NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Assessing Geotechnical Site Variability and Risk

February 22, 2024

1:00 – 2:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

ENGINEERING RCEP
REGISTERED CONTINUING EDUCATION PROGRAM

AICP Credit Information

1.5 American Institute of Certified Planners Certification Maintenance Credits

You must attend the entire webinar

Log into the American Planning Association website to claim your credits

Contact AICP, not TRB, with questions

Purpose Statement

This webinar will discuss the evaluation and mitigation of geotechnical risk as a crucial aspect of a successful construction project. Presenters will highlight risk management methods prescribed in existing Federal Highway Administration design guidelines and compare risk management practices. Presenters will also share a case history on a successful application in a recent accelerated bridge construction (ABC) project.

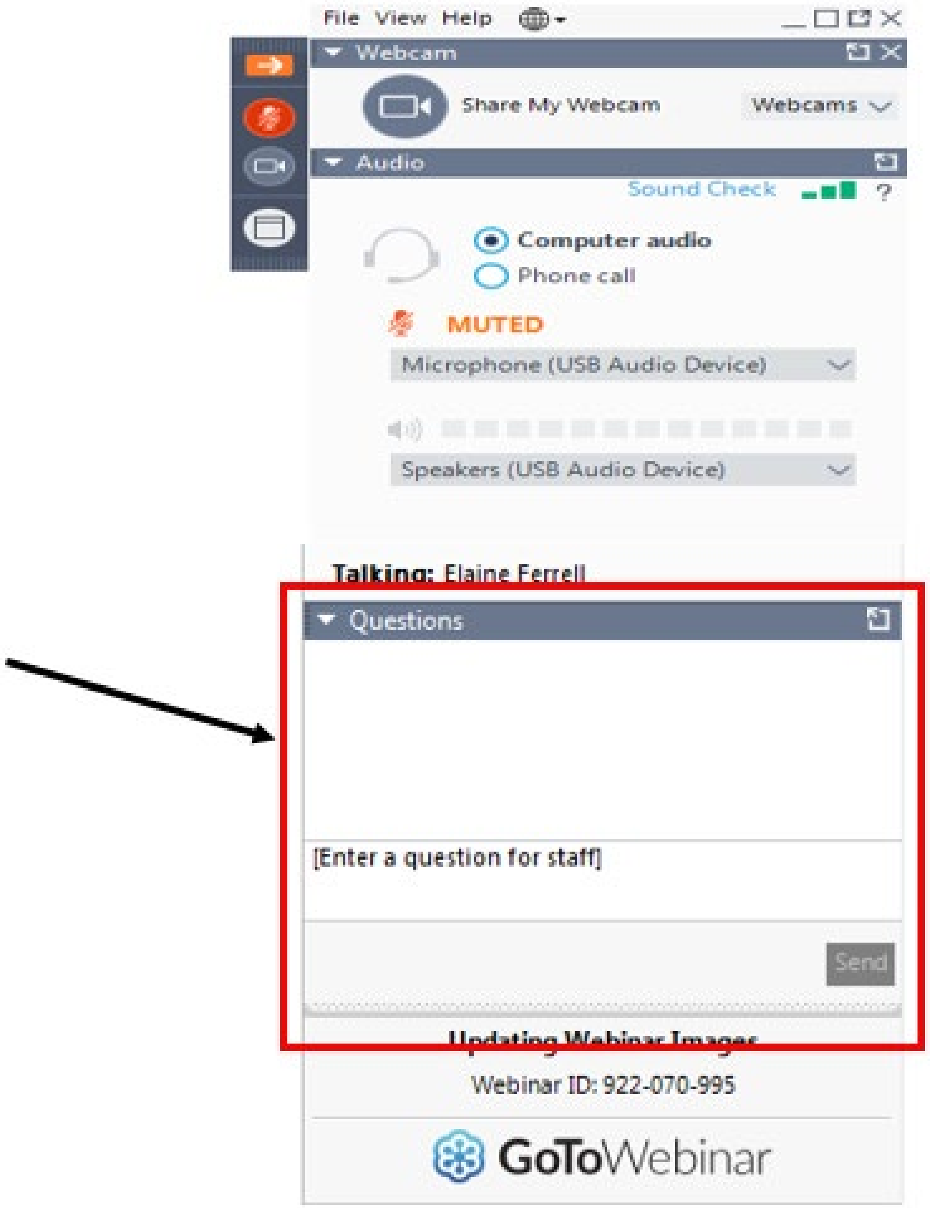
Learning Objectives

At the end of this webinar, you will be able to:

- Implement available guidelines on how to optimize exploration plans, resulting in lower risks to designer, owners, and contractors
- Identify geotechnical risks and either document risk mitigation or quantify the risk for the contractor
- Understand how to characterize risks in geotechnical design and construction for ABC and on alternate contract delivery projects

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Heather Shoup
Heather.Shoup@illinois.gov
Illinois Department of Transportation

Presenter Name
BCollins@bgcengineering.ca
BGC Consultants

Darren Beckstrand
Darren.Beckstrand@ccilt.com
Landslide Technology

Ryan Maw
ryanm@gerhartcole.com
Gerhart Cole, Inc.

Using Guidelines to Understand Subsurface Conditions and Mitigate Risk

Darren Beckstrand, CEG

LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

Geotechnical Investigations

- Characterization of subsurface conditions is one of the most challenging yet important activities required for successful planning, design, construction, and operation of transportation infrastructure.

  - Geotechnical Engineering Circular No. 5

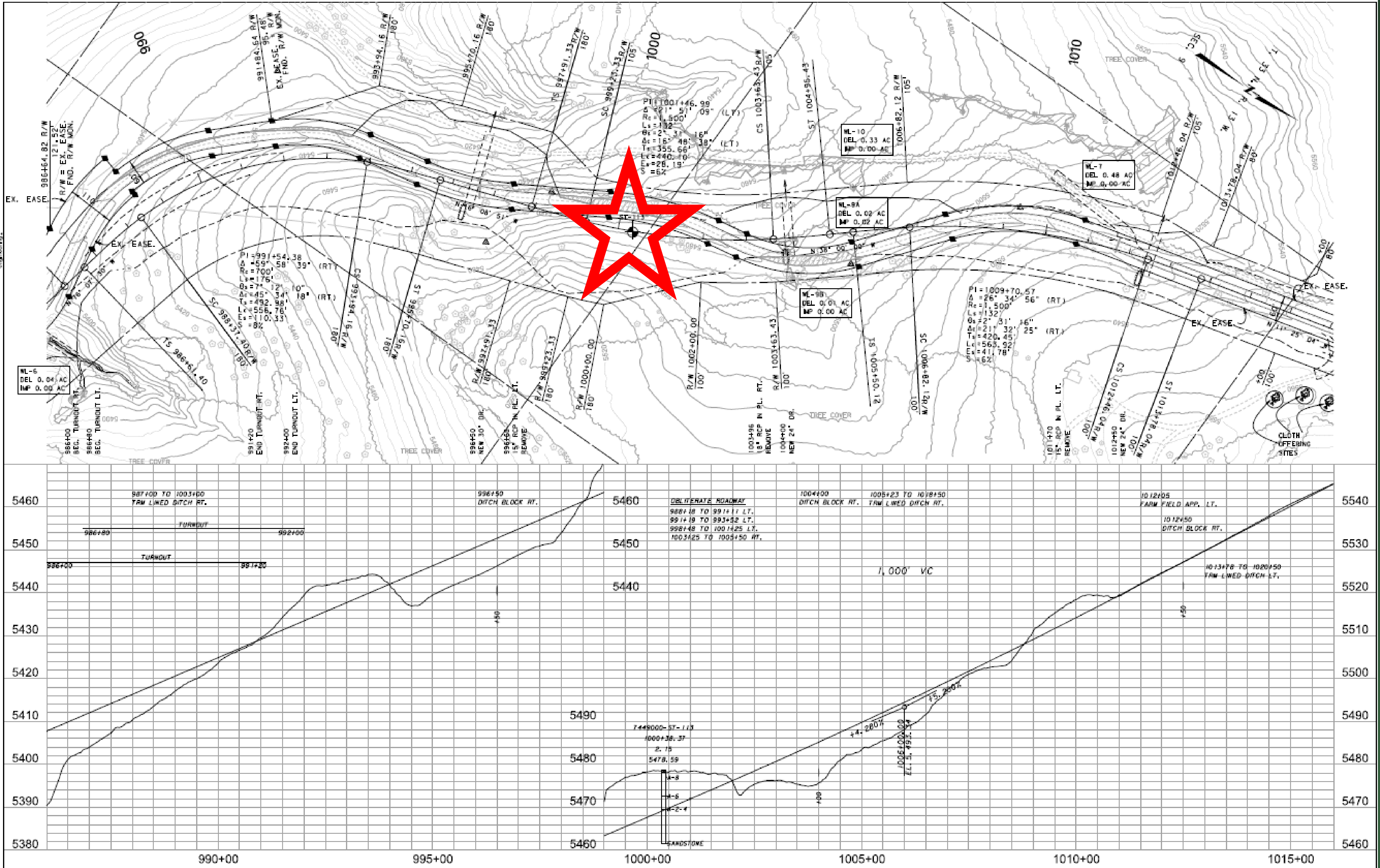
Geotechnical Investigations

- Characterization of subsurface conditions is one of the most **[EXPENSIVE, DEMANDING, IMPACTFUL, TIME CONSUMING]** yet important activities required for successful planning, design, construction, and operation of transportation infrastructure **[AND YET UNCERTAINTIES REMAIN…THEN WHY SUCCUMB TO ANALYSIS PARALYSIS?]**.

- Hypothetical personnel, not a real person!

Geotechnical Investigations

- ‘Chilling Effect’ in exploration planning can result
- Exploration plans then do not reflect the minimum recommendations
  - Do not identify
    - Risks
    - Hazards
    - Current or future stability
    - Groundwater conditions, dewatering needs
    - Soil and rock conditions and their variability
    - Effects of construction sequencing or stockpiling
    - Use of onsite materials for embankment fill
    - Many more!



990
1000
1010
EX. EASE.
TREE COVER
PI = 1001+46.99
WL-10
DEL 0.33 AC
IMP 0.00 AC
WL-7
DEL 0.48 AC
IMP 0.00 AC
WL-9A
DEL 0.02 AC
IMP 0.02 AC
WL-9B
DEL 0.01 AC
IMP 0.00 AC
WL-6
DEL 0.04 AC
IMP 0.00 AC
PI = 991+54.38
Rc = 700'
PI = 1009+70.57
Rc = 1,500'
CLOTH
OFFERING
SITES
987+00 TO 1003+00
TRM LINED DITCH RT.
TURNOUT
996+50
DITCH BLOCK RT.
OBLITERATE ROADWAY
988+18 TO 991+11 LT.
991+19 TO 993+52 LT.
998+48 TO 1001+25 LT.
1003+25 TO 1005+50 RT.
1004+00
DITCH BLOCK RT.
1005+23 TO 1018+50
TRM LINED DITCH RT.
1012+05
FARM FIELD APP. LT.
1012+50
DITCH BLOCK RT.
1013+78 TO 1020+50
TRM LINED DITCH LT.
1,000' VC
SANDSTONE
5460
5450
5440
5430
5420
5410
5400
5390
5380
5490
5480
5470
5540
5530
5520
5510
5500
990+00
995+00
1000+00
1005+00
1010+00
1015+00

One 20-foot boring for 2,500’ of highway

No Piezometers (GW observations only when drilling)

No Inclinometers

31 Borings for 6.2 miles for major alignment corrections


08.10.2020 15:06

Consequences Realized

- ~25 shallow cut side landslides, but could be simply mitigated
- Change orders from contractor
- Delays to design mitigation measures
- Construction delays in very short construction season
- Cost magnitude – unknown to me

Common Theme

- *NCHRP Synthesis 484 - Influence of Geotechnical Investigation and Subsurface Conditions on Claims, Change Orders, and Overruns*
  - Key Findings
    - **Causes**: Pile overruns, shallow groundwater and related costly dewatering, misclassified or mischaracterized subgrade, unexpected rock excavation/drilled shafts
    - **Costs**: Up to $10M annually per agency, 7% of all claims, near 1% of total budgets for new construction. Up to 7% of a project’s total budget, likely larger
    - **Conclusions**: Improve practice to improve design, reduce claims, change orders, and overruns.

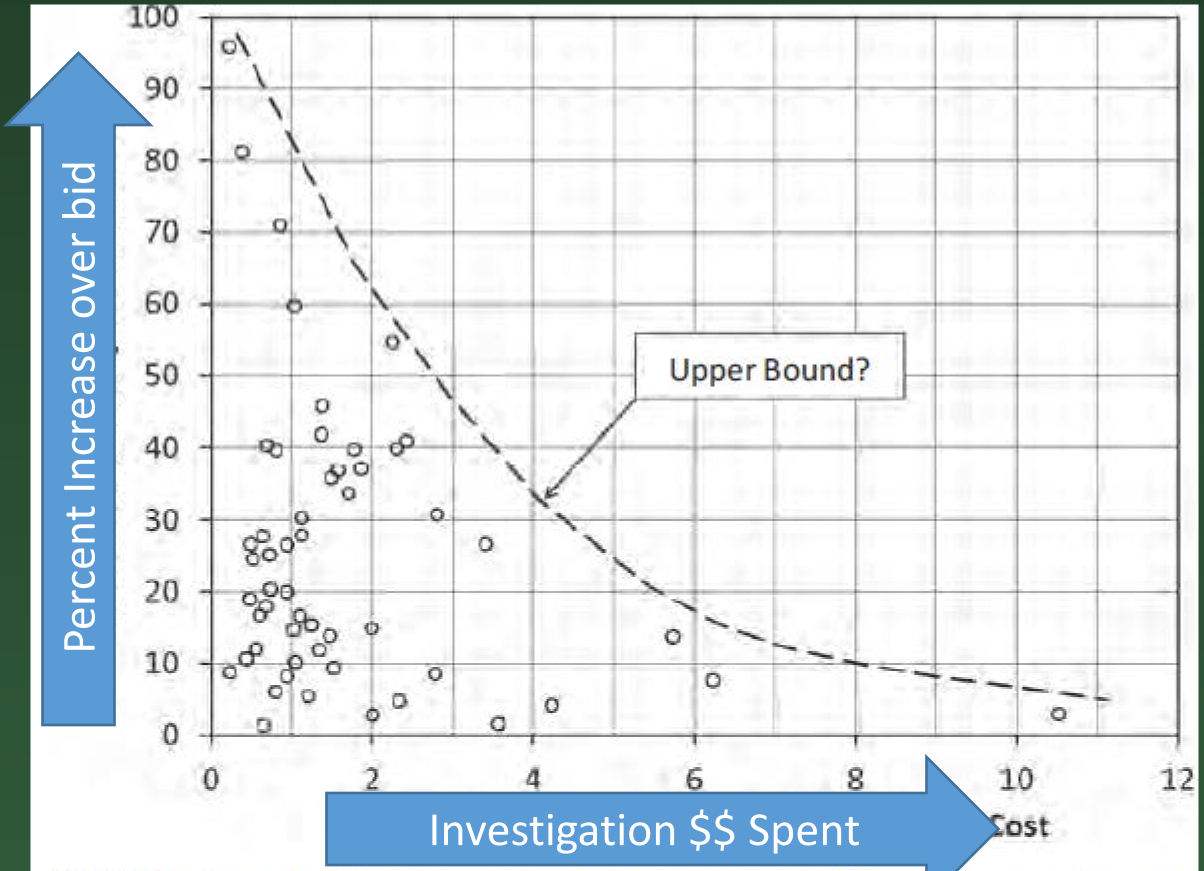


FIGURE 1 Graph of increases in construction cost for infrastructure projects as a function of cost of subsurface investigation (adapted from Clayton 2001 and Mott MacDonald and Soil Mechanics Ltd. 1994).

Less Investigation, More Problems

Brief Example

- State-funded project (i.e. maybe less federal oversight)
  - ~$14M Bond measure for ~9 miles of gravel road, partially through rugged terrain.
  - Dug about two dozen test pits, drilled for four bridges
  - Reconnaissance for the remainder

“Be careful, once a geotech walks a site, the geotech is done”

- Low bid came in at $31.8M (2x Bond Funding)
- Change orders, NOIs have inflated the original bid due to big equipment in steep terrain

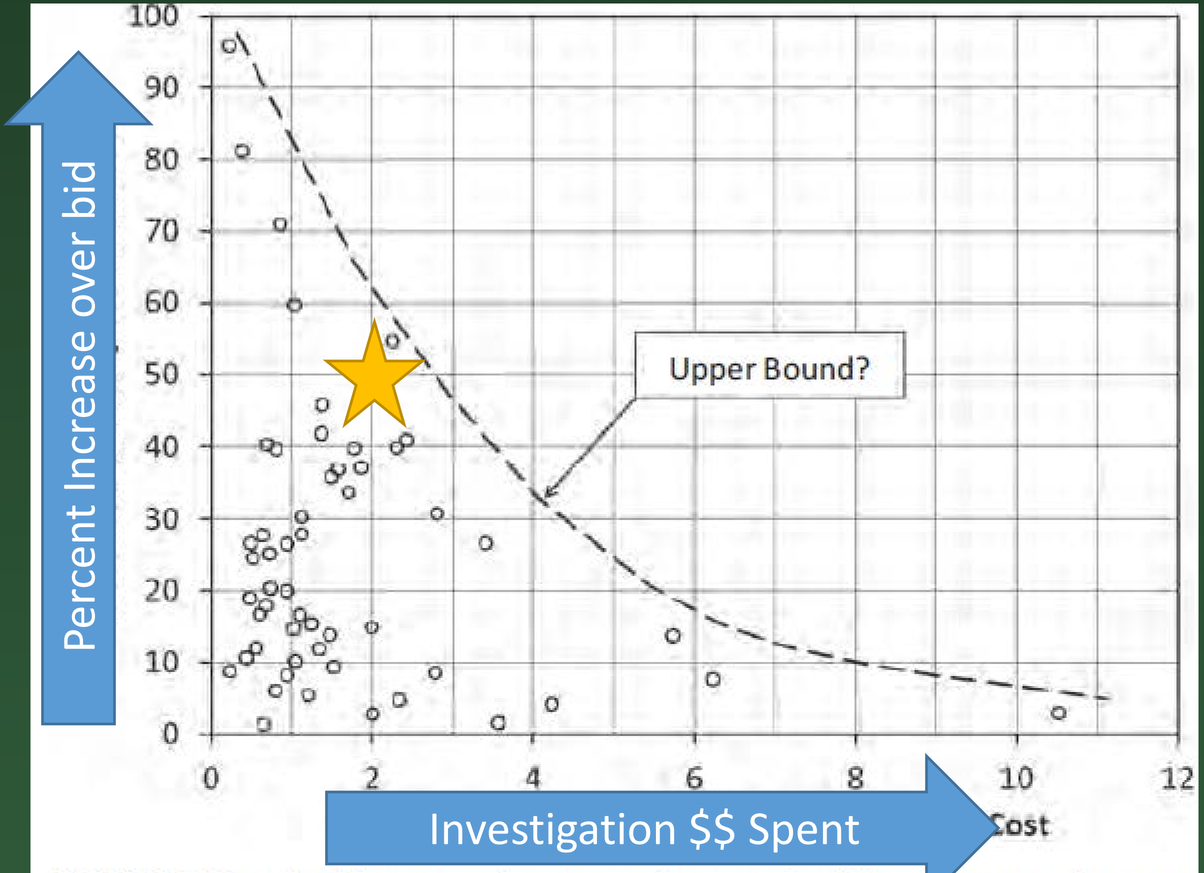


FIGURE 1 Graph of increases in construction cost for infrastructure projects as a function of cost of subsurface investigation (adapted from Clayton 2001 and Mott MacDonald and Soil Mechanics Ltd. 1994).

Less Investigation, More Problems

What are the recommendations?

- Using Geotechnical Engineering Circular No. 5: Geotechnical Site Characterization; focusing on boring depth and spacing (Table 3-2)

Application	Minimum Number and Location of Exploration Points	Minimum Depth of Exploration
Retaining Walls	• Minimum of one exploration point • Exploration points every 100-200 ft. • Additional exploration points behind walls for anchored structures	• Depth below bottom of wall where stress increase becomes less than 10 percent of existing effective overburden stress • Depth should extend below any soft, compressible soils into competent bearing material

  - Also, drill as close to wall face as possible.
  - Too often drilling is done at current road edge…too expensive at face, but that is where the soft, unconsolidated ground is!


2014/06/27 15:24

Shallow Foundations	• Minimum of one exploration point per substructure • For substructures with plan dimensions greater than 100 ft, a minimum of two exploration points • Additional exploration points for erratic subsurface conditions	• Depth below footing elevation where stress increase is less than 10 percent of existing overburden stress • Depth should extend below any soft, compressible soils into competent bearing material • Minimum of 10-ft penetration into competent rock if encountered prior to meeting other depth criteria • In formations with highly variable rock and/or boulders, great than 10-ft penetration into rock may be required

- Perform geologic reconnaissance and adjust accordingly
- Often overlooked, only encounter refusal and then onto the next boring. PREPARE FOR CORING!

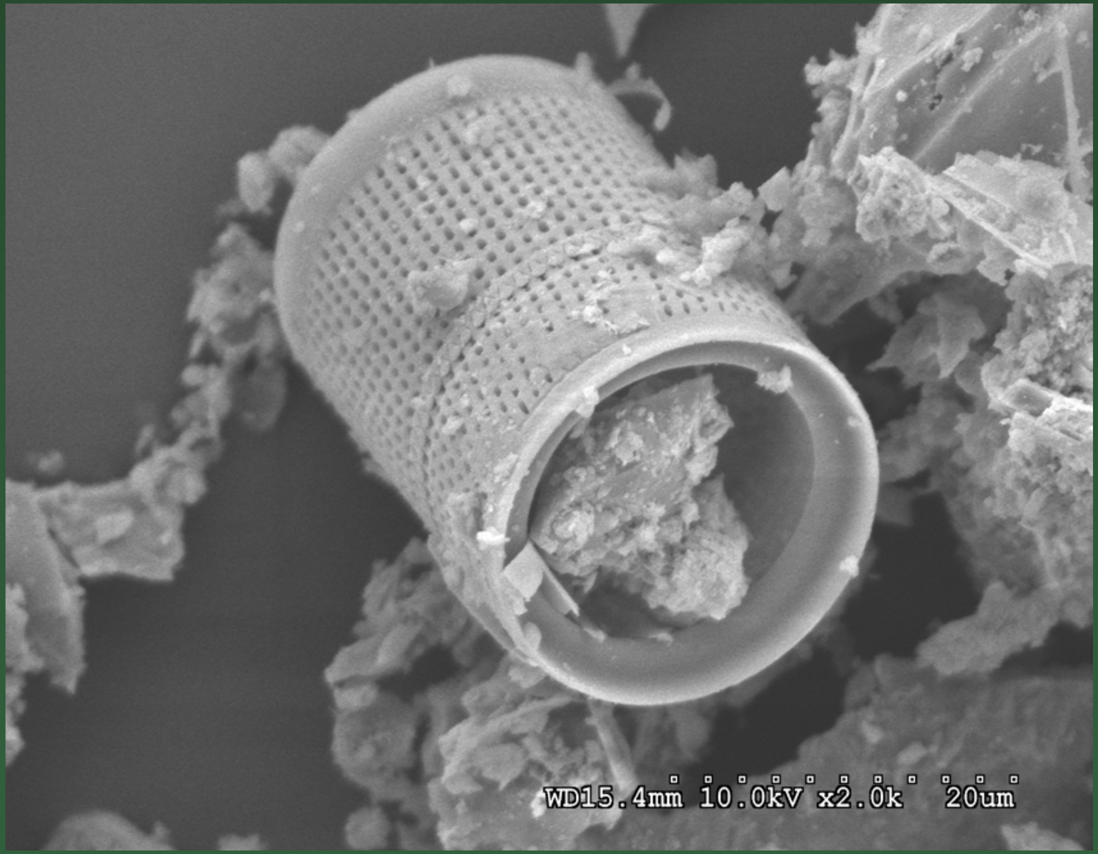
Deep Foundations	• Minimum of one exploration point per embankment • For substructures with plan dimensions greater than 100 ft, a minimum of two exploration points • Additional exploration points for erratic subsurface conditions	• Depth below anticipated tip of foundation that is the greater of 20 ft or two times the maximum foundation group dimension • Depth should extend below any soft, compressible soils to reach competent materials • Minimum of 10-ft penetration into competent rock for piles bearing on rock • Minimum penetration into competent rock should be 10 ft for piles tipped on rock and greater of 10 ft, three times the shaft diameter for individual drilled shafts, or two times the maximum group dimension below the anticipated tip elevation for drilled shafts

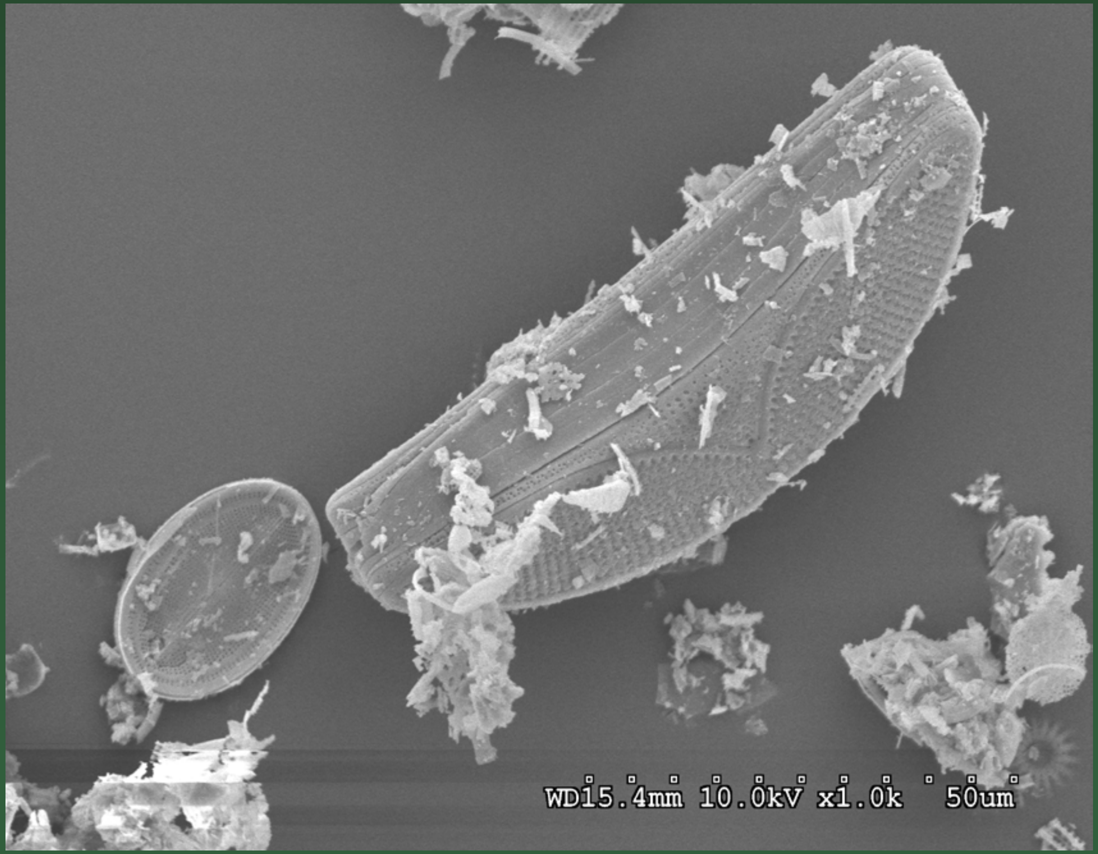
- Minimum of one per shaft. Two if large diameter and an inclined top of rock contact is expected.
- A phased approach may be required

Embankment Foundations	• Minimum of one exploration point per embankment • Minimum of one exploration point at each bridge abutment location • Minimum of one exploration point per 300 ft of embankment, locations staggered in transverse direction • Minimum of three exploration points in transverse direction • Additional exploration points for erratic subsurface conditions	• Minimum depth is greater of: ○ depth where induces vertical stress is less than 10 percent of applied stress at base of embankment, or ○ depth equal to twice embankment height below base of embankment unless competent hard stratum is encountered at shallower depth

- Be able to define a cross section for slope stability calculations
- Go deeper in especially soft or degradable conditions

Deep Degradable Material Affected Embankment and Abutment Foundation



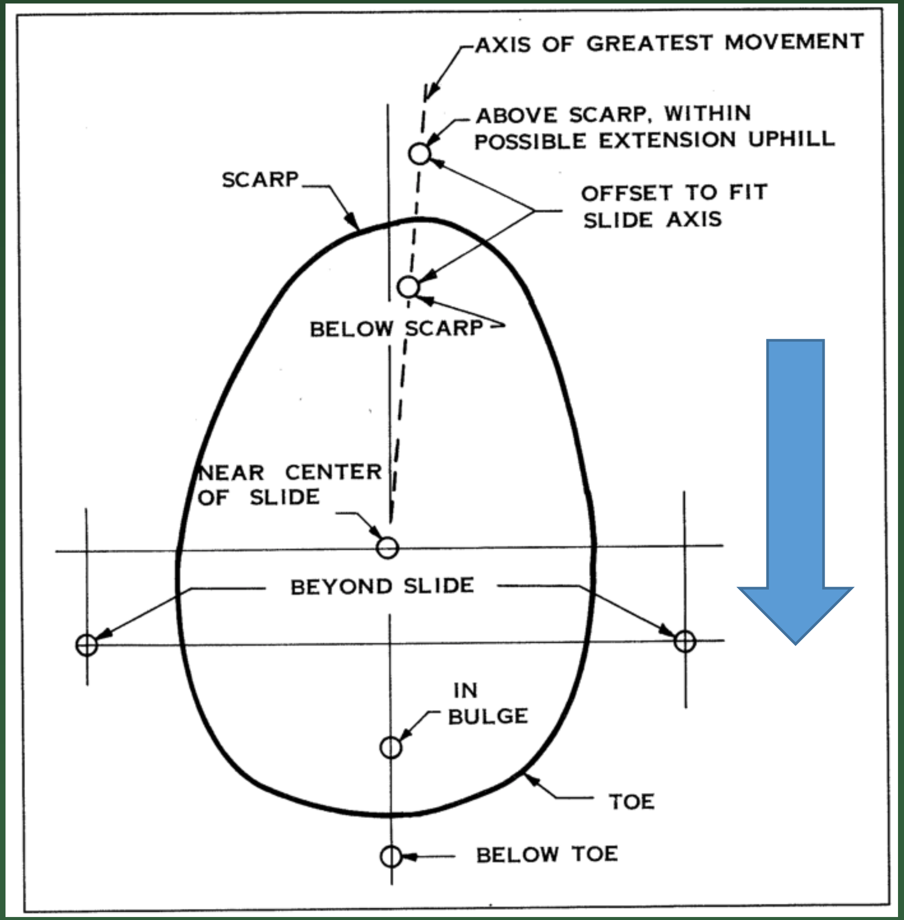


Excavated Slopes	• Minimum of one exploration point per 300 ft of slope length • Minimum of three exploration points in transverse direction • Additional exploration points for erratic subsurface conditions	• Minimum depth is depth equal to the maximum slope height below the minimum excavation elevation unless competent hard stratum encountered at shallower depth • Exploration depth should extend below potential soft or weak strata that might impact stability

- Cross sections for stability recommended.

- Go to bottom of ditch plus 10 feet…vertical grades may change.
- Take issue with 'competent hard stratum' … how does one evaluate rock slope stability and design cut angles without drilling into it?

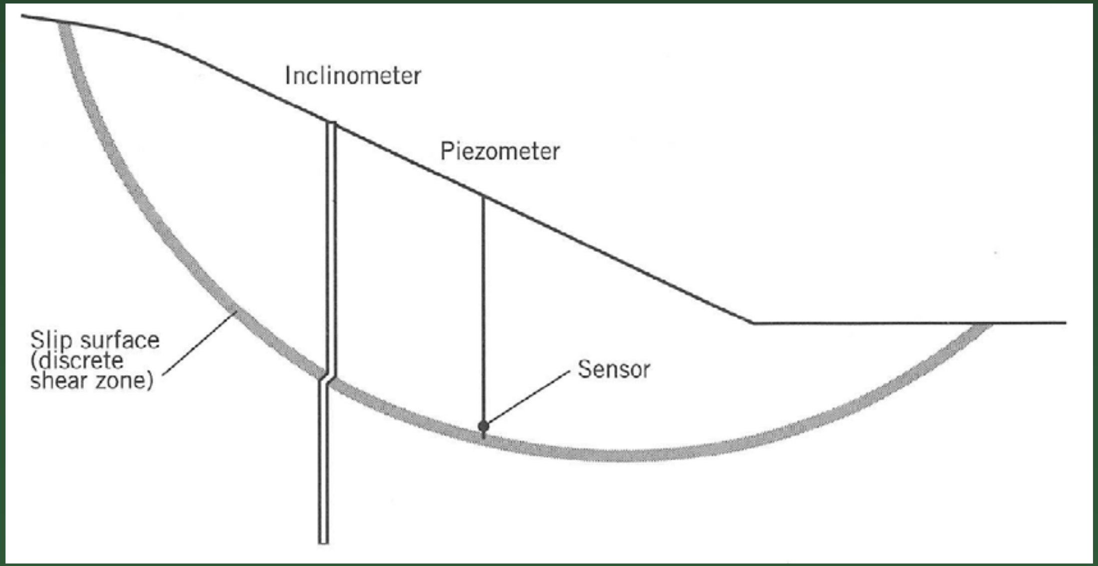
Not in GEC 5 Table 3.2: Landslides



TRB SR 247: Chapter 10

- Align borings with inclinometers and piezometers down landslide axis through the landslide
- Install additional borings beyond to monitor for growth of landslide

Not in GEC 5 Table 3.2: Landslides



Cornforth (2005): Landslides in Practice

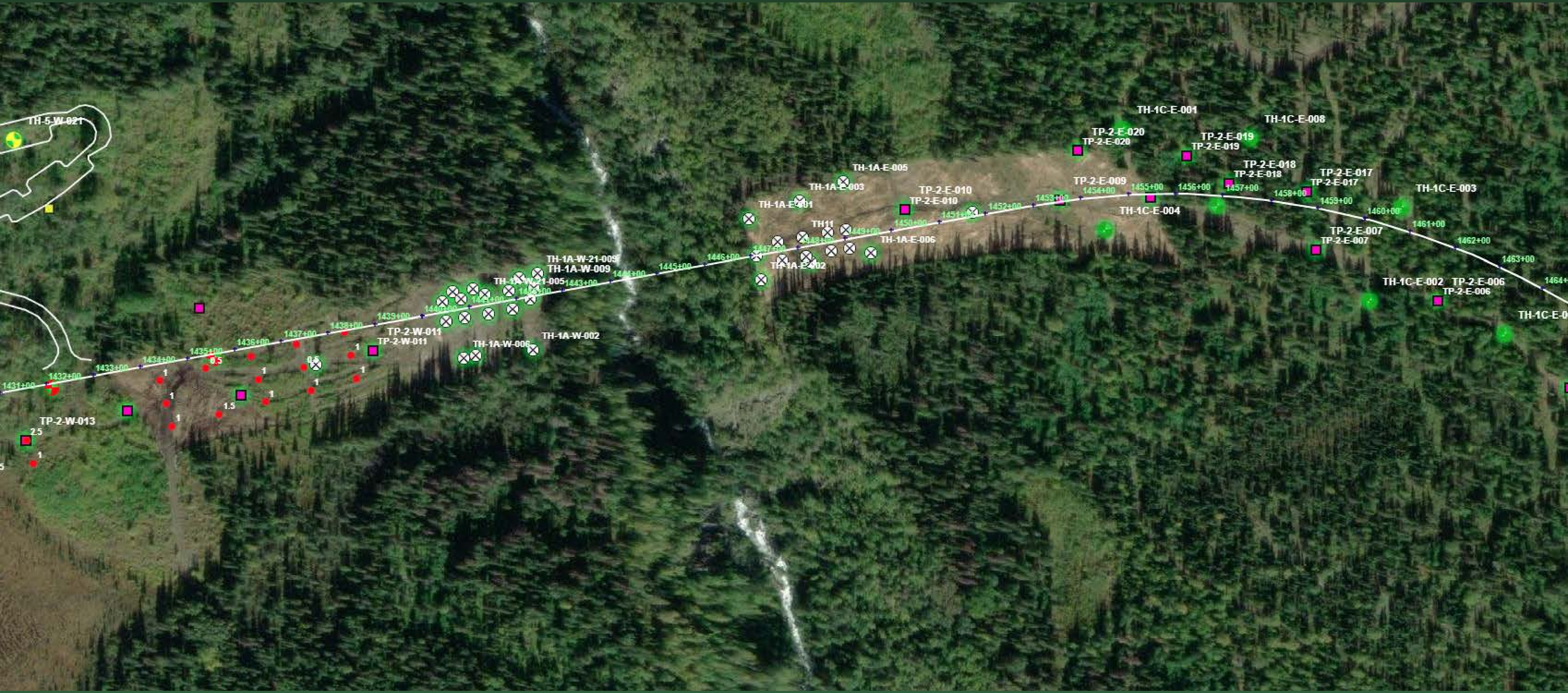
- Install inclinometers 10 to 20 feet beyond suspected slide depth. Be willing to go deeper!
- Install piezometers to sense pore pressures at the shear zone. Install more than one if needed…VWPs are inexpensive.

Approaching the recommended program

Approaching the recommended program

- 9.1 miles of realignment designed, just a bit to go
- Largest clear span bridge in Alaska
- 5 additional bridges
- 263 borings (so far), several inclinometers, few dozen piezometers
- 119 test pits, 300+ peat probes
- Downhole imagery in all rock cuts
- MASW, GPR at big bridge
- Foliated rock, overconsolidated and moisture sensitive glacial tills, reworked till, terrace gravel, and complex groundwater

TH-1A-E-005
TH-1A-E-003
1460+00
TH-1A-W-21-009
1440+00
TH-1A-W-006
TH-1A-W-007
1420+00
TT-KIE-1401+50
TT-KIE-1398+50


TH-5-W-021
TH-1C-E-001
TH-1C-E-008
TP-2-E-020
TP-2-E-020
TP-2-E-019
TP-2-E-019
TP-2-E-018
TP-2-E-018
TP-2-E-017
TP-2-E-017
TH-1A-E-005
TH-1A-E-003
TP-2-E-010
TP-2-E-010
TH-1A-E-001
TP-2-E-009
TH-1C-E-003
TH-1C-E-004
TP-2-E-007
TP-2-E-007
TH11
TH-1A-E-006
TH-1A-E-002
TH-1A-W-21-009
TH-1A-W-009
TH-1C-E-002
TP-2-E-006
TP-2-E-006
TP-2-W-011
TP-2-W-011
TH-1A-W-006
TH-1A-W-002
TP-2-W-013
1431+00
1432+00
1433+00
1434+00
1435+00
1436+00
1437+00
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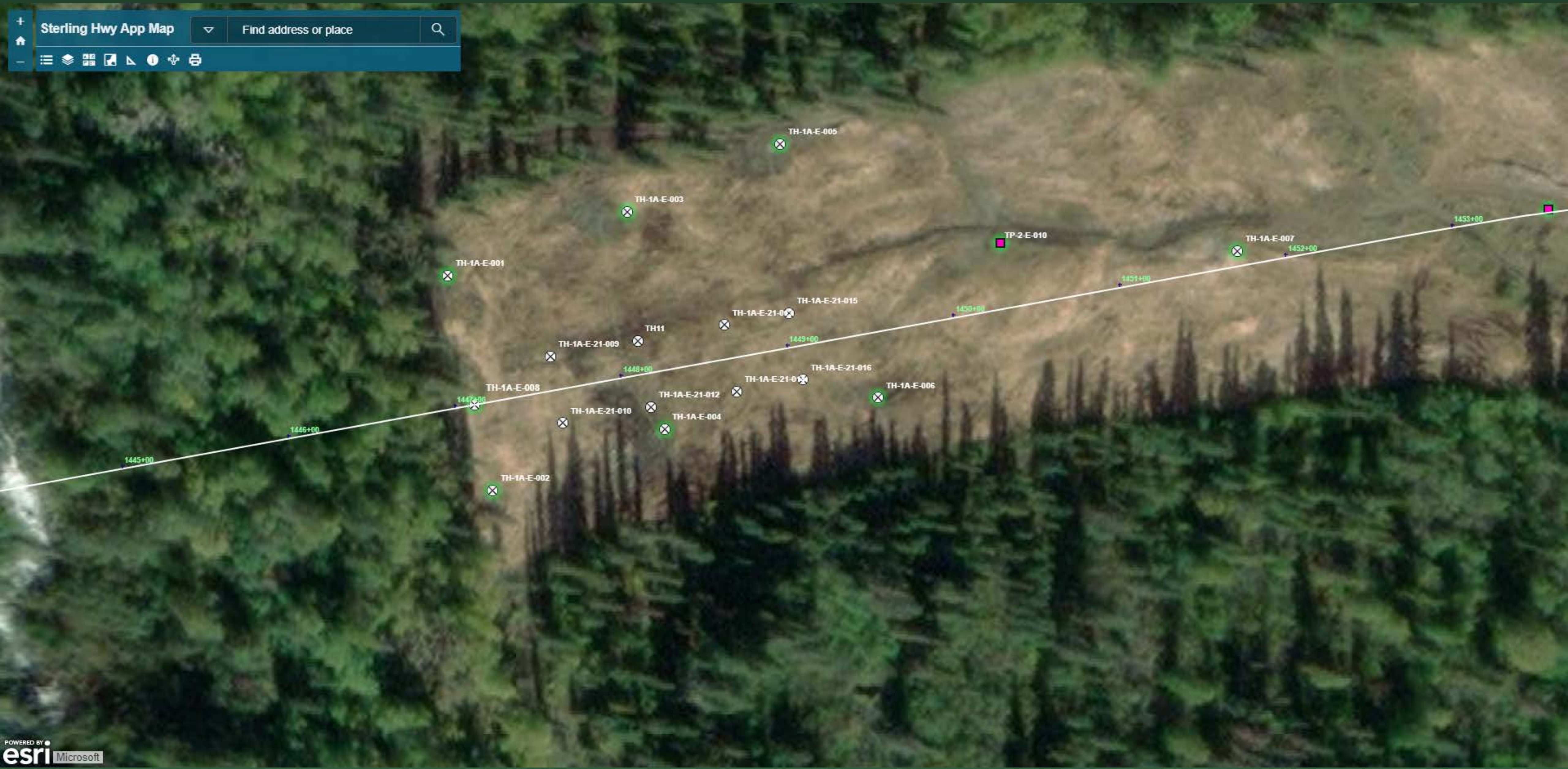
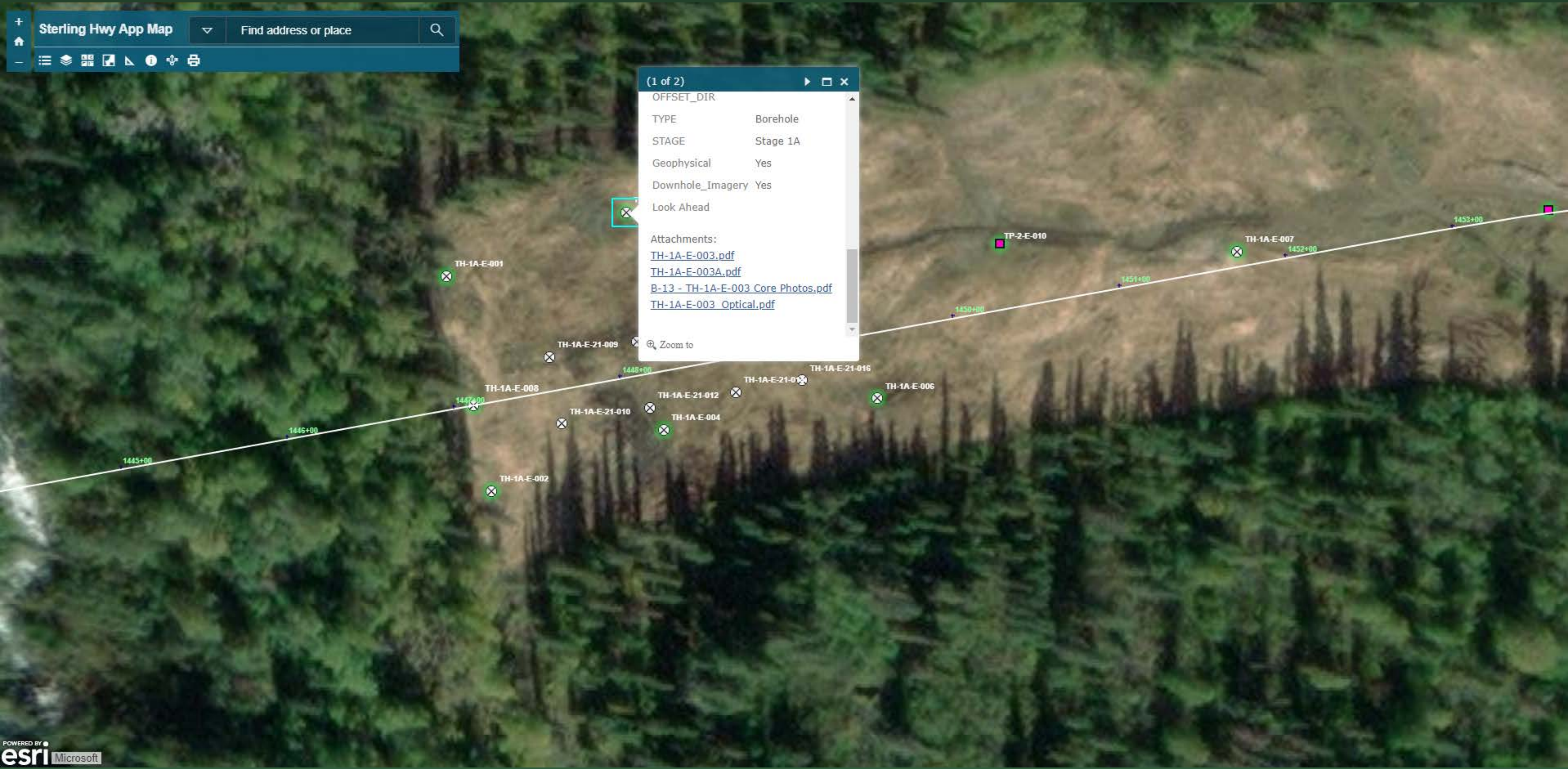


Sterling Hwy App Map
Find address or place
TH-1A-E-005
TH-1A-E-003
TP-2-E-010
TH-1A-E-007
1453+00
1452+00
1451+00
1450+00
1449+00
1448+00
1447+00
1446+00
1445+00
TH-1A-E-001
TH-1A-E-21-015
TH11
TH-1A-E-21-009
TH-1A-E-21-016
TH-1A-E-006
TH-1A-E-008
TH-1A-E-21-012
TH-1A-E-21-010
TH-1A-E-004
TH-1A-E-002
POWERED BY
esri
Microsoft



Sterling Hwy App Map
Find address or place
(1 of 2)
OFFSET_DIR
TYPE Borehole
STAGE Stage 1A
Geophysical Yes
Downhole_Imagery Yes
Look Ahead
Attachments:
TH-1A-E-003.pdf
TH-1A-E-003A.pdf
B-13 - TH-1A-E-003 Core Photos.pdf
TH-1A-E-003_Optical.pdf
Zoom to
TH-1A-E-001
TH-1A-E-21-009
TH-1A-E-008
TH-1A-E-21-010
TH-1A-E-21-012
TH-1A-E-004
TH-1A-E-21-016
TH-1A-E-006
TH-1A-E-002
TP-2-E-010
TH-1A-E-007
1445+00
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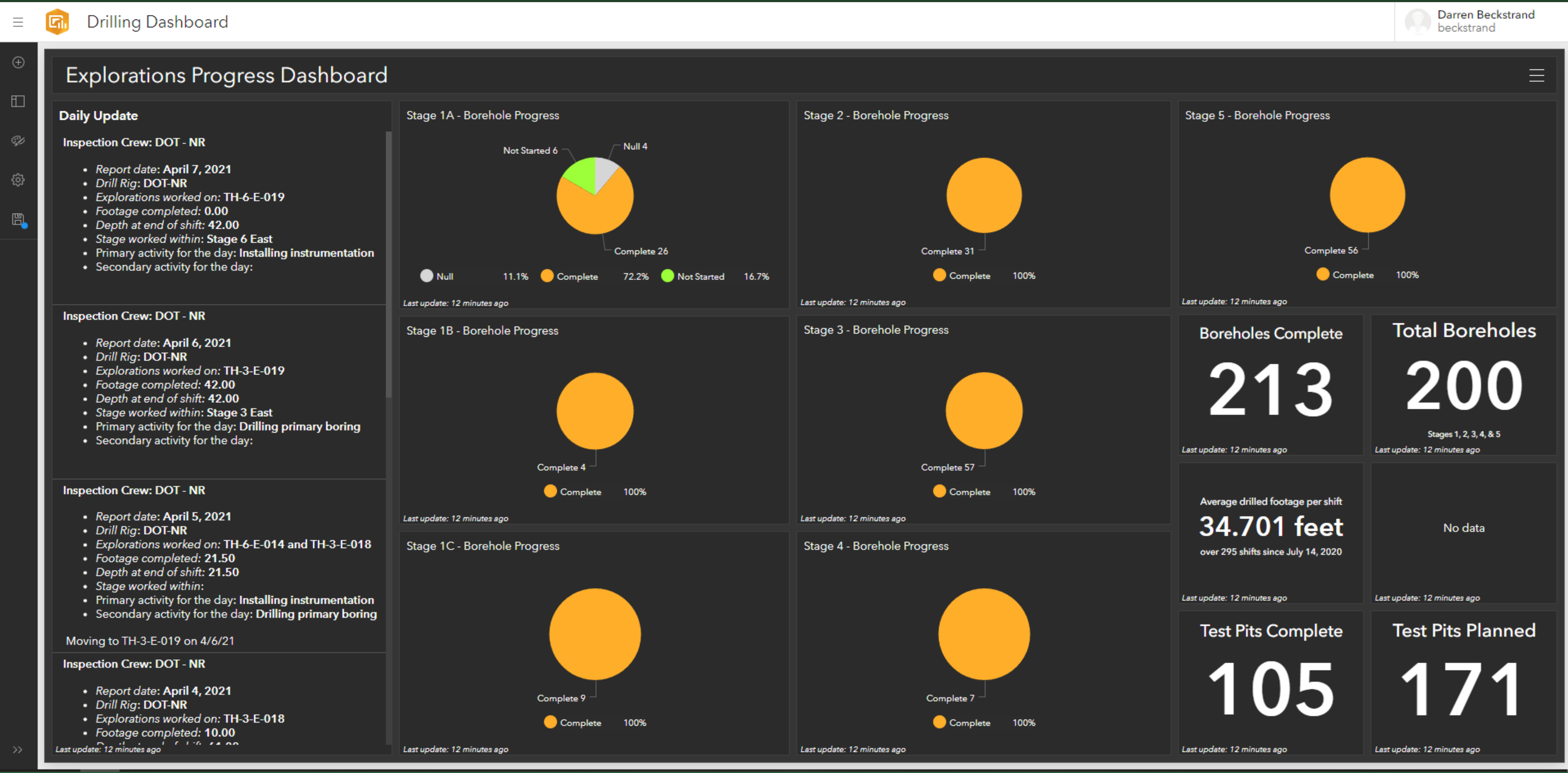
Drilling Dashboard
Darren Beckstrand
beckstrand
Explorations Progress Dashboard
Daily Update
Inspection Crew: DOT - NR
Report date: April 7, 2021
Drill Rig: DOT-NR
Explorations worked on: TH-6-E-019
Footage completed: 0.00
Depth at end of shift: 42.00
Stage worked within: Stage 6 East
Primary activity for the day: Installing instrumentation
Secondary activity for the day:
Inspection Crew: DOT - NR
Report date: April 6, 2021
Drill Rig: DOT-NR
Explorations worked on: TH-3-E-019
Footage completed: 42.00
Depth at end of shift: 42.00
Stage worked within: Stage 3 East
Primary activity for the day: Drilling primary boring
Secondary activity for the day:
Inspection Crew: DOT - NR
Report date: April 5, 2021
Drill Rig: DOT-NR
Explorations worked on: TH-6-E-014 and TH-3-E-018
Footage completed: 21.50
Depth at end of shift: 21.50
Stage worked within:
Primary activity for the day: Installing instrumentation
Secondary activity for the day: Drilling primary boring
Moving to TH-3-E-019 on 4/6/21
Inspection Crew: DOT - NR
Report date: April 4, 2021
Drill Rig: DOT-NR
Explorations worked on: TH-3-E-018
Footage completed: 10.00
Last update: 12 minutes ago
Stage 1A - Borehole Progress
Not Started 6
Null 4
Complete 26
Null 11.1%
Complete 72.2%
Not Started 16.7%
Last update: 12 minutes ago
Stage 2 - Borehole Progress
Complete 31
Complete 100%
Last update: 12 minutes ago
Stage 5 - Borehole Progress
Complete 56
Complete 100%
Last update: 12 minutes ago
Stage 1B - Borehole Progress
Complete 4
Complete 100%
Last update: 12 minutes ago
Stage 3 - Borehole Progress
Complete 57
Complete 100%
Last update: 12 minutes ago
Boreholes Complete
213
Last update: 12 minutes ago
Total Boreholes
200
Stages 1, 2, 3, 4, & 5
Last update: 12 minutes ago
Average drilled footage per shift
34.701 feet
over 295 shifts since July 14, 2020
Last update: 12 minutes ago
No data
Last update: 12 minutes ago
Stage 1C - Borehole Progress
Complete 9
Complete 100%
Last update: 12 minutes ago
Stage 4 - Borehole Progress
Complete 7
Complete 100%
Last update: 12 minutes ago
Test Pits Complete
105
Last update: 12 minutes ago
Test Pits Planned
171
Last update: 12 minutes ago

Conclusions

- Knowing what is going to be excavated into or built upon decreases risk
  - For Owners
    - Less risk for changed conditions (even for DB or CMGC), more certainty for volumes
    - Schedule risk diminished…deliver projects on time and on budget
    - Must work on managing cost and value expectations
    - Reputational risk reduced
  - For Designers
    - Adherence to a Standard of Practice reduces liability exposure
    - Reputational harm avoided with a complete investigation
    - Use guidance to properly scope and design, rather than targeting budgetary goals
  - For Contractors
    - Risk can be defined, compartmentalized, and isolated into specific bid items rather than spread across major quantities of unclassified excavation

Contractor Perspective on Quantifying Geotechnical Risk

Brian Collins, P.E., Senior Geotechnical Engineer

February 22, 2024

BGC

Agenda

- Risk Allocation
- Risk Management Process
- Other Risk Management Strategies
- Examples

Why?

(…do we care as geotechnical designers)

- Most of the construction risk is below the ground surface
- Need to execute a constructible design
- Need to help the contractor get the work at the right price

Risk Allocation

Differing Site Conditions (DSC)

- DSC = unforeseen subsurface conditions that damage the contractor
- Recognized as one of the most significant risks on highway projects
- Highway agencies generally take on risk of differing site conditions
  - Federal Acquisition Regulations (FAR) Clause 52-236.2
  - Required for all federally funded highway construction projects per CRF 635.109, <u>except design-build projects</u>
  - Beware of projects without a DSC clause or with exceptions
- The Contract is the means of allocating risk
- Decided before contractor is involved in project

52.236-2 Differing Site Conditions

Federal Acquisition Regulations

(a) The Contractor shall promptly, and before the conditions are disturbed, give a written notice to the Contracting Officer of-

(1) Subsurface or latent physical conditions at the site which differ materially from those indicated in this contract; or

(2) Unknown physical conditions at the site, of an unusual nature, which differ materially from those ordinarily encountered and generally recognized as inhering in work of the character provided for in the contract.

Risk Management Process

(Risk Assessment and Allocation for Highway Construction Management, FHWA-PL-06-032, 2006)

- Identification
- Assessment
- Analysis
- Mitigation
- Tracking and updating

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Risk Identification

- Relies on experience of designers and constructors (Subject Matter Experts - SMEs)
- Starts at beginning of project – likely during pre-advertisement phase
- All disciplines involved during review of Contract
- Continues through completion of proposal/bid
- Logged in the Risk Matrix

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Leading Causes of Claims, Change Orders, and Cost Overruns

(NCHRP Synthesis 484, 2016)

- Pile overruns
- Groundwater shallower than expected
- Seepage problems, including those requiring dewatering
- Misclassified or mischaracterized subgrade
- Unanticipated rock excavation
- Mischaracterized rock for drilled shaft construction

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Geotechnical Risks

- Differing site conditions
- Inadequate subsurface investigation
- Earthwork quantities
- Drilled shafts obstructions
- Weak subgrades
- Unstable slopes
- Adjacent structures/sensitive receptors
- Soft soils
- Liquefiable soils
- Settlement prone soils
- Temporary works/SOE
- Contract requirements
- Contaminated soil/groundwater
- Existing infrastructure/obstructions

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Risk Identification, Categorization, and Documentation of risks

Risk Categories used to organize and assign SMEs

- Geotechnical
- Materials
- Environmental
- Performance
- Schedule
- Labor
- Quantities
- Sub Performance
- Claims and Deductible
- General Project

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Risk Assessment

- Determine likelihood and impact of identified risks
- Impacts typically identified as cost or schedule impacts

Level	Likelihood
A	Remote
B	Unlikely
C	Likely
D	Highly Likely
E	Near Certainty

ASSESSMENT GUIDE

Likelihood	a	b	c	d	e
E	M	M	H	H	H
D	L	M	M	H	H
C	L	L	M	M	H
B	L	L	L	M	M
A	L	L	L	L	M

Consequence

RISK ASSESSMENT

High (Red)
Unacceptable. Major disruption likely. Different approach required. Priority management attention required

Moderate (Yellow)
Some disruption. Different approach may be required. Additional management attention may be needed

Low (Green)
Minimum impact. Minimum oversight needed to ensure risk remains low

Level	Schedule	and/or	Cost
a	Minimal or no impact		Minimal or no impact
b	Additional resources required; able to meet		<5%
c	Minor slip in key milestones; not able to meet need date		5-7%
d	Major slip in key milestone or critical path impacted		7-10%
e	Can't achieve key team or major program milestone		>10%

(FHWA, 2006)

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Risk Analysis quantify [cost] impacts of identified risks

Risk Matrix – Risk items go on the Risk Matrix

Title	Category	Description	Calculated Risk	Probability %	Factored Risk
Additional Pile Lengths	Geotechnical Risk	Additional pile lengths (+ splices) required to achieve capacity	Purchase additional lengths of pile and splice kits. [250LF x $50/LF = $12,500]+ [20EA x $500/EA = $10,000] = $22,500	30	$6750
Borrow Material Spec	Geotechnical Risk	Risk of no available A1 or A2 material as needed per Geotech Report	21,935 cy of borrow required; increased price of 5$/cy = $109,675	30	$32,903

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

Risk Mitigation

Determine mitigation or assign cost impact to estimate

Title	Category	Description	Calculated Risk	Probability %	Factored Risk
Early winter pushing work next season	Schedule Impact Risk	We could have a early cold season that push some works from 2023 to 2024. Increase in escalation possible, increase in labor and equipment cost possible.	Liquidated damages, overhead, mobilization Address in schedule with 6 days a week in Bid	Resolved	Resolved
Bulk materials (aggregates, concrete)	Materials Risk	Due to remoteness of construction sites, aggregates and concrete materials are subject to fuel cost volatility and delivery issues	Order/schedule materials and trucking earlier than for a normal job	Resolved	Resolved

IDENTIFICATION – ASSESSMENT – ANALYSIS – MITIGATION – TRACKING & UPDATING

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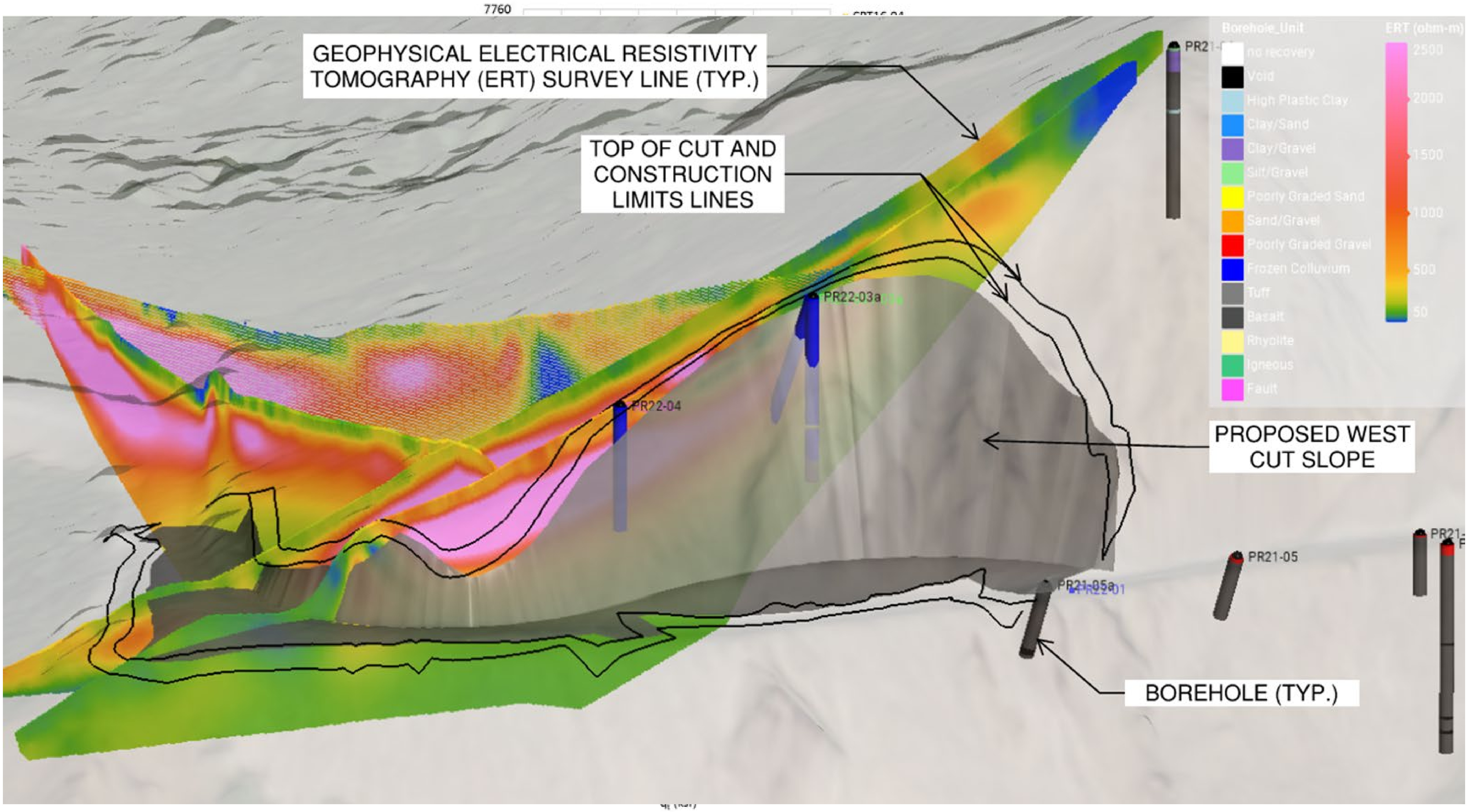
Other Risk Mitigation Strategies

- Consider the variability and uncertainty of the design parameters
- Detailed coordination between builders and designers during tender phase
- Alternative Technical Concepts – mitigate risks through innovation
- Technical Risk Assessment – panel of cross-functional Subject Matter Experts perform a “cold-eyes” review of contract and tender phase design deliverables
- Management Reviews – detailed review of deliverables and estimate with high-level managers
- Independent Cost Estimates – 2nd and 3rd party independent cost estimates



7760
GEOPHYSICAL ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) SURVEY LINE (TYP.)
TOP OF CUT AND CONSTRUCTION LIMITS LINES
PROPOSED WEST CUT SLOPE
BOREHOLE (TYP.)
PR22-03a
PR22-04
PR21-05
PR21-05a
PR22-01
Borehole_Unit
no recovery
Void
High Plastic Clay
Clay/Sand
Clay/Gravel
Silt/Gravel
Poorly Graded Sand
Sand/Gravel
Poorly Graded Gravel
Frozen Colluvium
Tuff
Basalt
Rhyolite
Igneous
Fault
ERT (ohm-m)
2500
2000
1500
1000
500
50

Risk Mitigation through Engineering Analysis

		Analyzed Loads (See Note 1)	Piles			KIE Design - 16"x0.5"						
Bridge ID	Description	Required Axial Compression Resistance for Strength Limit State (kips)	Type (See Note 6)	Bottom of Cap Elevation (ft)	Pile Tip Protection	Min Pile Tip EL Required to Saftisy Axial Resistance for Strength Limit State	# of Piles/ Bent	Total Length of Pile (ft) (See Note 2)	Pile or Shaft QC Testing	Comments, Key Asssumptions, Controlling Conditions, etc.	Pile QTY (ft)	Conical Points (each)
5112 single-span	Hwy 2 O/ Unger Coulee	299	16"Øx0.5" Steel Pipe	2234	Conical Point	2205	5	32	1 PDA/CAPWAP per bent	See Notes	160	5
		299	16"Øx0.5" Steel Pipe	2234	Conical Point	2205	5	32	1PDA/CAPWAP per bent	See Notes	160	5
5113 two-span	Hwy 2 O/ Buggy Creek	248	16"Øx0.5" Steel Pipe	2178	Conical Point	2135	5	46	1PDA/CAPWAP per bent	May need restrike or add 15' per pile @ ABUTS & 25' per pile at PIER to get capacity at EOD. ***Pier lengths at limits of available data.***	230	5
		451	16"Øx0.5" Steel Pipe	2178	Conical Point	2109	5	72	1PDA/CAPWAP per bent		360	5
		248	16"Øx0.5" Steel Pipe	2178	Conical Point	2135	5	46	1PDA/CAPWAP per bent		230	5
5114 single-span	Hwy 2 O/ Chapman Coulee	299	16"Øx0.5" Steel Pipe	2201	Conical Point	2166	5	38	1PDA/CAPWAP per bent	May need restrike or add 15' per pile @ Pier to get capacity at EOD	190	5
		299	16"Øx0.5" Steel Pipe	2201	Conical Point	2166	5	38	1PDA/CAPWAP per bent		190	5
	Hwy 2 O/											

Alternative Technical Concepts

Innovative solutions that promote efficiencies, reduce risks, accelerate project delivery schedules and reduce project costs

- Cost-effective solutions that are equal to or better than the State's design and/or construction criteria
- FHWA EDC-2 (2014)
  - https://www.fhwa.dot.gov/innovation/everydaycounts/edc-2/atc.cfm
- Most commonly used on DB projects
- Typically, confidential during bid phase, may be released to successful bidder after stipend
- Often win the bid through ATCs
- Example – Bridge abutments supported on MSE or GRS walls

How can Geotechnical Designers Reduce Risk for the Contractor?

- Get the Geotech data needed for design (both owner and contractor's designer)
- Identify the project Geotechnical Risks
- Quantify the risk
    - Cost
    - Schedule
- Mitigate risks when possible

Contact us

Brian Collins, P.E.

Senior Geotechnical Engineer

bcollins@BGCEngineering.ca

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Assessing Geotechnical Site Variability and Risk

Accelerated Bridge Construction (ABC) Geotechnical Risks and Challenges at an Operating Interchange

Presented by

Ryan Maw, PE, GE, BC.GE, F.ASCE

Principal

TRB Webinar: Assessing Geotechnical Site Variability and Risk

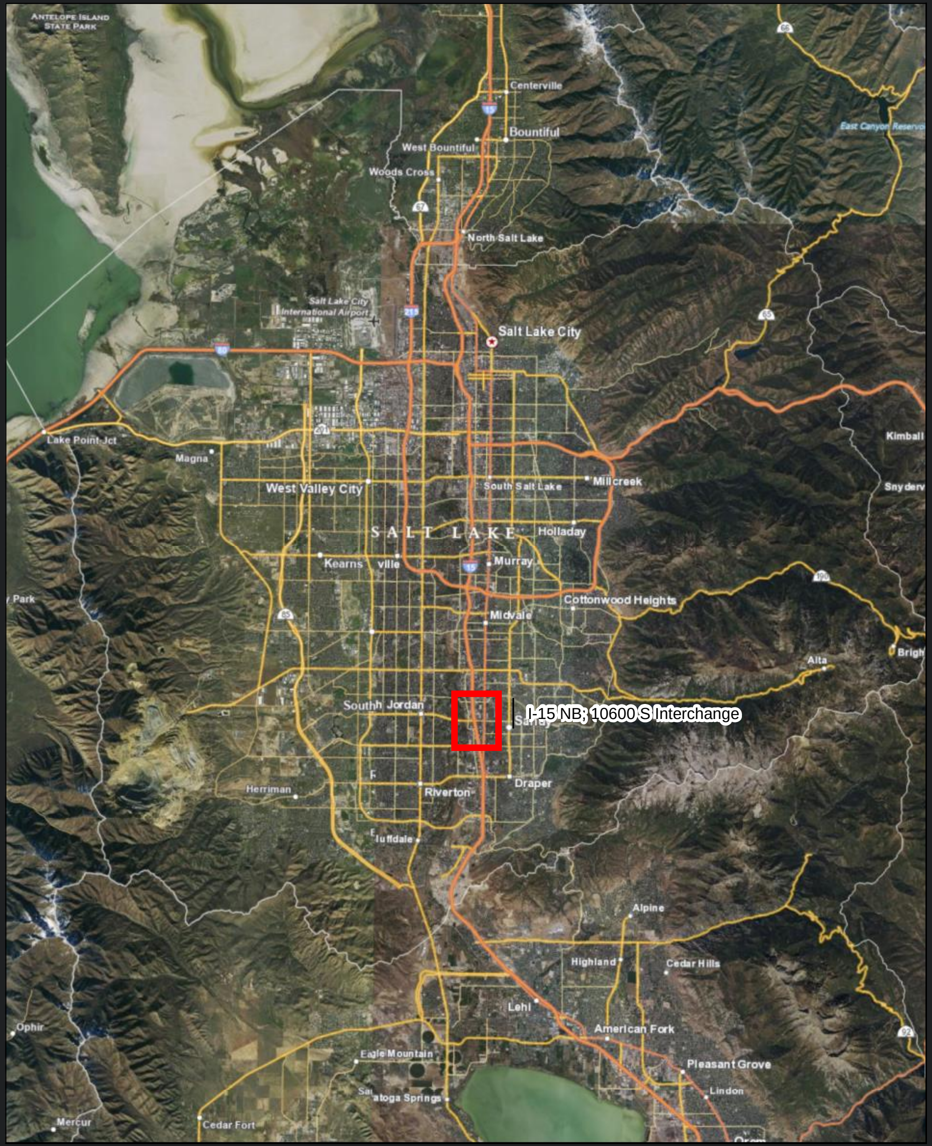
Gerhart Cole

Thursday, February 22, 2024

Virtual Meeting

I-15 NB; 10600 S Interchange

<u>Objective:</u> reduce traffic delays, improve access to shopping area / City, and resurface existing bridge deck at one of the State's busiest interchanges



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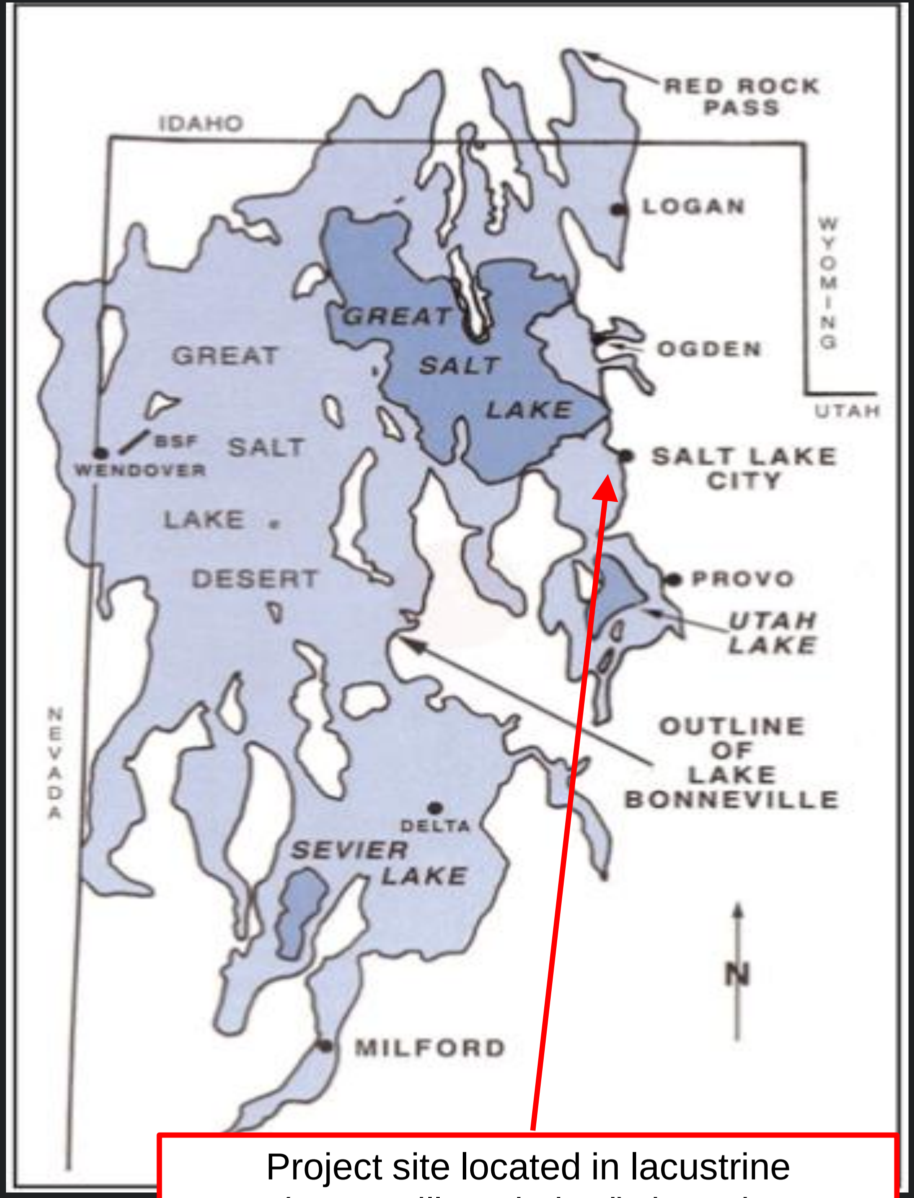

Project site located in lacustrine (Bonneville Lakebed) deposits

Lake Bonneville

- Ancient lake ~14,000 years
- 325 miles long,
- 135 miles wide,
- Depth of over 1,000 feet
- Our site:
  - Variable fill materials (I-15 Recon in 1996),
  - Interbedded deposits to 10 ft,
  - 90 ft of Clay (soft to medium stiff),
  - Laterally discontinuous and variable thickness of sand layers (a couple thousand feet to bedrock),
  - Groundwater: shallow, artesian, perched

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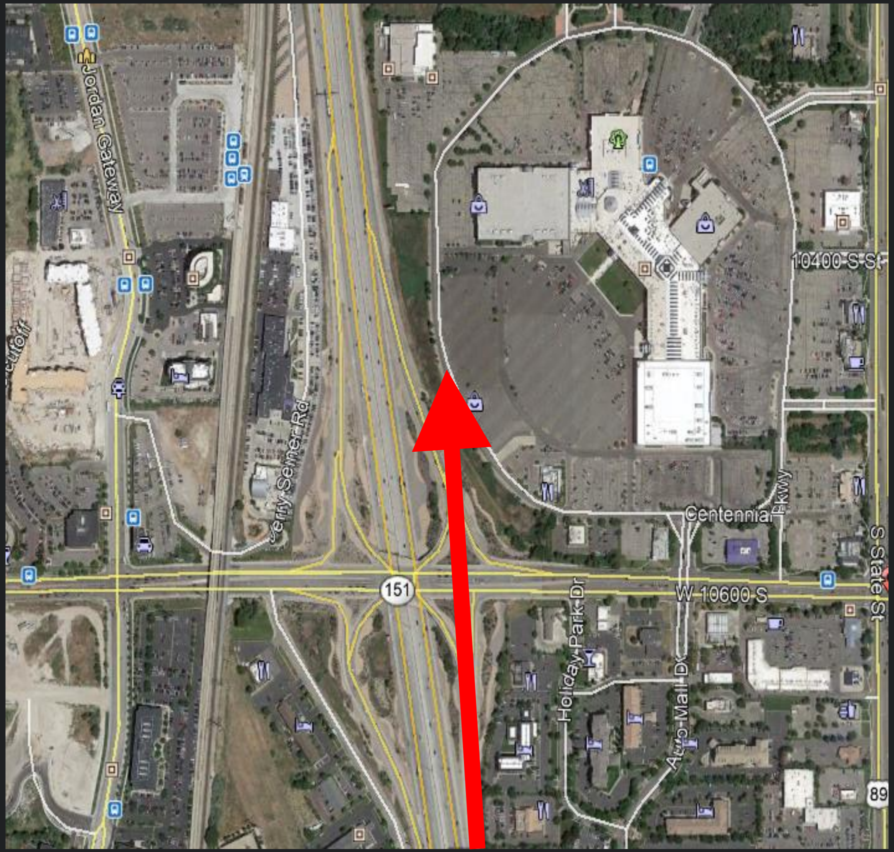
Structure Type Selection (Pick Your Adventure):

1) Multi-span bridge over (existing bridge on deep foundations)
2) Go around (widen ramp and new structure on deep foundations)
3) Go through the existing embankments (foundations ??)



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Widen ramp, property take, and new multi-span structure

I-15 NB; 10600 S Interchange

Construction Manager / General Contractor (CMGC)

UDOT
Keeping Utah Moving

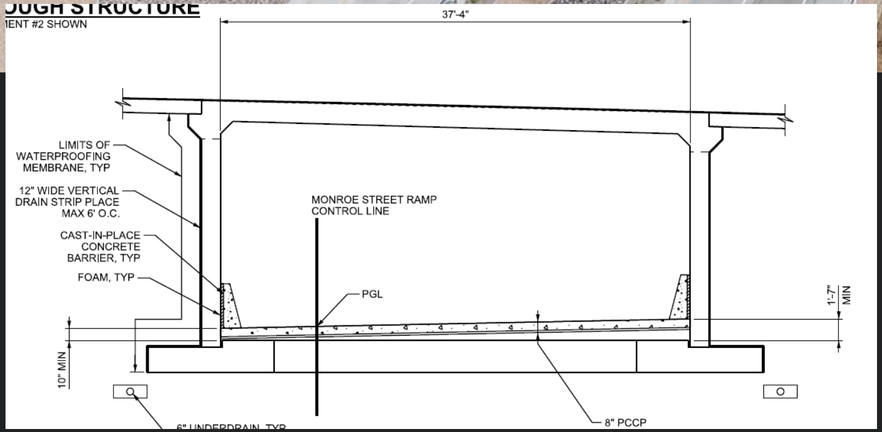
Michael Baker
INTERNATIONAL

GRANITE

MERIDIAN
ENGINEERING, INC

LOCHNER

I-15 NB; 10600 S Interchange



Maw’s Big 5 Geotechnical Risks

☑ Water, water, water (GEC05 – 10.5 and 10.6)

- Effective stresses (artesian / perched)
- Fluctuations over time (high quality piezometers)
- Excavation dewatering and site variability

☑ Schedule (GEC05 2.1 – Field Program Focus)

- Construction, dewatering, settlement, existing sewer utility
- Maximum past pressure / yield stress
- Tight construction window (16 days)

☑ Undocumented / historic construction (GEC05 12)

- Undocumented / poorly documented fill materials
- Buried debris (damage to drilling equipment)

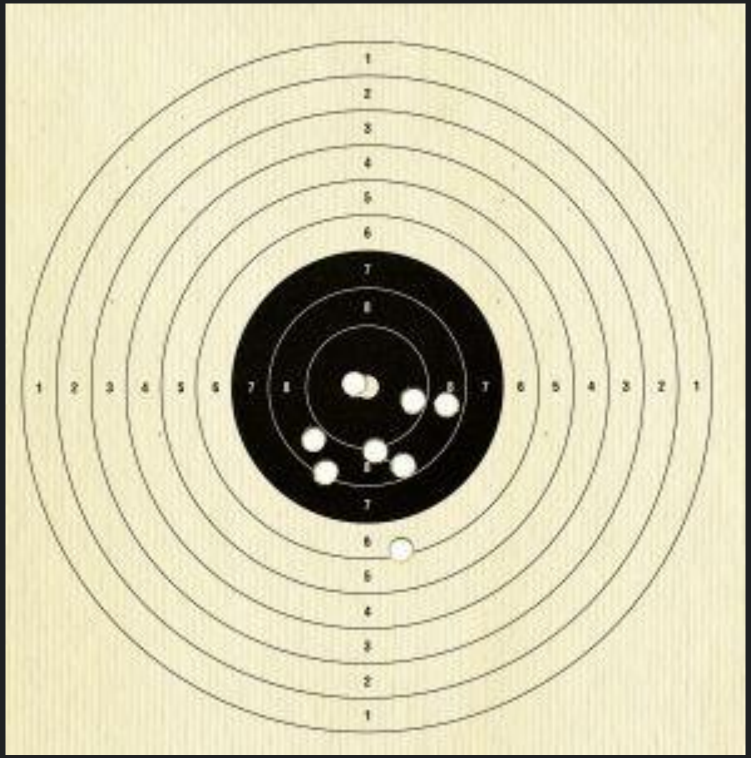
☑ Unusual or especially large loads (GEC05 3.1 / 7.4.6)

- Accelerated bridge construction (SHANSEP)

☑ Politics & Budget

- Thanksgiving / Black Friday…making the impossible, possible (9 months → 16 days)
- $16MM project funding (how nice would it be to go back to 2017….)

I-15 NB; 10600 S Interchange



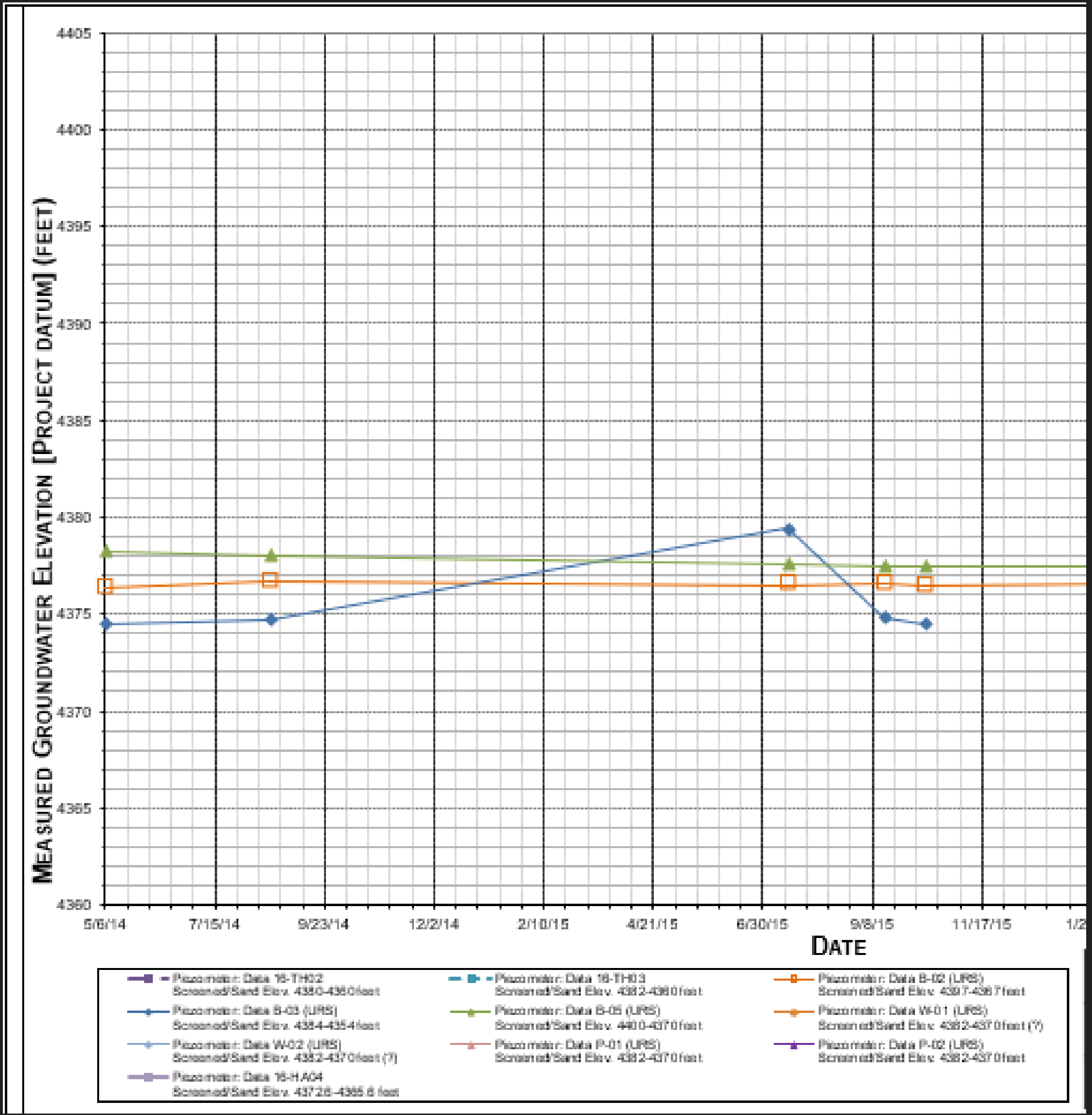
Pareto's Principal Applied to Geotechnical Engineering:

- 80% of the effort goes into a **<u>focused</u>** field study and laboratory program, and detailed site characterization
- 20% of the effort goes into analysis and reporting
- "Keep the main thing, the main thing" in data collection and site characterization

Water, Water, Water

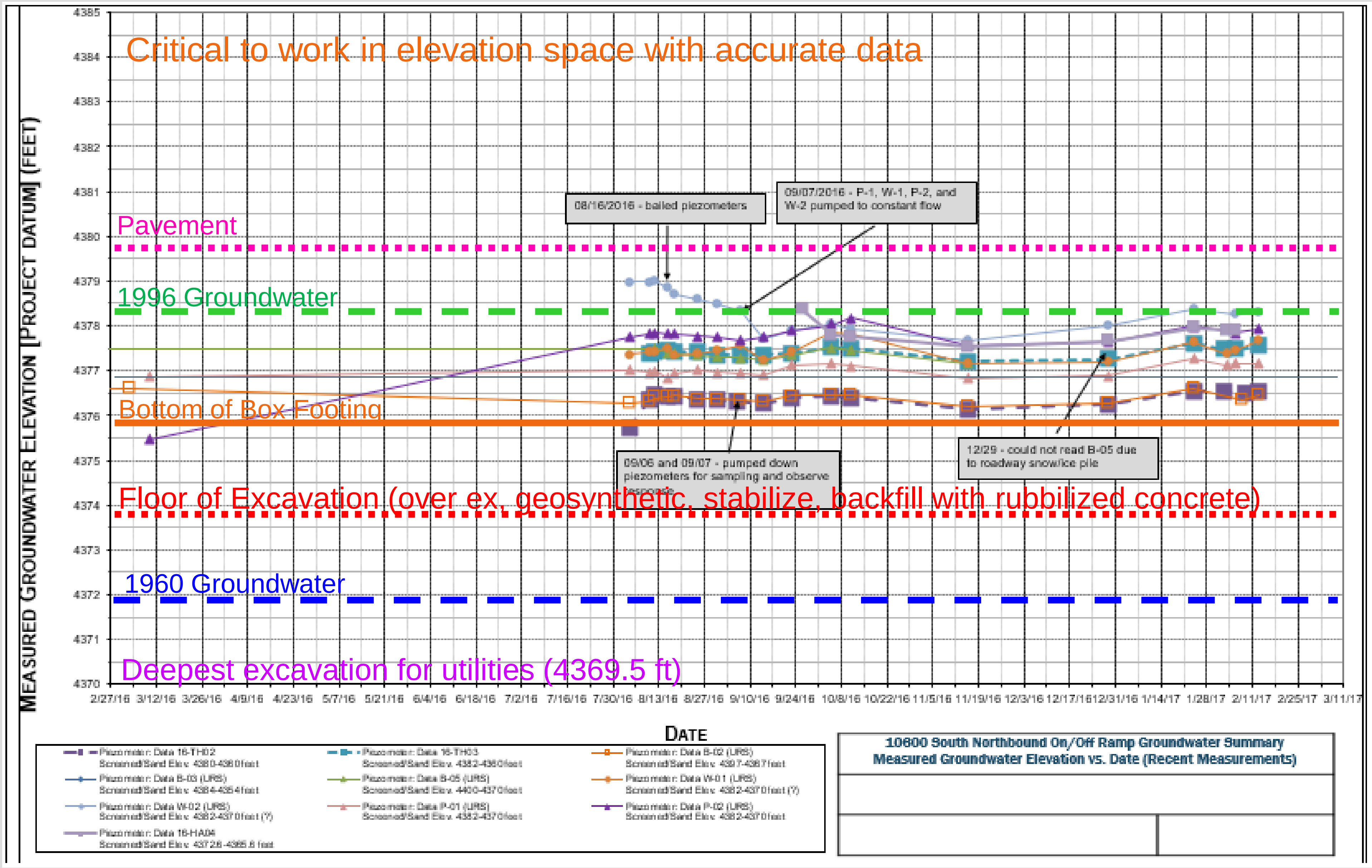
Historic / existing groundwater data

‘Elevation is estimated to the nearest half foot based on project topography’



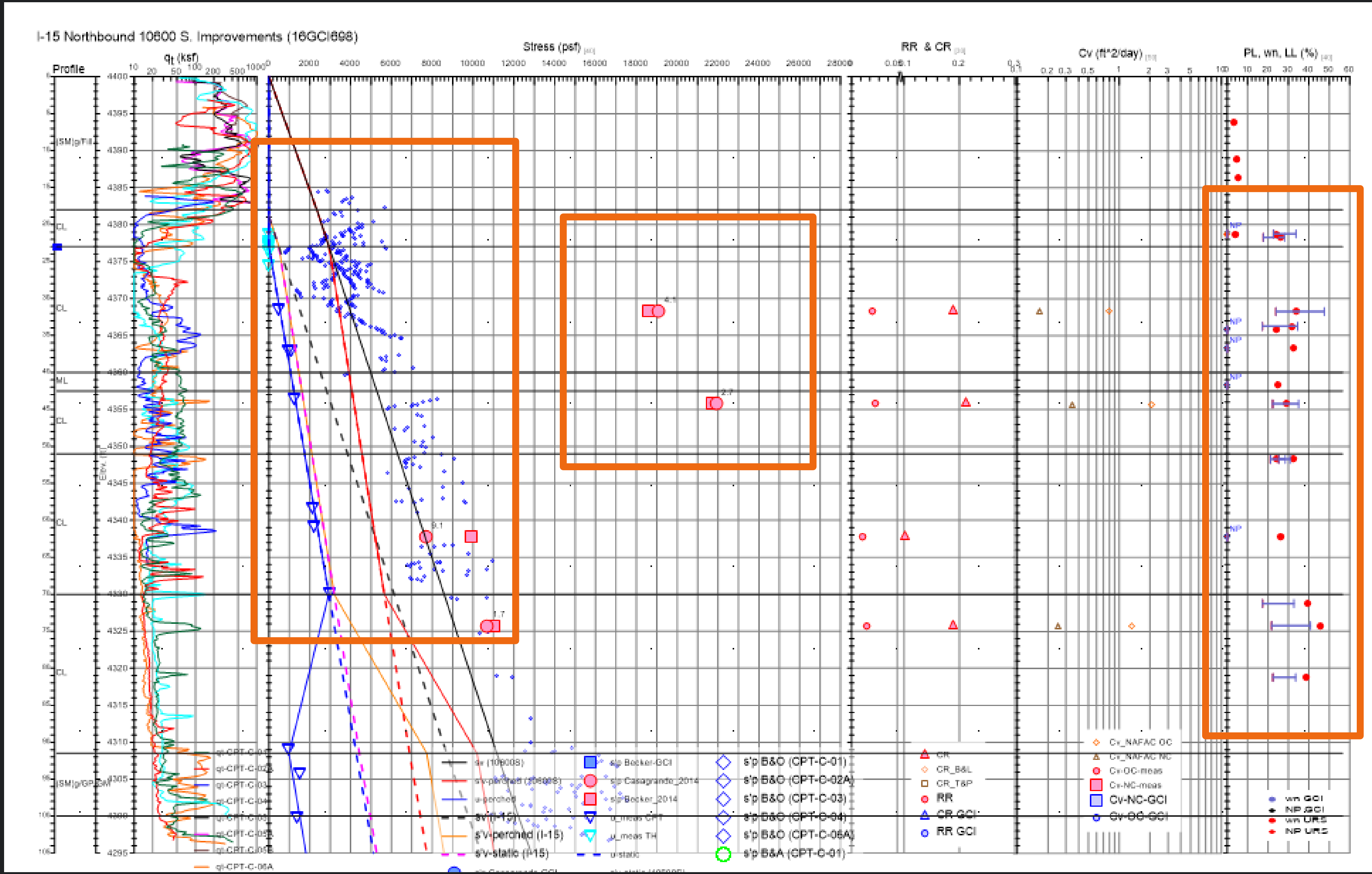
Water, Water, Water

Historic / existing groundwater data

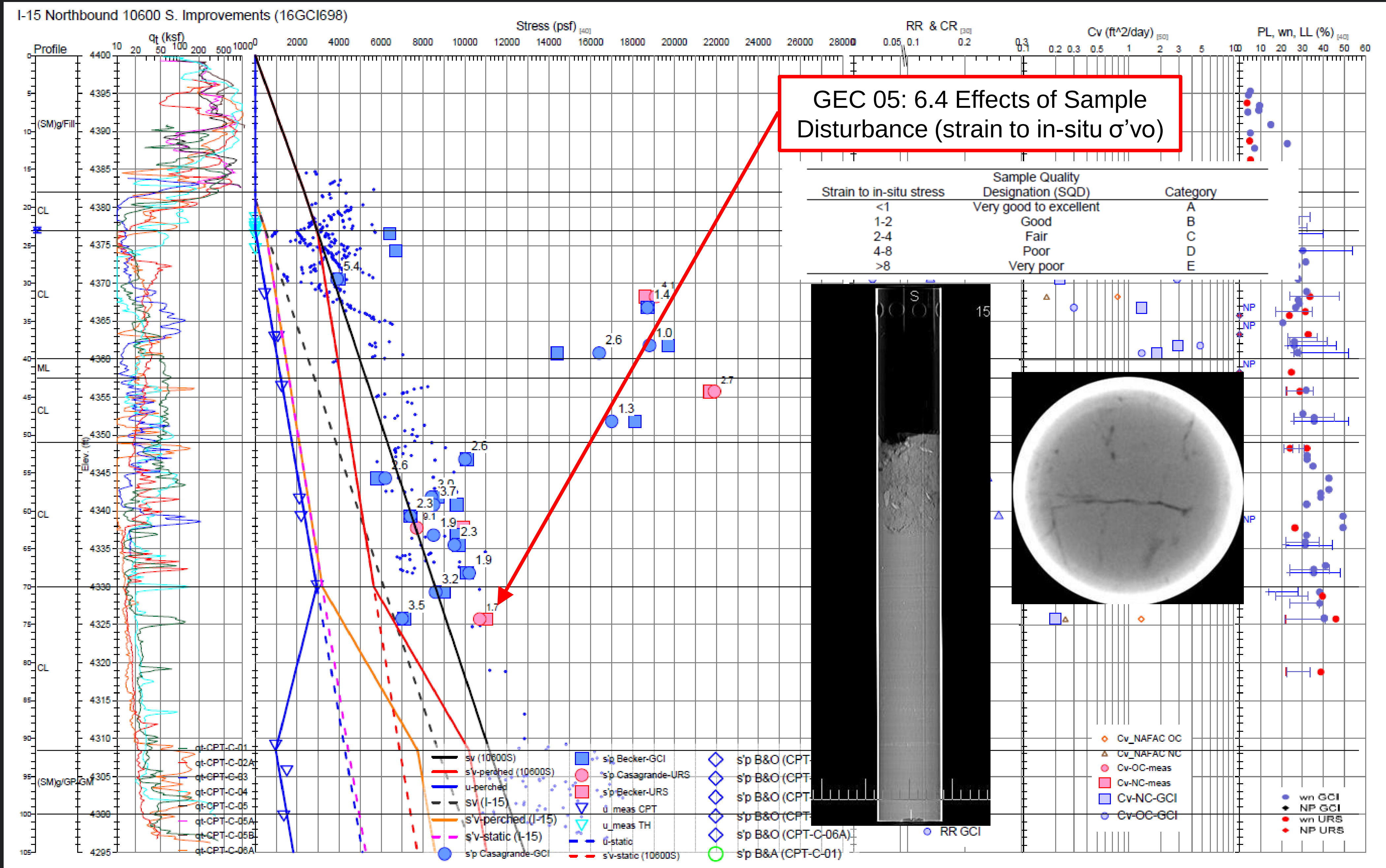


Schedule: Settlement

Where are the data gaps and what are we going to do about them?



Schedule: Settlement



GEC 05: 6.4 Effects of Sample Disturbance (strain to in-situ σ'vo)

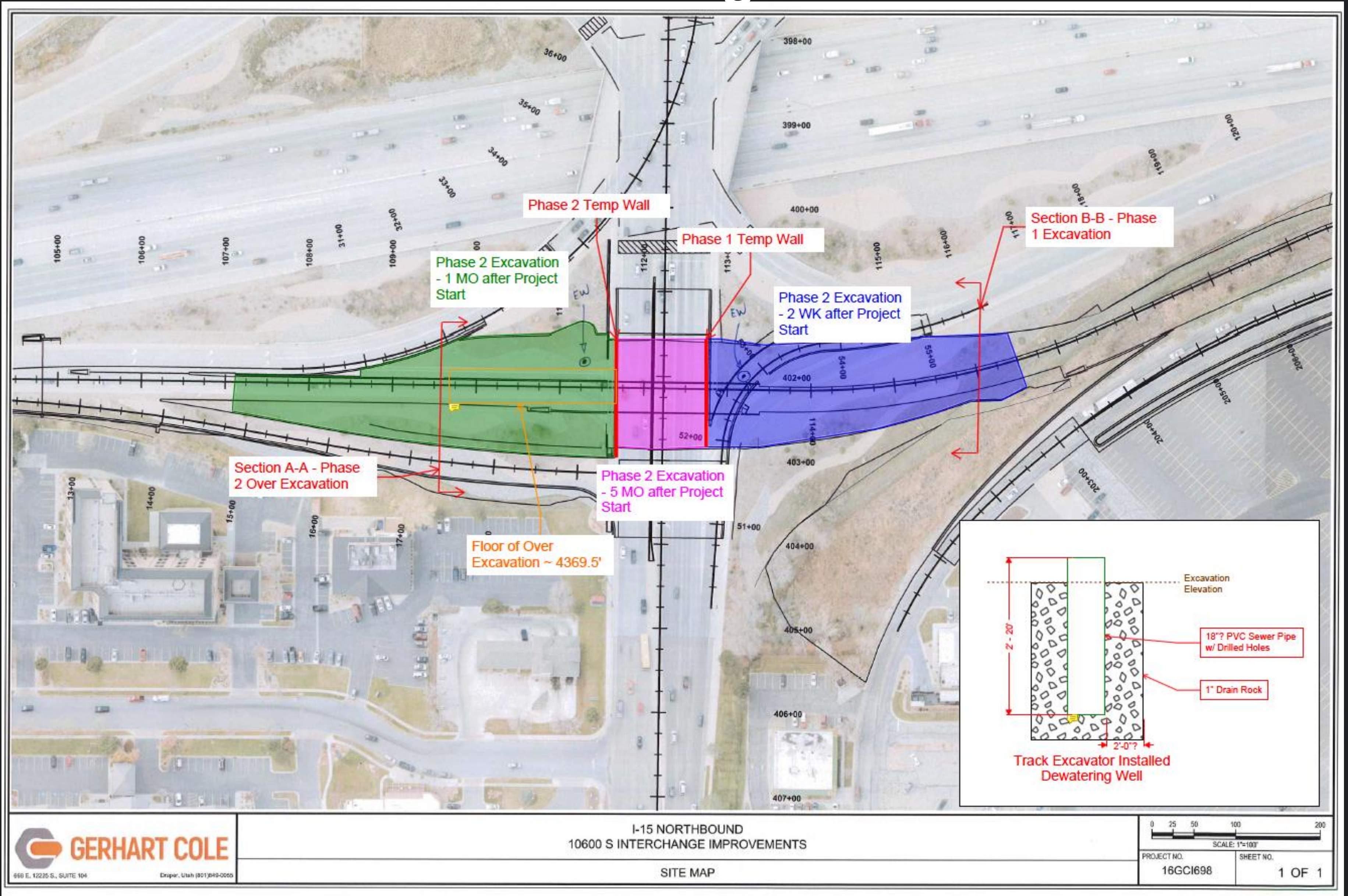
Strain to in-situ stress	Sample Quality Designation (SQD)	Category
<1	Very good to excellent	A
1-2	Good	B
2-4	Fair	C
4-8	Poor	D
>8	Very poor	E

Schedule: Construction

Schedule: Construction

Schedule: Construction

Some risks are best managed in construction….



Undocumented / Historic Construction

"….potential construction debris resulted in broken drilling equipment in 16-TH-03."

Unusual Loads or Especially Large Loads / ABC

- Settlement tolerance of ¼ inch
- 9 months → 16 days
- Three-sided, box & precast footings (1st by UDOT) and reduced factor of safety
- 123-ft long, 22-ft high – 3 million pounds moved in about 2 hours
- Completed with bottom slab after being in place

I-15 NB; 10600 S Interchange

Closing Thought

Today's presenters

Heather Shoup
Heather.Shoup@illinois.gov
Illinois Department of Transportation

Presenter Name
BCollins@bgcengineering.ca
BGC Consultants

Darren Beckstrand
Darren.Beckstrand@ccilt.com
Landslide Technology

Ryan Maw
ryanm@gerhartcole.com
Gerhart Cole, Inc.

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February 26, 2024

TRB Webinar: Disruptive Technologies and the Future of the Transportation Agency

June 23-26, 2024

2nd International Roadside Safety Conference

https://www.nationalacademies.org/trb/events

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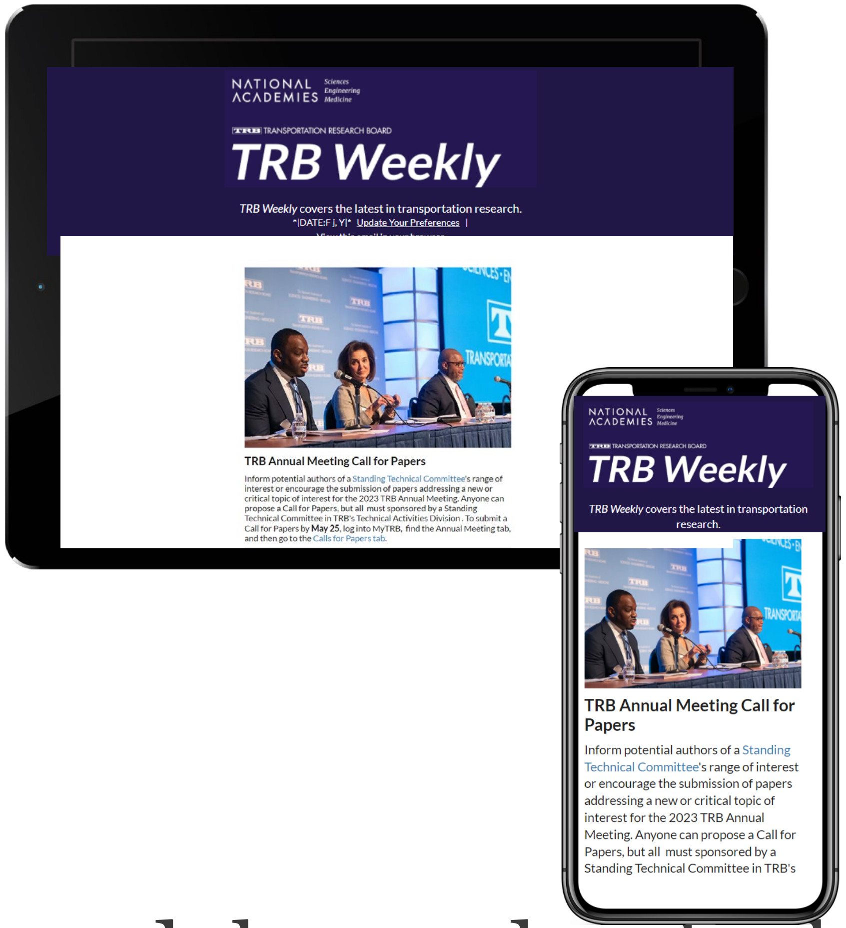

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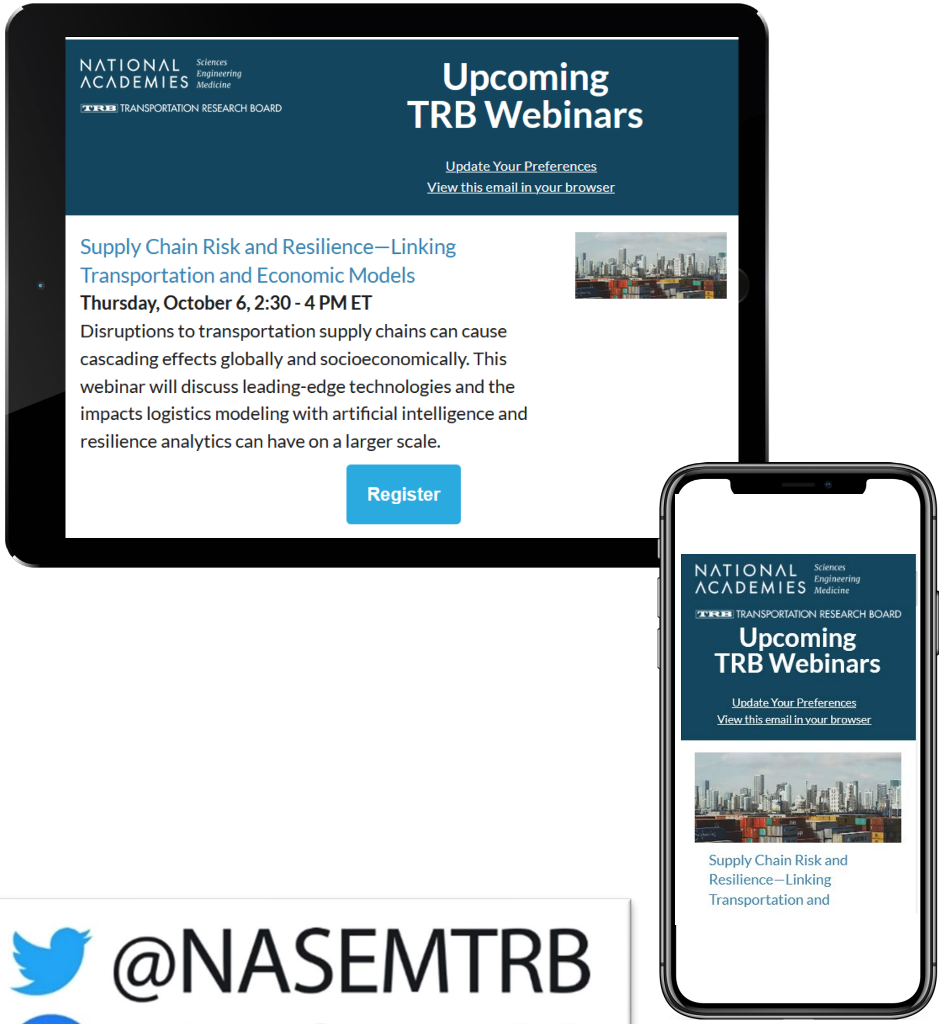

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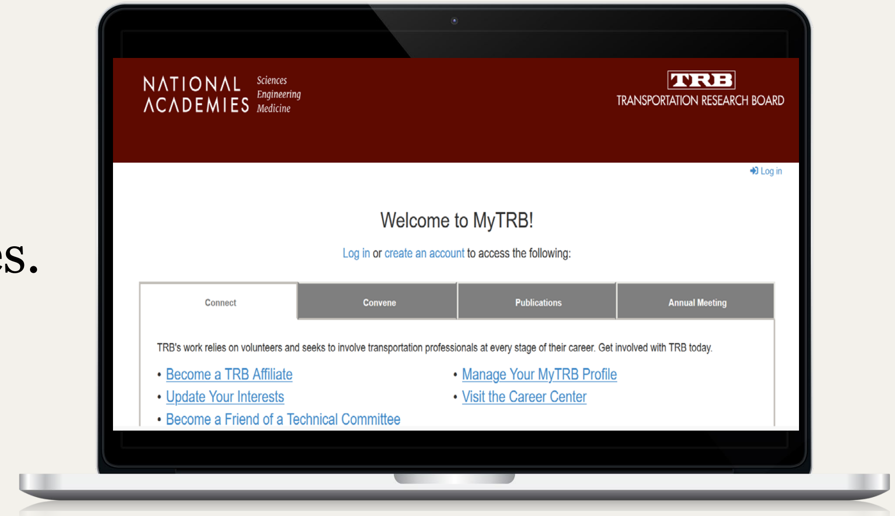

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