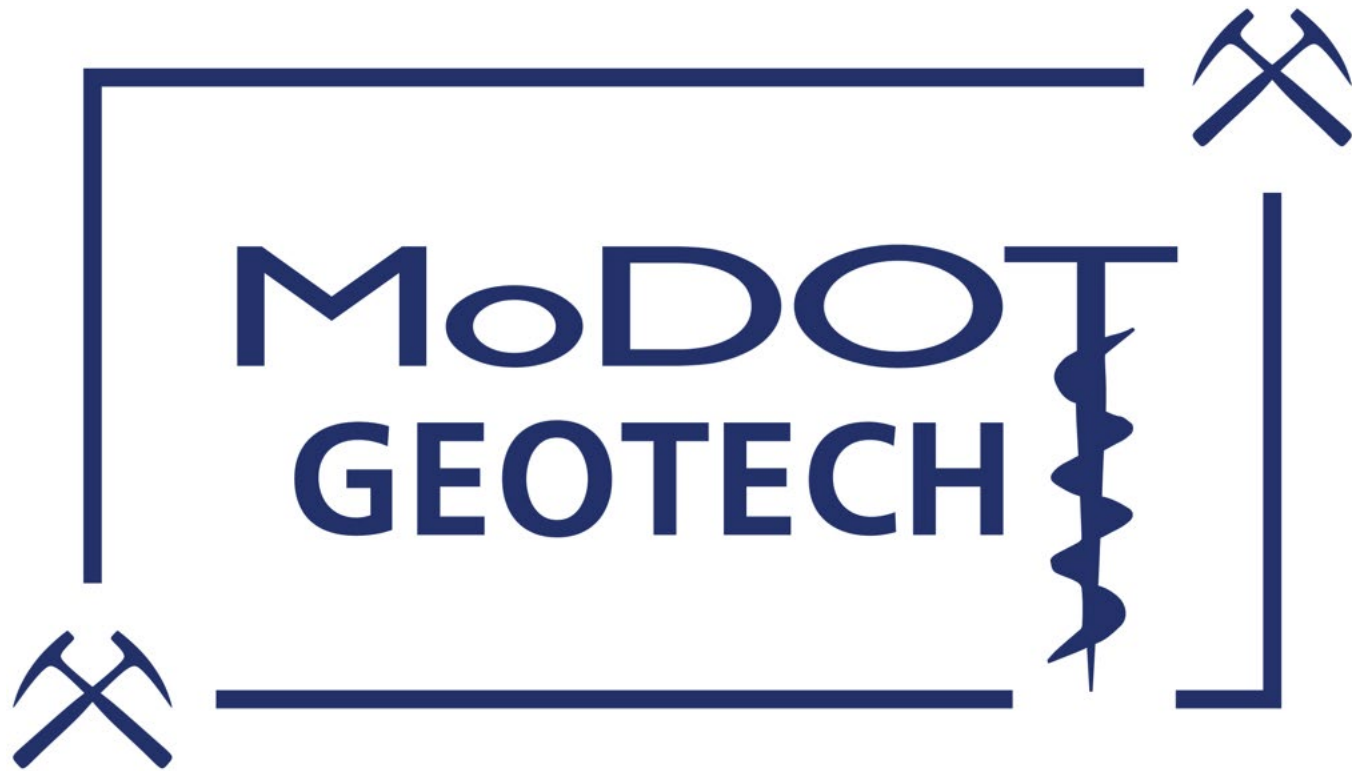


# The Good, The Bad, The Ugly!



Midwest Geotech Conference 2025

Zachary Troesser, P.E.

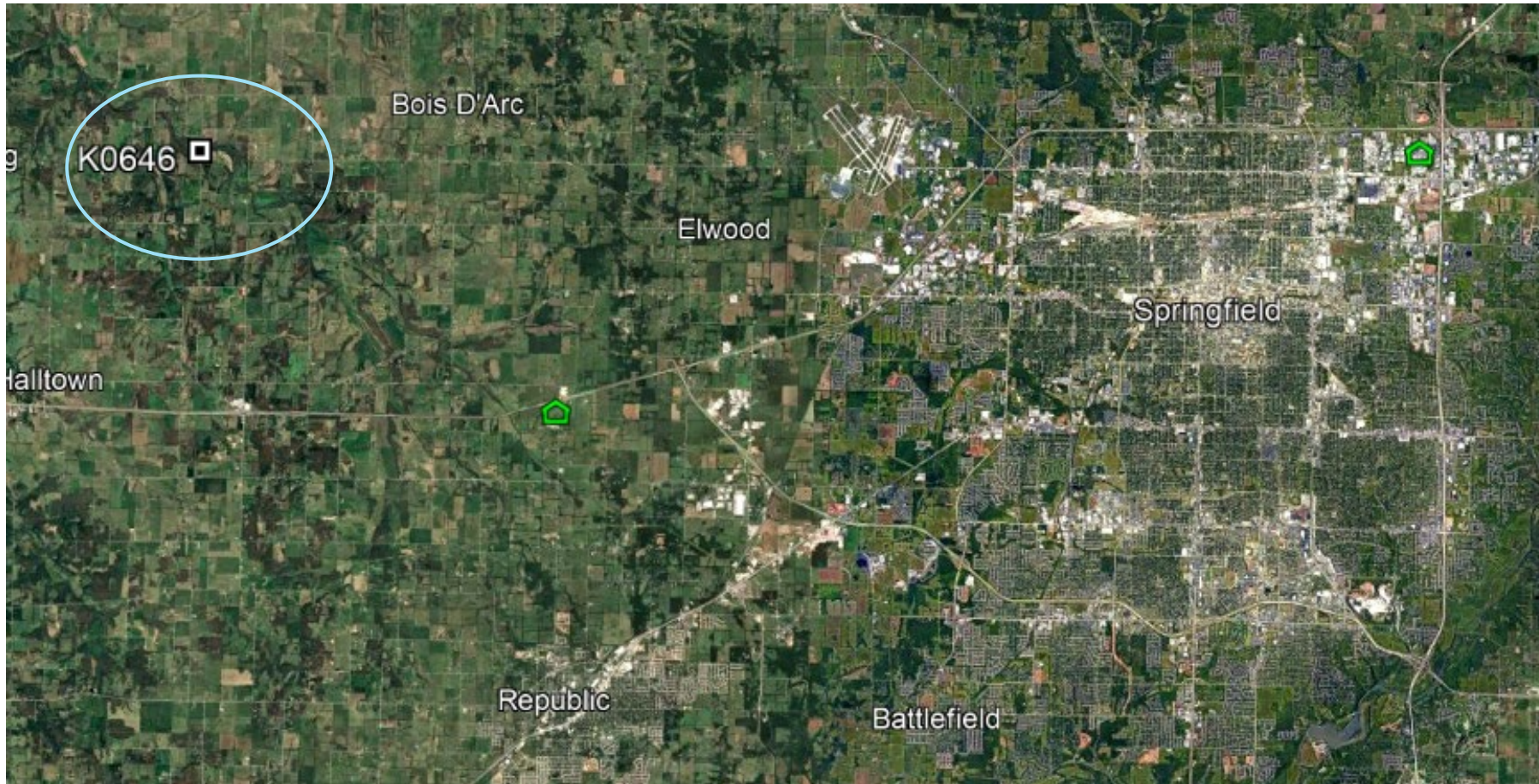
Lydia Brownell, P.E.

The background features abstract, overlapping geometric shapes in various shades of blue, ranging from light sky blue to deep navy blue. These shapes are primarily located on the right side of the image, creating a modern, architectural feel. The text is centered on the left side of the image.

# Route F over the Sac River Branch Bridge Replacement Southwest Missouri

# Project Location

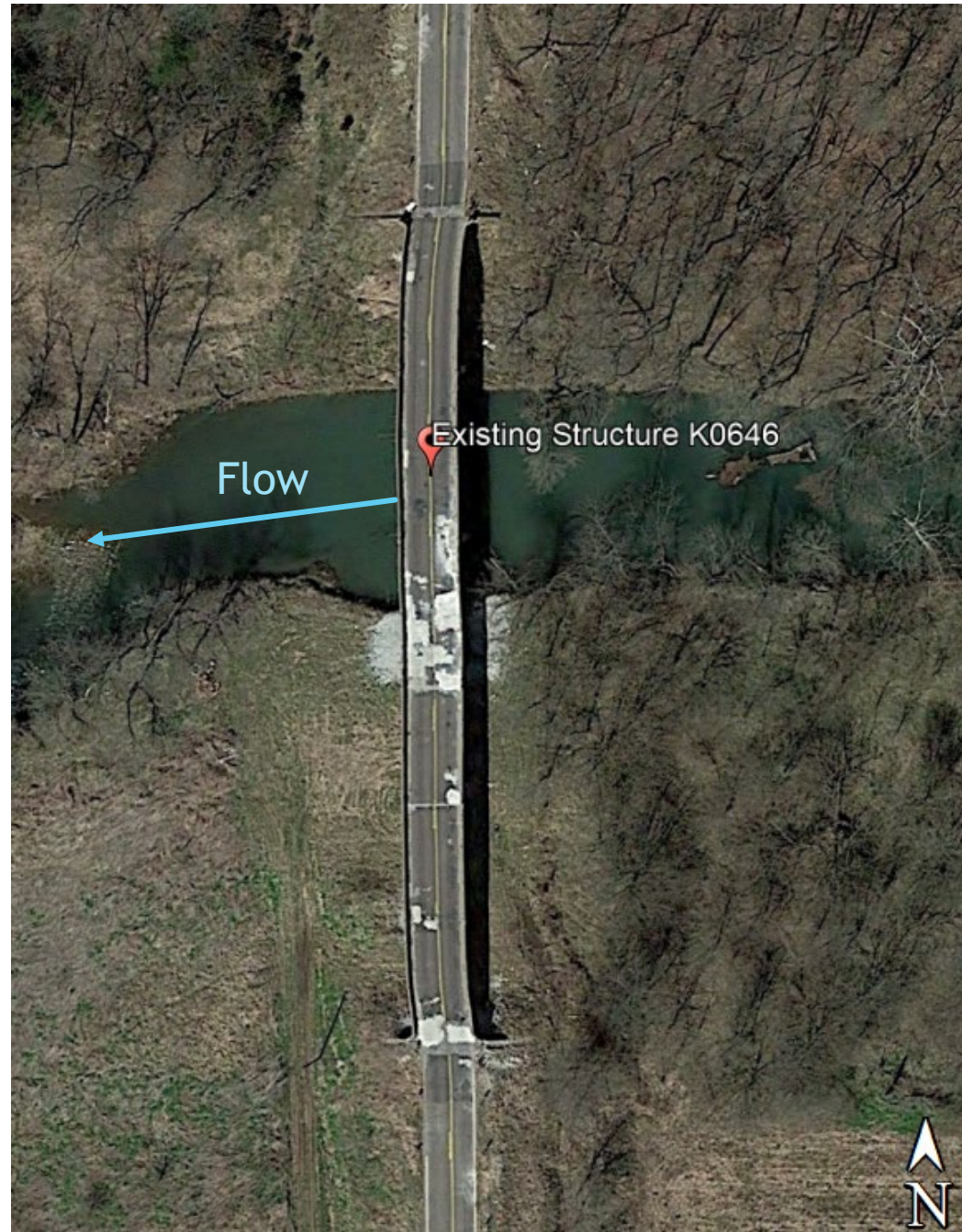
- ▶ 15 miles west northwest of Springfield, Missouri





# Project Location

- ▶ Sac River Branch
  - ▶ Locally flows west
  - ▶ Broadly flows northwest

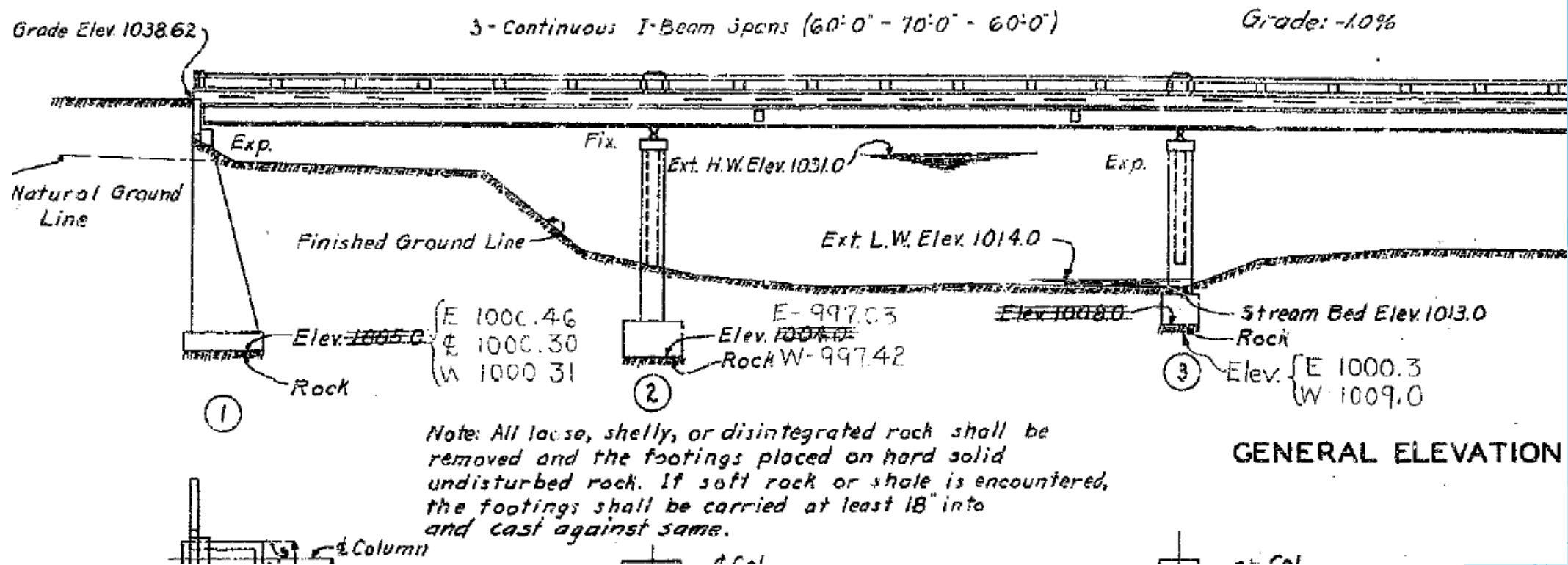




▶ As-Built Plans from October 1935



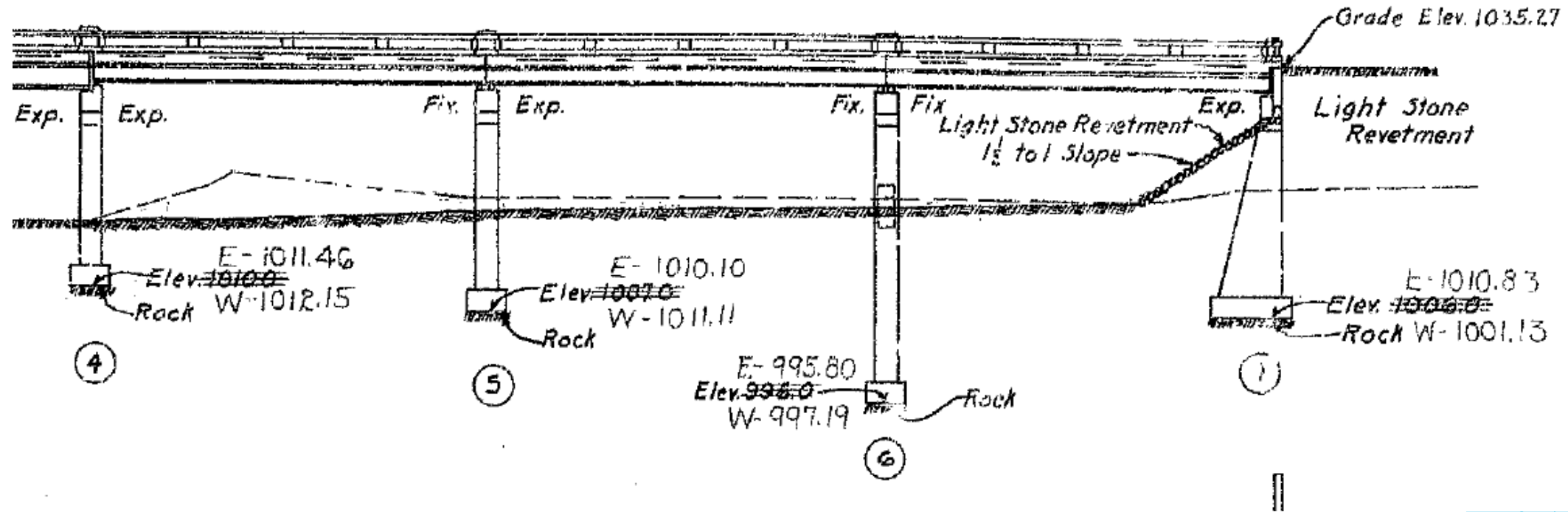
# Existing Structure K0646





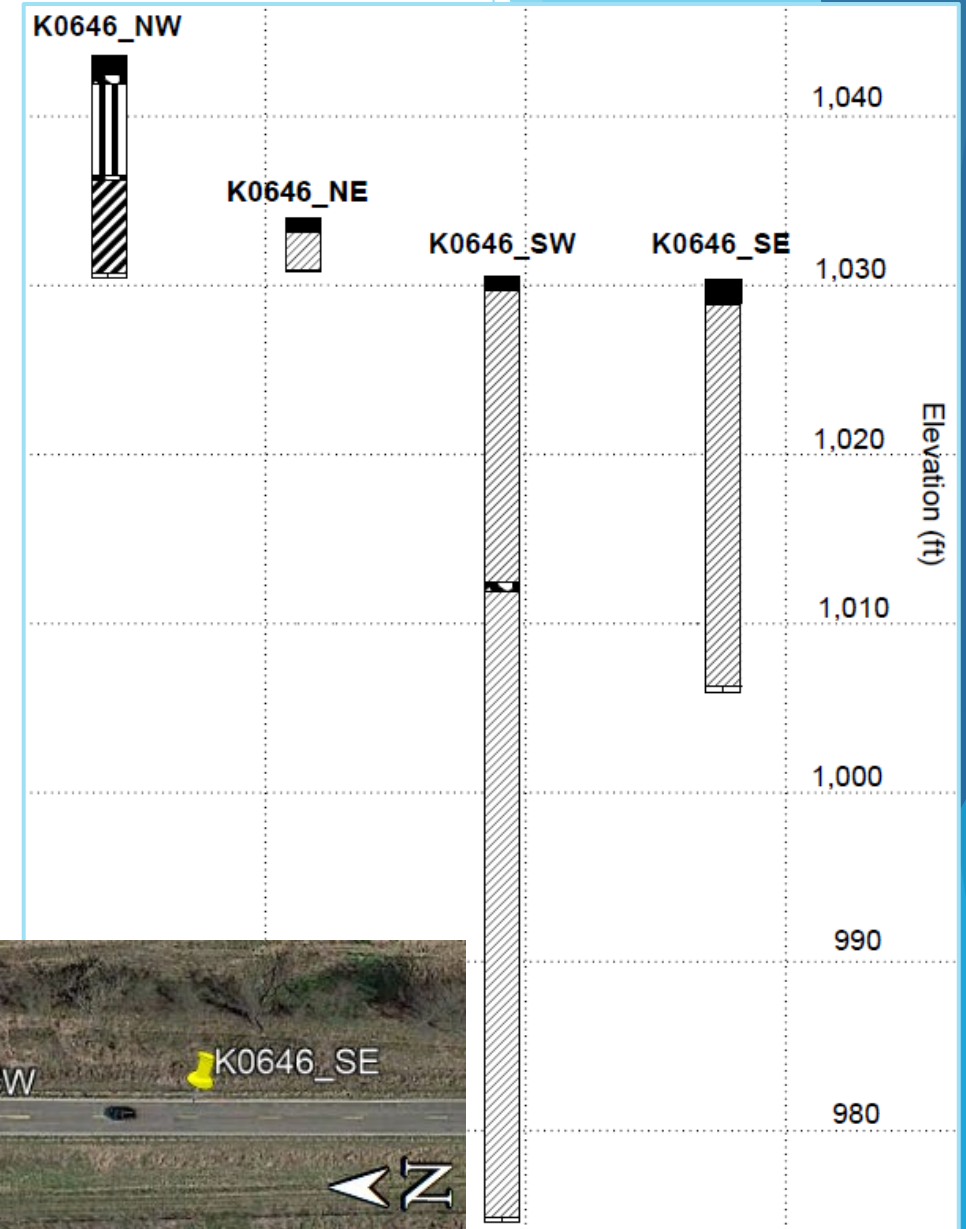
# Existing Structure K0646

3- 45'-0" I-Beam Spans



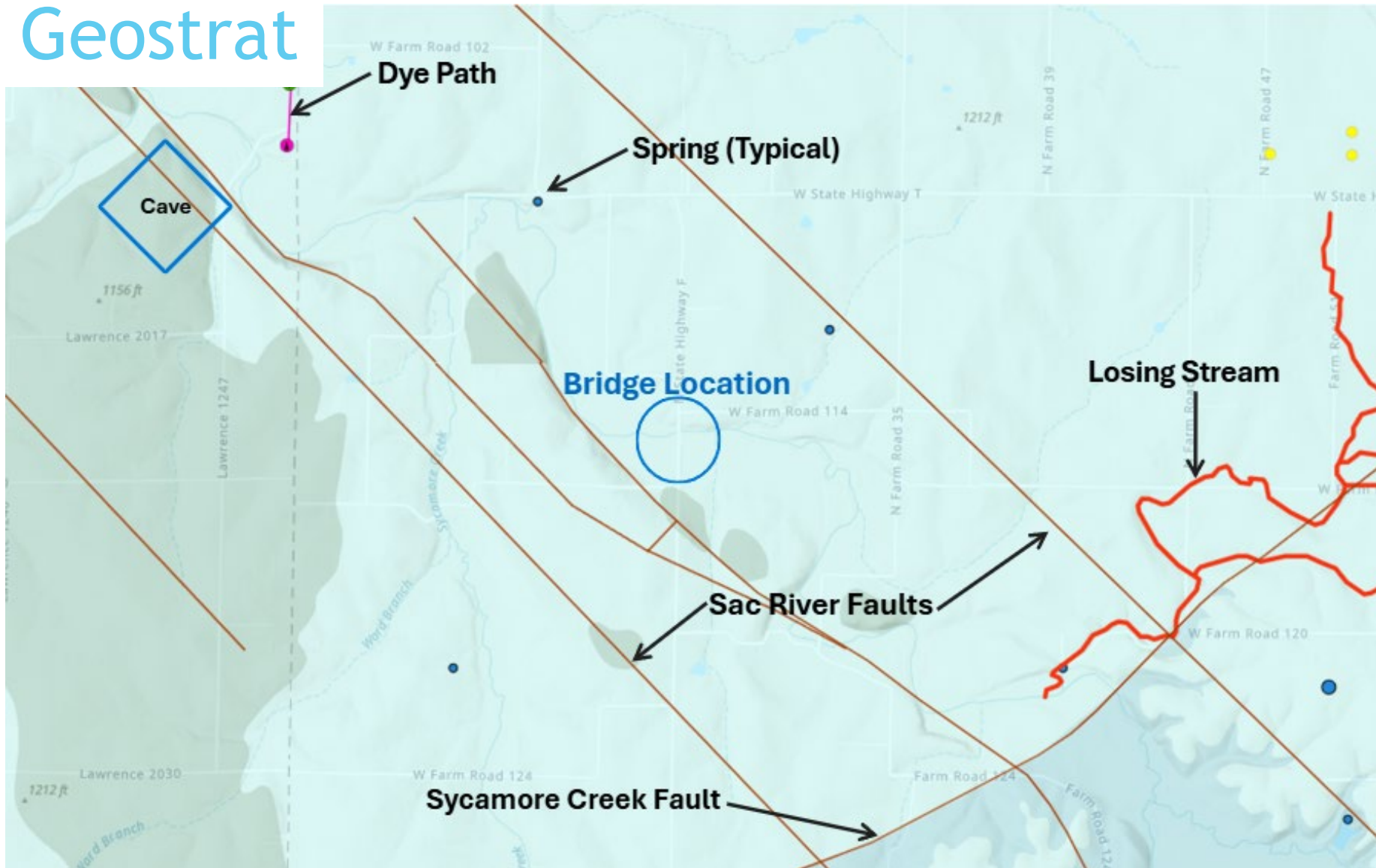
# Preliminary Geotechnical Investigation

- ▶ MoDOT is divided into 7 Districts
- ▶ District Geologists perform PGR's
  - ▶ Auger borings only with limited lab testing of samples
  - ▶ Typically limited to roadway and gentle shoulders
  - ▶ Preliminary planning
- ▶ PGR Findings on this Project:
  - ▶ Larger variation in top of rock than anticipated from the existing plans!
  - ▶ At least auger refusal occurred quickly...

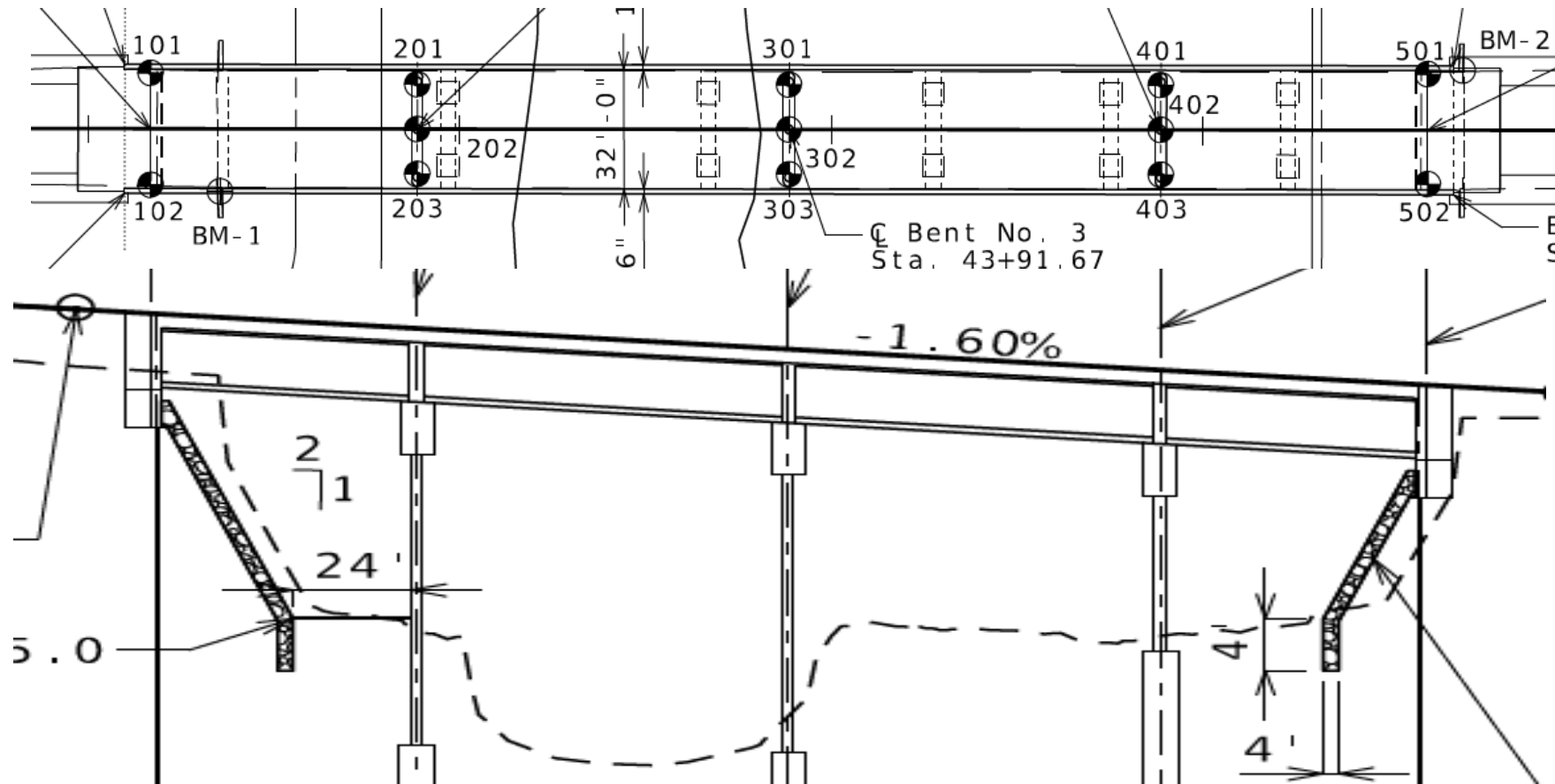




# Geostrat



# Replacement Structure A9077

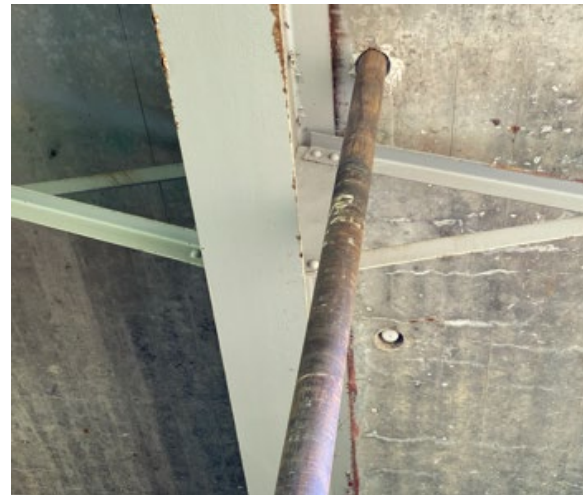


- ▶ H Pile Supported End Bents and Drilled Shaft Supported Intermediate Bents
- ▶ 70'-100'-100'-70' Span Layout



# Best-Laid Plans

- ▶ Initial plan
  - ▶ Complete 2 borings per bent
    - ▶ Borings on location of outer pile on each end bent
    - ▶ Borings on Left and Right Drilled Shaft Locations on intermediate Bents
- ▶ Adjustments!
  - ▶ Access to requested locations not possible due to steep embankments
  - ▶ Narrow Bridge -> Close the Road
  - ▶ Minor Flooding
  - ▶ Drift Debris
  - ▶ Girders and Bracing
  - ▶ Environmental



# Begin Drilling

Bent 4 - Boring B-403



Bent 4 - Boring B-401



- ▶ Great Recovery
- ▶ Great RQD
- ▶ Great Strength



# Continue Drilling

Bent 3 - Boring B-301 Offset

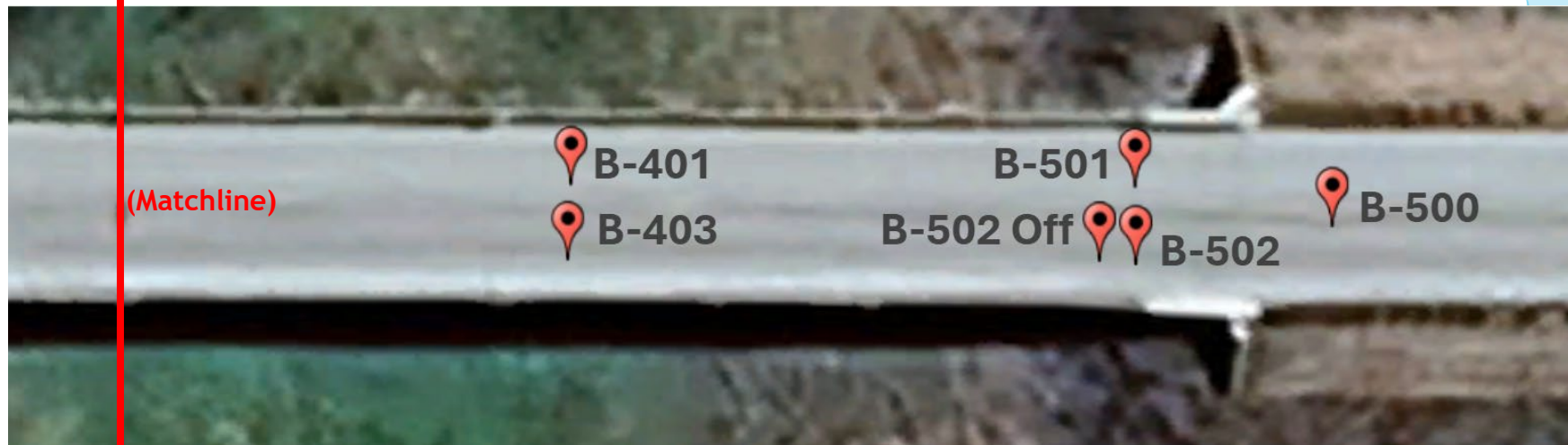
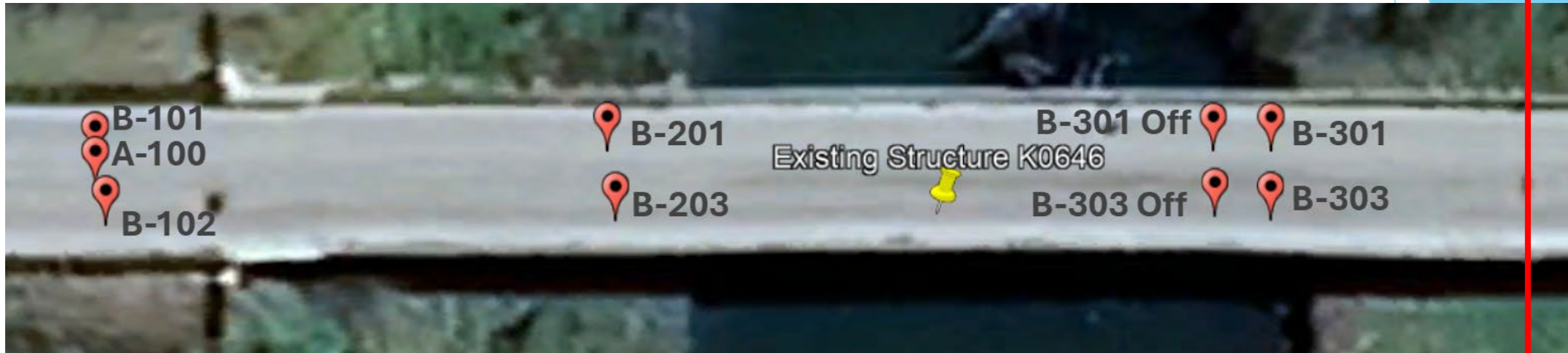


Bent 1 - Boring B-102

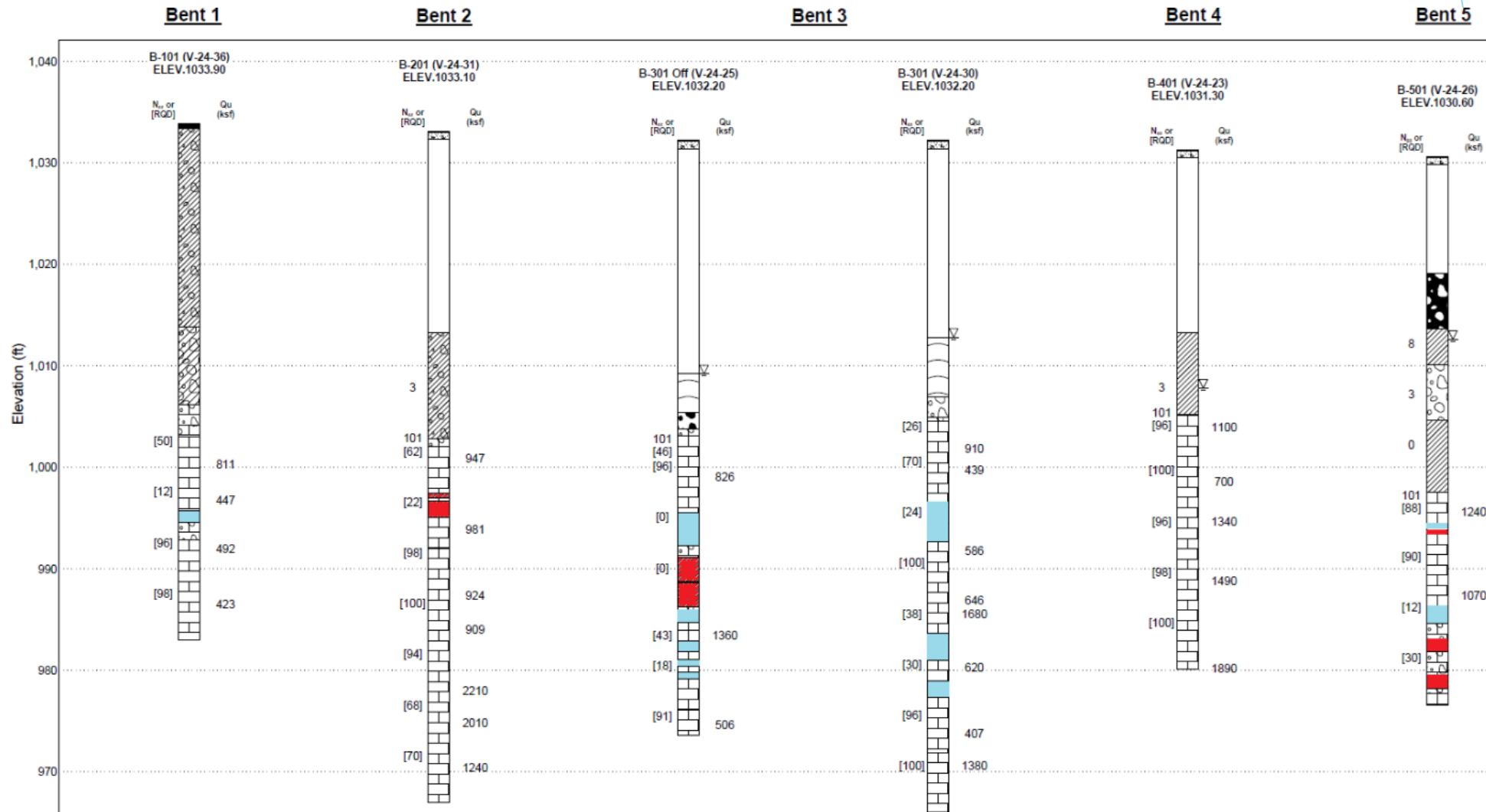


- ▶ Voids
- ▶ Clay Seams
- ▶ Low RQD
- ▶ Poor Recovery
- ▶ Water Current within Void at Bent 1
- ▶ Made Design Team Aware of Conditions

# Field Investigation Complete

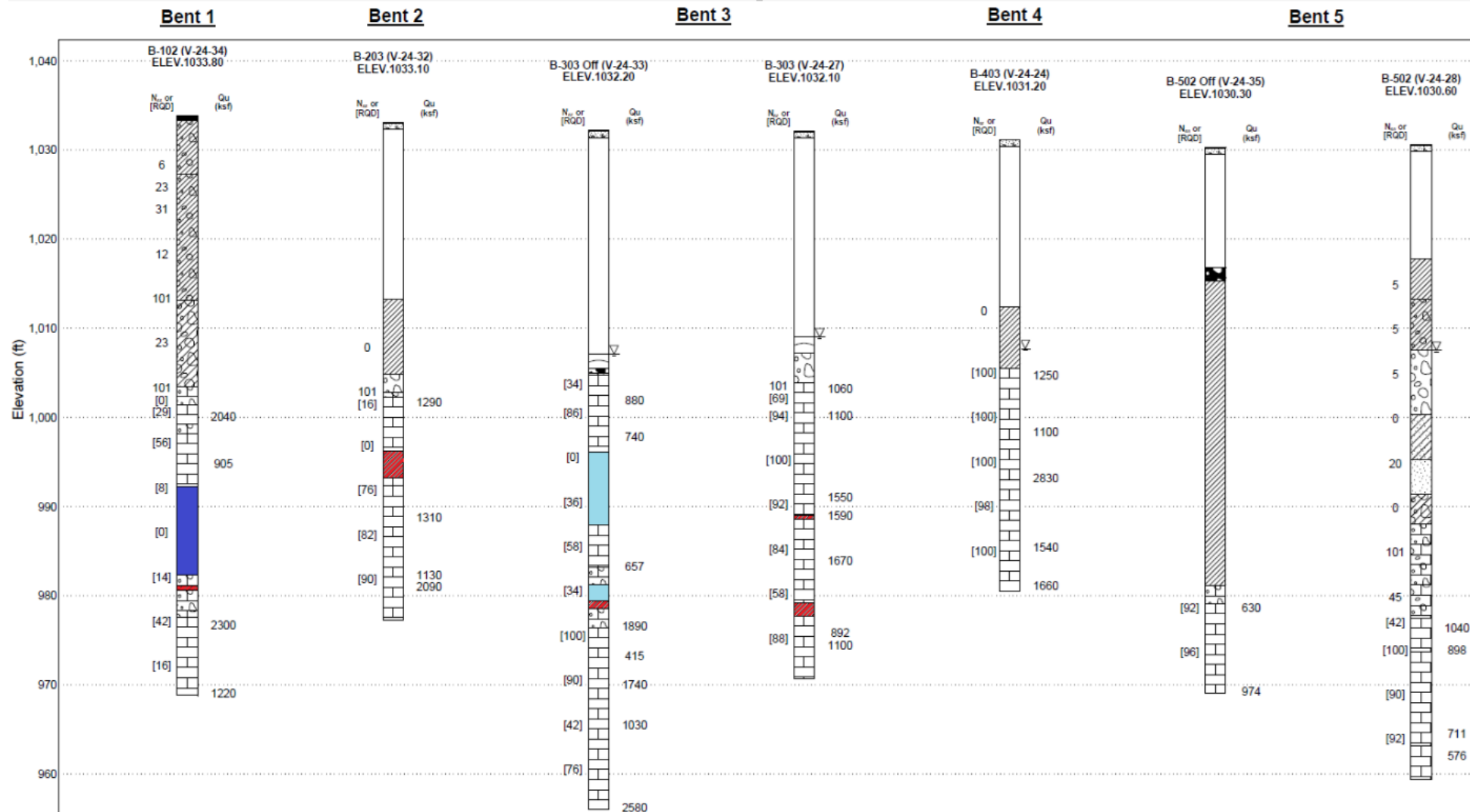


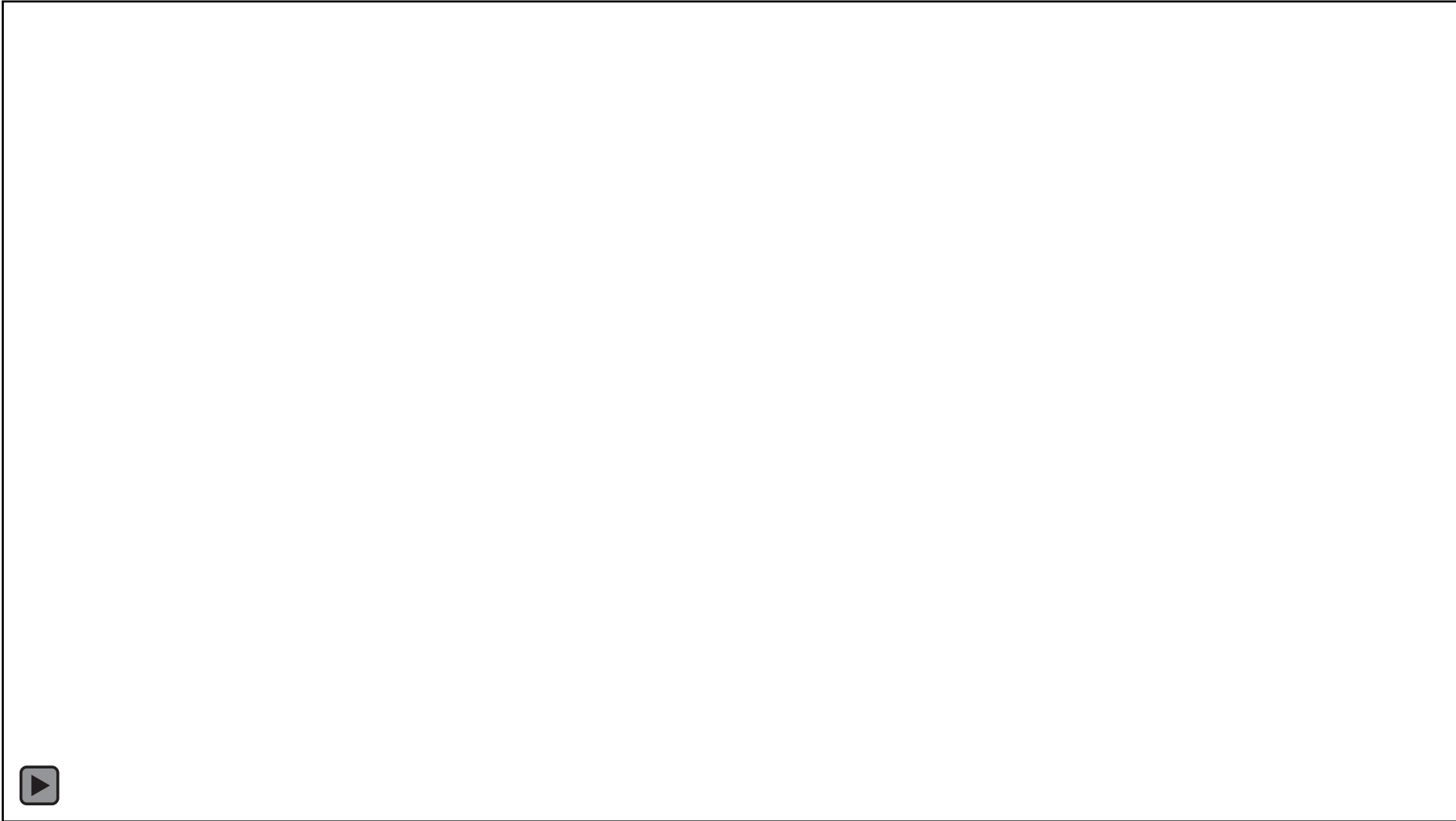
# North Bound Diagram

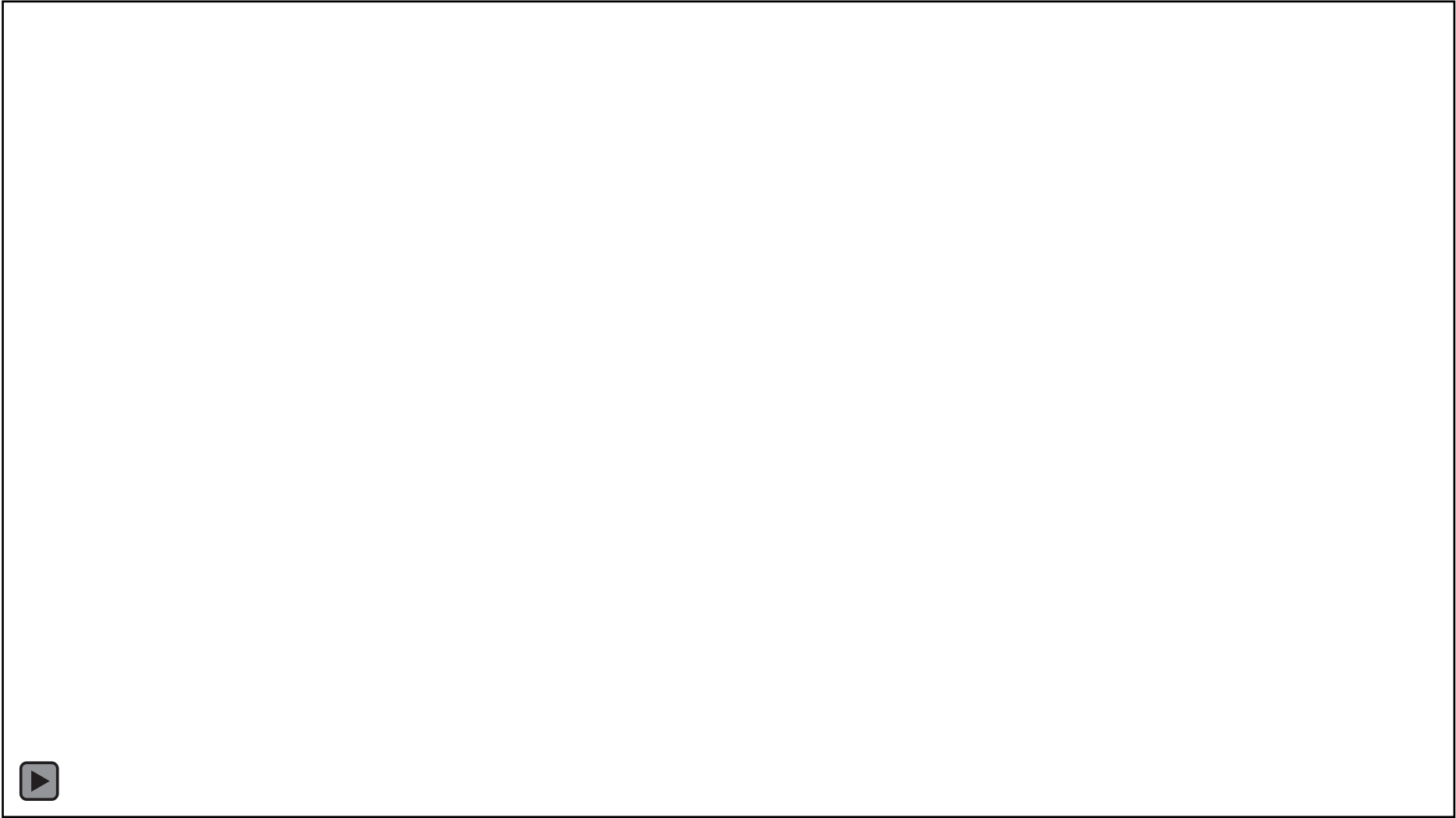




# South Bound Diagram



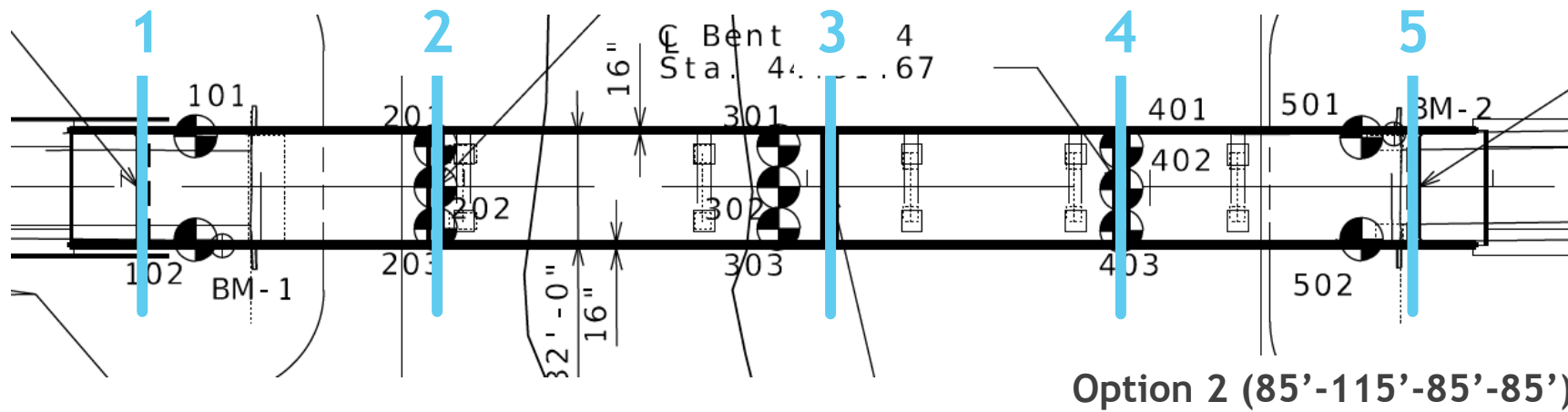
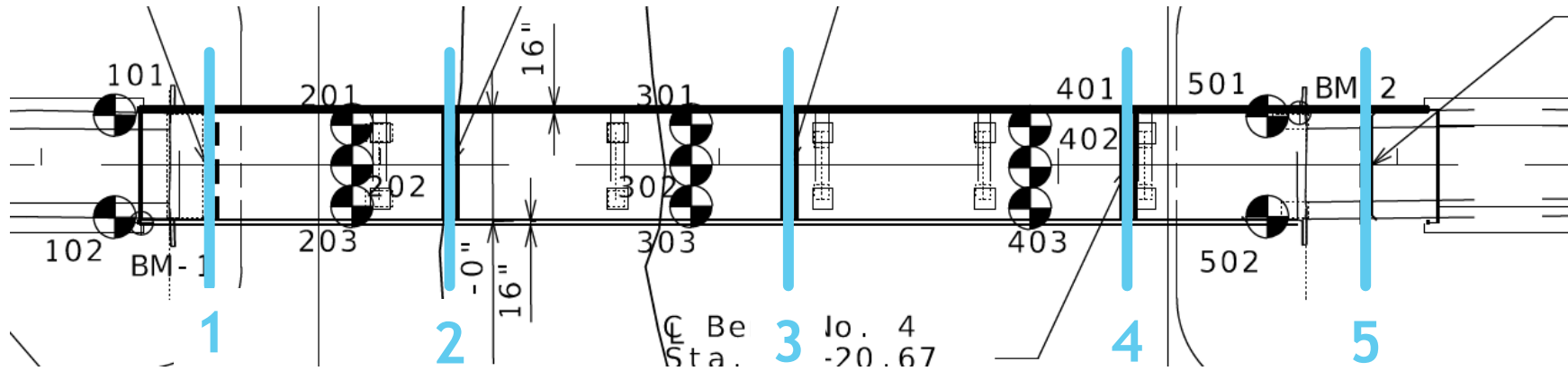






# Alternate Layout(s)

Option 1 (70'-100'-100'-70')



# Drilling Plan For Options 1 & 2

- ▶ Compared Layout Options to Anticipated Subsurface Conditions
  - ▶ Elected to Explore Option 1 First
    - ▶ Preferred Option by Designer
    - ▶ Maintained Span Layout
  - ▶ 1 Boring Per Bent
    - ▶ Prioritize Areas of Highest Concern
    - ▶ Additional Borings if Findings are Favorable
    - ▶ Move on to Option 2 if Findings are Not Favorable
    - ▶ Focus on Rock Conditions and Limit Soil Sampling

# Option 1 Drilling

Bent 3 - Boring Opt1 B-302



Bent 5 - Boring Opt1 B-502



- ▶ Good Recovery
- ▶ Good RQD
- ▶ Good Rock
- ▶ Few Karst Features



# Drilling Continued

Bent 2 - Boring Opt1 B-201

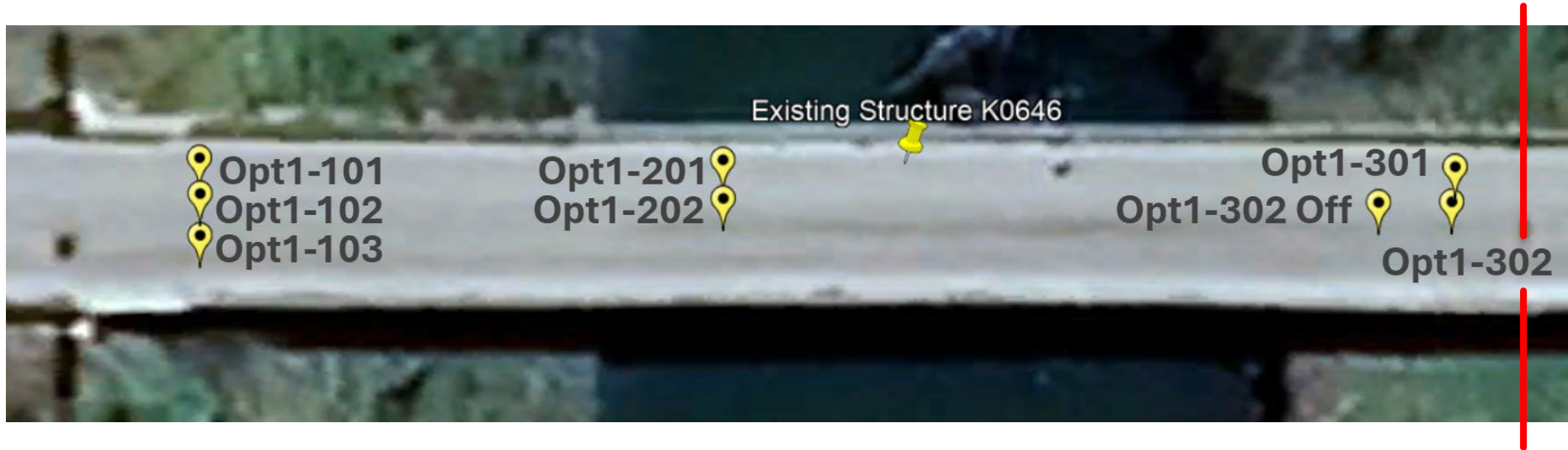


Bent 4 - Boring Opt1 B-401



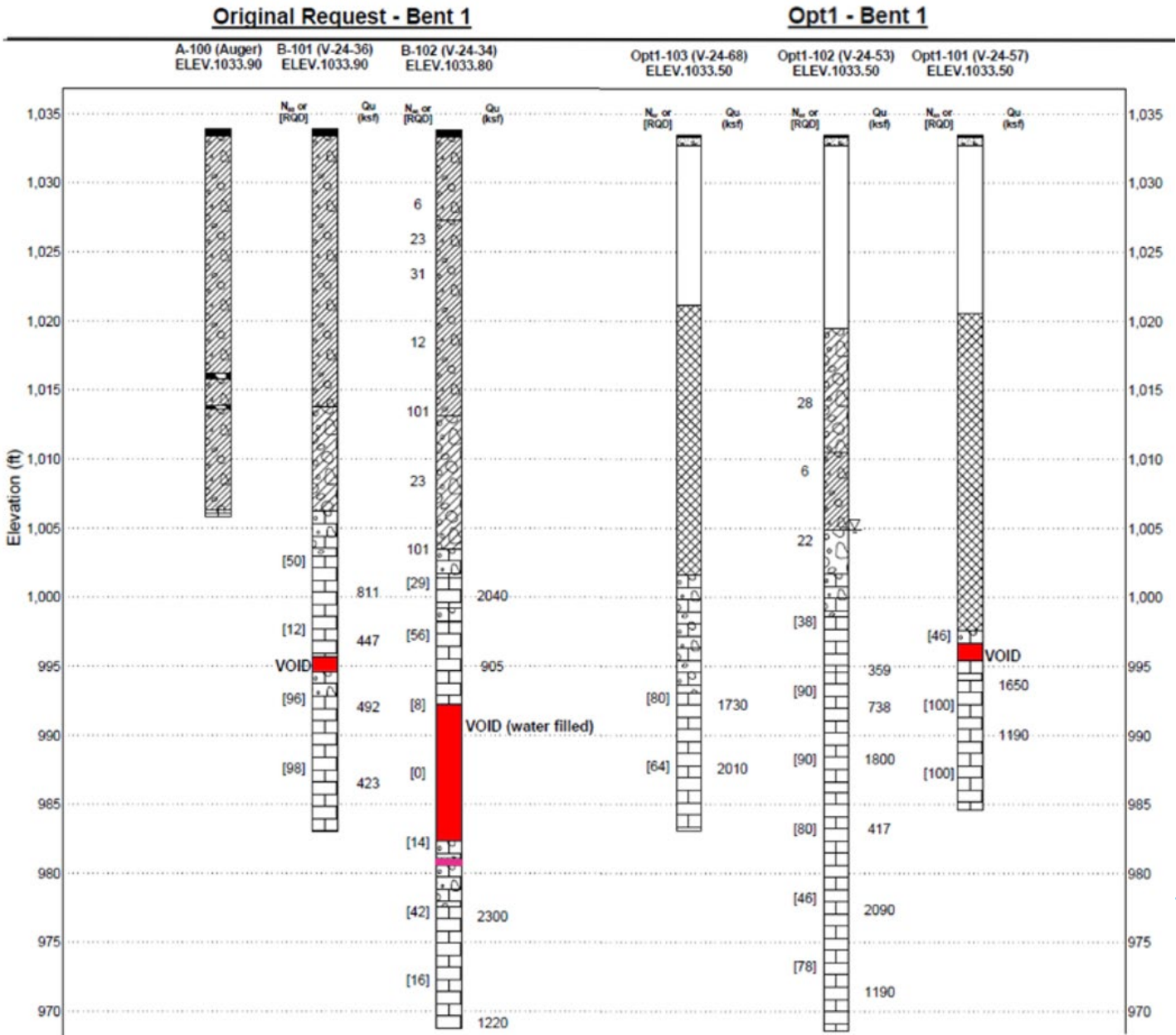
- And the remaining borings encountered similar conditions

# Field Investigation - Option 1



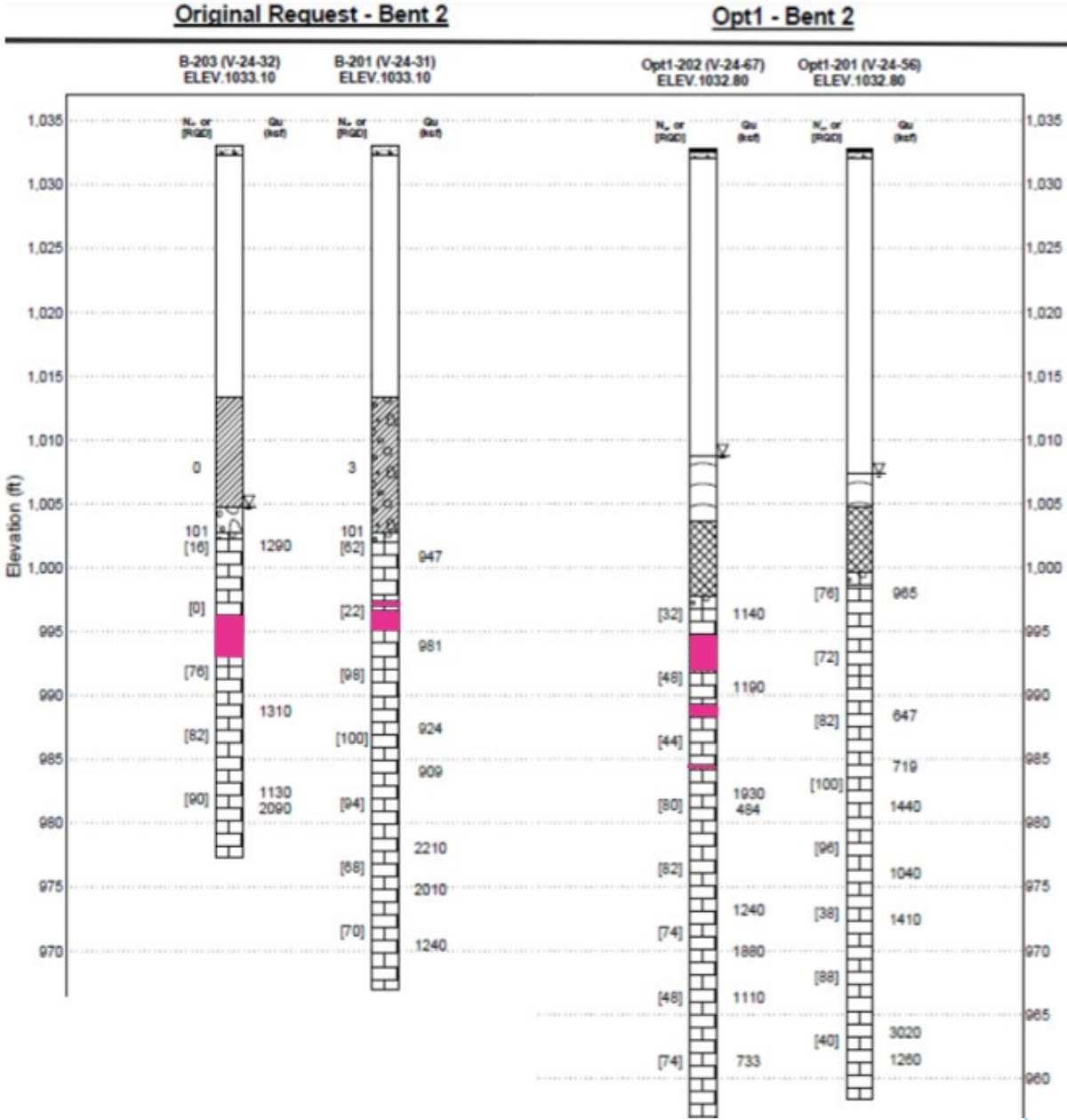


# Bent 1

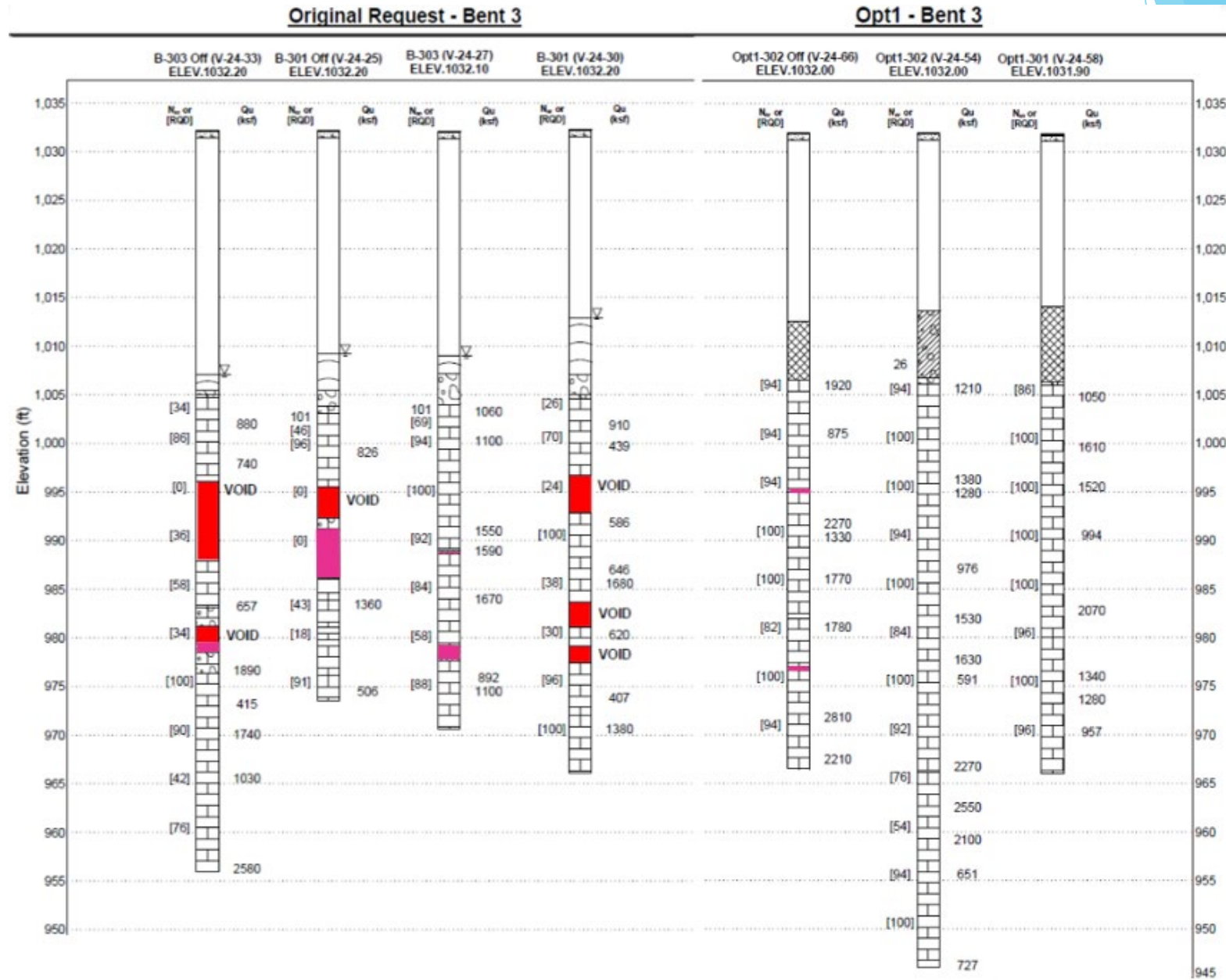




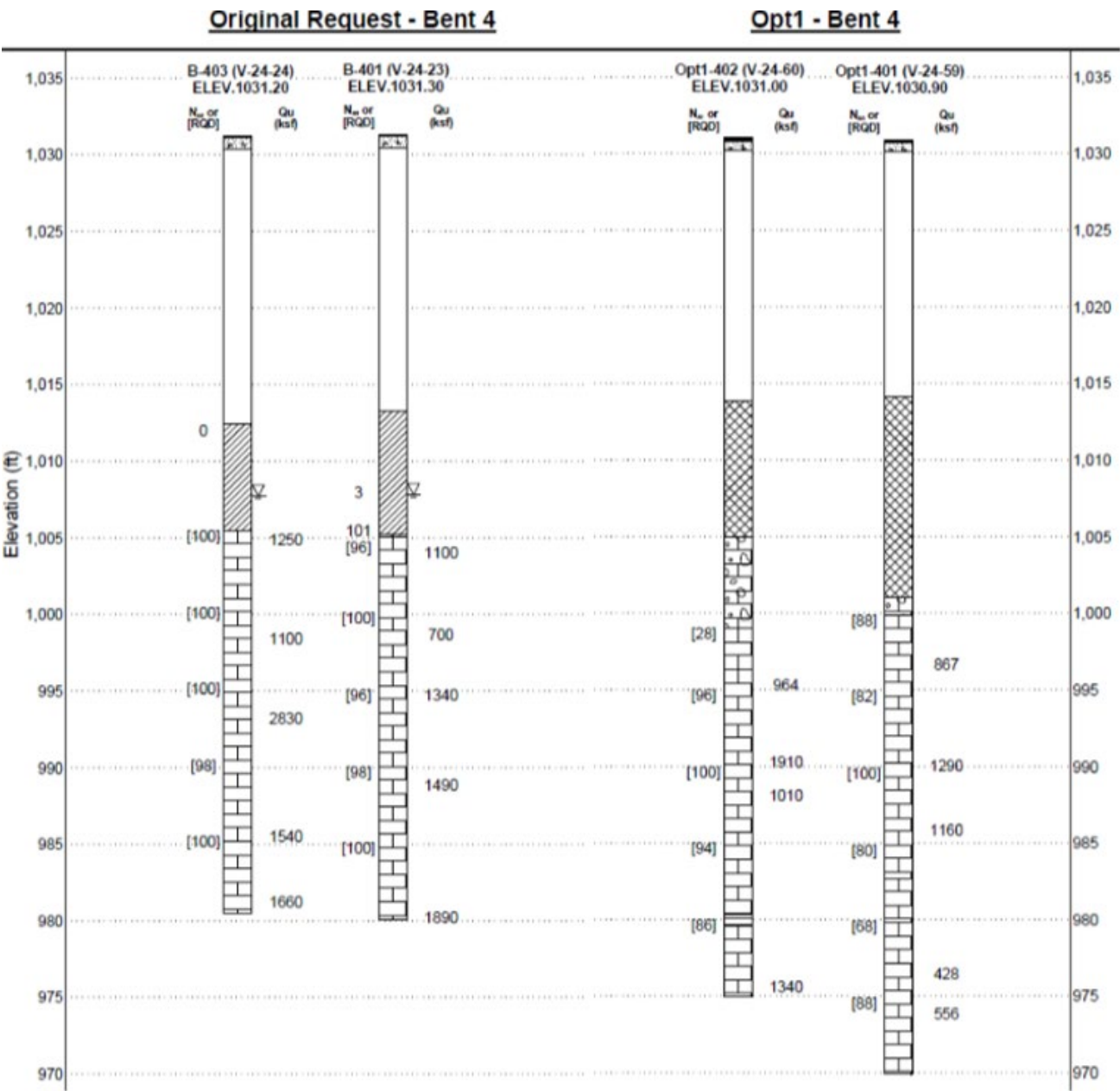
# Bent 2



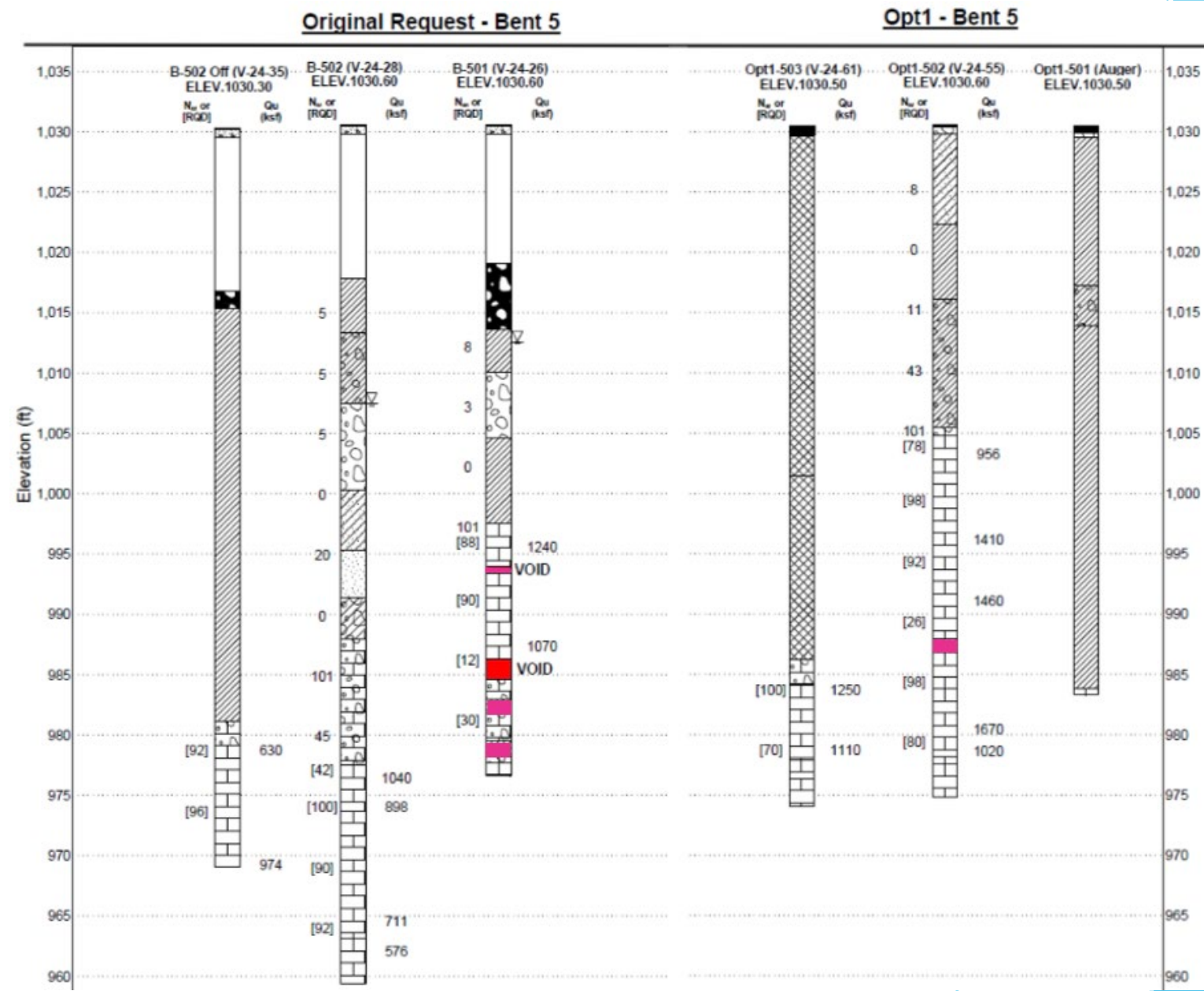
# Bent 3



# Bent 4



# Bent 5





# Moving Forward

- ▶ Elected to utilize Option 1 Layout.
- ▶ Overall Improvement
  - ▶ Reduced karst impact -
    - ▶ 20+ voids and clay seams/filled voids in original investigation to 7 for Option 1
      - ▶ Nearly 50 feet less of encountered voids and clay seams
  - ▶ Complexity of casing through the underground flow avoided
  - ▶ Risk of lost return from additional drilling paid off
    - ▶ Considerable Savings at Bents 1 and 3
  - ▶ Anticipated shorter construction schedule

# Take Aways

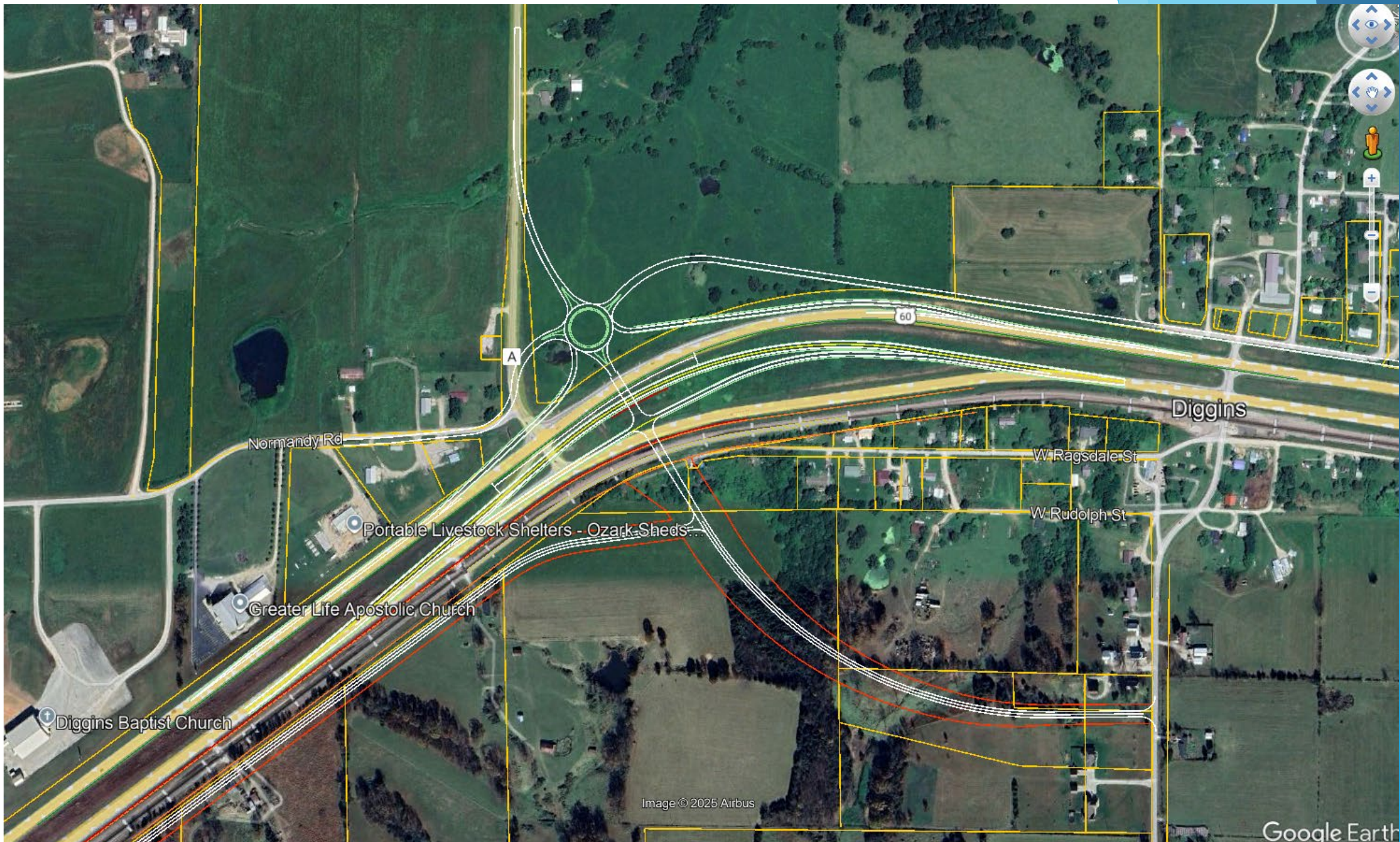
- ▶ Keep an Open Mind
- ▶ Reduce risk of construction complications where possible
- ▶ Allow your design to work with the site
- ▶ **COMMUNICATE!**
  - ▶ Early
  - ▶ Often

Thank you!

# The Ugly But Ended...Good

Highway 60  
Route A/Route N Cross Overs  
Webster County







- ▶ The roadway design, geotech, and bridge design were all consulted out due to the desire to expedite this project.
- ▶ It was an interesting project from the start!
  - ▶ The geotechnical report mentioned karst and possible filled in sinkholes in the General Geology section but did not specifically mention any problem areas along the project site other than highly variable depths to rock.
  - ▶ The original geotechnical report provided 7 different methods to reduce the time for settlement without guidance for each method provided as well as a few other items we had requested clarification for after reviewing their report.
  - ▶ No additional reports or revisions were provided for our review.
- ▶ Fast forward to a phone call from our bidding department asking me about jet grouting for a project...

THE PROFESSIONAL, MICRO, SIGNATURE AND PERSONAL  
SAL. APPEAR HEREIN. ADDRESS RESPONSIBLE. IT  
ONLY FOR WHAT APPEARS ON THIS PAGE, AND  
DISCLAIMS PERSONALITY TO OTHERS. IT IS NOT  
SPECIFICATION, ESTIMATES, REPORTS, OR OTHER  
DOCUMENTS OR INSTRUMENTS NOT DEALING OF THE  
UNDERSTOOD PROFESSIONAL RELATING TO OR  
ATTACHED TO A PROJECT, AND PART OR PARTS OF  
THE PROJECT TO WHICH THIS PAGE REFERS.



# Value Engineer (VE) Review

## Where did the Jet grouting come from?

- ▶ The Geotech report mentioned
  - ▶ Settlement of the upper soils which could be addressed with over-excavation
  - ▶ Settlement of the lower clay soils accounted for 40-60% of the overall settlement with it taking about 20 months to occur
- ▶ The Geotech report did not recommend jet grouting
  - ▶ Wick drains
  - ▶ Aggregate columns
  - ▶ Adding pavement repairs as settlement occurs
- ▶ We later learned the consultant designer had reached out to Keller for options due to time constraints.

# Contractor submitted VE study

## V.E. Jet Grouting

### Underrun

Item	Description	QTY	UNITS	UNIT PRICE	TOTAL
	70 Pore Pressure Measuring Device	-4	EA	\$ 8,500.00	\$ (34,000.00)
	1480 Misc. Jet Grouting MOB & Testing	-1	EA	\$ 1,210,000.00	\$ (1,210,000.00)
	1490 Misc. Concrete Groute	-7100	LF	\$ 1,100.00	\$ (7,810,000.00)
					<hr/> <hr/>
					\$ (9,054,000.00)

### Overrun

Item	Description	QTY	UNITS	UNIT PRICE	TOTAL
5001	Initial Engineering	1	LS	\$ 30,000.00	\$ 30,000.00
	Final Engineering, Layout, Equip &				
5002	Testing	1	LS	\$ 350,000.00	\$ 350,000.00
5003	Wick Drain System	1	LS	\$ 1,750,000.00	\$ 1,750,000.00
5004	Site Grading, Maintenance & MOB	1	LS	\$ 50,000.00	\$ 50,000.00
5005	Select Granular Backfill 2' Thick	16,500	SY	\$ 50.00	\$ 825,000.00
710	Seperation Geotextile	16,500	SY	\$ 5.50	\$ 90,750.00
					<hr/> <hr/>
					\$ 3,095,750.00

Total Savings: \$ (5,958,250.00)

50% MoDOT \$ 2,979,125.00

50% Capital \$ 2,979,125.00



# Wick Drain Recommendations

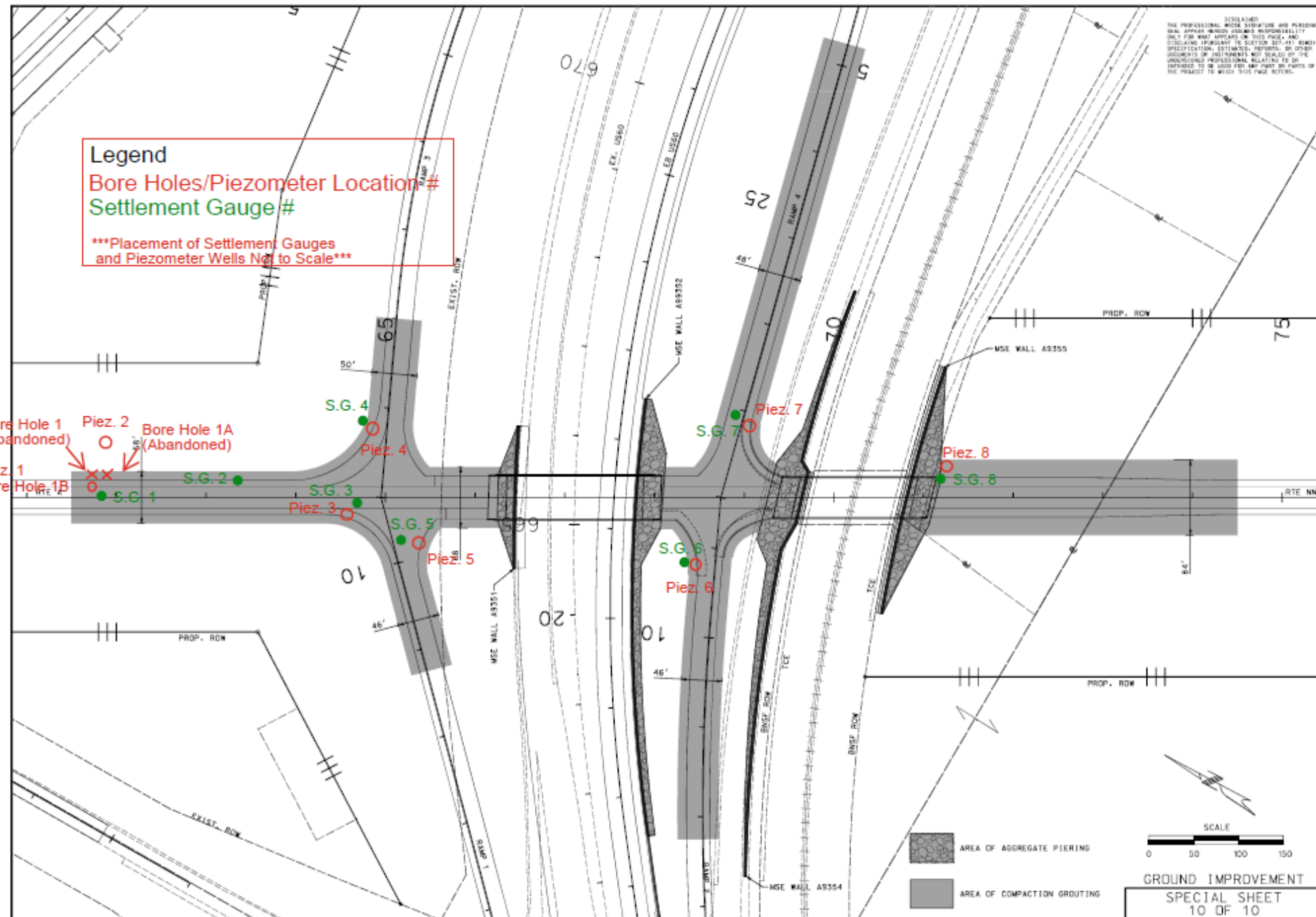
- ▶ Another consultant, FTC, completed additional borings to design the wick drains for the contractor
  - ▶ Wick drains were designed to be 4-inch diameter with a 7-foot center to center spacing
  - ▶ Some wick drains will be pushed, and other wick drains will be drilled due to the chert content in the clay materials
  - ▶ Provided a settlement monitoring plan with monitoring plates and piezometers.

# Legend

Bore Holes/Piezometer Location #  
Settlement Gauge #

\*\*\*Placement of Settlement Gauges  
and Piezometer Wells Not to Scale\*\*\*

Bore Hole 1  
(Abandoned)  
Piez. 1  
Bore Hole 1B  
Piez. 2  
Bore Hole 1A  
(Abandoned)



DISCLAIMER  
THE PROFESSIONAL ENGINEER'S SIGNATURE AND PERSONAL SEAL, APPEARING HEREON, ASSURES RESPONSIBILITY ONLY FOR WHAT APPEARS ON THIS PAGE, AND DOES NOT CONSTITUTE A GUARANTEE OF THE ACCURACY OF THE INFORMATION PROVIDED. THE ENGINEER'S SIGNATURE AND SEAL ARE NOT TO BE USED FOR ANY PART OF THE PROJECT TO WHICH THIS PAGE REFERS.

THIS MEDIA SHOULD NOT BE CONSIDERED A CLERICAL DOCUMENT.

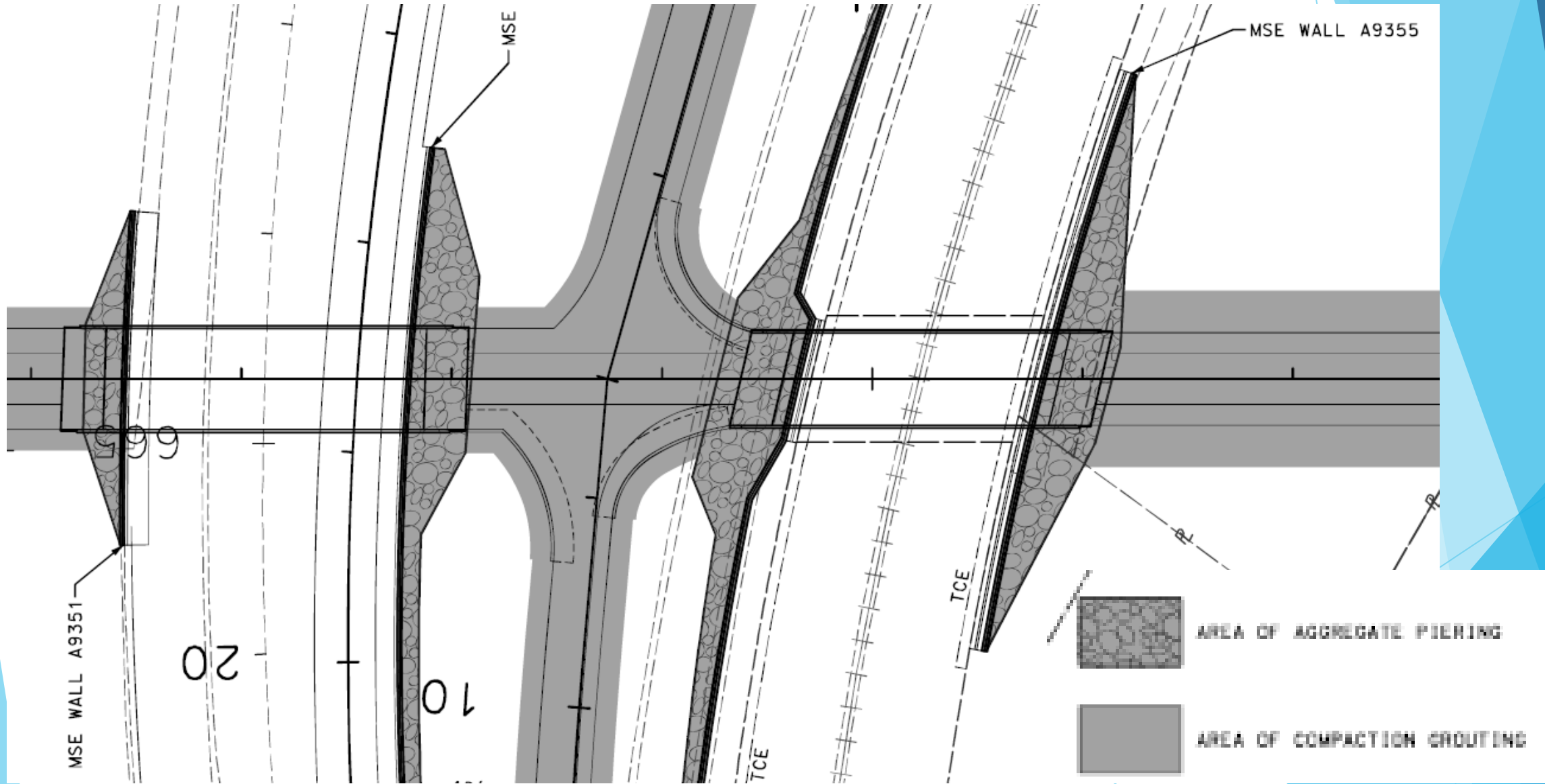
DATE PREPARED  
9/3/2024  
SHEET  
60 OF 60  
DESIGNED BY  
SW  
CHECKED BY  
89  
DESIGNER  
WEBSTER  
JOB NO.  
JTP3425C  
CONTRACT NO.  
PROJECT NO.  
BRIDGE NO.

DESCRIPTION	DATE

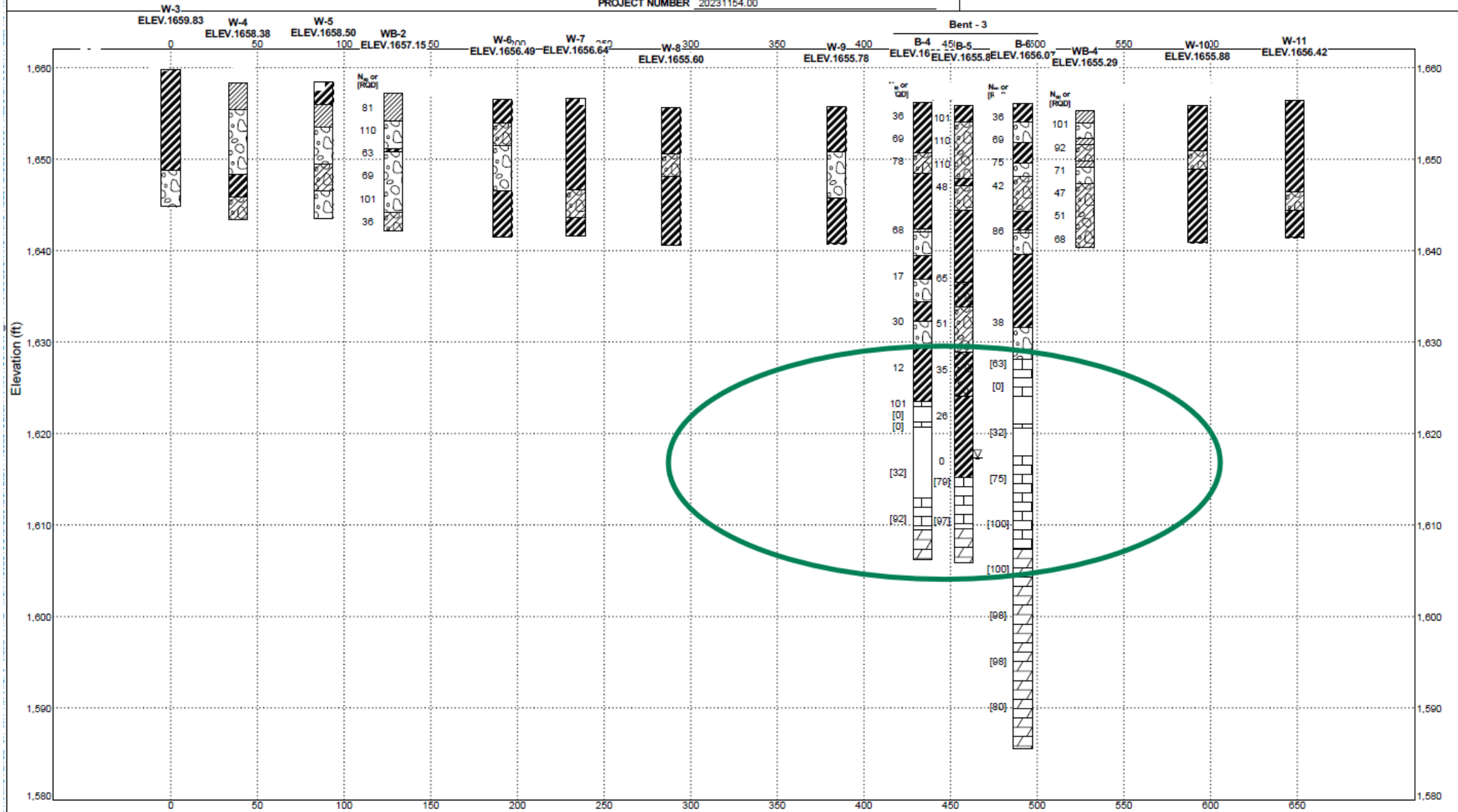
MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION  
MDOT  
100 WEST CAPITOL  
JEFFERSON CITY, MO 65102  
1-888-ASK-MDOT 1-888-275-6831

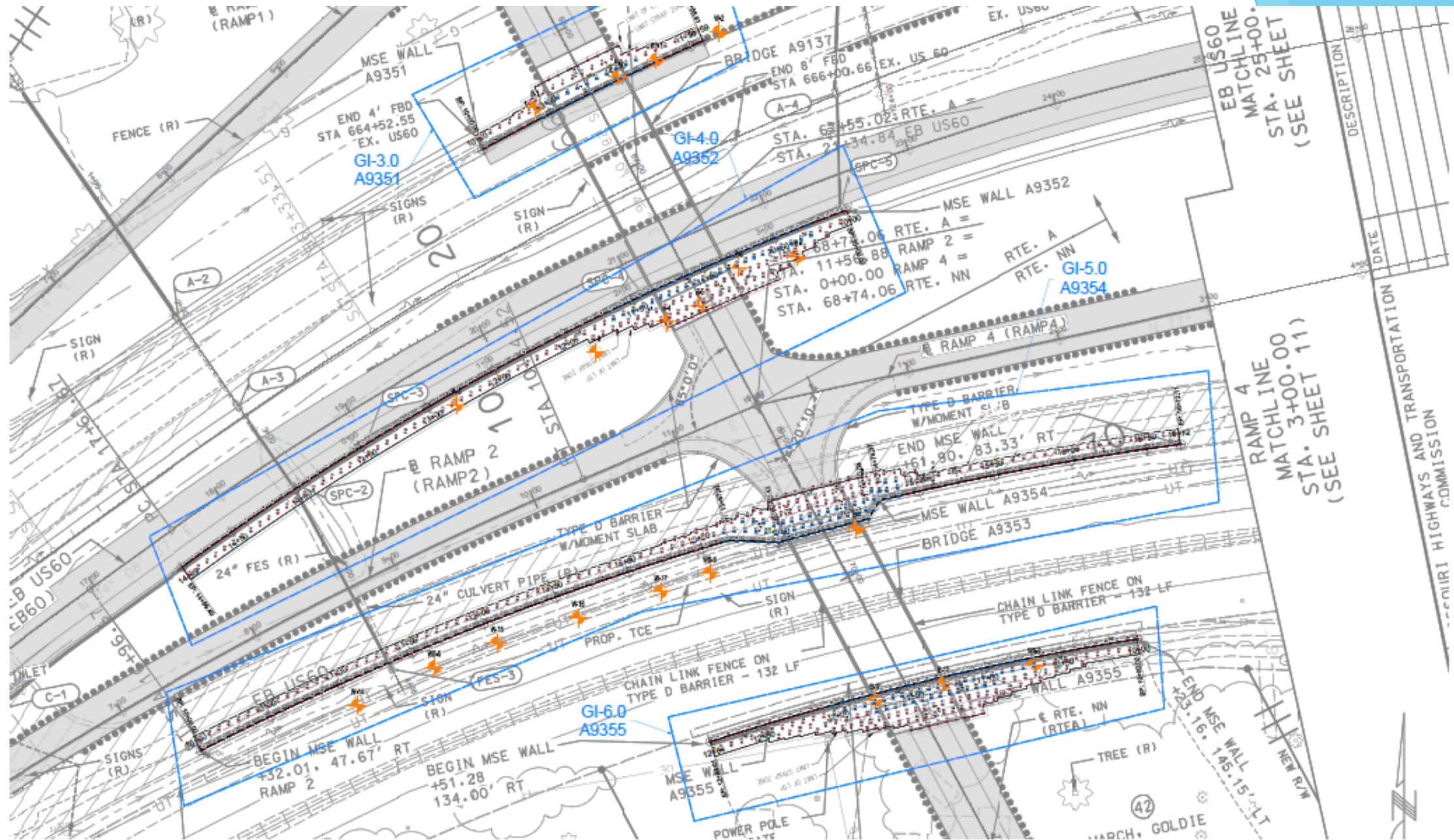


# Hatching Confusion









# LEGEND:

XX — RIGID INCLUSION ID NUMBER

## NOTE:

KELLER HAS NOT RECEIVED UTILITY PLANS IF EXIST, KELLER IS NOT RESPONSIBLE FOR POSSIBLE CONFLICTS AND NEED TO REVIS THE DESIGN AND LAYOUT PER GROWNER DIRECTION.

816-292-4170

www.kellerusa.com

Engineer of Record:

Mike A. Noguera



Missouri

Certificate Of Authorization

2008030651

THIS SEAL IS VALID FOR THE STATE OF MISSOURI ONLY. IT DOES NOT GUARANTEE THE QUALITY OF THE DESIGN OR CONSTRUCTION OF THE PROJECT. THE ENGINEER OF RECORD IS RESPONSIBLE FOR THE DESIGN AND CONSTRUCTION OF THE PROJECT. THE SEAL IS NOT TO BE USED FOR ANY OTHER PURPOSE.

DESIGN, CONSTRUCTION, AND MAINTENANCE OF HIGHWAYS AND TRANSPORTATION PROJECTS. KELLER USA, INC. IS A LEADER IN THE INDUSTRY OF GROUND IMPROVEMENT TECHNOLOGY. OUR EXPERTISE AND INNOVATION HAVE BEEN A MAJOR FACTOR IN THE SUCCESS OF OUR CLIENTS. WE ARE COMMITTED TO PROVIDING THE HIGHEST QUALITY OF SERVICE AND TO THE PROGRESS OF THE INDUSTRY.

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

DESCRIPTION

DATE

OVERALL PLAN VIEW

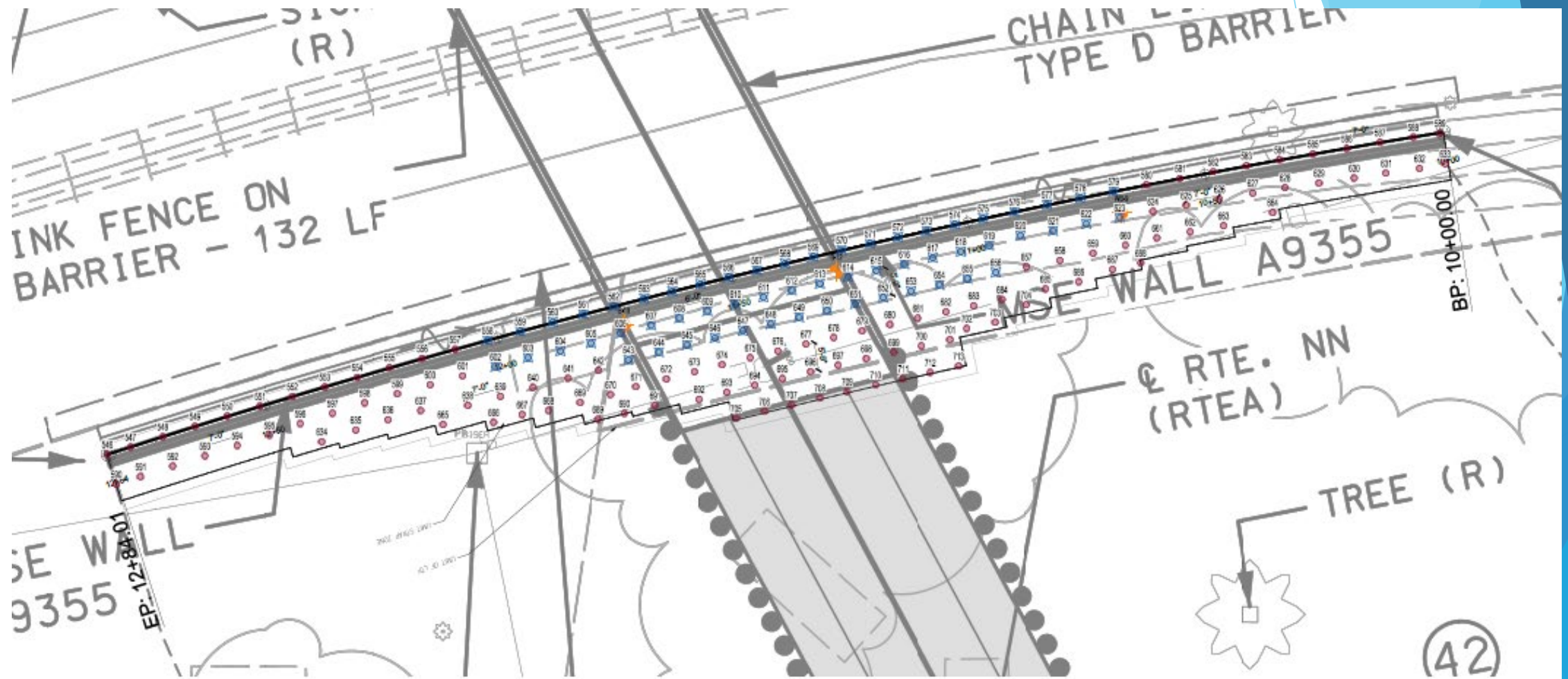
WEBSTER COUNTY, MO - GROUND IMPROVEMENT

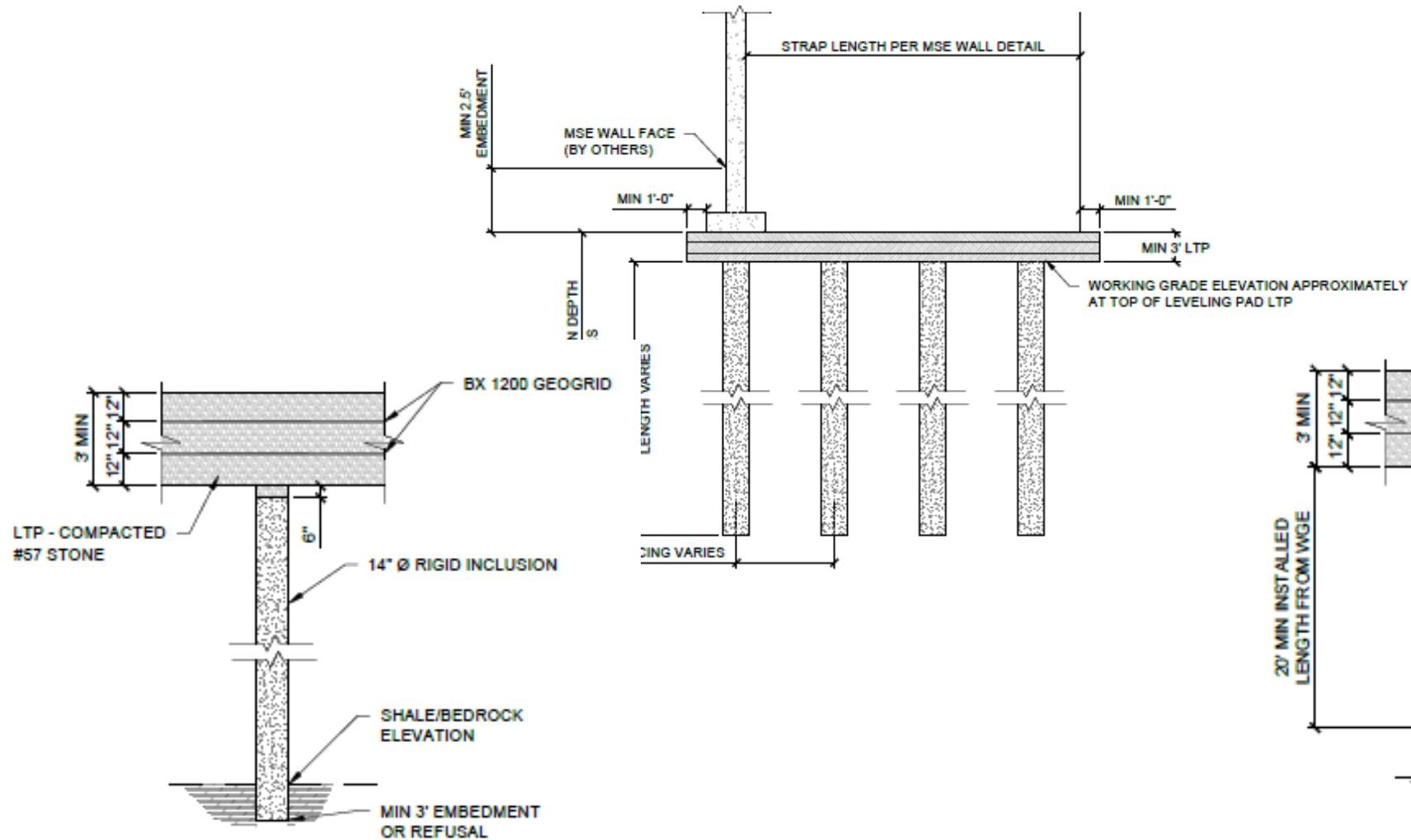
Seymour, Missouri

Design by:

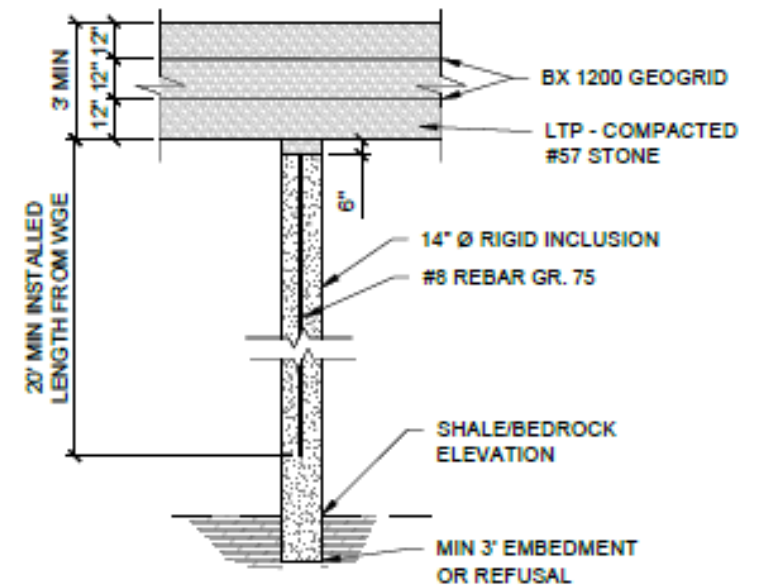
Approved by:







3 RIGID INCLUSION FOUNDATION DETAIL  
NO SCALE



4 REINFORCED RIGID INCLUSION FOUNDATION DETAIL  
NO SCALE



# Project is still under way

- ▶ We just completed review of the design calculations and plans for the rigid inclusions.
- ▶ Still waiting to see the final cost savings overall.

# The Bad & Ugly

Reviewing Drilled Shaft  
Foundation Inspection Cores

**701.4.11 Foundation Inspection.** NX size cores will be required for drilled shafts with rock sockets, where NX refers to the nominal diameter of rock core, and the NX core barrel has a 2 1/8-inch inside diameter. At least 15 days prior to drilled shaft construction the contractor shall drill one NX size core at the center of each rock socket to a depth of 10 feet or twice the diameter of the rock socket, whichever is greater, below the bottom of the rock socket. The contractor shall use the foundation inspection hole to determine the amount of casing needed and casing ordered prior to foundation inspections holes is at the contractor's risk. The contractor may be directed to extend the rock socket to a lower elevation, resulting from the engineer's evaluation of the foundation inspection cores.

**701.4.11.1 Log of Excavated Material.** The contractor shall maintain a log of excavated material for each foundation inspection hole, and a rough draft of the logs shall be delivered to the engineer within 24 hours of completion of the boring. A typed log prepared by a geologist or engineer along with recommendations for the tip of casing shall be delivered to the engineer within 5 days. The log shall include the following:

- (a) The amount of NX cored per run and the amount recovered. All core loss shall be noted and explained. Clay layers shall be noted and located on the log by depth.
- (b) The Rock Quality Designation (RQD) for the NX core. The bedding thickness and degree of weathering shall also be noted.
- (c) One unconfined compression test shall be run per 5 feet of NX core. The results of these tests shall be delivered to the engineer. The results of the unconfined compression tests shall be reported in units of kips per square foot (ksf). Any effect on time of performance resulting from delays in delivery of the above test results to the engineer will be nonexcusable.
- (d) Color photographs of the core.

**701.4.11.2 Storage and Labeling of Rock Cores.** Rock cores shall be stored in structurally sound core boxes and shall be protected from the elements. The core boxes shall be properly labeled to indicate location, depth, beginning elevation, contractor and date, and shall be delivered to the engineer.



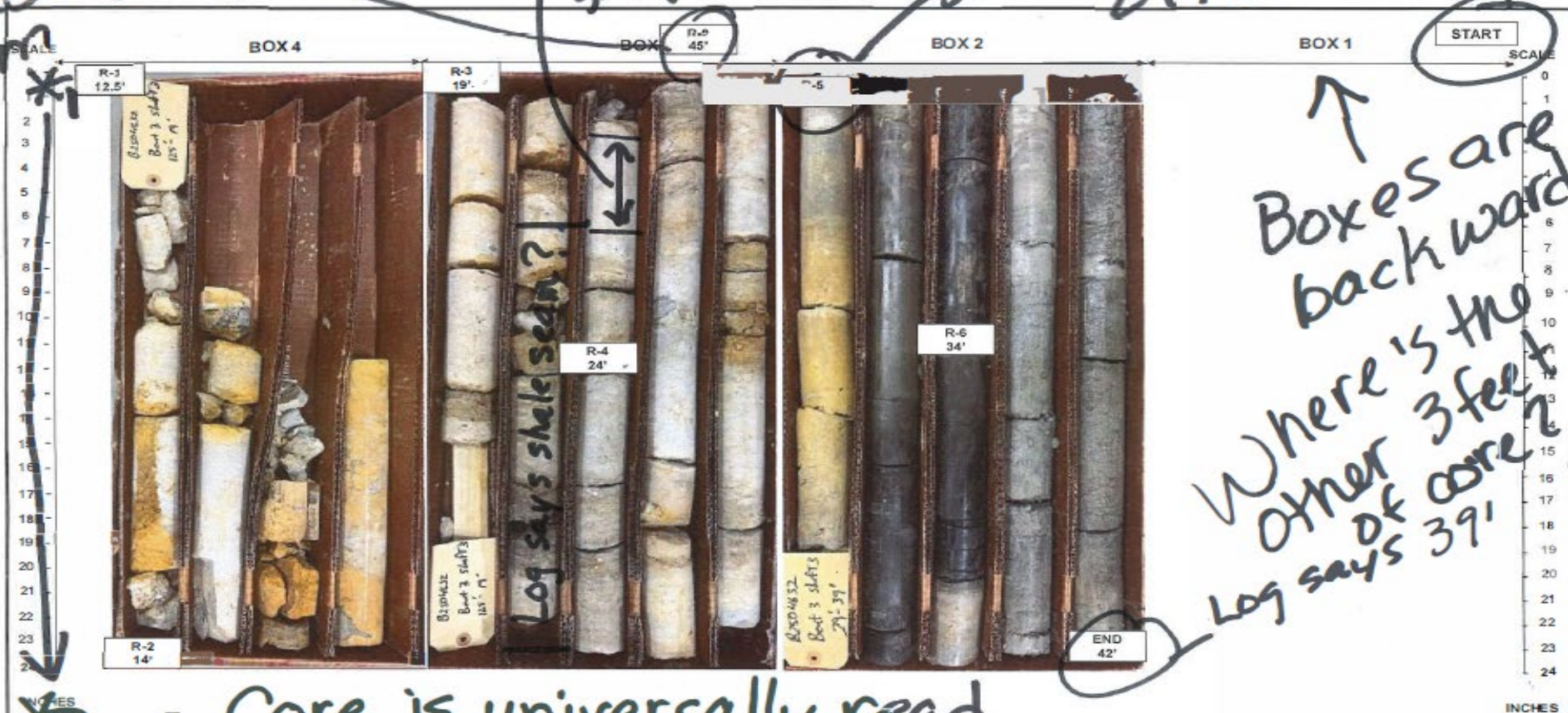


Are we reading from ~~\*~~

R-92.

Log skys washout?

Should this be 29 feet?



↑  
Boxes are  
backwards.  
Where is the  
other 3 feet  
of core?  
Log says 39'

NOTES  
\*2

Core is universally read  
from left to right  
in a box laying horizontally

Unconfined Compression Test Result

PROJECT NO.
DRAWN BY:
CHECKED BY:

PROJECT NO. B250-4632	ROCK CORE PHOTOGRAPHS A9615 Bent 3 Shaft 3 (12.5' to 39')	Figure
DRAWN BY: JMH		A-1
CHECKED BY: MWL	Route NN over Platte River Nodaway County, Missouri	





- ▶ Not all Consultants are amazing, and some may need a little coaching!
- ▶ It pays to review even if it is sign/sealed by a P.E.

Thank you!





# Drilled Shafts

Nominal Side Resistance ( $q_s$ ), ksf	Nominal Side Resistance Factor	Nominal Tip Resistance ( $q_b$ ), ksf	Nominal Tip Resistance Factor	COV Mean	Rock Type
25.7*	0.57	Ignore	Ignore	0.05	Strong Rock GSI = 53

# Rough Costs

- ▶ Additional Drilling: \$30k
- ▶ Bent 1 Prebore and Piling \$230/LF
  - ▶ Est. Difference in Layouts: 75 LF
- ▶ 3' 6" to 4'6" Drilled Shaft in Rock \$1,050/LF\*
- ▶ 5' to 6'6" Drilled Shaft in Rock \$1,400/LF\*
  - ▶ \*Typical for Shafts in Soil
  - ▶ Telescoping casing expected
- ▶ Foundation Inspection Holes \$175/LF
  - ▶ Est. Difference in Layouts: 90 LF

# Environmental

- ▶ Environmental Group Notified
  - ▶ Known Caves near site
  - ▶ No dye traces in area
  - ▶ No endangered species
  - ▶ No permitting needed!
  - ▶ No serious construction limitation