# EVOLUTION OF THE ROUGH RIVER DAM SAFETY MODIFICATION PROJECT


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Specialty Geotechnical Workshop for Dam + Levee Investigations + Modifications
Fort Lauderdale, FL | Dec 6-8, 2021



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# PRESENTATION OVERVIEW

- **Project Introduction and Background**
- 2012 Dam Safety Modification Project Overview
  - Phase I: Grouting Overview
  - Phase 2: 2017 Cutoff Wall Design
- Dam Safety Modification Report (DSMR) Supplement
- 2021 New Outlet Works and Cutoff Wall Project Overview

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# PROJECT LOCATION


# GENERAL PROJECT LAYOUT


**Outlet Works Construction:**

**Nov. 1955 to Jan. 1958**

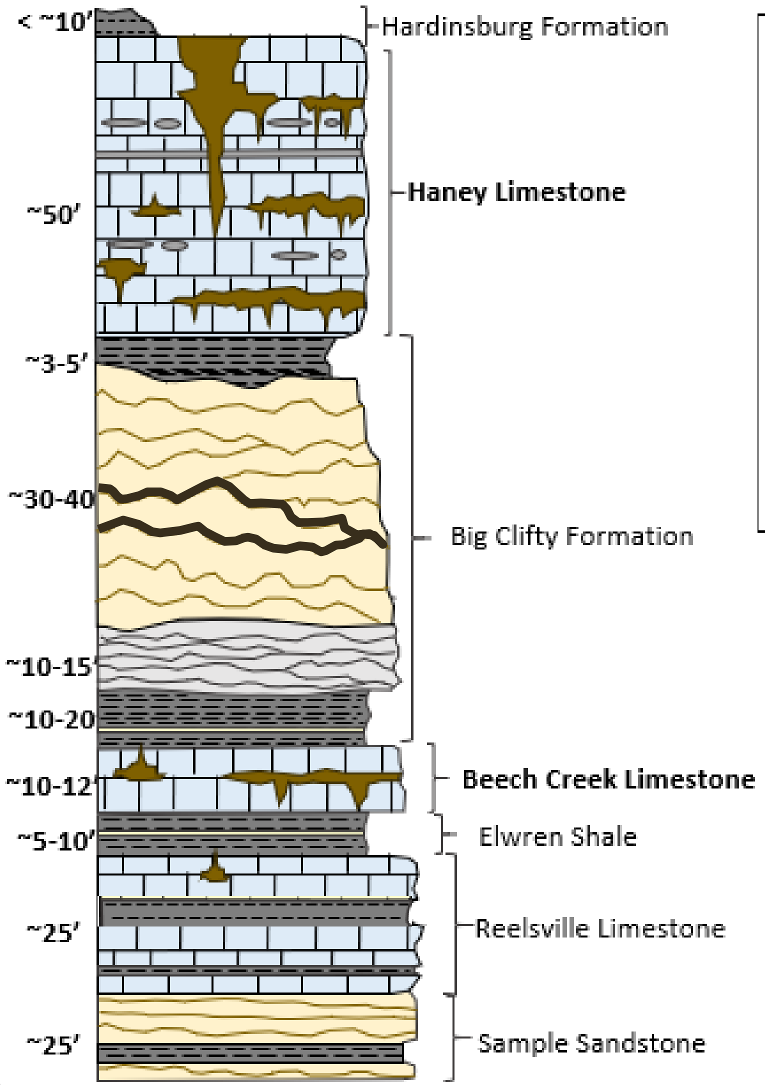
**Dam & Spillway Construction:**

**May 1957 to Dec. 1958**

| | |
|---|---|
| Dam Type | Earth Fill, partial Inclined Filter |
| Maximum Height | 130 feet |
| Crest Length | 1,590 feet |
| Outlet Features | ~600-ft long, 12-ft x 12-ft Semi-elliptical Concrete Conduit 65-ft wide Rock Spillway |

# MISSISSIPPIAN ROCKS AT ROUGH RIVER DAM

GOLCONDA FORMATION
- Beech Creek Limestone Member, Big Clifty Sandstone Member, and Haney Limestone Member.

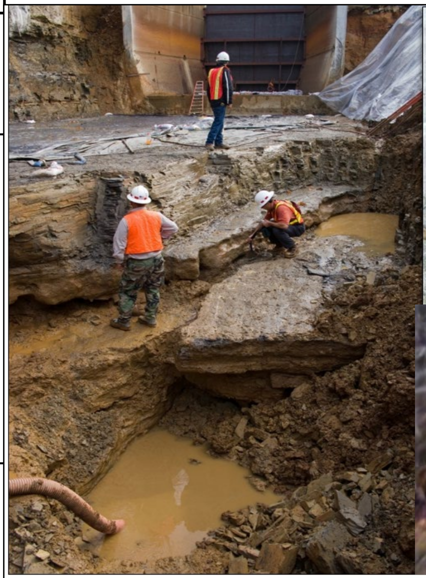



**Haney Limestone (Mgh) – ~50 feet thick**

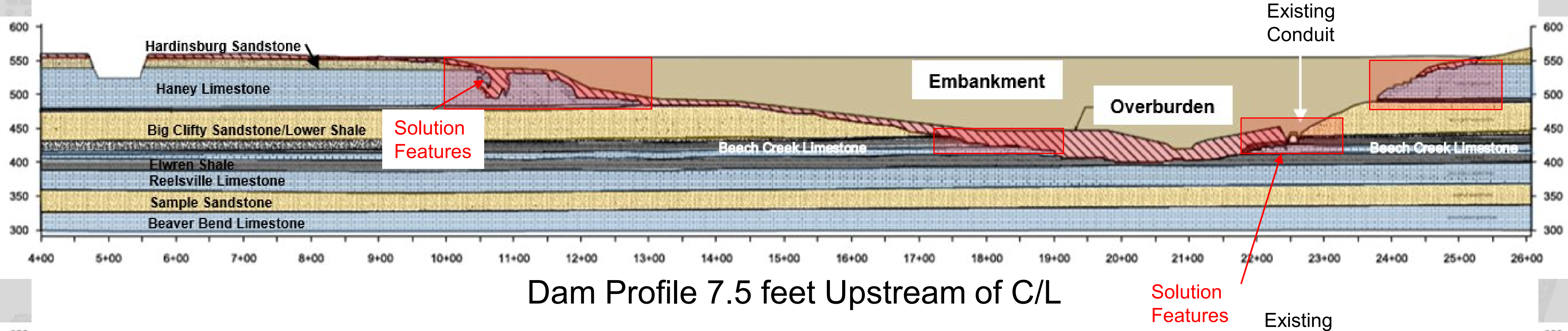
- Bedding is very thin to thick bedded with some laminated beds
- Light gray siliceous limestone with a fine to coarse crystalline texture – Cherty
- Highly karstic with known cavernous features
- Perched water table, piezometers read higher than pool


**Beech Creek Limestone (Mgc) - 10-15 feet thick**

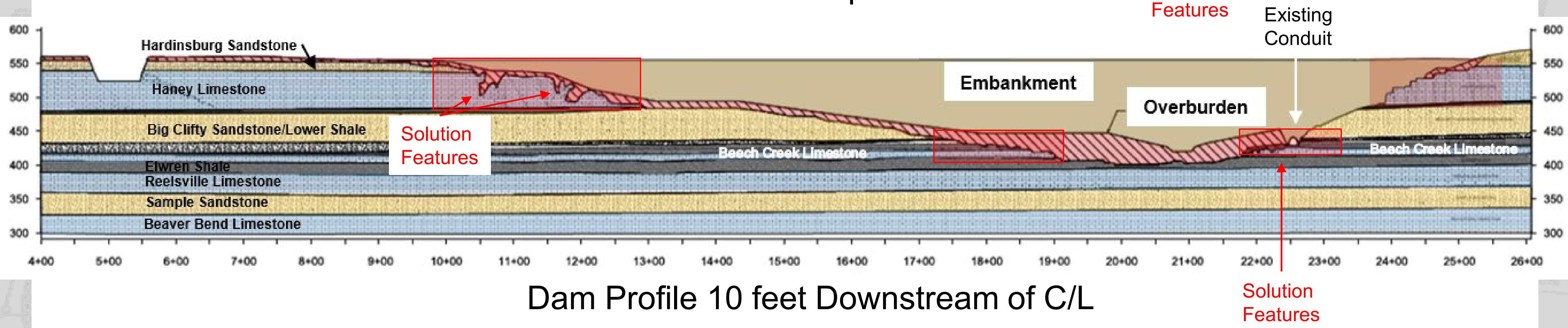
- Thinly bedded, fine to medium-grained
- Light to medium gray color
- Very karstic with open and clay filled voids
- Large solution features near weathered exposures



# GEOLOGIC PROFILES



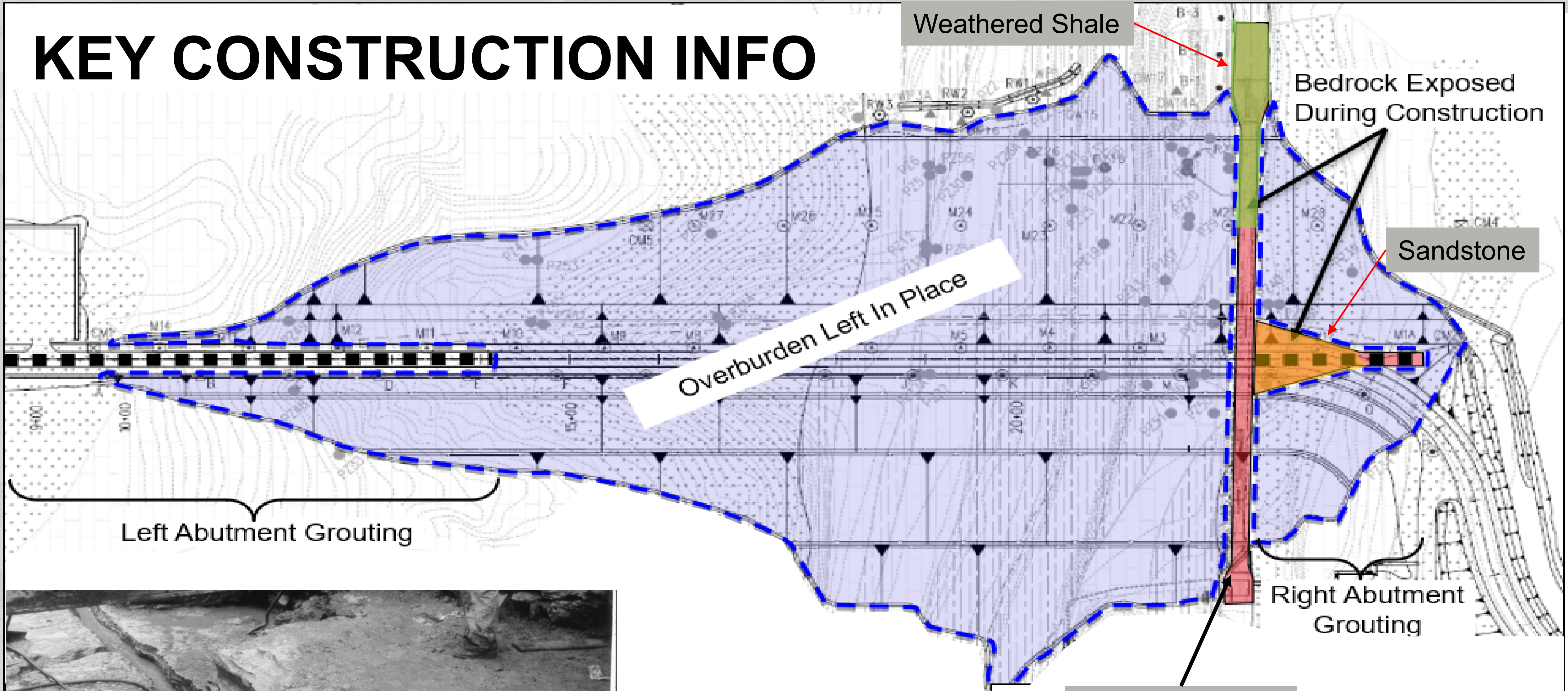

Dam Profile 7.5 feet Upstream of C/L



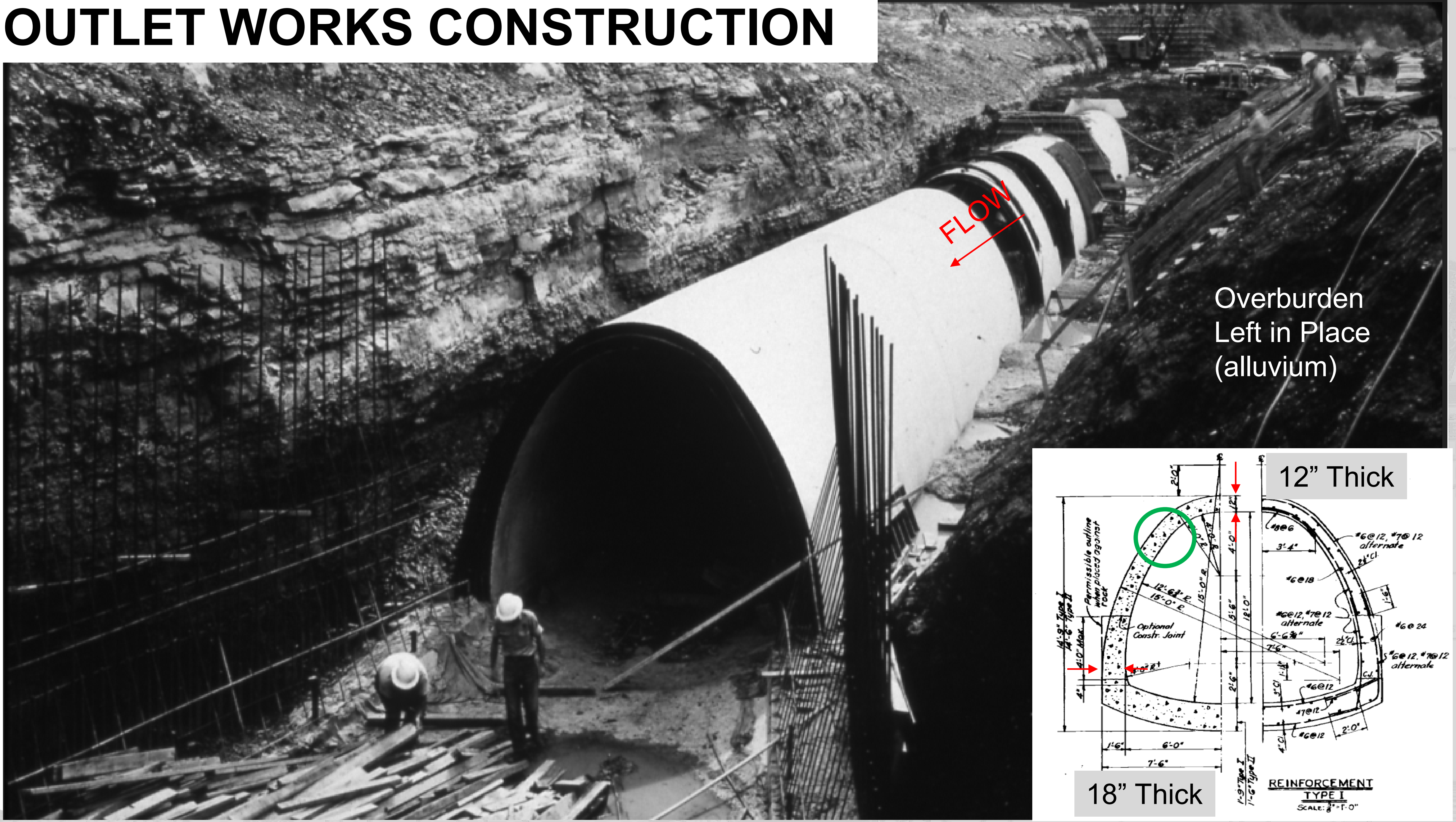

Dam Profile 10 feet Downstream of C/L

Limestone
Siltstone
In-situ Soils
Sandstone
Shale
Embankment

# KEY CONSTRUCTION INFO

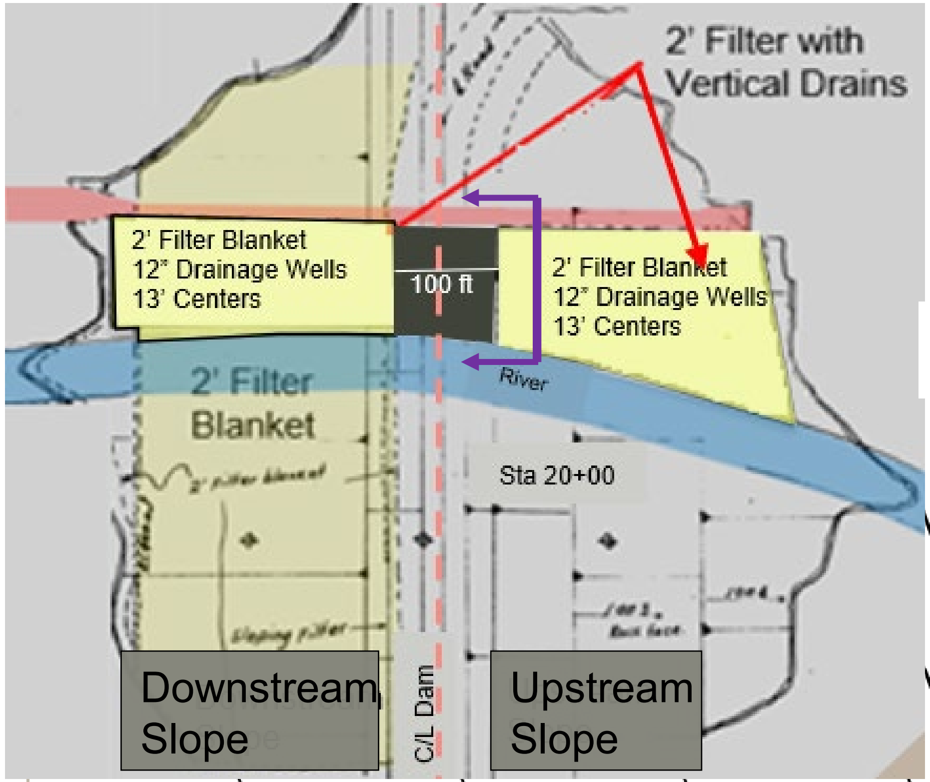


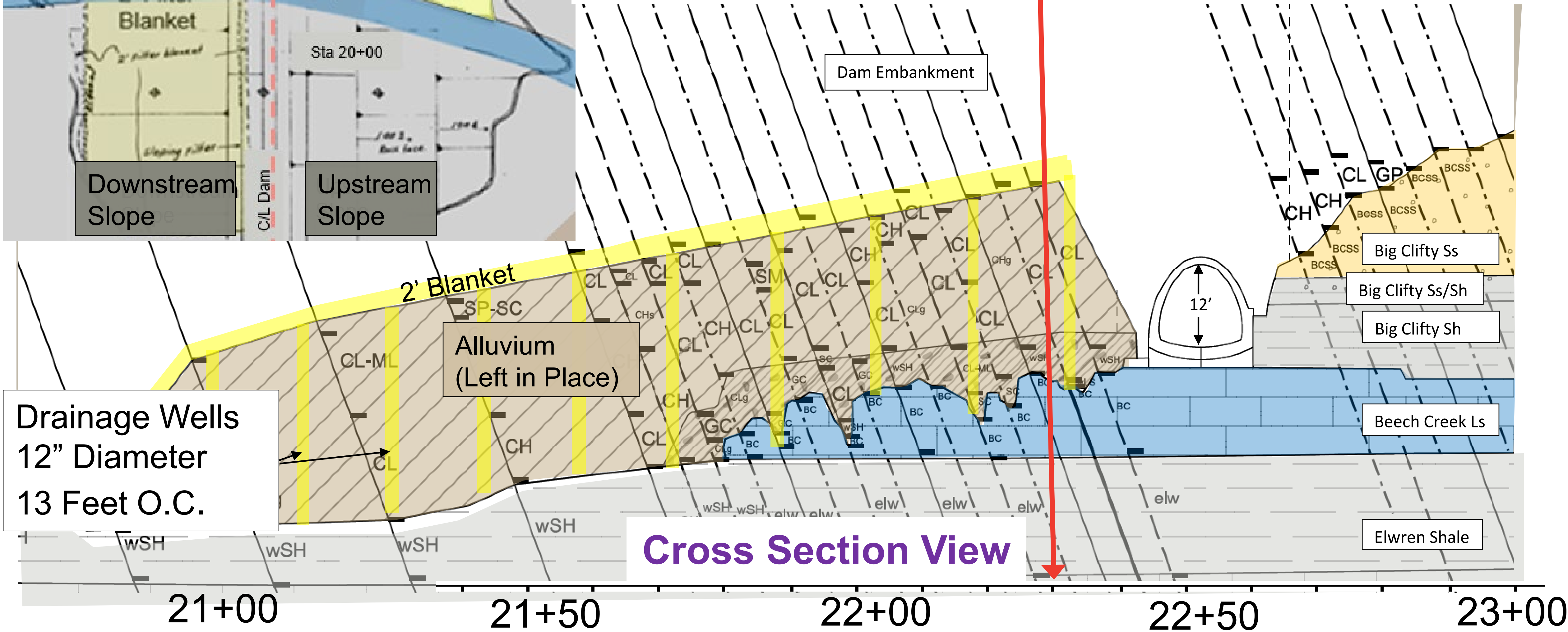

# OUTLET WORKS CONSTRUCTION



# UPSTREAM BLANKET AND BEECH CREEK LS

***C/L ROCK PROFILE PROJECTED 50' U/S TO END OF BLANKET DRAIN***



# HISTORIC DAM OPERATIONS – FLOOD CONTROL

## KEY ELEVATIONS

Winter (Flood Pool) = 470

Summer pool (Recreational Pool) = 495

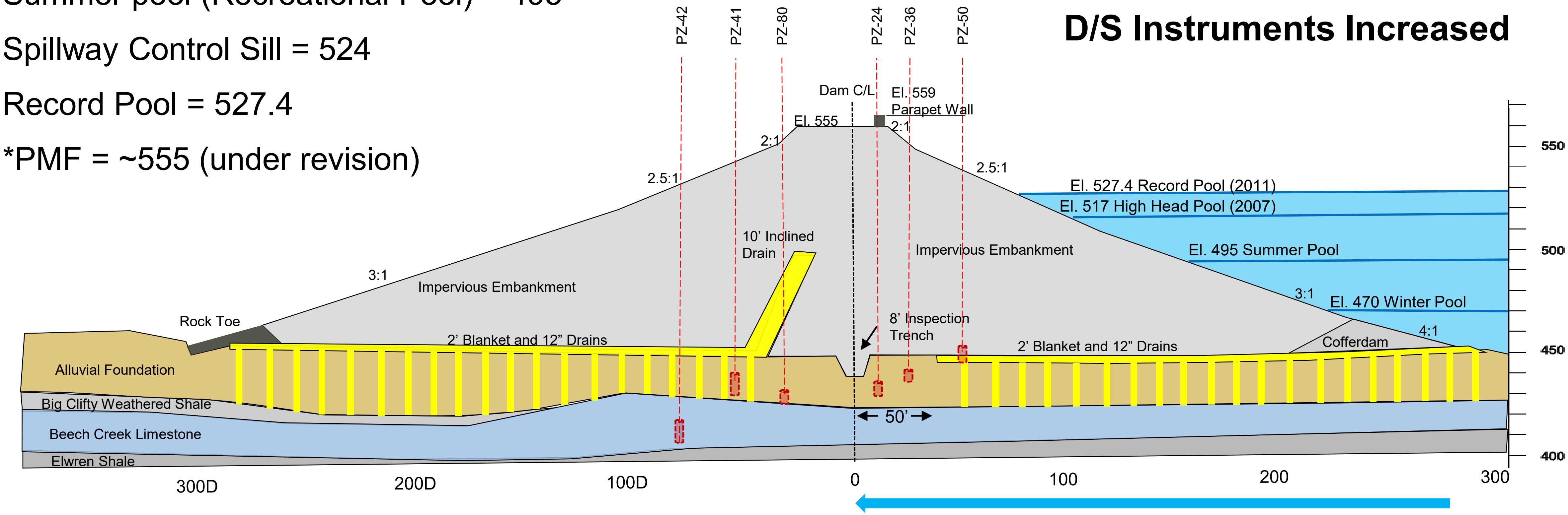
Spillway Control Sill = 524

Record Pool = 527.4

*PMF = ~555 (under revision)

**U/S Instruments Decreased**

**D/S Instruments Increased**




Blanket and drainage wells transmit full reservoir pressure into the foundation D/S – very high gradients at elevated pools

Stilling Basin Floor = 427

BCLS = 410 - 424

CROSS SECTION STA 22+30

# IMPACTS FROM THE 2011 RECORD POOL


Dam and Reservoir


2011 Stilling Basin Dewatering


Stilling Basin Discharge

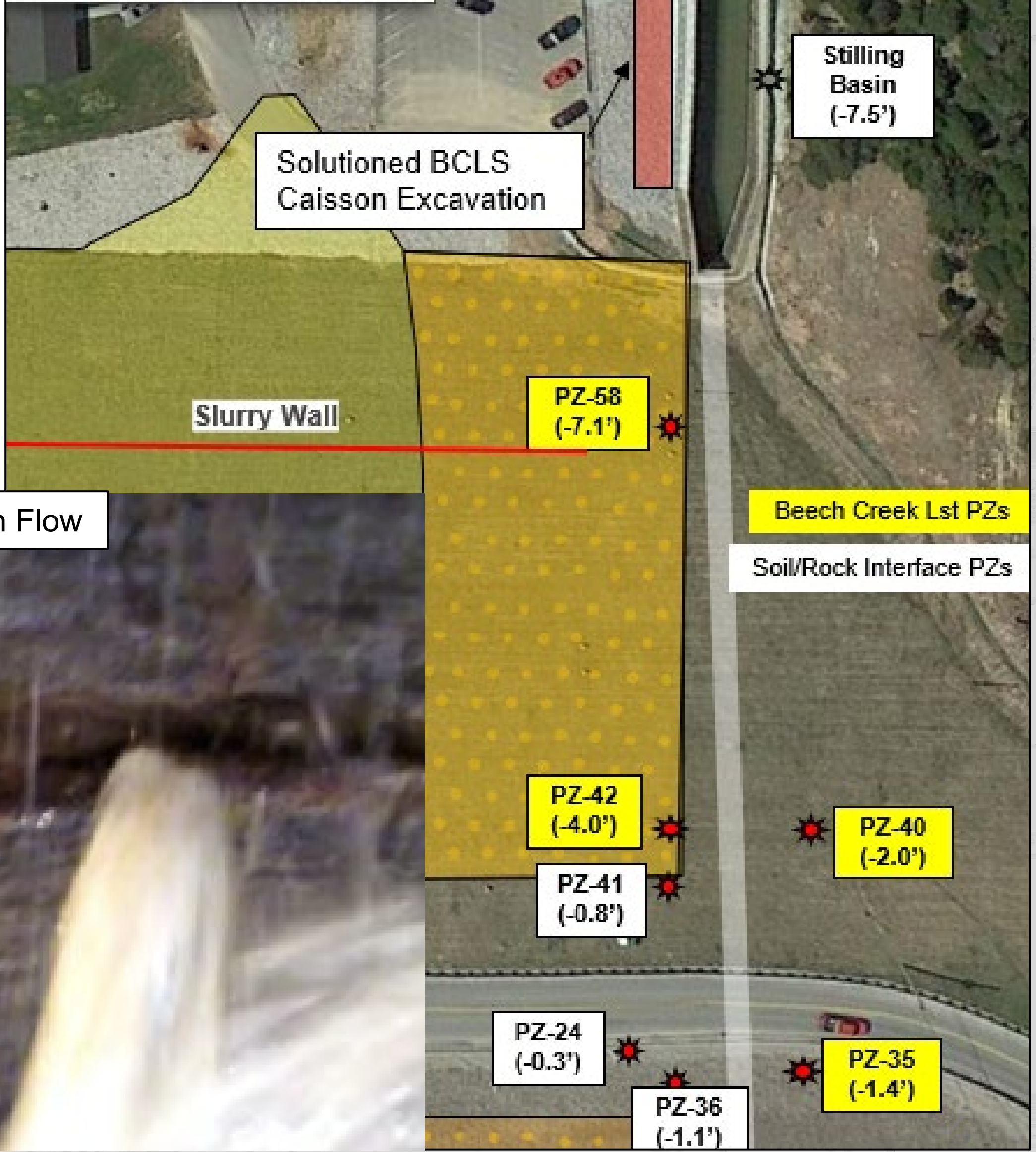

Artesian Flow Through Weep Hole

# 2012 STILLING BASIN REPAIRS

2012 Caisson Recovered Rock Plug

Caisson Excavation – Observed High Flow

Dewatering Influence on Piezometers



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Note: The DSMR for Rough River predates USACE guidance from Engineering Regulation (ER) 1110-2-1156 Safety of Dams – Policies and Procedures.

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# 2012 Dam Safety Modification Report (DSMR) Overview

- Classified as Dam Safety Action Classification (DSAC) 2 due to 5 internal erosion related failure modes.

- The approved plan for mitigation required a multi-phased approach to include Phase I and Phase II Projects:

<u>Phase I:</u>

- An upstream traffic platform;
- Enhanced instrumentation;
- A full-length exploratory grout line;
- Evaluation of the Phase I results to determine if a cutoff wall was needed;

<u>Phase II:</u>

- Two grout lines for slurry control;
- A full-length cutoff wall placed around the existing conduit;
- Grouting from within the conduit;
- A downstream filter around the conduit;

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DAM SAFETY MODIFICATION REPORT
ROUGH RIVER DAM

GREEN RIVER BASIN
FALLS OF ROUGH, KENTUCKY

STATUS: Final Submittal
FOR OFFICIAL USE ONLY

JULY 2012

# PHASE 1A HWY 79 RELOCATION - 2014



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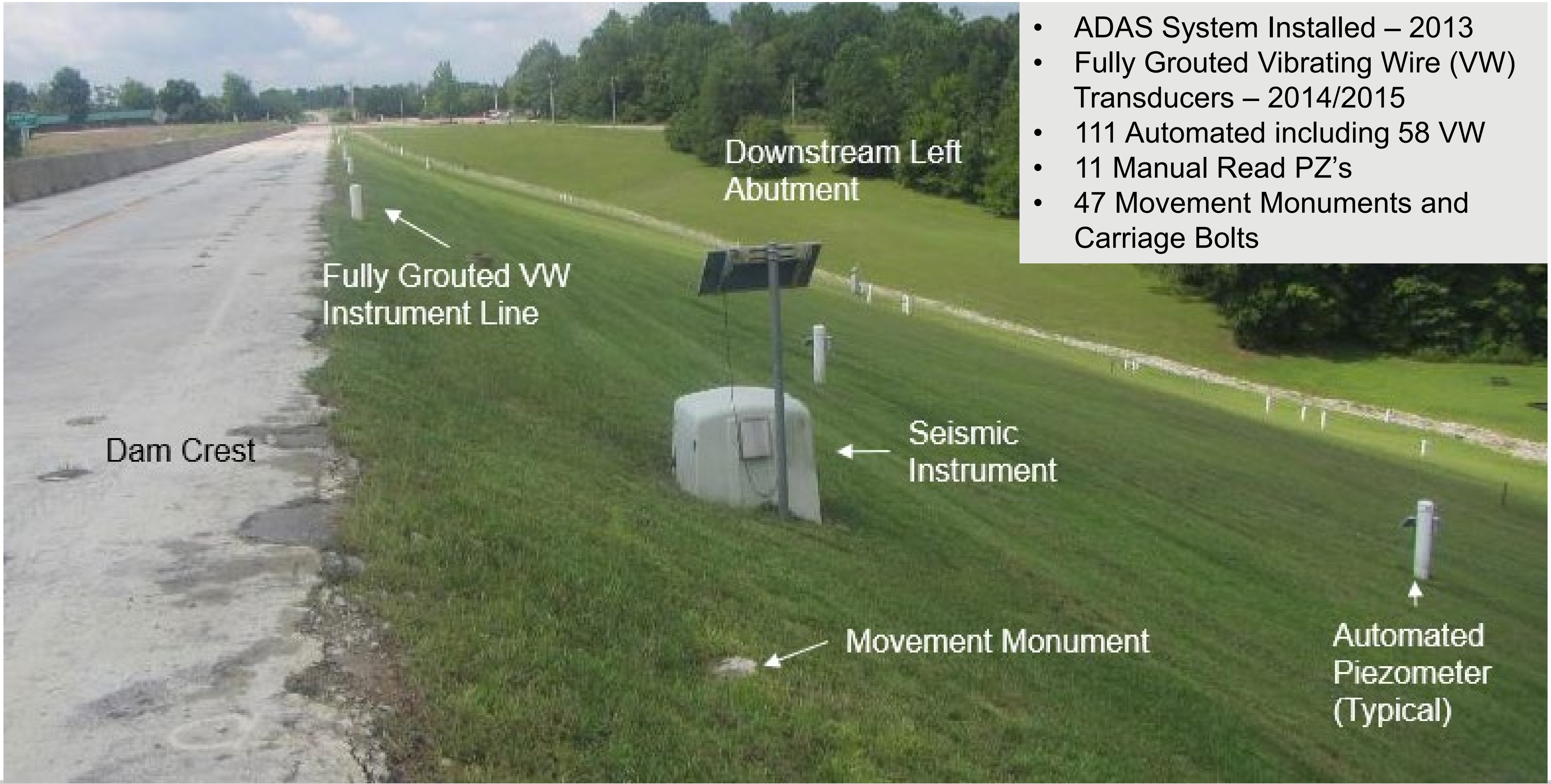
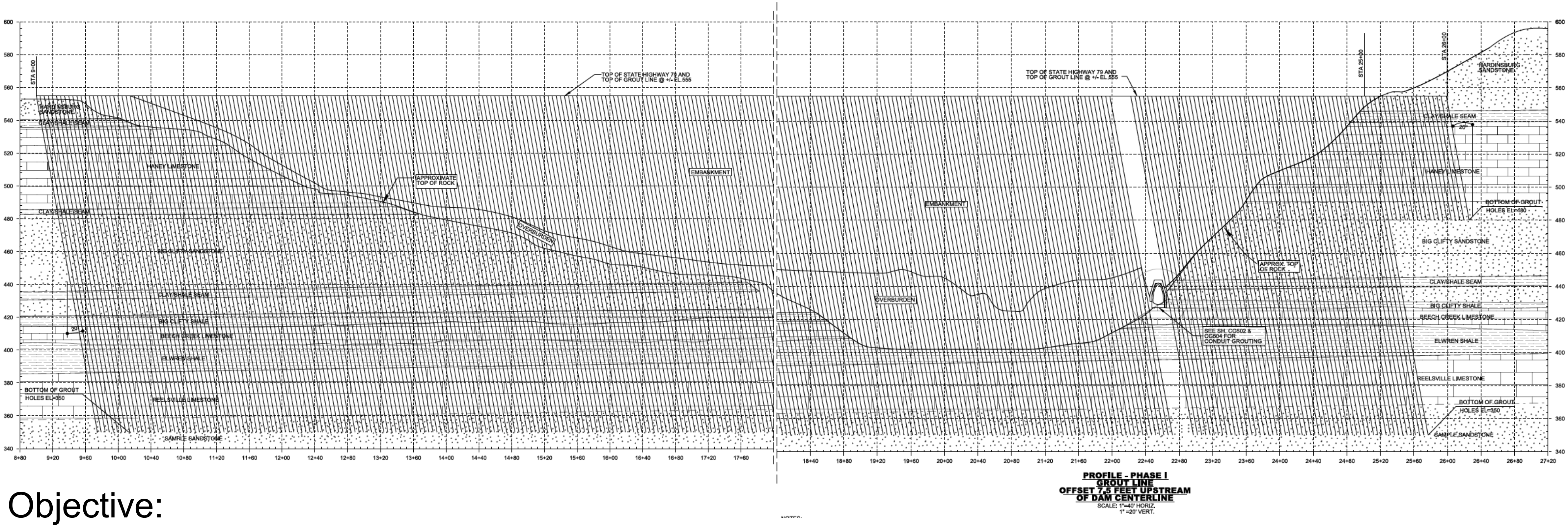
# ENHANCED INSTRUMENTATION

- ADAS System Installed – 2013
- Fully Grouted Vibrating Wire (VW) Transducers – 2014/2015
- 111 Automated including 58 VW
- 11 Manual Read PZ’s
- 47 Movement Monuments and Carriage Bolts



# 2012 DSMR – PROPOSED EXPLORATORY GROUTING




Objective:

1) Explore and evaluate subsurface conditions and evaluate the need for a future cutoff wall.

2) Determine the extents of additional grouting, if needed.

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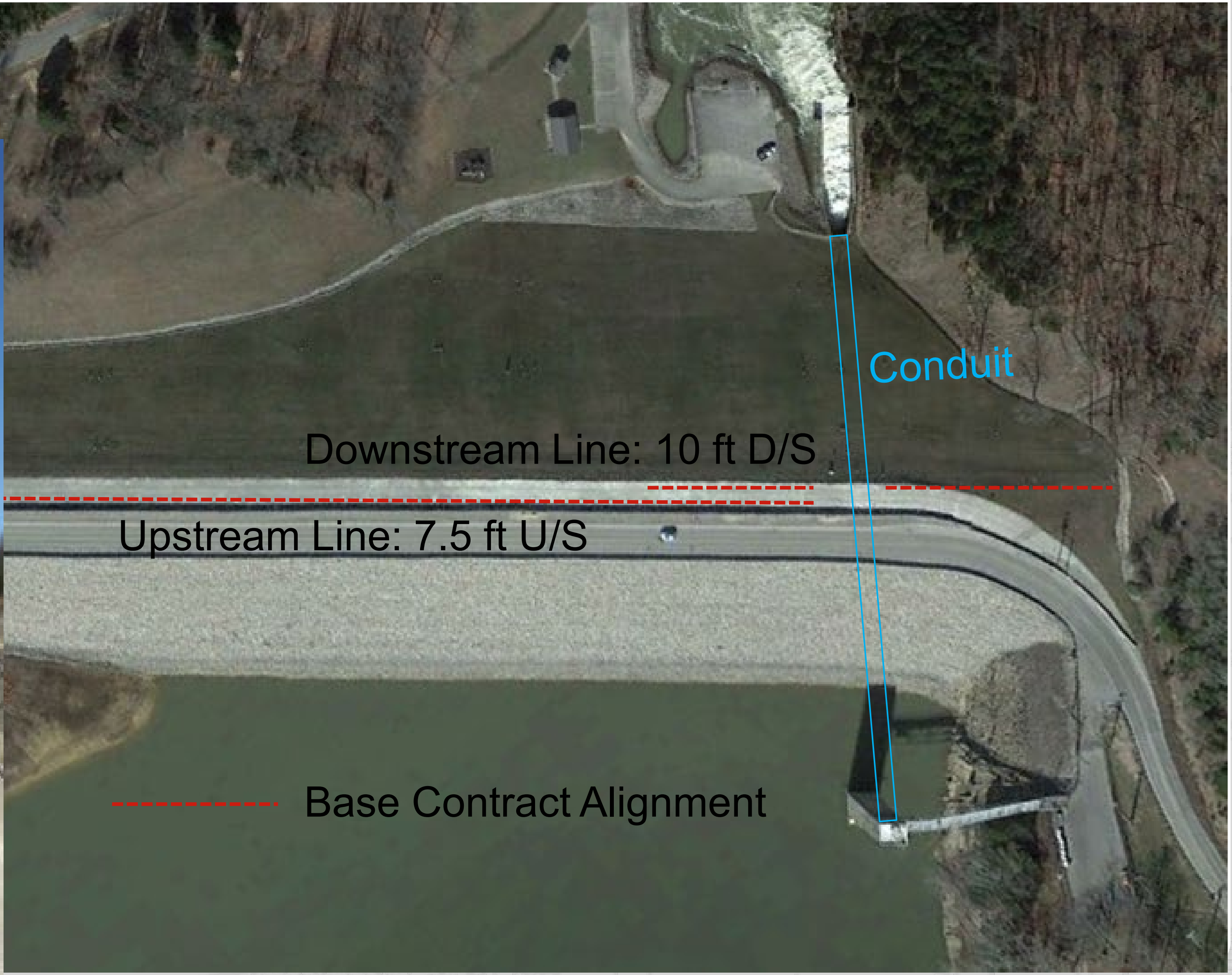
# PHASE IB EXPLORATORY GROUTING (BASE CONTRACT)

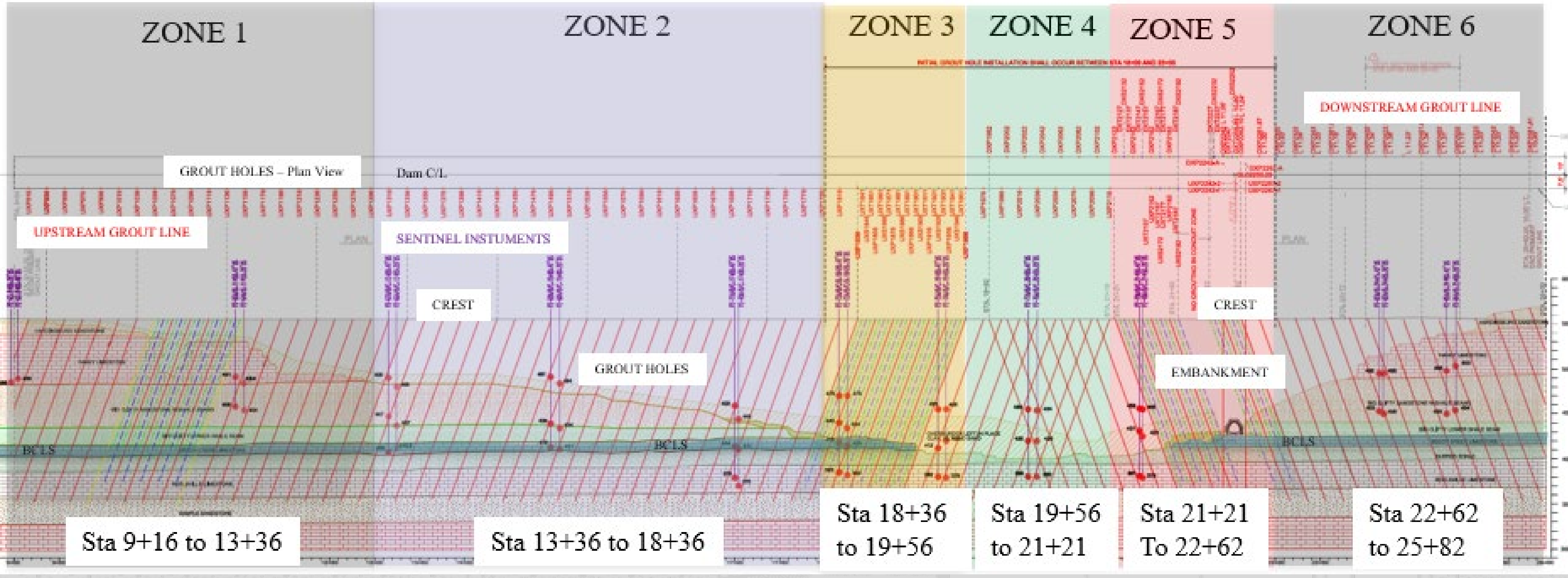



# PHASE IB EXPLORATORY DRILLING AND GROUTING



Technical Approach - Base Contract

1) The dam was broken up into zones based on the bedrock in contact with the embankment.
2) Each zone was required to be fully isolated from the embankment before pressure grouting could proceed.
3) Required the use of an instrumented packer for all grouting and water pressure testing.



# GROUTING SPECIFICATION REQUIREMENTS

- Mandatory downstage grouting in rock required if drill fluid return was lost or hole communication occurred.
- Concurrent drilling and grouting operations were not allowed within 80 feet of adjacent holes.
- Used a balanced, stable grout mix.
- Refusal for gravity grout stages was 0 flow for 1 hour. Refusal for pressure grout stages was 1 gal/min held for 10 min.
- The Contractor was required to perform optical and acoustic televiewer (OATV) surveys for primary boreholes to verify rock contacts and the condition of the bedrock.
- The project required an automated data management system to provide the real time status for grouting progress and any noted instrumentation reactions.

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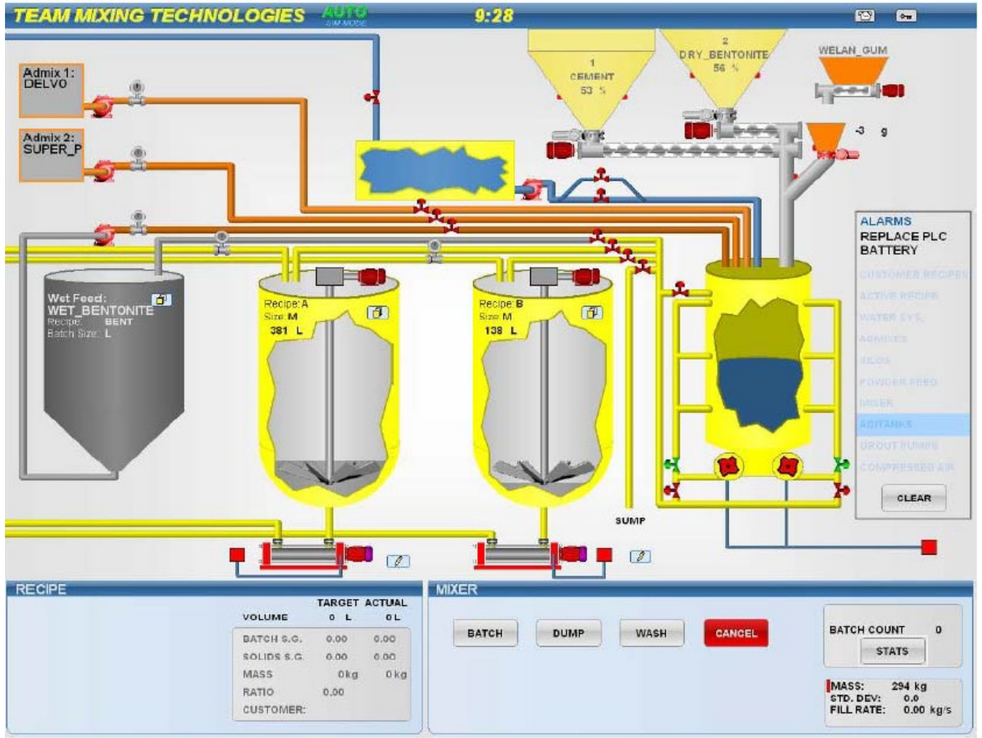
# GROUT MIXES

- Cement-Bentonite High Mobility Grout Mixes
  - All are balanced, stabilized grouts, <1% bleed
  - E mix is a sanded mix
- W/C content varies from 0.7 – 1.5
- Specific Gravity from 1.4-1.7
- Marsh Funnel Times
  - A mix – 35-40
  - B mix – 40-55
  - C mix – 55-70
  - D mix >70
  - Flow cone for E mix >12
- Use a neat A mix for barrier bag inflation

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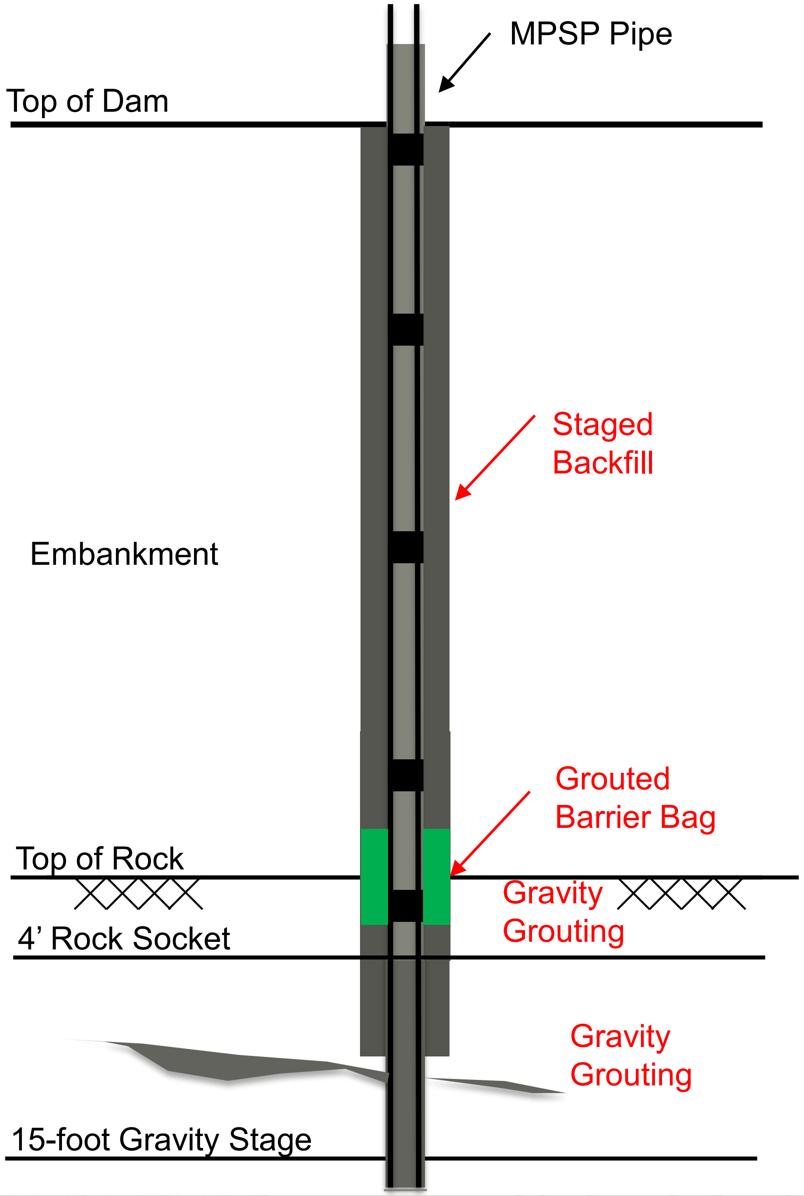
# DRILLING/GROUTING PROCESS - GRAVITY ZONE




Work conformed to USACE EM 1110-2-3506 Grouting Technology and ER 1110 -1-1807 Drilling and Earth Embankment Dams and Levees;

Sequence for each hole was:

a) Advance borehole to 4' rock socket with resonant sonic drilling;
b) Install MPSP Pipe with barrier bag;
c) Inflate barrier bag, stage backfill the annular space of standpipe;
d) Grout the 4' rock socket zone at gravity pressure;
e) Grout the upper 15' gravity stage.
f) Complete gravity stage for the entire zone before deeper pressure grouting can commence.

**Instrumented packers were required for all water pressure testing and grouting**

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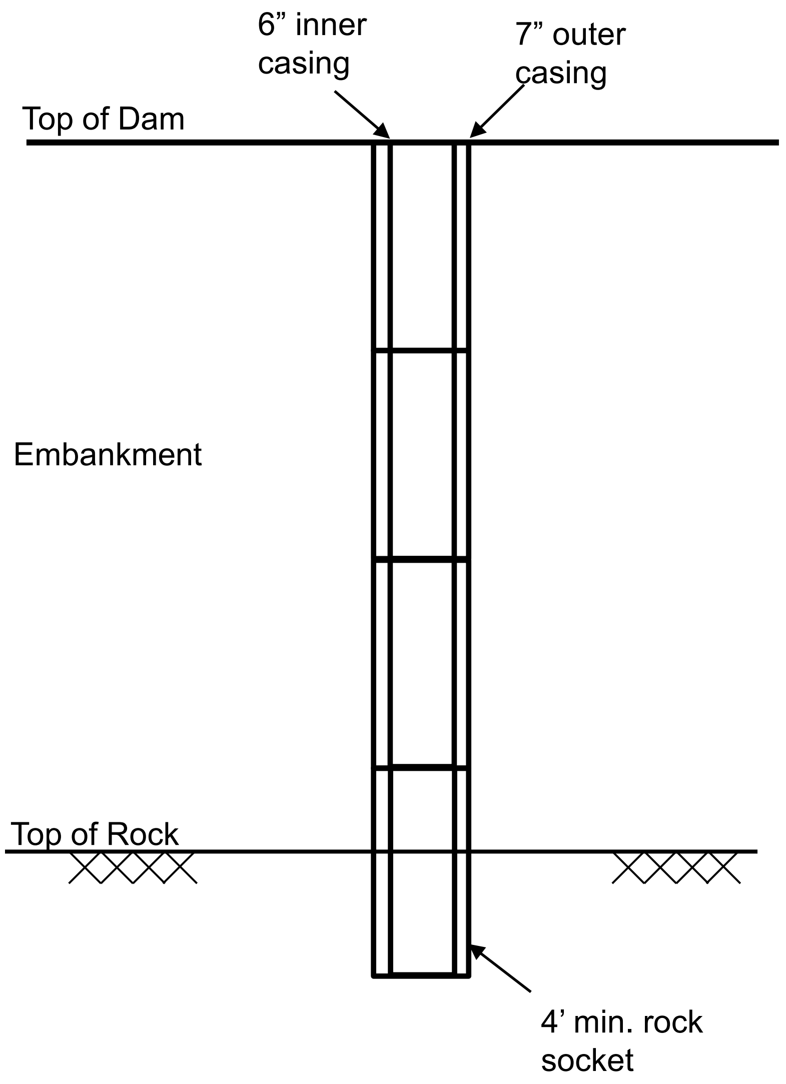
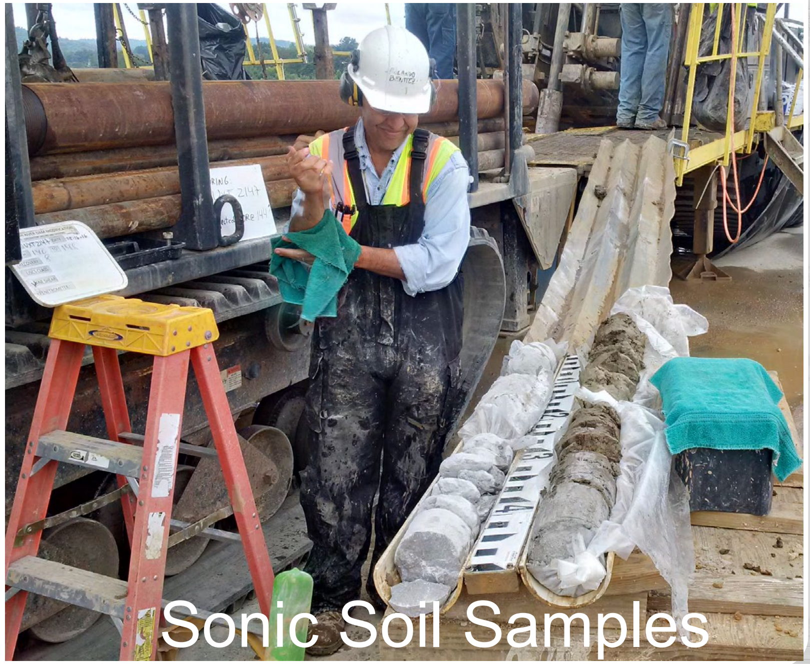
# EMBANKMENT DRILLING

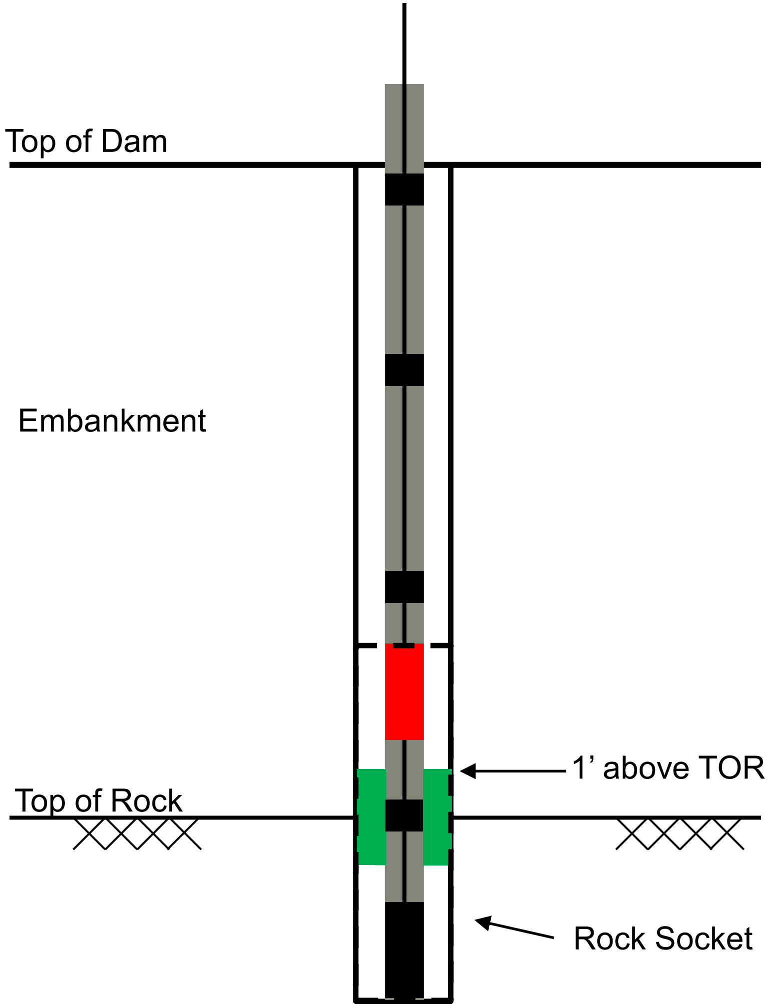



- Utilized 7X6 drilling method (6” sample, 7” override casing).
- Continuous soil sampling and logging.
- Steel casing is socketed a minimum of 4 feet into rock.
- Inner Casing is removed, PVC Multiple Port Sleeve Pipe (MPSP) installed in the borehole.
- All on-site drilling conformed to USACE Engineering Regulation (ER) 1110-1-1807, Drilling in Earth Embankment Dams and Levees.

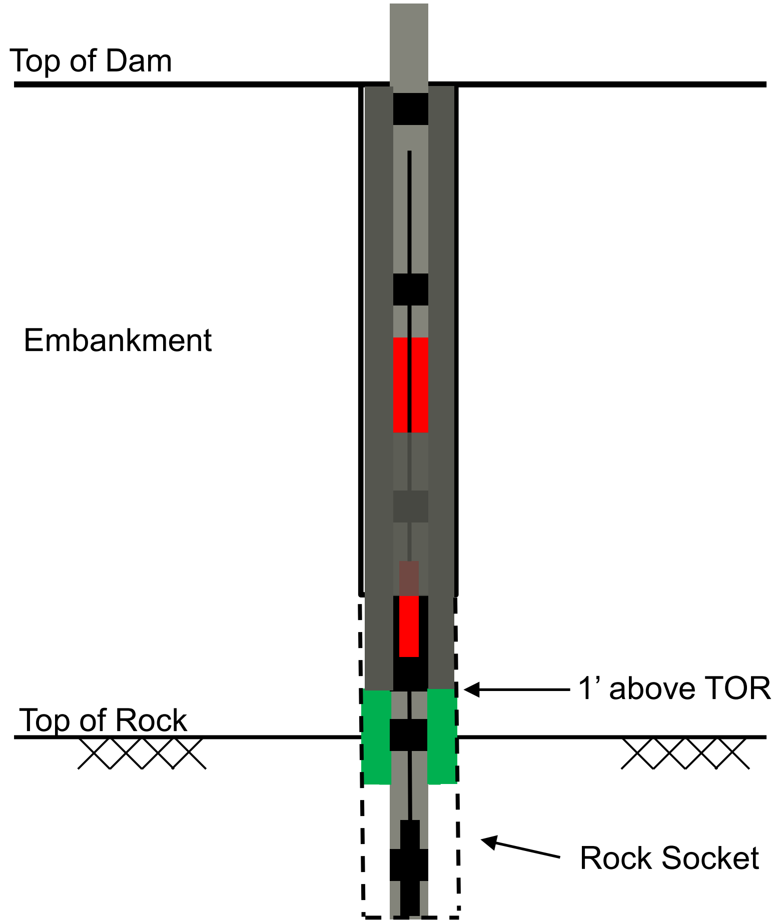
# INSTALLATION OF PROTECTIVE BARRIER BAG

- A Multiple Port Sleeve Pipe (MPSP) installed in the hole with a barrier bag 1 ft. above the top of rock.
- Outer casing raised above soil/rock interface.
- Dual Packer setup is lowered into the hole and inflated.
- Barrier bag is inflated using neat grout.
- Barrier bag isolates the casing annulus from the soil/rock interface.





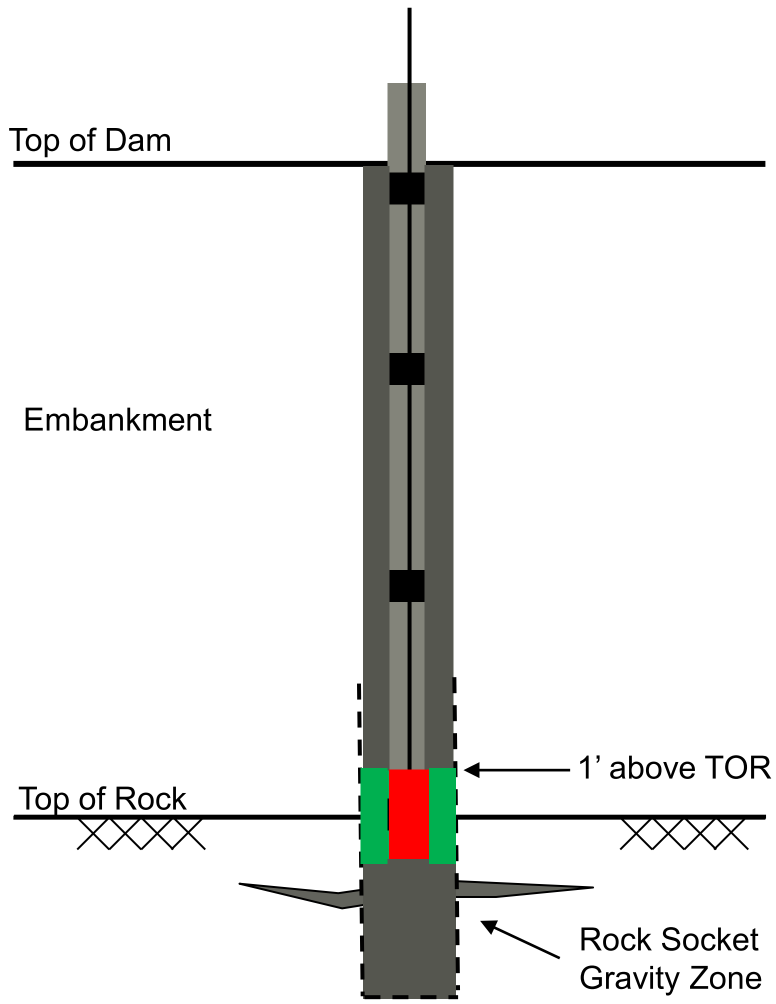
# GROUTING MSPS ANNULAR SPACE




- Dual packer is raised to the next port and inflated.
- The casing annulus is grouted through the port.
- Dual packer is then deflated and removed.
- The remaining steel casing is removed, and the hole topped off.

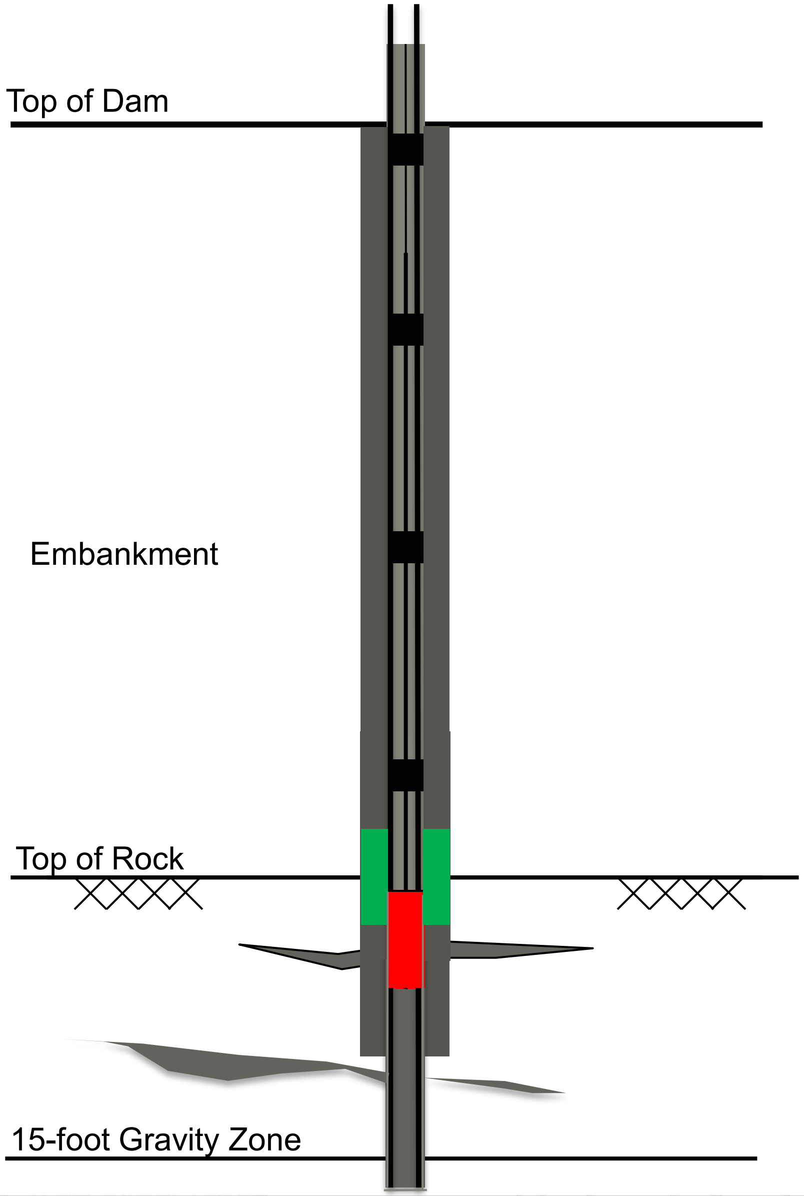

Typical Grout Cart and Grout hole layouts

# SOCKET INTERFACE GROUTING




- Single instrumented packer is lowered to 1 foot above TOR and inflated.
- Soil-Rock interface is then grouted through the bottom port.
- Packer is deflated and removed.
- The casing is flushed with water.

# DRILLING/GROUTING PROCESS - GRAVITY ZONE

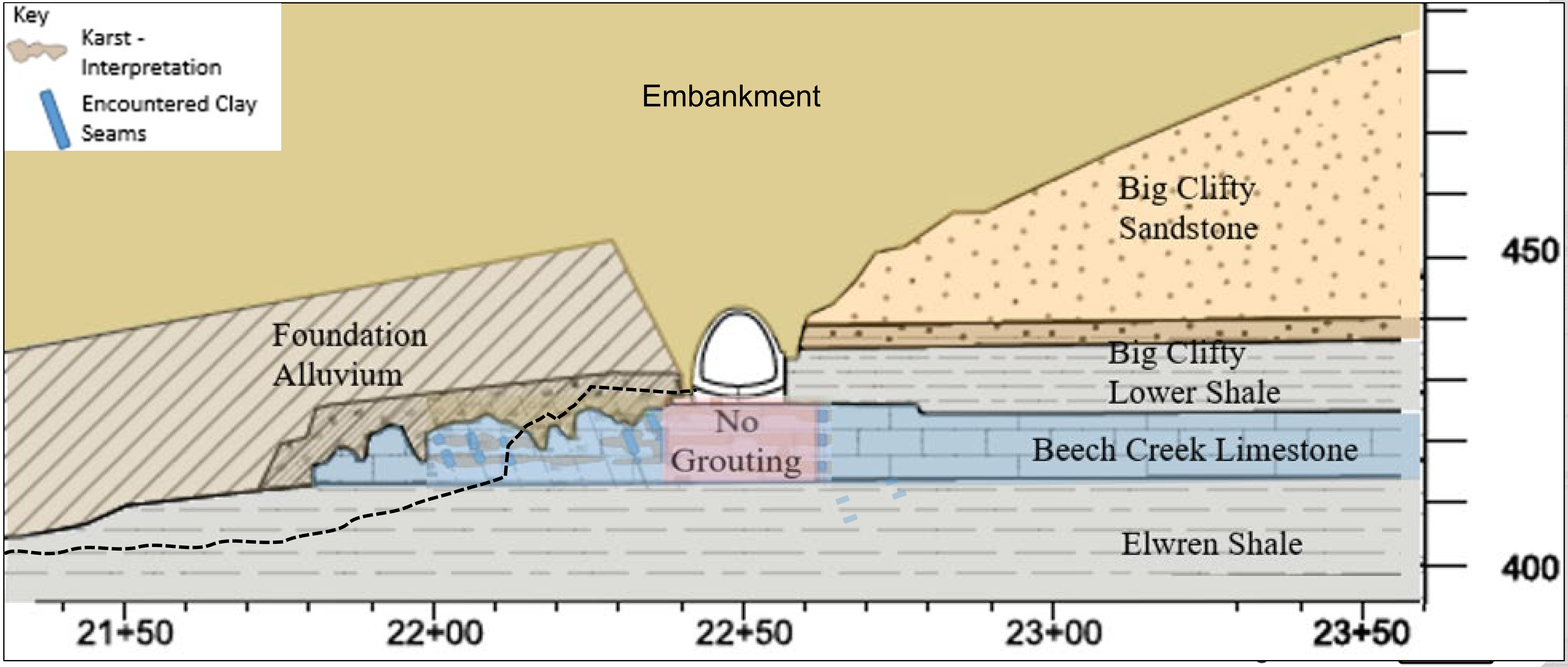



- Drill old grout and rock using a core drill.
- Single instrumented packer lowered to 1 foot below TOR and inflated.
- 15’ Gravity Zone grouted through a port on the packer.
- Packer is deflated and removed.
- The casing is flushed with water inside the casing.
- Each individual zone required full gravity grout completion before pressure grouting was permitted.

Water-actuated, down-the-hole hammer

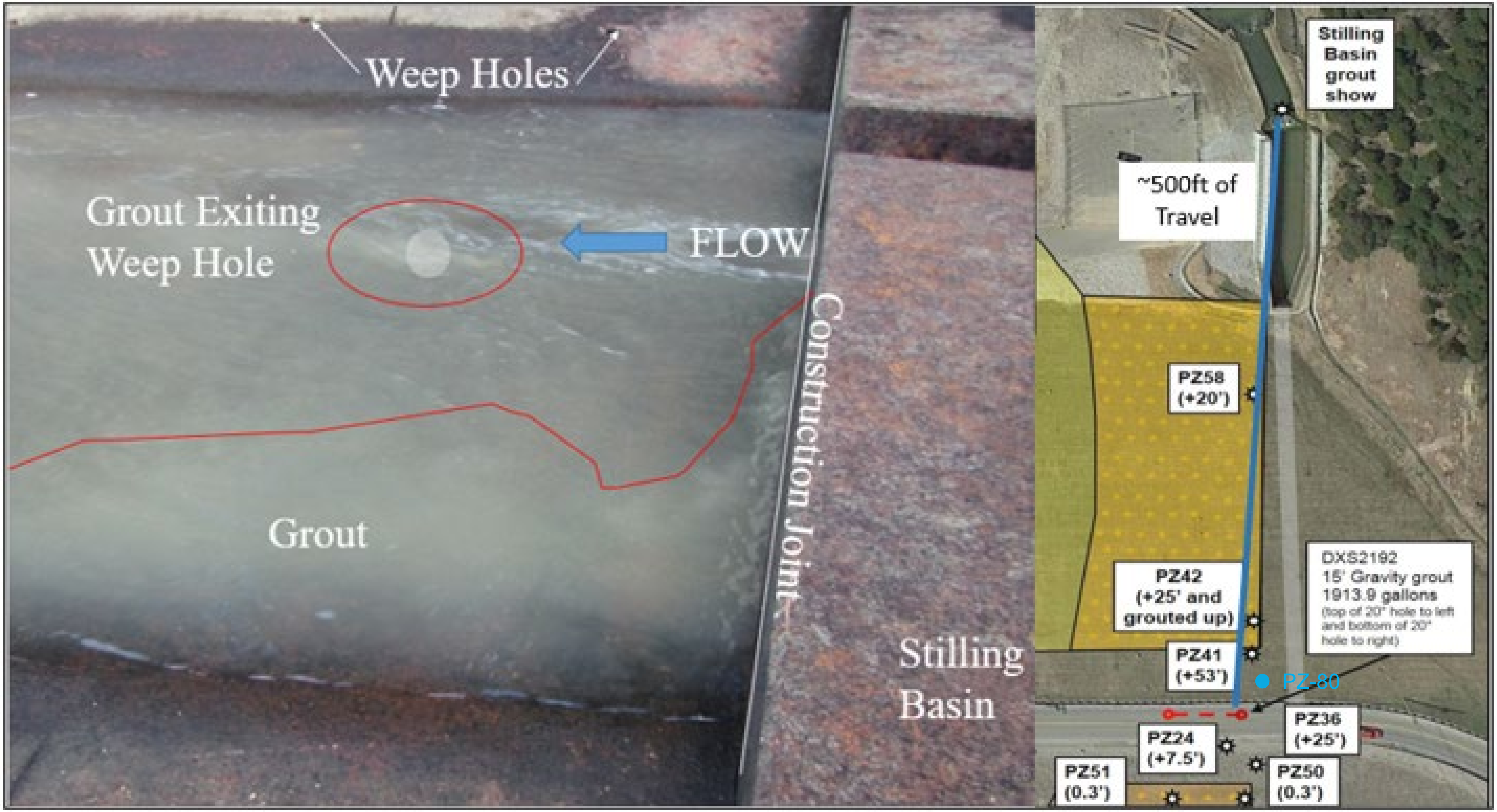
# GEOLOGIC INTERPRETATION – BCLS RIGHT



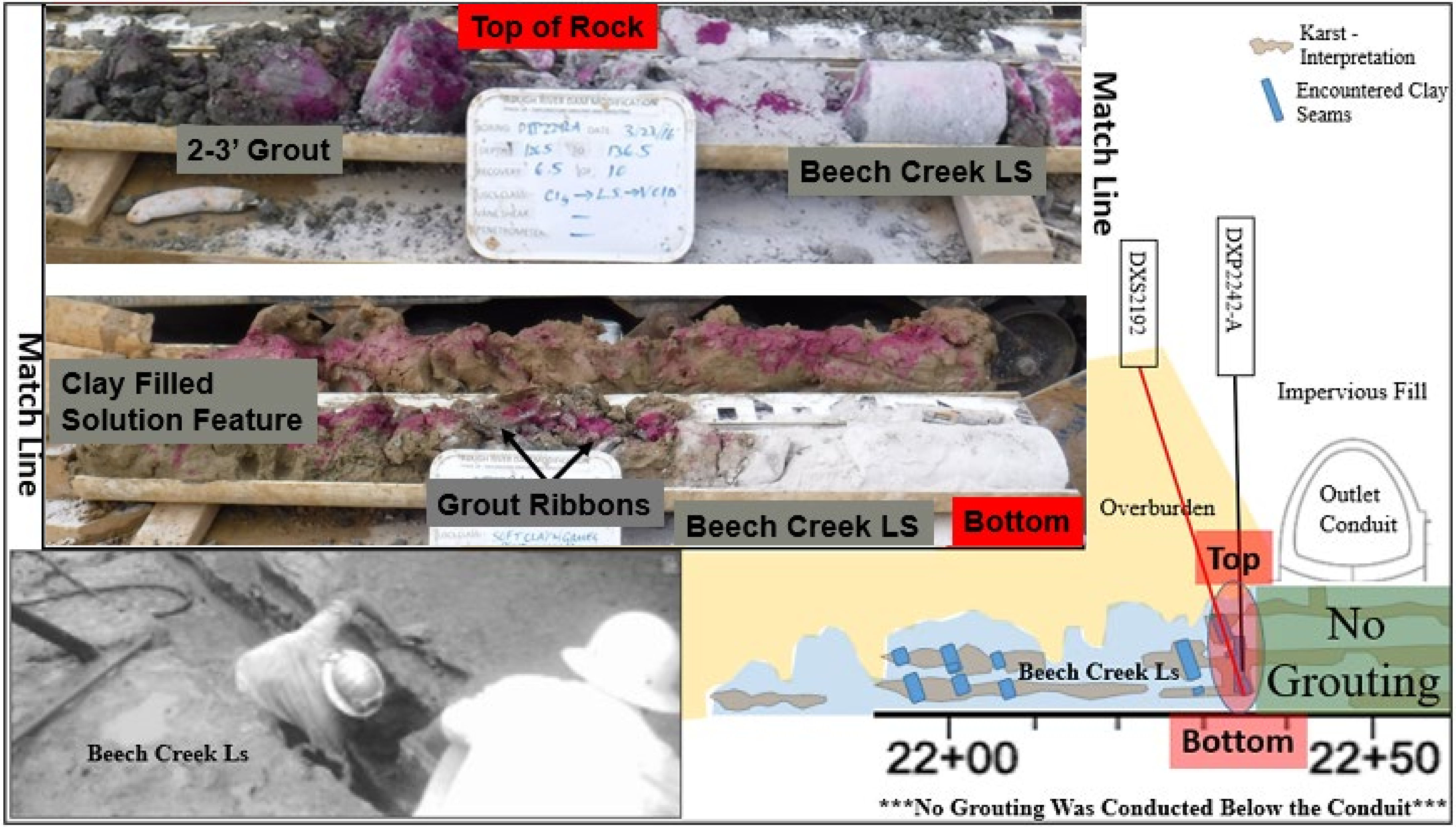


# BCLS UNFILTERED EXIT INTO THE STILLING BASIN

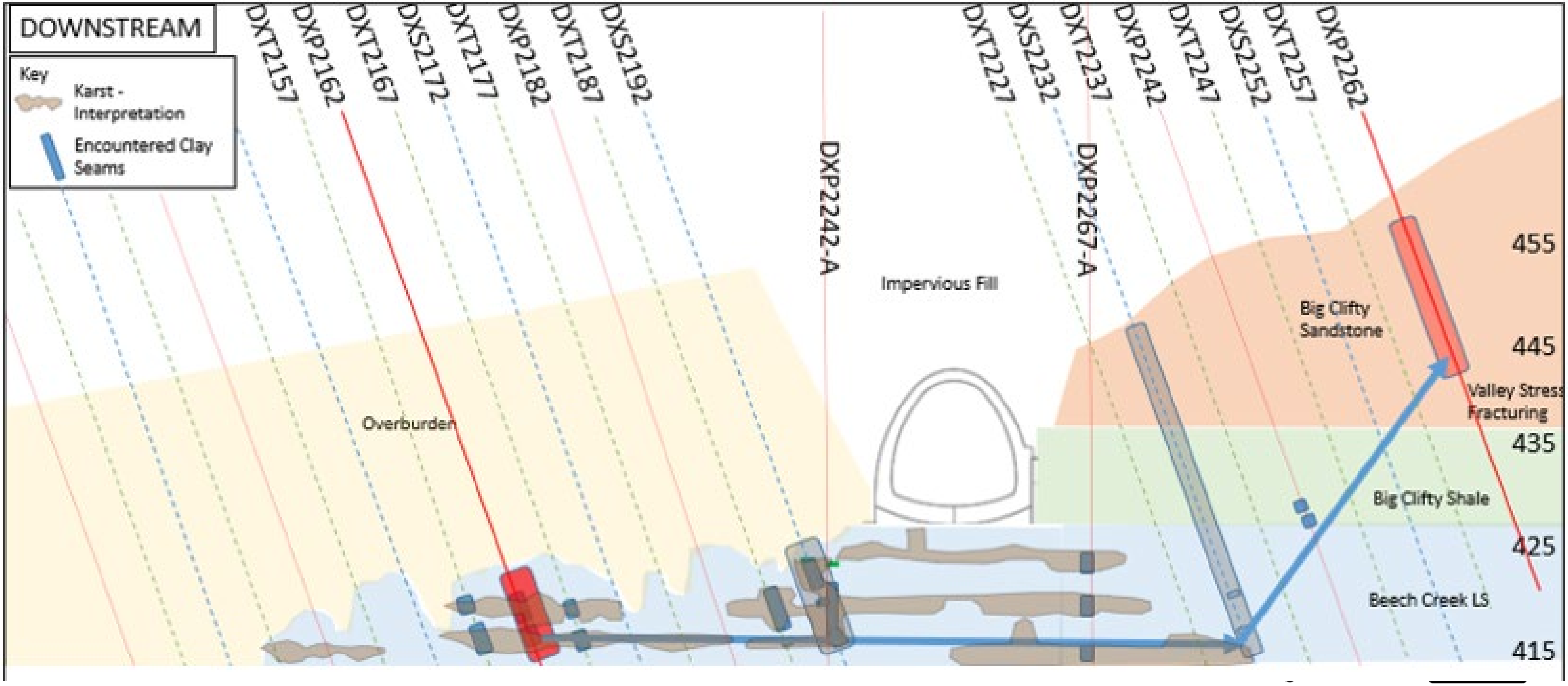




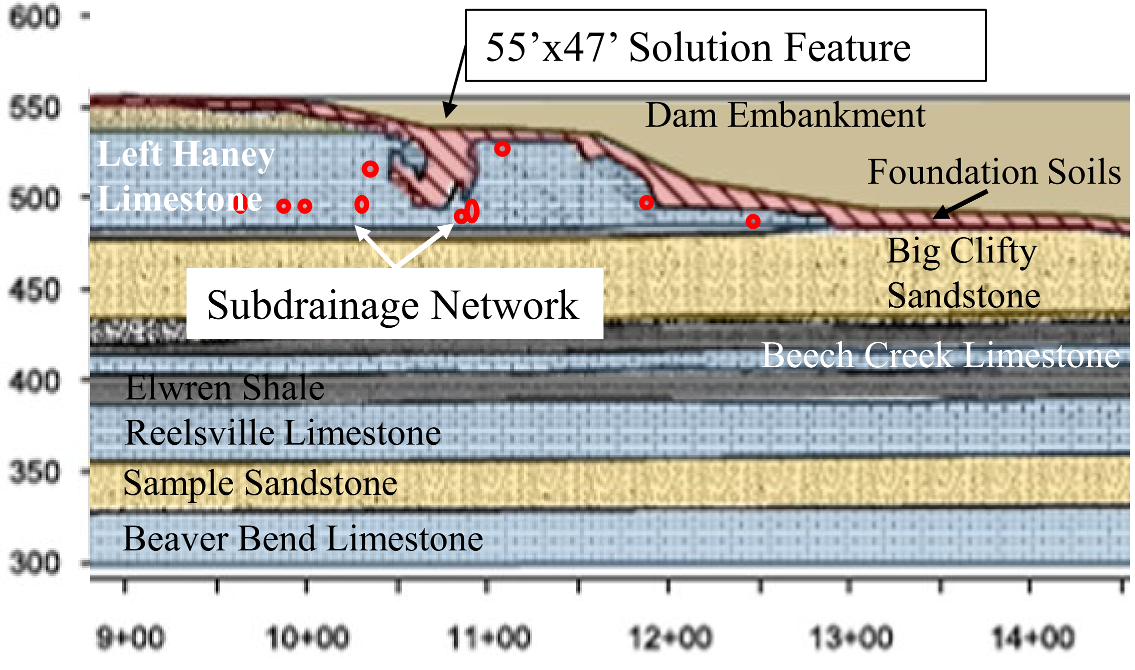
# BCLS VOIDS AND CLAY INFILL



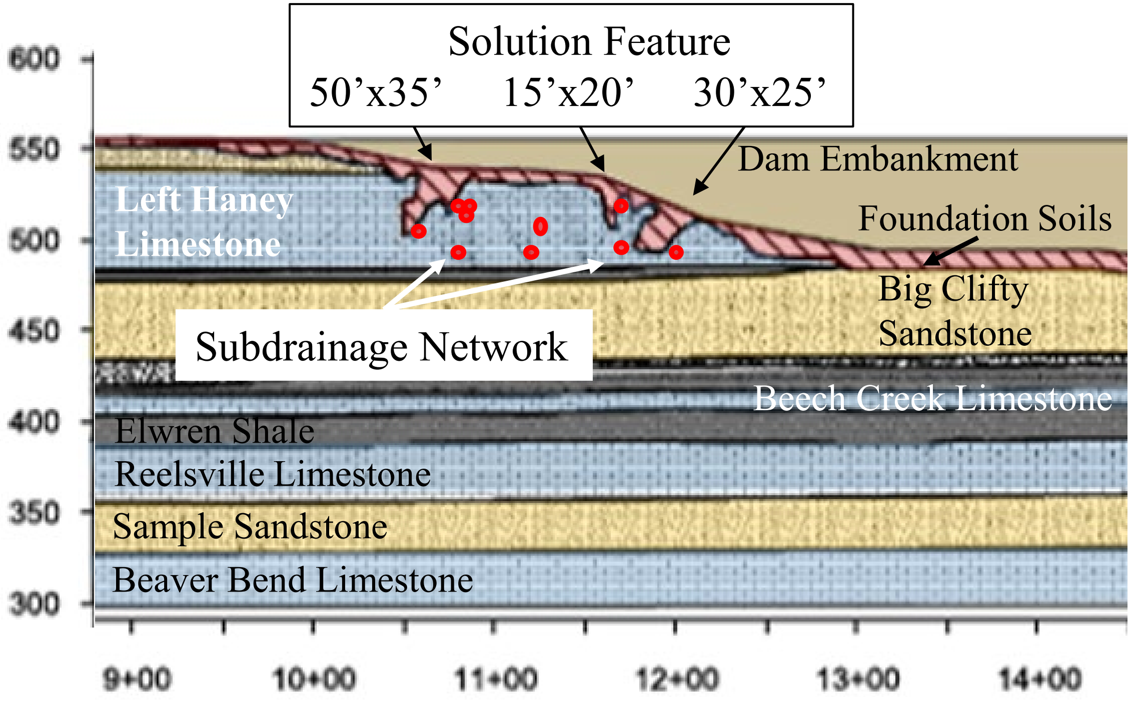
# COMMUNICATION BELOW THE CONDUIT



# LEFT ABUTMENT HANEY LIMESTONE




Upstream Crest




Downstream Crest

# 2016 SQRA

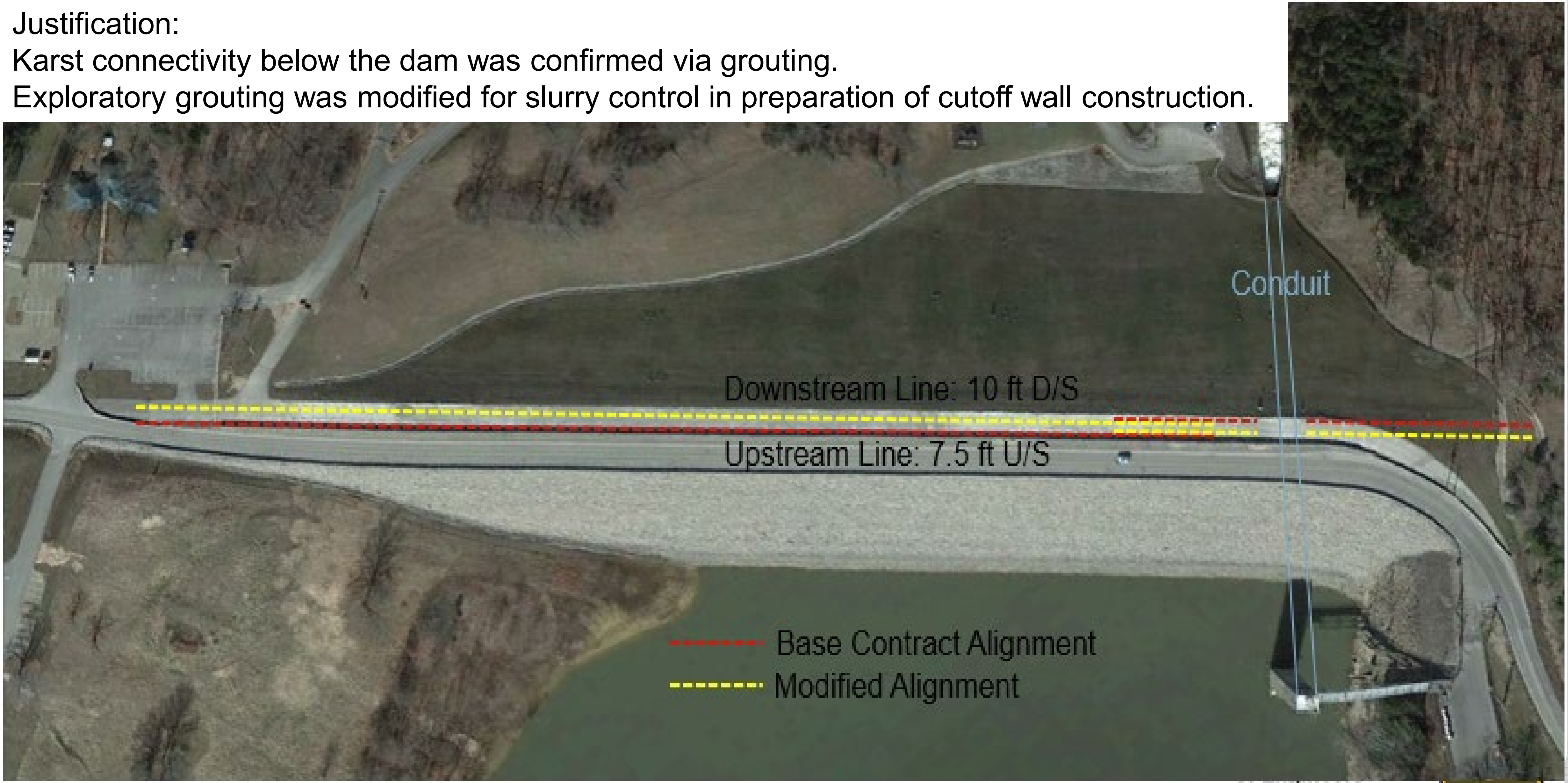
- Purpose: Evaluation and confirmation of the original DSMR risk assumptions.
  - Recommended Approval of Cutoff Wall.
  - Recommended Installation of additional instruments near the conduit.

- Received approval from ASA(CW) in February 2017 to proceed with design and budgeting for the cutoff wall construction.

- LRL Modified Phase IB to complete both grout lines for slurry control in advance of cutoff wall.
  - Serves as an Interim Risk Reduction Measure (IRRM) until cutoff wall is installed.

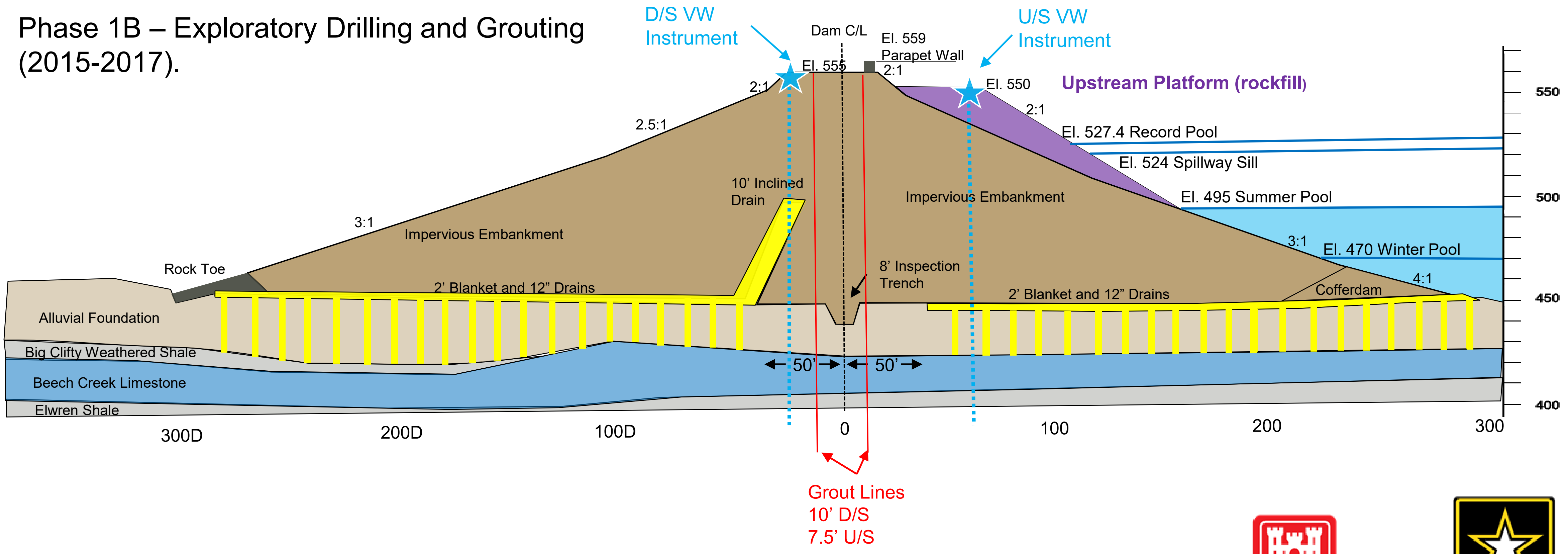
# PHASE IB EXPLORATORY GROUTING (MODIFICATION)

Justification:
Karst connectivity below the dam was confirmed via grouting.
Exploratory grouting was modified for slurry control in preparation of cutoff wall construction.



# OVERVIEW OF PHASE 1 MODIFICATIONS

- Phase 1A – Relocation of SR 79 (2013-2015).
- Install additional "real-time" instrumentation (2014-2015).
- Phase 1B – Exploratory Drilling and Grouting (2015-2017).

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# PHASE IB GROUTING SUMMARY



The project successfully installed a total of 308 production grout holes and 20 verification holes.

- 32,422 linear feet of overburden soil drilling;
- 7,477 linear feet rock coring;
- 26,058 linear feet percussion rock drilling;
- 212,763 gallons of grout;

- The grouting program was considered successful as a model state of the art grouting program.

- The results of Phase IB grouting were applied to the future cutoff wall design.

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# POST GROUTING RISK ASSESSMENT



**Key Points**

- Head loss improved across many zones of the dam;
- Grouting did not repair the flaws that allow internal erosion to initiate;
- Pathways will re-establish over time subject to the frequency of dam loading;
- A cutoff wall is still required for permanent risk reduction;

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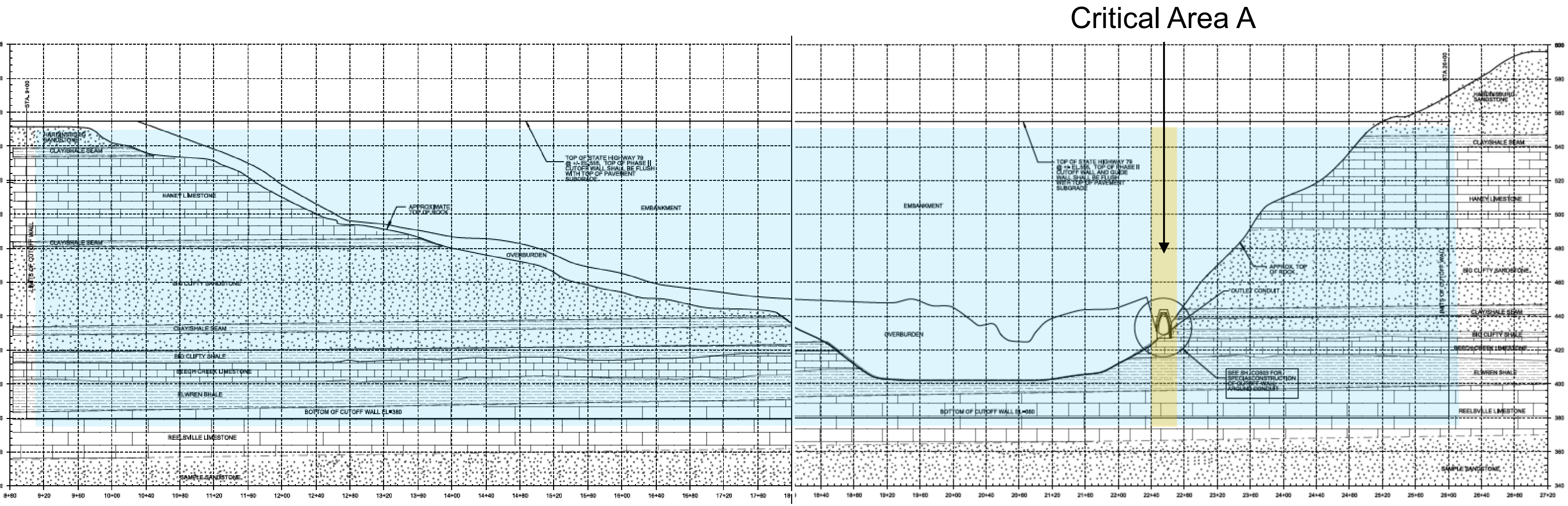
# 2012 DSMR - CUTOFF WALL DESIGN




CHALLENGES:

1) CUTOFF WALL GEOMETRY

2) HOW TO INSTALL A SEEPAGE BARRIER AT THE CONDUIT, CRITICAL AREA A

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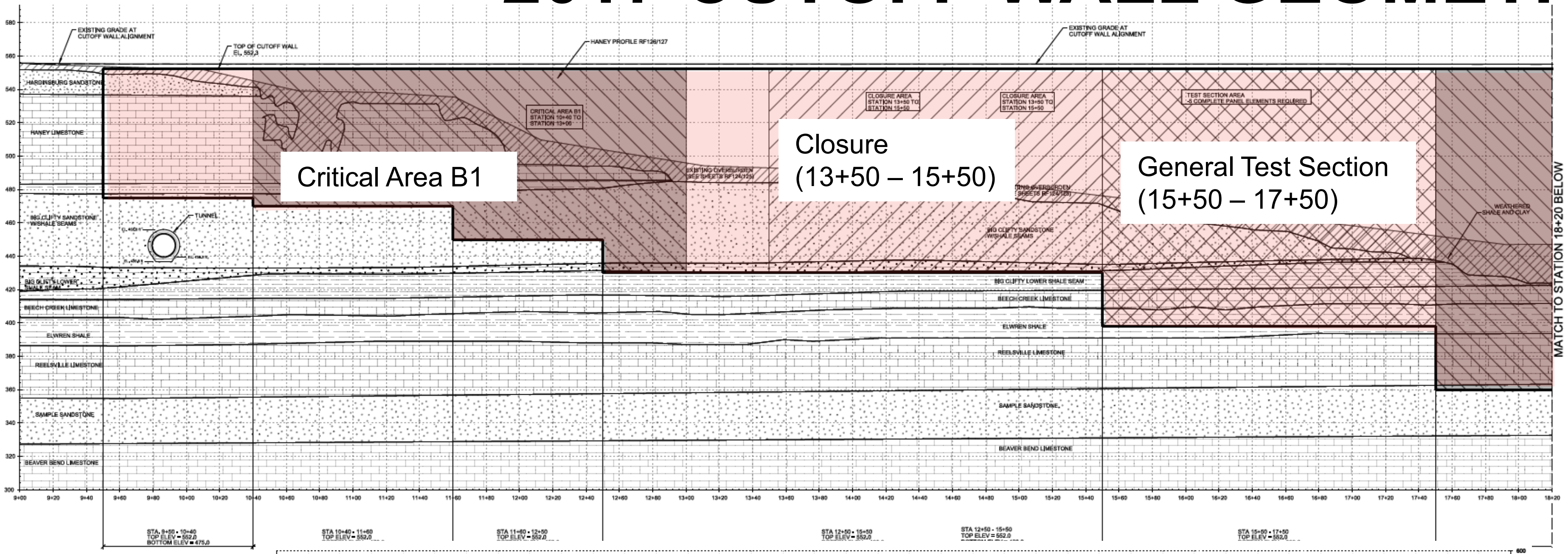
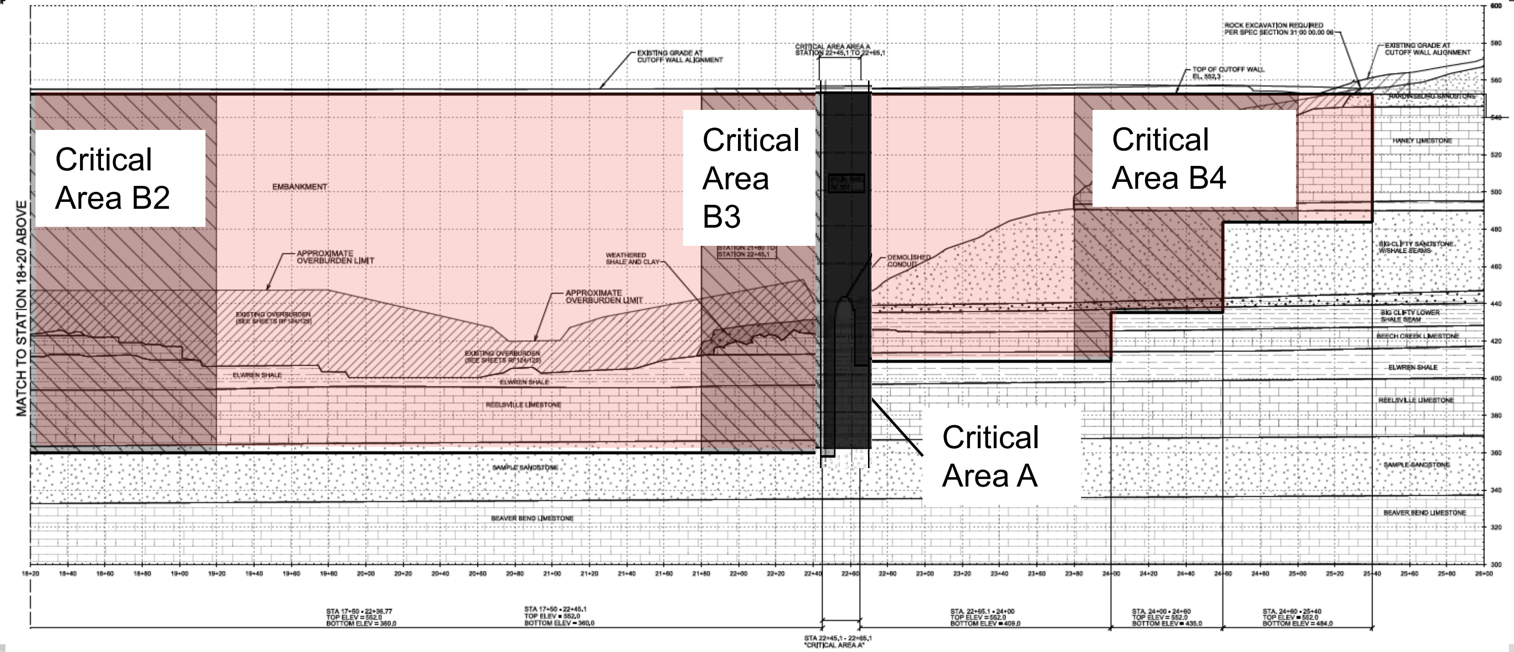
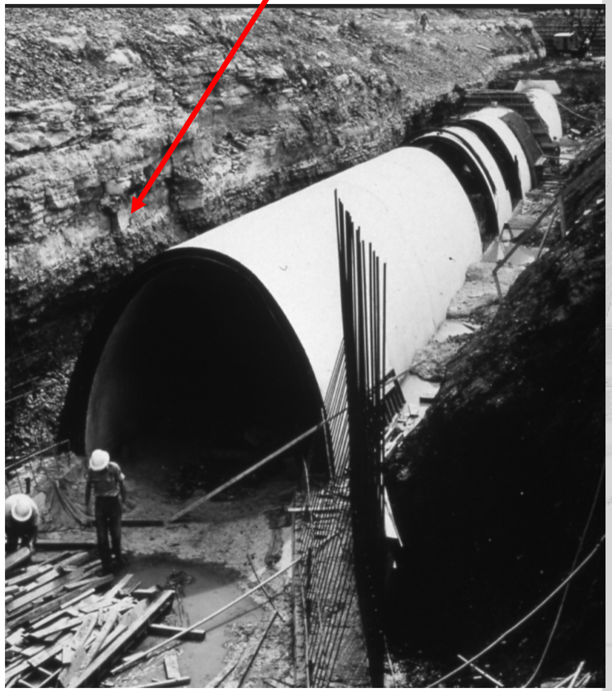
# 2017 CUTOFF WALL GEOMETRY






Low Stress Zone



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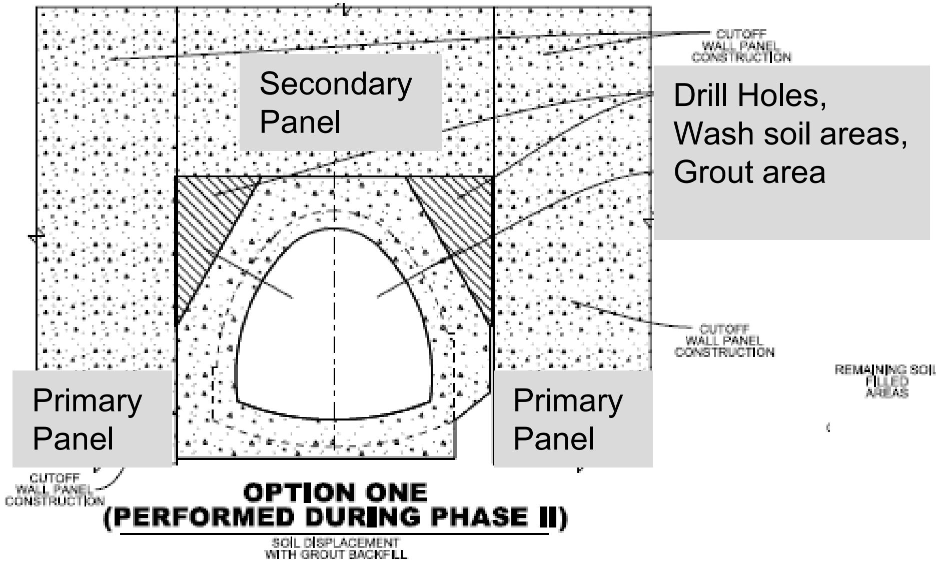
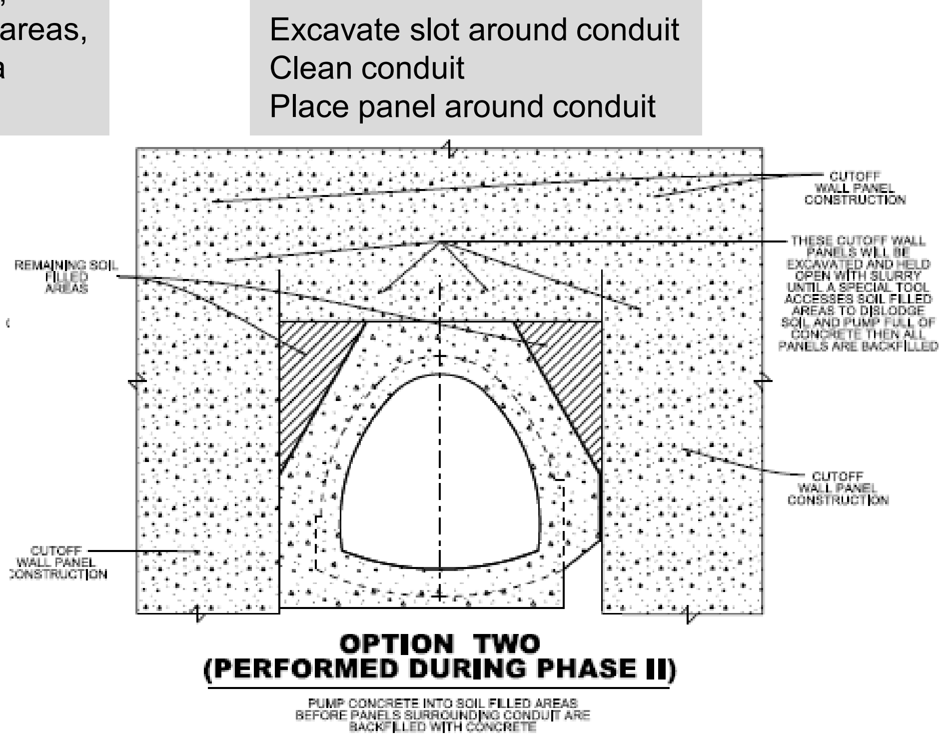
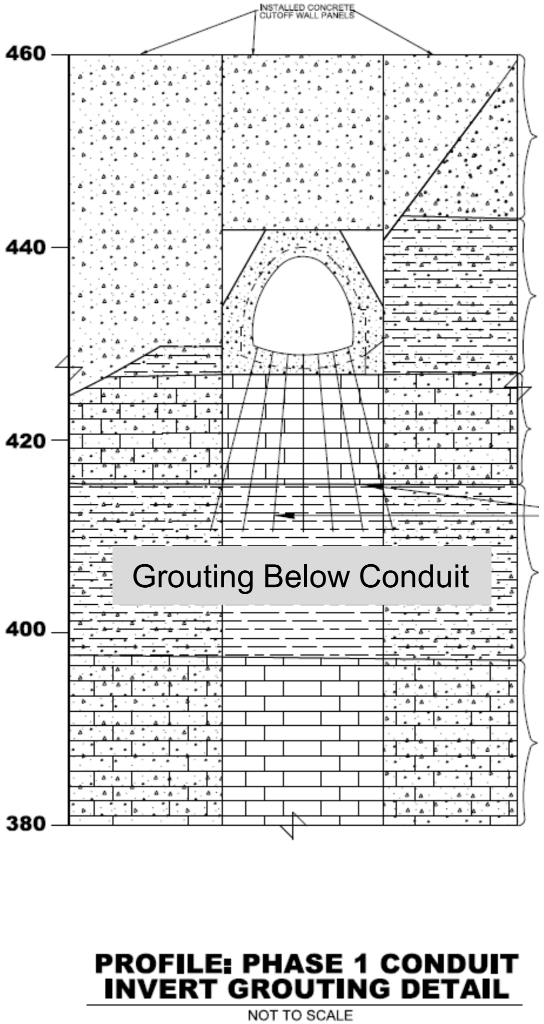
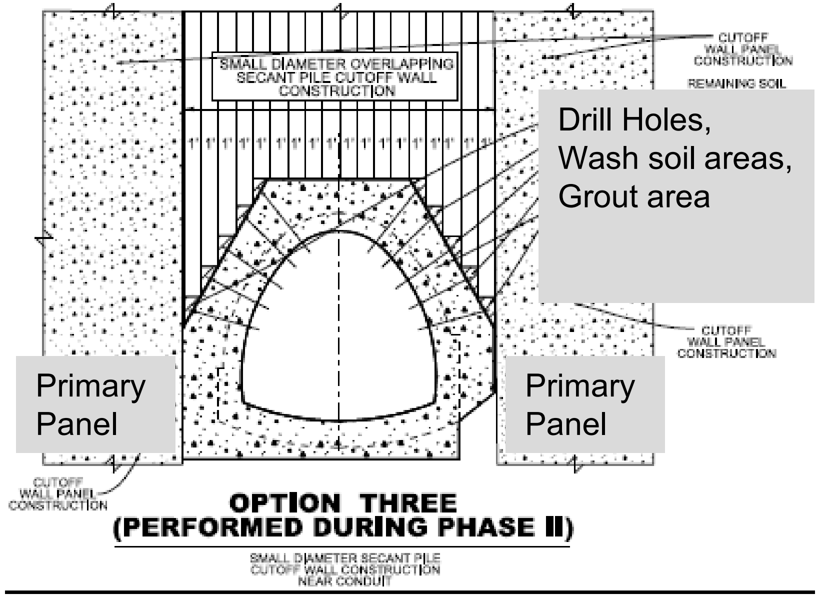
# 2012 DSMR RECOMMENDATIONS AT CRITICAL AREA A

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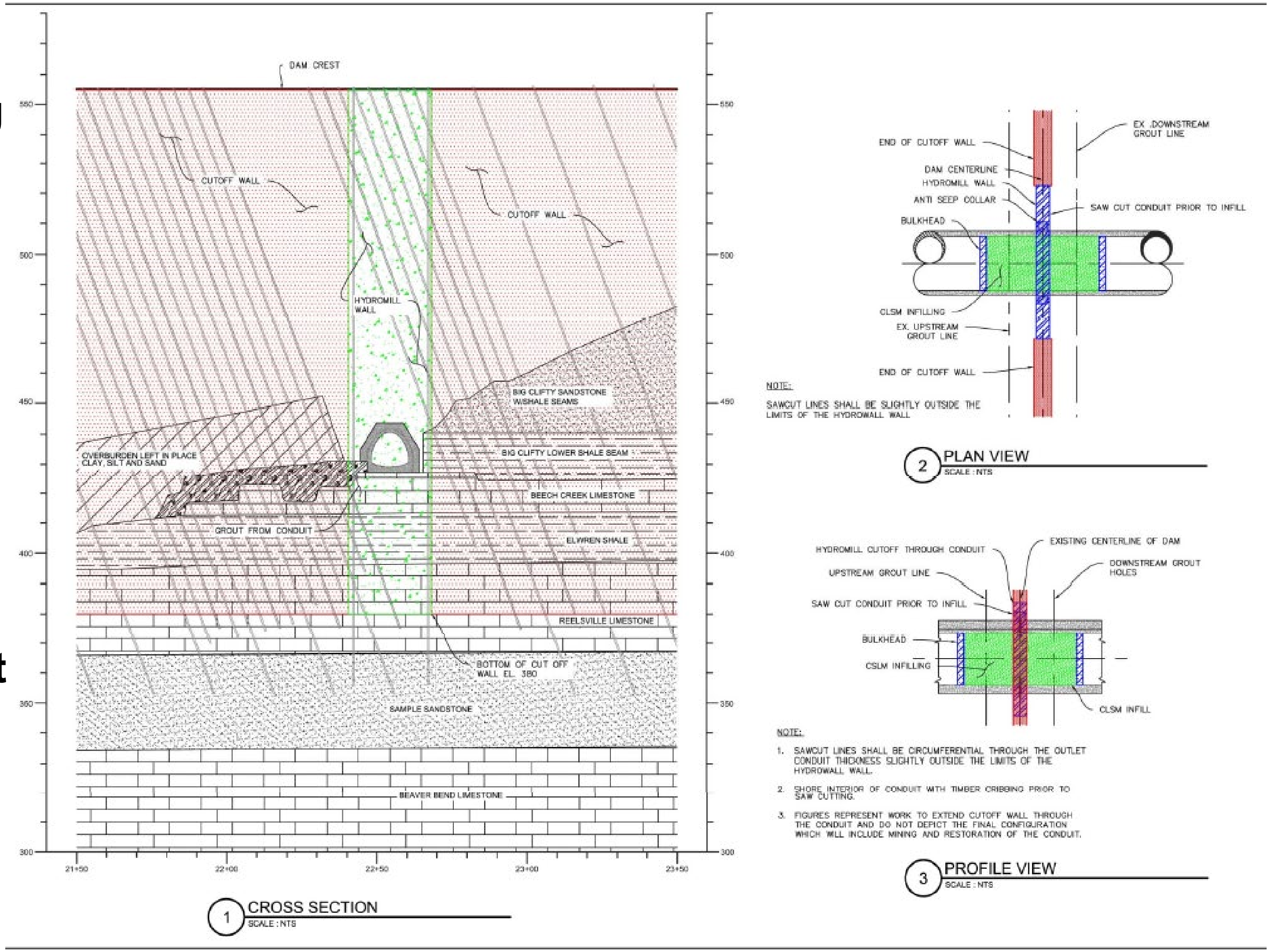
# USACE AND A/E RECOMMENDATIONS AT CRITICAL AREA A



- Alt. 1 – Grouting Only
- Alt. 2 – Incomplete Cutoff Wall and Grouting
- Alt. 3 – Secant Pile Wall Through Conduit
- Alt. 4 – Jet Grouting Around the Conduit
- Alt. 5 – Secant Along Perimeter and Grouting From Conduit
- Alt. 6 – Line Grouting Through Conduit
- **Alt. 7 – Hydromill Panel Through Conduit**
- Alt. 8 – Construct New Conduit and Extend Cutoff Wall Through Abandoned Existing Conduit



# CONDUIT LINING WITH CUTOFF WALL CUT

- Cutoff wall would cut through the conduit at the centerline.
- Structural lining of existing conduit (steel and concrete).
- Estimated construction time was 1 year and 40% reduction in release capacity.
- Would likely result in uncontrolled spillway flow.
- Greatly increased breach and non-breach risks.
- Significant construction risks.

Pine Creek Dam

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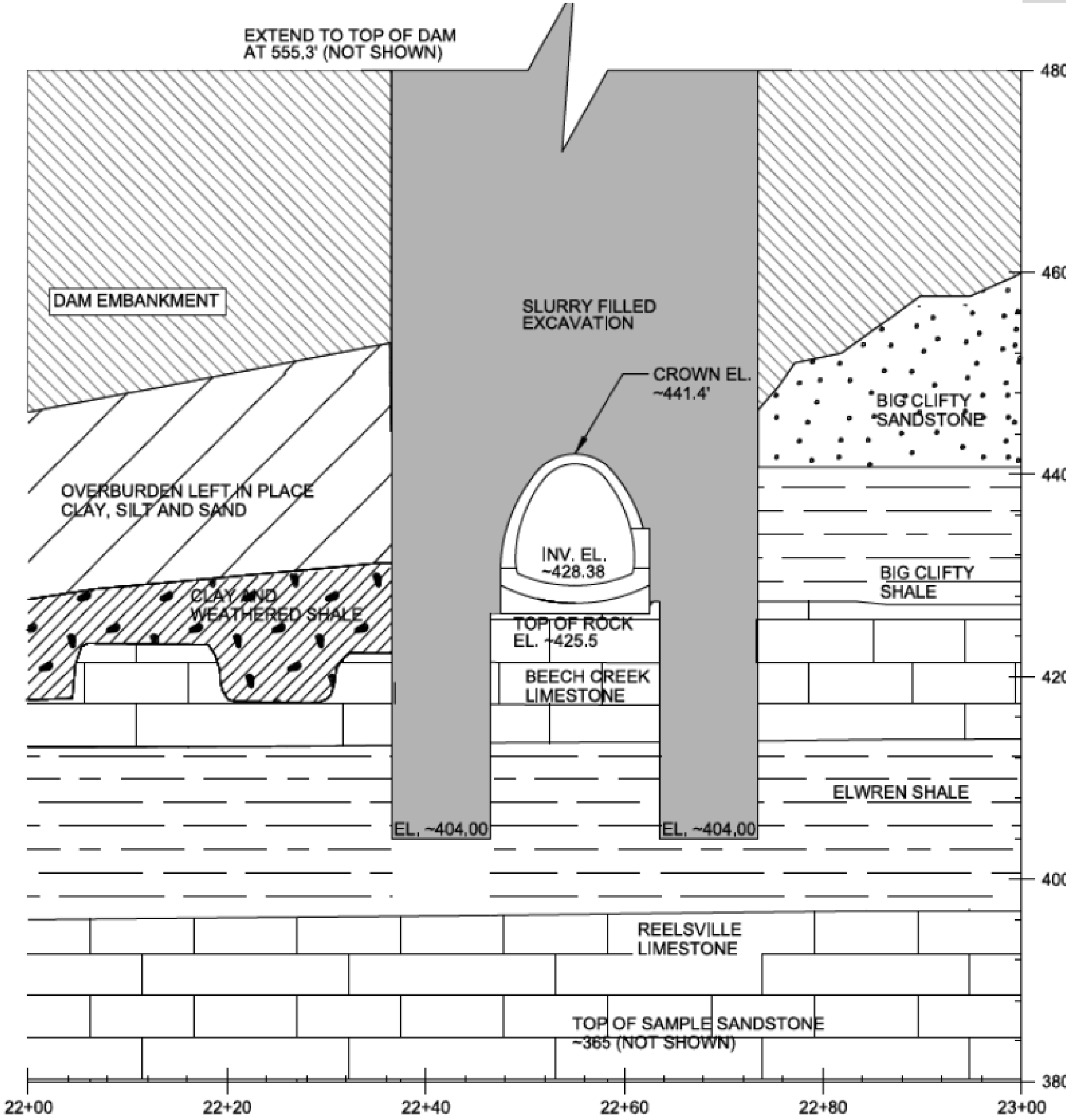
# CRITICAL AREA A TREATMENT

USACE elected to go with Option 2 from the DSMR.

• A panel excavated above and around the conduit.

•The soils around the conduit would be cleaned and the panel filled with concrete.



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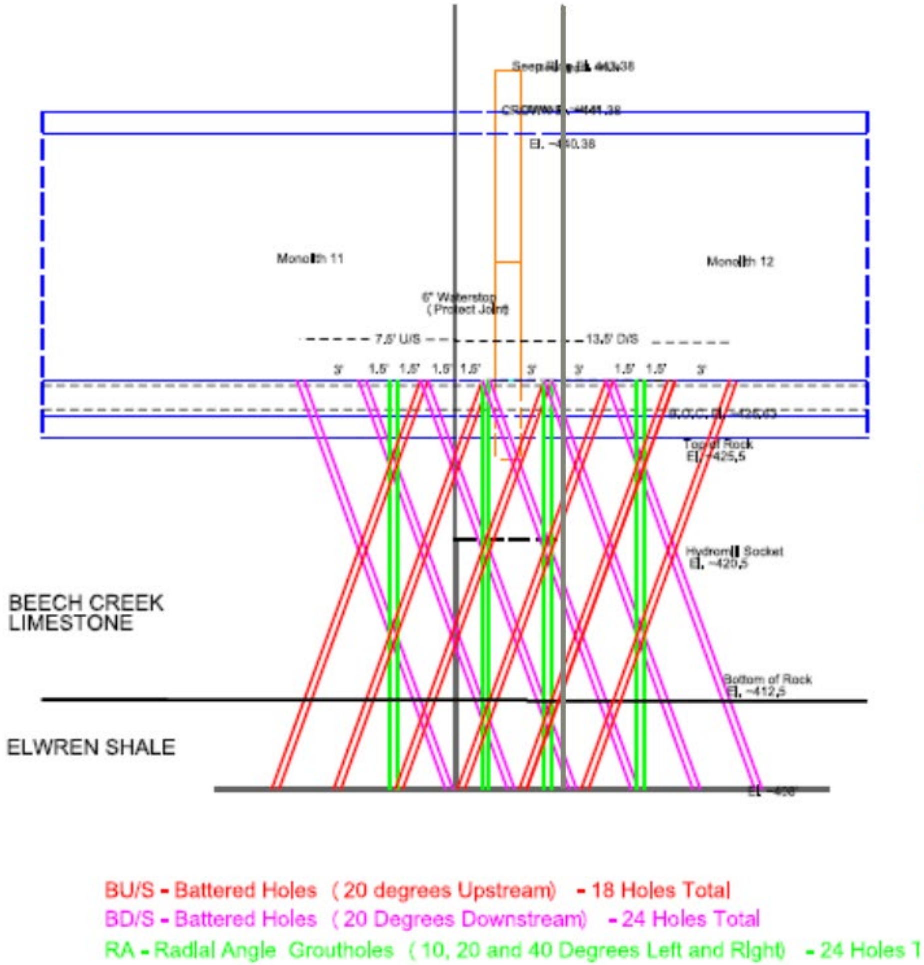
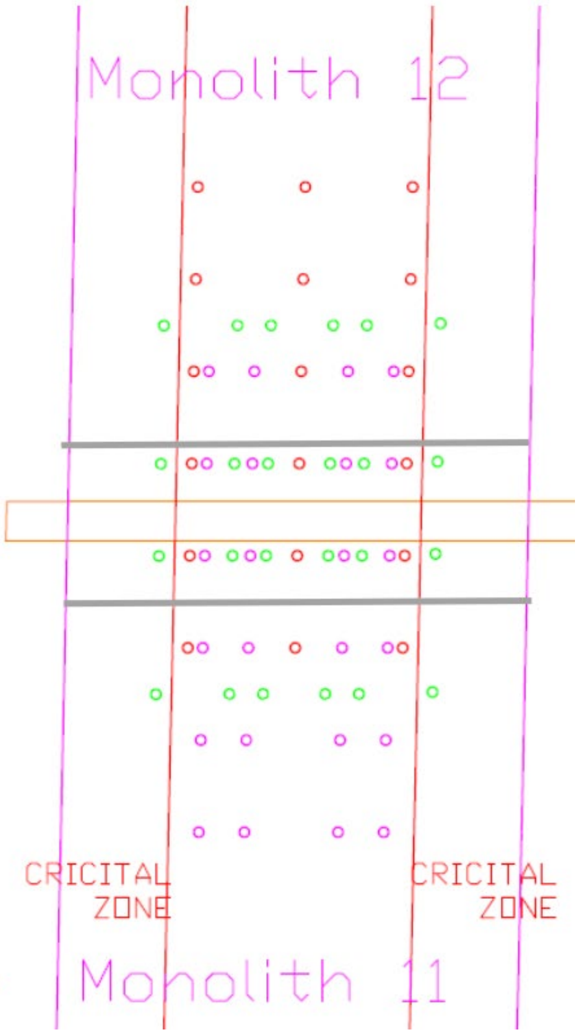
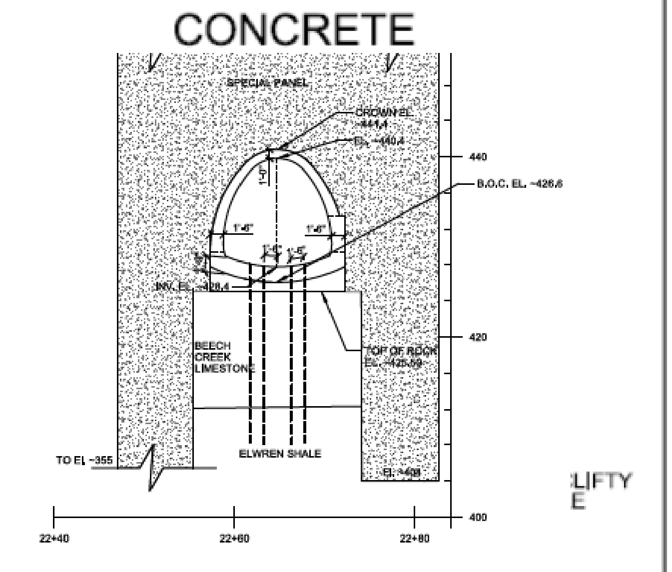
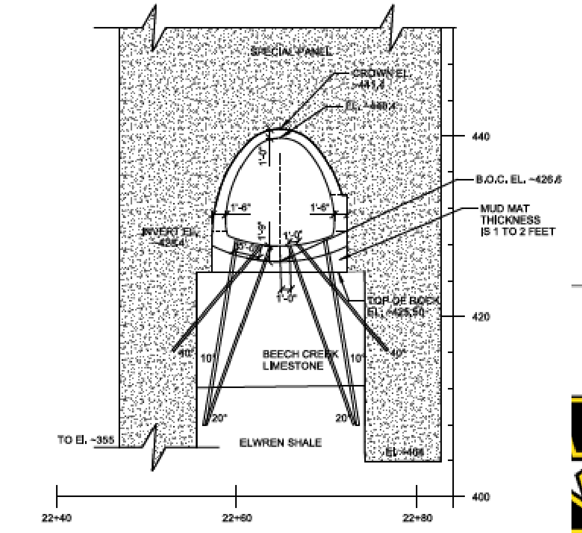



D1 BD/S - BATTERED HOLES (20 DEGREES DOWNSTREAM) LINES 1,2,4, AND 5
SCALE: 1 1/2" = 1'-0"




A1 RA - RADIAL ANGLE GROUTHOLES (10, 20 AND 40 DEGREES LEFT AND RIGHT) LINES 3,7,8, AND 10
SCALE: 1 1/2" = 1'-0"

# CONDUIT/CUTOFF WALL DESIGN ISSUES

- Early in the design, a 3-D finite element analysis was performed to evaluate the existing conduit design and future loads.

- Results indicated the conduit was overstressed in its existing condition.
  - No rebar could be cut within 2 ft. of the sidewalls.
  - A majority of the rebar needed to be located and avoided in the floor area.

- The PDT analyzed how the conduit would be loaded and unloaded during excavation and concrete placement to prevent overstressing the conduit.
  - Conduit bracing greatly increased.
  - Excavation sequences prescribed to not overload conduit.

- Limits placed on concrete lift heights with joint treatment for the cutoff wall panel.



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# UNACCEPTABLE CONSTRUCTION RISK



- The final SAR review indicated unacceptable structural concerns remained.
- Considerations for how long term increases in the hydrostatic loading upstream of the cutoff wall were factored into the design.
- Recent inclinometer measurements monitoring a cutoff wall at another project indicated measurable ground displacements during the cutoff wall installation.

    - The condition would result in eccentric loading on the conduit and potentially increase the stress regime beyond predicted limits.

- An incident occurred where grouting pressure near a steel lined conduit caused significant damage to a conduit - Limited ability to repair conduit.



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# PAUSING OF THE 2017 CUTOFF WALL PROJECT



USACE concluded that construction risk for the Phase 2 project was not acceptable because:

- High likelihood of structural damage to the conduit;
- Increased potential for internal erosion into the conduit;
- Conduit is the only means of controlled flow conveyance;
- Increased overtopping risk in the event construction difficulties limited reservoir releases for a prolonged period;

**USACE determined the DSMR Plan to saddle the cutoff wall around the conduit was incomplete and additional design measures were required.**



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# PRESENTATION OVERVIEW

- Project Introduction and Background
- 2012 Dam Safety Modification Project Overview
  - Phase I: Grouting Overview
  - Phase 2: 2017 Cutoff Wall Design
- **Dam Safety Modification Report (DSMR) Supplement**
- 2021 New Outlet Works and Cutoff Wall Project Overview

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# INITIATION OF THE DSMR SUPPLEMENT

- It was decided not to advertise the Phase 2 cutoff wall as designed.
- Previously approved Tentatively Selected Plan (TSP) considered incomplete.
  - *Slurry control grouting, a full-length cutoff wall placed around the existing conduit, grouting from within the conduit, and a D/S filter.*
- Supplemental Dam Safety Modification Study (DSMS) was required due modified TSP and increase in cost .

- *“Do the best you can until you know better. Then when you know better, do better.” – Maya Angelou*

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# INITIATION OF THE DSMR SUPPLEMENT

- Cutoff wall still needed to achieve risk reduction.

- Re-Initiation of the Planning Phase – Identification of objectives, constraints and evaluation criteria.

Evaluation Criteria

- Technical Feasibility
- Construction Risk
- Maintenance sustainability
- Environmental Impacts
- Real Estate
- Project First Cost
- O&M Cost
- Impacts to cutoff wall construction

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# DESIGN MEASURES

- PDT prepared concept level designs for four measures:
  - Conduit Lining with cutoff wall through conduit
  - Spillway outlet works
  - Right abutment tunnel/outlet works
  - Left abutment tunnel/outlet works
- PDT prepared multiple versions of each concept
- Concept designs were presented to Constructability Evaluation team for review (June 2018).
- Risk Analysis of recommend measure (July 2018).

# CONSTRUCTABILITY EVALUATION (JUNE 2018)

- Purpose – Review conceptual designs, discuss design optimizations, discuss constructability/performance issues, and make a recommendation for a design measure to complete the TSP.

- Participants included:
  - PDT – Geology, Geotechnical, Structural, Civil, Water Management, Construction, Planning, Cost
  - Operations
  - DSMMCX – H&H, Planning, Construction, Geology, Cost
  - RMC – Geotech/Geology, Construction, Geology
  - LRD
- Process
  - Site Visit
  - Measure evaluation and optimization
  - Comparison and recommendation
- Outcome
  - Vertical team concurrence for a new outlet works through left abutment

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# ALTERNATIVE EVALUATION

- Revised structural alternative
  - Slurry control grouting, *new left abutment outlet works*, a full-length cutoff wall placed around the existing conduit, grouting from within the conduit, and a D/S filter.

- Alternative comparison:
  - Do nothing (FWAC)
  - Remove Dam
  - Remove and Replace Dam
  - Structural alternative

- Project Cost, Performance Risk, and Benefit Cost analysis updated for all alternatives.

- Presented to DSOG in Nov 2018

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# TSP ENDORSEMENT AND DSAC CHANGE



- On 6 November 2018, the Modified TSP was presented to and endorsed by DSOG.
- Recommendation to proceed with design and Supplemental DSMR for a new left abutment outlet works and full-length cutoff wall severing the existing conduit.
- DSOG voted to lower the project risk classification from DSAC 2 to DSAC 3 based on the 2017 Post Grouting Risk Assessment. The DSAC Change MFR was received on 29 March 2019.
- The DSMR Supplement was approved by USACE HQ DSO on 22 February 2021 and endorsed by ASA(CW) on 20 Oct 2021.
- The project is currently awaiting appropriation.
- From the time of award, it will take approximately 5 years to complete the repairs at Critical Area A.

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# PRESENTATION OVERVIEW



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- **2021 New Outlet Works and Cutoff Wall Project Overview**

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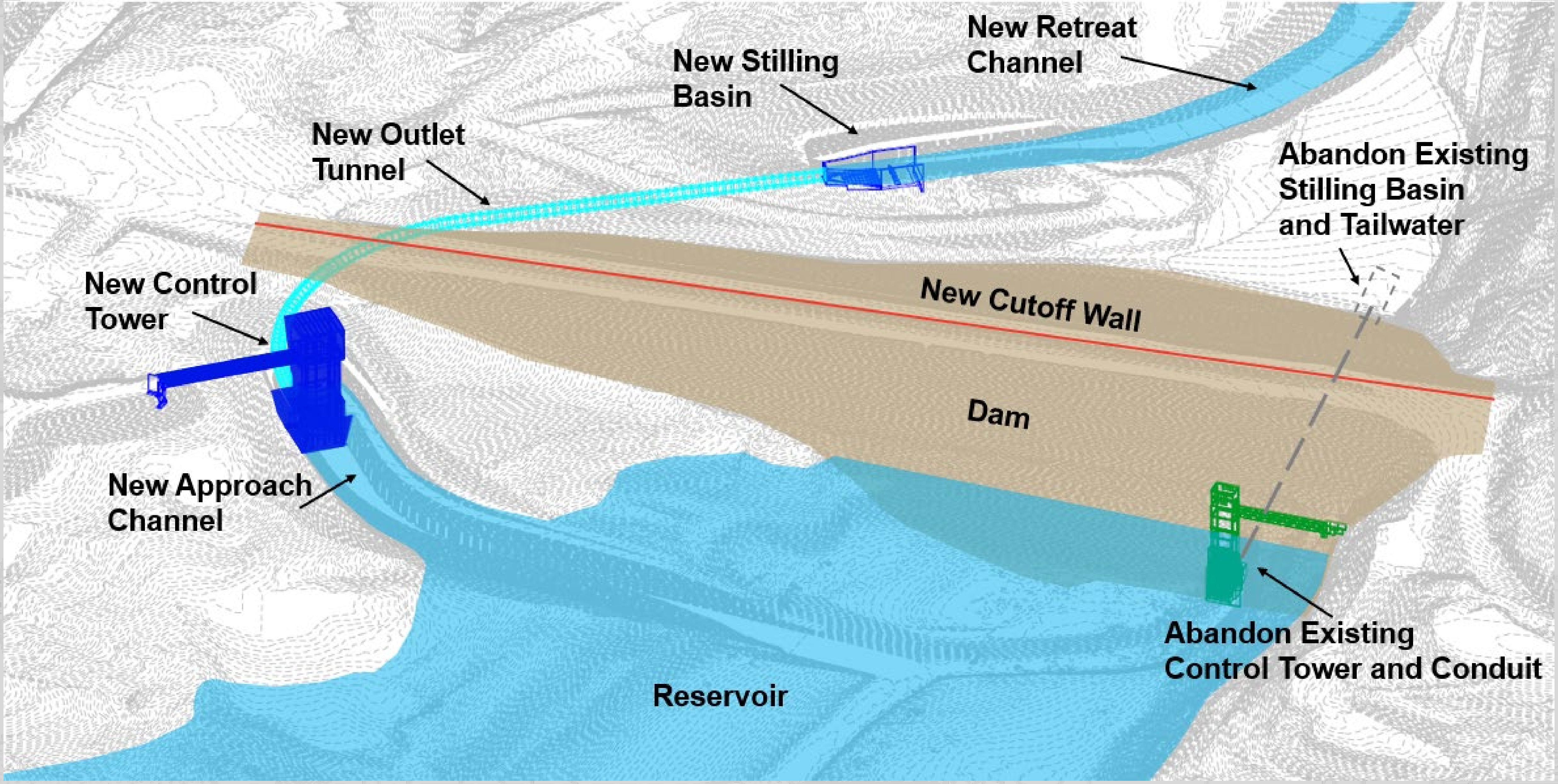
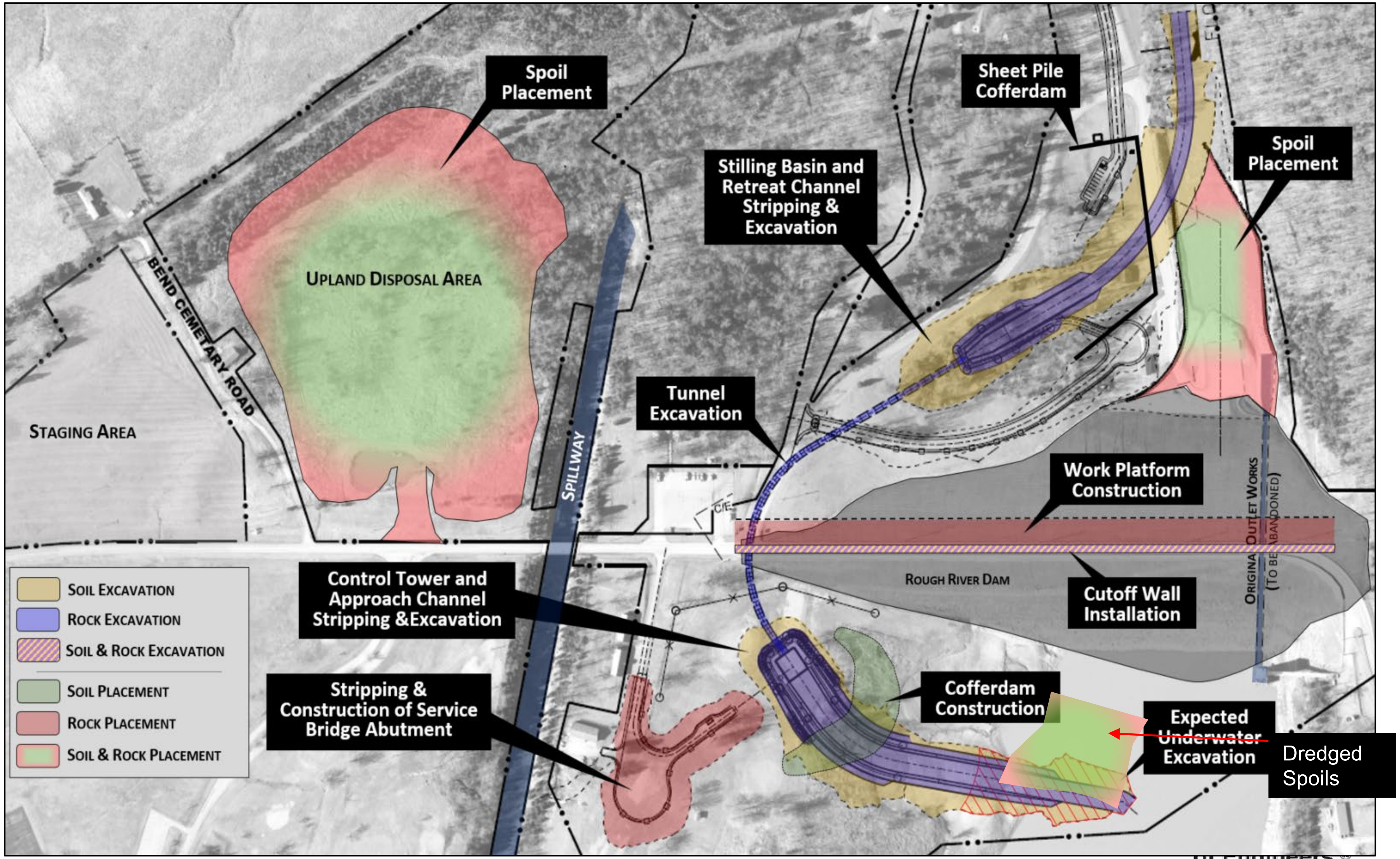
# PHASE II: NEW OUTLET WORKS AND CUTOFF WALL





# Key Features of Work



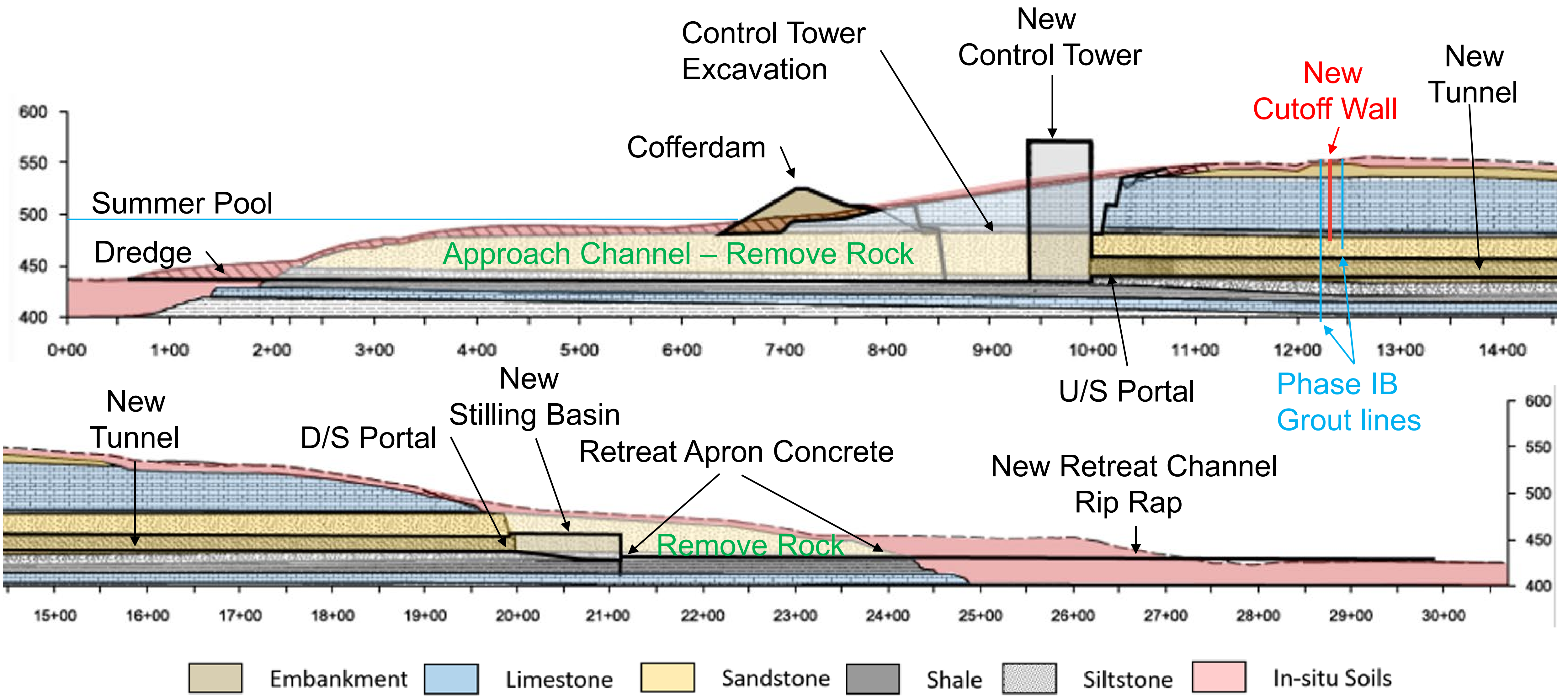
# PHYSICAL MODEL - ERDC



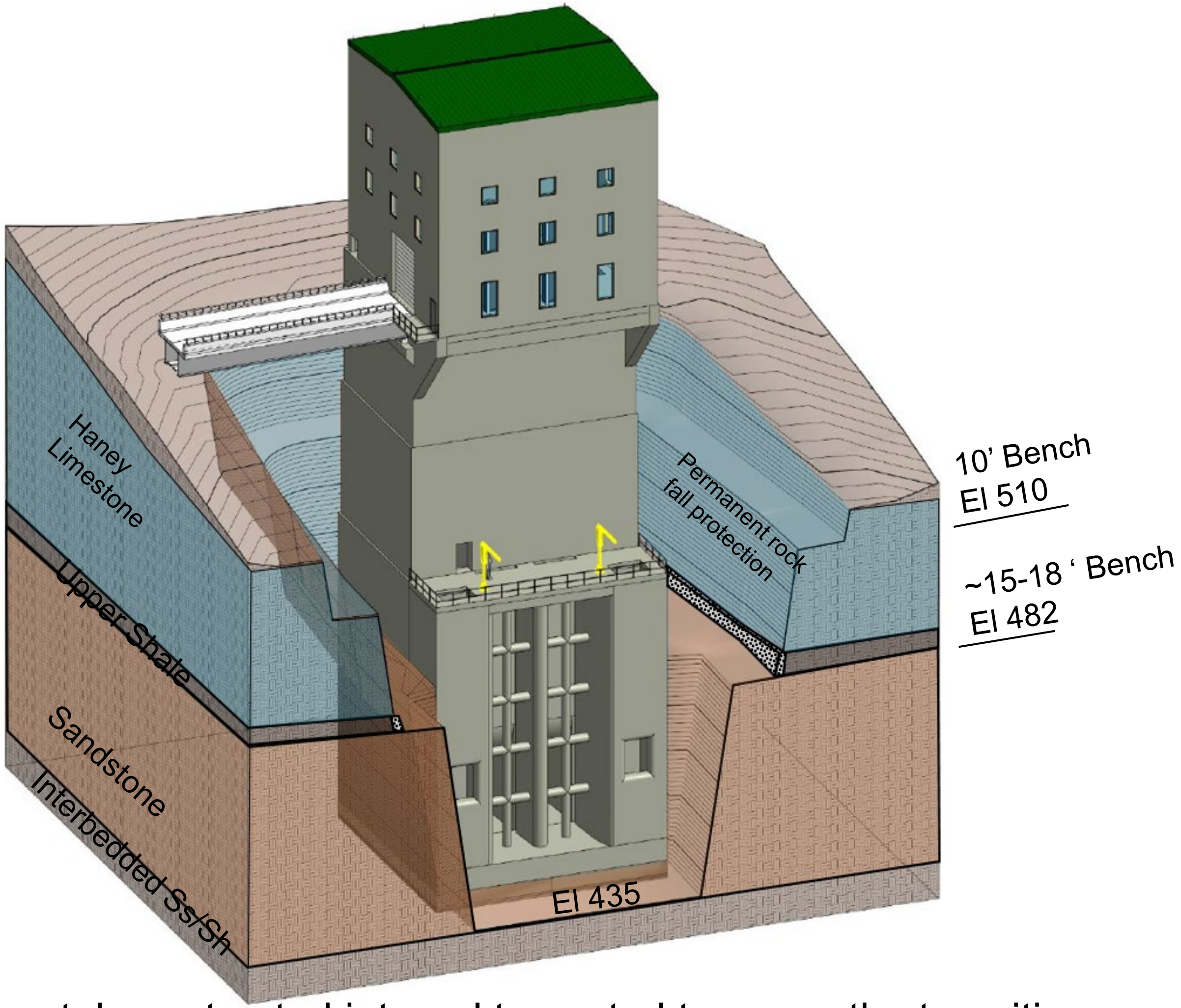
**Photos of Physical Model construction at ERDC:**

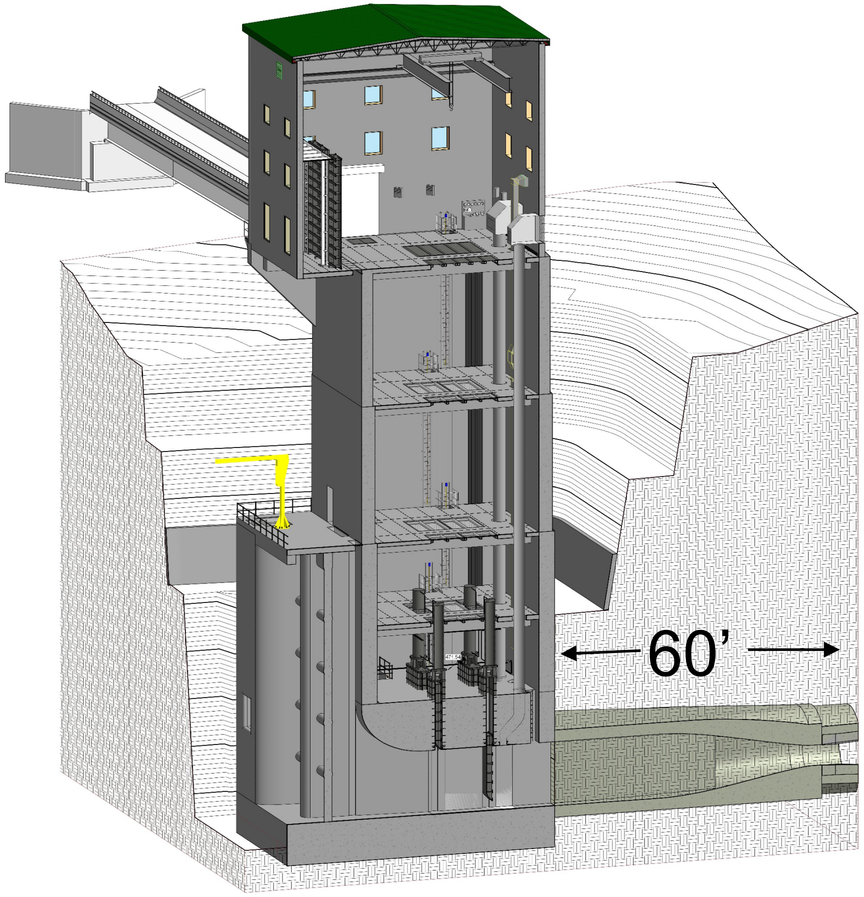
1. Reservoir, Approach Channel, and Intake Tower.
2. Intake Tower leading to Curved Conduit.
3. Retreat Channel and Stilling Basin, looking upstream.

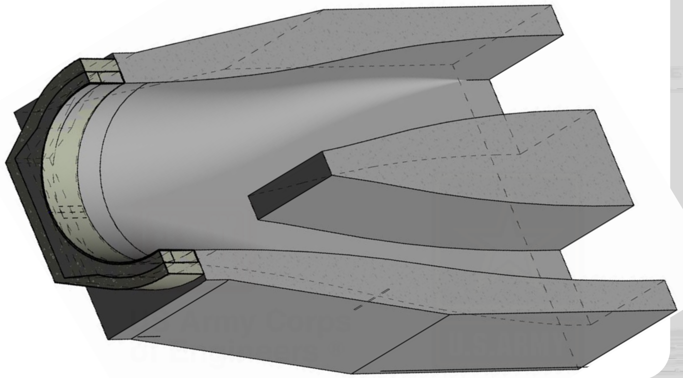
# NEW OUTLET WORKS PROFILE



# CONTROL TOWER RENDERINGS



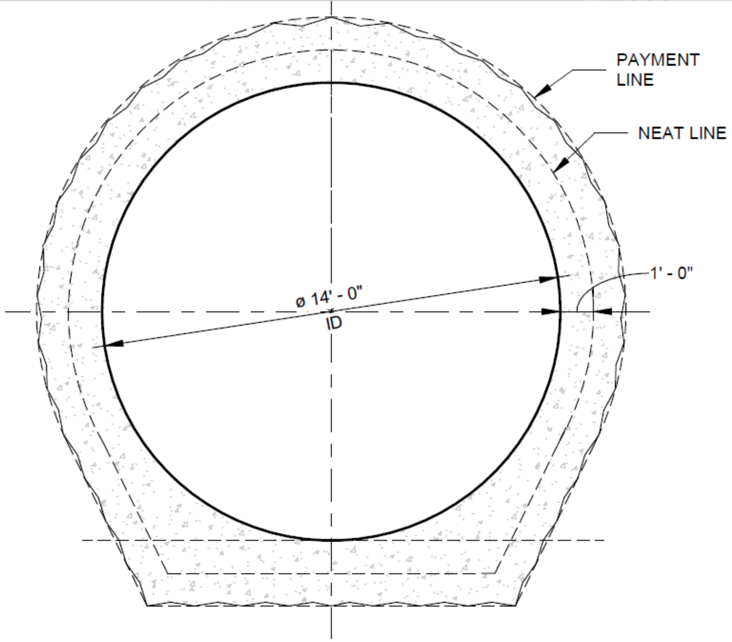



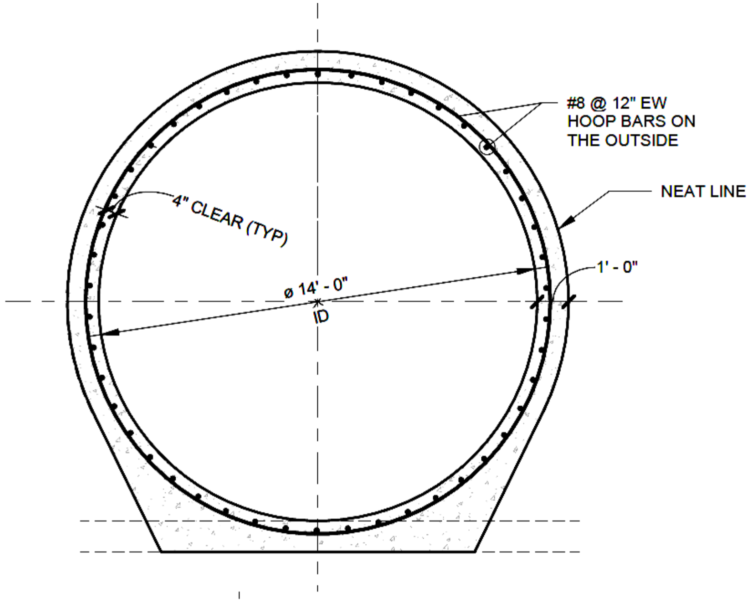
- Upstream portal constructed integral to control tower as the transition.
- Maximum upstream portal width is 24.5 feet.
- Temporary support can be cast integral to tower walls.

# TUNNEL LINER DESIGN

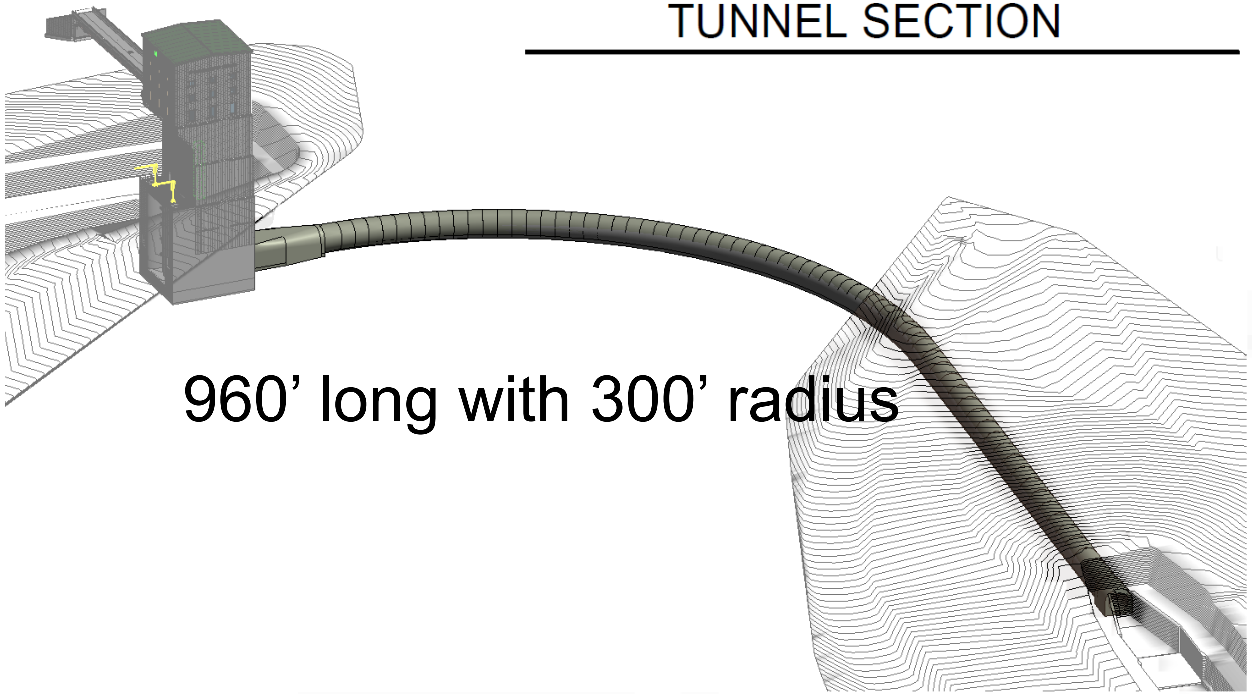
- Cast-in-place, reinforced concrete, with Class B finish.
- 20’ monoliths. Monoliths within the curve are 20’ with a mitered angle every 10’.
- 14’ ID, 1’ min liner thickness.
- Non-metallic water stops at contraction joints.




TUNNEL SECTION




TUNNEL REINFORCEMENT

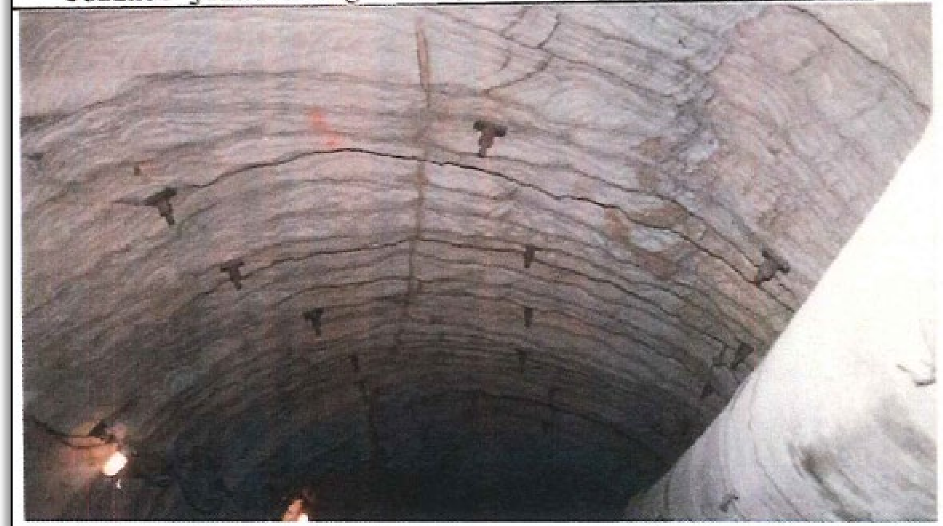


960’ long with 300’ radius

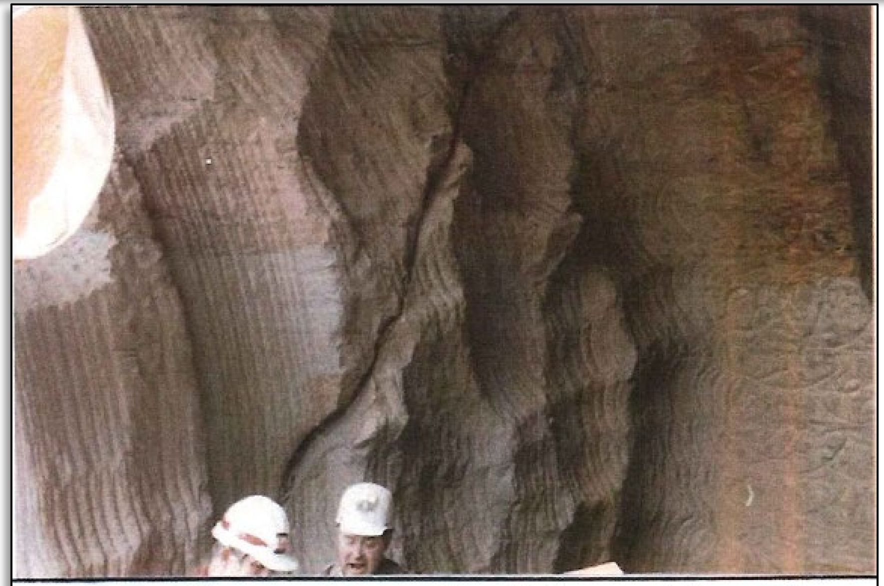
# TUNNEL PROTOTYPE: YATESVILLE DAM

- Roadheader used at Yatesville Dam in a sandstone bedrock.
- Tunnel has radius similar to proposed at Rough River.
- Rough River will require a large road header.

22 Feb 1985 - Rock bolt pattern with high angle, iron stained joint along crown, Sta. 5+60W to 6+25.



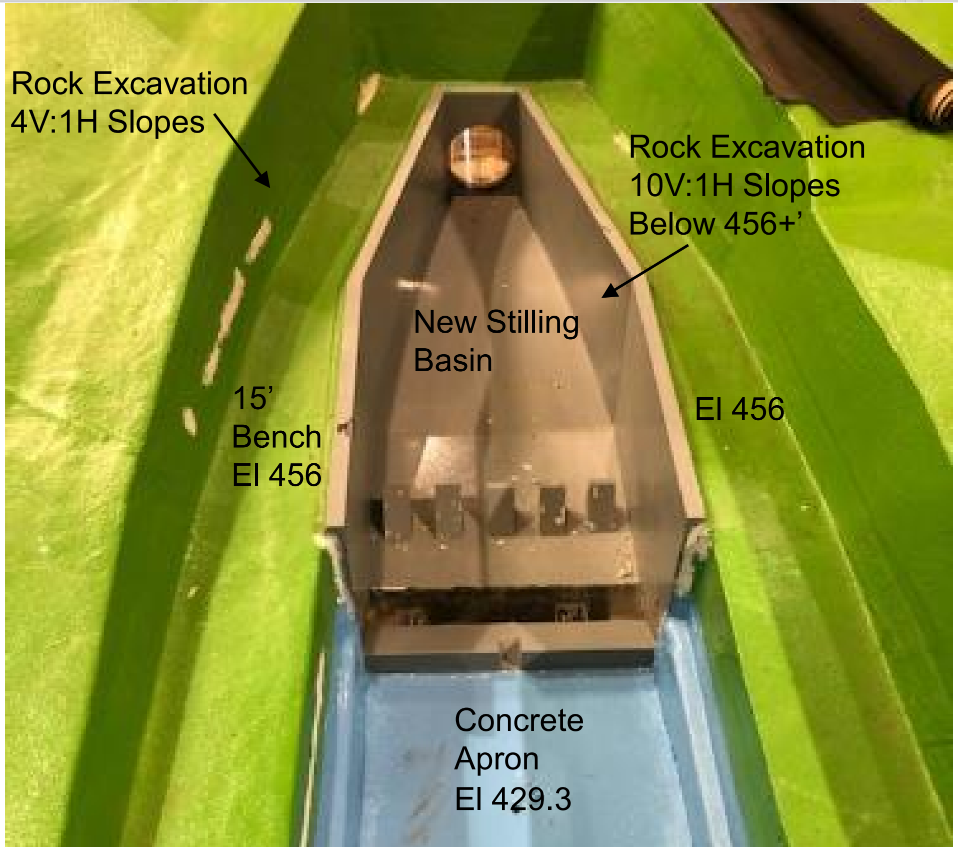
23 Jan 1985 - Dosco SL 120 Roadheader mining machine

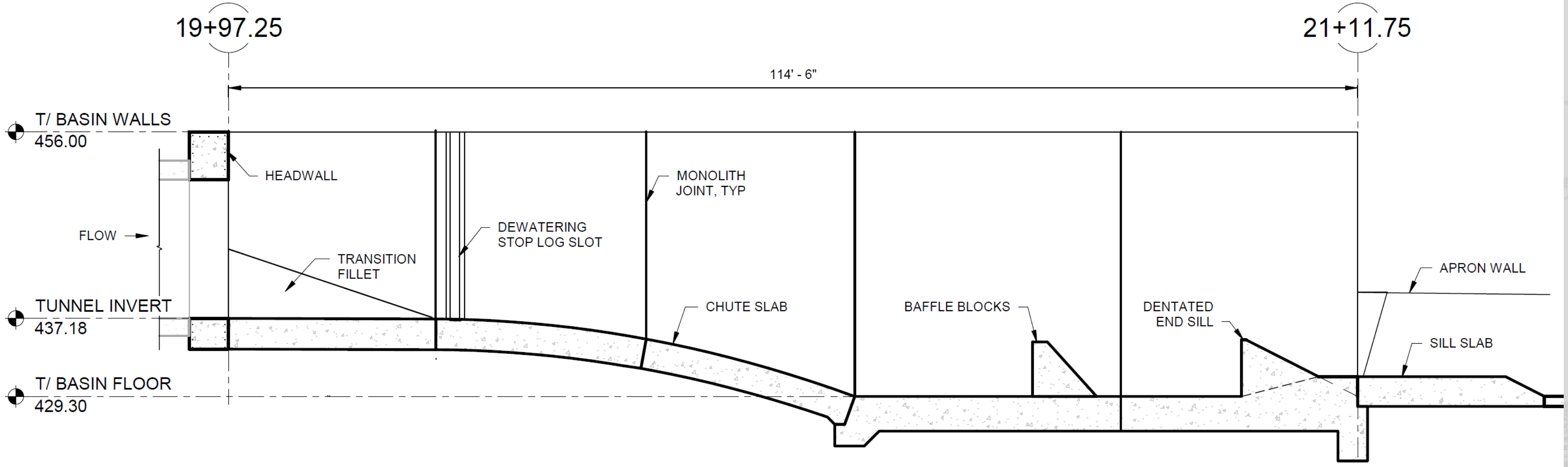


28 Dec 1984 - Open joint along left transition wall, monolith #3.

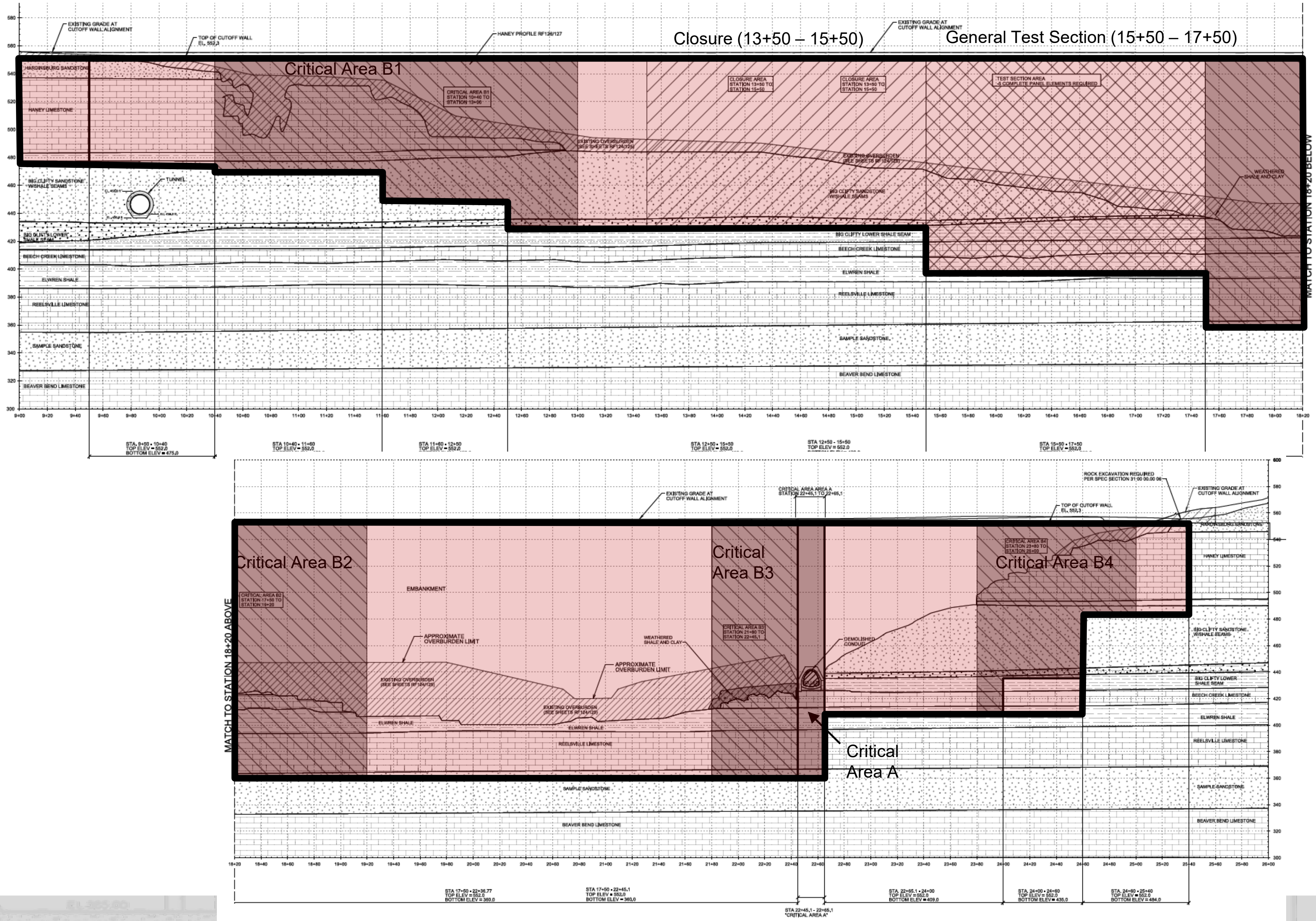
# STILLING BASIN AND APRON DESIGN

- USACE Type III basin, 115' long x 46' wide.
  - Single row of baffle blocks, dentated end sill
  - Designed using ERDC Physical Model
- Cast-in-place reinforced concrete.
- 5 monolithic sections of varying length.
- Embedded upstream stop log slots and sill.
- Sloped end sill provides debris sweep out.
- Extended sill slab provides space for dewatering systems at normal tailwater elevations.
- Concrete apron lining retreat channel at El 429.3 extending from end sill to Sta 24+10.

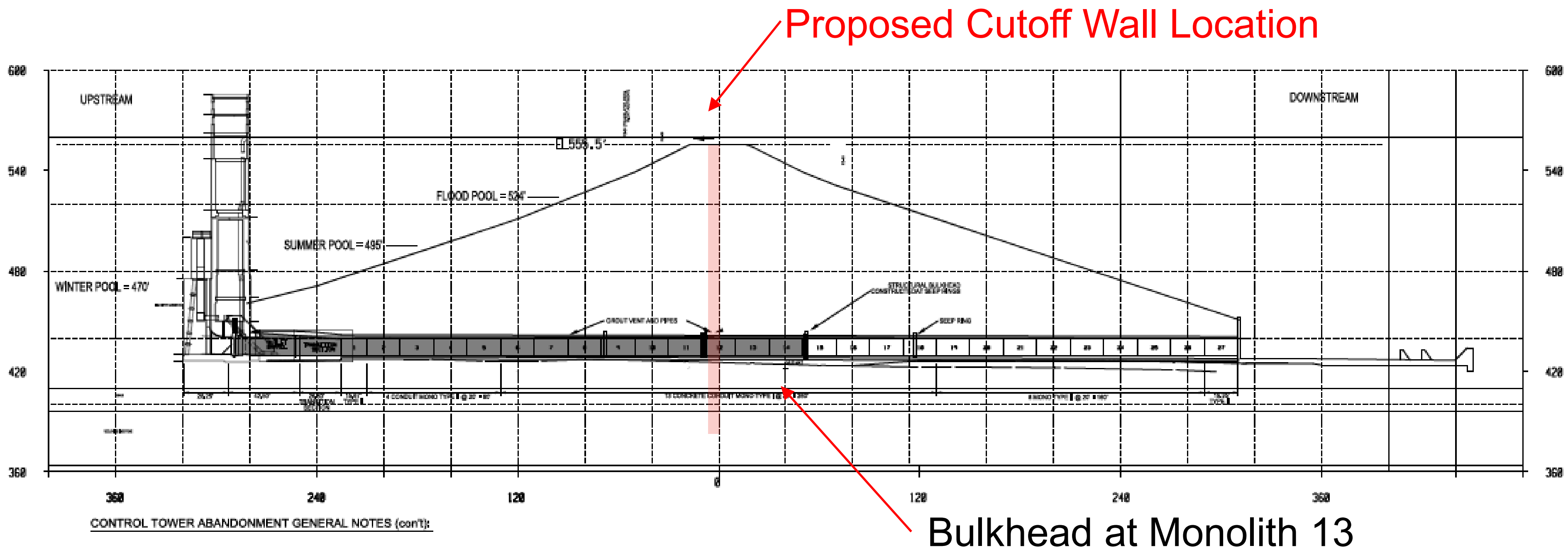


# CUTOFF WALL PROFILE



# ABANDONMENT OF EXISTING CONDUIT – UPSTREAM SEAL TO MON. 13




CONTROL TOWER ABANDONMENT GENERAL NOTES (con't):

9. PLACE A-MIX GROUT THROUGH EACH BY-PASS PIPE CONCURRENTLY UNTIL CONCRETE RETURN IS OBSERVED THROUGH THE AIR VENT PIPES IN THE DOWNSTREAM BULKHEAD. CLOSE THE AIR VENT PIPES AT THE BULKHEAD.
10. CONTINUE PLACEMENT UNTIL GROUT RETURN OCCURS IN THE TOWER AIR VENT PIPES.
11. 24 HOURS AFTER INTIAL GROUTING HOOK UP, PUMP "A-MIX GROUT" INTO ANY REMAINING VOID SPACES THROUGH REDUNDANT GROUT PIPES POSITIONED AT THE DOWNSTREAM BULKHEAD UNTIL A PRESSURE OF 5 PSI IS OBTAINED PER EM 1110-2-2902.

KEY COMPONENTS OF PLAN

- Use series of slotted grout pipe and valves to ensure complete grouting.
- Use balanced, stable, flowable  material.

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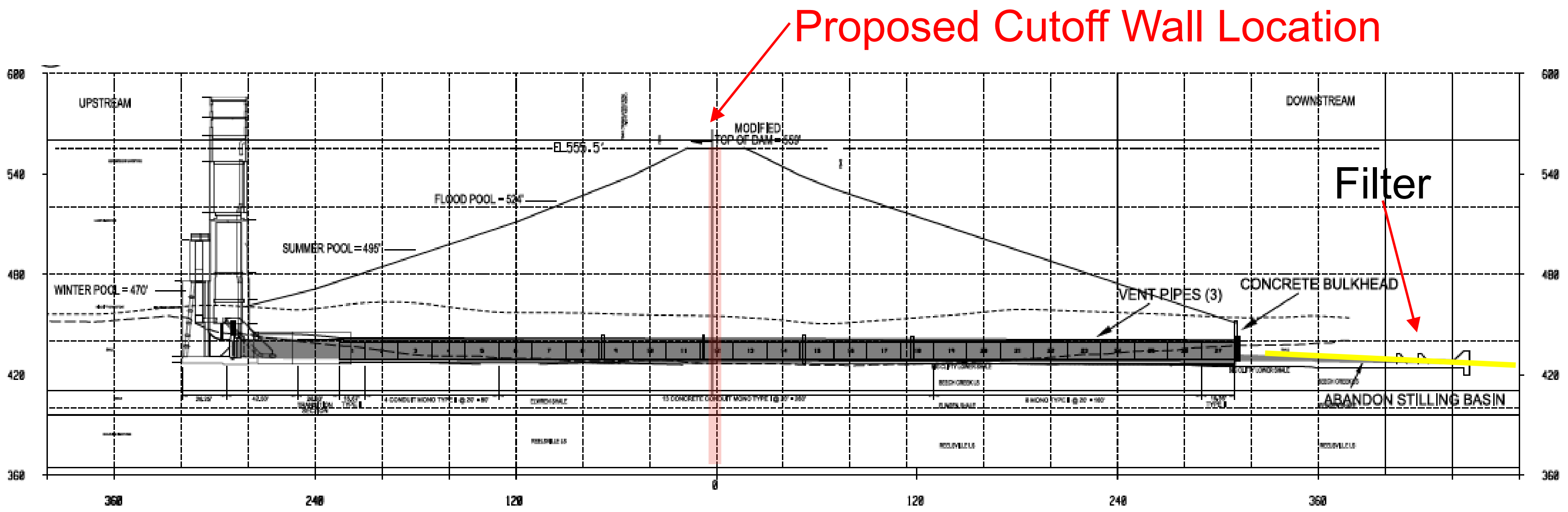
# ABANDONMENT OF EXISTING CONDUIT – DOWNSTREAM FROM MON. 13




CONTROL TOWER ABANDONMENT GENERAL NOTES (con't):

12. CONSTRUCT A BULKHEAD AT THE CONDUIT HEADWALL EXIT.
13. EXAMPLE CONFIGURATION AT THE HEADWALL EXIT, INCLUDE 3 SLOTTED AIR VENT PIPES (1.5 INCH DIAMETER MINIMUM, TYPE OF PIPE, SLOT CONFIGURATION, FINAL DIAMETER SUBMITTED FOR APPROVAL) ALONG THE CROWN OF THE CONDUIT. INSTALL 6 SLOTTED GROUT PIPES, 2.25 INCHES MINIMUM, AS FOLLOWS:
    PIPE 7 = 2.25 INCH GROUT PIPE FROM 0-90 FEET DOWNSTREAM OF THE BULKHEAD.
    PIPE 8 = 2.25 INCH GROUT PIPE FROM 90-180 FEET DOWNSTREAM OF THE BULKHEAD.
    PIPE 9 = 2.25 INCH GROUT PIPE FROM 180-270 FEET DOWNSTREAM OF THE BULKHEAD.

CONTROL TOWER ABANDONMENT GENERAL NOTES (con't):

14. ABANDON THE STILLING BASIN BY PLACING A 12 INCH FILTER DRAIN PER DRAWING XXXXXXXX.
15. REMOVE SALVAGEABLE EQUIPMENT FROM LOWER THREE CONTROL TOWER LEVELS AND ABANDON WITH A-MIX GROUT.
16. CONTROL TOWER ABOVE ELEVATION 477 TO THE FLOOR OF THE OPERATING LEVEL SHALL BE FILLED WILL CELLULAR GROUT WITH A UNIT WEIGHT BETWEEN 64 AND 75 PCF.

## KEY COMPONENTS OF PLAN

- Use series of slotted grout pipe and valves to ensure complete grouting.
- Use balanced, stable, flowable material.
- Pumped into the outlet conduit from the stilling basin upstream.

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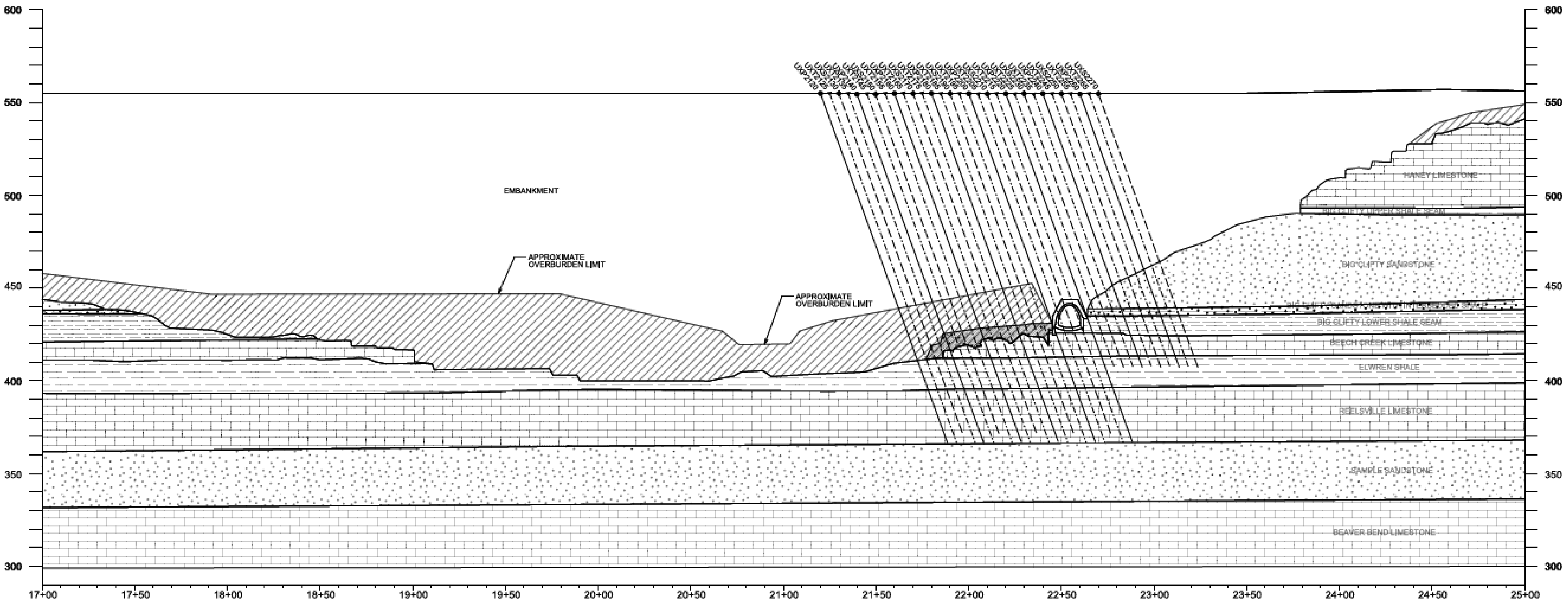
# COMPLETION OF GROUT CURTAIN THROUGH EXISTING CONDUIT (CRITICAL AREA B3 AND A)




1) Grout Critical Area B3 Before Abandonment.
2) Grout Through the Existing Conduit at Critical Area A.

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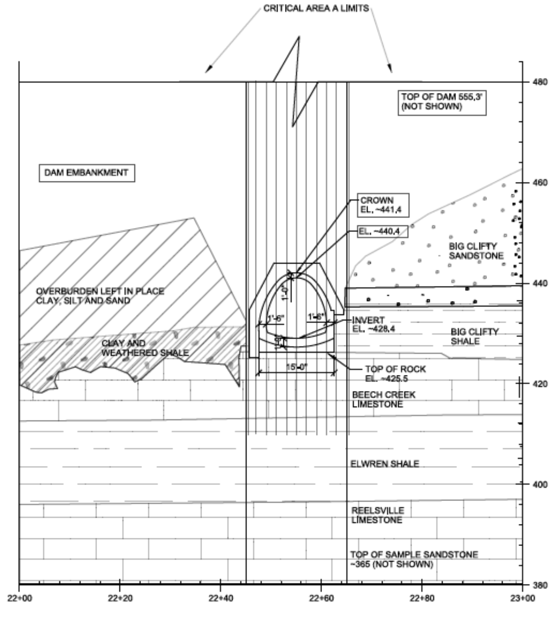
# CUTOFF WALL AT CRITICAL AREA A

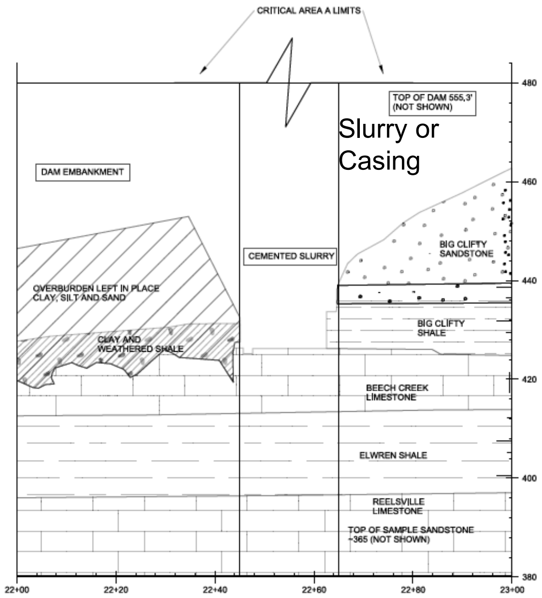
CUTOFF WALL PANEL THROUGH EXISTING CONDUIT

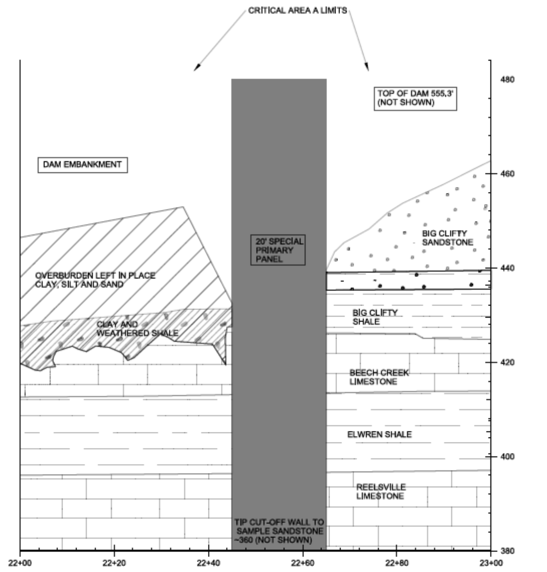
- Completely sever the existing conduit to construct a continuous cut-off wall.
  - 2-foot continuous cut-off 25-30’ long Panel/Secant Elements.
- Means and methods for conduit demolition submitted with RFP for consideration.
- The existing outlet works to be fully abandoned.

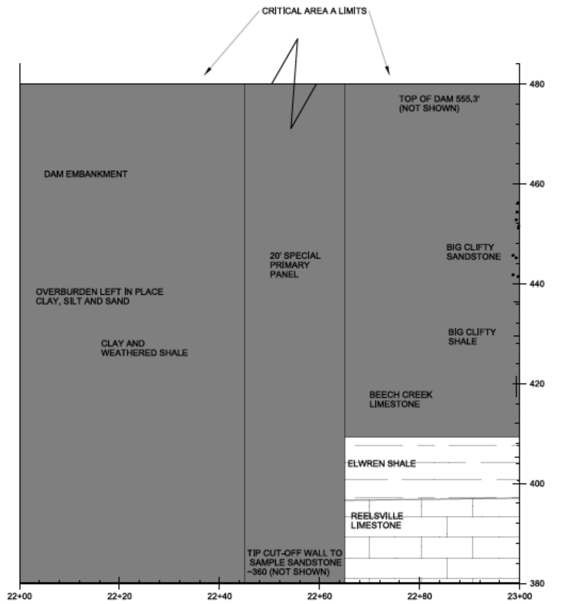



D1 DETAIL 10 - CRITICAL AREA A - SPECIAL DEMOLITION

SCALE: 1" = 1'-0"




C7 DETAIL 12 - CRITICAL AREA A TIE-IN WITH PANELS

SCALE: 1" = 1'-0"

# SUMMARY



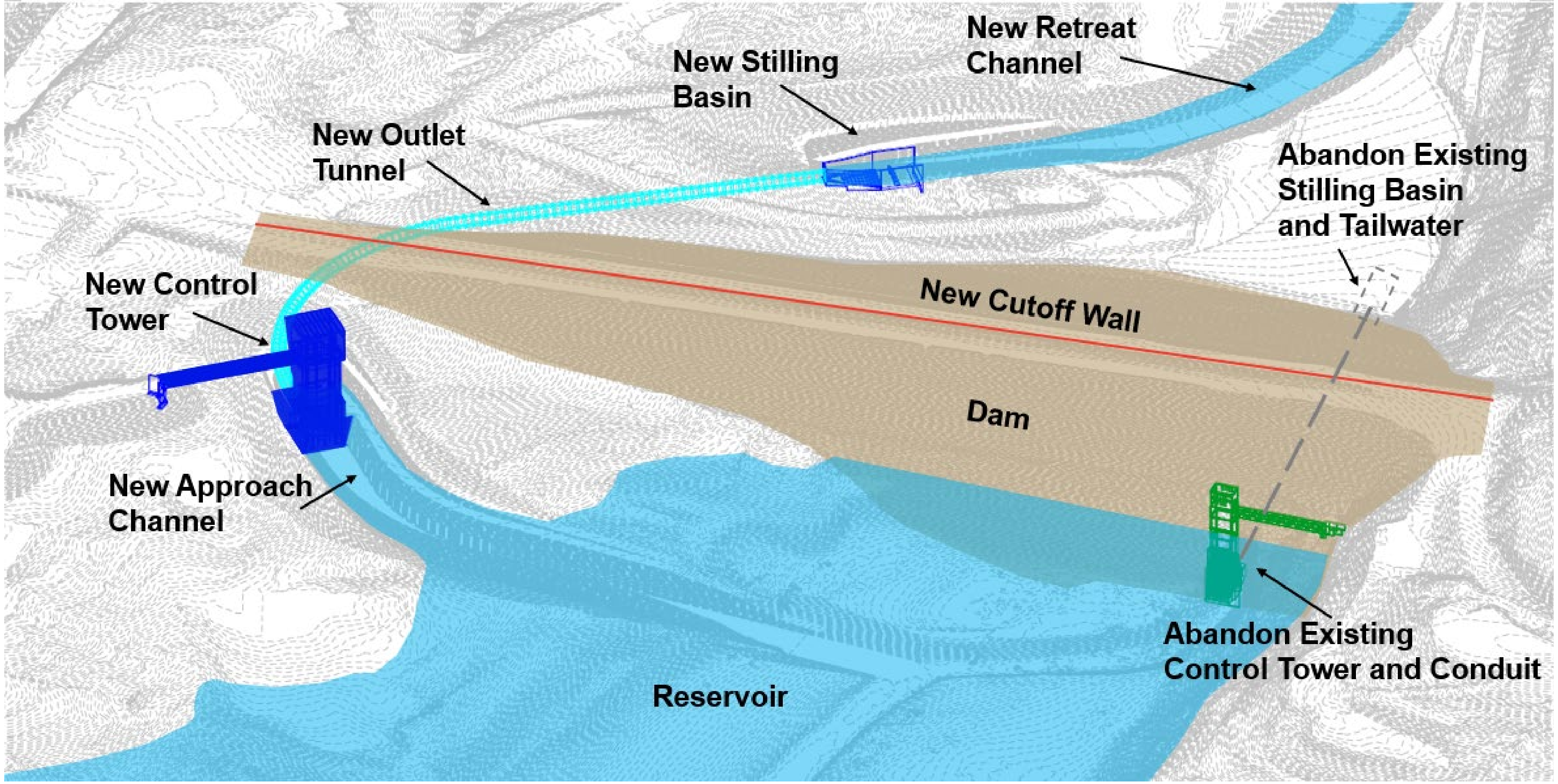
- Field Data and Lessons Learned used to refine design approach.
- Results of Phase 1 Grouting were utilized for risk-informed decision making.
- Evaluation of Construction risk led to postponement of cutoff wall solicitation.
- Strategic coordination with Vertical Team led to efficient concurrence on revised approach.
- The Supplemental DSMR and design are complete and the project is authorized.

# CONCLUSIONS



- Vertical Team Coordination/Communication
- Incorporation of Lessons Learned
- Strong technical personnel in Construction and Engineering
- Proactive interpretation and evaluation of Construction Data
- The right decisions are rarely the easy decisions.

# QUESTIONS ???

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