KU 57th Annual Geotechnical Engineering Conference

November 2025

Using digital data delivery to get closer to the edge at Denali and Yellowstone National Parks

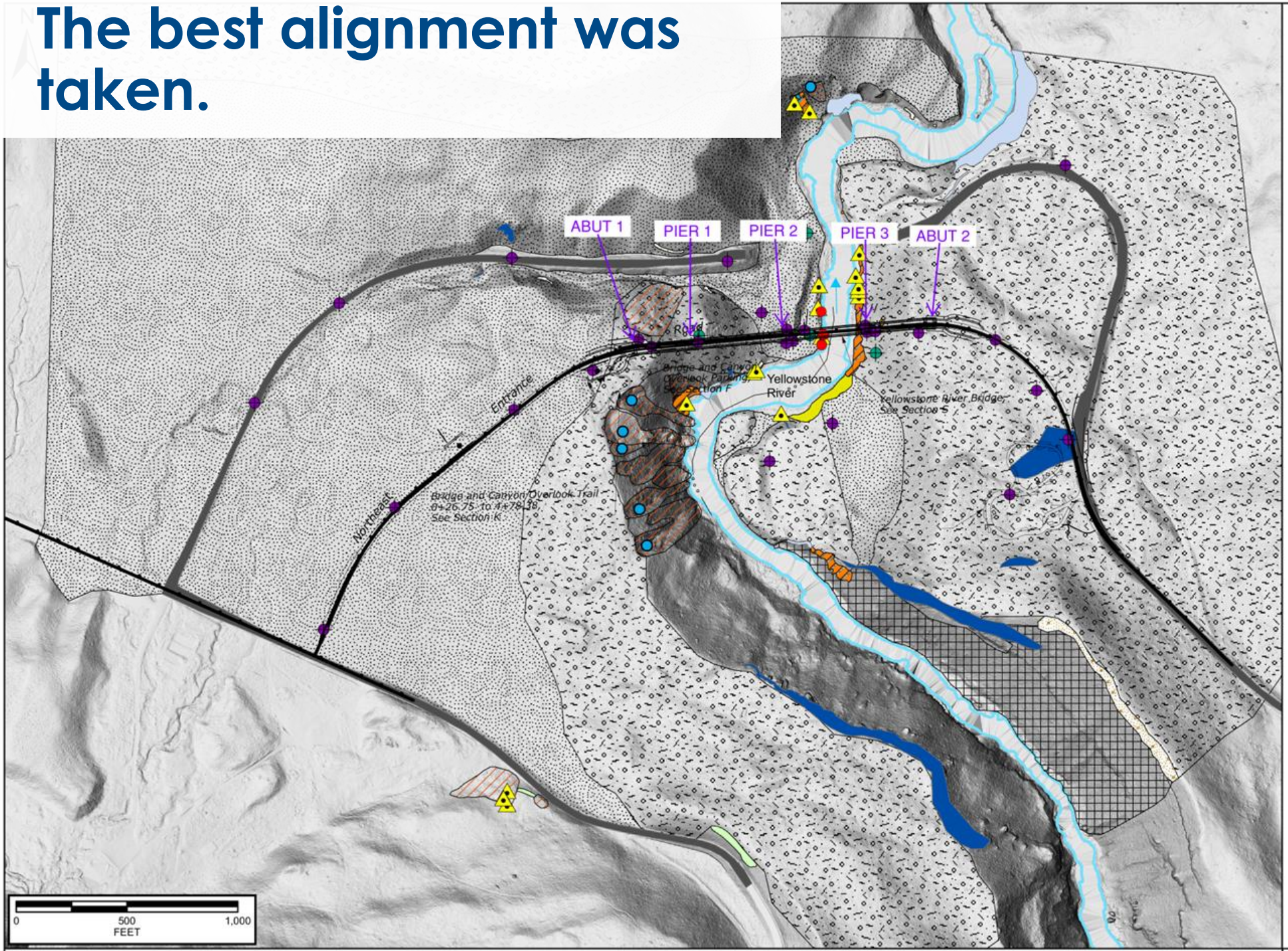
Scott Anderson, Ph.D., PE

BGC Engineering, Inc.

The yellow stone of the Yellowstone River and Yellowstone National Park, home of a Supervolcano.

An off-alignment bridge replacement was needed.

The best alignment was taken.



Qa - Alluvium

Sand with gravel, trace to some silt, some cobbles and boulders, gap graded, fine to coarse sand, fine to coarse gravel, rounded to subrounded, brown, dry, heterogenous. Glacial boulder erratics were observed on the ground surface, particularly on the west side of the river.

Qg - Glacial Till

Sand with silt, trace clay, gravel, cobbles and boulders, fine to coarse, low plasticity, brown to gray, dry, homogeneous, gap graded. Gravel was subangular to subrounded and basalt and granite boulders up to 15 feet were observed on the ground surface,

Talus

Slopes characterized by large boulders and cobbles. Talus was inferred from what could be observed from the slope crests. Some lopes were steep and unsafe for BGC to map on foot.

Basalt

Dark grey to black, columnar jointed, aphanitic with plagiclose phenocrysts, medium strong, unaltered, slightly weathered with orange iron staning primarily on fracture and joint surfaces. Basalt forms exposed cliff bands high up on the banks of the Yellowstone River and ouctoprs in several locations near the picnic area.

Conglomerate

Orange to light brown, cemented with gravel, cobbles, and boulder sized clasts in a coarse arkosic matrix, calcareous matrix, subrounded to rounded clasts, medium strong to strong, moderately to highly weathered in places. Locally, the conglomerate overlies sandstone beds, white to light brown, fine to medium grained sand, highly weathered, weak..

Agglomerate

Dark greenish grey, coarse, clastic, subangular to subrounded clasts up to 6-inches are common with some subrounded cobble and boulder sized clasts, welded matrix with porphyritic texture, medium strong to strong, moderately altered, with pervasive disseminated calcite alteration, some chlorite, and sparse sulfides, with moderately to widely spaced joint sets, abundant calcite veins. Some outcrops are highly weathered and highly altered.

Travertine

Tan to grey, calcium carbonate, fine, high porosity with open void spaces, weak to medium strong. At the outcrop along Tower Road, the travertine was interbedded with sandstone and conglomerate, with some calcite and sulfur infilling along bedding planes.
The bedding was oriented at 04/200 (dip/dip direction).

Highly Altered

Zones of highly to completely altered rock, extremely weak to very weak bedrock where the parent rock is difficult to distinguish and in some areas, have been replaced with calcareous and sulfuric hydrothermal deposits. These zones are typically yellow to white with green and orange mottling, have a sulfuric odor, and are
friable.

Highly Weathered

Zones of highly to completely weathered sandstone and conglomerate. Sandstone was tan, very fine, very weak, with some sulfur crystalization throughout.

Landslides

Inferred inactive and dormant landslides. Maturity of features varies.

Vents

Areas of hydrothermal alteration and deposits. At several locations H2S gas was measured and a strong sulfuric odor was observed.

- Hydrothermal Springs
- Seeps
- 2020/2021 Borehole Locations
- 2019 Borehole Locations
- Yellowstone River Survey
- Existing Road
- Centerline Bridge & Rdwy.

An active hydrothermal system with altered rock, hot springs, and hydrogen disulfide (H2S) gas in ‘stovepipes’.

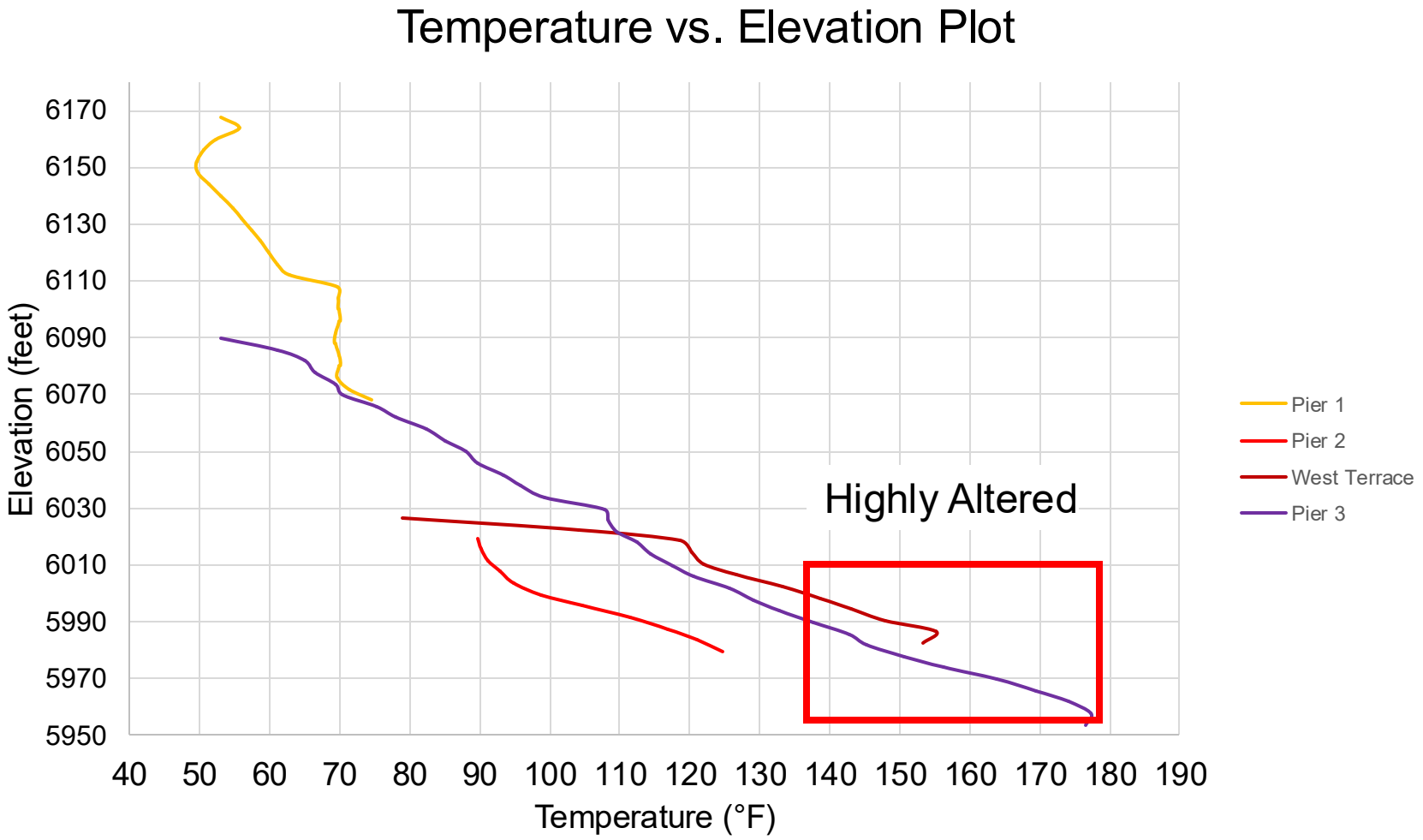
Slightly Altered – Calcic . Strong (R4)

Moderately Altered – Calcic. Weak (R2)

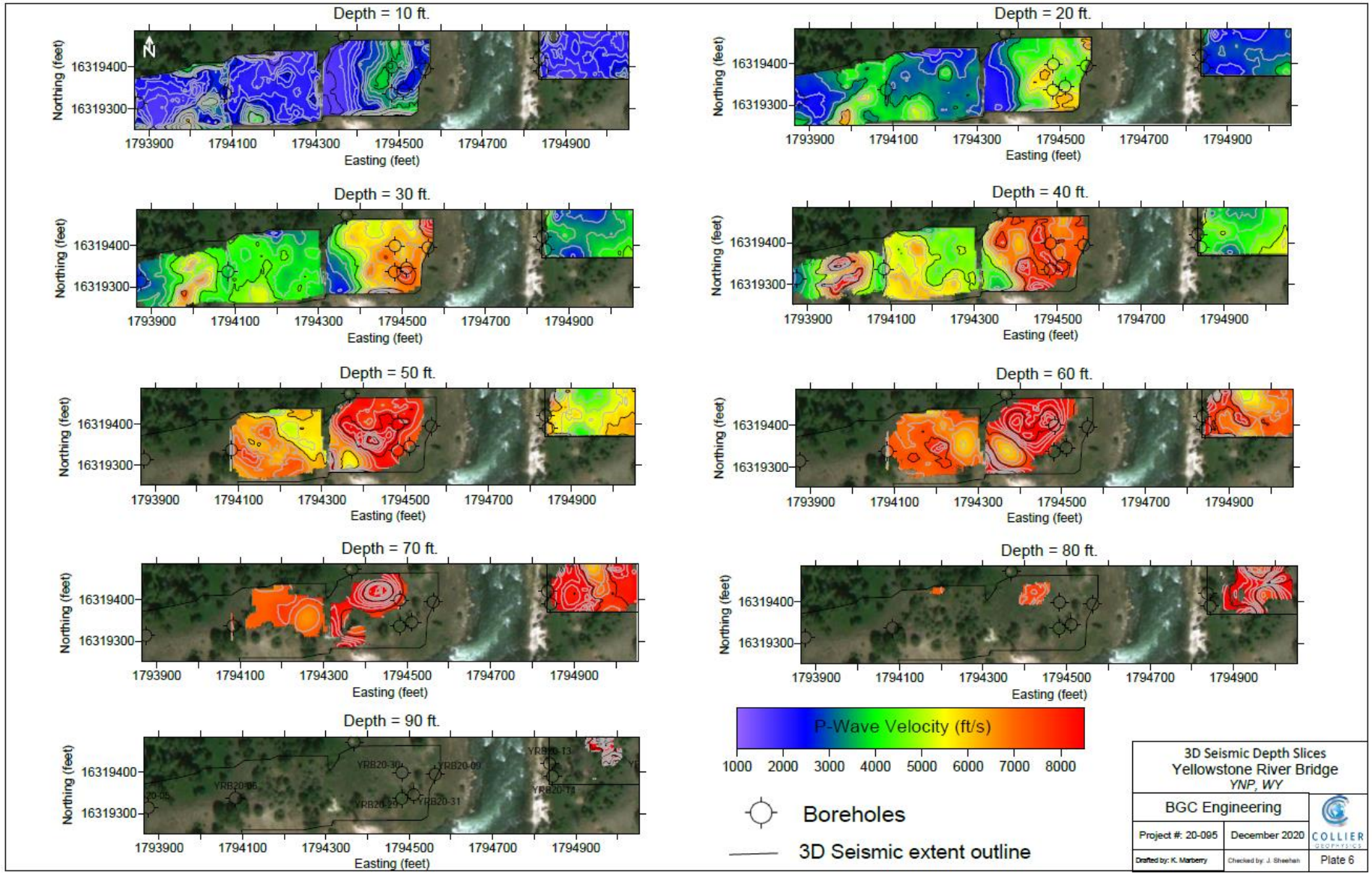
Highly Altered & Fractured – Silica + Sulfide +Epidote

Sepulcher Formation Agglomerate (Eocene)

The highly altered rock has a lower RMR, occurs with hot groundwater (>140 F (60 C), H2S gas, and pH<3.

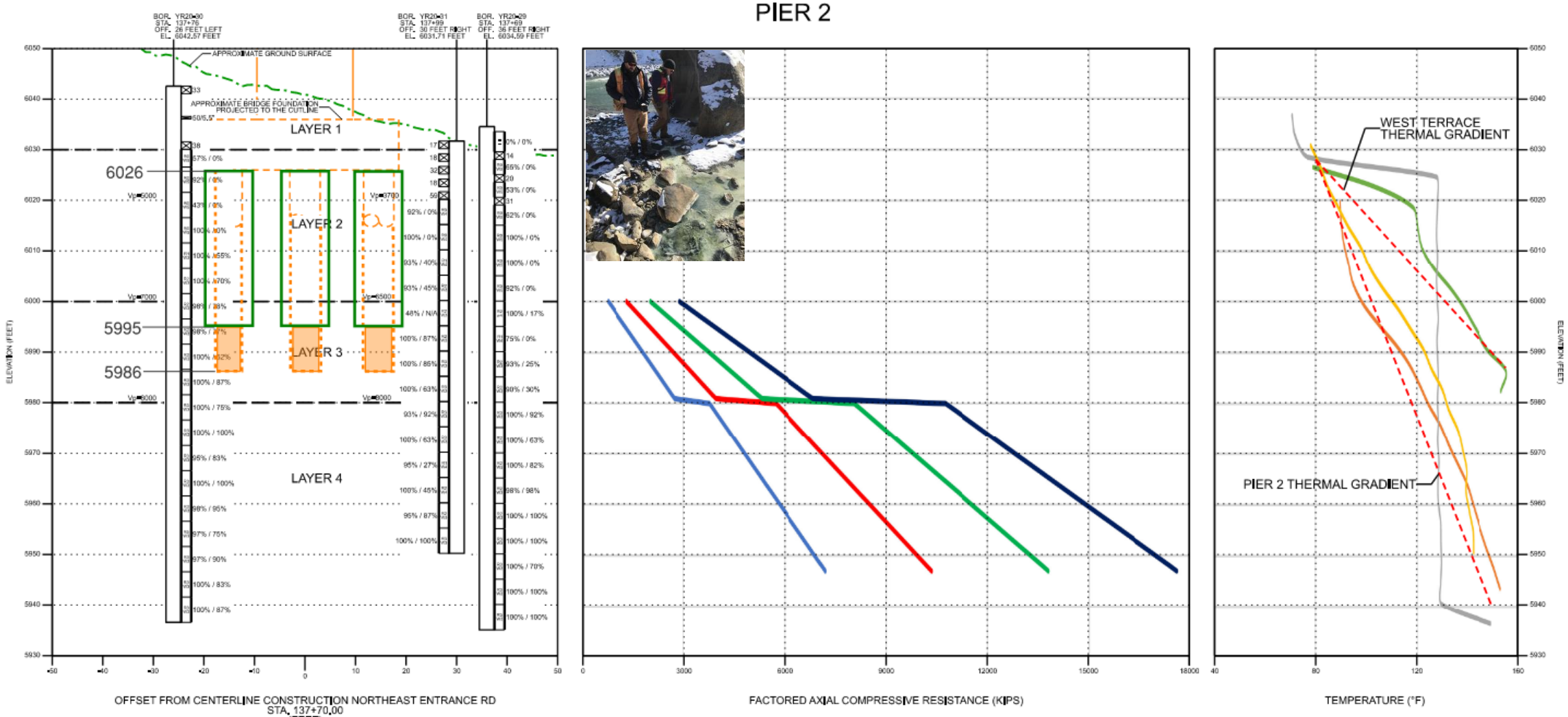


Seismic and resistivity methods were used to look for stovepipes and locate piers.



Confident deep foundation design.

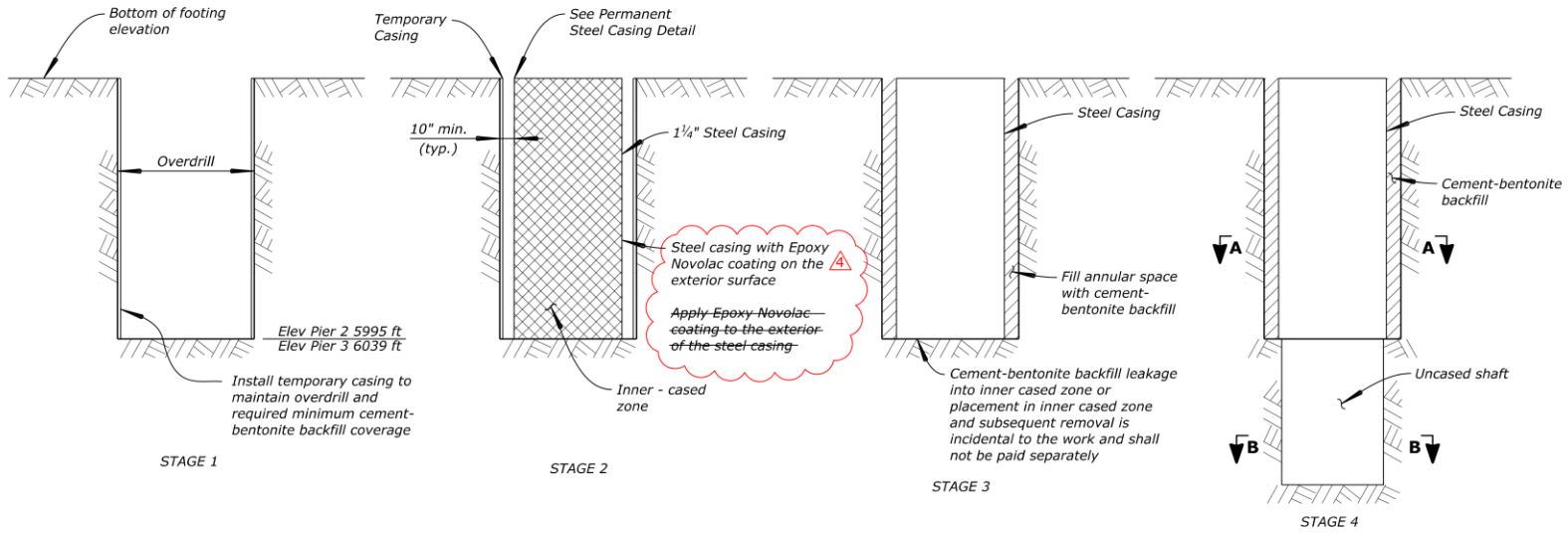
FOUNDATION DESIGN DRAWING
PIER 2



LAYER	MATERIAL DESCRIPTION	ELEVATION (ft)		DESIGN GSI	DRILLED SHAFT RESISTENCE VALUES		RQD (%)
		TOP	BOTTOM		NOMINAL SIDE RESISTANCE (ksf)	NOMINAL TIP RESISTANCE (ksf)	
1	COLLUVIUM / GLACIAL TILL	6035	6030	--	--	--	--
2	COMPLETELY WEATHERED BEDROCK	6030	6000	0	--	--	0
3	UPPER AGGLOMERATE INTERVAL	6000	5980	45	20	190	50
4	LOWER AGGLOMERATE INTERVAL	5980	5935	65	20	450	80

AXIAL CAPACITY PLOT:
(DRILLED SHAFT DIAMETER)
- 3 FEET
- 4 FEET
- 5 FEET
- 6 FEET

Detailed for longevity.



ELEVATION - CONSTRUCTION STAGING

Deep foundation safely constructed with a TARP.

Deep foundations made this possible – Nov. 2024

BRIDGE DESIGN: PRETTY ROCKS LANDSLIDE

POLYCHROME PASS, DENALI NATIONAL PARK, ALASKA

NATIONAL PARK SERVICE

DEPARTMENT OF TRANSPORTATION FHWA

BGC

CLIRIO

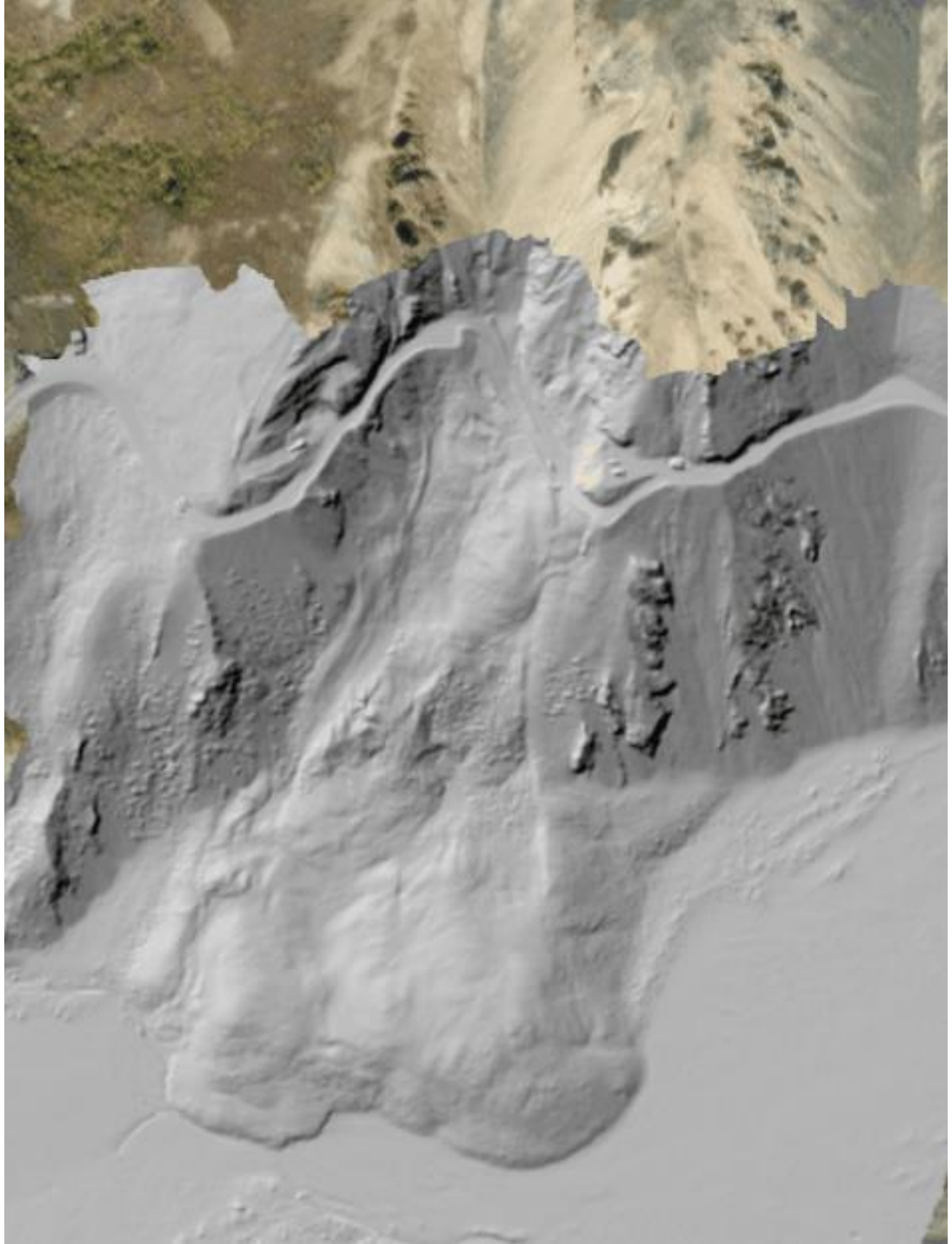
Jacobs

2024 Activity

UAS Photogrammetric Change

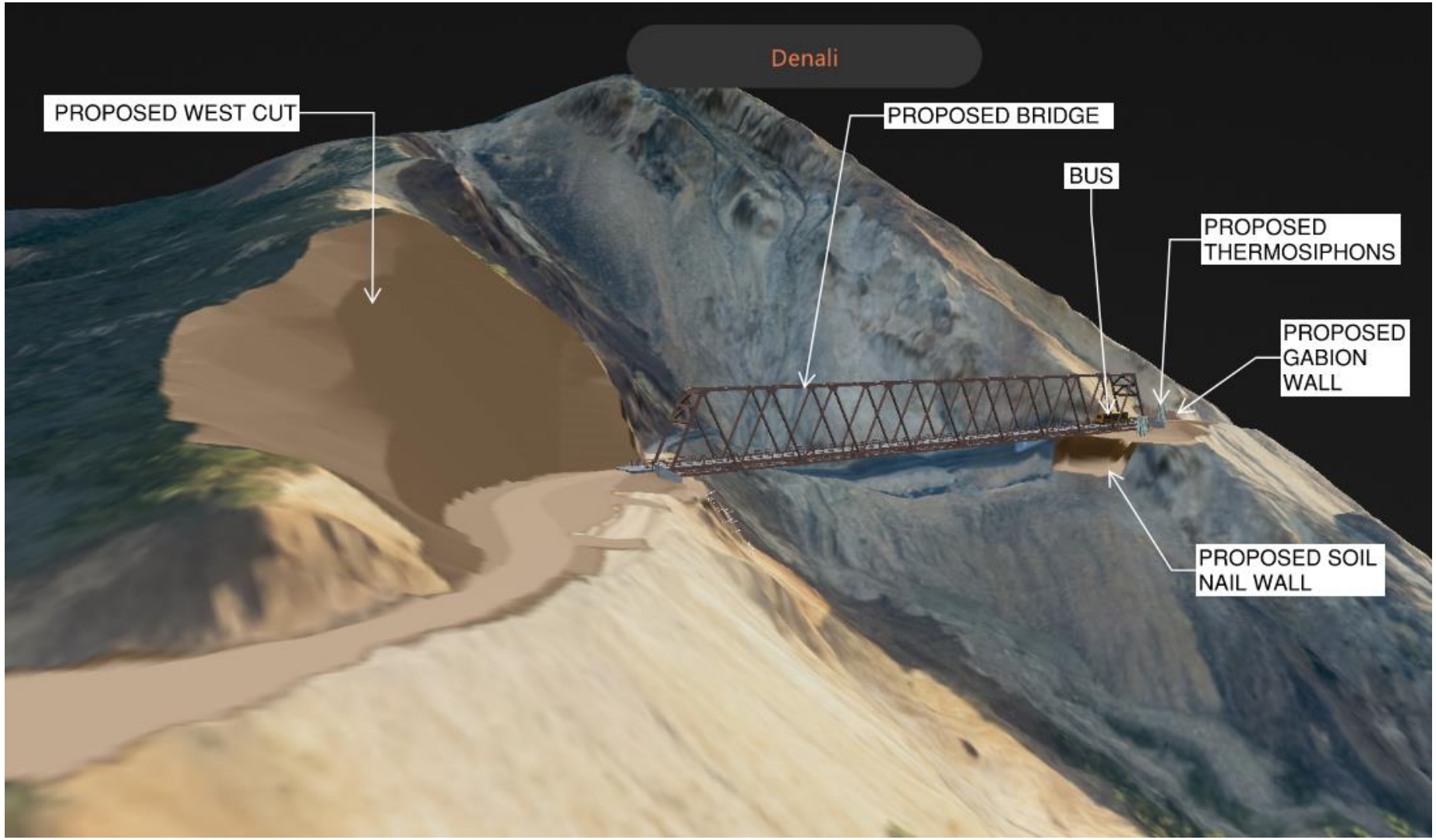
Cool blue = loss

Warm red = gain

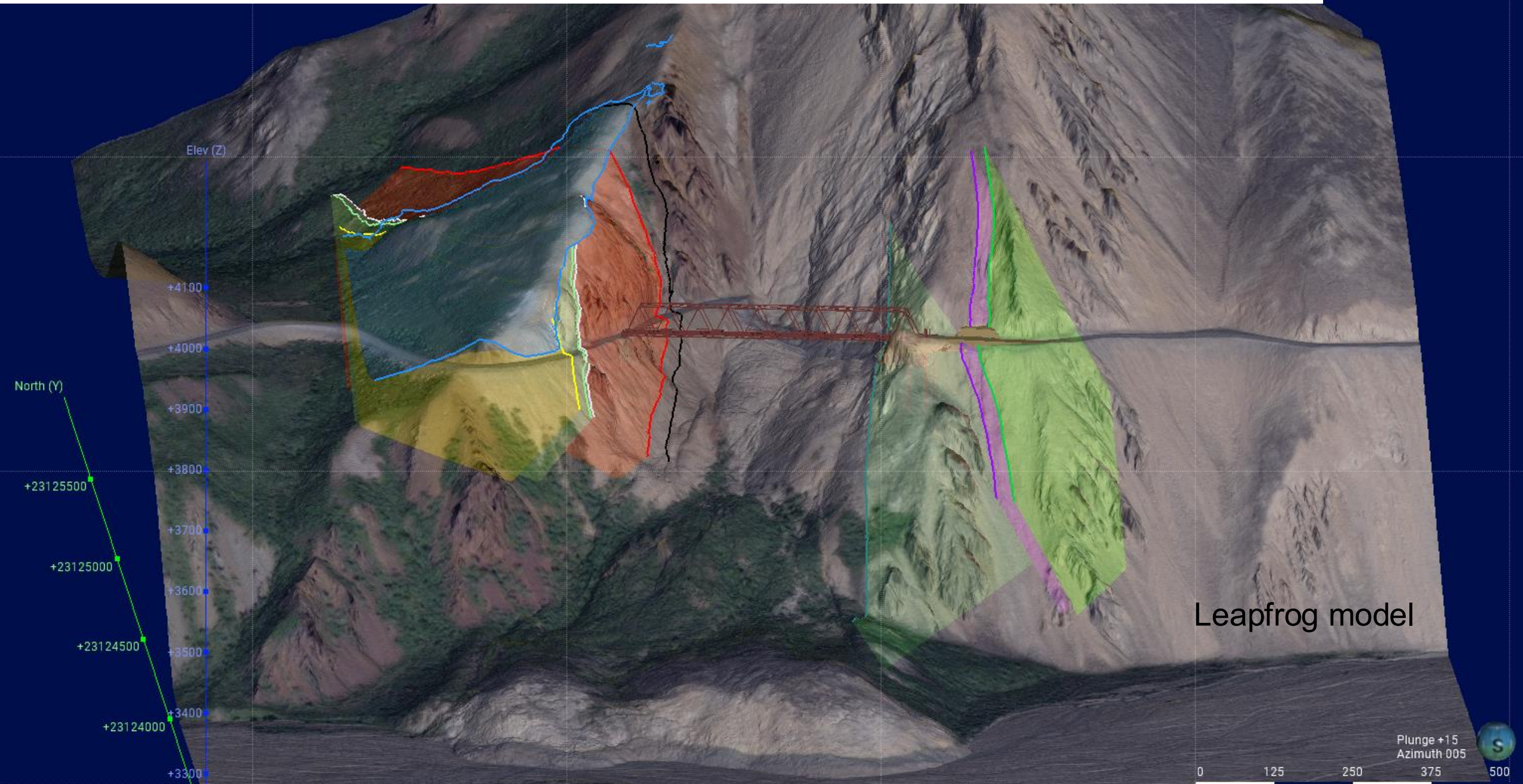


Site Understanding

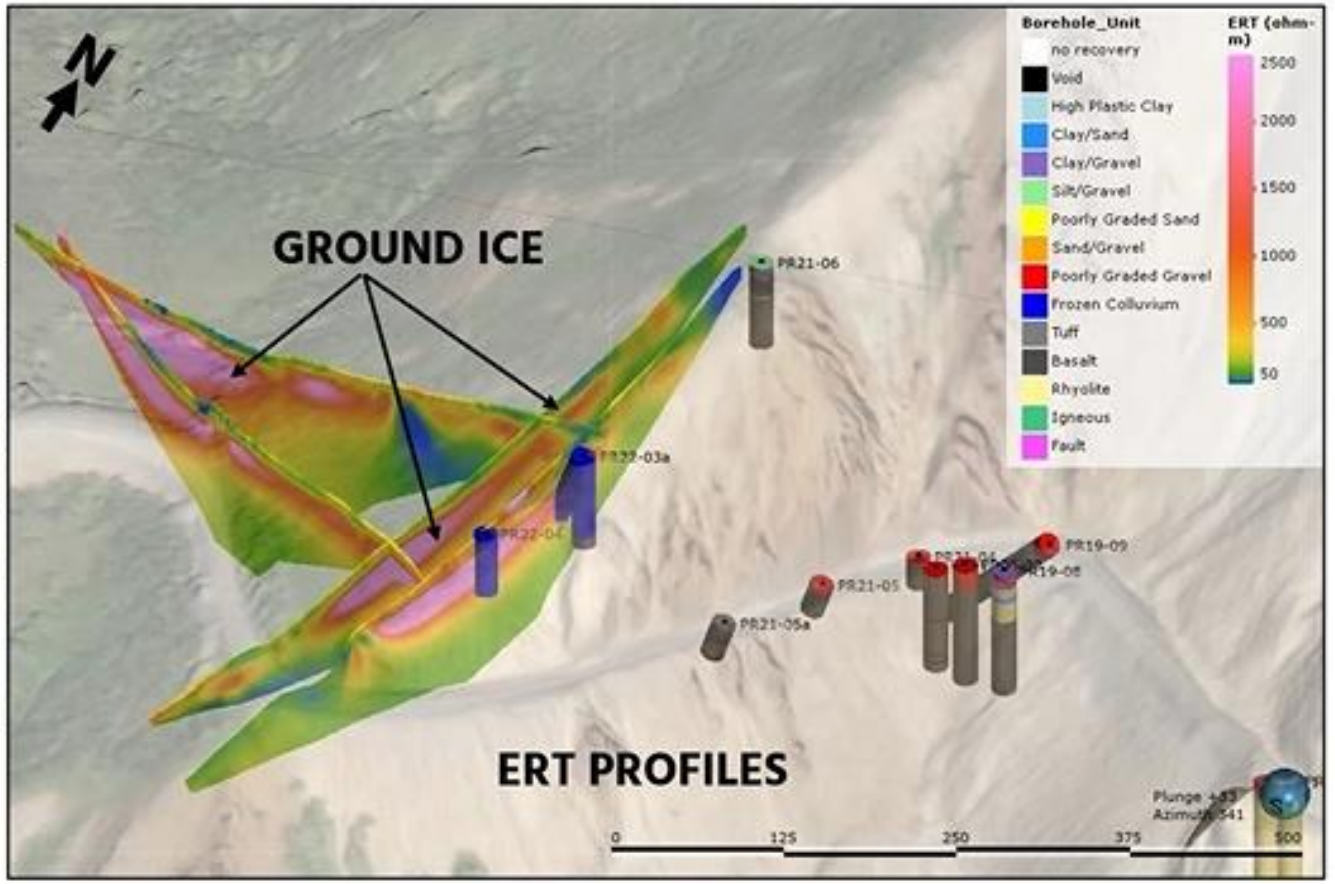
The solution seen as a digital twin.



Rock structure was the key. Well, that and ice.



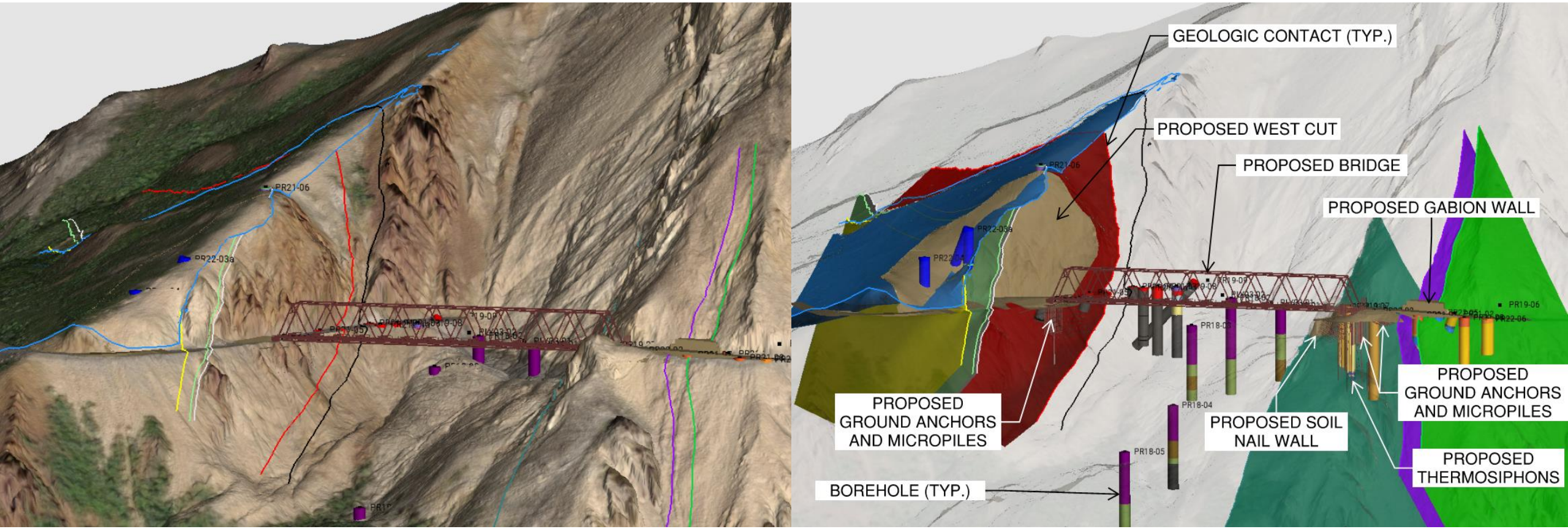
Rock structure was the key. Well, that and ice.



Ice exposure

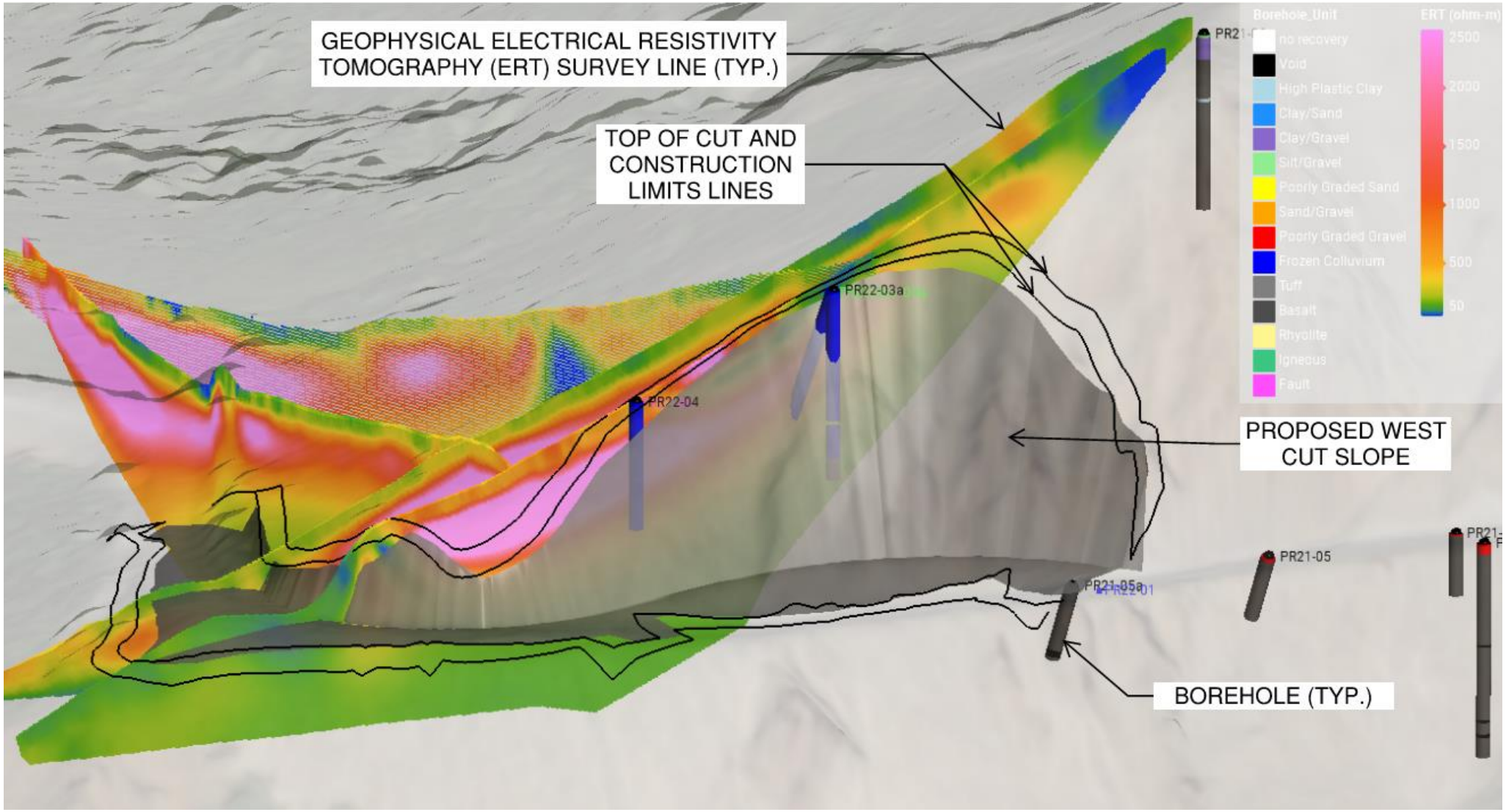
Leapfrog – Subsurface Model

https://www.seequent.com/products-solutions/leapfrog-viewer/



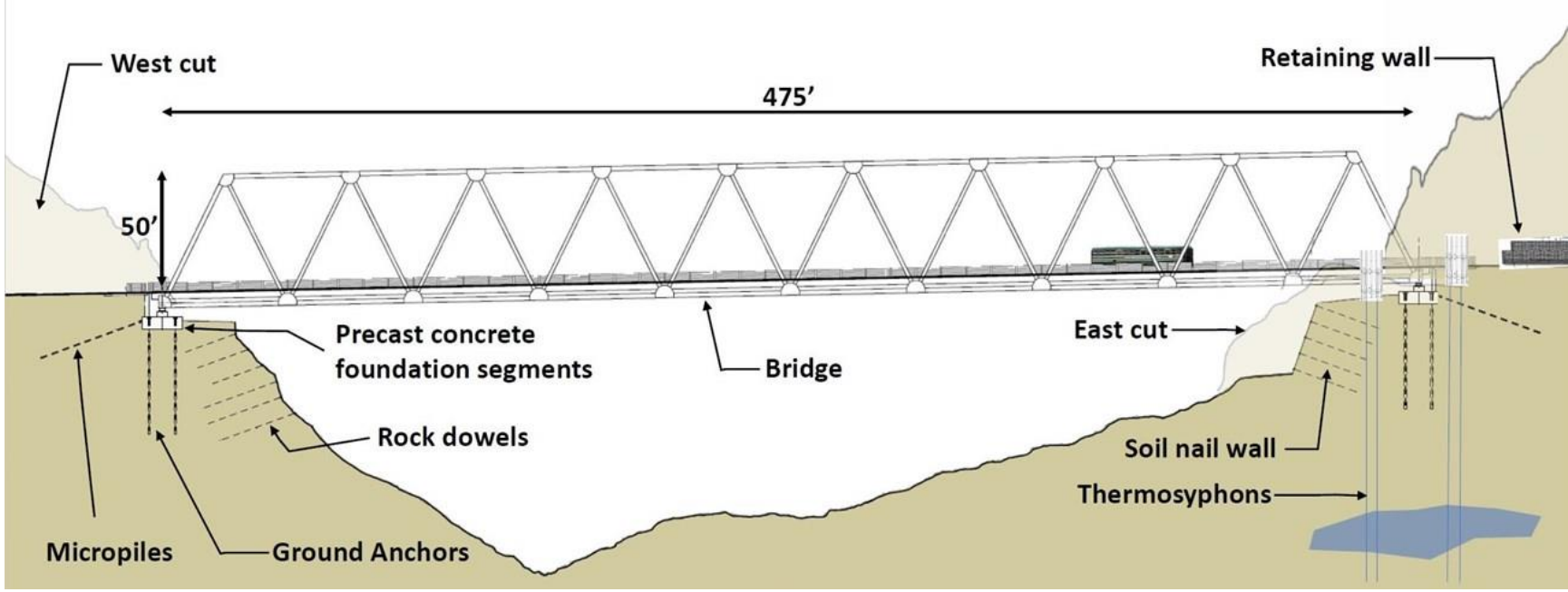
Leapfrog – Subsurface Model

https://www.seequent.com/products-solutions/leapfrog-viewer/

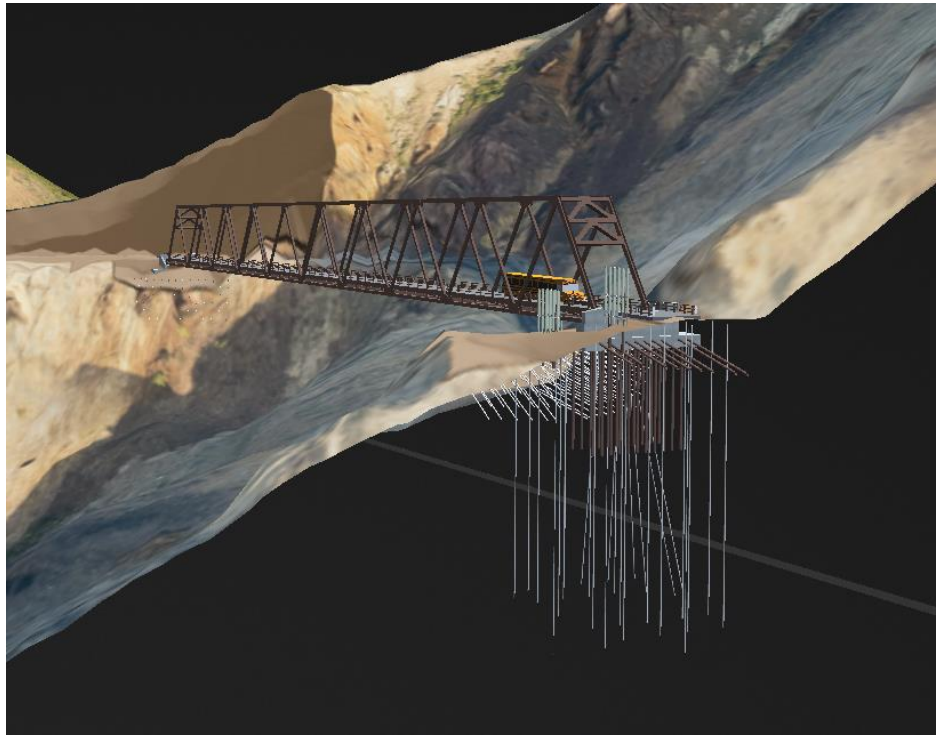


Design

2D Schematic



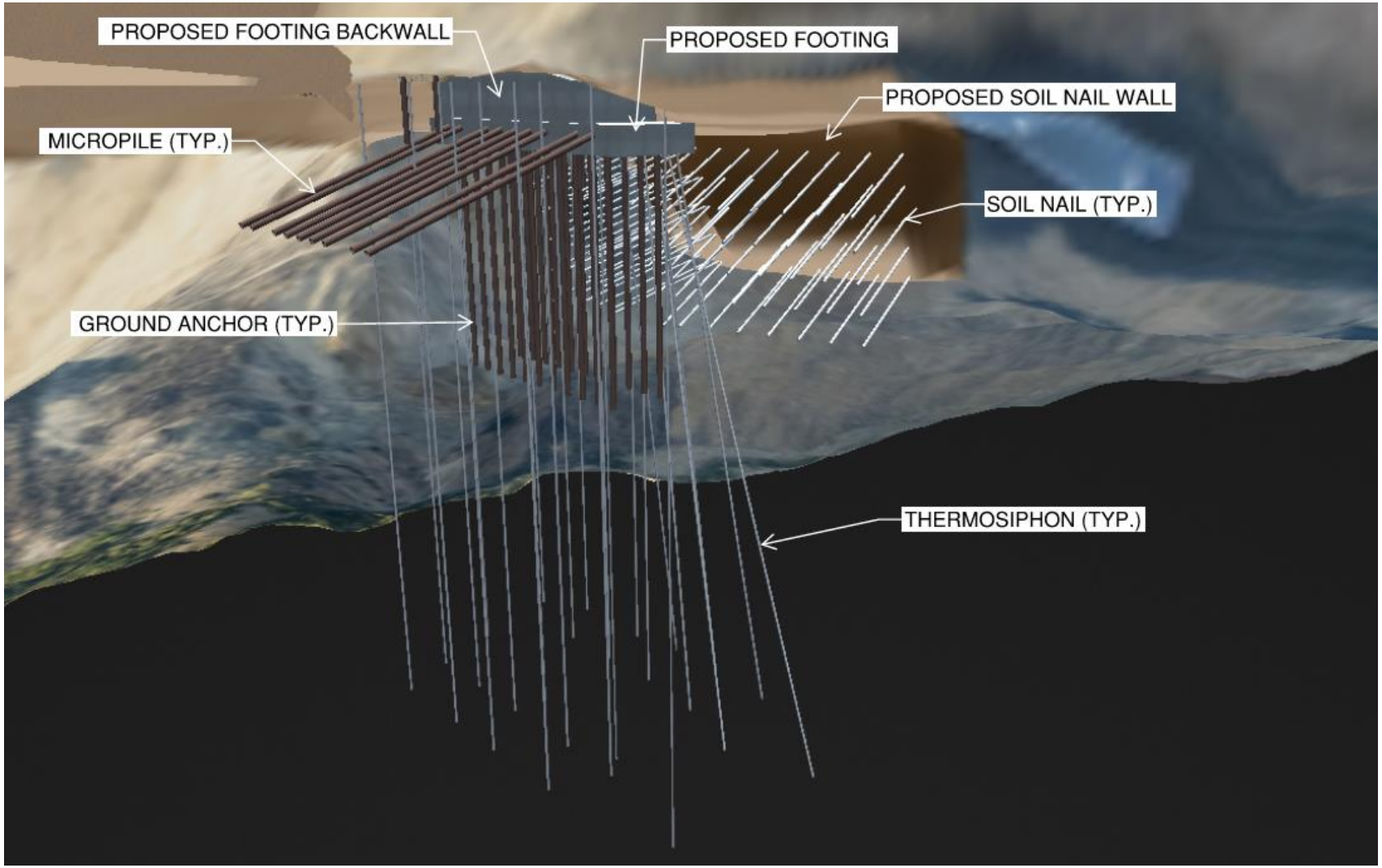
3D Digital Twin



Focus here


Denali
3D
Reset Map
Create New Observation

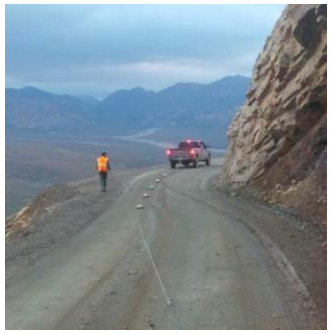
A digital site and construction model – a digital twin.

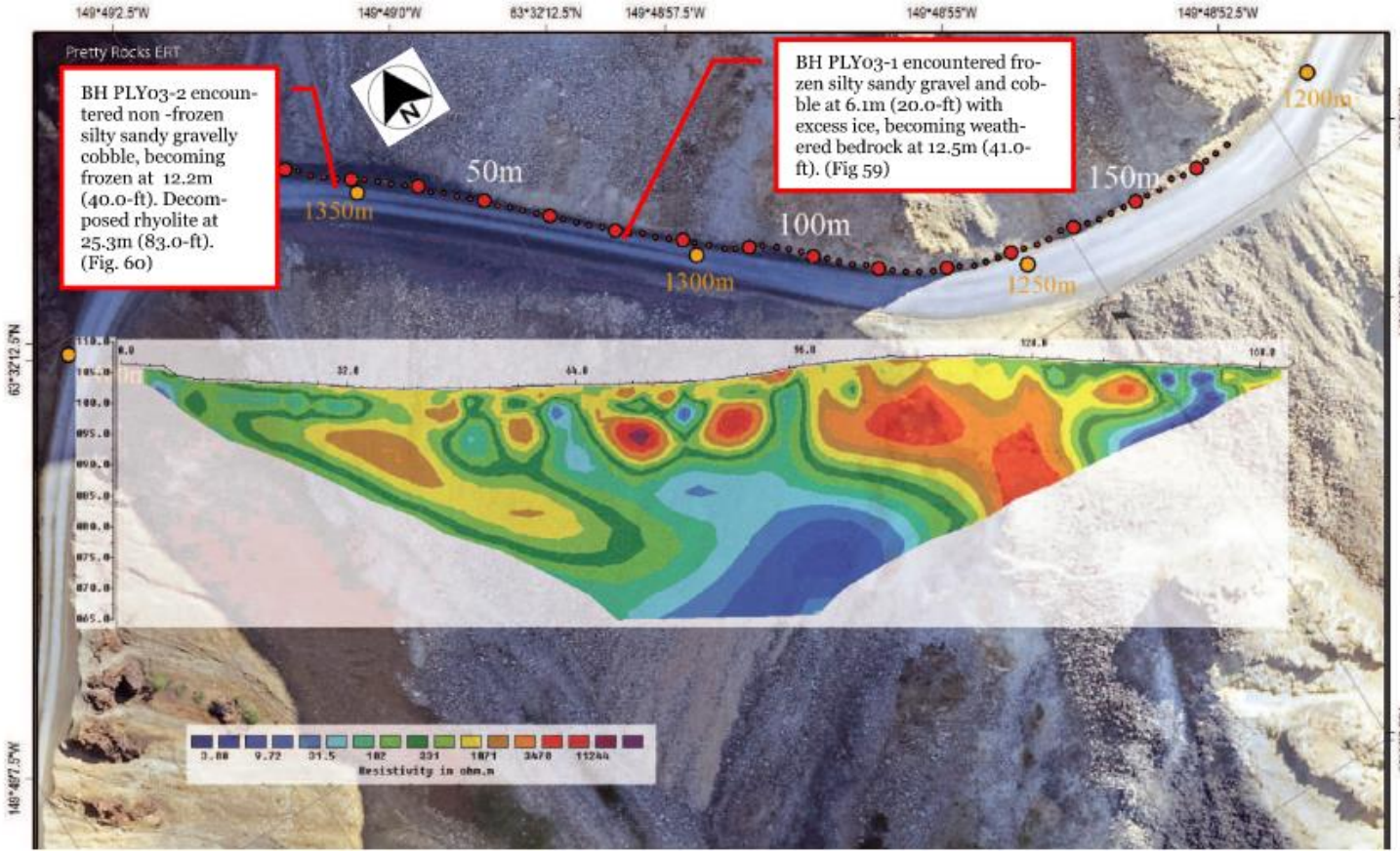


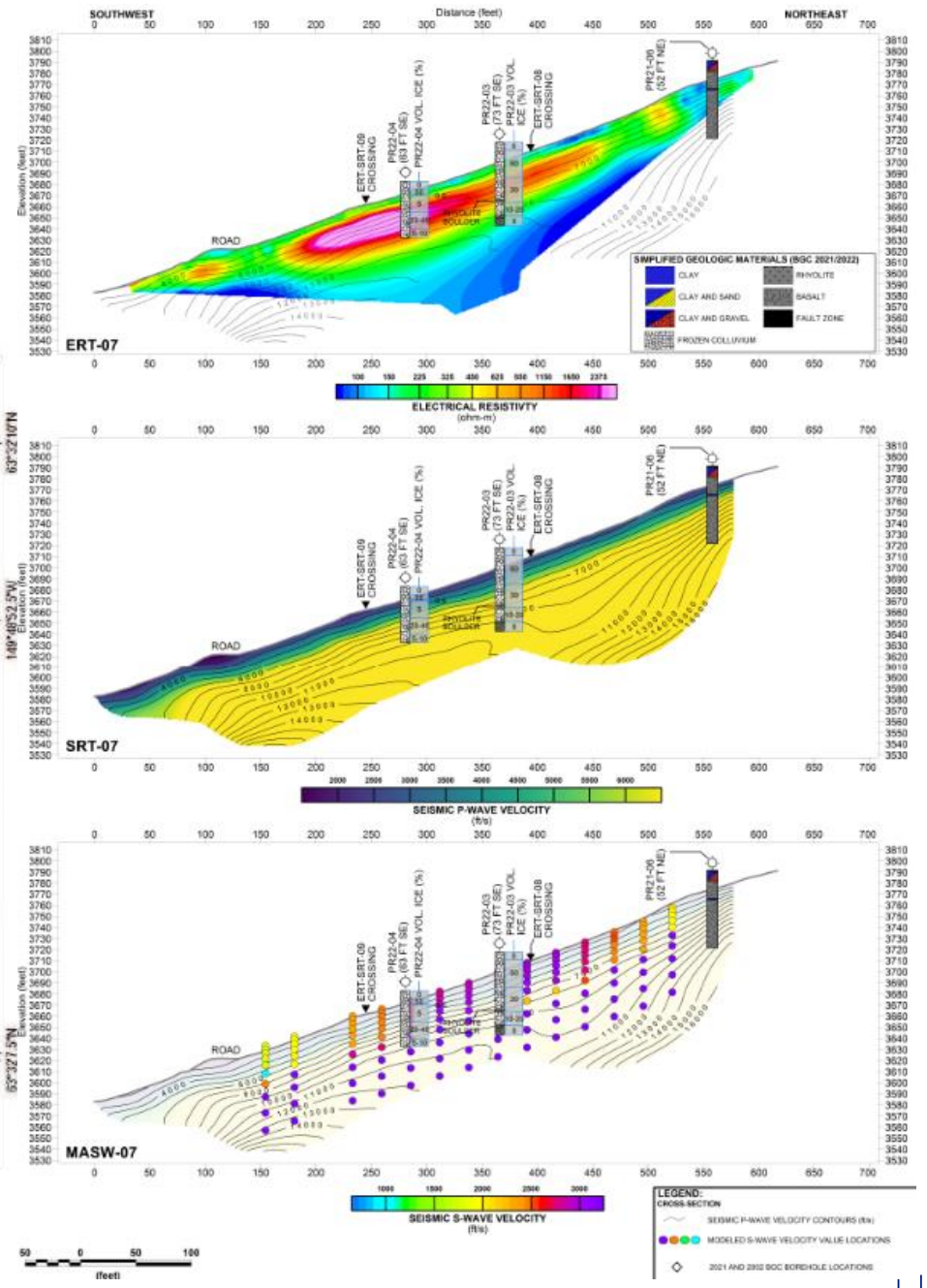
Procurement

Sharing the extensive site understanding.

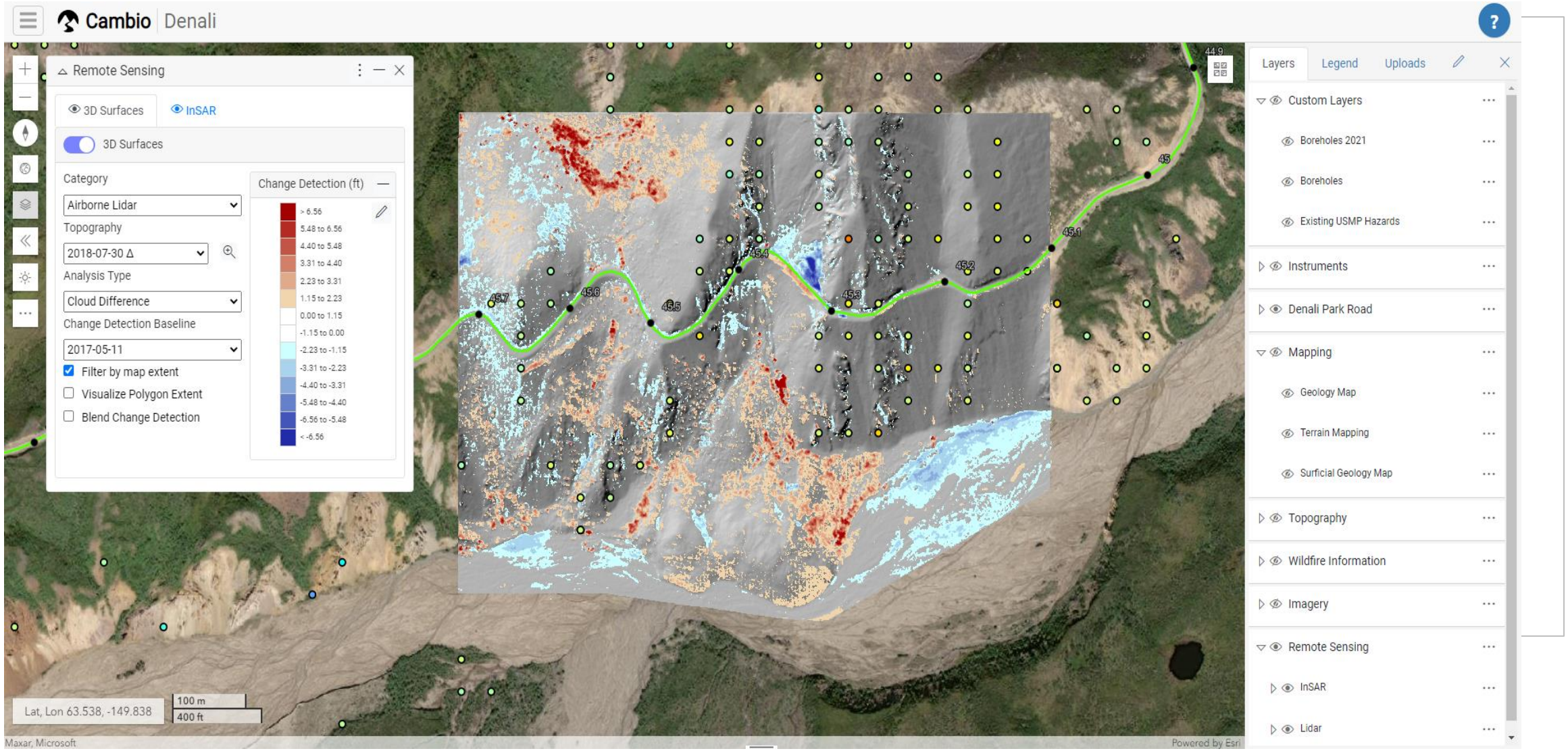
Geophysical profiles.



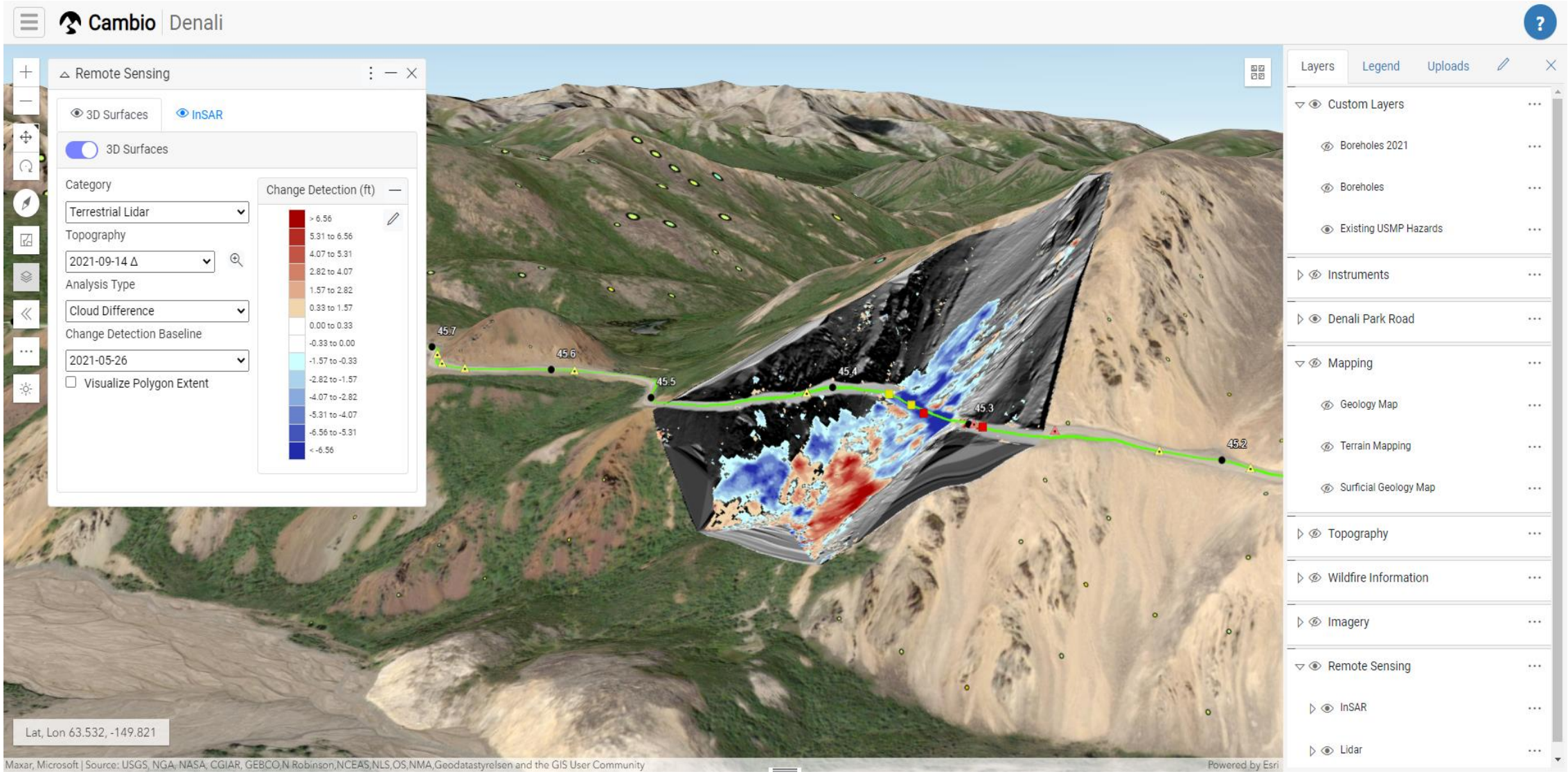




Combining lidar and photogrammetry, and InSAR.



Terrestrial lidar (and InSAR). So many options.

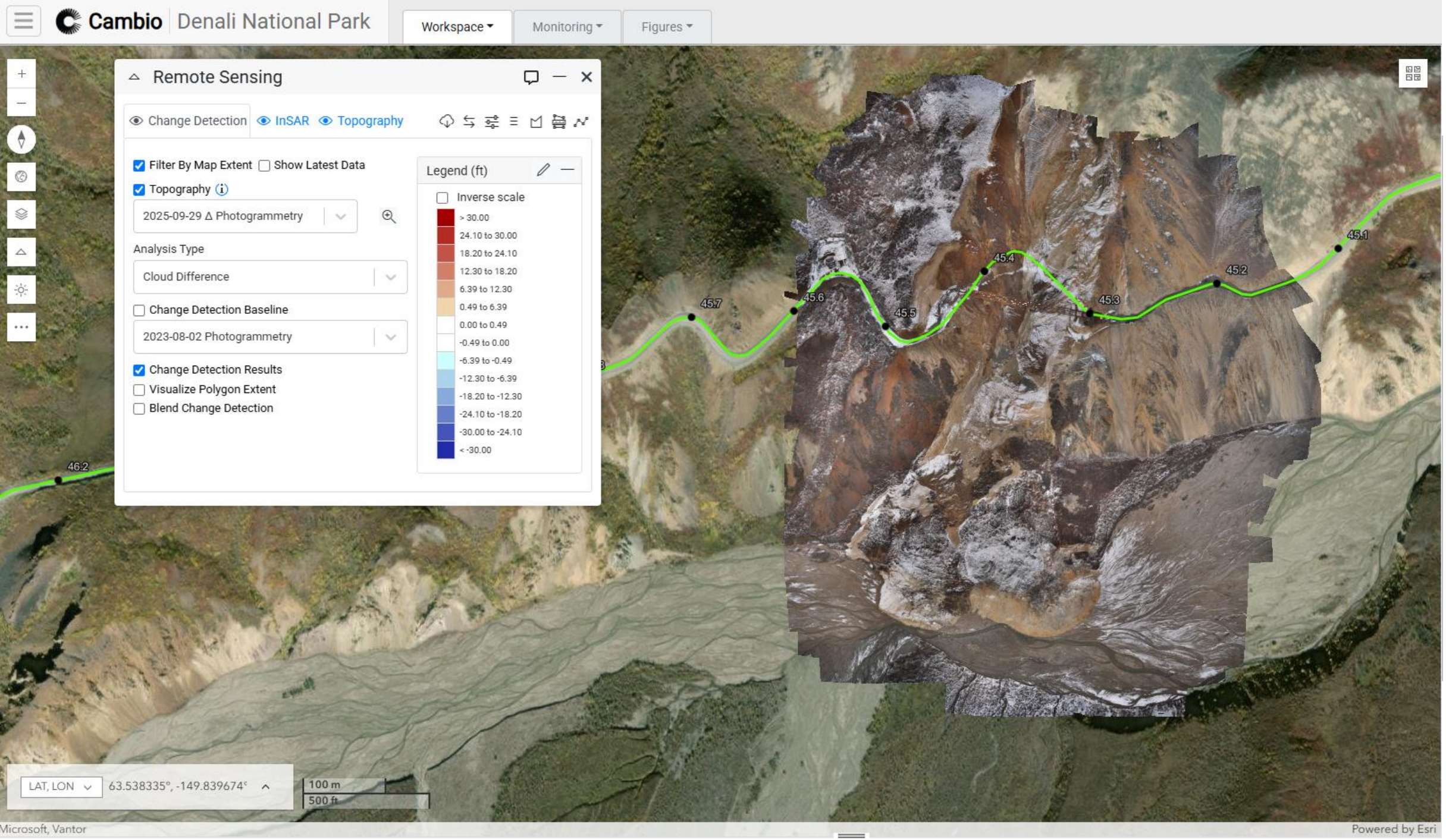


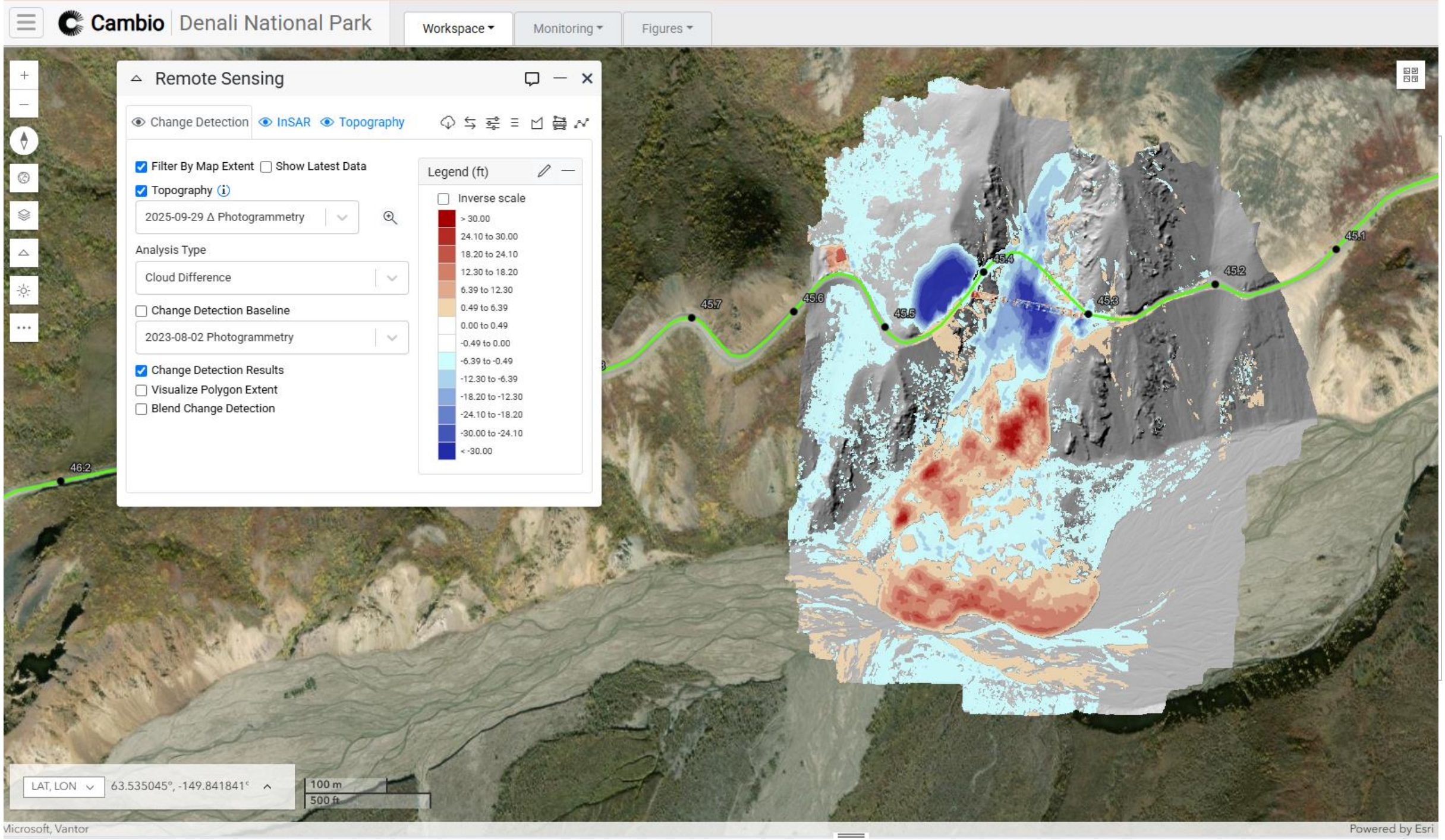
Construction

Expectations met, and surprises. Communication built confidence.

October 2024

October 2025


Cambio
Denali National Park
Workspace
Monitoring
Figures
Remote Sensing
Change Detection
InSAR
Topography
Filter By Map Extent
Show Latest Data
Topography
2025-09-29 Δ Photogrammetry
Analysis Type
Cloud Difference
Change Detection Baseline
2023-08-02 Photogrammetry
Change Detection Results
Visualize Polygon Extent
Blend Change Detection
Legend (ft)
Inverse scale
> 30.00
24.10 to 30.00
18.20 to 24.10
12.30 to 18.20
6.39 to 12.30
0.49 to 6.39
0.00 to 0.49
-0.49 to 0.00
-6.39 to -0.49
-12.30 to -6.39
-18.20 to -12.30
-24.10 to -18.20
-30.00 to -24.10
< -30.00
45.7
45.6
45.5
45.4
45.3
45.2
45.1
46.2
LAT, LON
63.538335°, -149.839674°
100 m
500 ft
Microsoft, Vantor
Powered by Esri


Cambio
Denali National Park
Workspace
Monitoring
Figures
Remote Sensing
Change Detection
InSAR
Topography
Filter By Map Extent
Show Latest Data
Topography
2025-09-29 Δ Photogrammetry
Analysis Type
Cloud Difference
Change Detection Baseline
2023-08-02 Photogrammetry
Change Detection Results
Visualize Polygon Extent
Blend Change Detection
Legend (ft)
Inverse scale
> 30.00
24.10 to 30.00
18.20 to 24.10
12.30 to 18.20
6.39 to 12.30
0.49 to 6.39
0.00 to 0.49
-0.49 to 0.00
-6.39 to -0.49
-12.30 to -6.39
-18.20 to -12.30
-24.10 to -18.20
-30.00 to -24.10
< -30.00
45.7
45.6
45.5
45.4
45.3
45.2
45.1
46.2
LAT, LON
63.535045°, -149.841841°
100 m
500 ft
Microsoft, Vantor
Powered by Esri

Digital delivery brought us closer to the edge.

….. to meet a critical challenge.

Contact us

Scott Anderson, Ph.D., P.E.

Principal Geotechnical Engineer

SAnderson@BGCEngineeing.com

www.bgcengineering.com

BGC Locations

CANADA
VICTORIA
VANCOUVER
KAMLOOPS
CALGARY
EDMONTON
TORONTO
SUDBURY
KINGSTON
OTTAWA
MONTREAL
QUEBEC CITY
HALIFAX
FREDERICTON
DOMINICAN REPUBLIC
SANTO DOMINGO
USA
GOLDEN
NASHVILLE
AUSTRALIA
BRISBANE
CHILE
SANTIAGO