SECTIONS ARE HP14X102 (web horizontal)
- CONNECTION NEEDS TO BE REMOVEABLE

POSSIBLE SOLUTION

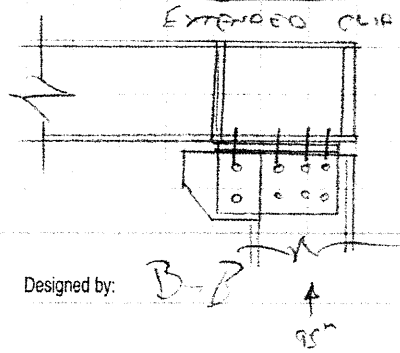
- Try heavy double angle connection - bolted to short beam web, welded or bolted to long beam flange
- If additional strength is needed, then it is possible to make extended clip angle connection on short beam by trimming flange and add web extension plate.



OPTION #1
STANDARD CLIP ANGLE



OPTION #2
EXTENDED CLIP ANGLE



Designed by: B-B
Checked by: MAT 3/18/10

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LOAD PATH

→ ALONG LONG BEAM
WELD OR BOLTS TO FLANGE WILL SEE 95^k shear

→ CLIP ANGLES WILL SEE 95^k compression

→ BOLTS ON SHORT BEAM WEB WILL SEE COMBO shear force
$= \sqrt{95^2 + 95^2} = 135^k$ shear

ISSUE:
→ CONNECTION TO LONG BEAM FLANGE SHOULD BE BOLTED IN ORDER TO REUSE CONNECTION. IF welded to flange, IT WILL BE DIFFICULT TO REMOVE SHORT BEAM WITHOUT BURNING OFF CLIP ANGLES. However, the problem w/ bolting both sides of clip angle is fit up. The cofferdam structure will MOST likely NOT be square, therefore making it almost impossible TO MAKE CONNECTION.

POSSIBLE SOLUTION
→ Try designing BOLTED / BOLTED Connection

GIVEN INFO:

1"Ø A325 BOLTS
A36 CLIP ANGLES

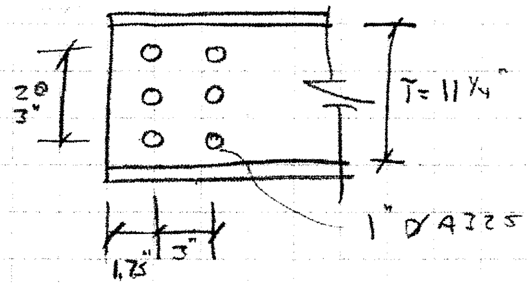
Designed by: [signature] Checked by: MAT 3/18/10

Recycled

Stantec

→ Try 3 rows and 2 columns of bolts on Beam web

$l_v = 1.5'' + 1/8'' = 1.625'' \Rightarrow 1.75''$



$S = 3d = (3)(1'') = 3''$

ANGLE $L = (2)(3) + (1.75)(2) = 9.5''$

Bolt Shear Capacity (short beam web)

Shear / bolt = 23.6^k A325-N 1" Ø Double Shear

$R = (6)(23.6) = 141.6^k > 135^k$ ✓ OK

Eccentricity on Bolt Group

$e'' = 1'' + 3/2'' + 1.75'' = 4.25''$

from ASD 9th edition Table XII pg 4-63

$C = 2.94$

$P_{all} = C r_v = (2.94)(23.6) = 69.4^k < 95^k$

→ Will need additional rows to meet 95^k load

→ Look @ extended plate connection

→ If we use extended plate w/ (2) additional rows then:

$C = 6.66$

$P_{all} = (6.66)(23.6) = 157.2^k > 135^k$ OK

→ Resultant load OK

Designed by: RB Checked by: MAT 3/18/10

Shear on Flange Bolts

R = (11.8^k)(5x2) = 118^k > 95^k ✓ok

Clip Angle Check

→ assume ∠ 8x6x3/4"

Bearing (clip)

Fu t Ø N

R = (1.2)(58 ksi)(0.75")(1")(10 bolts)

R = 522^k > 95^k ✓ok

Edge Distance (clip)

le t N

R = 0.5 (58ksi)(1.75")(0.75")(10 bolts)

R = 381^k > 95^k ✓ok

Spacing (clip) Fu t s - dh N

R = (0.5)(58)(0.75)(2.5)(10)

R = 544^k > 95^k ✓ok

Gross Shear (clip) Fy t l angle

R = (0.4)(36)(0.75)(15.5")(2)

R = 335^k > 95^k

Net Shear (clips)

R = (0.3)(58)(0.75)(15.5 - (5)(1.25"))(2)

R = 241^k > 95^k ✓ok

Designed by: B.B

Checked by: MAT 3/18/10

Shear Capacity (Short Beam WEB)

$R = 0.4(50)(14")(.705")$ (F_y, d, t_w)

$R = 197^k > 95^k$ ✓OK

Bearing (long beam flange)

$R = (1.2)(65)(0.705)(1")(10)$ (F_u, t_f, ϕ)

$R = 550^k > 95^k$ ✓OK

→ Connection angle will be in compression. No need to check prying action.

Local Flange Force (Long Beam)

13th edition

$R_n = 0.5(6.25)(0.705)^2(50)$ (t_f^2, F_{yf})

$R_n = 77.7^k$

$\frac{R_n}{\Omega} = \frac{77.7^k}{1.67} = 46.5^k < 95^k$ STIFFENERS NEEDED

→ Web yielding, crippling >> 95^k ✓OK

STIFFENER DESIGN

$L = 95^k - 46.5^k = 48.5^k$ → Will use (4) stiffeners total

$= 48.5^k / 4 = 12.1^k$

HP 14x102 $d = 14"$ $t_f = 0.705"$ $= 14 - (0.705)(2) = 12.6"$

Designed by: RB

Checked by: MAT 3/18/10

P = 12.6" long and 36 ksi steel assumed

$t_p = \frac{\text{Load req'd}}{F_y \ \ell} = \frac{48.5^k}{(36)(12.6")} = 0.11"$ → use 11/16" plate to match flanges.

→ use 5/16" fillet weld connection

Solution:

TRIM FLANGE (INSIDE) OF SHORT BEAM - ADD 11/16" Web plate - Use 5 rows of bolts and 2 columns 1" ⌀ A325-N BOLTS w/ oversized holes on beam web - standard holes in clip angle - oversized holes on long beam flange - standard holes on 2L 8x6x3/4 outstanding clip angle legs - add (4) 11/16" thick web stiffeners to long beam w/ 5/16" weld fillet.

Note:

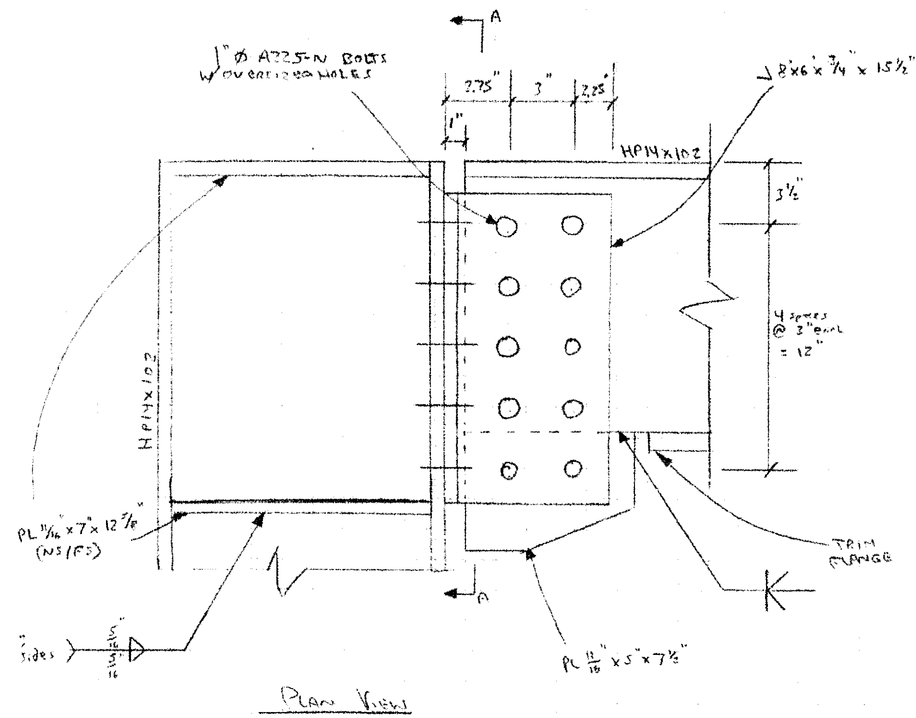
AFTER DISCUSSION WILL SPECIFY A325-N BOLTS w/ oversized holes. MUST NOT REUSE BOLTS FOR SUCCESSIVE USES.

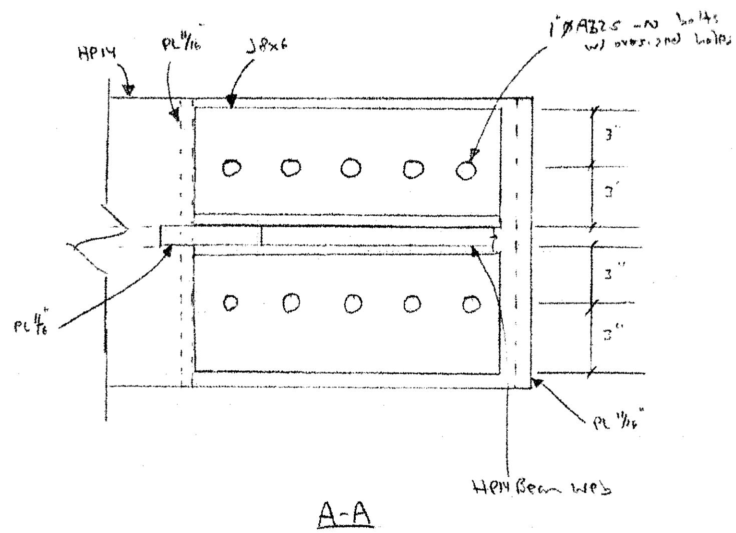
Designed by: RoB

Checked by: MAT 3/18/10

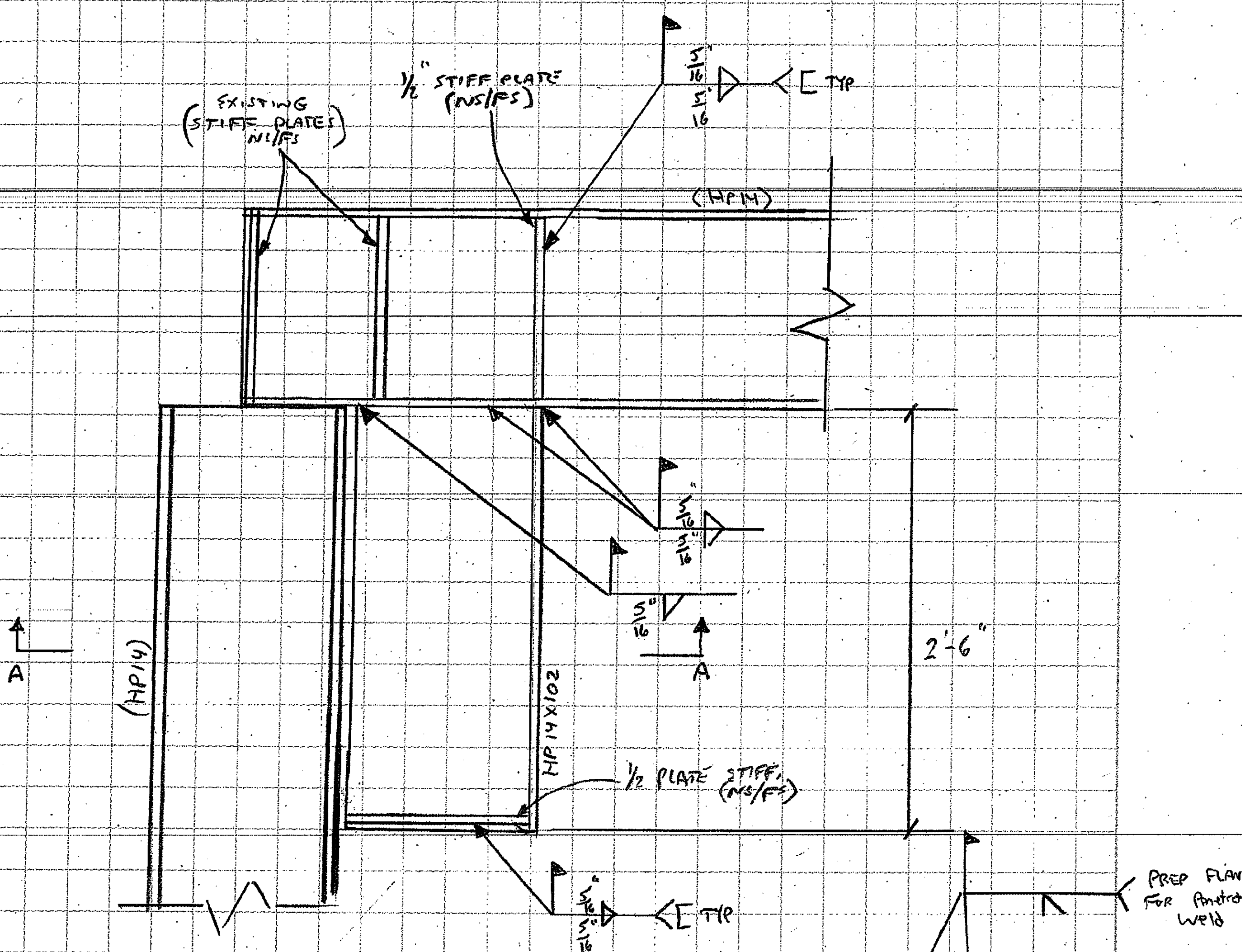
Stantec

JOB NO. 175559008 FILE NO. 2.1
JOB TITLE WALE CONNECTION DESIGN
CLIENT TVA - JOHNSONVILLE
PREPARED BAP DATE 3/18/10 CHECKED MAT DATE 3/18/10
SCALE SHEET 1 OF

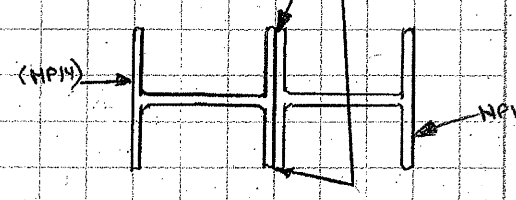




NOTE:
1. DO NOT REUSE BOLTS.
2. CLIP ANGLE MATERIAL TO BE A36.



Corner Detail Plan



A-A

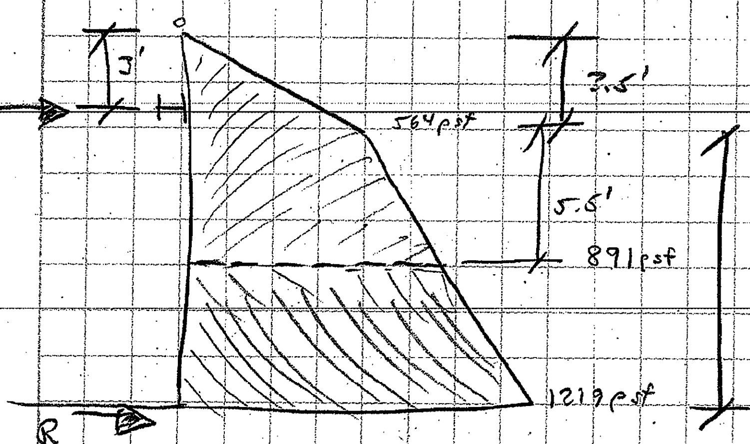
NOTES:

1. See TVA DRWG 10W505-07 for additional information.

Designed by: BuB Checked by: MAT

→ NEW WALER FORCE for 3' depth instead of 6' depth

$F_{waler} = (\frac{1}{2})(564)(3.5) + (\frac{564+891}{2})(5.5) = 4,988$ #/ft



$Shear = \frac{wl}{2} = \frac{(5^k)(21.67')}{2} = 54.1$ kips

⇒ Use 5.25 k/ft = w

$V = \frac{(5.25)(21.67)}{2} = 56.9$ kips

→ For HP 14X102 DESIGN FOR WALER:

STAAD output
RATIO = 0.92 < 1.0 ✓ OK for reduced load

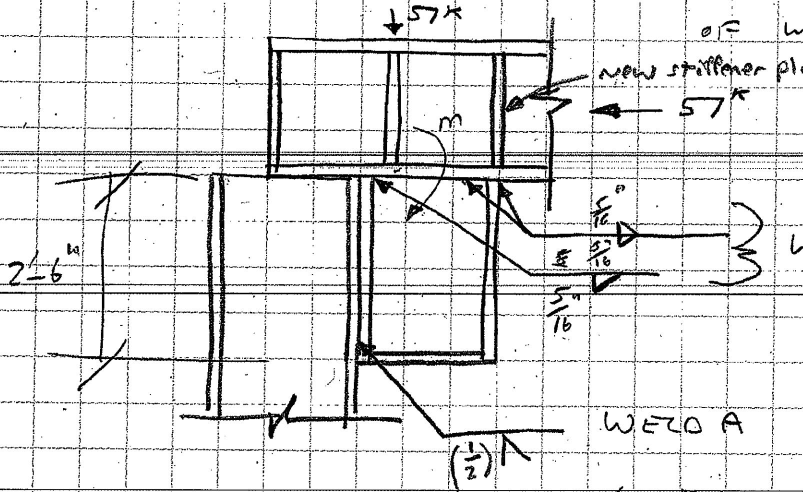
→ See STAAD PAGES FOR DETAILED DESIGN *

→ For WELD DESIGN

NOTE: Since weld is less than expected between walers and eccentricity in connection will induce additional moment, we will design weld for twice its needed capacity.

Designed by: [signature] Checked by: MAT

Solution: ADD 14HP14X102 STUB PIECE TO INSIDE CORNER OF WALER CONNECTION.



$M = \frac{wh^2}{24} + \frac{wh^2}{24} = \frac{wh^2}{12} = \frac{(525^{k/ft})(21.67)^2}{12} = 205^{k\,ft} = 2465^{k\,in}$

Total Moment = Moment from frame + Moment due to load eccentricity

$M = 2465^{k\,in} + (57^k)\left(\frac{14.5''}{2}\right) = 2878^{k\,in}$

Shear = 57^k

Moment = $2878^{k\,in}$

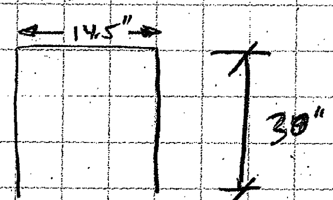
NOTE: Welds will be partial penetration welds from flange to flange

WELD AS LINES

Try 30" depth

$S = \frac{2bd + d^2}{3} = \frac{(2)(14.5)(30) + 30^2}{3}$

$S = 590 \text{ in}^2$



$= f_{bm} = \frac{M}{S} = \frac{2878}{590} = 4.88 \text{ k/in}$

$f_{bv} = \frac{57^k}{60''} = 0.95^{k/in}$

Designed by: BwB Checked by: MAT

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→ Resultant Load

$$f_r = \sqrt{f_v^2 + f_m^2} = \sqrt{0.95^2 + 4.88^2}$$

$f_r = 4.97$ K/in

Weld Size

$$= \frac{f_r}{(0.8)(0.928)} = \frac{4.97}{(0.8)(0.928)} = 6.68 \text{ 16ths of an inch}$$

7/16" minimum

→ For existing penetration weld flange to flange

$t_f = 0.705 > \frac{6.69}{16} = 0.418"$ ✓ OK

→ For new flange to flange penetration welds,

Effective weld $= t_f - 1/8" = 0.705 - 0.125 = 0.58" > 0.42"$ ✓ OK

$S = 5/8"$ $E = 1/2"$

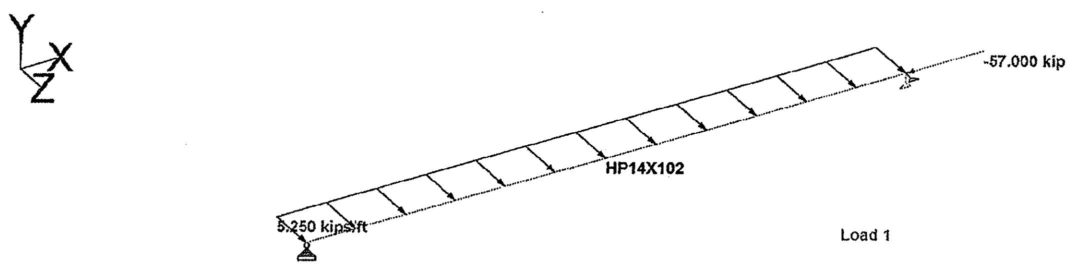
Designed by: BNB Checked by: MAT

Software licensed to Stantec Consulting Ltd.	Job No 17559008.321.:	Sheet No 1	Rev
	Part		
Job Title JOF Spillway Closure Project	Ref		
	By BGB	Date 21 July 10	Chd MAT
Client TVA	File HP Section Design TVA (	Date/Time 28-Jul-2010 14:22	

WEB HORIZONTAL
SPAN = 21.67'

PG 5 OF 7

ASD LOADS



STAAD INPUT FILE

PG. 6 OF 7

MAT

BGB

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 21 July 10
JOB NAME JOF Spillway Closure Project
JOB CLIENT TVA
JOB NO 17559008.321.2
ENGINEER NAME BGB
CHECKER NAME MAT
CHECKER DATE 21 July 10
END JOB INFORMATION
INPUT WIDTH 79
UNIT FEET KIP
JOINT COORDINATES
1 0 0 0; 2 21.67 0 0;
MEMBER INCIDENCES
1 1 2;
DEFINE MATERIAL START
ISOTROPIC STEEL
E 4.176e+006
POISSON 0.3
DENSITY 0.489024
ALPHA 6e-006
DAMP 0.03
END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
1 TABLE ST HP14X102
CONSTANTS
BETA 90 ALL
MATERIAL STEEL ALL
SUPPORTS
2 FIXED BUT FX MY MZ
1 PINNED
LOAD 1 LOADTYPE None  TITLE LOAD CASE 1
JOINT LOAD
2 FX -57
MEMBER LOAD
1 UNI GZ 5.25
PERFORM ANALYSIS
PARAMETER 1
CODE AISC
BEAM 1 ALL
FYLD 7200 ALL
CHECK CODE ALL
FINISH
```

PG 7 OF 7

Job Information

	Engineer	Checked	Approved
Name:	BGB	MAT	
Date:	21 July 10	21 July 10	

Structure Type	SPACE FRAME

Number of Nodes	2	Highest Node	2
Number of Elements	1	Highest Beam	1

Number of Basic Load Cases	1
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	LOAD CASE 1

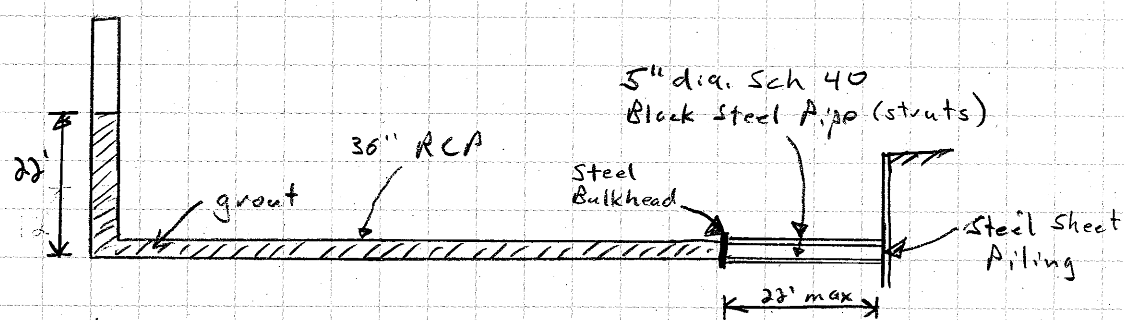
Utilization Ratio

Beam	Analysis Property	Design Property	Actual Ratio	Allowable Ratio	Ratio (Act./Allow.)	Clause	L/C	Ax (in^2)	Iz (in^4)	Iy (in^4)	Ix (in^4)
1	HP14X102	HP14X102	0.916	1.000	0.916	AISC- H1-3	1	30.000	1.05E+3	380.000	5.400

JOF Existing Spillway Closure Project
Steel Strut Design

Stantec

Size the steel struts that will be used to brace the bulkhead.



Load

$P_{grout} = (150 \frac{lb}{ft^3})(22 ft) = 3,300$ psf

$L_{grout} = 3,300 psf [\pi (\frac{3'}{2})^2] = 23,330$ lbs

$L_{grout, factored} = 23,330 (1.7) = 39,660 lbs \approx 39.7$ kips

Resistance

One Sch 40, 5" diameter steel pipe with 22' length can resist 47 kips. Four steel struts will be used to distribute load.

$F_{struts} = 47k (4) = 188$ kips > 39.7 kips **OK**

Designed by: Joshua Kopp   Checked by: Paul J Cooper

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Cert no. SCS-COC-00867
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COLUMNS
Standard steel pipe
Design axial strength in kips ($\phi = 0.85$)

Nominal Dia.		12	10	8	6	5	4	3½
Wall Thickness		0.375	0.365	0.322	0.280	0.258	0.237	0.226
Weight per ft		49.56	40.48	28.55	18.97	14.62	10.79	9.11
F_y		36 ksi						
Effective length *KL* (ft)	0	447	364	257	171	132	97	82
	6	440	357	249	162	122	86	70
	7	438	354	246	159	118	82	67
	8	436	351	243	155	115	78	63
	9	433	348	239	151	111	74	58
	10	429	344	235	147	106	70	54
	11	426	340	231	142	102	65	49
	12	422	336	227	138	97	60	45
	13	418	331	222	133	92	55	40
	14	413	326	216	127	86	51	36
	15	409	321	211	122	81	46	32
	16	404	315	205	116	76	41	28
	17	399	309	199	111	71	37	25
	18	393	303	193	105	66	33	22
	19	387	297	187	99	61	30	20
	20	381	291	181	94	56	27	18
	22	369	277	168	83	47	22	15
	24	356	263	155	72	39	19	
	25	349	256	149	67	36	17	
	26	342	249	142	62	33		
	28	328	234	129	53	29		
	30	313	219	117	47	25		
	31	306	212	111	44	23		
	32	298	205	105	41			
	34	283	190	93	36			
	36	268	176	83	32			
	37	260	169	79	31			
	38	253	162	75				
	40	237	148	67				

Properties

Properties	12	10	8	6	5	4	3½
Area *A* (in.^{2})	14.6	11.9	8.40	5.58	4.30	3.17	2.68
I (in.^{4})	279	151	72.5	28.1	15.2	7.23	4.79
r (in.)	4.38	3.67	2.94	2.25	1.88	1.51	1.34

Note: Heavy line indicates Kl/r of 200.

Design graded filter to be constructed around abandoned spillway pipes.

Use USACE EM 1110-2-2300, Appendix B design method.

1) The base material is represented by gradations obtained from toe borings along stability sections E and K. The borings are from approximate elevations at which the filter will be constructed and they are assumed to provide a representation of material along the entire toe. The base material will consist of lean clay.

Both gradations have > 85% passing the No. 200 sieve, therefore according to Table B-1, both fall under Category 1.

2) Filter Criteria

a) $D_{15} \leq 9 \times d_{85,min}$ $d_{85,min} = 0.041$ mm (Table B-2)

$D_{15} \leq 9 \times (0.041)$

$D_{15} \leq 0.369$ mm

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b) $D_{15} \geq$ 3 to 5 $\times$ $d_{15,max}$, but not less than 0.1 mm

$d_{15,max} < 0.001$ mm, therefore use minimum of 0.1 mm

c) Maximum Particle Size = 3"
Maximum Passing No. 200 Sieve = 5%

Try TDOT Fine Aggregate for Concrete (sand)
(Section 903.01 Standard Specifications for Road and Bridge Construction)

- Avg. D_{15} for concrete sand ~ 0.28 mm
- Max. Particle Size ~ 3/8"
- Percent Passing No. 200 Sieve ~ 0-3%

Check Criteria:

a) $D_{15} = 0.28 \leq 0.369$ mm <u>OK</u>

b) $D_{15} = 0.28 \geq 0.1$ mm <u>OK</u>

c) Max. Particle Size ~ 3/8" < 3" <u>OK</u>
Max. % Passing No. 200 ~ 3% < 5% <u>OK</u>

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3) Select First Intermediate Filter Material

New base material is TDOT Fine Aggregate for Concrete (sand) which falls into Category 4.

a) $D_{15} \leq 4 \text{ to } 5\ d_{85}$ $\quad d_{85,sand} = 2.0$ mm

$D_{15} \leq 4 \text{ to } 5\ (2.0)$
$\leq 8 \text{ to } 10$ mm

b) $D_{15} \geq 3 \text{ to } 5\ d_{15}$ $\quad d_{15,sand} = 0.28$ mm

$D_{15} \geq 3 \text{ to } 5\ (0.28)$
$\geq 0.84 \text{ to } 1.4$ mm

c) Max. Particle Size = 3"
Max. % Passing No. 200 Sieve = 5%

Try TDOT No. 57 crushed stone

- Avg. $D_{15} \sim 7$ mm
- Max. Particle Size = $1\frac{1}{2}$"
- % Passing No. 200 = 0%

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Check Criteria

a) $D_{15} = 7mm \leq 8$ to 10 mm <u>OK</u>

b) $D_{15} = 7mm \geq 0.84$ to 1.4 mm <u>OK</u>

c) Max. Particle Size $= 1\frac{1}{2}" < 3"$ <u>OK</u>
Max. Percent Passing No. 200 ~0% < 5% <u>OK</u>

4) Select Second Intermediate Filter Material

New base material is TDOT #57 stone which falls into Category 4.

a) $D_{15} \leq 4 \times d_{85}$ (per Note 4 on Table B-2)

$D_{15} \leq 4(20)$
≤ 80 mm

$d_{85,\#57} = 20$ mm

b) $D_{15} \geq 3$ to $5 \times d_{15}$

$d_{15,\#57} = 7$ mm

$D_{15} \geq 3$ to $5(7)$
≥ 21 to 35 mm

c) Max. Particle Size = 3"
Max. % Passing No. 200 = 5%

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Try TDOT #3 stone.

- Avg. D_{15} ~ 36 mm
- Max. Size = $2\frac{1}{2}$"
- Percent Passing No. 200 = 0%

Check Criteria

a) D_{15} = 36 mm ≤ 80 mm <u>OK</u>

b) D_{15} = 36 mm ≥ 21 to 35 mm <u>OK</u>

c) Max. Particle Size = $2\frac{1}{2}$" < 3" OK
Percent Passing No. 200 Sieve = 0% < 5 % <u>OK</u>

4) Use the following materials for the graded filter to be placed around the abandoned spillways.

12" (min.) TDOT No. 3 crushed stone
12" (min.) TDOT No. 57 crushed stone
12" (min.) Fine Aggregate for Concrete. (sand)

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Particle-Size Analysis of Soils
ASTM D 422

Project Name: TVA Facility Assessment, P2: Johnsonville, TN
Source: Section E - Toe, 17.5'-19.0', 19.0'-20.5'

Project Number: 171468118
Lab ID: 562

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: RHB
Test Date: 03-24-2009
Date Received: 03-17-2009

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	100.0
No. 10	99.9

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

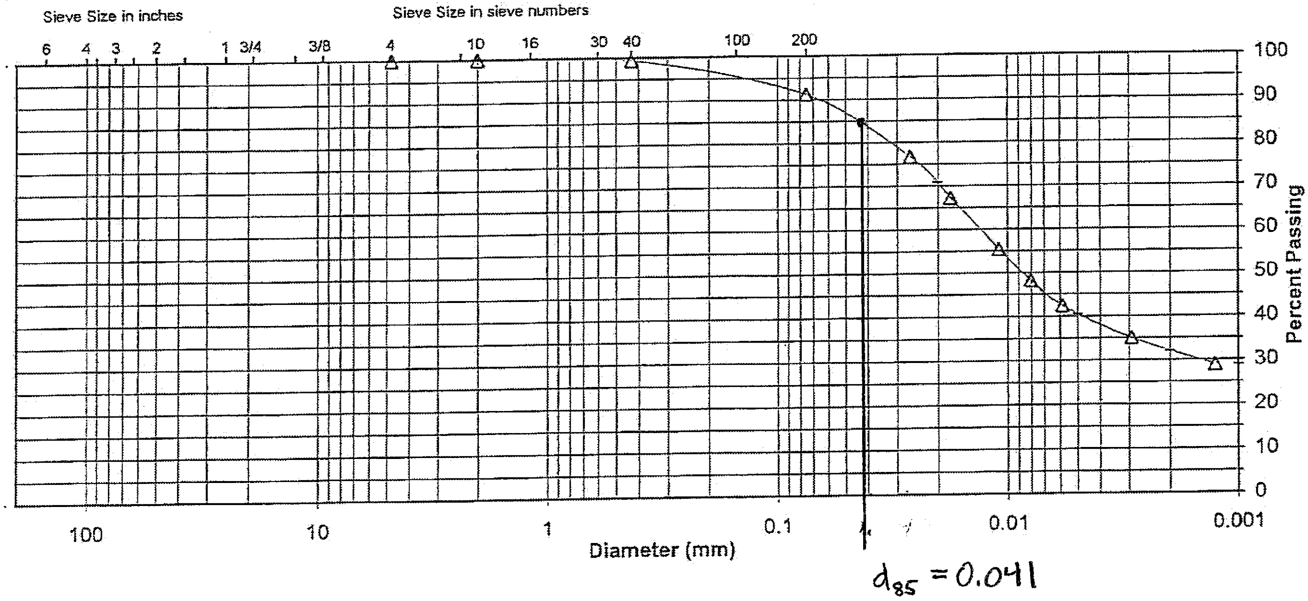
Specific Gravity: 2.64

Dispersed using: Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
No. 40	99.3
No. 200	91.3
0.02 mm	70.8
0.005 mm	40.5
0.002 mm	32.1
0.001 mm	28.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.1	0.6	8.0	50.8	40.5
AASHTO	Gravel			Coarse Sand	Fine Sand	Silt	Clay
	0.1			0.6	8.0	59.2	32.1



Comments

Reviewed By RHB

File: 171468118_Sum-562 Sheet: Hydro-Report
Preparation Date: 1998
Revision Date: 3-2008

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Laboratory Document
Prepared By: JW
Approved BY: TLK

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Particle-Size Analysis of Soils
ASTM D 422

Project Name: TVA Facility Assessment, P2: Johnsonville, TN
Source: Section K - Toe, 3.0'-4.5', 4.5'-6.0'

Project Number: 171468118
Lab ID: 894

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Rounded and Angular
Particle Hardness: Hard and Durable

Tested By: AR
Test Date: 04-21-2009
Date Received: 04-07-2009

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	99.1
No. 10	98.2

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity: 2.73

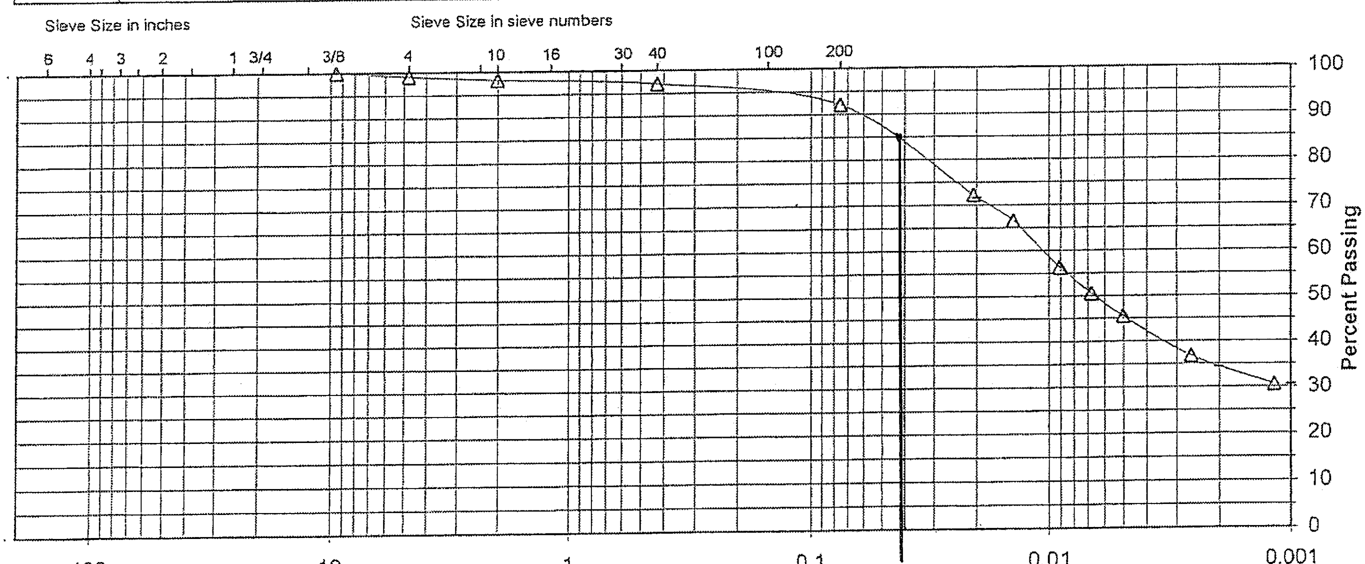
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	97.1
No. 200	92.1
0.02 mm	71.6
0.005 mm	45.6
0.002 mm	34.4
0.001 mm	30.6

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	0.0	0.9	0.9	1.1	5.0	46.5	45.6

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	1.8	1.1	5.0	57.7	34.4



$d_{85,min} = 0.041$ mm

Comments

Reviewed By RHB

File: 171468118_Sum-894 Sheet: Hydro-Report
Preparation Date: 1998
Revision Date: 3-2008

Laboratory Document
Prepared By: JW
Approved BY: TLK

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Particle-Size Analysis of Soils

Project Name: JOF Existing Spillway Closure Project
Source: Graded Filter Design

Project Number: 175559008
Lab ID:

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method:
Prepared using:

Particle Shape:
Particle Hardness:

Tested By:
Test Date:
Date Received

Sieve Size	% Passing
3"	
2.5"	
2"	
1.5"	
1"	
5/8"	
No. 4	
No. 5	
No. 10	

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity

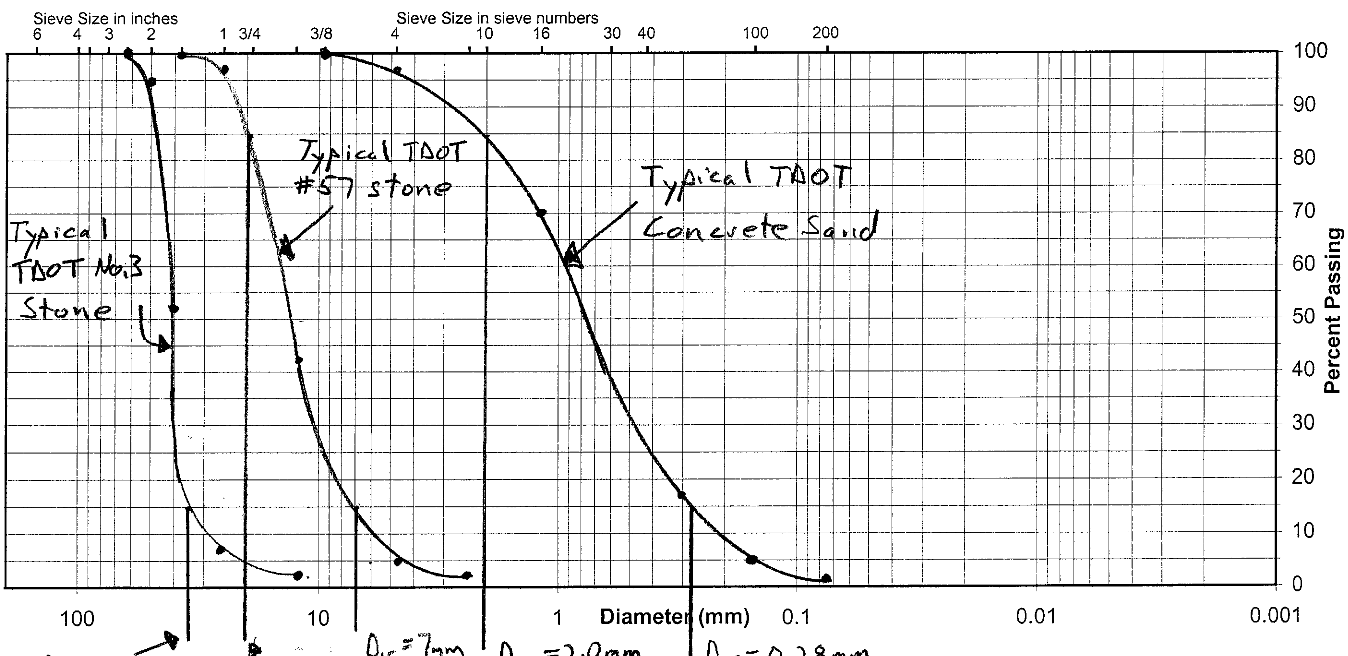
Dispersed using:

No. 40	
No. 200	
0.02 mm	
0.005 mm	
0.002 mm	
0.001 mm	

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	N/A	N/A	N/A	N/A	N/A	N/A	N/A

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	N/A	N/A	N/A	N/A	N/A



Comments

Reviewed By

SECTION 903-AGGREGATES

903.01-Fine Aggregate for Concrete. Fine aggregate for portland cement concrete or slag modified portland cement concrete shall conform to the requirements of AASHTO M 6, with the following exceptions and added stipulations.

(a) The option regarding alternate freeze-thaw tests for soundness will not be exercised.
(b) The fine aggregate shall be washed in the processing operations.
(c) Fine aggregate manufactured from limestone or dolomite shall be processed from material which has been scalped to remove quarry fines. The material from which the fine aggregate is processed shall have a percentage of wear, AASHTO T 96, of not greater than 40.
(d) The amount of deleterious substances shall not exceed the following limits:

	Maximum Permissible Limits Per Cent by Weight
1. Clay Lumps	0.5
2. Coal and Lignite	0.5
3. *Material Passing the No. 200 (75 µm) Sieve	3.0
4. *Other deleterious substances (such as shale, alkali, mica, coated/grains, soft and flaky particles)	3.0

*If the fine aggregate is manufactured from limestone or dolomite and if the material finer than the No. 200(75 µm) sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 5%.

(e) Fine aggregate shall be well graded from coarse to fine and when tested by means of laboratory sieves, shall conform to the following requirements:

Sieve Size	Total Per Cent Passing by Weight
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 16 (1.18 mm)	50-90
No. 50 (300 µm)	5-30
No. 100 (150 µm)	0-10
No. 200 (75 µm)	0-3

903.22-Sizes of Coarse Aggregate. See AASHTO M 43

TABLE 1 Standard Sizes of Processed Aggregate

Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent

Size	Nominal Size, Square openings	100 mm (4")	90 mm (3-1/2")	75 mm (3")	63 mm (2-1/2")	50 mm (2")	37.5 mm (1-1/2")	25.0 mm (1")	19.0 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")	4.75 mm (No 4)	2.36 mm (No 8)	1.18 mm (No 16)	300 µm (No 50)	150 µm (No 100)
1	90 - 37.5 mm (3-1/2" - 1-1/2")	100	90-100	—	25-60	—	0-15	—	0-5	—	—	—	—	—	—	—
2	63 - 37.5 mm (2-1/2" - 1-1/2")	—	—	100	90-100	35-70	0-15	—	0-5	—	—	—	—	—	—	—
24	63 - 19.0 mm (2-1/2" - 3/4")	—	—	100	90-100	—	25-60	—	0-10	0-5	—	—	—	—	—	—
3	50 - 25.0 mm (2" - 1")	—	—	—	100	90-100	35-70	0-15	—	0-5	—	—	—	—	—	—
357	50 - 4.75 mm (2" - No. 4)	—	—	—	100	95-100	—	35-70	—	10-30	—	0-5	—	—	—	—
4	37.5 - 19.0 mm (1-1/2" - 3/4")	—	—	—	—	100	90-100	20-55	0-15	—	0-5	—	—	—	—	—
467	37.5 - 4.75 mm (1-1/2" - No. 4)	—	—	—	—	100	95-100	—	35-70	—	10-30	0-5	—	—	—	—
5	25.0 - 12.5 mm (1" - 1/2")	—	—	—	—	—	100	90-100	20-55	0-10	0-5	—	—	—	—	—
56	25.0 - 9.5 mm (1" - 3/8")	—	—	—	—	—	100	90-100	40-85	10-40	0-15	0-5	—	—	—	—
57	25.0 - 4.75 mm (1" - No. 4)	—	—	—	—	—	100	95-100	—	25-60	—	0-10	0-5	—	—	—
6	19.0 - 9.5 mm (3/4" - 3/8")	—	—	—	—	—	—	100	90-100	20-55	0-15	0-5	—	—	—	—
67	19.0 - 4.75 mm (3/4" - No 4)	—	—	—	—	—	—	100	90-100	—	20-55	0-10	0-5	—	—	—
68	19.0 - 2.36 mm (3/4" - No 8)	—	—	—	—	—	—	100	90-100	—	30-65	5-25	0-10	0-5	—	—
7	12.5 - 4.75 mm (1/2" - No 4)	—	—	—	—	—	—	—	100	90-100	40-70	0-15	0-5	—	—	—
78	12.5 - 2.36 mm (1/2" - No 8)	—	—	—	—	—	—	—	100	90-100	40-75	5-25	0-10	0-5	—	—
8	9.5 - 2.36 mm (3/8" - No 8)	—	—	—	—	—	—	—	—	100	85-100	10-30	0-10	0-5	—	—
89	9.5 - 1.18 mm (3/8" - No 16)	—	—	—	—	—	—	—	—	100	90-100	20-55	5-30	0-10	0-5	—
9	4.75 - 1.18 mm (No. 4 - No. 16)	—	—	—	—	—	—	—	—	—	100	85-100	10-40	0-10	0-5	—
10	4.75 mm (No. 4 - 0*)	—	—	—	—	—	—	—	—	—	100	85-100	—	—	—	10-30

*Screenings

Appendix B
Filter Design

B-1. General

The objective of filters and drains used as seepage control measures for embankments is to efficiently control the movement of water within and about the embankment. In order to meet this objective, filters and drains must, for the project life and with minimum maintenance, retain the protected materials, allow relatively free movement of water, and have sufficient discharge capacity. For design, these three necessities are termed piping or stability requirement, permeability requirement, and discharge capacity, respectively. This appendix explains how these requirements are met for cohesionless and cohesive materials, and provides general construction guidance for installation of filters and drains. The terms filters and drains are sometimes used interchangeably. Some definitions classify filters and drains by function. In this case, filters must retain the protected soil and have a permeability greater than the protected soil but do not need to have a particular flow or drainage capacity since flow will be perpendicular to the interface between the protected soil and filter. Drains, however, while meeting the requirements of filters, must have an adequate discharge capacity since drains collect seepage and conduct it to a discharge point or area. In practice, the critical element is not definition, but recognition, by the designer, when a drain must collect and conduct water. In this case the drain must be properly designed for the expected flows. Where it is not possible to meet the criteria of this appendix, the design must be cautiously done and based on carefully controlled laboratory filter tests (Perry 1987).

B-2. Stability

Filters and drains[1] allow seepage to move out of a protected soil more quickly than the seepage moves within the protected soil. Thus, the filter material must be more open and have a larger grain size than the protected soil. Seepage from the finer soil to the filter can cause movement of the finer soil particles from the protected soil into and through the filter. This movement will endanger the embankment.[2] Destruction of the protected soil structure may occur due to the loss of material. Also, clogging of the filter may occur causing loss of the filter's ability to remove water from the protected soil. Criteria developed by many years of experience are used to design filters and drains which will prevent the movement of protected soil into the filter. This criterion, called piping or stability criterion, is based on the grain-size relationship between the protected soil and the filter. In the following paragraphs, the lower case "d" is used to represent the grain size for the protected (or base) material and the upper case "D" the grain size for the filter material. Determine filter gradation limits using the following steps (Soil Conservation Service 1986):

a. Determine the gradation curve (grain-size distribution) of the base soil material. Use enough samples to define the range of grain size for the base soil or soils and design the filter gradation based on the base soil that requires the smallest D_{15} size.

b. Proceed to step *d* if the base soil contains no gravel (material larger than No. 4 (4.75 mm) sieve).

c. Prepare adjusted gradation curves for base soils with particles larger than the No. 4 (4.75 mm) sieve:

(1) Obtain a correction factor by dividing 100 by the percent passing the No. 4 (4.75 mm) sieve.

[1] In paragraphs B-2 and B-3 the criteria apply to drains and filters; for brevity, only the word filter will be used.
[2] In practice, it is normal for a small amount of protected soil to move into the filter upon initiation of seepage. This action should quickly stop and may not be observed when seepage first occurs. This is one reason that initial operation of embankment seepage control measures should be closely observed by qualified personnel.

(2) Multiply the percentage passing each sieve size of the base soil smaller than No. 4 (4.75 mm) by the correction factor from step *c*(1).

(3) Plot these adjusted percentages to obtain a new gradation curve.

(4) Use the adjusted curve to determine the percent passing the No. 200 (0.075 mm) sieve in step *d*.

d. Place the base soil in a category based on the percent passing the No. 200 (0.075 mm) sieve in accordance with Table B-1.

Table B-1
Categories of Base Soil Materials

Category	Percent finer than the No. 200 (0.075 mm) sieve
1	85
2	40-85
3	15-39
4	15

e. Determine the maximum D_{15} size for the filter in accordance with Table B-2. Note that the maximum D_{15} is not required to be smaller than 0.20 mm.

Table B-2
Criteria for Filters

Base soil category	Base soil description, and percent finer than No. 200 (0.075 mm) sieve[1]	Filter criteria in terms of maximum D_{15} size[2]	Note
1	Fine silts and clays; more than 85% finer	$D_{15} \leq 9 \times d_{85}$	(1)
2	Sands, silts, clays, and silty and clayey sands; 40 to 85% finer.	$D_{15} \leq 0.7$ mm	
3	Silty and clayey sands and gravels; 15 to 39% finer	$D_{15} \leq \frac{40-A}{40-15}\{(4 \times d_{85}) - 0.7\text{ mm}\} + 0.7\text{ mm}$	(2),(3)
4	Sands and gravels; less than 15% finer.	$D_{15} \leq 4$ to $5 \times d_{85}$	(4)

[1] Category designation for soil containing particles larger than 4.75 mm is determined from a gradation curve of the base soil which has been adjusted to 100% passing the No. 4 (4.75 mm) sieve.
[2] Filters are to have a maximum particle size of 3 in. (75 mm) and a maximum of 5% passing the No. 200 (0.075 mm) sieve with the plasticity index (PI) of the fines equal to zero. PI is determined on the material passing the No. 40 (0.425 mm) sieve in accordance with EM 1110-2-1906. To ensure sufficient permeability, filters are to have a D_{15} size equal to or greater than $4 \times d_{15}$ but no smaller than 0.1 mm.

NOTES:
(1) When $9 \times d_{85}$ is less than 0.2 mm, use 0.2 mm.
(2) A = percent passing the No. 200 (0.075 mm) sieve after any regrading.
(3) When $4 \times d_{85}$ is less than 0.7 mm, use 0.7 mm.
(4) In category 4, the d_{85} can be based on the total base soil before regrading. In category 4, the $D_{15} \leq 4 \times d_{85}$ criterion should be used in the case of filters beneath riprap subject to wave action and drains which may be subject to violent surging and/or vibration.

f. To ensure sufficient permeability, set the minimum D_{15} greater than or equal to 3 to 5 × maximum d_{15} of the base soil before regrading, but no less than 0.1 mm.

g. Set the maximum particle size at 3 in. (75 mm) and the maximum passing the No. 200 (0.075 mm) sieve at 5 percent. The portion of the filter material passing the No. 40 (0.425 mm) sieve must have plasticity index (PI) of zero when tested in accordance with EM 1110-2-1906.

h. Design the filter limits within the maximum and minimum values determined in steps *e*, *f*, and *g*. Standard gradations may be used if desired. Plot the limit values and connect all the minimum and maximum points with straight lines. To minimize segregation and related effects, filters should have relatively uniform grain-size distribution curves, without "gap grading"--sharp breaks in curvature indicating absence of certain particle sizes. This may require setting limits that reduce the broadness of filters within the maximum and minimum values determined. Sand filters with D_{90} less than about 20 mm generally do not need limitations on filter broadness to prevent segregation. For coarser filters and gravel zones that serve both as filters and drains, the ratio D_{90}/D_{10} should decrease rapidly with increasing D_{10} size. The limits in Table B-3 are suggested for preventing segregation during construction of these coarser filters.

Table B-3
D_{10} and D_{90} Limits for Preventing Segregation

If minimum D_{10}, mm	Then maximum D_{90}, mm
<0.5	20
0.5 - 1.0	25
1.0 - 2.0	30
2.0 - 5.0	40
5.0 - 10	50
10 - 50	60

B-3. Permeability

The requirement that seepage move more quickly through the filter than through the protected soil (called the permeability criterion) is again met by a grain-size relationship criterion based on experience:

Permeability

$$\frac{\text{15 percent size of filter material}}{\text{15 percent size of protected soil}} \geq 3 \text{ to } 5 \qquad \text{(B-1)}$$

Permeability of a granular soil is roughly proportional to the square of the 10 to 15 percent size material. Thus, the permeability criterion ensures that filter materials have approximately 9 to 25 or more times the permeability of the protected soil. Generally, a permeability ratio of at least 5 is preferred; however, in the case of a wide band of uniform base material gradations, a permeability ratio as low as 3 may be used with respect to the maximum 15 percent size of the base material. There may be situations, particularly where the filter is not part of a drain, where the permeability of the filter is not important. In those situations, this criterion may be ignored.

B-4. Applicability

The filter criteria in Table B-2 and Equation B-1 are applicable for all soils (cohesionless or cohesive soils) including dispersive soils (Sherard and Dunnigan 1985). However, laboratory filter tests are recommended for dispersive soils, very fine silt, and very fine cohesive soils with high plastic limits.

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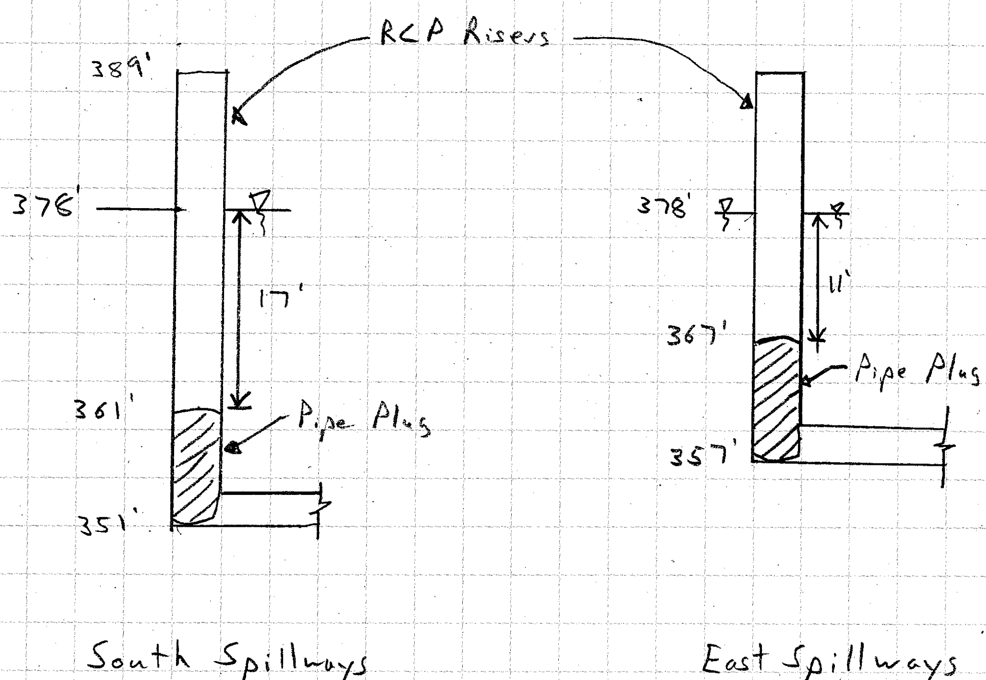
JOF Existing Spillway Closure Project
Pipe Plug Design
1 of

A pipe plug will be inserted into each South and East spillway riser to prevent ash from discharging through the spillway pipe in the event that the riser tips over. The following calculation determines the maximum pressure that may be exerted on the plug if it were fully loaded with an ash/water slurry.

Prior to construction, ash ponds will be lowered to elevation 378' by using siphons.



Designed by: Joshua Kopp

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The maximum height of water over the plug will be used. It is assumed that where ever the riser tips over, it will be completely filled with water and ash.

$H_{max} = 17'$ (South Spillways)

Density of Submerged Ash $= \rho_{ash,sub} = \left(\frac{SG+e}{1+e} - 1\right)\rho_w$ — Civil Engineering Reference Manual; Lindeburg, M.R.; 2006

$SG_{ash} = 2.43$ — Johnsonville Geotechnical Report (see Attached)
$e = 0.68$
$\rho_w = 62.4 \frac{lb}{ft^3}$

$$\rho_{ash,sub} = \left(\frac{2.43+0.68}{1+0.68} - 1\right)(62.4) = 53.1 \frac{lb}{ft^3}$$

Pressure exerted on top of plug:

$$P_{max} = (\rho_{ash,sub} + \rho_w) H_{max} = (53.1 + 62.4)(17')$$
$$= 1,964 \text{ psf} = 13.6 \text{ psi}$$

Multiply by 1.5 to account for factor of safety.

$$P_{max,factored} = 13.6(1.5) = \underline{20.4 \text{ psi}}$$

Use Petersen 129-048 Multi-flex Plug with specifications listed on attachement.

Designed by: Joshua Kopp
Checked by: Paul J Cooper

Table 5. Summary of Soil Parameters for Seepage Analyses

Soil Horizon	k_v (cm/s)	k_v / k_h	G_s	Dry Unit Weight (pcf)	Void Ratio e	w_{sat} (%)	w_{res} (%)
Upper Dike	1.0e-06	0.100	2.66	110	0.51	34	2
Lower Dike	1.0e-06	0.100	2.66	110	0.51	34	2
Fill	1.0e-04	0.067	2.73	120	0.42	30	2
Alluvial Clay and Silt	1.0e-06	0.050	2.64	100	0.65	39	2
Alluvial Sand and Gravel	1.0e-02	0.050	2.68	125	0.34	25	1
Ash	1.0e-03	0.013	2.43	90	0.68	41	3
Rip Rap*	1.0	1.000	2.60	61	1.66	62	0

*Note: Rip rap is present along the toe of the slope along the northwest portion of the pond as a result of dike repairs performed in 1994 and 1997.

After initial parameters were estimated, the model was run and the results were compared to observed field data including: piezometer readings, observed seepage on outslopes and benches, and laboratory natural moisture content measurements. The results were adjusted as necessary to develop reasonable and conservative depictions of phreatic surface for use in subsequent slope stability analyses.

7.4. Shear Strength Parameters Selection

The strength parameters used for the dikes and existing foundation materials were derived using both current and historical results of laboratory unconfined compression tests, consolidated undrained triaxial tests, standard penetration test data and classification test data. In addition, the strength parameters selected were further refined by comparisons with the strength parameters used in the historical reports reviewed. Tables showing the results of historical and current laboratory strength testing are included in Appendix D. Representative strengths for each horizon were selected using the methodology outlined in the US Army Corps of Engineers Engineer Manual EM 1110-2-1902. Results of triaxial testing were evaluated and effective stress p' versus q scatter plots were prepared of all of the data points. The maximum effective principal stress ratio was used to determine failure criteria for selection of these values within Stantec's laboratory test results. Once the p' versus q plots were prepared, a failure envelope was then selected such that two thirds of the plotted values were above the envelope. The p' versus q plots and selection of the failure envelope are shown for each horizon on the graphs presented in Appendix D. The strength parameters were rounded down to the nearest degree with regards to Ø' and to the nearest 50 pounds per square foot for the cohesion intercept. The following table provides a summary of the final effective stress shear strengths selected for use in the analyses.

April 8, 2010

SPECIFICATIONS FOR:
129-048-X PETERSEN MULTI-FLEX™ PLUG
For Stantec application in 48" RCP riser, per Quote 1003301215 Rev 1

MULTI-FLEX™ LINE STOP PLUG:

Max. OD = 48"
Max. Deflated (bundled) diameter = 16"
Max. Inflation Pressure = 50 psig at invert, to withstand 25 psig max. head pressure
Design Contact Length = 96" (2X Dia.) when in full 48" pipe. This is longer than typical 1.5X Dia. because actual contact = approx. 4-5' with end resting on bottom of 4'x4' box and so is partially unsupported there.
Ballistic Nylon Reinforced Polyurethane Outer Ply, for exposure to water, concrete, external temps.
Polyurethane bladder
Nylon positioning loops on inflation (top) end for lowering/raising plug into position.
2X min. loops to be used. Using all 8 loops could support 25% of plug filled with water if necessary
Inflation Flange on top end including:

1) Water Port with 1.5" cam & groove male plug
2) Air Port with ½" Industrial style quick connect male plug

PO Box 340
421 Wheeler Ave.
Fredonia, WI 53021-0340 USA

Tel: 800-926-1926, 262-692-2416
Fax: 800-669-1434, 262-692-2418
E-Mail mail@petersen.cc

Purpose:

Calculation of piping and slope stability Factor of Safety at South Spillways.

Assumptions / Notes

1. Borings SB-1 & SB-2 drilled near South Spillways to confirm depths of alluvial material.
2. Seepage parameters taken from geotechnical Report or typical values.
3. Short term Strength parameters taken from Laboratory testing.
4. Gradient information taken from Seep/W analysis.
5. Assume water would be ½ ft in bottom of Excavation

Equation:

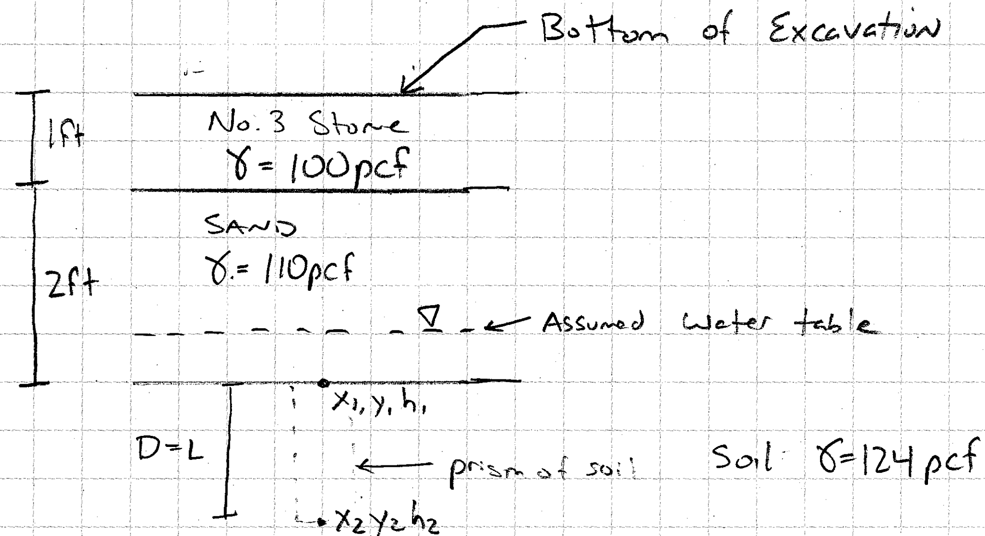
$$FS_{piping} = \frac{\gamma_{sub} D + \gamma_m T}{i \gamma_w D}$$

From Soil Mechanics in Engineering Practice Terzaghi, Peck, Mesri Article 24

D: Depth of critical gradient interval
T = thickness of cover material
γ_m = moist unit weight of cover material
γ_{sub} = submerged unit weight of Soil
γ_w = unit weight water

Designed by: Paul J. Cooper   Checked by: Jason Guntsinger

General Cross Section



For Lake level @ 354

$x_1 = 214$ $\quad y_1 = 345$ $\quad h_1 = 348.77$

$x_2 = 214.3$ $\quad y_2 = 341.1$ $\quad h_2 = 352.16$

$$i = \frac{\Delta h}{\Delta L} = \frac{3.39}{3.91} = 0.87$$ ✓

$$FS_{piping} = \frac{\gamma_{sub} D + \gamma_{SAND} T + \gamma_{NO3} T}{i \gamma_w D}$$

$$FS_{piping} = \frac{(124-62.4)(3.91) + 110(1.5) + 100(1) + (110-62.4)(0.5)}{(0.87)(62.4)(3.91)}$$

FS_{piping} @354 = 2.5 ✓

Designed by: Paul J. Cooper Checked by: Jason Curtsinger

Stantec

TVA JOF Ash Disposal Area No. 2
Existing Spillway Closure Project (JOF-100407- WP-4)
South Spillways

For Lake level @ 356ft

$x_1 = 214$ $x_2 = 214.3$
$y_1 = 345$ $y_2 = 341.1$
$h_1 = 349.91$ $h_2 = 353.04$

$i = \Delta h / \Delta l = 4.13/3.91 = 1.06$ ✓

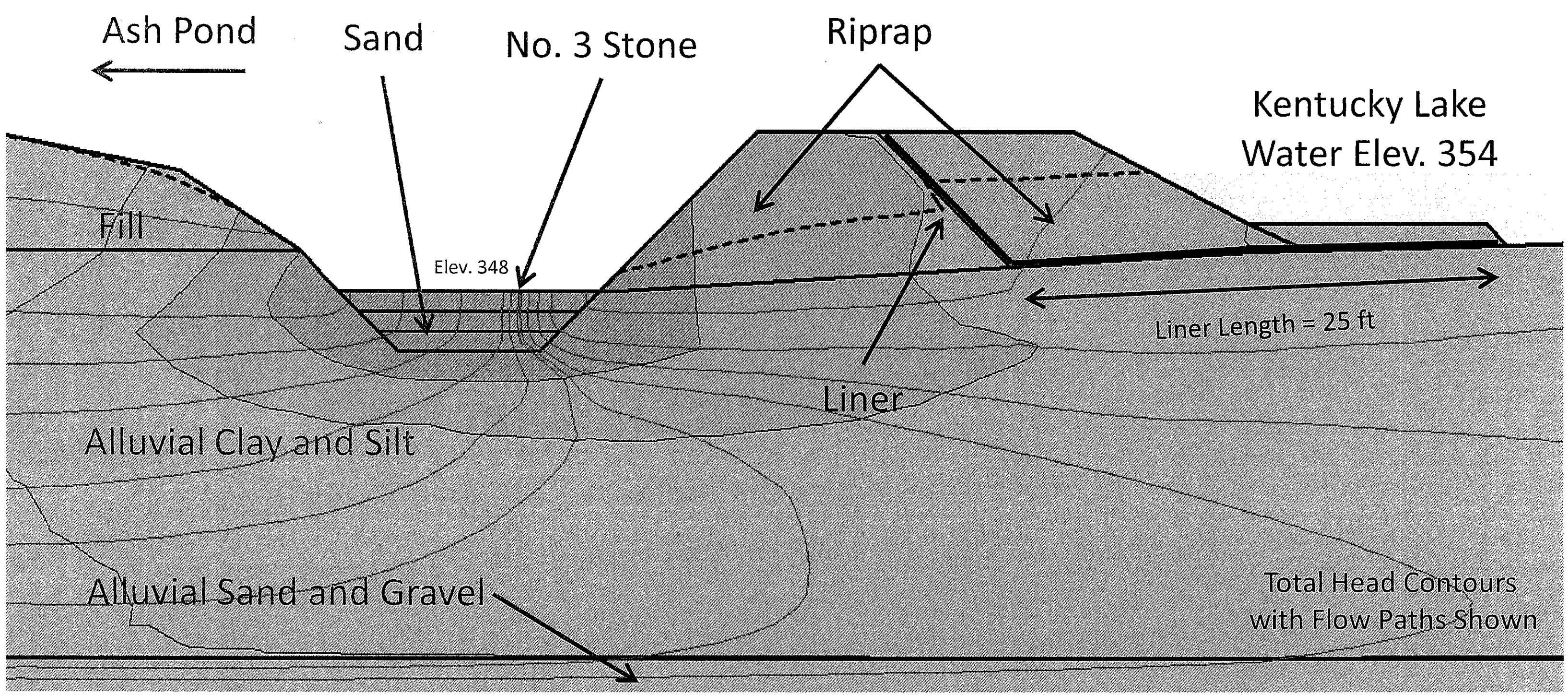
$$FS_{piping} = \frac{(124-62.4)(3.91) + 110(1.5) + 100 + (110-62.4)(0.5)}{(1.06)(62.4)(3.91)}$$

FS_{piping} @ 356 = 2.0

Designed by: Paul J. Cooper Checked by: Jason Curtsinger

Stantec

Johnsonville Existing Spillway Closure Project
(JOF-100407-WP-4)
South Spillway – Hydraulic Divider Dike
Section near Spillway #9

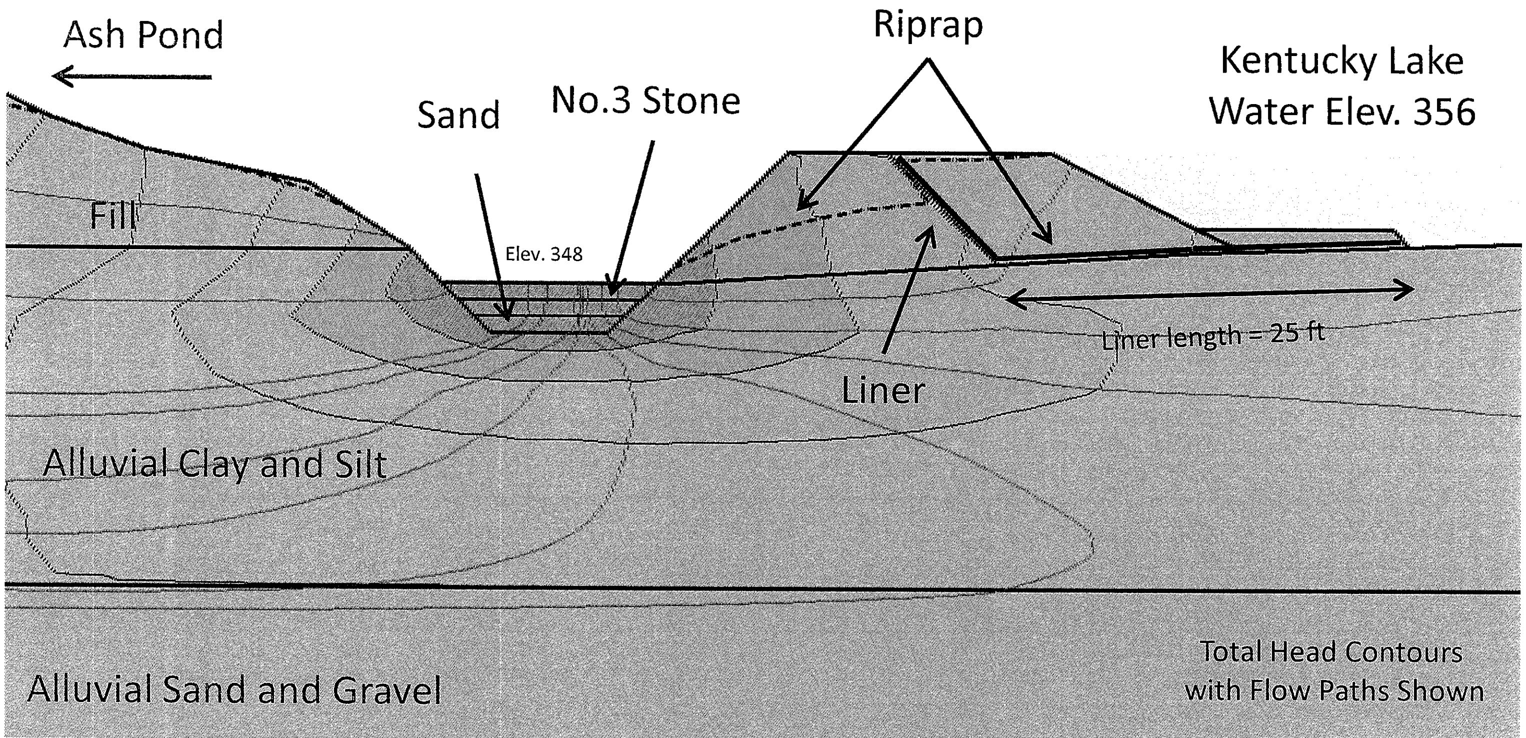


FSpiping = 2.5

Material	Kh/Kv	Kv (ft/sec)
Sand	30	9.8e-6
Riprap / No. 3 Stone	1	0.033
Liner	---	1.0e-10
Fill	3	1.97e-6
Alluvial Clay and Silt	20	6.56e-7
Alluival Sand and Gravel	20	6.56e-3

Stantec

Johnsonville Existing Spillway Closure Project (JOF-100407-WP-4) South Spillway – Hydraulic Divider Dike Section near Spillway #9



FSpiping = 2.0

Material	Kh/Kv	Kv (ft/sec)
Sand	30	9.8e-6
Riprap	1	0.033
Liner	---	1.0e-10
Fill	3	1.97e-6
Alluvial Clay and Silt	20	6.56e-7
Alluival Sand and Gravel	20	6.56e-3

Johnsonville Existing Spillway Closure Project
(JOF-100407-WP-4)
South Spillway – Hydraulic Divider Dike
Section near Spillway #9

Stantec

Short Term Slope Stability Analysis
FS = 1.5

Material	Unit Weight	Cohesion	Phi
Sand	110	0	30
Riprap / No. 3 Stone	100	0	38
Liner	---	---	---
Ash	100	0	10
Fill	124	470	16.7
Alluvial Clay and Silt	124	522	16.7
Alluival Sand and Gravel	120	0	30
Upper Clay Dike	125	521	16.2
Lower Clay Dike	125	211	19.0