TAKING THE MYSTERY OUT OF USACE'S ER 1110-1-1807 DRILLING IN EARTH EMBANKMENT DAMS AND LEVEES

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USACE-IWR Risk Management Center

15 September 2017

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PURPOSE OF ENGINEERING REGULATION 1110-1-1807 DRILLING IN EARTH EMBANKMENT DAMS AND LEVEES

This regulation establishes policy and requirements and provides guidance for drilling in or near dam and levee earth embankments and/or their earth and rock foundations. The primary purpose of this regulation is to prevent damage from hydraulic fracturing, erosion, filter/drain contamination, heave, or other mechanisms during drilling operations, sampling, in-situ testing, instrumentation installation, utility installation, borehole completion, and borehole abandonment.

The purpose of the boring does not matter.

POLICY

An approved Drilling Program Plan (DPP) is required prior to any drilling, sampling, grouting, or any other invasive in-situ testing. This includes drilling activities related to investigation, construction, and remediation.

Justification for drilling shall include an approved recommendation from a risk assessment if performed in support of the Dam or Levee Safety risk management process, or justification in support of modifications by outside entities (this includes utility crossings via horizontal directional drilling)

WHEN DO THEY APPLY

Any drilling or investigation into or near a structure with Federal Interest including Dams, Locks, and Levees (Includes those in PL84-99)

If the investigation is being instituted by an outside group it requires a 408 Permit

Enterprise Products Partners, LP

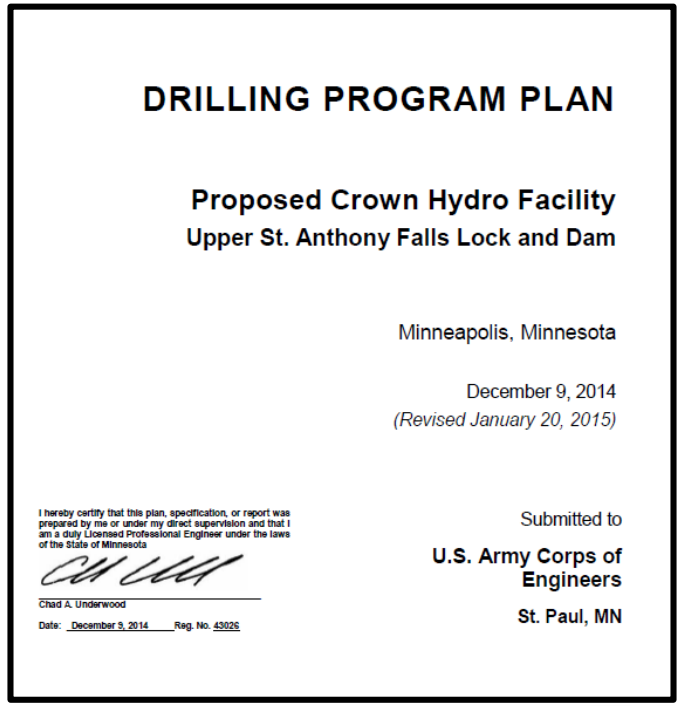
Acadian Gas, LLC
Cypress Gas Pipeline Replacement

Mississippi River & Levee HDDs
Drilling Program Plan

Iberville Parish, Louisiana

September 28, 2015

Section 408 – Authorized in Section 14 of the Rivers and Harbors Appropriations Act of 1899 (33 USC 408): Provides that the Secretary of the Army may, on recommendation of the Chief of Engineers, **grant permission for the alteration of a public work as long as that alteration is not injurious to the public interest and will not impair the usefulness of the work.**



DRILLING PROGRAM PLAN

Proposed Crown Hydro Facility
Upper St. Anthony Falls Lock and Dam

Minneapolis, Minnesota

December 9, 2014
(Revised January 20, 2015)

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota

Chad A. Underwood

Date: December 9, 2014 Reg. No. 43026

Submitted to

U.S. Army Corps of Engineers

St. Paul, MN

DRILLING PROGRAM PLANS

- Paramount that all existing subsurface information is thoroughly evaluated and understood by the exploration team prior to developing a plan.
- Existing subsurface information shall be assimilated into essential plan and section drawings showing the proposed drill holes, target sample areas and/or proposed instrumentation.

Location	Drill Hole Specification		Vertical Drill Hole Configuration[1]			Testing[1]				Instrumentation[1]				Additional Information	
	Borehole ID	Elevation (feet amsl)	Thickness of Overburden (tailing / embankment, glacial foundation, colluvium, till) (ft)	Drilled Length in Bedrock (ft)	Total Drill Length (ft)	Number of SPT/Modified California Tests	Number of Shelby Tube Samples	Number of Falling and/or Constant Head Tests	Proposed Number of Packer Tests	Planned Piezometer Installation	Estimated Number of 1-1/2" PVC Stand-Pipe Piezometers Per Hole	Piezometer ID	Estimated Screen Length (0.020" continuous slot, PVC well screen) (ft)	Geologic Conditions	Purpose / Intent of Drill Hole
Tailing Impoundment	BH-01A	2,906	150	15	165	30	5	10	2	Yes	2	P-2014-01	5	Impoundment tailing, embankment material, glacial till and/or alluvium underlying the impoundment, and bedrock (pyroxinite intrusive)	Evaluate the conditions, stratigraphy, and characterize geotechnical engineering and hydrogeologic parameters through the tailing materials, KDID embankment, and foundation. Drill into bedrock and install multi-level piezometers in all the materials encountered to assess the potentiometric conditions and vertical gradients in the tailing, embankment and foundation.
												P-2014-02	5		
	BH-01B[2]	2,906	120	0	120	--	--	--	--	Yes	2	P-2014-03	10	Impoundment tailing, embankment material	
												P-2014-04	10		
Embankment Crest	BH-02A	2,909	165	15	180	33	0	11	2	Yes	2	P-2014-05	5	Embankment fill, glacial till and/or alluvium in the dam foundation, and bedrock (pyroxinite intrusive)	Evaluate the conditions, stratigraphy, and characterize geotechnical engineering parameters through the KDID embankment, and foundation. Drill into bedrock and install multi-level piezometers in all the materials encountered to assess the potentiometric conditions and vertical gradients in the dam and foundation.
												P-2014-06	5		
	BH-02B[2]	2,909	135	0	135	--	--	--	--	Yes	1	P-2014-07	15	Embankment material	
Downstream Embankment Slope	BH-03A	2,818	70	15	85	14	0	4	2	Yes	2	P-2014-08	5	Embankment fill, glacial till and/or alluvium in the dam foundation, and bedrock (pyroxinite intrusive)	
												P-2014-09	5		
	BH-03B[2]	2,818	40	0	40	--	--	--	--	Yes	1	P-2014-10	15	Embankment material	
Right Abutment	BH-04	2,919	45	15	60	9	0	3	2	Yes	2	P-2014-11	10	Embankment fill, glacial till in the dam abutment, overlying bedrock (pyroxinite intrusive)	Evaluate the geologic conditions, stratigraphy, and characterize geotechnical engineering parameters through the embankment and foundation adjacent to the right and left abutments. Install multi-level piezometer in all the materials encountered to assess hydrogeologic conditions to evaluate the cross valley potentiometric surface and vertical gradients in the dam abutments.
												P-2014-12	10		
Left Abutment and Principal Spillway Intake	BH-05	2,931	45	15	60	9	0	3	2	Yes	2	P-2014-13	10		
												P-2014-14	10		
Spillway Downstream	BH-06	2,834	45	15	60	9	0	3	2	No	0	--	--	Glacial till or colluvium overlying bedrock (pyroxinite intrusive)	Evaluate the geologic conditions, stratigraphy, and characterize geotechnical engineering parameters along the downstream portion of the re-aligned principal spillway.
	9		815	90	905	104	5	34	12	8	14		120		

Notes:
1) The borehole final location, orientation, drilled length, drive-sampling testing, number of hydraulic conductivity tests, and piezometer construction is not fixed and may change based on site restrictions, access issues, results from the geologic and hydrogeological field studies, or materials encountered in the drill holes.
2) BH-01B, BH-02B, and BH-03B will be "blow-down", or companion holes to construct an isolated embankment piezometer. NO testing or sampling is anticipated in these holes

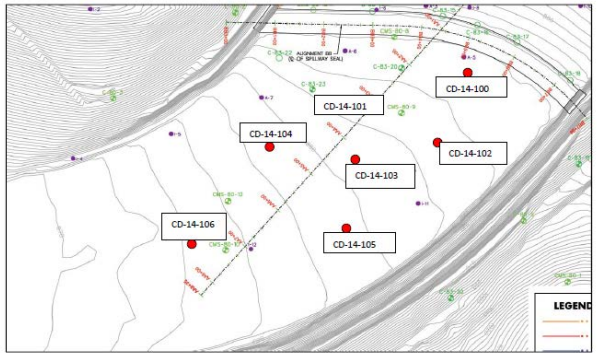
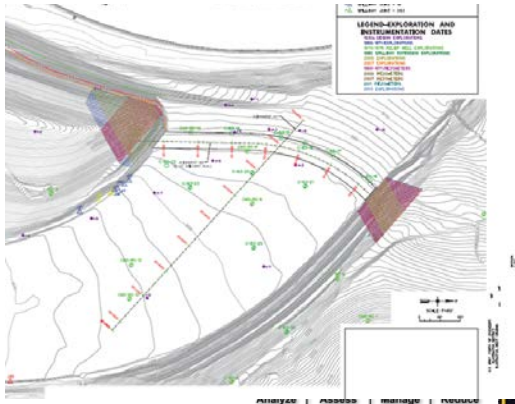


Figure 7.6: Plan view of preliminary boring locations (D-14-100 to D-14-106) through the Mohawk spillway channel.

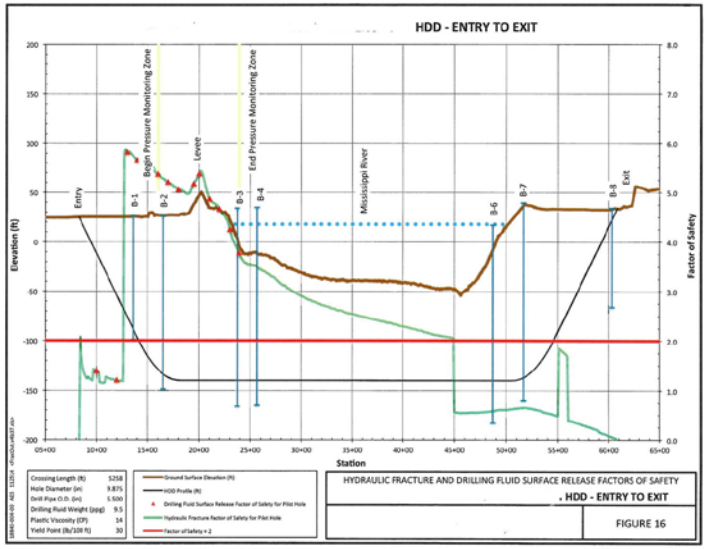


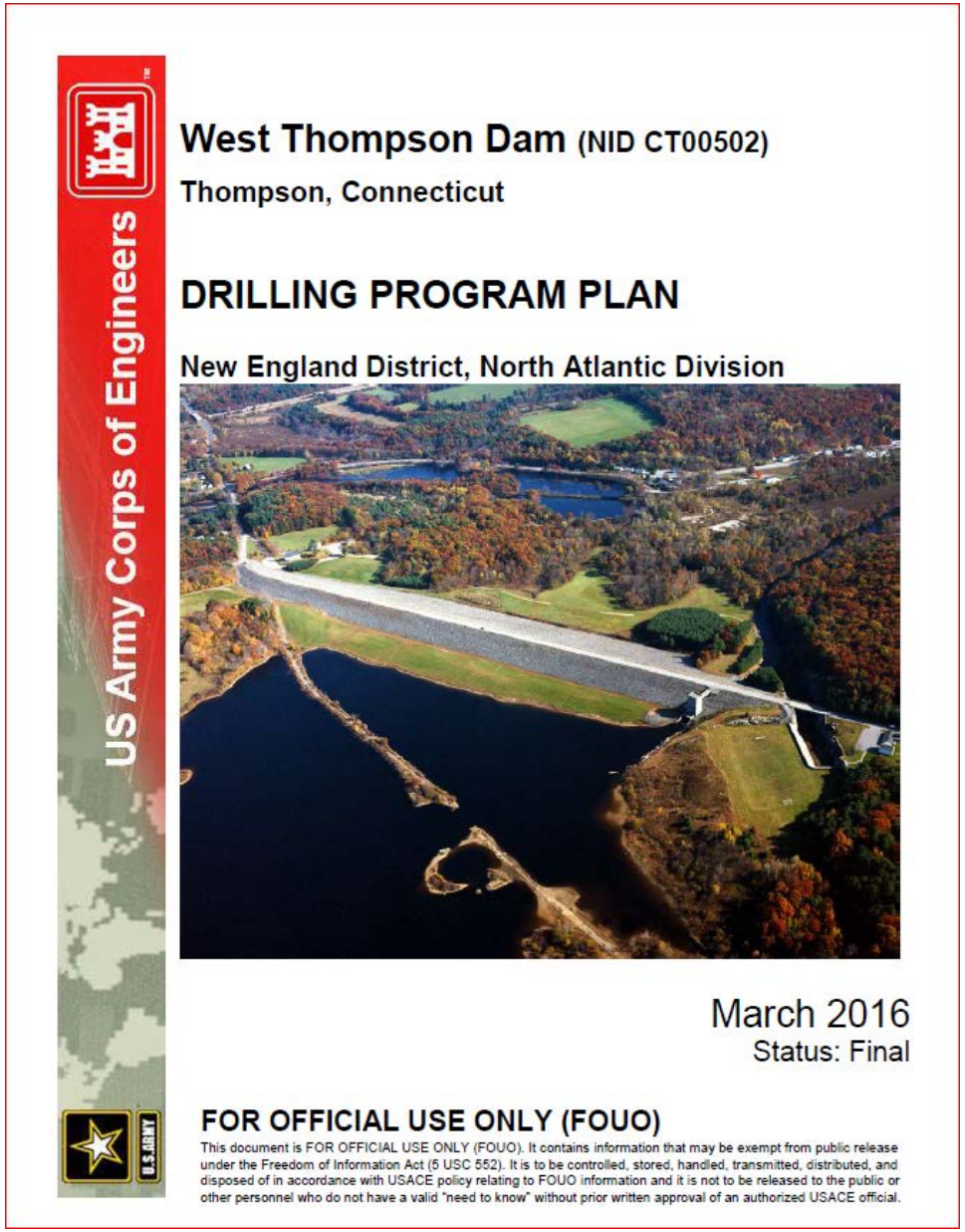
RESTRICTION ON USE OF DRILLING FLUIDS

Drilling programs in Dams and Levees should be designed to minimize the need for any pressurized drilling fluid such as air, gas, water, mud, polymers, slurries or any other drilling fluid.

If drilling fluids must be used DPP shall contain an analysis of the potential to cause damage (hydraulic fracture analysis) and a plan that covers the measures that will be used to minimize the risk.

Pressurized air or foam is not permitted.





DPP CONTENTS

- Objective and Justification
- Exploration Team
- Existing Information Review
- Essential Geologic and Engineering Drawings
- Drilling Scope and Methodology
- Risk Evaluation
- DSO/LSO Certification

OBJECTIVE AND JUSTIFICATION (PFMA/RISK ASSESSMENT)

- Purpose of the drilling and how the information will be used
- Need must be thoroughly justified.
- Non-destructive alternatives considered
- Justification should include approved recommendation from a risk assessment for USACE plans
- For outside entities Why are you planning on drilling and What information do you hope to generate.

The investigation is to support the design of a replacement bridge across the New River.

Investigations to support a more detailed risk assessment or design of a modification to a dam or levee.

PERSONNEL

- Drill rig operators shall have a minimum of 5 years experience drilling with the equipment and procedures described in the drilling program on dams and levees.

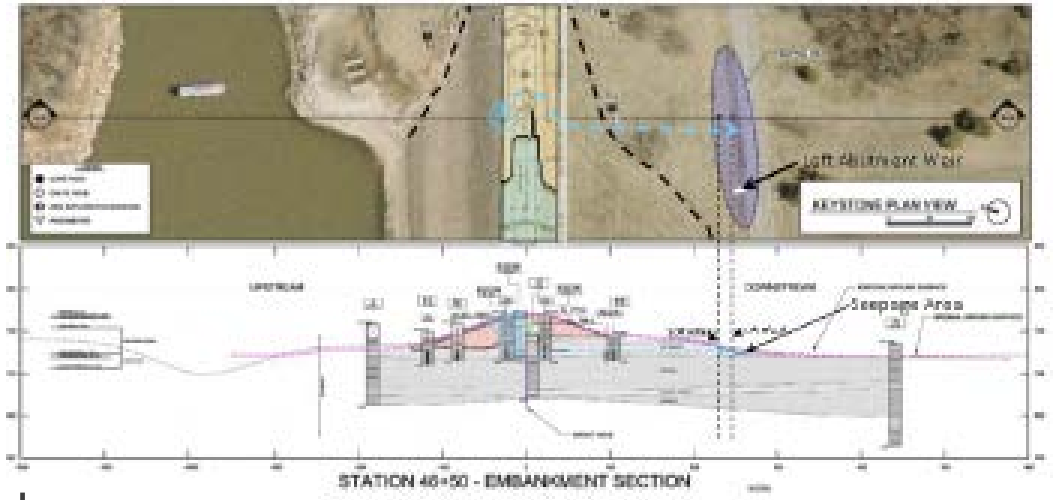
- All drilling activities on USACE dams or levees shall be conducted in the presence of a registered professional geotechnical engineer or geologist who shall be responsible for maintaining the integrity of the structure.

- Include resumes of Key Personnel – Plan Developers, Field Personnel, Drillers

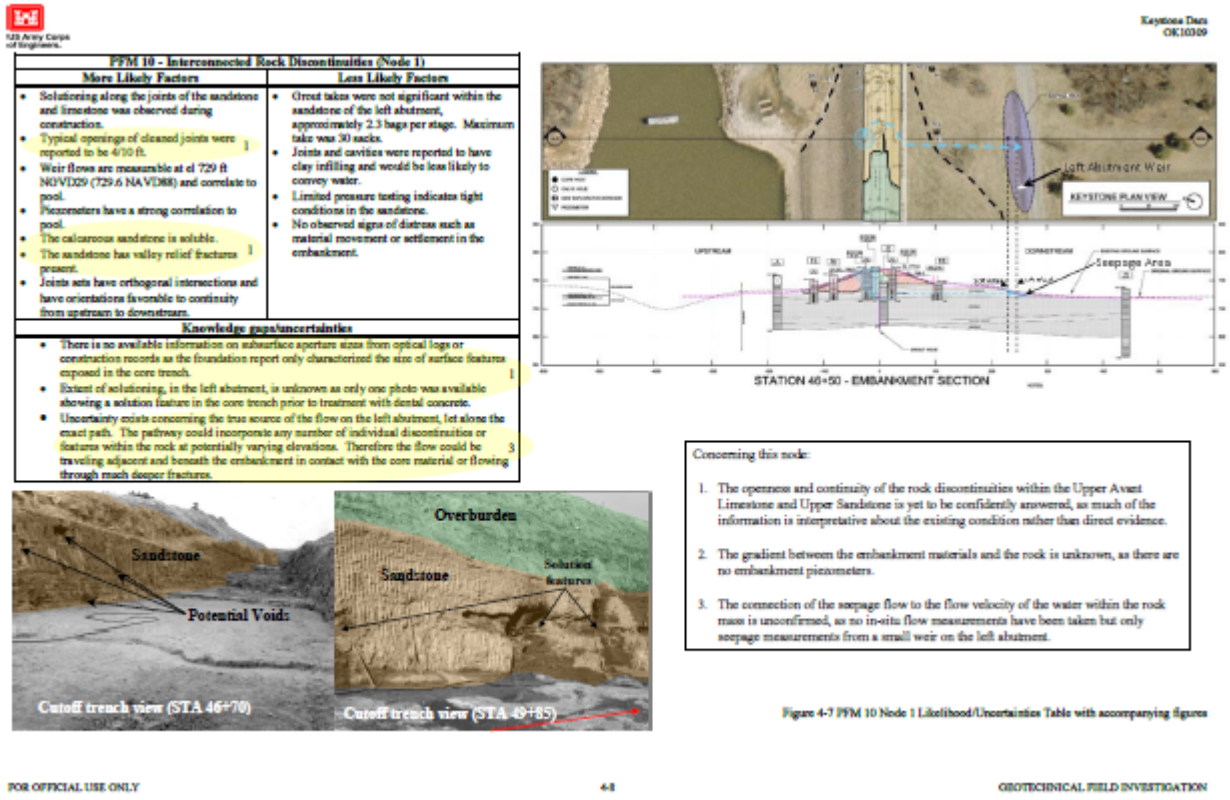
ESSENTIAL GEOLOGIC AND ENGINEERING DRAWINGS

COMPILATION OF INFORMATION TO IDENTIFY DATA GAPS

- Locations of prior and planned subsurface explorations (borings, test pits, instruments, tunnels, adits, etc.)
- Location of all structures
- Embankment zones and other features
- Details of subsurface material classification
- Geologic contacts and continuity interpretations
- Depth of the top of rock or other important layer
- Piezometer showing screened influence zones
- Piezometric levels tied to the pool
- Other instrumentation in context of the geology and structure
- Test Results defining Engineering Properties.
- Geophysical data
- Estimated extent of any zones of interest, including natural and made-made
- Seepage areas tied to Geology



EXISTING INFORMATION REVIEW



US Army Corps of Engineers

Keystone Dam
OK10309

PFM 10 - Interconnected Rock Discontinuities (Node 1)

More Likely Factors	Less Likely Factors
• Solutioning along the joints of the sandstone and limestone was observed during construction. • Typical openings of cleaned joints were reported to be 4/10 ft. • Weir flows are measurable at el 729 ft NGVD29 (729.6 NAVD88) and correlate to pool. • Piezometers have a strong correlation to pool. • The calcareous sandstone is soluble. • The sandstone has valley relief fractures present. • Joints sets have orthogonal intersections and have orientations favorable to continuity from upstream to downstream.	• Grout takes were not significant within the sandstone of the left abutment, approximately 2.3 bags per stage. Maximum take was 30 sacks. • Joints and cavities were reported to have clay infilling and would be less likely to convey water. • Limited pressure testing indicates tight conditions in the sandstone. • No observed signs of distress such as material movement or settlement in the embankment.

Knowledge gaps/uncertainties

- There is no available information on subsurface aperture sizes from optical logs or construction records as the foundation report only characterized the size of surface features exposed in the core trench.
- Extent of solutioning, in the left abutment, is unknown as only one photo was available showing a solution feature in the core trench prior to treatment with dental concrete.
- Uncertainty exists concerning the true source of the flow on the left abutment, let alone the exact path. The pathway could incorporate any number of individual discontinuities or features within the rock at potentially varying elevations. Therefore the flow could be traveling adjacent and beneath the embankment in contact with the core material or flowing through much deeper fractures.

Concerning this node:

1. The openness and continuity of the rock discontinuities within the Upper Avant Limestone and Upper Sandstone is yet to be confidently answered, as much of the information is interpretative about the existing condition rather than direct evidence.
2. The gradient between the embankment materials and the rock is unknown, as there are no embankment piezometers.
3. The connection of the seepage flow to the flow velocity of the water within the rock mass is unconfirmed, as no in-situ flow measurements have been taken but only seepage measurements from a small weir on the left abutment.

Figure 4-7 PFM 10 Node 1 Likelihood/Uncertainties Table with accompanying figures

FOR OFFICIAL USE ONLY 4-8 GEOTECHNICAL FIELD INVESTIGATION

- Project records available in district and project offices
- Archived records
- Geologic mapping, boring logs
- Geotechnical files and reports
- Foundation Completion Reports
- Embankment Construction Reports
- As-built drawings, Construction Reports, and Photos
- Periodic Inspection Reports
- Instrumentation plans, data, and reports

DRILLING SCOPE AND METHODOLOGY

- Utilities, surface and underground obstacles, and accessibility
- Number and location of proposed borings
- Depth, diameter, and inclination of borings
- Materials to be drilled, sampled, and tested
- Drilling, sampling, and testing methods
- Details of the proposed drilling equipment
- Required sample type, location, and reason for sampling
- Instrumentation and borehole completion requirements

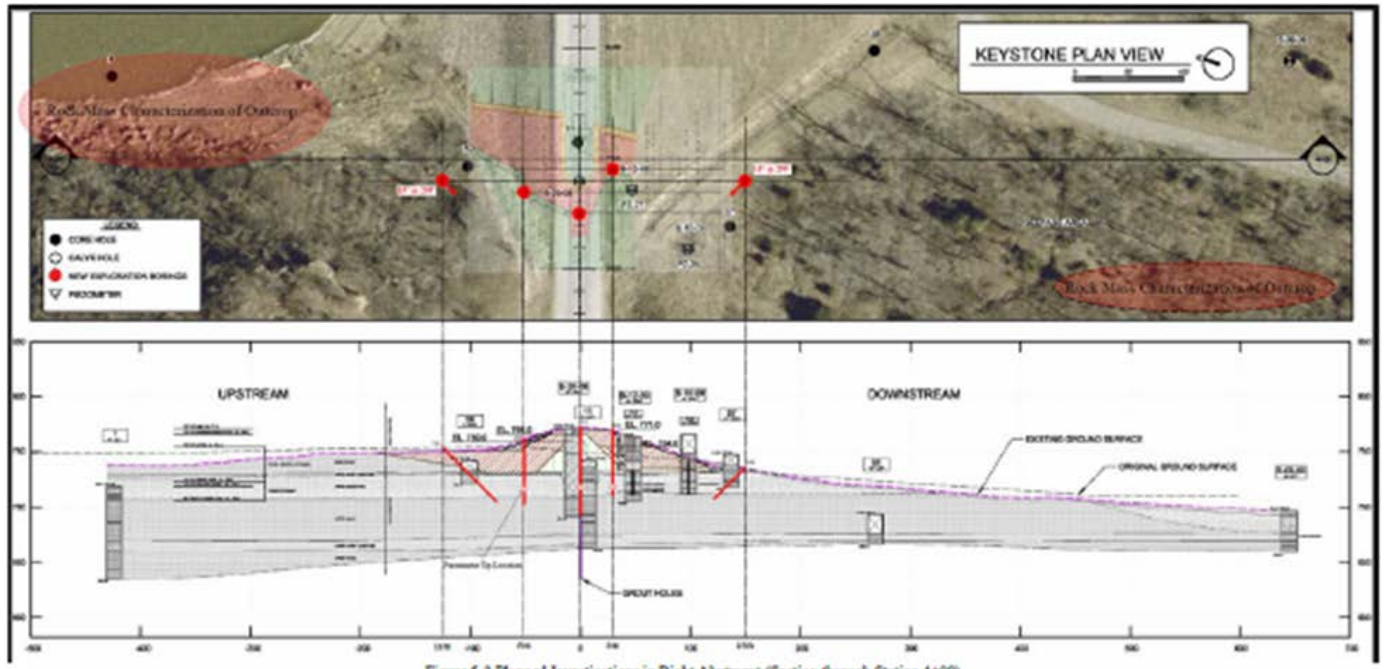


Figure 5-3 Planned Investigations in Right Abutment (Section through Station 4+00)

DRILLING SCOPE AND METHODOLOGY

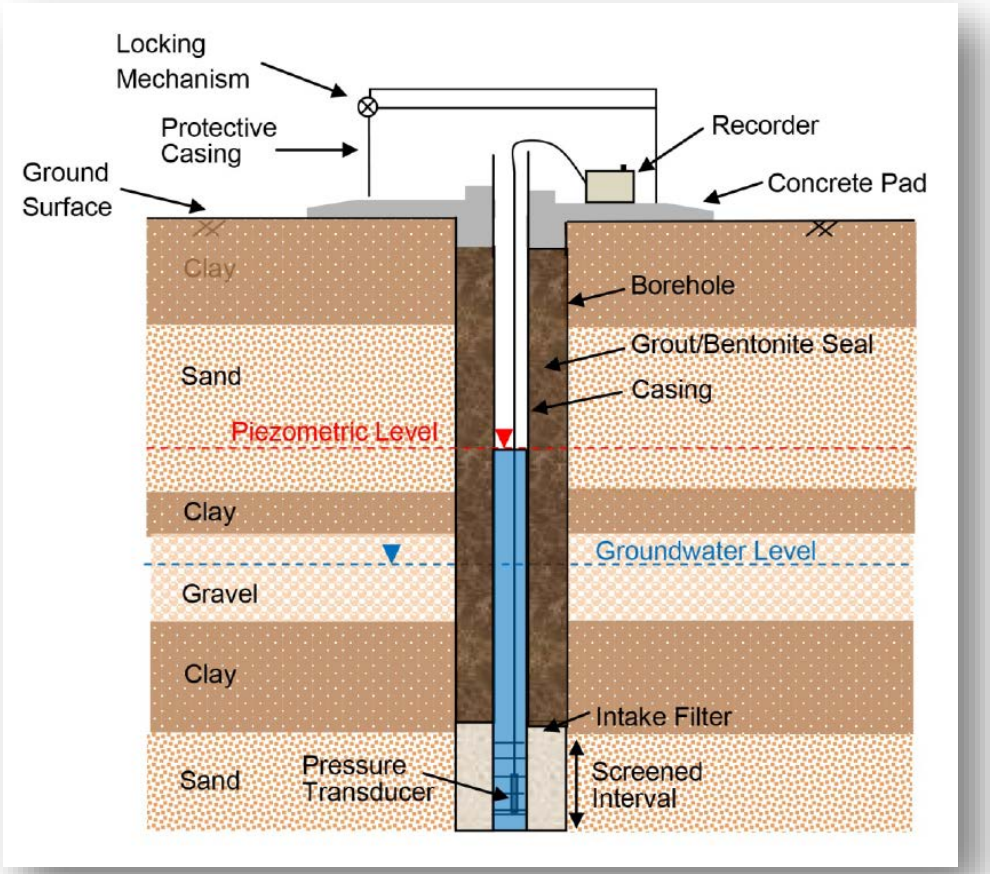
- Evaluation of the risk of contamination of drainage features, heave, or other damage
- Evaluation of the risk of hydro-fracturing
  - Detail description of any drilling fluid
  - Details on the circulation system,
  - Locations where fluid will contact soil
  - Circulation pressures that will be used

- Measures to minimize the risk of damage to the dam or foundation.
- Nearby instruments to be monitored and their expected response

- Contingency plans for unexpected response.
- List of emergency equipment and supplies onsite

BOREHOLE COMPLETION – HOW IS THE HOLE FILLED?

- All boreholes and other penetrations shall be sealed after completion
- Backfilling with drill cuttings is not acceptable
- Penetrations in the impervious zones shall be backfilled by tremie placed cement-bentonite grout or bentonite pellets
- Penetrations in the pervious zones shall be backfilled by tremie placed filter and drainage compatible materials



RISK EVALUATION

- Detailed description of any drilling fluid used including circulation and pressures
- Need to monitor
  - Loss of fluids
  - Sudden drop in casing/drill string
  - Rapid changes in piezometer levels
- Measures to minimize the risk
- Measures to prevent cross-contamination between aquifers
- Measures to prevent contact with structural members
- Emergency action plan

REVIEW PROCESS

- Drilling plans are submitted through the local district in support of the 408 process
- District to the USACE drilling review plan coordinator
- Plans are reviewed by 3 experienced engineers or geologists
- Comments are consolidated and transmitted back to the District
- Revised Plan is submitted by the district or outside entity
- Revised plan is back checked
- When the plan address all of the received comments the Community of Practice (CoP) lead is notified
- The CoP lead then sends concurrence with the plan back to the District

REVIEW TIME FRAME

Typical Plans – goal is 2 weeks for the initial review

Back check – typical less than a week

Atypical plans can take longer

Plan on longer review times at the end of the fiscal and calendar years

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	16
27	28	29	30			

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	16
27	28	29	30			

January	February	March
April	May	June
July	August	September
October	November	December