



Digitally Mapping The Bonita Peak Mining District in Three Dimensions

Tor Holm, Dr. Nate Klema



FLC Geosciences, Physics, Geographic Information Systems



COLORADO
Division of Reclamation,
Mining and Safety
Department of Natural Resources

Introduction



Key Topics



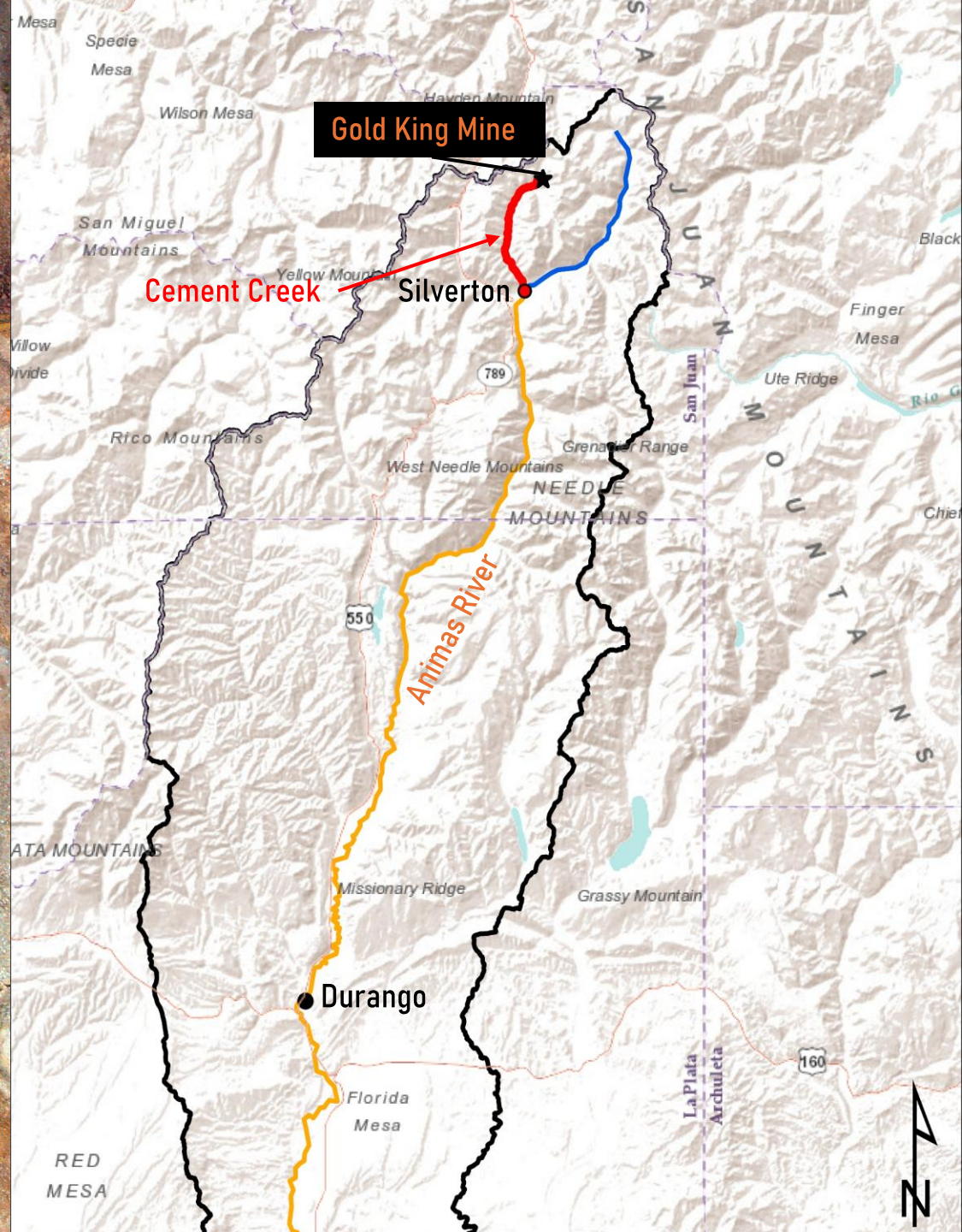
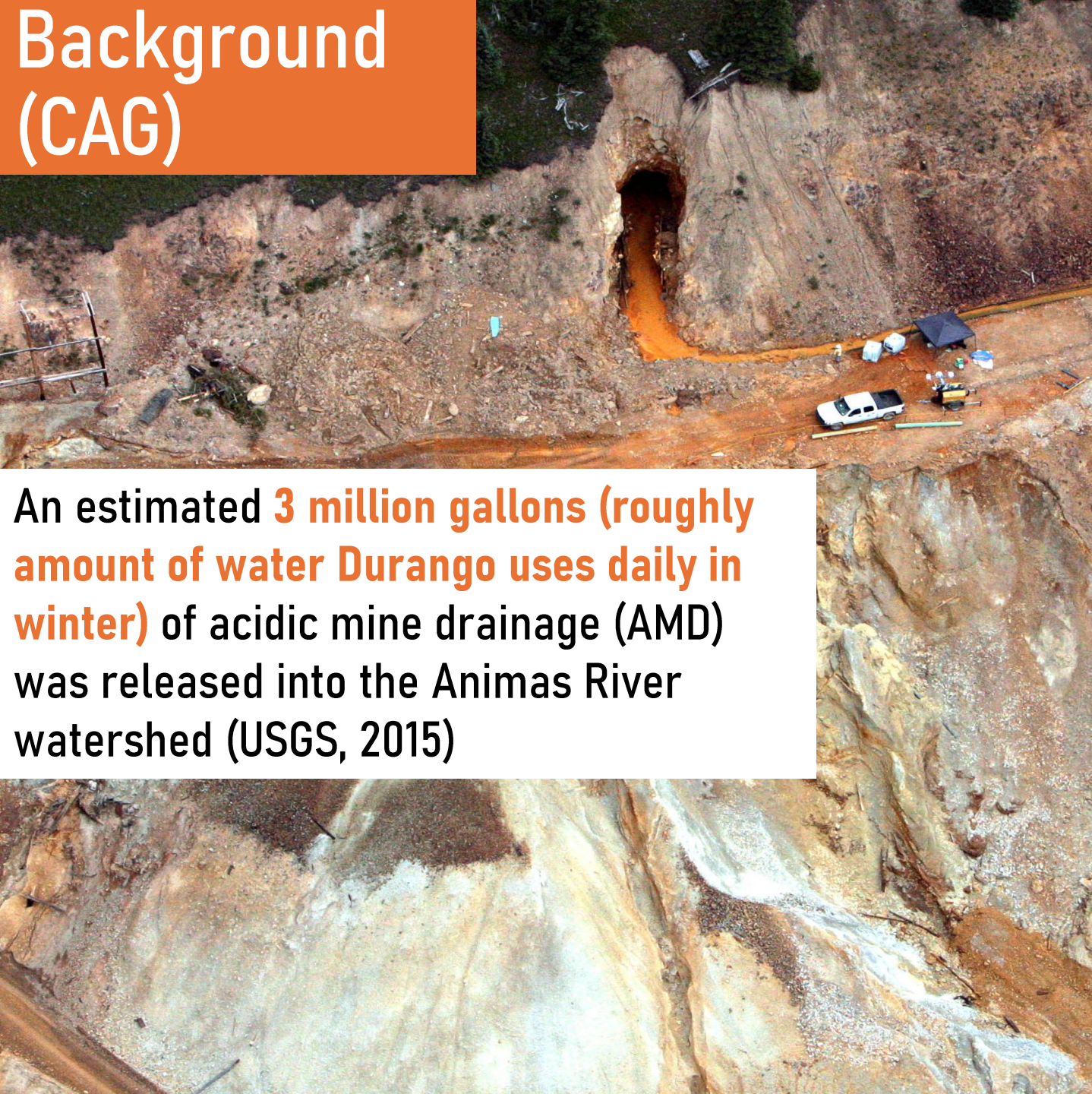
- 1. Digitizing historical maps allows for modern interpretation of fluid connections.**
- 2. Opportunities for future research made possible by modern mapping techniques.**

Background

On August 5th, 2015, the United States Environmental Protection Agency accidentally breached the entrance to the Gold King Mine.

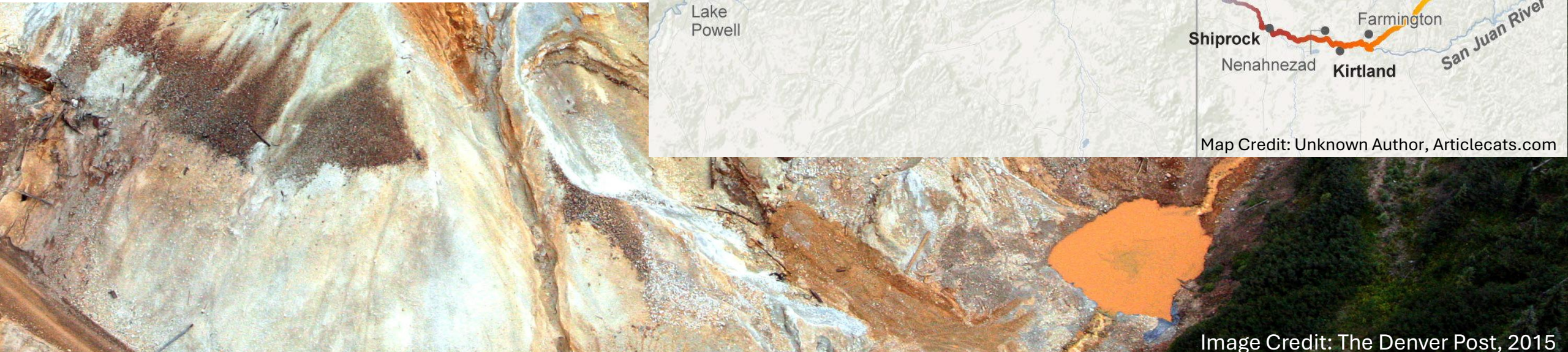
Background (CAG)

An estimated **3 million gallons (roughly amount of water Durango uses daily in winter)** of acidic mine drainage (AMD) was released into the Animas River watershed (USGS, 2015)



Background

Acid mine drainage worked its way down the Animas watershed into the San Juan River through the Navajo Nation.



Background

The orange color of the spill was caused by iron oxides and hydroxides along with sulfur.

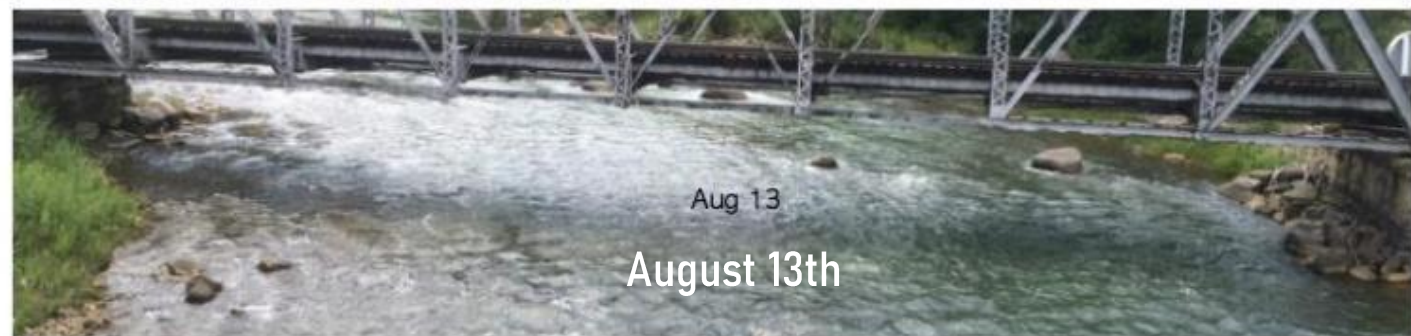
Metal	Pounds
Iron	248,582
Lead	4,481
Manganese	1,953
Zinc	1,101
Barium	244
Arsenic	206
Vanadium	137

Data Source: Chief et al, 2015

Image Credit: The Denver Post, 2015

Background

The visual impact of the spill was immediate, but the plume was quickly diluted over a few days with few long-term effects (Roberts, 2016).



Background

However, an estimated **5.4 million gallons** of AMD are released from 32 sources in the Bonita Peak Region **Every Day**. (EPA, 2016)

The first effort to manage this was installation of bulkheads (concrete plugs) in major tunnels starting in the 1990s.



Outflow of the Natalie-Occidental Mine flowing into Cement Creek 2025



Gold King Mine Portal, 2025

Background

To combat AMD drainage, a treatment plant was installed and management of the bulkheads is ongoing.



Outer Terry Tunnel Bulkhead

Background

Bulkheads- Barriers placed inside a mine to prevent or limit the flow of water, allowing heavy metals to precipitate inside of the mine.



Mogul Mine Bulkhead By-pass Pipe



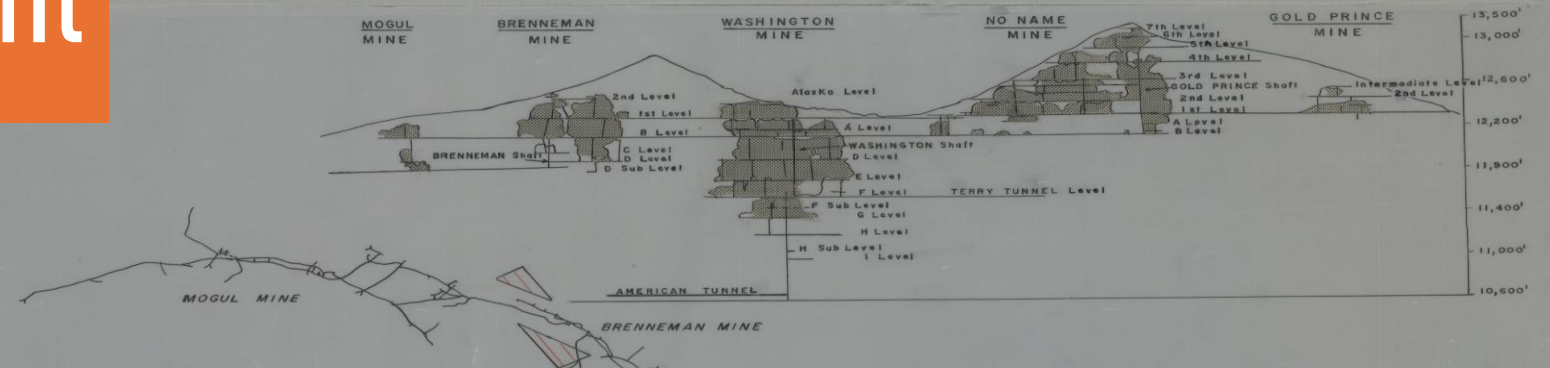
Flow around Terry Tunnel Bulkhead

Problem Statement

To best manage AMD drainage in the Bonita Peak Region, the internal workings and connections of the mines, and their geologic context must be understood.

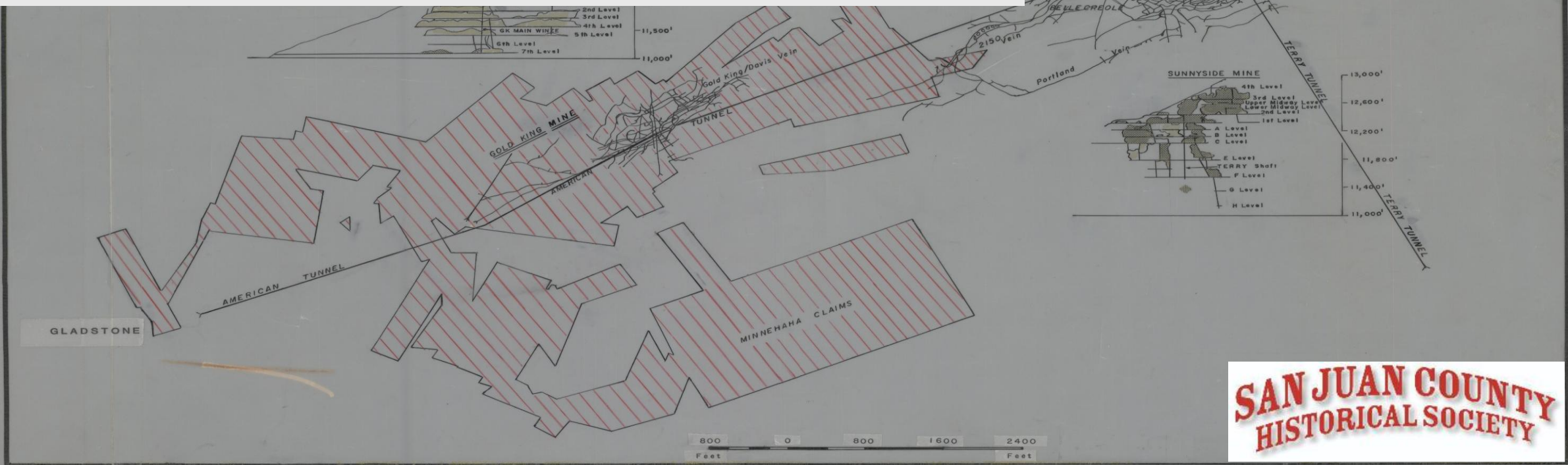


Problem Statement



PROPERTY OF THE
SAN JUAN COUNTY HISTORICAL SOCIETY
CONTENT MAY NOT BE USED FOR COMMERCIAL PURPOSES

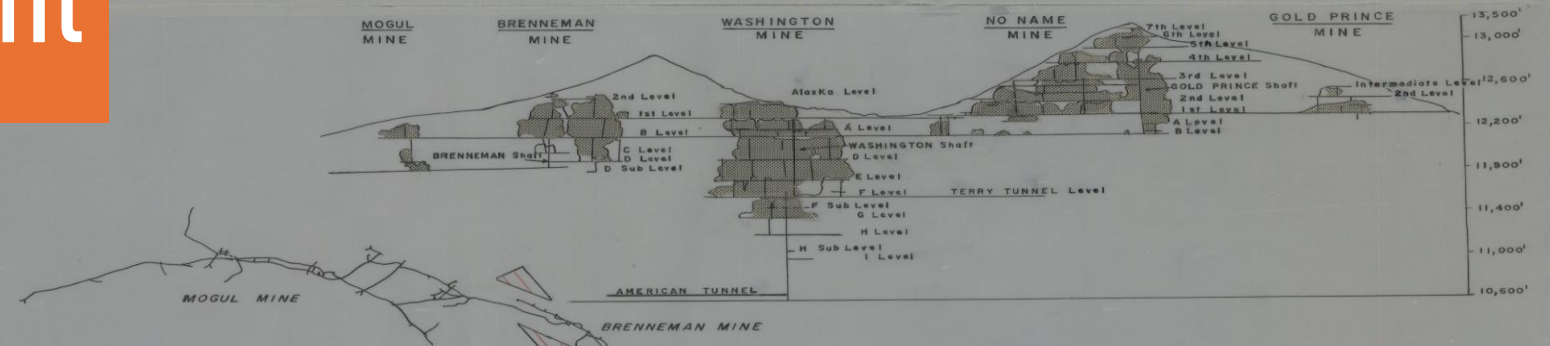
6,392 historical mine maps have been cataloged by the San Juan Historical Society.



**SAN JUAN COUNTY
HISTORICAL SOCIETY**

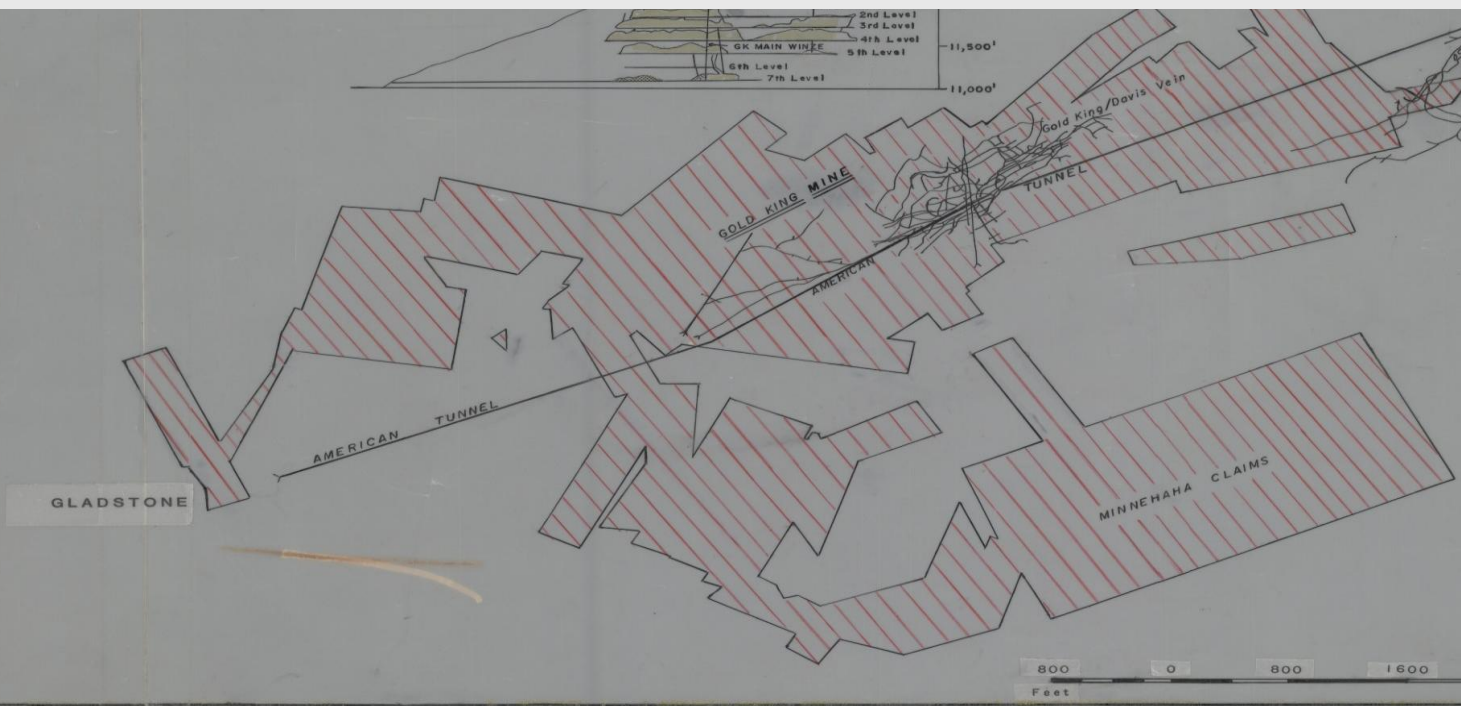
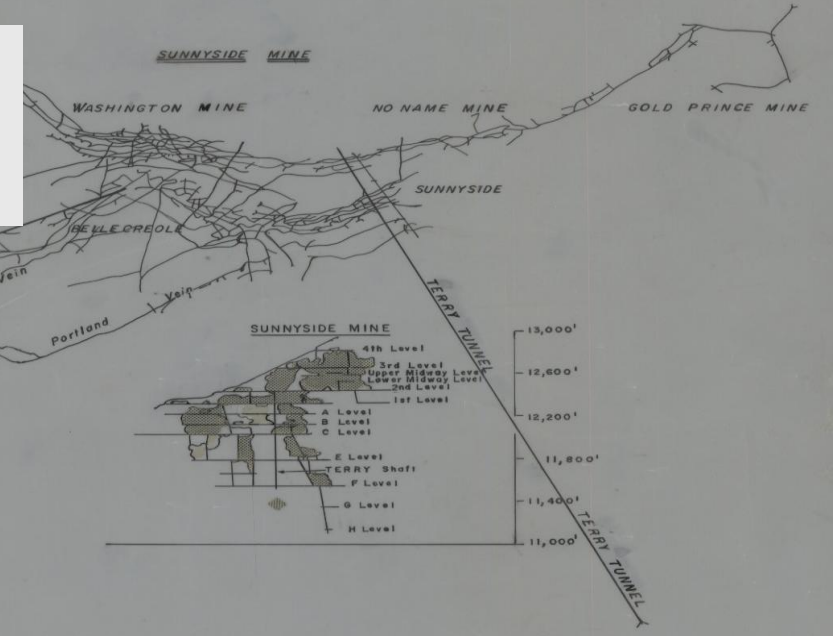
MM-Fearn-2427

Problem Statement



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3,530 of those maps are of the Sunnyside, Mogul, Gold King, Red and Bonita, and Gold Prince mines.



**SAN JUAN COUNTY
HISTORICAL SOCIETY**

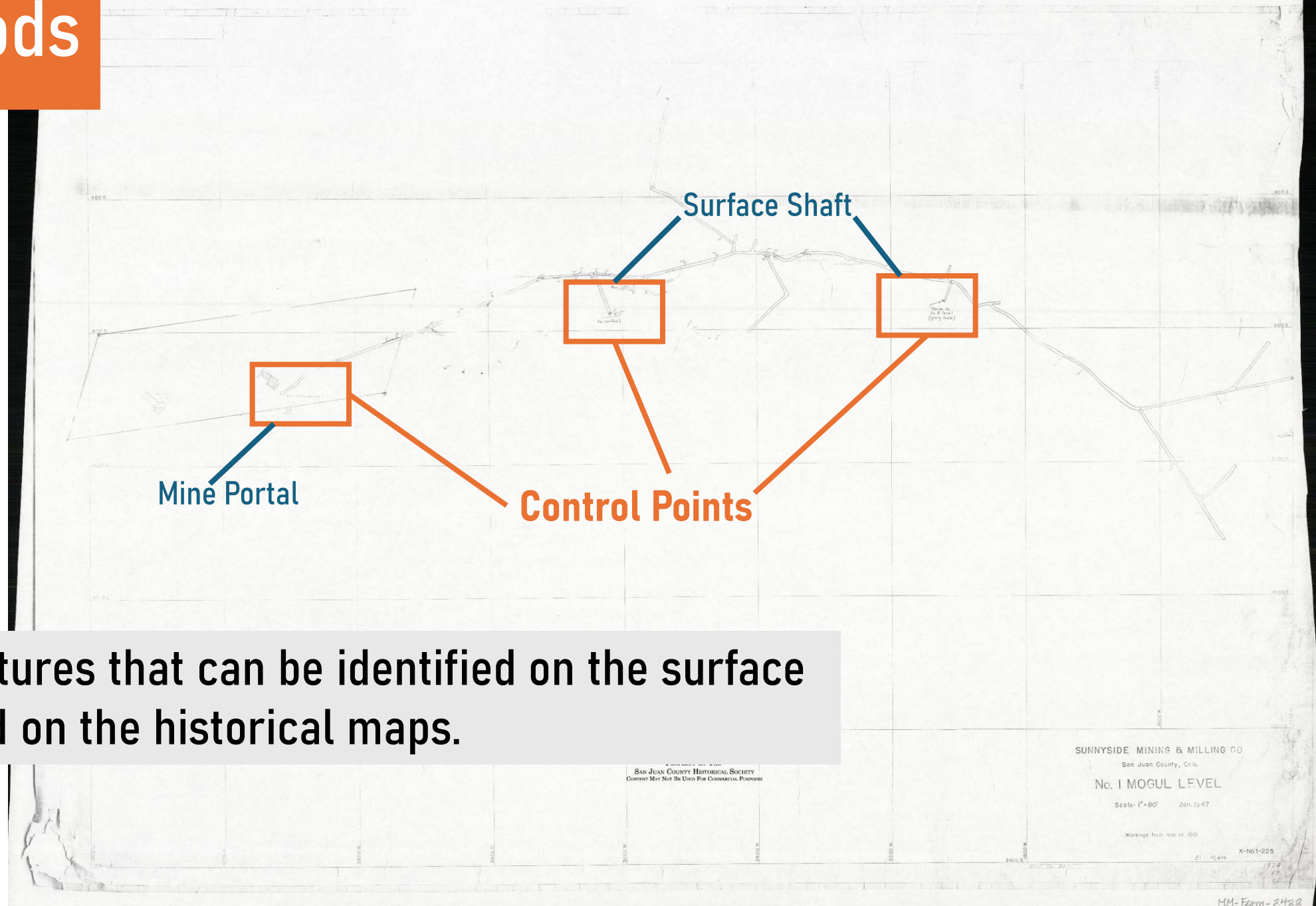
MM-Fearn-2427

Methods



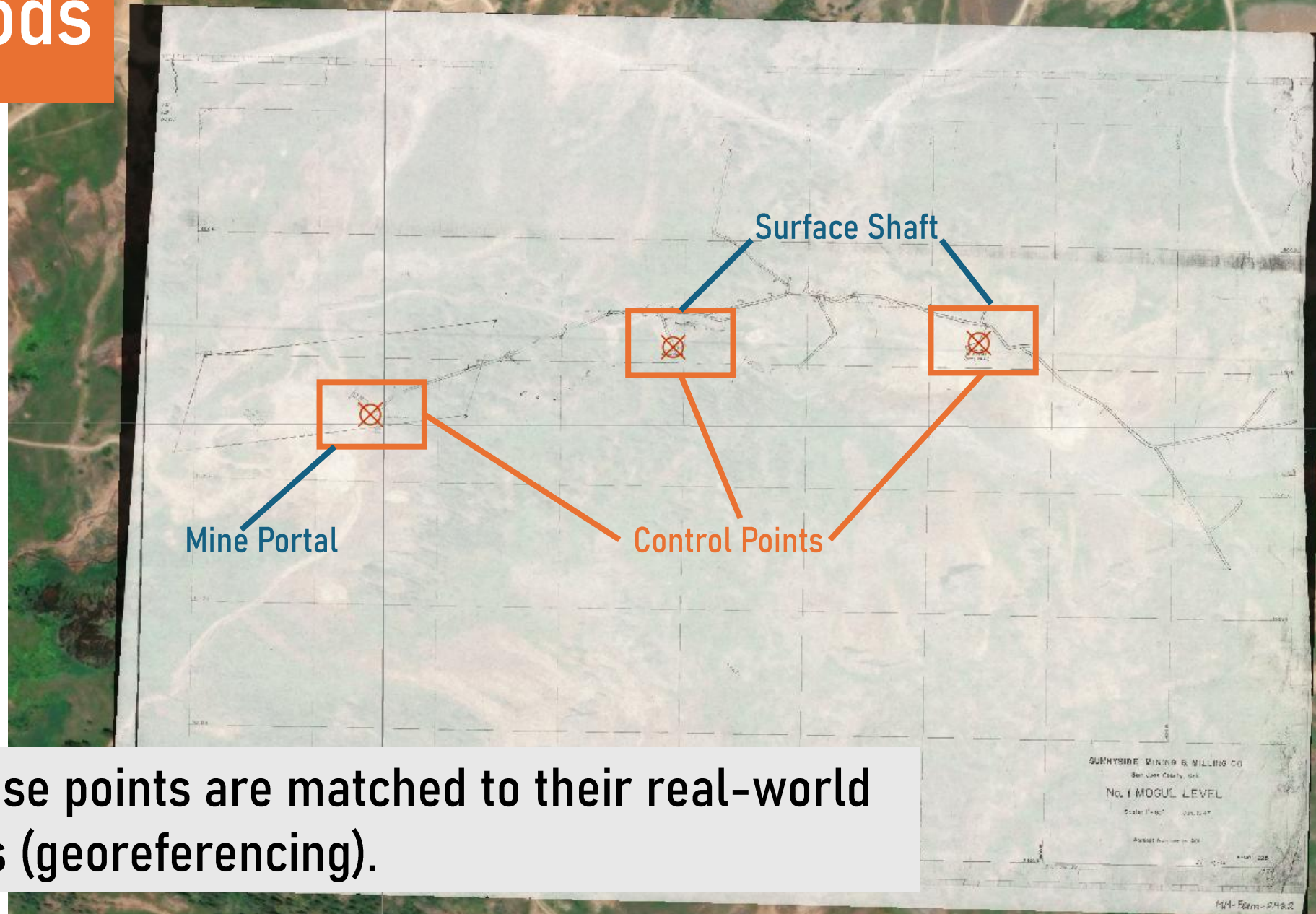
**Mogul No 1 Level Map
(1940s)**

Methods



First, features that can be identified on the surface are found on the historical maps.

Methods



Next, these points are matched to their real-world locations (georeferencing).

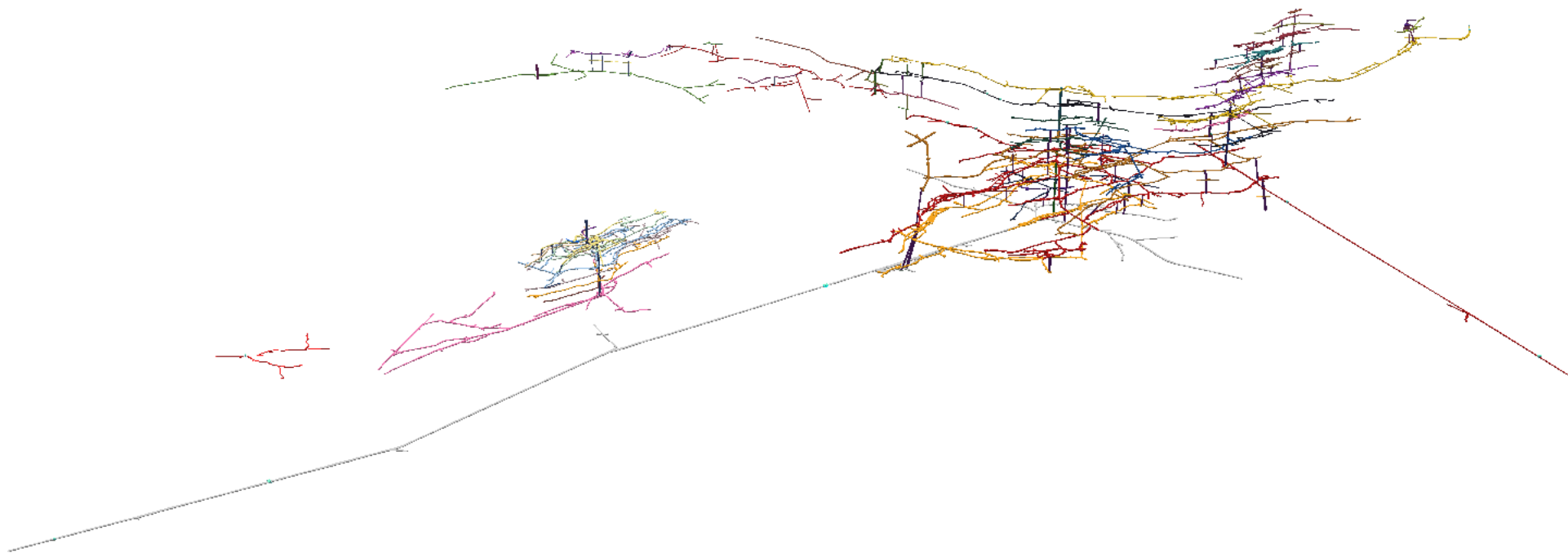
Methods

Using real world elevations and estimates of tunnel height, 2D polygons are then brought into 3D.

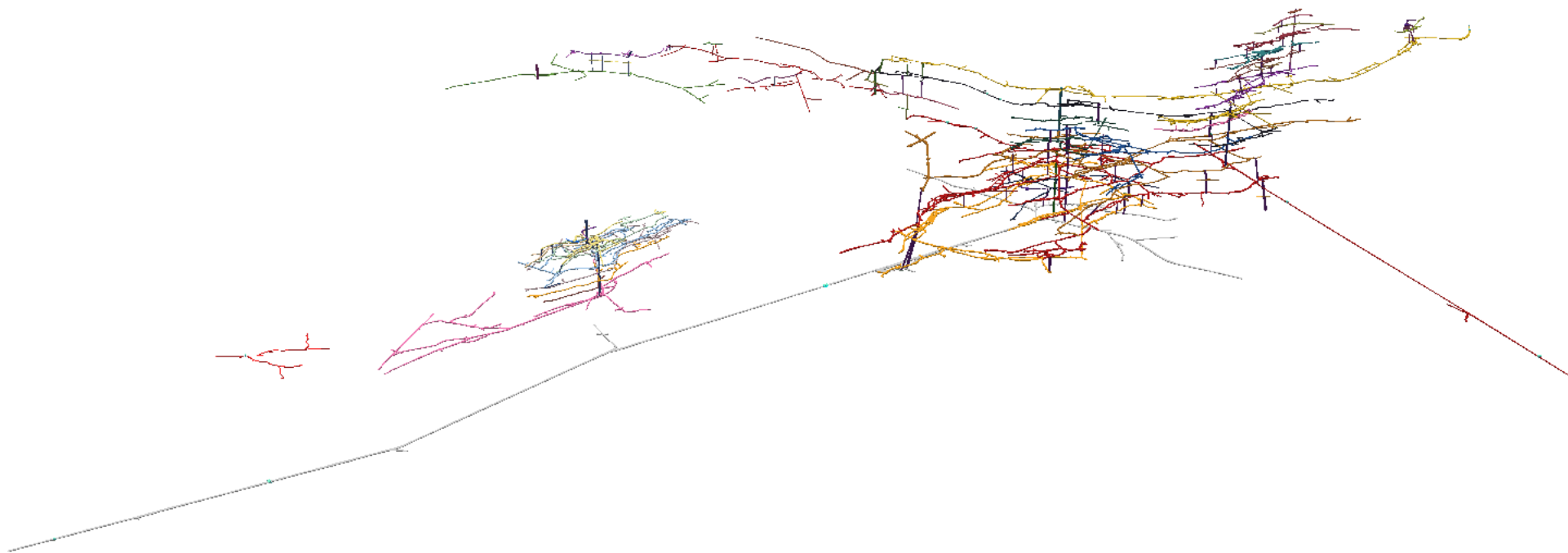
Elevation + Extrusion = 3D Layer



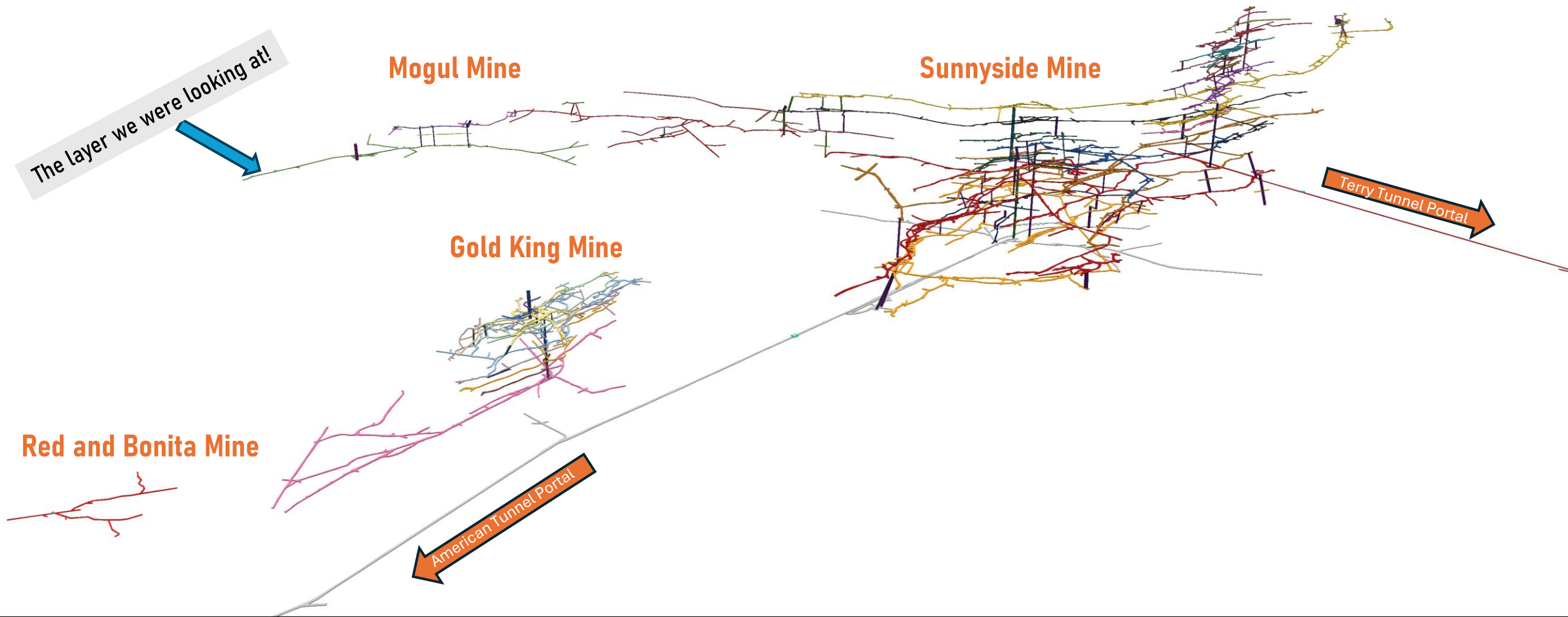
Results



Results

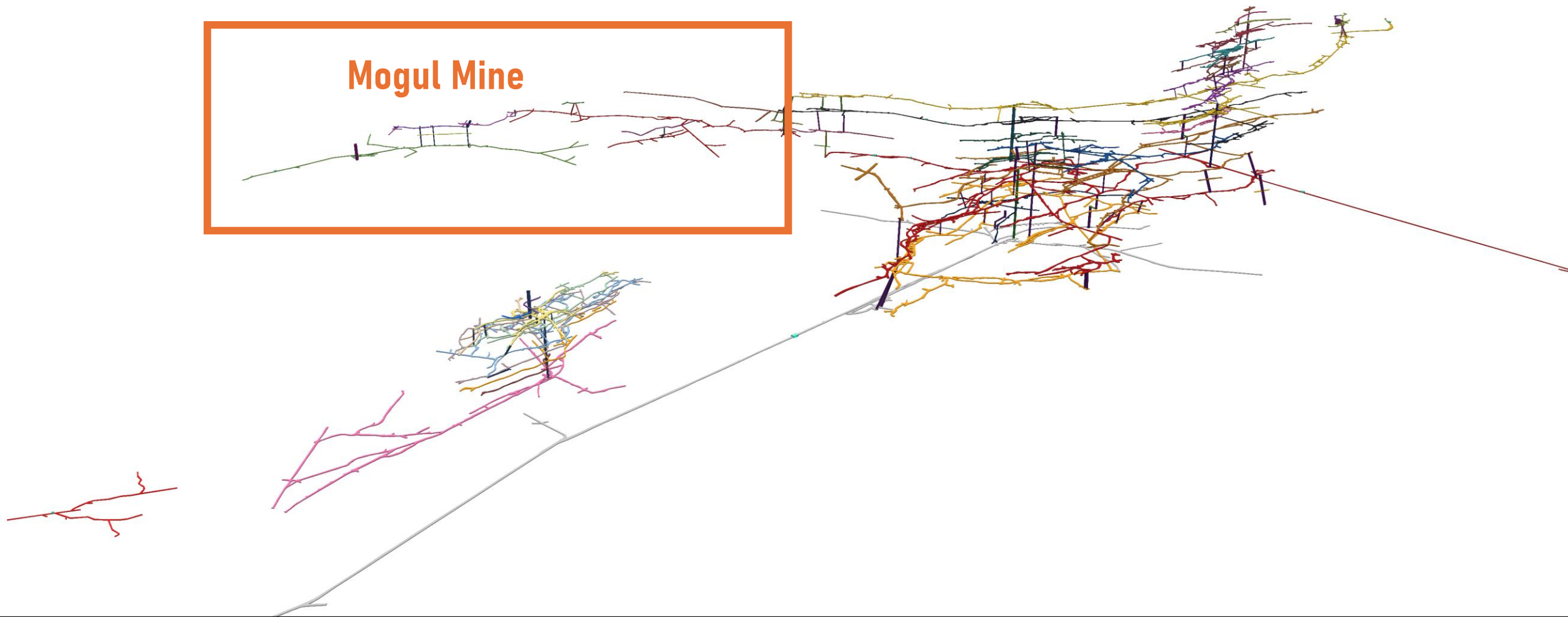


Results



Results

Mogul Mine



Results

Mogul Mine

Water Visible in
Surface Shaft

Mogul
Bulkhead

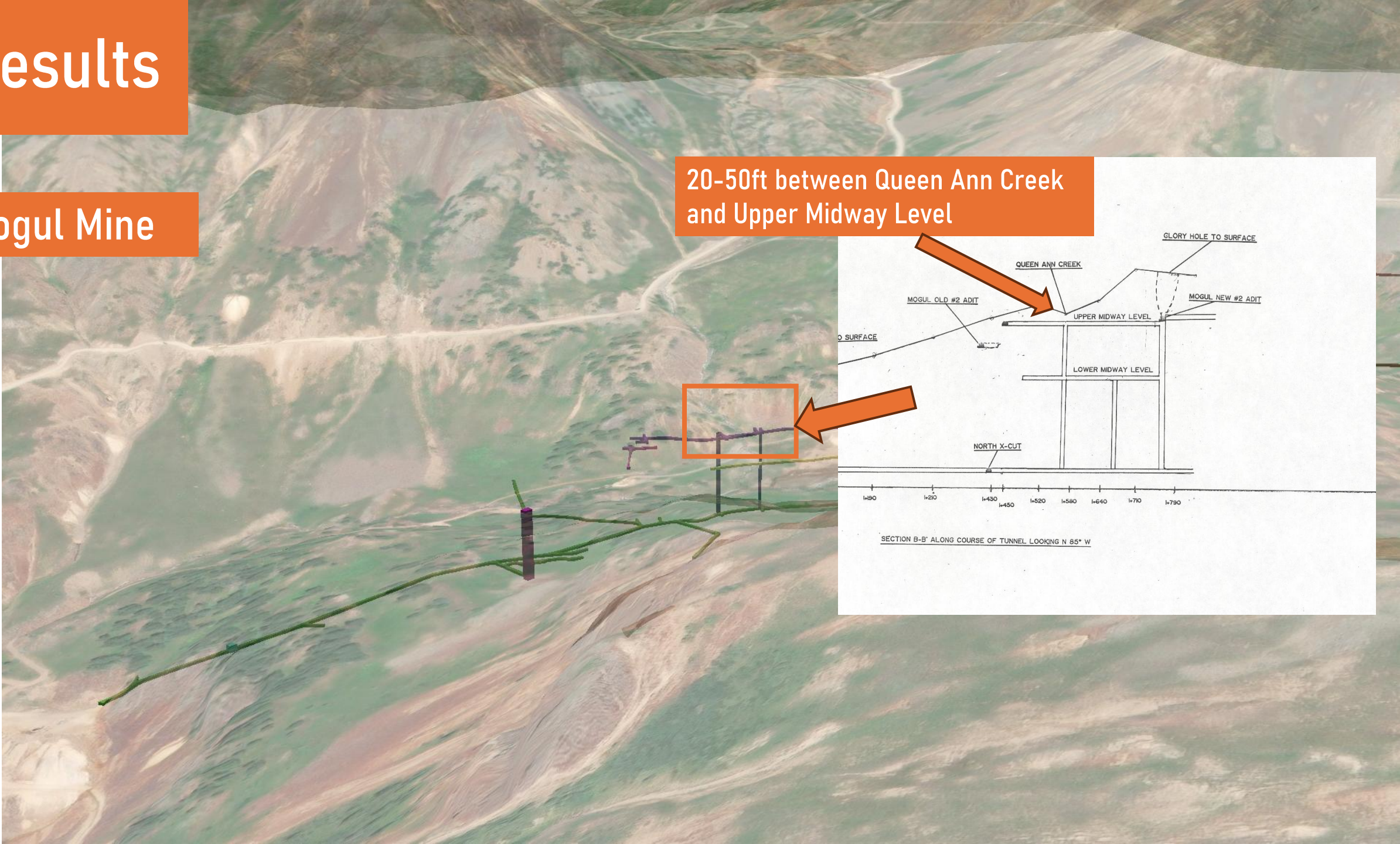
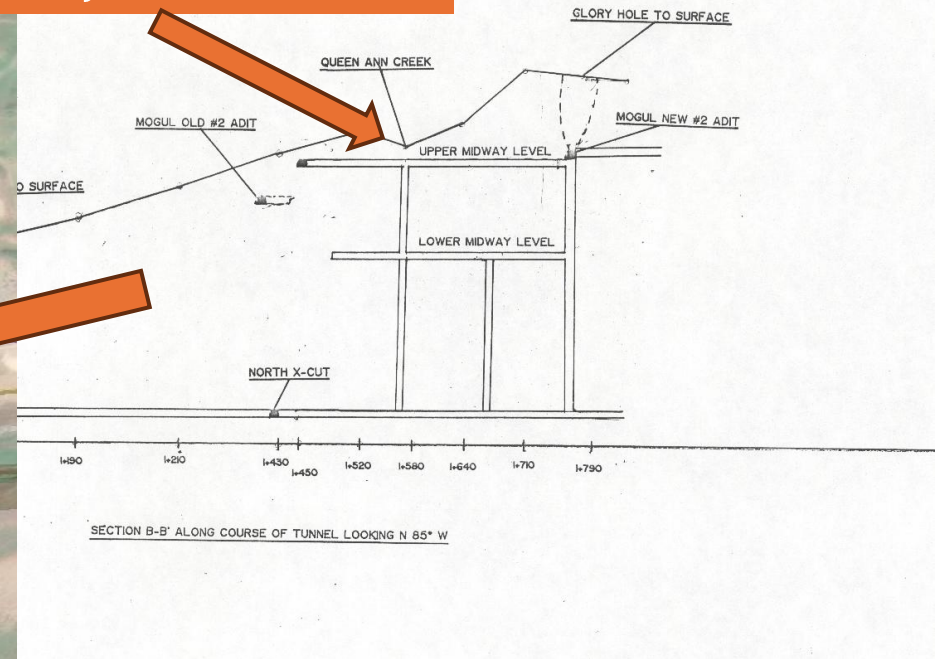
Mogul No 1 Portal



Results

Mogul Mine

20-50ft between Queen Ann Creek and Upper Midway Level



Results

Mogul Mine

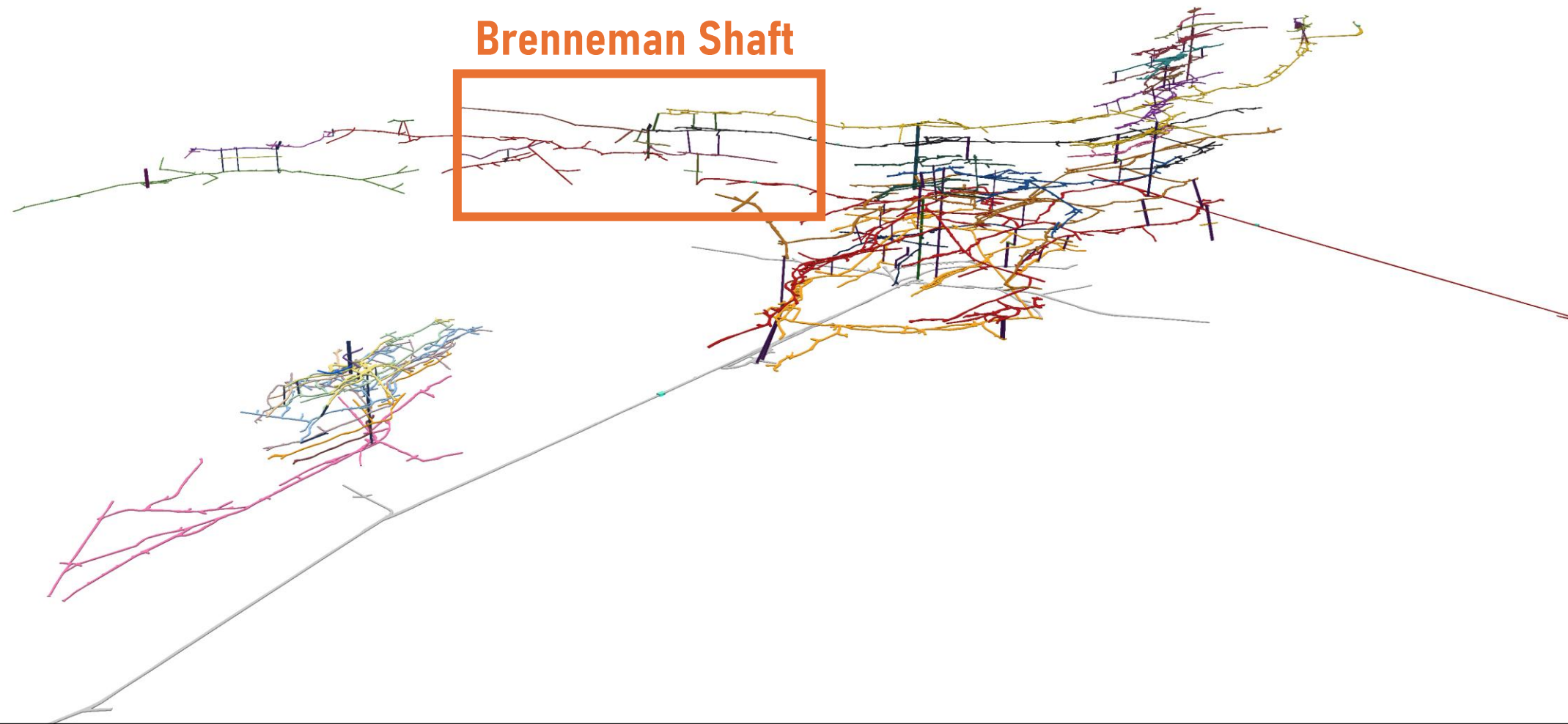


AMD outflow from base of Mogul No 3 tailings pile

Audible water flow from surface glory hole

Brenneman Shaft

Results



Results

Brenneman Shaft Region

To Sunnyside Mine

To Mogul Mine



Results

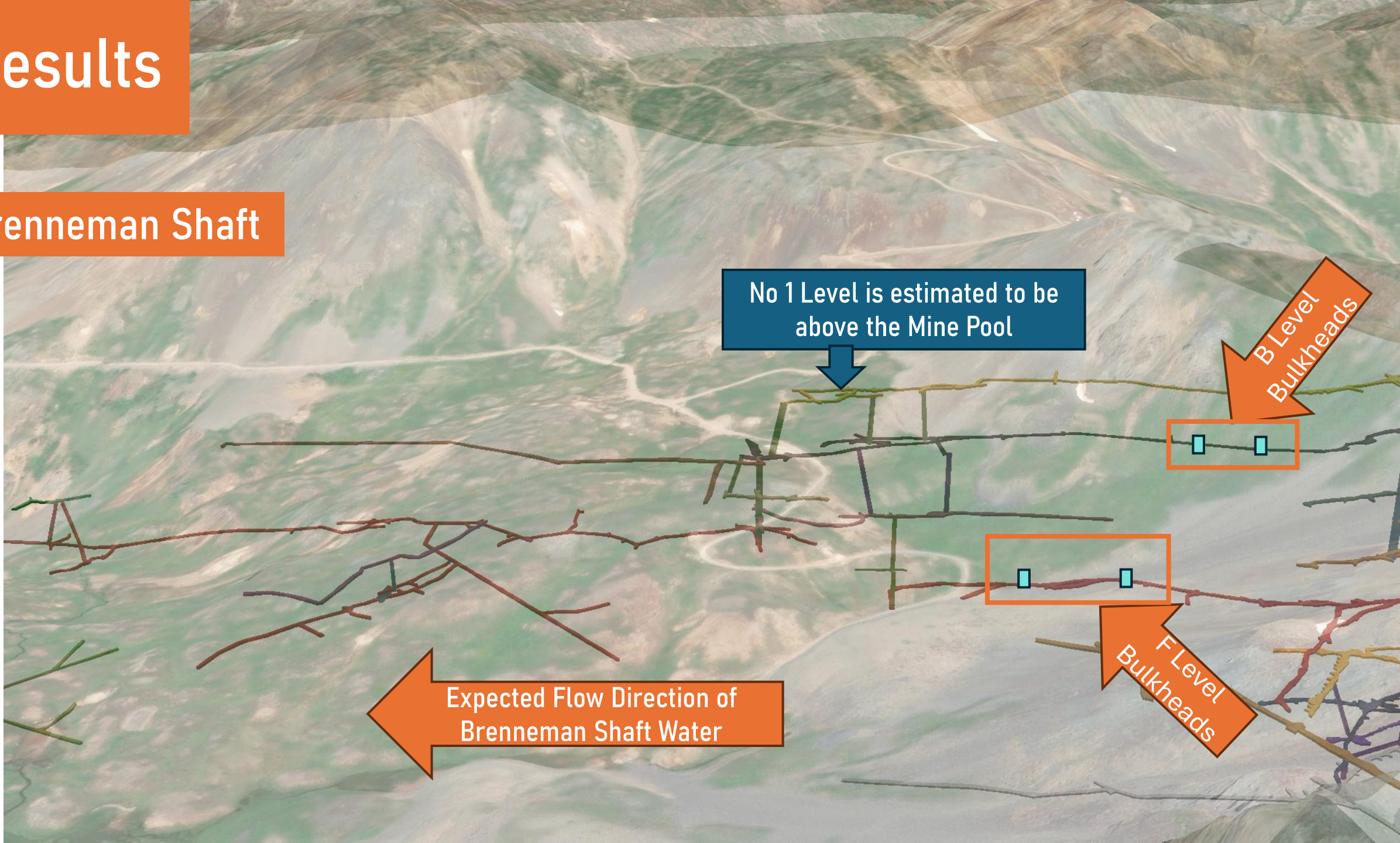
Brenneman Shaft



Levels that connect to the Sunnyside Mine

Results

Brenneman Shaft



No 1 Level is estimated to be above the Mine Pool

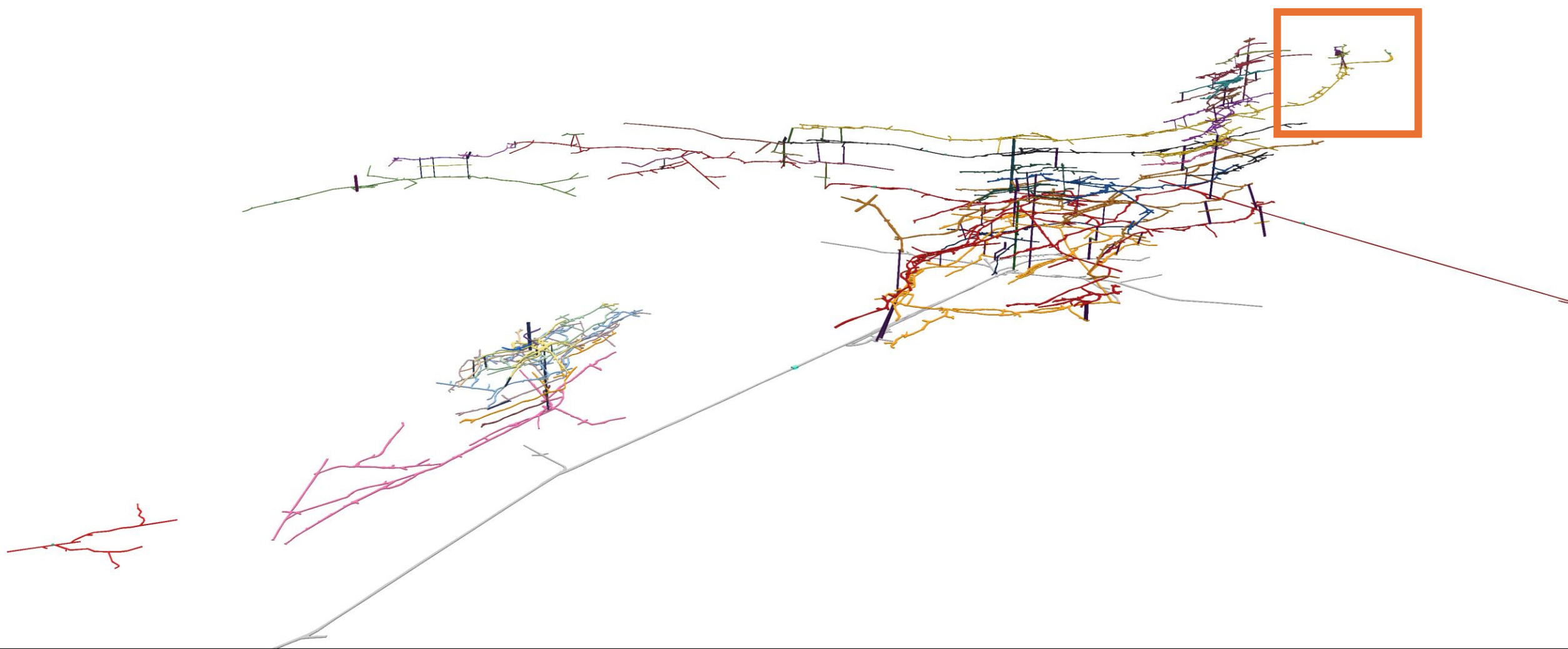
B Level Bulkheads

F Level Bulkheads

Expected Flow Direction of Brenneman Shaft Water

Results

Gold Prince Mine

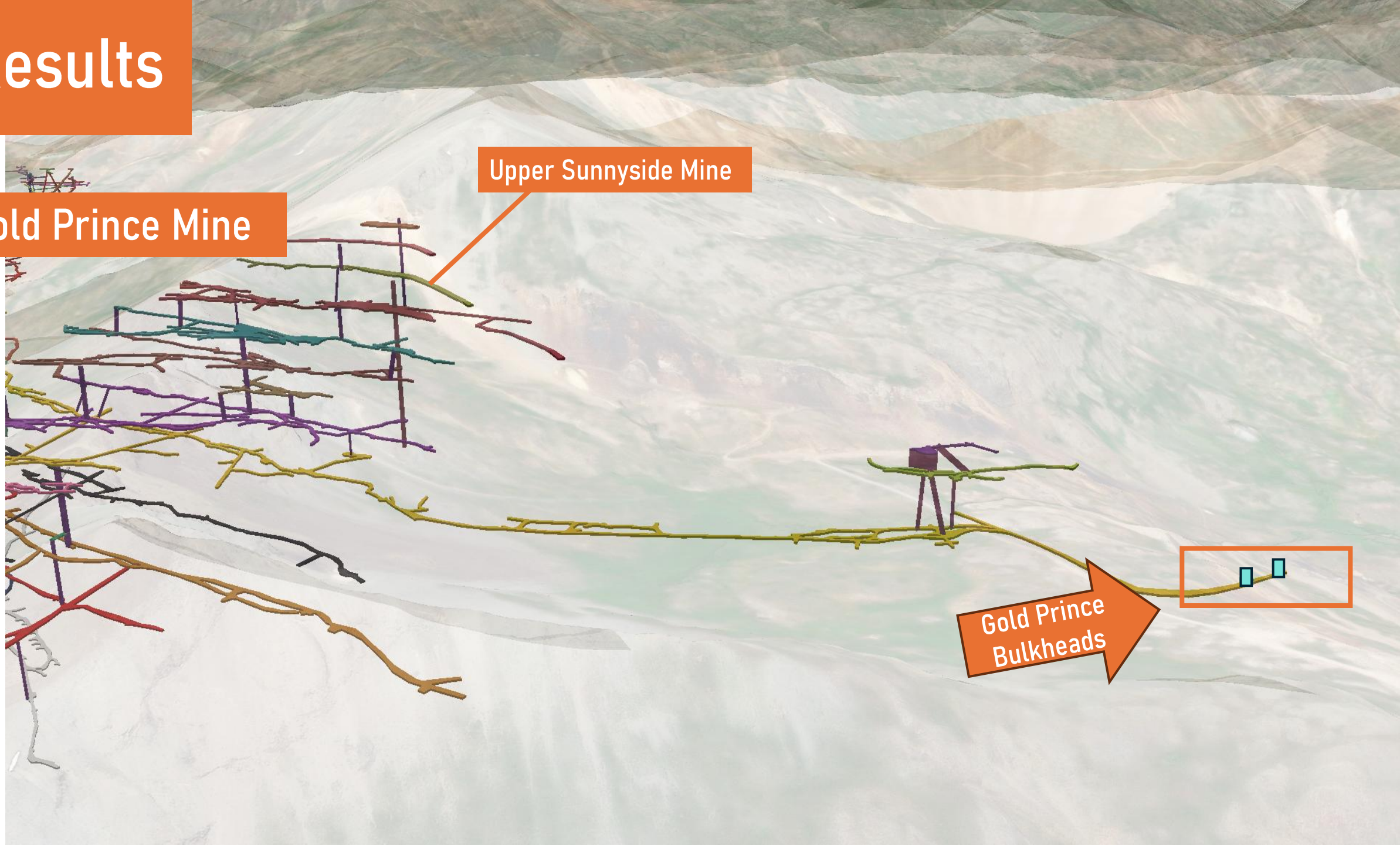


Results

Gold Prince Mine

Upper Sunnyside Mine

Gold Prince Bulkheads



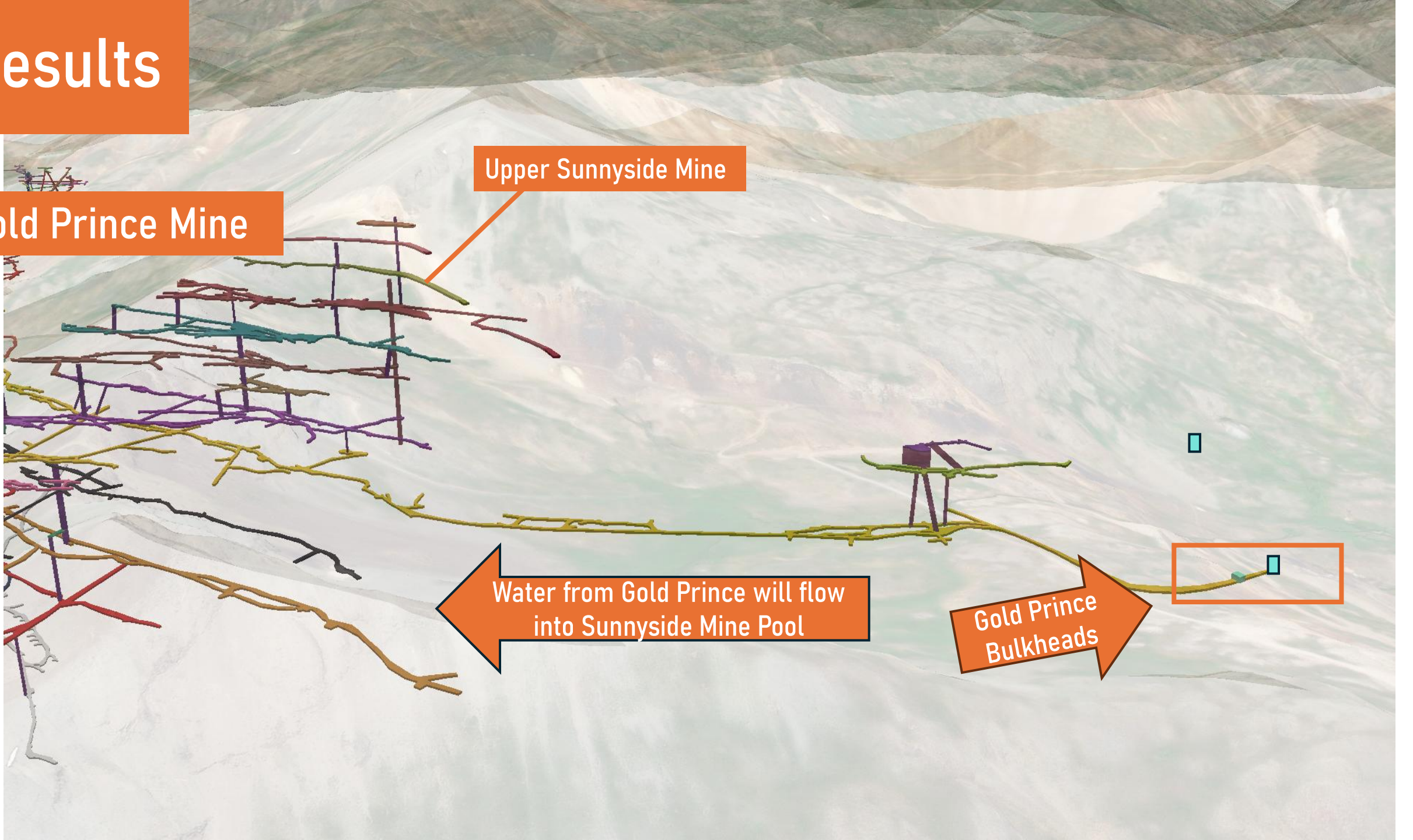
Results

Gold Prince Mine

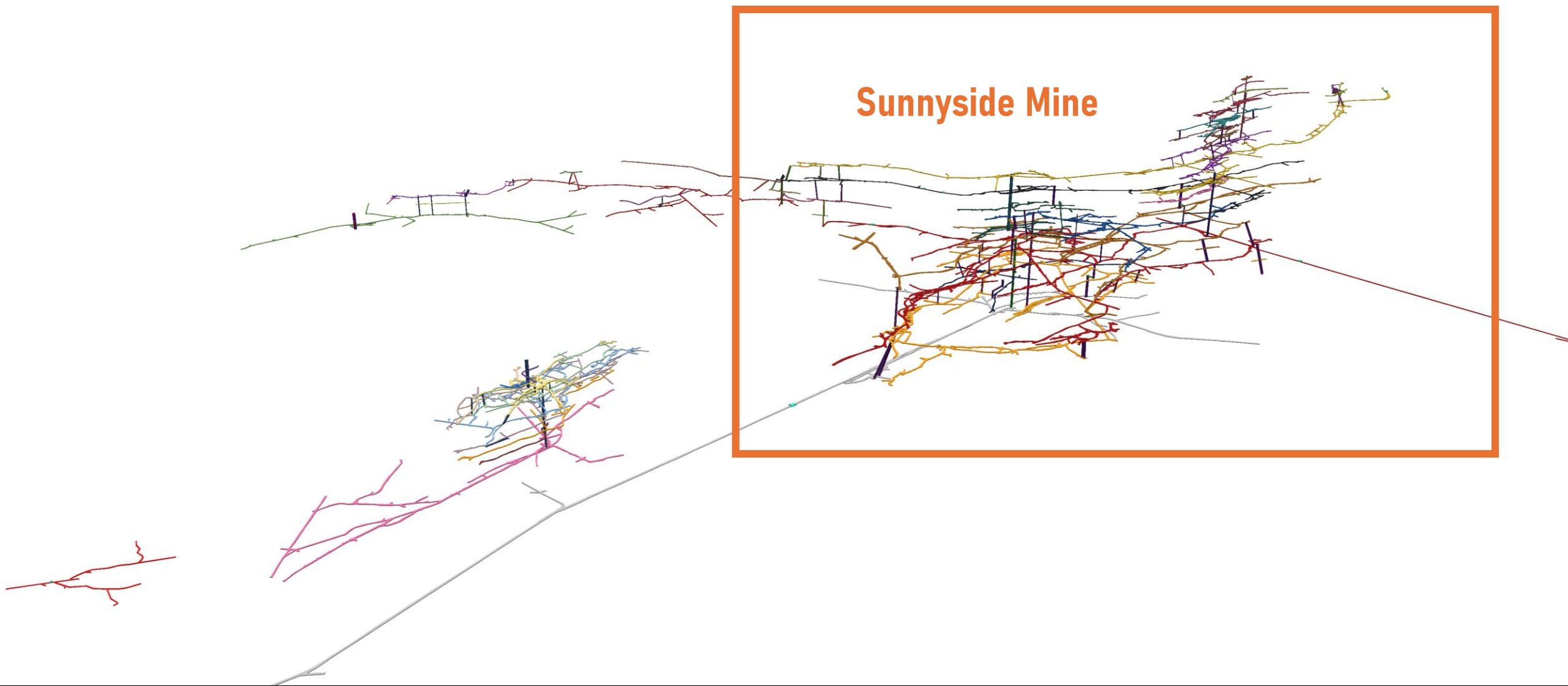
Upper Sunnyside Mine

Water from Gold Prince will flow into Sunnyside Mine Pool

Gold Prince Bulkheads

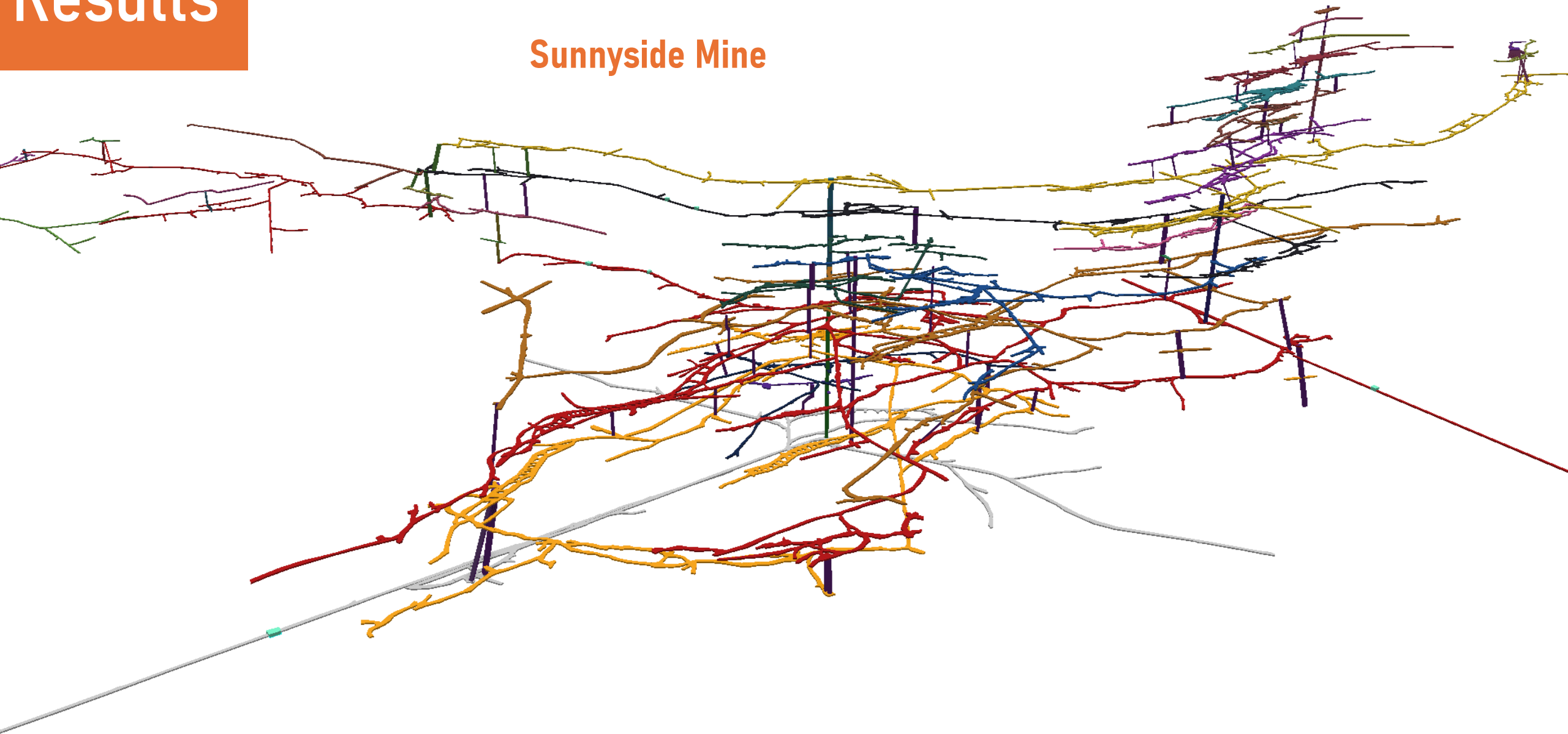


Results



Results


Sunnyside Mine




Results

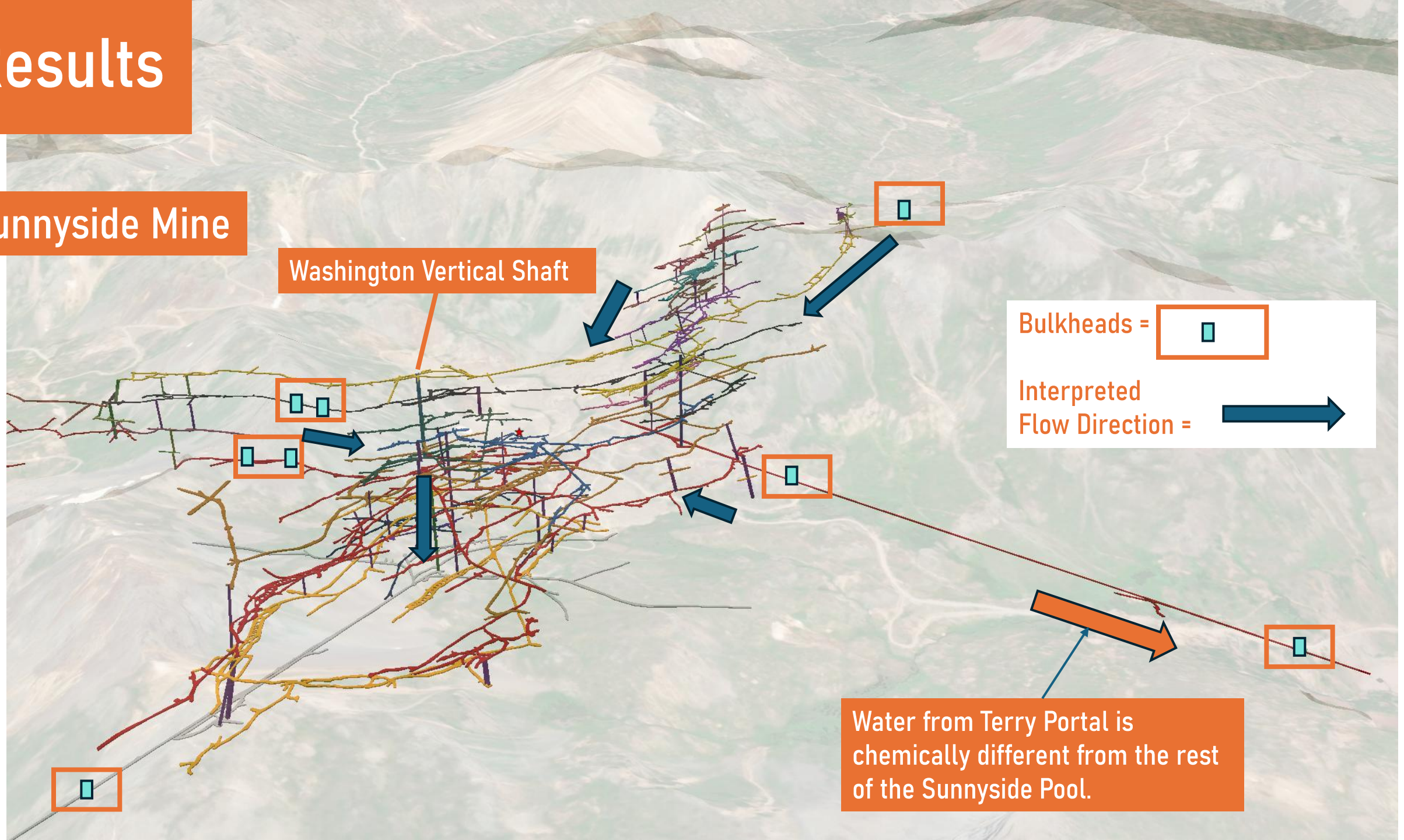
Sunnyside Mine

Washington Vertical Shaft

Bulkheads = 

Interpreted Flow Direction = 

Water from Terry Portal is chemically different from the rest of the Sunnyside Pool.





Results

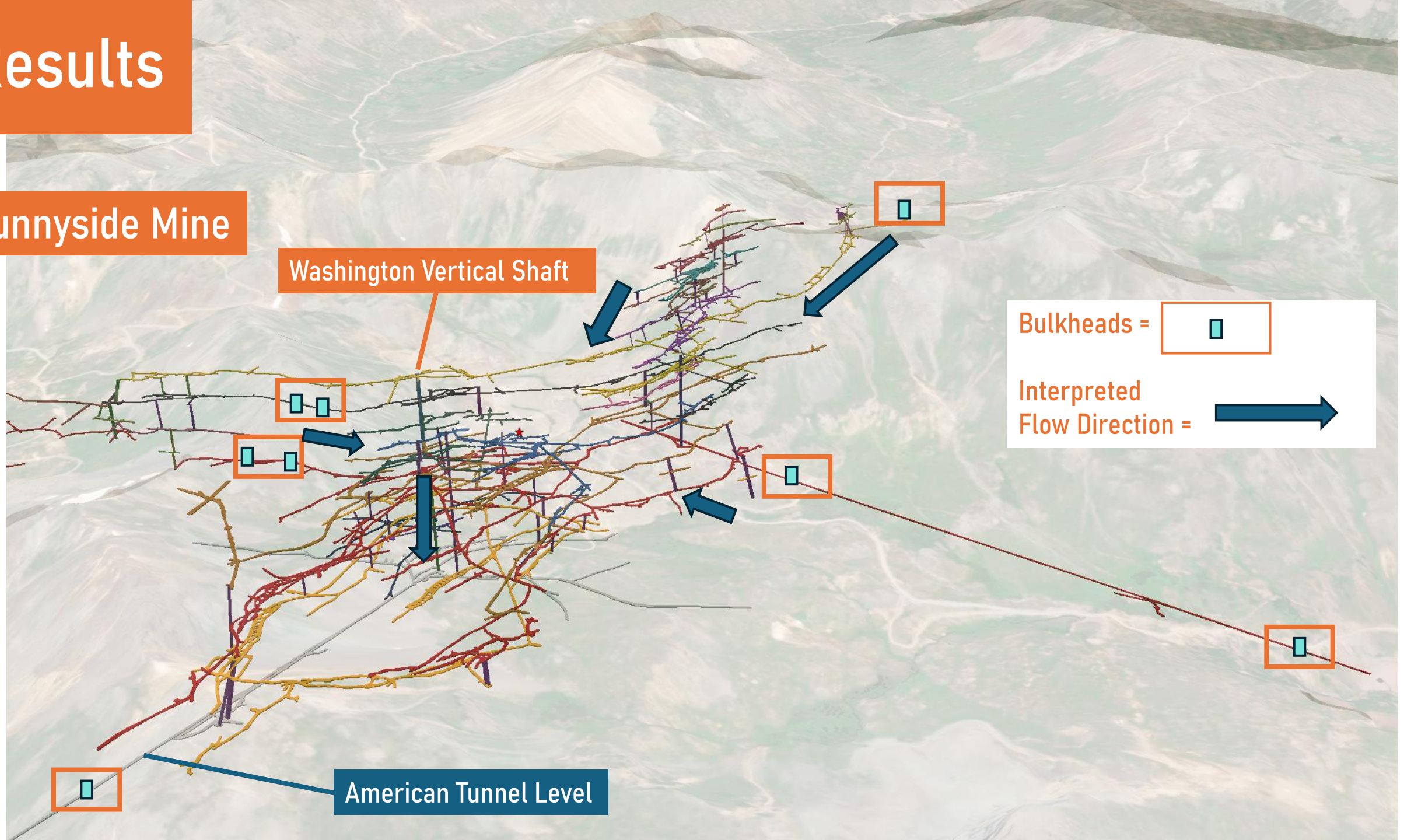
Sunnyside Mine

Washington Vertical Shaft

American Tunnel Level

Bulkheads = 

Interpreted Flow Direction = 

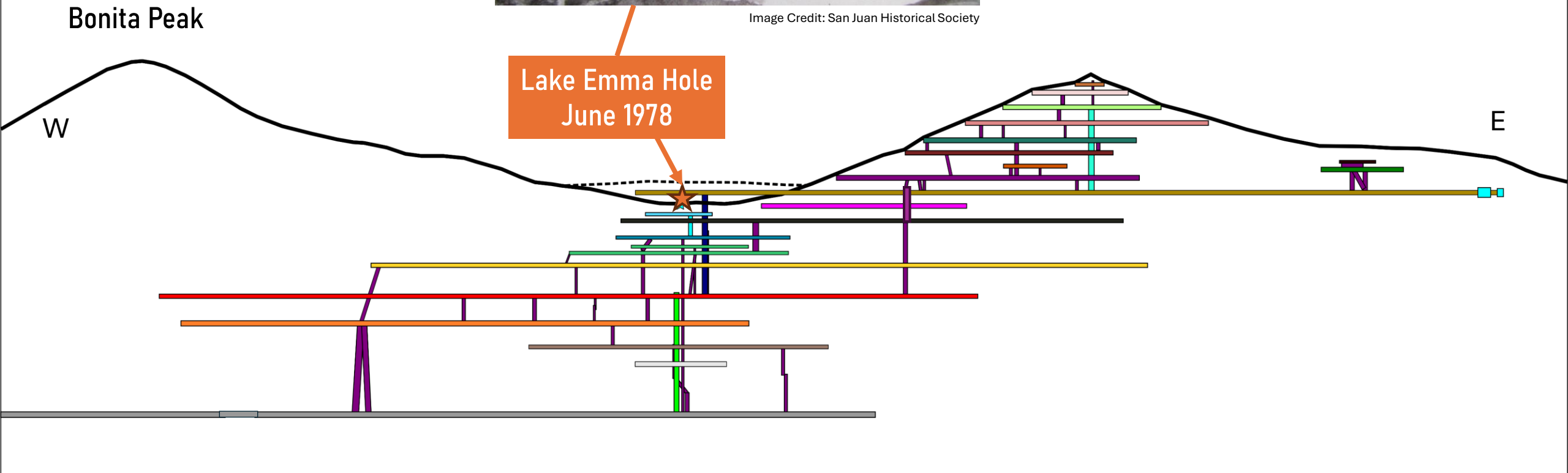


Results

Sunnyside Mine

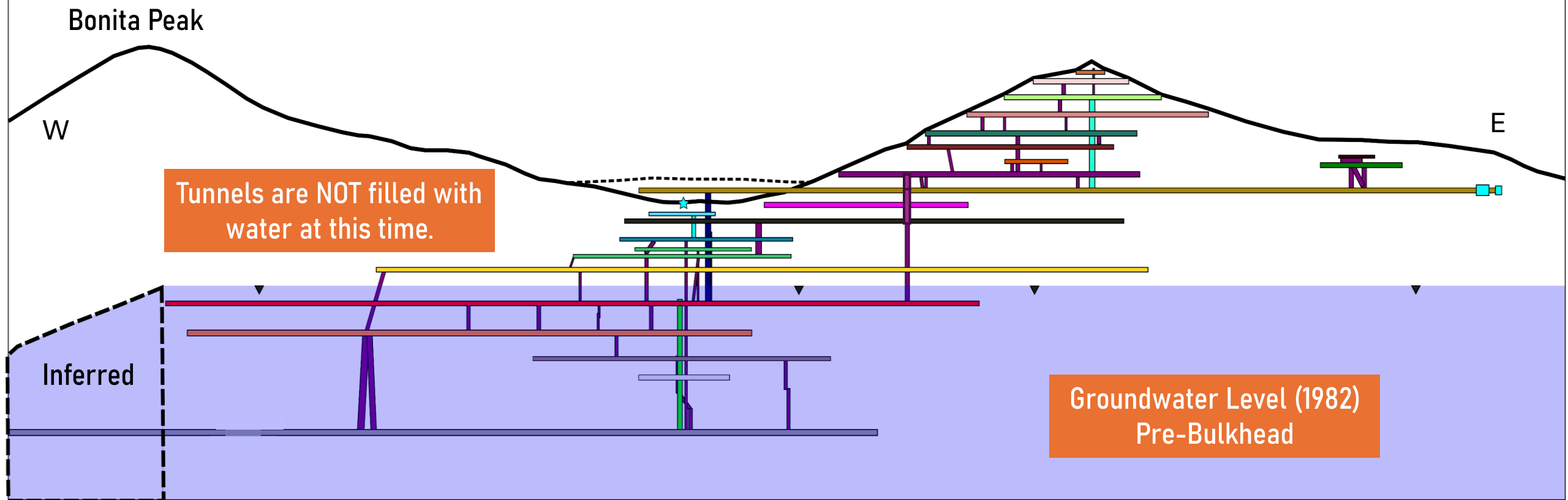


Image Credit: San Juan Historical Society

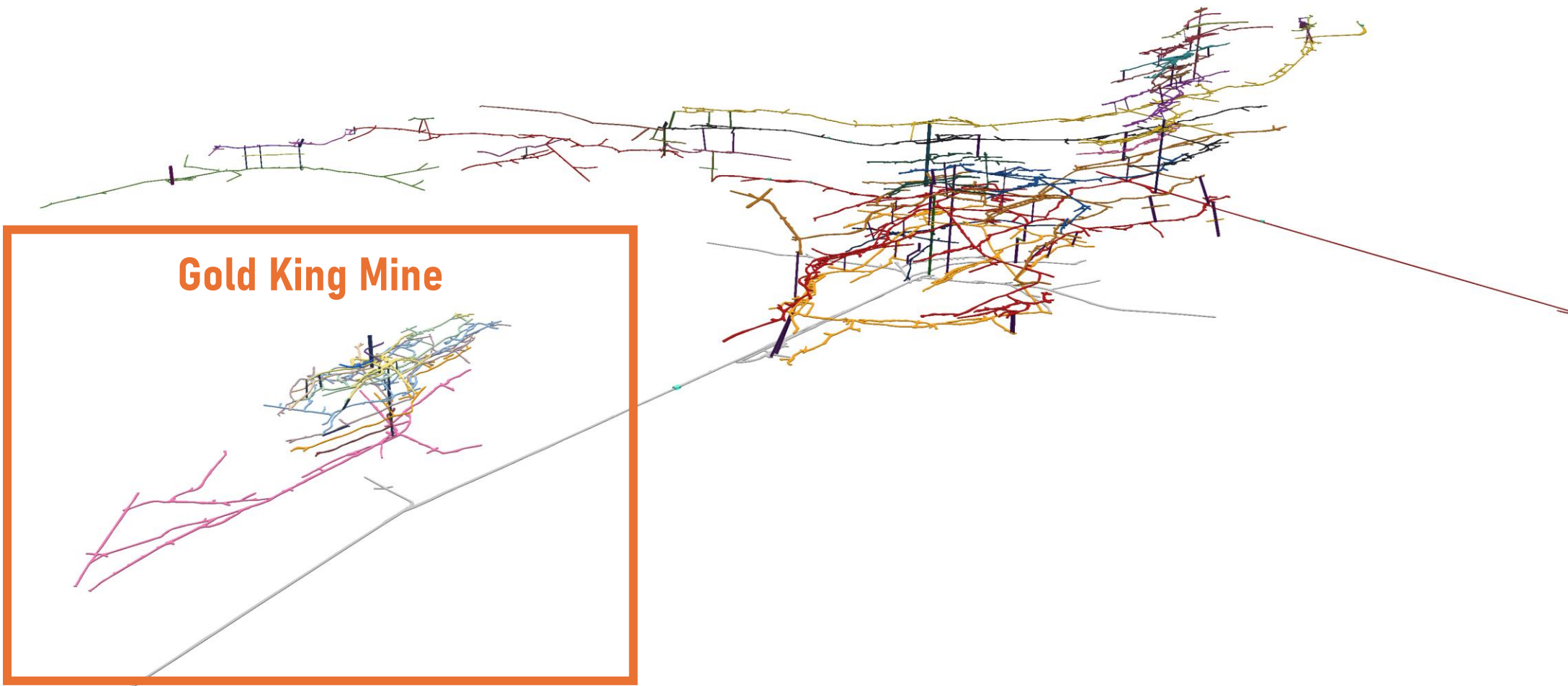


Results

Sunnyside Mine

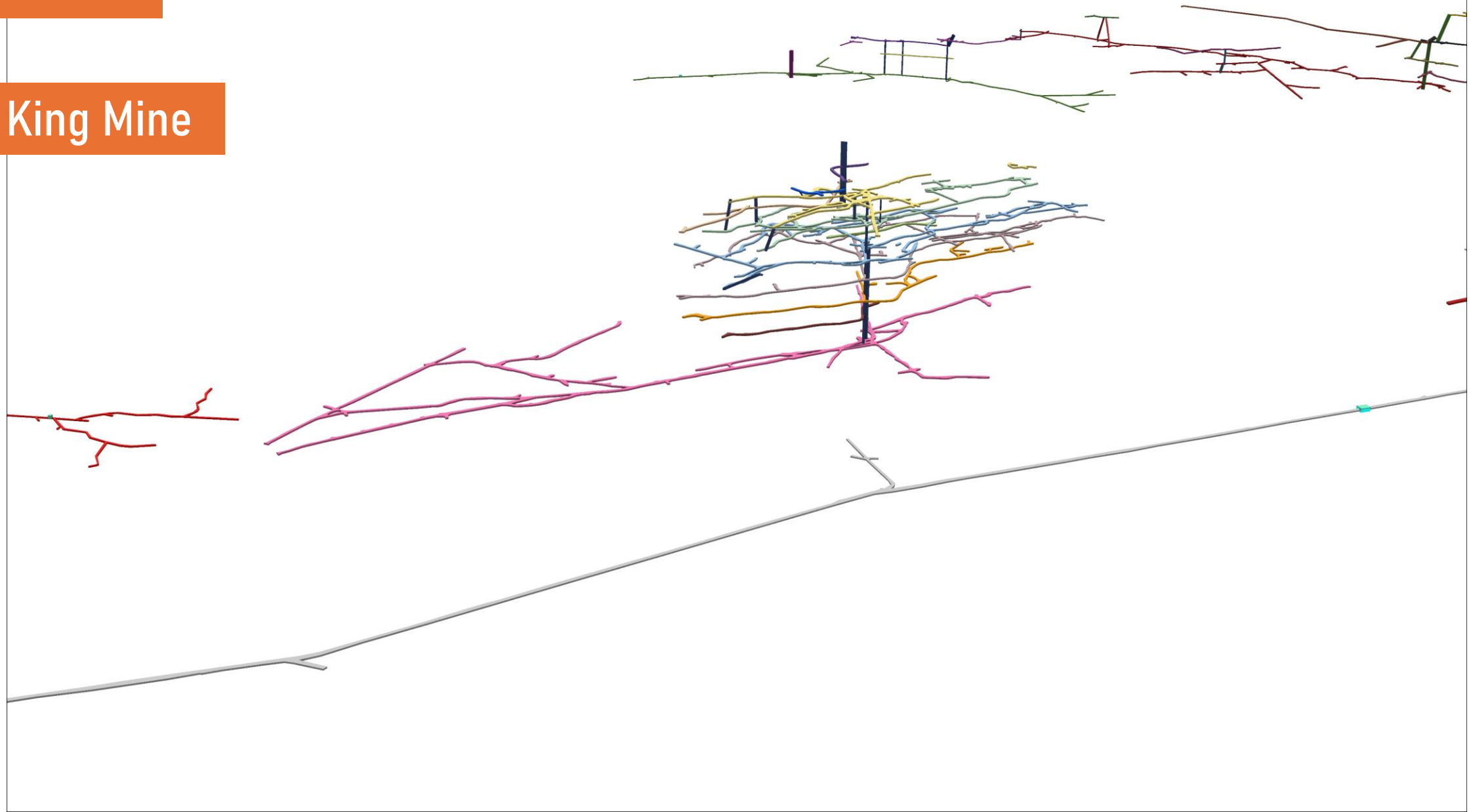


Results



Results

Gold King Mine

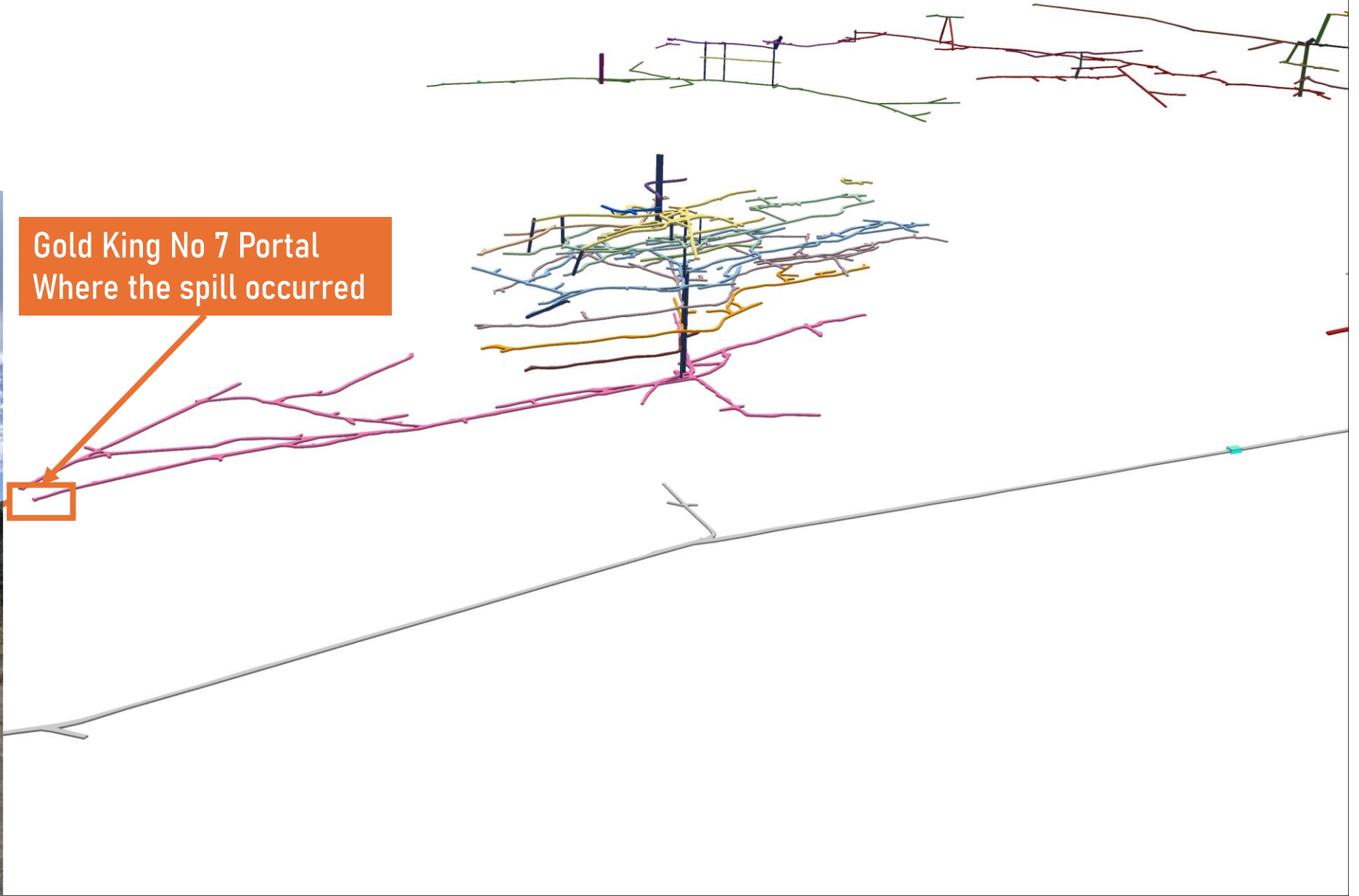


Results

Gold King Mine



Gold King No 7 Portal
Where the spill occurred



Results

Gold King Mine



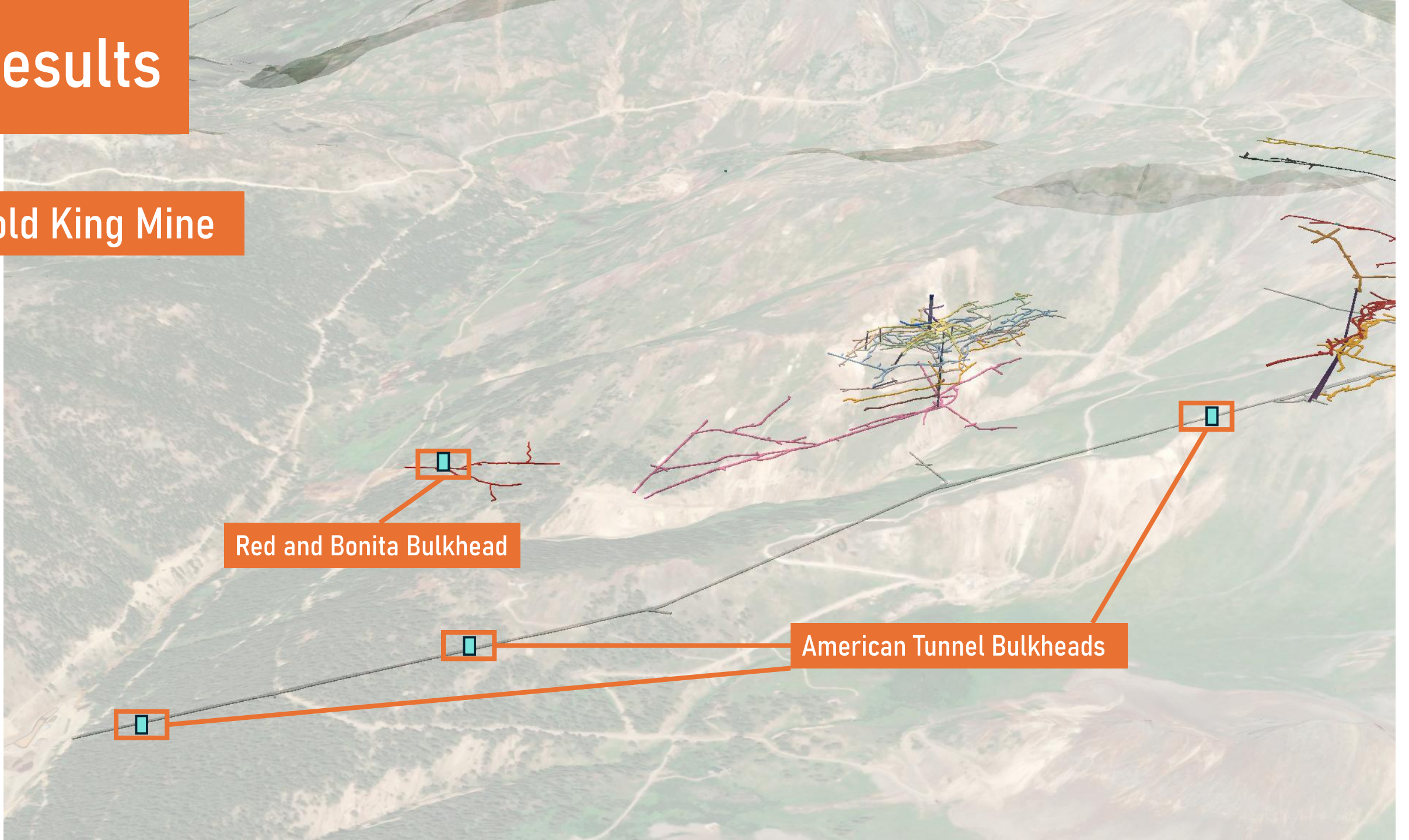
Red and Bonita Mine

American Tunnel

Sunnyside F Level

Results

Gold King Mine

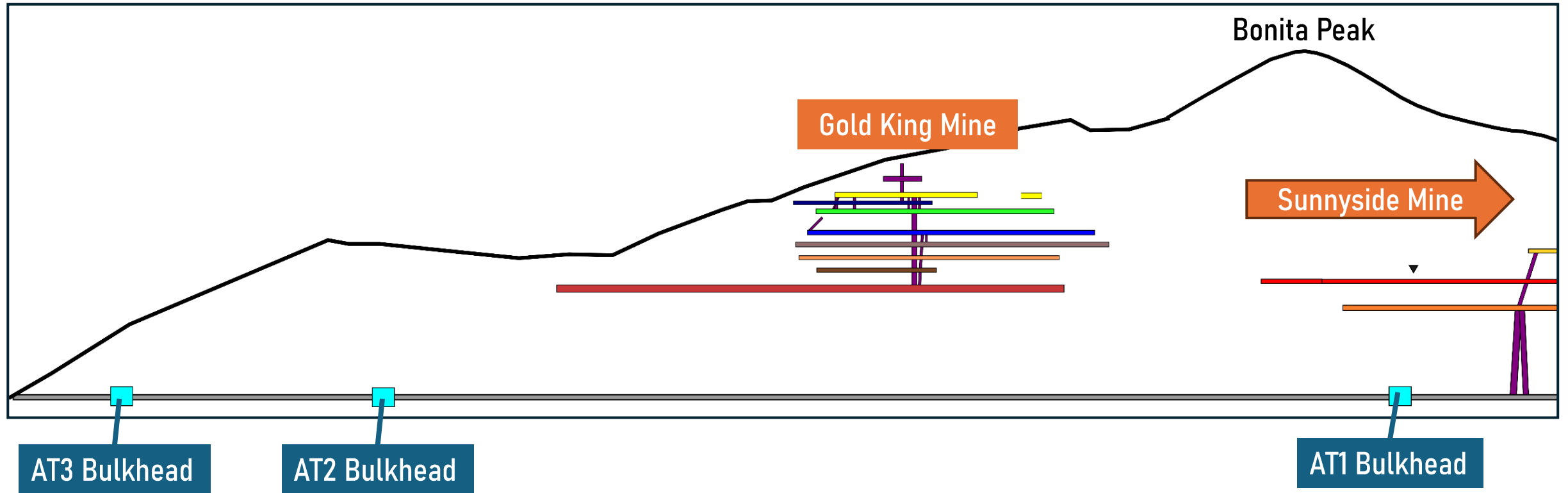


Red and Bonita Bulkhead

American Tunnel Bulkheads

Results

Gold King Mine

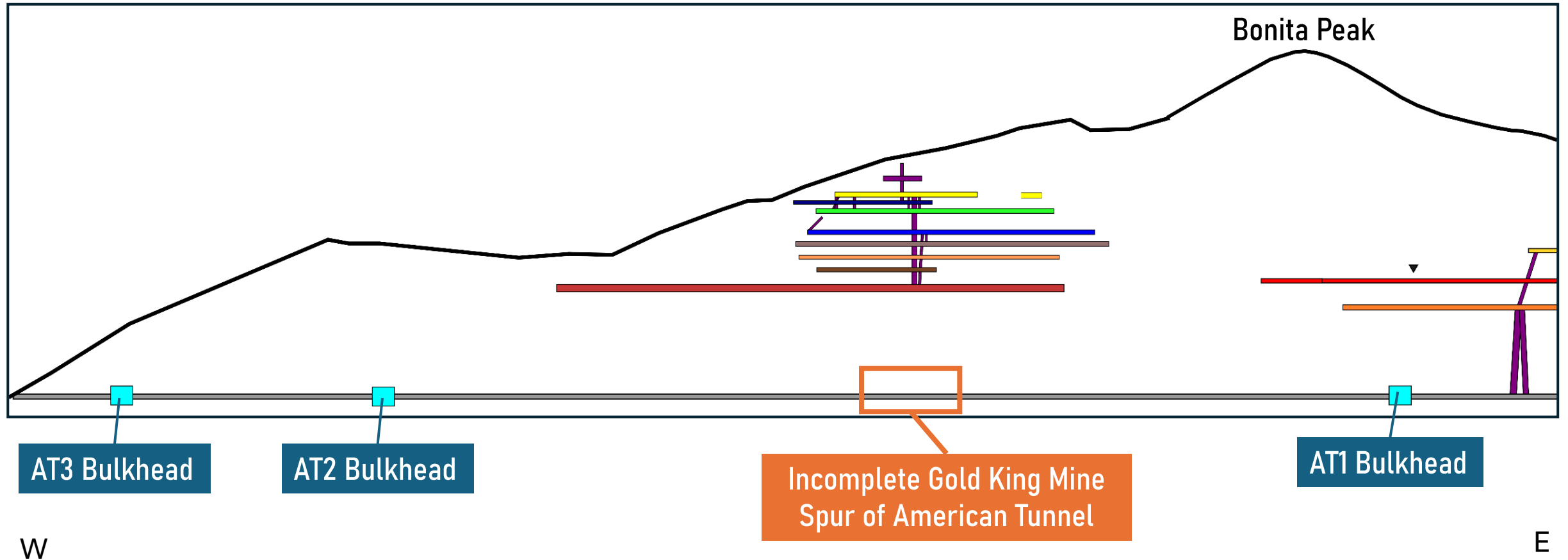


W

E

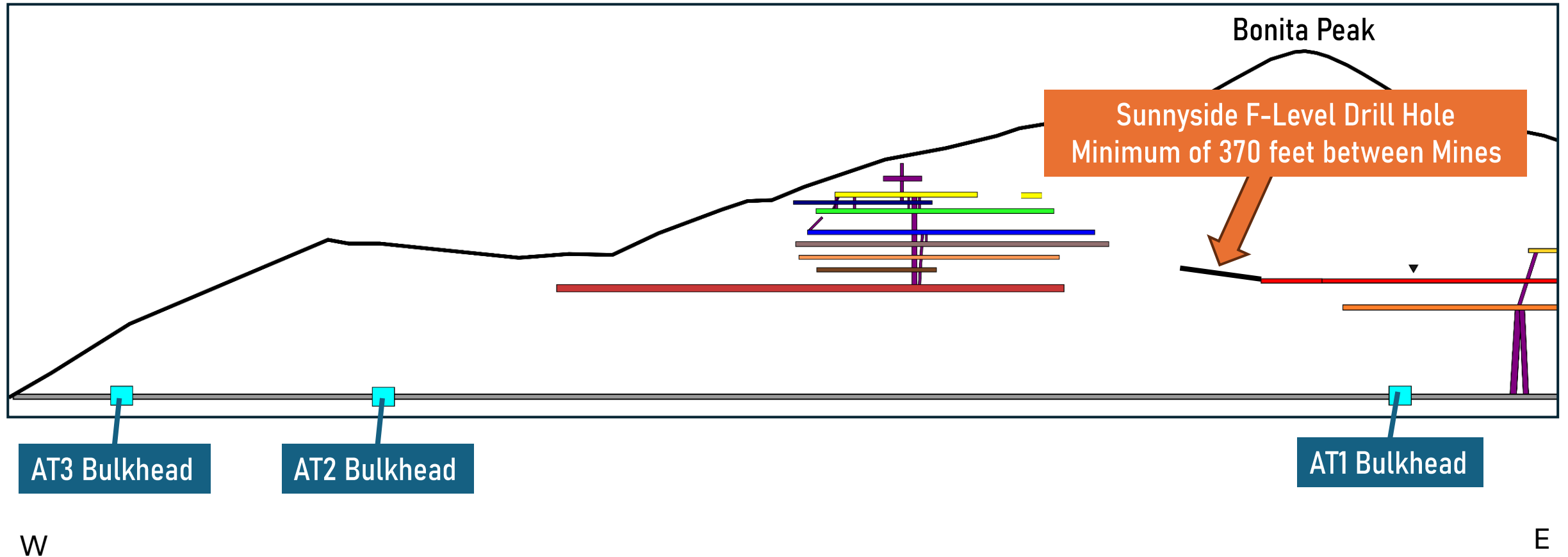
Results

Gold King Mine



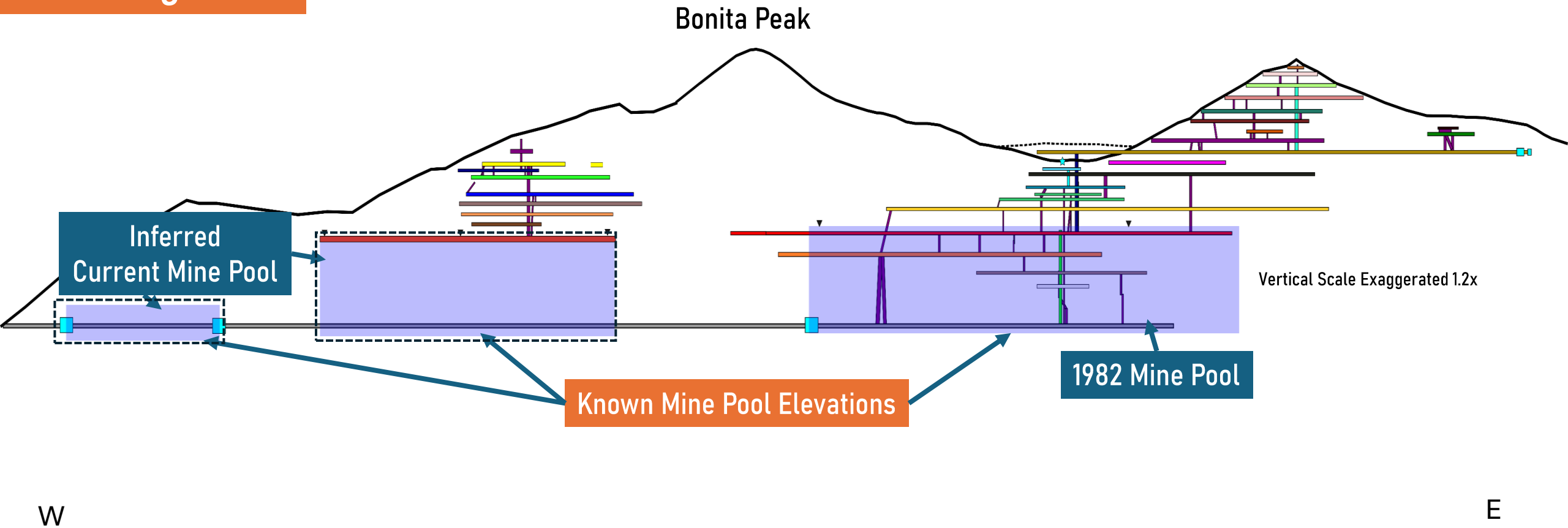
Results

Gold King Mine



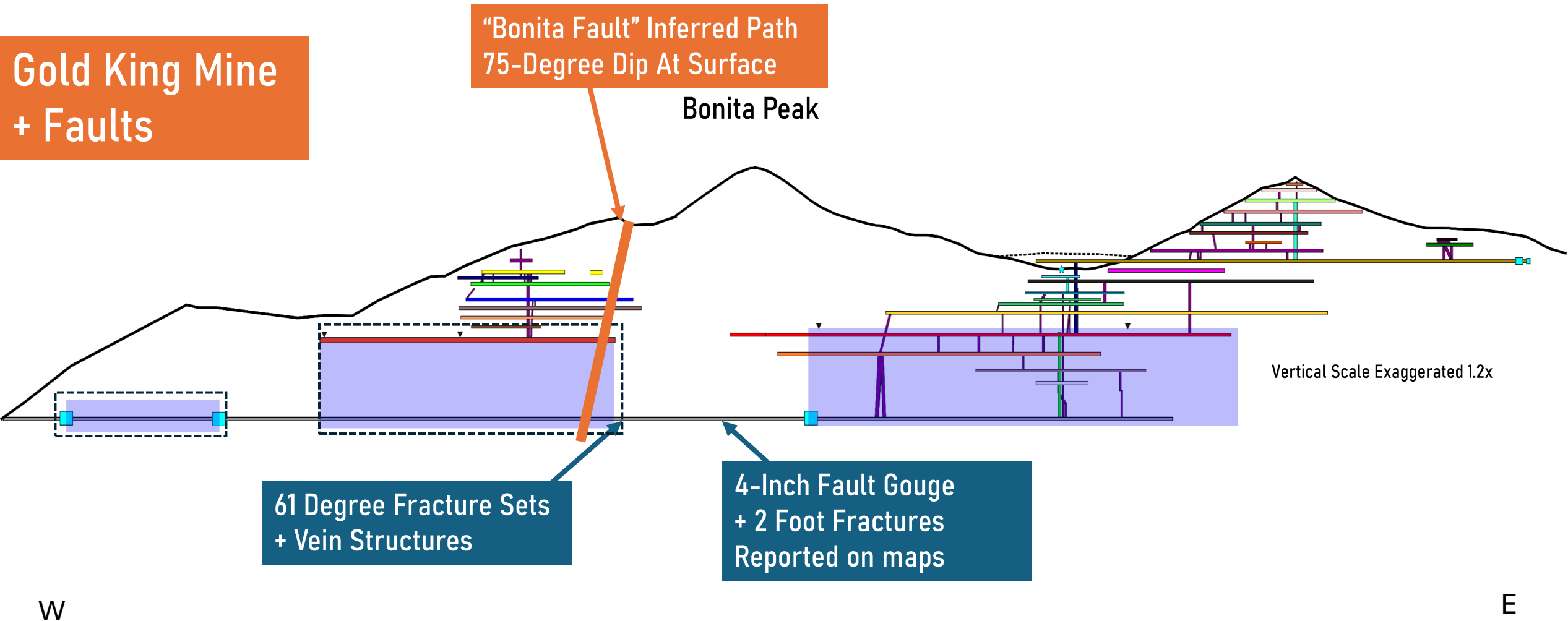
Results

Gold King Mine

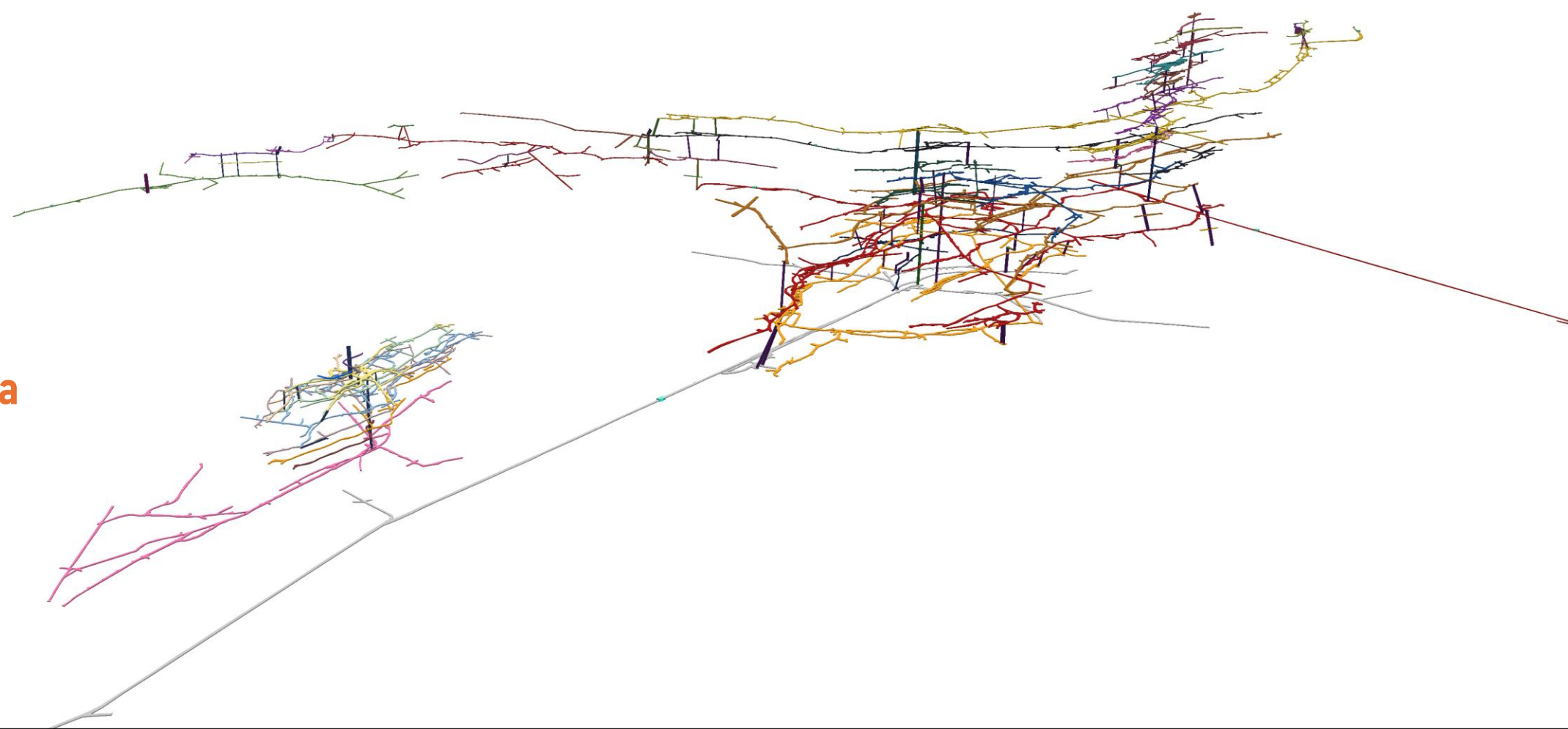


Results

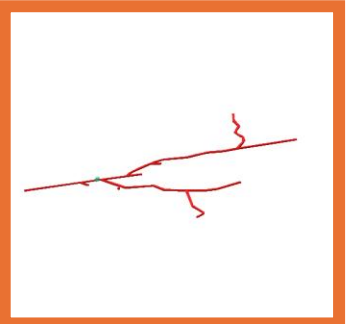
Gold King Mine + Faults



Results

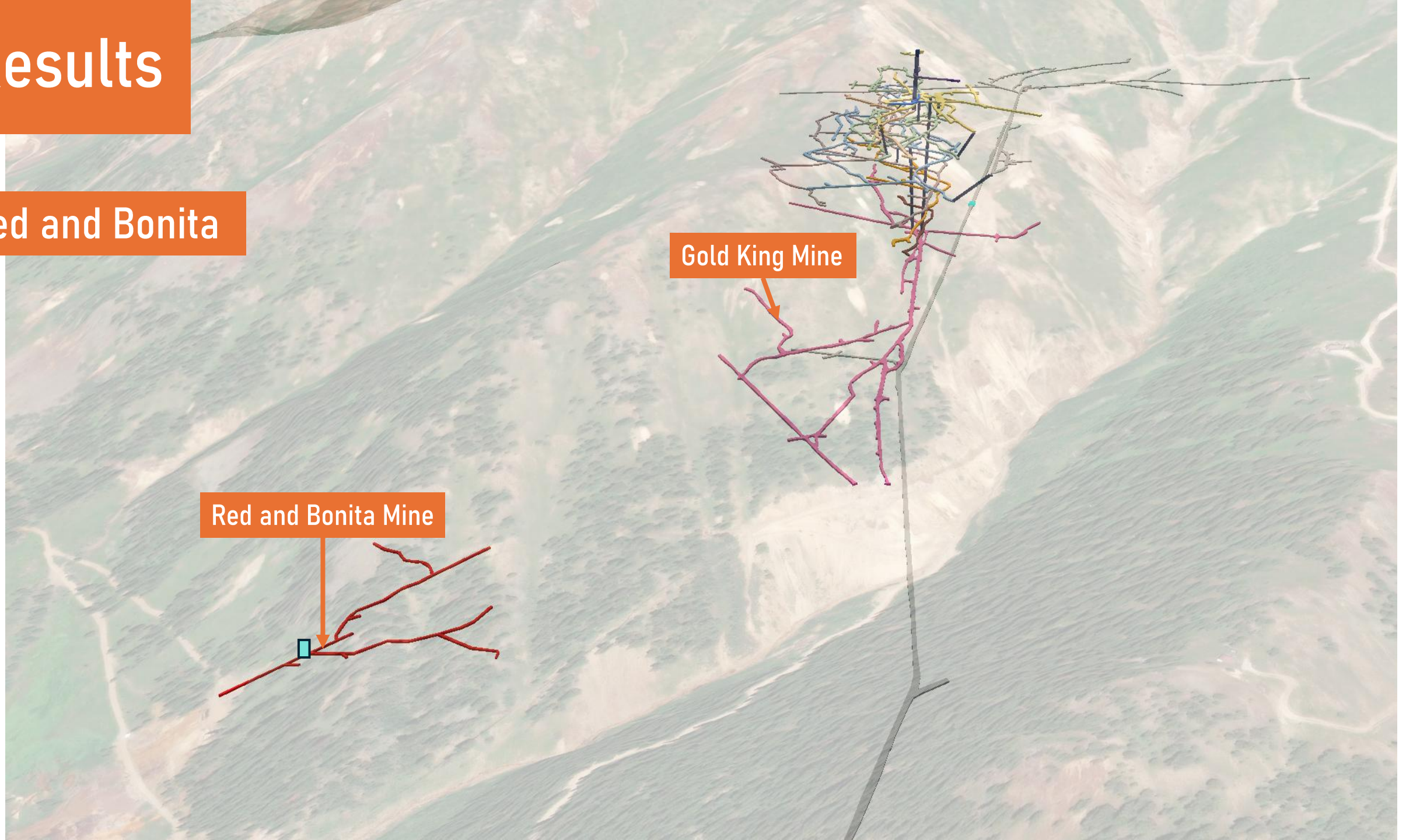


**Red and Bonita
Mine**



Results

Red and Bonita



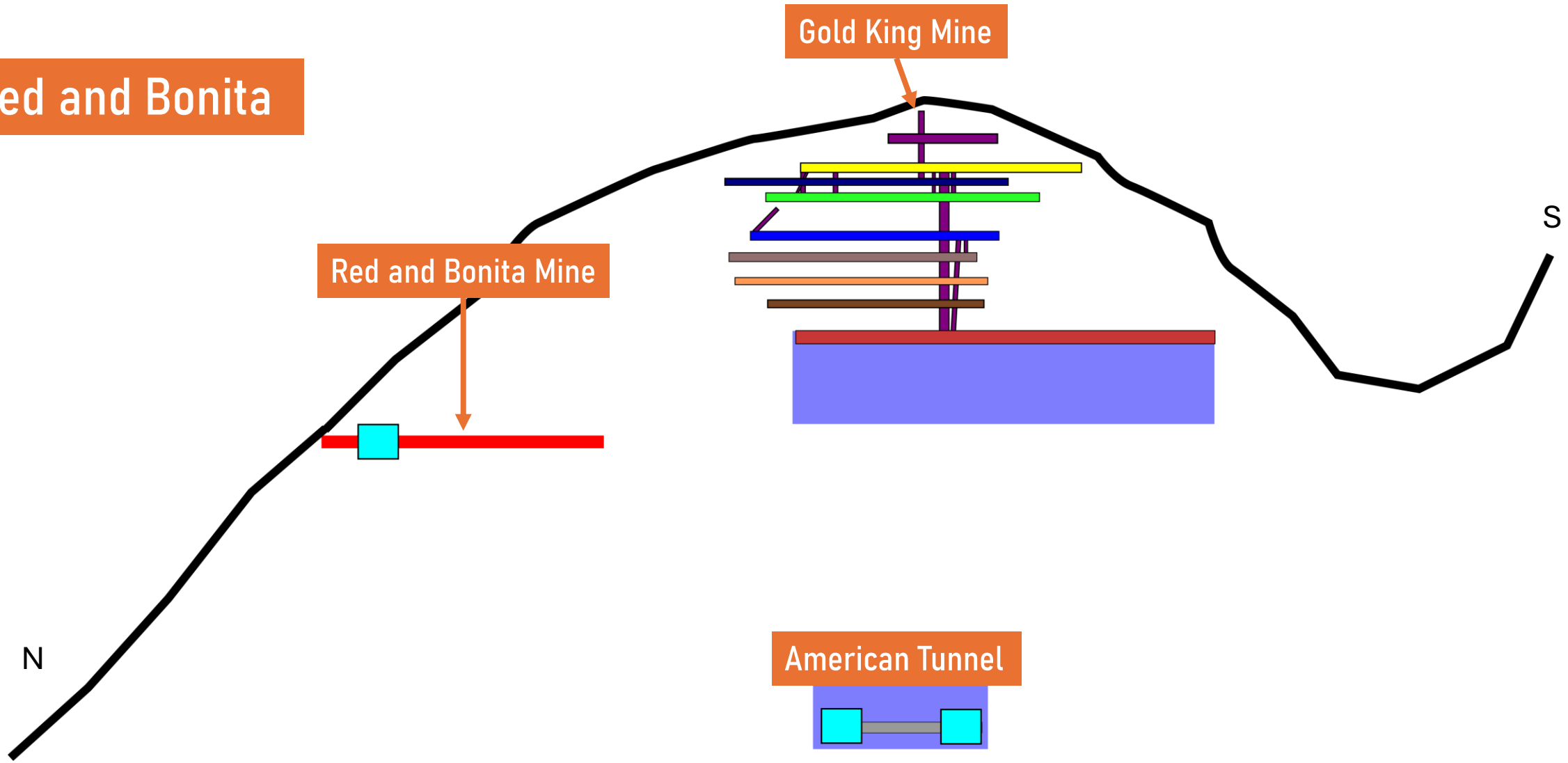
Gold King Mine

Red and Bonita Mine

Results

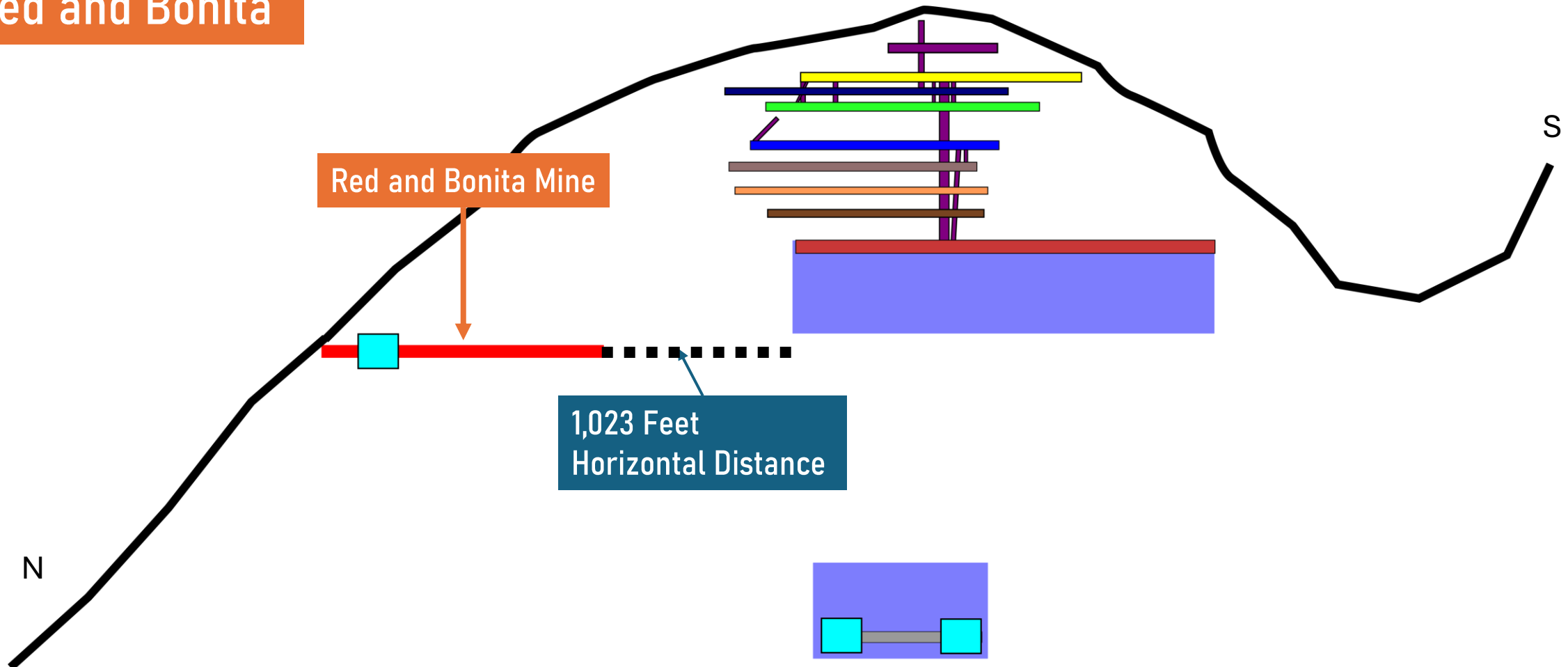
Note: position of minor shafts are approximated for view angle

Red and Bonita



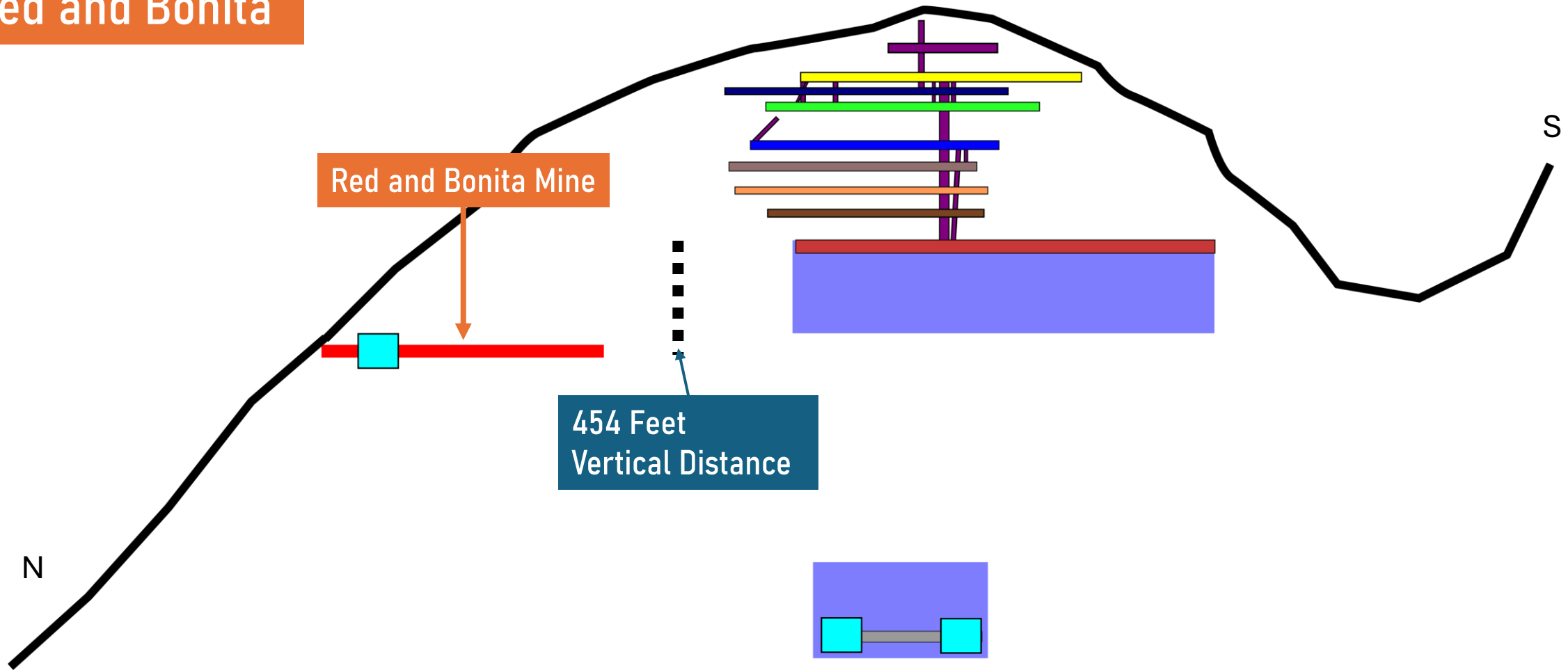
Results

Red and Bonita



Results

Red and Bonita

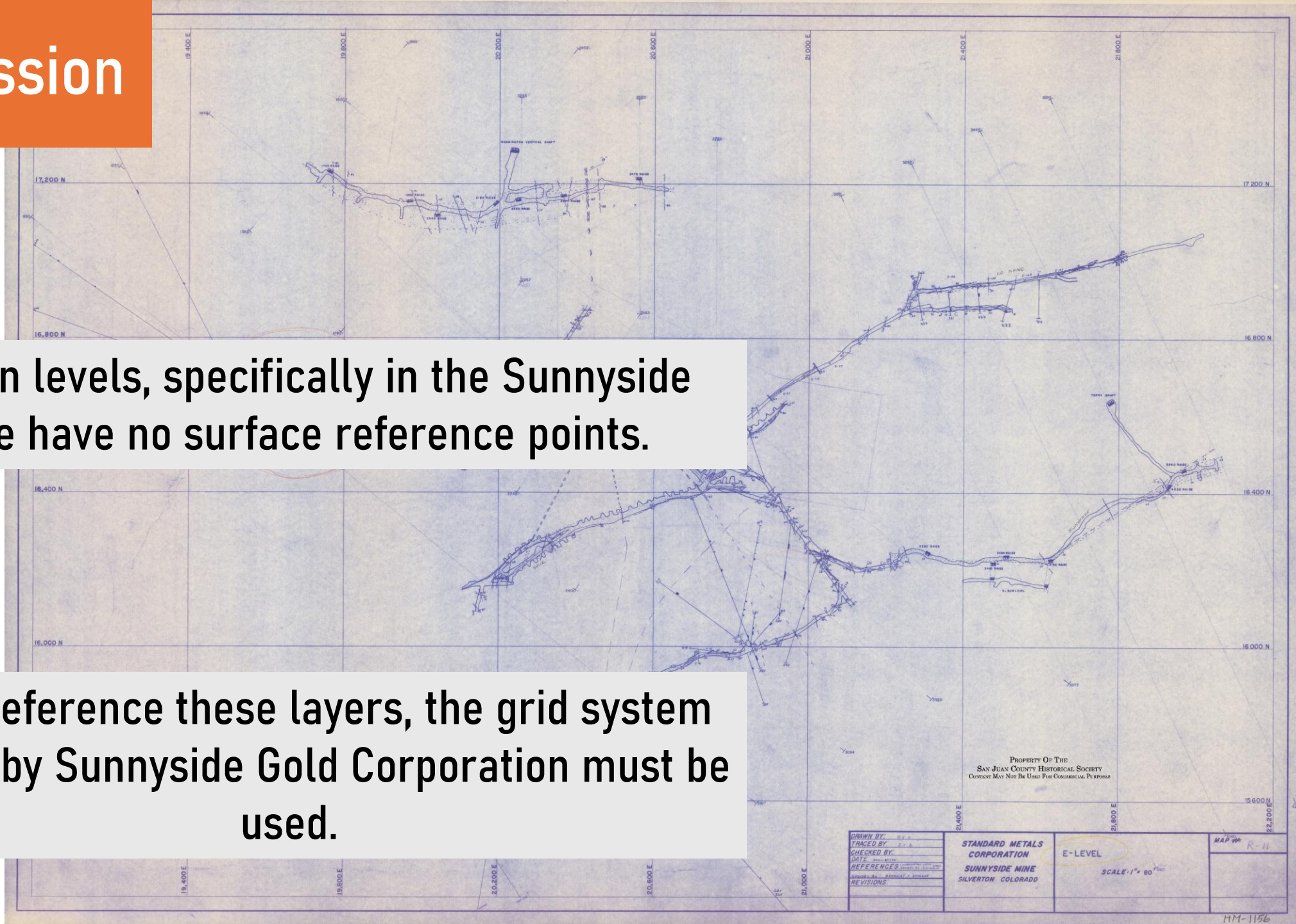


Discussion

Error

Certain levels, specifically in the Sunnyside Mine have no surface reference points.

To georeference these layers, the grid system created by Sunnyside Gold Corporation must be used.

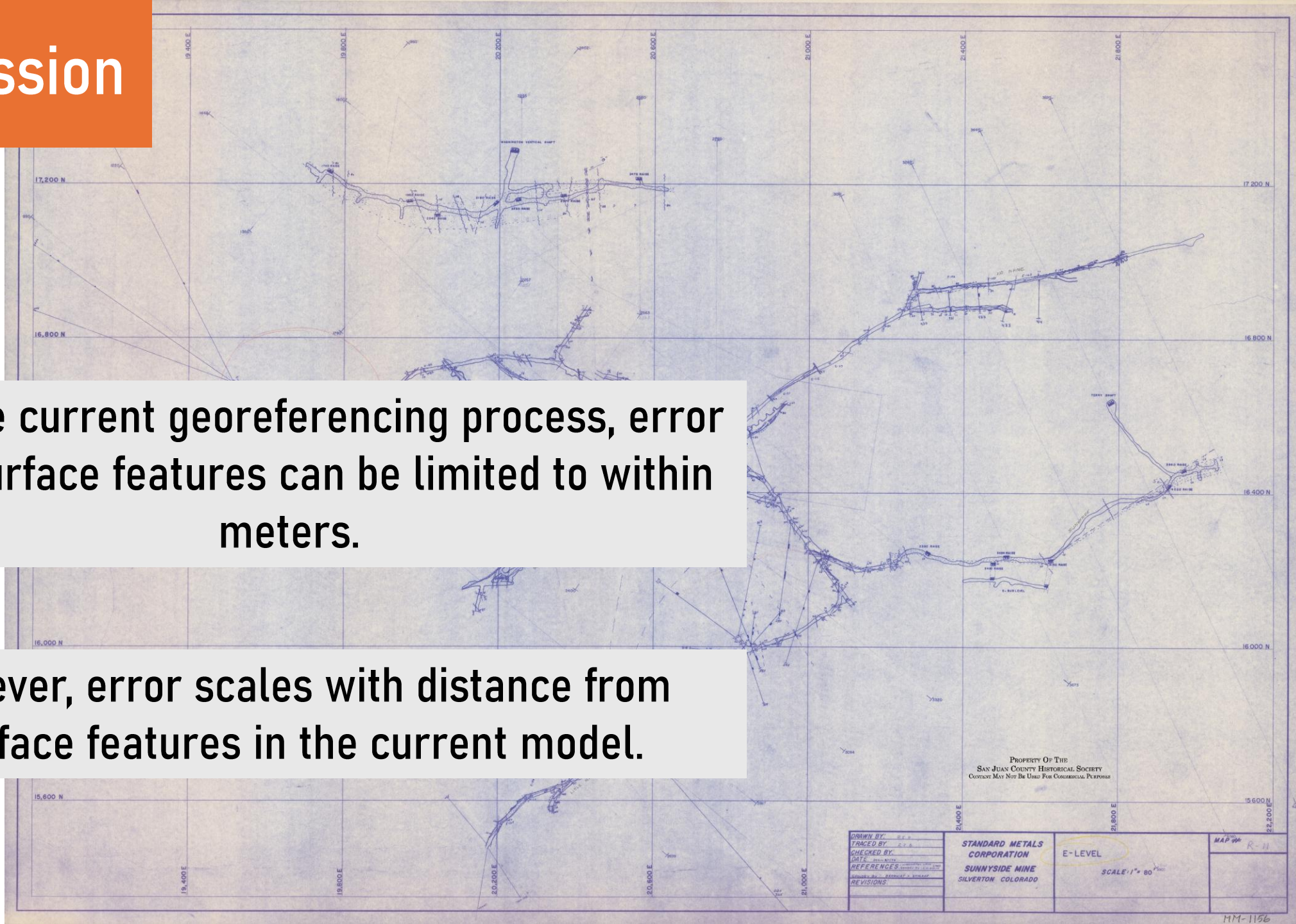


Discussion

Error

With the current georeferencing process, error near surface features can be limited to within meters.

However, error scales with distance from surface features in the current model.



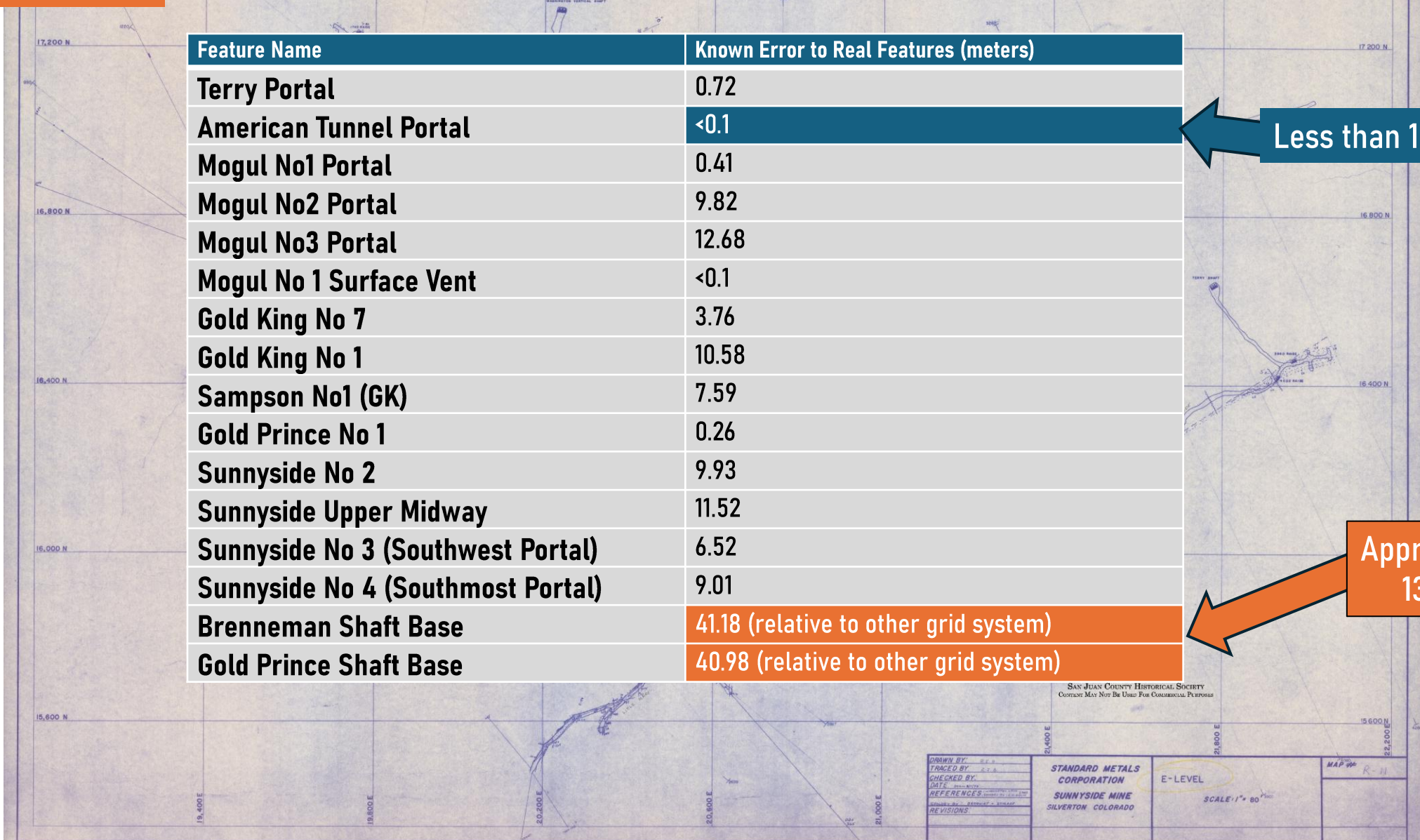
Discussion

Error

Feature Name	Known Error to Real Features (meters)
Terry Portal	0.72
American Tunnel Portal	<0.1
Mogul No1 Portal	0.41
Mogul No2 Portal	9.82
Mogul No3 Portal	12.68
Mogul No 1 Surface Vent	<0.1
Gold King No 7	3.76
Gold King No 1	10.58
Sampson No1 (GK)	7.59
Gold Prince No 1	0.26
Sunnyside No 2	9.93
Sunnyside Upper Midway	11.52
Sunnyside No 3 (Southwest Portal)	6.52
Sunnyside No 4 (Southmost Portal)	9.01
Brenneman Shaft Base	41.18 (relative to other grid system)
Gold Prince Shaft Base	40.98 (relative to other grid system)

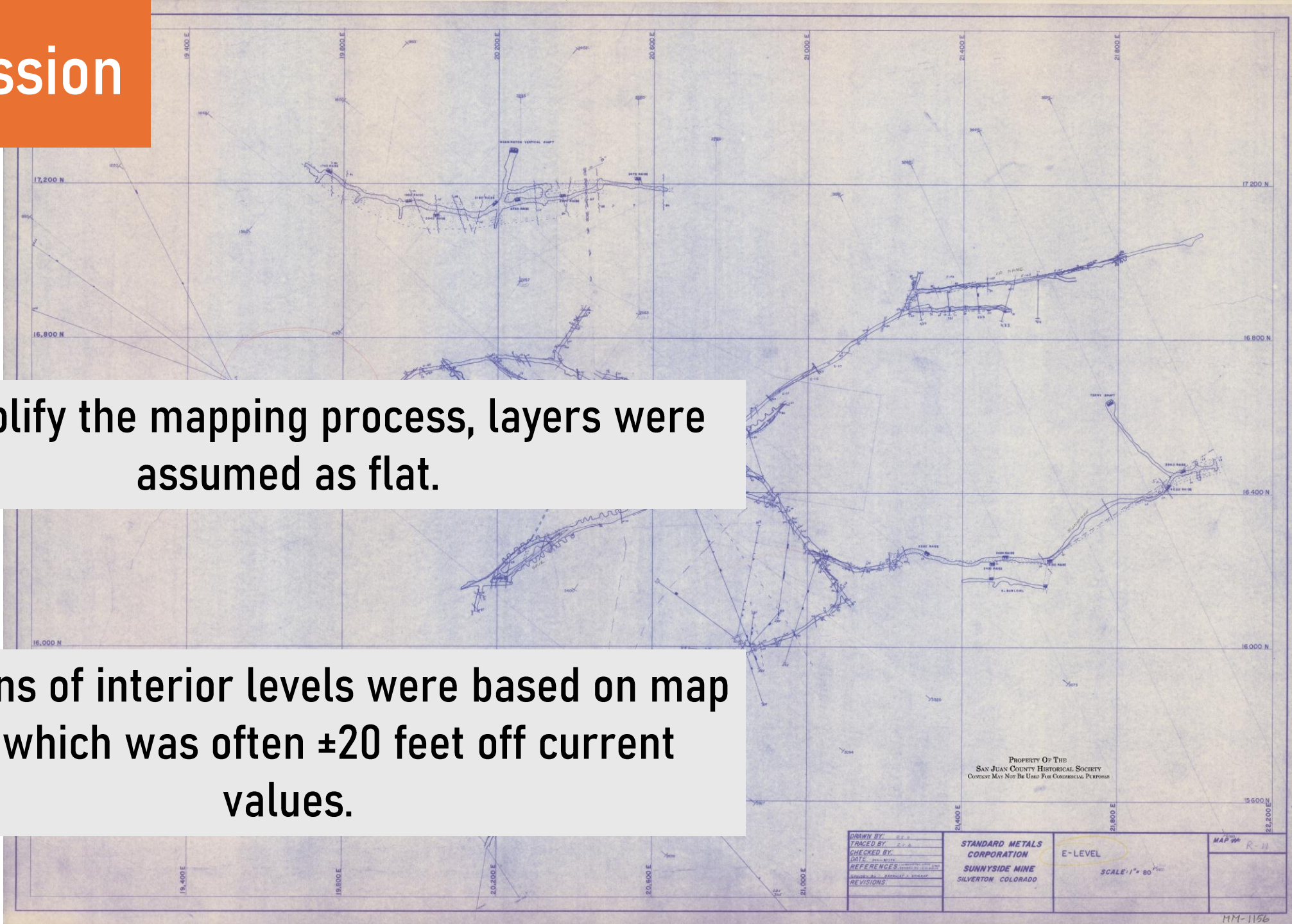
Less than 1 foot

Approximately 135 Feet



Discussion

Error



To simplify the mapping process, layers were assumed as flat.

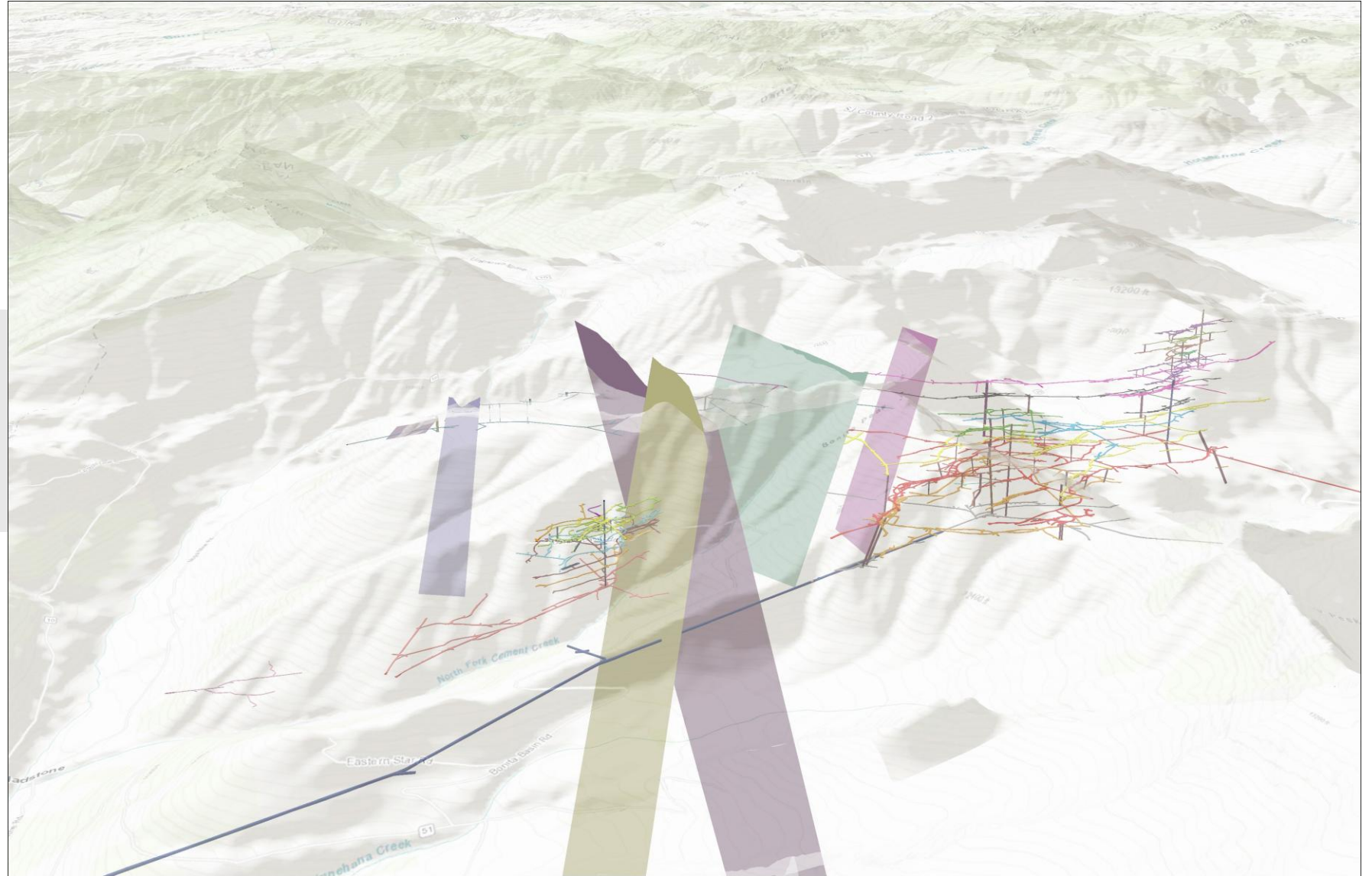
Elevations of interior levels were based on map data, which was often ± 20 feet off current values.

Discussion

Future Work

Geology:

- Fault Mapping, 2D and 3D

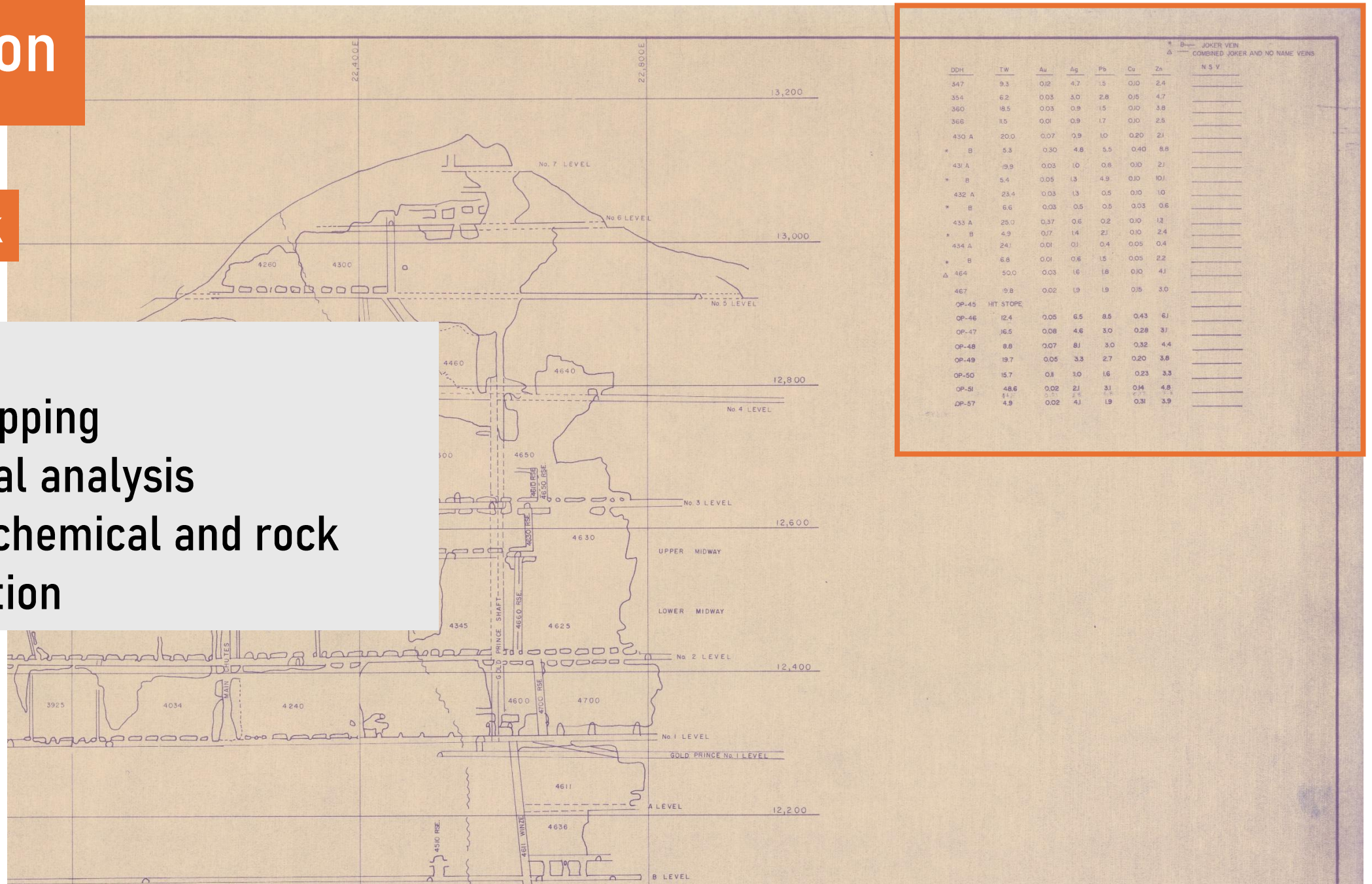


Discussion

Future Work

Geology:

- Fault Mapping
- Structural analysis
- Data on chemical and rock composition



Discussion

Future Work

Geology:

- Fault Mapping
- Structural analysis
- Data on chemical and rock composition
- **Groundwater Analysis**

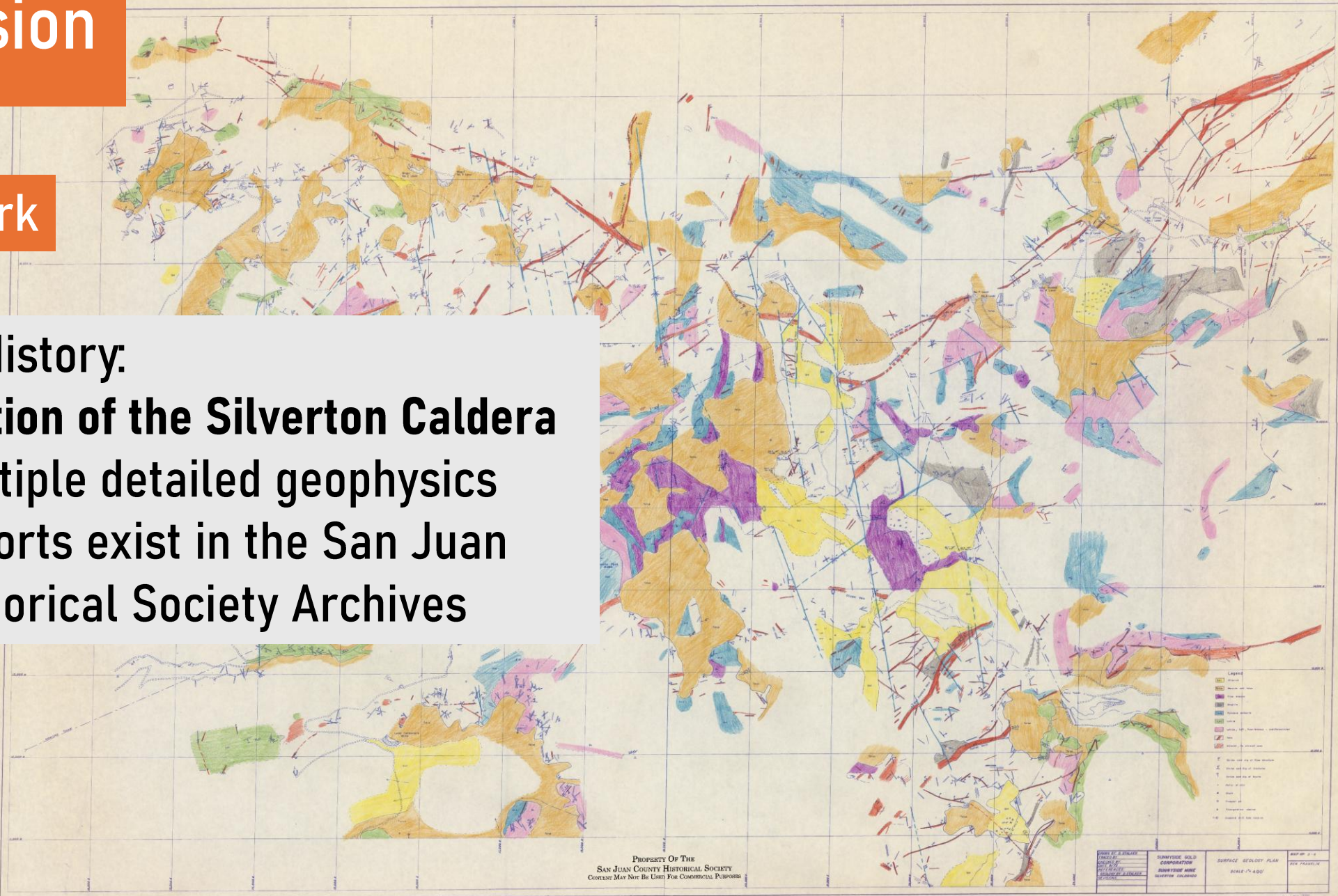


Discussion

Future Work

Geologic History:

- **Formation of the Silverton Caldera**
- Multiple detailed geophysics reports exist in the San Juan Historical Society Archives

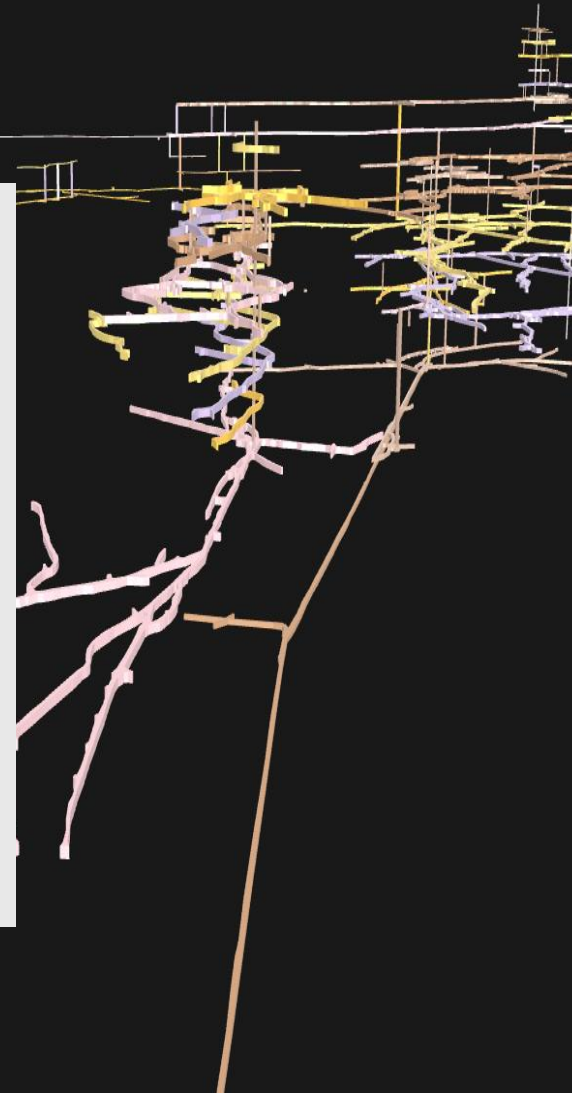


Discussion

Future Work

Engineering:

- Further understanding of bulkhead systems
- Understanding of ongoing tracer studies
- Improvement of 3D models for fluid analysis (finite element models)
- Guidance for further reclamation



Acknowledgements

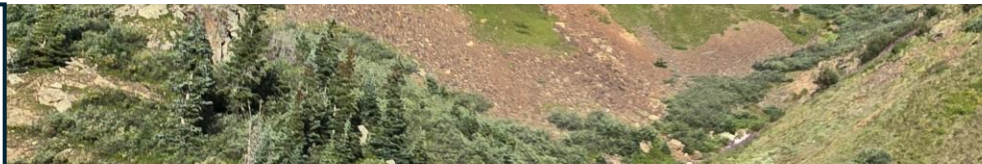
Thanks to:

- Terry Morris, Chris Landry, and the San Juan Historical Society for inspiring this project and providing the data needed to build this model.

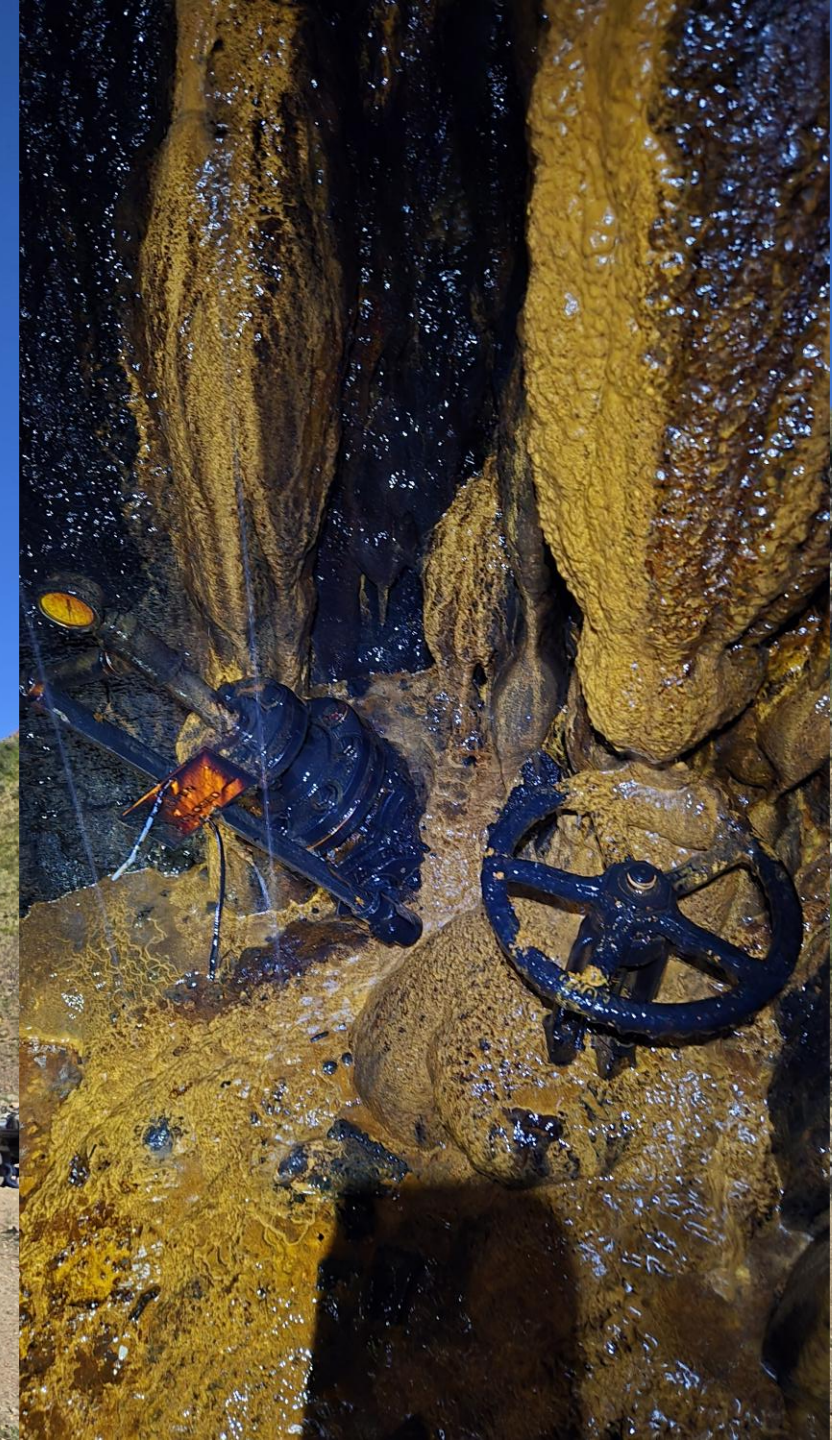
**SAN JUAN COUNTY
HISTORICAL SOCIETY**



- Kirstin Brown and the Colorado Division of Reclamation, Mining and Safety for sharing of bulkhead data and invitation to go underground during bulkhead week.



- Doug Taylor for providing insight on shaft connections and insight into the mapping process of the Gold King and Sunnyside Mines.
- Schnabel Engineering for guidance in the underground mines of the Bonita Peak Region and insight into mining practices.



Acknowledgements

Thanks to:

- Alpine Water Resources for providing gear and information on tracer studies in the Bonita Peak region.



- United States Environmental Protection Agency for access and tour of the Gladstone Treatment Plant



- Fort Lewis College Engineering and Physics department for funding this project.

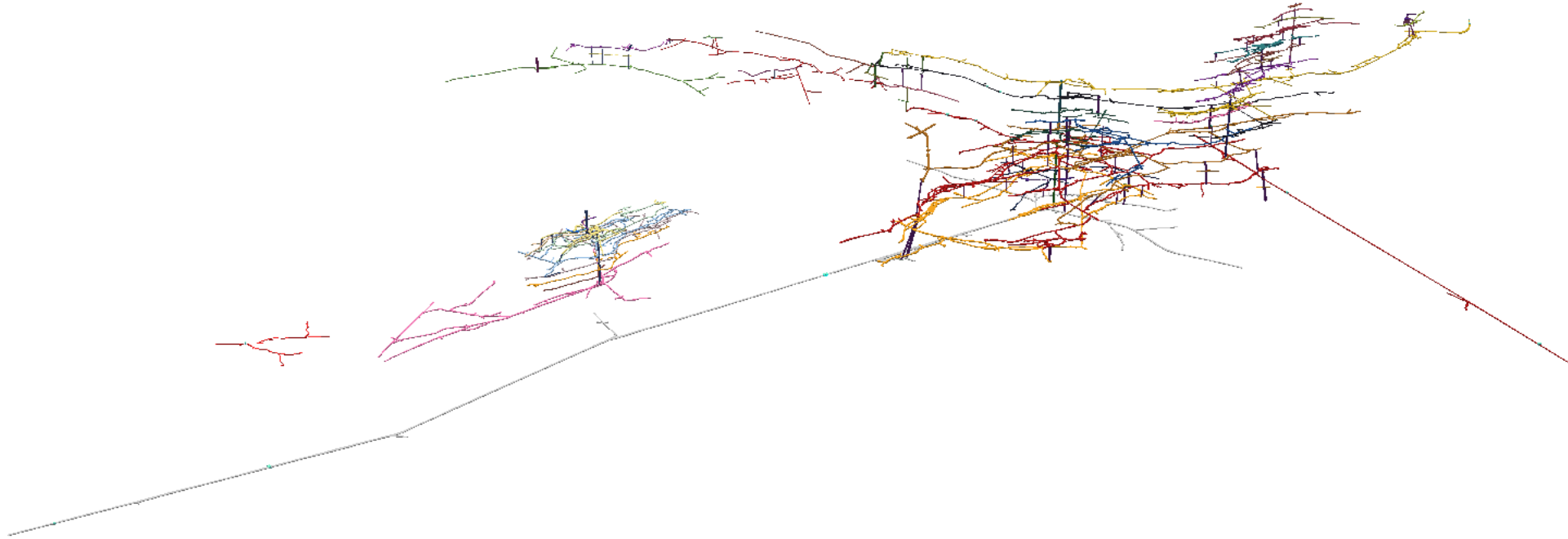


Questions?



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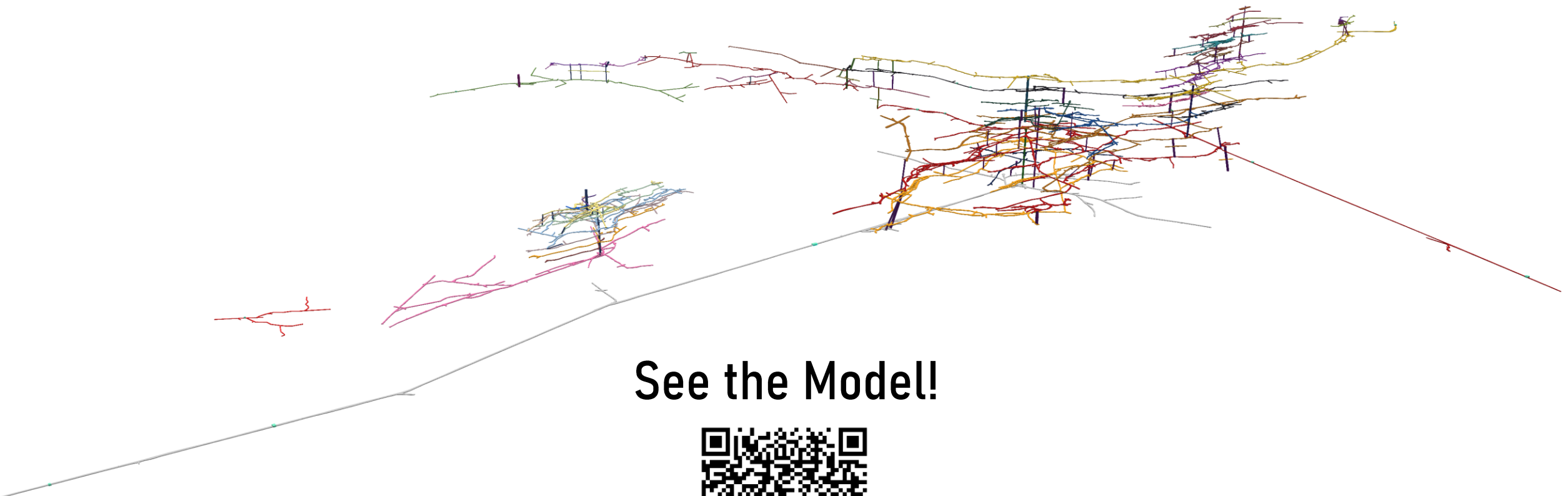
See the Model!



Questions?



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HISTORICAL SOCIETY**



See the Model!



Sources

- Chief, K., Artiola, J.F., Wilkinson, S.T., Beamer, P., and Maier, R.M., 2015, *Understanding the Gold King Mine spill*. University of Arizona, revised November 2015, 10 p.
- Roberts, S., 2016, *Animas River 2015 benthic macroinvertebrate (BMI) report: Gold King Mine release monitoring*. Prepared for U.S. Environmental Protection Agency Region 8, Mountain Studies Institute, Durango, Colorado, June 2016, 40 p.
- U.S. Environmental Protection Agency (EPA), 2016, *EPA adds Bonita Peak Mining District site in San Juan County, Colo. to Superfund list*. U.S. EPA News Release, September 7, 2016, accessed March 31, 2026, <https://www.epa.gov/archive/epa/newsreleases/epa-adds-bonita-peak-mining-district-site-san-juan-county-colo-superfund-list.html>
- U.S. Geological Survey (USGS), 2015., *Gold King Mine release (2015): USGS water-quality data and activities*. U.S. Geological Survey, accessed March 31, 2026, <https://www.usgs.gov/mission-areas/water-resources/science/gold-king-mine-release-2015-usgs-water-quality-data-and>

