Staff Report

TO: Board of Directors

FROM: Doug Roderick, P.E., Interim Engineering Manager

DATE: September 8, 2021

SUBJECT: South Yuba Canal Condition Assessment Report (Project #2419)

ENGINEERING

RECOMMENDATION:

Receive and file the South Yuba Canal Condition Assessment Report by GHD and receive a presentation from GHD staff.

BACKGROUND:

The existing South Yuba Canal delivers water from PG&E's Lake Spaulding to Deer Creek forebay, a distance of about 19 miles. The facility is currently owned and operated by PG&E, but will soon become a District-owned and operated facility. When this facility becomes part of the District's water conveyance system, it is important to evaluate the condition of the facility in order to develop a capital improvement plan (CIP) that will be utilized for future maintenance and repair, as well as for prioritizing projects to improve or replace this critical infrastructure.

GHD staff will make a presentation giving an overview of their findings. With the information presented in this report, staff will be able to develop a CIP for this facility based on the assessments and priorities given once this facility becomes part of the District's water conveyance system.

BUDGETARY IMPACT:

The contract with GHD was for $295,796, and the budget for this work was in 10151-52910 - Raw Water Replacement Program. This contract was approved and signed during the 2020 budget year. This amount was rolled over from the 2020 budget. Currently, $172,302.65 has been spent to date.

ATTACHMENTS: (2)

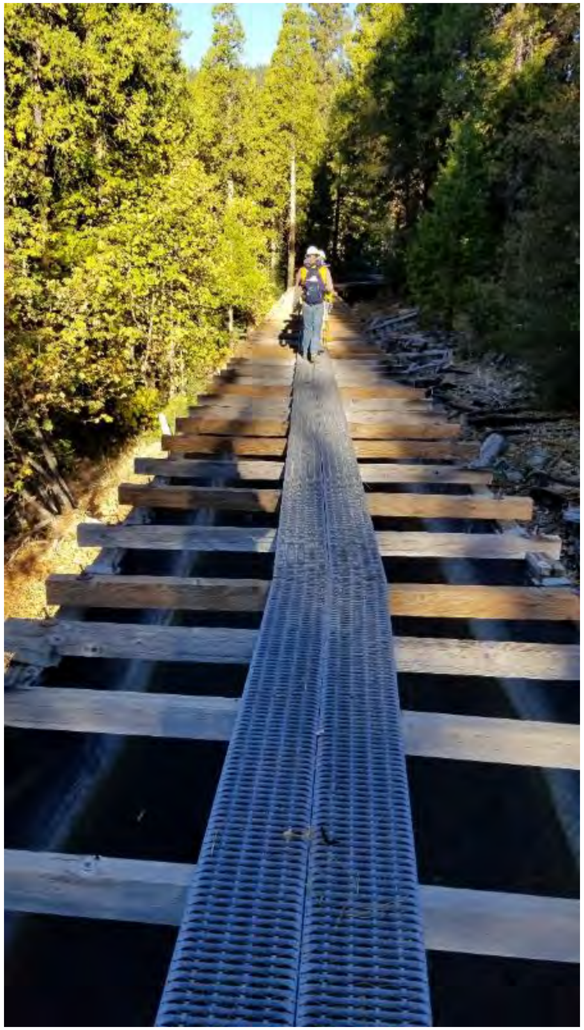
- PowerPoint presentation
- South Yuba Canal Condition Assessment Report

South Yuba Canal
2021 Condition Assessment

September 8, 2021

Inspection Methodology

- Site Investigations
  - Full System Walk Down October 2020
  - Focused Field Walk November 2020
  - Tunnel Inspection November 2020
  - Geophysical Investigation
- Condition Ratings
  - 1 = Immediate Attention Required
  - 5 = Good condition
- Importance Factors
  - 1 = More important
  - 3 = Less important



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Inspection Methodology

- General Assessment
- Structural
- Geotechnical
- Spillways
- Tunnels
- System Divided into 23 Segments based on:
  - Geology
  - System Features
  - Inspection Findings

Canal System Condition Assessment – General

- Access Points
  - Limited access to Chalk Bluff Canal (Segments 20 through 22) and Telephone House Flume (Segment 4)
- Freeboard
  - Generally sufficient, i.e. greater than 12 inches

1	<6"	High Risk	None
2	6"-12"		**Hwy 20 Crossing**
3	12"-18"		Majority of Canal
4	18"-24"		
5	>24"	Low Risk	

  - Critical Location at Highway 20 (Segment 1)
- Vegetation
  - Generally minor hazards observed
  - Lowest rating at 9 Mile Spill (Segment 10)

Canal System Condition Assessment - Structural

- Superstructure and Substructure
  - Most timber members are exceeding their useful life.
  - Insufficient connections
- Foundation
  - Minor cracking of concrete
  - Loss of support within Segment 3
- Liner
  - Liner of elevated Lennon flume missing brackets and adequate connections

Canal System Condition Assessment - Geotechnical

- Foundation Stability
  - Portion of flume out of plumb in Segment 4
- Erosion
  - Minor erosion and scour, critical section at Hickman Spill (Segment 12)
- Slope Stability
  - Sporadic separation of bench from canal liner in select locations
  - History of instability and landslides in several segments
  - Most notable location at Hickman Spill (Segment 12)
- Rock Fall
  - Minor observations within Segment 1

Tunnel Condition Assessment

- Tunnels generally in good condition, no major findings

Spillway Condition Assessment

The team reviewed **15** spillways and **3** siphons.

Features assessed:

- Structural components
- Handrails
- Retaining walls
- Geotechnical issues
- Hydraulic conditions
- Mechanical/electrical components
- Maintenance access

General assessment/needs:

- Aging equipment will require regular renewal
- Some spills abandoned or partially abandon
- Significant concerns with spill channel backcutting on major spill channels
- Attention to fall protection and worker access/safety
- Operational experience turnover

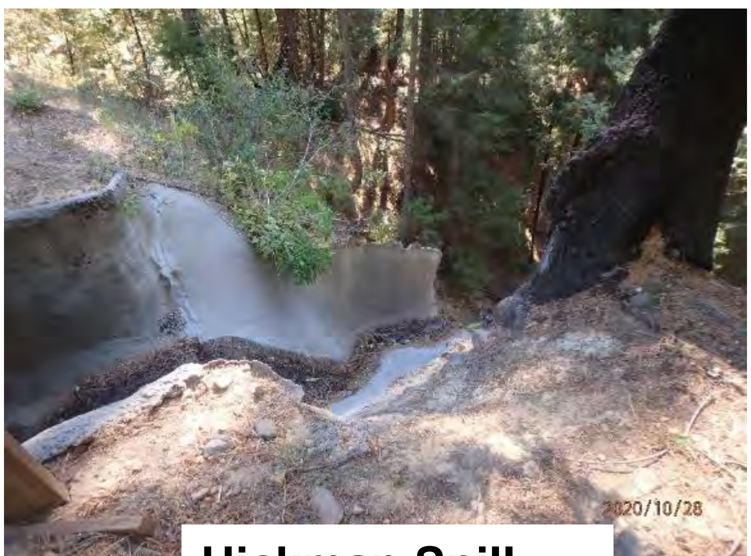
Mead & Hunt GHD

Spillway Condition Assessment

Highest risk/investment need spillways:

- Yunk's spill
- Hickman Spill
- Big Tunnel Spill

Yunk's Spill



Hickman Spill

Big Tunnel Spill

Risk Assessment – Critical Findings

- Majority of timber members are deteriorated, a great many are split, dry-rotted, and lack competent connections.
- Segment 1 – Erosion of the foundation and freeboard limitations at Highway 20
- Segment 9 – Erosion at the downslope side of the flume
- Segment 12 – Erosion and slope stability at Hickman Spill
- Segment 15 – Deteriorated timber flume and upslope landslide
- Big Tunnel Spill – Erosion and structural condition of the spillway chute
- Yunk’s Spill – Wood box flume through the right bank of the canal failing

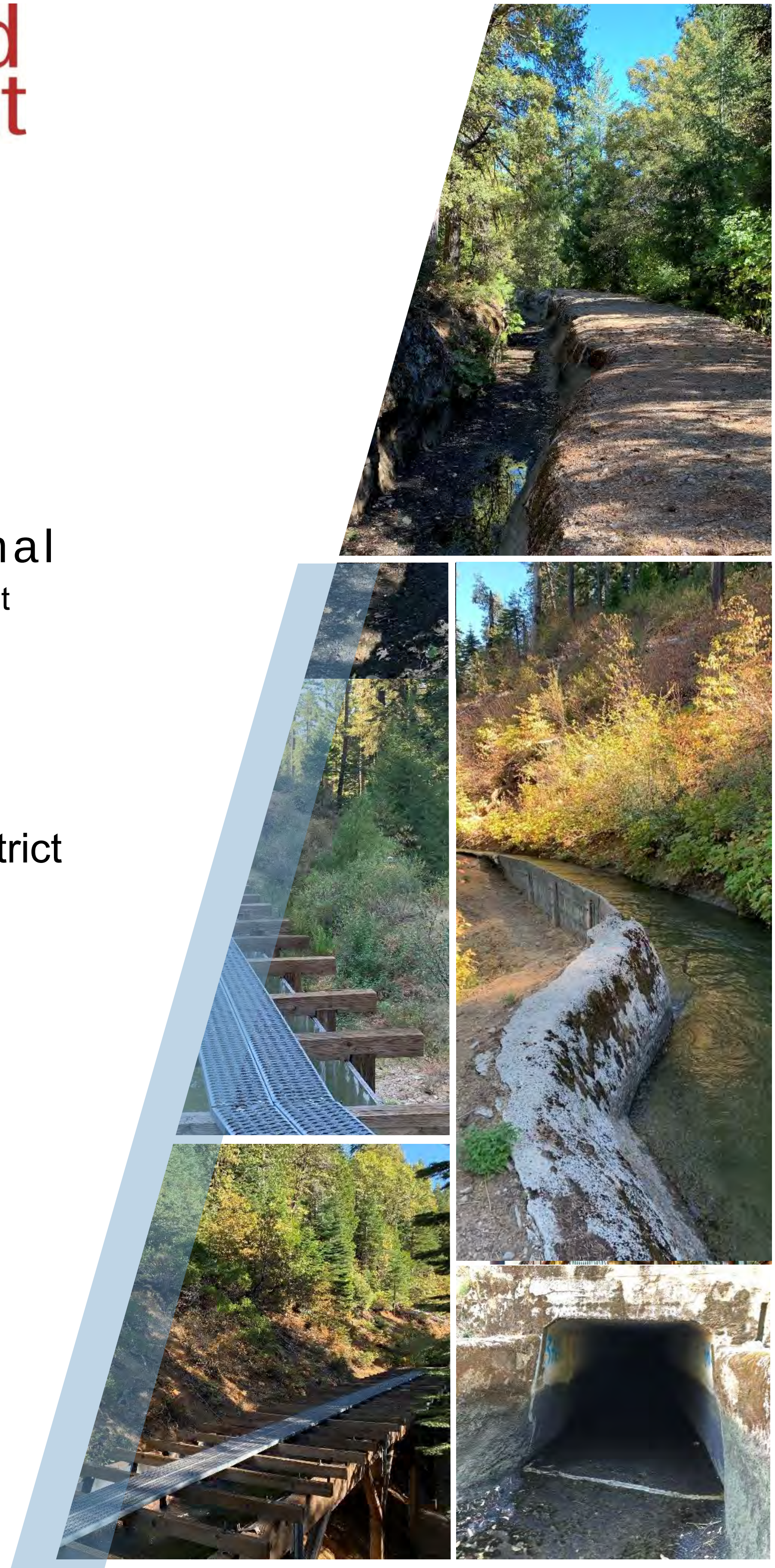
Conclusions and Recommendations

- Freeboard
  - Critical location at Highway 20 - modify flume to provide additional freeboard
- Vegetation
  - Remove hazard trees, monitor embankments
- Liner, Superstructure, Substructure, and Foundation
  - Robust Maintenance Program with Targeted Replacements
- Foundation Stability and Erosion
  - Monitor for additional erosion
- Slope Stability
  - Monitor for further movement
- Rock Fall
  - Continue to monitor potential rockfall locations
- Spillways
  - Stabilization of spillway chutes/discharge points
- Rough order of magnitude CIP estimates for critical sites

Final Report

South Yuba Canal

2021 Condition Assessment



Nevada Irrigation District

11211964 | August 2021

Executive Summary

The South Yuba Canal and Chalk Bluff Canal are part of Pacific Gas & Electric Company's (PG&E's) Drum-Spaulding Project, Federal Energy Regulatory Commission (FERC) Project No. 2310. These canals deliver water from Lake Spaulding in eastern Nevada County to Deer Creek Forebay east of Nevada City, a distance of about 19 miles. Nevada Irrigation District (NID) is in the process of purchasing a large portion of South Yuba Canal, the entire Chalk Bluff Canal, and the Deer Creek Powerhouse from PG&E, as these canals provide a consumptive water supply for NID and are used to generate electricity at Deer Creek hydroelectric powerhouse. The Deer Creek facilities began operating in 1908, and the powerhouse has a generating capacity of 5.7 megawatts. NID and PG&E have requested FERC to create a separate hydroelectric license for the Deer Creek facilities.

This Condition Assessment Report has been prepared based on initial findings of field inspections along the System and a review of background information provided by NID. The report includes a discussion of the project background, the methodology of the field inspection, the findings of the field inspections of the canal and flumes, tunnels and spillways, the risk matrix, and conclusions and recommendations.

The System consists of a combination of several conveyance types including approximately 14,900 feet of raised Lennon flume, 6,600 feet of wood box flume, 64,100 feet of gunite-lined canal, and 1,800 feet of concrete bench flume. Lennon flumes consist of half round steel canal with both timber or steel structures. Timber box and concrete box flumes are generally supported on timber substructures. The gunite-lined canal is generally lined on all sides, with portions having unlined walls or floors.

Field inspections were performed between October 27 and November 4, 2020. Prior to the field inspection, a meeting was held onsite with PG&E and NID to discuss historic performance of the System. NID personnel accompanied the field inspection team for the duration of the inspection.

The inspection team focused on a general assessment of the canal, geotechnical and structural components, spillways, and the two tunnels as described in the following sections.

- The general assessment included access points, freeboard estimates, and vegetation threat analysis.
- Structural components of the raised flumes include the superstructure, substructure, foundations, and liner. The term "liner" is used for both gunite or shotcrete "lined" in-earth or freestanding structure and the "lining" within a wood flume structure.
- Geotechnical issues include foundation stability of the canal system, erosion of the System and foundation, slope stability of the benches and slopes along the canal, and rock fall potential of areas upslope of the canal.
- For spillways the inspection team looked at structural components, handrails, retaining walls, geotechnical issues, hydraulic conditions, mechanical/electrical components, and maintenance access.

- The tunnel inspection team focused on the tunnel liner condition, bedrock condition, and other features.

Following the field inspection and background information review, the canal was segmented into 23 reaches based on the type of conveyance, geologic conditions, and other identifiers. Ratings were applied to the observations summarized above ranging from 1 to 5. Features assigned a rating of 1 are higher priority items that should be addressed as soon as possible, as there may be a threat to the System if the issue is not resolved. Features assigned a rating of 5 are in good condition and no action is required.

In addition to the condition rating, an importance factor was assigned to each rating criteria. An importance factor of 1 was assigned to those criteria that would have more impact to the System and an importance factor of 3 was assigned to those that would have the least impact.

A weighted risk rating was calculated for each segment based on the features included. The condition rating was multiplied by the importance factor for the applicable features, and these values were averaged. Lower values reflect areas that will need focused attention.

Preliminary findings show that the following canal and flume segments have more associated risk and should be prioritized for future work and additional field testing:

- Segment 1 had a poor rating due largely to erosion of the foundation and freeboard limitations at Highway 20. In addition, the timber structure is weathered, and the liner is separated from the supports.

- Segment 9 received a poor rating largely due to the continuing erosion at the downslope side of the flume.

- Segment 12 received a poor rating due to concerns at Hickman Spill, where erosion and slope stability was a concern at the spillway discharge.

- Segment 15 received a poor rating due to the poor nature of the existing timber flume and the upslope landslide.

The spillway weighted risk ratings account for a wide range of disparate factors. The complexity of individual spillways, as well as their function in regulating the system, varies greatly. At certain sites a moderate investment can significantly improve the ratings, whereas significant investments are necessary elsewhere to make moderate risk reductions. The risk rating should be employed accordingly. Preliminary findings show that the following spillways have more associated risk:

- Big Tunnel spill received poor ratings largely due to the geotechnical conditions related to erosion and structural condition of the spillway.

- Yunk's spill had a poor rating due to failing wood box flume through the right bank of the canal at this abandoned spill.

The following recommendations apply to the System based on the results of the risk assessment:

- The primary area of freeboard concern is the Lennon flume immediately upstream of the Highway 20 crossing. Although further review is required, crossing modifications may be too destructive. Surface roughness improvements for the box culvert may be possible but would provide marginal capacity upgrades. Lennon Flumes by their nature do not lend themselves to modifications to increase freeboard. Additional freeboard may be achieved by partial replacement with an alternative flume type.

- Hazard trees should be removed from the System footprint. Dense vegetation near the timber structures should be minimized to reduce fire danger.
- Required repairs for the timber superstructure and substructure include replacing split timber members, tightening bolts in hardware clips that are not fastened down, replacing hardware that does not fit with proper fitting hardware and replacing beams with splits through connectors.
- Consideration should be given to installing missing longitudinal bracing where it is missing, and all new construction should include the bracing.
- Material that has accumulated at the flume foundations should be cleared away and formerly buried timber inspected for dry rot. Erosion at foundation piers should be repaired and monitored. Seasonal draws may need to be further channelized through the foundation areas to prevent further erosion.
- Hardware supports should be replaced where the liner is not sufficiently supported on the flume substructure.
- Minor cracking of the gunite liner should be monitored and patched as needed. If voids have formed in areas where the liner is cracked should be filled prior to patching.
- Areas where instability is observed should be monitored and repaired as needed to maintain stability of the System.
- Potential landslide areas should be monitored for future movement and repaired as required. 8.1.8
- Areas where rock fall could impact the conveyance should be monitored.

August 30, 2021

Doug Roderick
Interim Engineering Manager
Nevada Irrigation District
1036 W. Main Street
Grass Valley, CA 95945

RE: Final Condition Assessment Report – South Yuba Canal
Nevada County, California

Dear Mr. Roderick,

GHD Inc and Mead & Hunt are pleased to present the attached Final Condition Assessment Report for the South Yuba Canal in Nevada County, California. The findings included in the final report are based on a field condition assessment performed in October and November of 2020 as well as a review of available background information related to the design, construction and maintenance of the system. The findings reflect our assessment of the condition of the canal at the time of the inspection, and recommendations are provided pertaining to the critical findings associated with the assessment.

If you have any questions regarding the information contained in this report, or if we may be of further assistance, please do not hesitate to contact us.

Sincerely,

Anthony Quintrall, P.E.
Senior Engineer

Stephen Sullivan, P.E.
Senior Engineer

Amy Deakyne, P.E.
Project Manager

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1. Introduction

The South Yuba Canal and Chalk Bluff Canal are part of Pacific Gas & Electric Company's (PG&E's) Drum-Spaulding Project, Federal Energy Regulatory Commission (FERC) Project No. 2310. These canals deliver water from Lake Spaulding in eastern Nevada County to Deer Creek Forebay east of Nevada City, a distance of about 19 miles. Nevada Irrigation District (NID) is in the process of purchasing a large portion of South Yuba Canal, the entire Chalk Bluff Canal, and the Deer Creek Powerhouse from PG&E, as these canals provide a consumptive water supply for NID and are used to generate electricity at Deer Creek hydroelectric powerhouse. The Deer Creek facilities began operating in 1908, and the powerhouse has a generating capacity of 5.7 megawatts. NID and PG&E have requested FERC to create a separate hydroelectric license for the Deer Creek facilities.

GHD and Mead & Hunt entered into an agreement with NID to perform a condition assessment of a portion of the South Yuba Canal and Chalk Bluff Canal (the System) as part of the transfer of ownership from PG&E to NID. The work was authorized under Task Order 1 of the Consultant Service Agreement (FATR #2419) between GHD Inc and NID dated April 7, 2020.

This Condition Assessment Report (Report) has been prepared based on initial findings of field inspections along the System and a review of background information provided by NID. The report includes a discussion of the project background, the methodology of the field inspection, the findings of the field inspections of the canal and flumes, tunnels and spillways, the risk matrix, and conclusions and recommendations.

1.1 Background Information Review

NID provided as-built drawings and plan sheets related to the System that were reviewed prior to the field inspection. The drawings included realignments of the canal, flume replacements, spillway design drawings, and other informational drawings that provided background. Available LiDAR data was obtained from the United States Geologic Survey (USGS) and utilized to prepare a contour map to assist in the condition assessment. The contour map was reviewed for potential landslide and breach locations along the system to identify areas that may be of interest during the field inspection.

1.2 Existing Features

1.2.1 Types of Conveyance

The System consists of a combination of several conveyance types including approximately 14,900 feet of raised Lennon flume, 6,600 feet of wood box flume, 64,100 feet of gunite-lined canal, and 1,800 feet of concrete bench flume. Lennon flumes consist of half round steel canal with both timber or steel structures. Timber box and concrete box flumes are generally supported on timber substructures. The gunite-lined canal is generally lined on all sides, with portions having unlined walls or floors.

1.2.2 Spillways

Several spillways are located along the system to provide relief points for water from the canal. Spillways include gated structures and passive overflow weirs that discharge into side chutes/pipes that discharge into natural or manmade drainage channels. Siphon pipe spills, which actuate when water levels reach excessive heights to siphon off excessive flows in the canal, are also employed as canal relief elements.

1.2.3 Tunnels

There are two tunnels along the alignment of the System totaling approximately 3,940 feet: Little Tunnel and Big Tunnel. Little Tunnel is located within the South Yuba Canal; Big Tunnel is located between South Yuba Canal and Chalk Bluff Canal.

1.2.4 Access Roads

Access roads are located throughout the area and are generally unpaved. In addition, equipment ramps are located sporadically throughout the system to provide access. A map showing existing access roads was provided by NID and used during the information review and field inspection to identify access limitations to the system.

1.2.5 Map Book

Appendix A includes a Map Book that shows existing features of the System, as well as pertinent findings of the condition assessment.

1.3 History of Improvements

The following sections describe a history of major improvements to the System based on the information provided by NID.

1.3.1 1937 to 1941 Canal Realignment

Historic plans were provided showing the realignment of the South Yuba Canal from original project Stations 40+08 to 289+04 between 1937 and 1941, which includes the current project from the YB-139 Spill through Telephone House Flume. The realignment included the replacement of portions of the existing wooden flume and gunite canal with Lennon Flume on a wooden substructure. The remainder of the wooden flume was left in place.

1.3.2 1957 Gunite Bench Canal

In 1957, a portion of the existing wood flume between YB-139 and Highway 20 was replaced with a gunite bench canal. The canal had a bottom width of seven feet and 0.25H:1V slopes. The gunite was two inches thick with wire mesh reinforcement. A section of the gunite bench included a freestanding concrete wall, which was two inches thick with wire mesh.

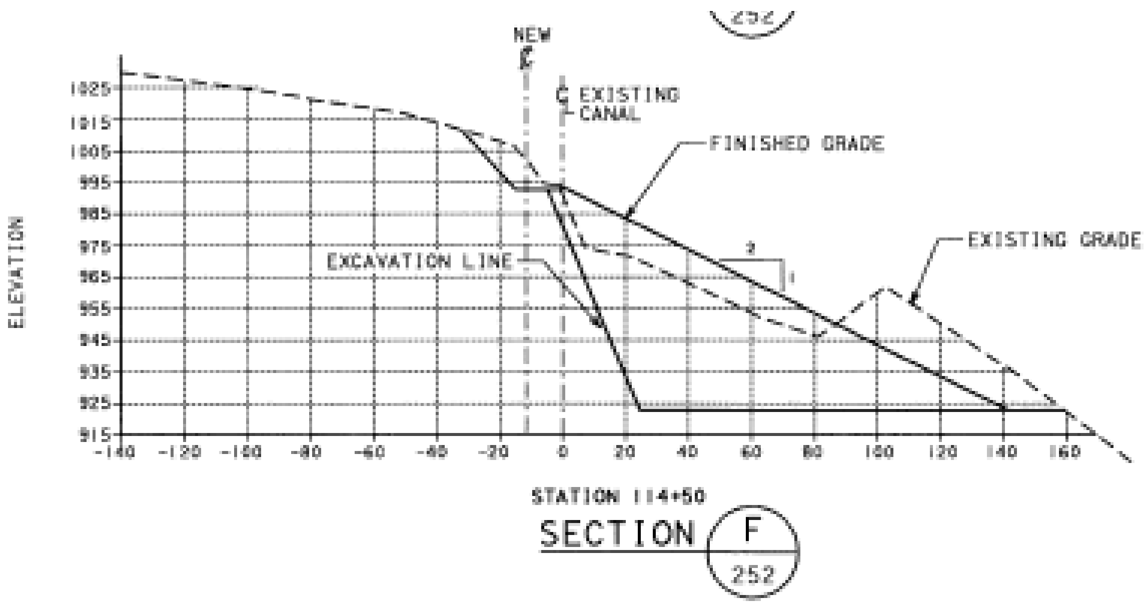
1.3.3 2012 Shotcrete Improvements

Four sites were identified for shotcrete improvements in 2012. Based on the provided drawings, three of the sites were deferred, and it is not clear if the work has been completed. Site 12-01 was completed downstream of Steep Hollow Flume for a distance of approximately 600 linear feet.

1.3.4 1993 Chalk Bluff Canal Landslide Repair

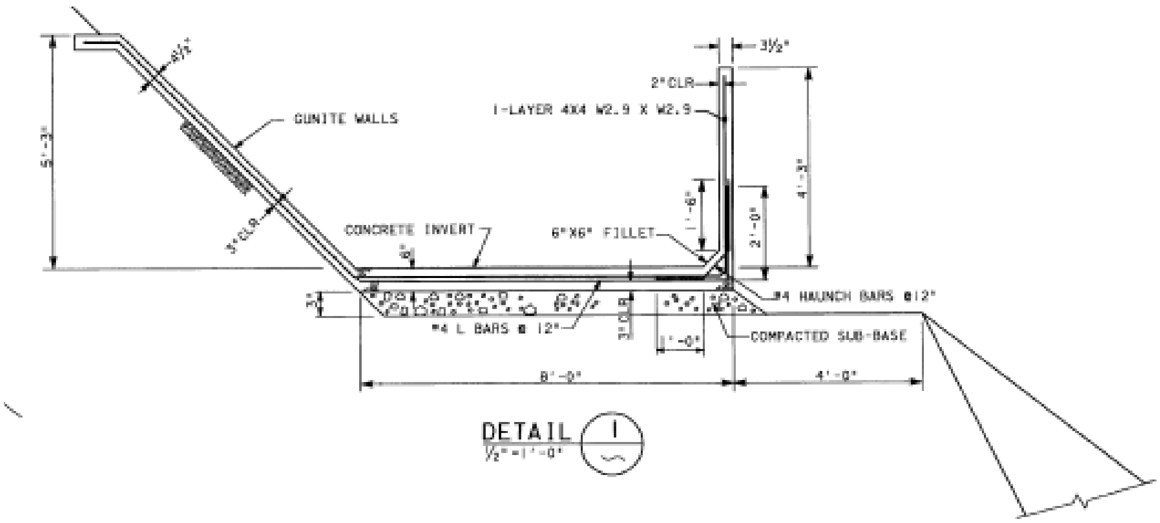
In January 1993, a large landslide approximately 550 feet of Chalk Bluff Canal. The landslide impacted the entire in-grade canal, resulting in slumping of the existing slope. The repair included the excavation of the landslide mass to the slide plane and the reconstruction of the embankment with a combination of drained fill and a Mechanically Stabilized Earth (MSE) wall. Figure 1.1 shows a typical section of the slope repair, along with the existing grade of the landslide mass.

Figure 1.1 Typical Section of 1993 Landslide Repair



The replacement canal consisted of gunite on the upslope side, concrete bottom, and a freestanding concrete wall on the downslope side, as shown on Figure 1.2.

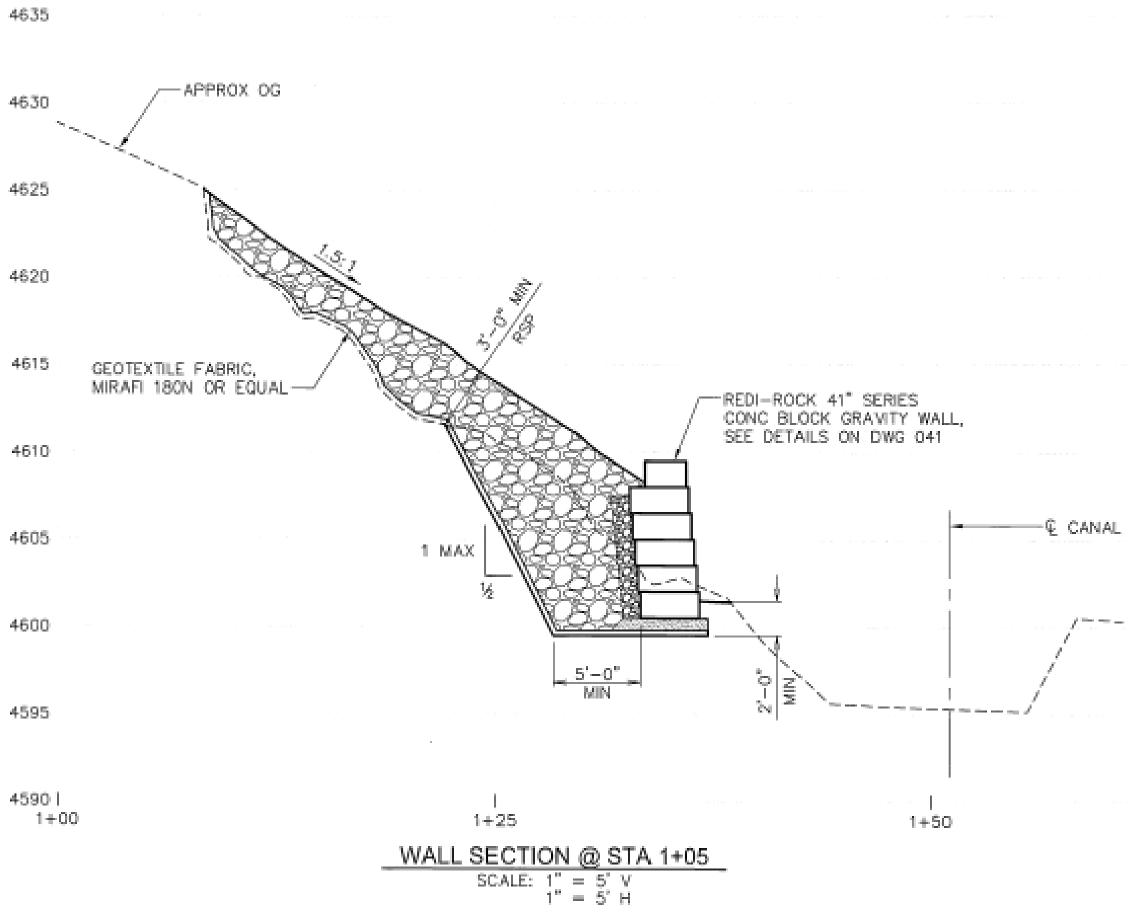
Figure 1.2 Typical Replacement Canal at 1993 Landslide Repair



1.3.5 2013 Big Tunnel Landslide

In 2013, a shallow landslide was repaired upstream of Big Tunnel. The landslide repair was approximately 70 linear feet along the canal and consisted of a concrete block gravity wall in front of rock slope protection with a 1.5H:1V slope. The wall ranged from 3 to 10 feet high. A typical section is shown in Figure 1.3.

Figure 1.3 Big Tunnel Landslide Repair Typical Section



1.3.6 2014 Big Tunnel Spillway Rehabilitation

Big Tunnel Spill was rehabilitated in 2014 after a void was discovered under the existing gunite. The void was backfilled with riprap, and a new shotcrete liner was placed on the spillway. Rock slope protection was placed along the edge of the liner.

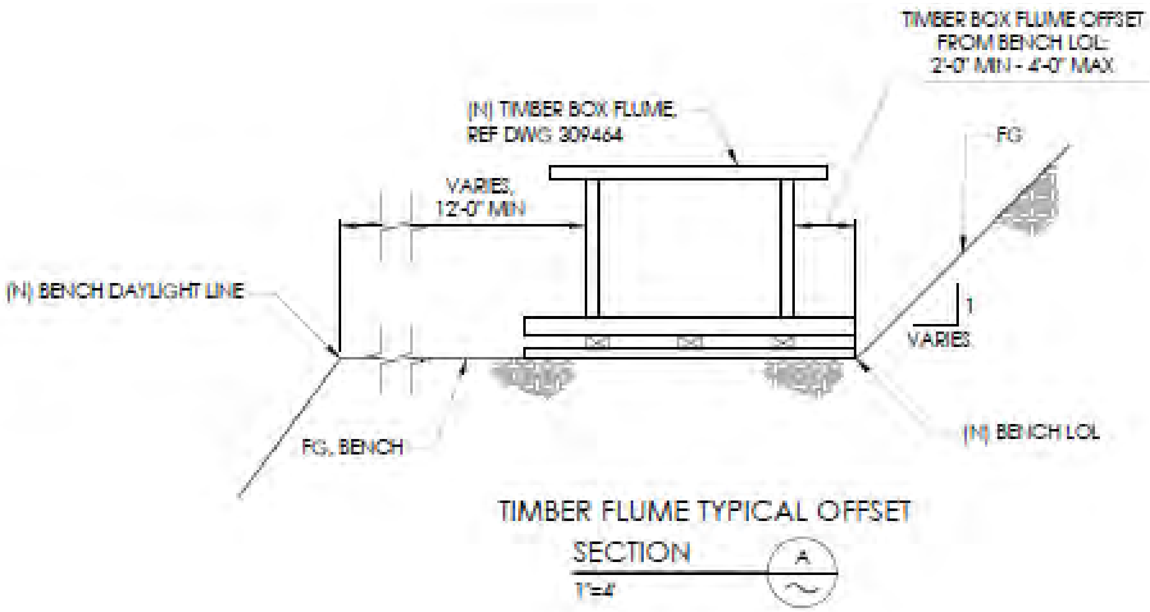
1.3.7 2015 Big Tunnel Shaft Backfill

In 2015 the shaft used for construction of Big Tunnel was backfilled with polyurethane foam and topped with a bentonite seal underlaying an unreinforced concrete cap. The unreinforced concrete had a total height of approximately 8.4 feet. A reinforced concrete pad was placed on top of the unreinforced concrete. A 72-inch corrugated metal standpipe was placed above the bentonite seal protruding approximately two feet above the concrete pad.

1.3.8 2017 Flume 8/5 Landslide Repair

A landslide occurred in 2017 near Flume 8/5 that impacted approximately 250 feet of canal. The repair project consisted of the excavation of the upslope area and the realignment of the canal to the south. New transition structures were constructed to tie the new timber bench flume into the existing canal on either end. A typical section of the timber box flume is shown on Figure 1.4.

Figure 1.4 Timber Box Flume at 8/5 Flume Landslide Repair



1.4 Previous Condition Assessment

A Microsoft Excel spreadsheet was provided by NID that summarized the 2012 condition assessment of the canal performed by PG&E. This condition assessment was referenced for the site inspection to highlight areas that would be of interest to the inspection team. An updated condition assessment was requested from PG&E but was not made available prior to this report.

Areas identified as potential hazards in the 2012 assessment that were not repaired or scheduled to be repaired were included in the rating of the system. These hazards generally consisted of geotechnical and geologic features such as landslides and slope instability. The details of the application of these ratings based on the PG&E condition assessment are described in Section 3.

2. Methodology

2.1 Field Inspection

An initial field inspection of the System was performed on October 27 and October 28, 2020, which included a preliminary assessment of the canal features and components. Prior to the field inspection, a meeting was held onsite with PG&E and NID to discuss historic performance of the System. Field inspectors took notes and photographs of notable observations. NID personnel accompanied the field inspection team for the duration of the inspection.

Select areas along the canal were revisited on November 3, 2020 for a more detailed inspection of areas identified on the preliminary site walk. The two tunnels included were inspected on November

4, 2020. Similar to the initial site walk, NID personnel were present for the duration of both the additional field inspection and the tunnel inspection. PG&E and a consultant performed an inspection of the tunnel concurrently with the GHD team.

The inspection team focused on a general assessment of the canal, geotechnical and structural components, spillways, and the two tunnels as described in the following sections.

2.1.1 General Assessment

The general assessment included access points, freeboard estimates, and vegetation threat analysis. Access points were reviewed in the field as well as from access road information provided by NID and available aerial photography to determine where access is available to each segment as well as to identify staging areas for future construction activities.

For each segment of canal, the freeboard has been classified based upon field measurements. Ratings were assigned in 6-inch increment ranges from High Risk at less than 6 inches to Low Risk at over 24 inches of freeboard. Field measurements were taken at various points along the reach, at transitions, and at critical areas of flow disruption as required. The measurements were based upon visible highwater marks. Care was taken to select the highwater mark based upon current operation as it is understood that the canal was historically operated at higher flow rates.

Vegetation threat analysis included hazard trees or stumps that could pose a threat to the canal system as well as density of vegetation with regard to potential file damage for the timber components.

2.1.2 Structural

Structural components of the raised flumes include the superstructure, substructure, foundations, and liner. The term “liner” is used for both gunite or shotcrete “lined” in-earth or freestanding structure and the “lining” within a wood flume structure.

2.1.3 Geotechnical

Geotechnical issues include foundation stability of the canal system, erosion of the System and foundation, slope stability of the benches and slopes along the canal, and rock fall potential of areas upslope of the canal.

2.1.4 Spillway Assessment

The inspection team looked at structural components, handrails, retaining walls, geotechnical issues, hydraulic conditions, mechanical/electrical components, and maintenance access.

2.1.5 Tunnel Inspection

The tunnel inspection team observed the Little and Big Tunnels, focusing on the tunnel liner condition, bedrock condition, and other features.

2.1.6 Geophysical Analysis

A geophysical investigation was performed subsequent to the field inspection to further identify potential landslide conditions in one critical area identified during the site walk as described below.

2.2 Segmentation of Conveyance

Following the field inspection and background information review, the canal was broken down into 23 segments based on the type of conveyance, geologic conditions, and other identifiers, as shown in the following table. During a review of the background infomration, it was determined that the previous alignment diverted from the canal in several locations. For the purpose of tracking the inspection findings, a new alignment was created with Station (Sta) 0+00 at the YB-139 spillway, the beginning of the System.

Table 2.1 Segmentation of Canal System

Segment	Approximate PG&E Stationing		New Alignment Stationing			Notes
	Beg Station	End Station	Beg Station	End Station	Distance (feet)	
1	82+93	153+43	0+00	70+50	7,050	From YB-139 to Highway 20 crossing
2	153+43	202+18	70+50	119+50	4,900	From Highway 20 to Bear Valley Spill
3	202+18	212+84	119+50	130+00	1,050	Gunite Flume from Bear Valley Spill to Segment 3 Wood Box Flume
4	212+84	274+04	130+00	192+00	6,200	Wood Box Flume between Segment 3 Gunite Flume and Segment 4 Lennon Flume
5	274+04	289+64	192+00	206+90	1,490	Telephone House Lennon Flume
6	289+64	402+33	206+90	319+50	11,260	Gunite Canal between Telephone House flume and Little Tunnel
7	402+33	405+91	319+50	323+60	410	Little Tunnel
8	405+91	452+08	323+60	370+00	4,640	Lined Canal with short Lennon Flume between Little Tunnel and 2017 Landslide Repair
9	452+08	453+78	370+00	372+50	250	2017 Landside Repair
10	453+78	505+70	372+50	425+00	5,250	Lined Canal between 2017 Landslide Repair and Steep Hollow Flume
11	505+70	507+83	425+00	427+50	250	Steep Hollow Flume
12	507+83	561+10	427+50	482+00	5,450	Lined Canal between Steep Hollow Flume and Hickman Spill
13	561+10	649+54	482+00	555+00	7,300	Lined Canal between Hickman Spill and Excelsior Spill
14	649+54	682+47	555+00	605+00	5,000	Lined Canal between Excelsior Spill and Existing Landslide
15	682+47	684+32	605+00	606+50	150	Wood Box Flume with Landslide
16	684+32	716+09	606+50	625+40	1,890	Lined Canal and Lennon Flume between Existing Landslide and Steep Hollow #2 Flume
17	716+09	779+94	625+40	637+50	1,210	Steep Hollow #2 Flume and Boot Road Flume

Table 2.1 Segmentation of Canal System

Segment	Approximate PG&E Stationing		New Alignment Stationing			Notes
	Beg Station	End Station	Beg Station	End Station	Distance (feet)	
18	779+94	789+07	637+50	712+00	7,450	Lined Canal between Flumes and Big Tunnel
19	789+07	821+19	712+00	747+30	3,530	Big Tunnel and Pipe
20	821+19	11+75	747+30	755+00	770	Concrete Box Flume downstream of Big Tunnel
21	11+75	111+55	755+00	856+50	10,150	Lined Canal between Concrete Box Flume and 1993 Landslide
22	111+55	118+60	856+50	862+40	590	1993 Landslide
23	118+60	169+11	862+40	913+60	5,120	Chalk Bluff Lined Canal downstream of 1993 Landslide

3. Canal System Condition Assessment

The following sections describe specific findings for each segment as observed in the field. Photographs of representative observations are included in Appendix B.

3.1 Segment 1

Segment 1 extends from the YB-139 spillway structure at Sta 0+00 to the downstream end of the Highway 20 crossing at Sta 70+80. The segment consists of elevated Lennon Flume with a wooden substructure with a gunite bench flume from approximate Stations 32+80 to 34+50. A concrete box culvert crosses under Highway 20. The condition of this segment was observed along the top of the flume on metal grates to assess the superstructure, and along the foundation piers to assess the substructure and foundation.

3.1.1 General Assessment

3.1.1.1 Access Points

At the upstream end of the segment, access is available at the PG&E Bear Valley Yard through Chicken Ladder Road, which is accessed from Bowman Lake Road. At the downstream end, access is available off Highway 20 from Burnt Point Road. Burnt Point Road is located between approximately 60 and 180 feet south of the flume, with smaller spur roads perpendicular to the flume. However, access to the flume is limited to pedestrian, as the spur roads are largely undeveloped. Potential staging areas along the segment include the Bear Valley Yard and an approximately 0.5-acre clearing adjacent to Burnt Point Road near Station 46+00.

3.1.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates ranged from 10 inches just upstream of Highway 20 to 18 inches at the greatest. Freeboard estimates ranged between 11 and 12 inches at YB139 and one other point along the segment. NID noted that this area is a constriction in the system and impacts the ability to pass additional flows in the System.

The Highway 20 concrete culvert crossing was visible and found to be open channel flow (with an air gap) with the lower section steel-lined and shaped to match Lennon Flume sections, no abrupt upstream and downstream transitions, and one minor angle point. Short of replacement, minor culvert capacity improvements (e.g., lowering roughness) would likely not have a significant affect. Modification to increase the freeboard on the flume immediately upstream would be the most effective approach to address this deficiency. A flow test to visualize deficiencies may yield more data.

3.1.1.3 Vegetation Threat Analysis

The inspection team identified sporadic potential hazard trees along the segment, though no imminent threats were observed. The flume substructure is wooden and would be susceptible to fire damage; however, the adjacent areas were largely cleared of dense vegetation and trees.

3.1.2 Structural Assessment

3.1.2.1 Superstructure

Consistent issues were identified for timber members as described below. These findings were consistent throughout most of the System and will be discussed in detail within this segment and referenced in later segments as appropriate.

Extremely weathered main beams, columns and secondary members were prevalent, including checking (longitudinal, non-through cracks) and splitting (through cracks) at connection nail and bolt holes. Dry rot was observed in various locations mostly at the ends of beams and bracing members as well as in and around bolt holes.

Poorly designed beam to column connection hardware did not provide sufficient bolt end and edge distance, resulting in split members.

The flume support hardware layout results in mis-installed hardware and little or no support for the flume. This problem is exacerbated in tightly turning flume alignments. More specifically, where hanger rod attachment plates occur at supporting beam splices, the beam-to-column attachment hardware prevents installation, so the clips are set loosely on top of the beam with no means of positive attachment. In tight turns, the difference between the straight-line timber construction and curving canal tin results in fit-up problems where standard support plates do not work, and an alternate plate size/design is warranted. In the worst cases there may be three to four hanger rods in a row without support.

Numerous hanger plates were not adequately attached to the supporting beams including locations where lag bolts were not fully installed. There was discussion in the field that installers preferred to leave the bolts loose, however once installation is complete and during the first waterup, bolts should have been torqued properly. Bolts were found with as much as three inches between the head and connector plate.

3.1.2.2 Substructure

Weathered columns in older constructs included some checking and splitting at column connection bolt holes. In areas of unstable soils, some foundations were buried, and some wood columns were exposed to earth.

Bracing members at bents that utilize nails at connection points were loose and ineffective. Many members were checked and split. There was a general lack of effective substructure bracing in the longitudinal direction.

Dry rot was observed in several columns and connections throughout the System. No immediate hazards were observed, but timber members should be monitored for further degradation.

3.1.2.3 Foundation

In areas of unstable soils there were some buried foundations, and some foundation bottoms were exposed as a result of erosion and/or shallow slides.

Most concrete was found intact and in good condition. In some locations, concrete was more weathered and even cracked, suggesting inferior concrete.

3.1.2.4 Liner

Along the downstream portion of the elevated flume, several locations were observed where there was a significant gap between the Lennon flume lining, its support rods, and the supporting wood beams. In these locations the standard support plates had inadequate reach. This primarily occurs in tight turns where straight beams and curved metal flume were coincident. A hardware change at the turns would have been appropriate. As a result, the flume is often only supported 25 to 50% of its length.

3.1.3 Geotechnical Assessment

3.1.3.1 Foundation Stability

Foundation stability at a seasonal draw near Sta 44+00 should be monitored, as it relates to loss of support due to erosion of foundation soils.

3.1.3.2 Erosion

Erosion of surface soils was observed near the seasonal draw at Sta 44+00. The area should be monitored for future erosion. In addition, the Highway 20 culvert directed drainage flows at the foundation of the flume, causing erosion around the piers.

3.1.3.3 Slope Stability

No slope stability issues were identified within Segment 1.

3.1.3.4 Rock Fall

PG&E identified two potential rock fall locations along the flume at PG&E Stations 132+64 and 134+44. These areas should be monitored for future rock fall potential.

3.2 Segment 2

Segment 2 extends from Highway 20 at Sta 70+80 to Bear Valley Spillway at Sta 119+40. The segment consists of elevated Lennon Flume with a wooden substructure. The condition assessment was completed along the top of the flume on metal grates and along the foundation piers.

3.2.1 General Assessment

3.2.1.1 Access Points

Access to Segment 2 is via Zeibright Road from Highway 20. Bear Valley Spillway Road begins at Zeibright Road on the south side of the flume, crosses under the flume near Sta 87+00, and extends along the north side of the flume to Sta 128+00 within Segment 3. Staging areas are relatively limited along Segment 2, although there are several locations for truck turnaround and for access to the flume foundation.

3.2.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates ranged from 15 inches to 20 inches.

3.2.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 2.

3.2.2 Structural Assessment

3.2.2.1 Superstructure

Findings within Segment 2 were consistent with Segment 1 above.

3.2.2.2 Substructure

Findings within Segment 2 were consistent with Segment 1 above. In addition, a temporary support had been constructed at a location where the flume was known to be sagging, which may be indicative of other issues.

3.2.2.3 Foundation

Findings within Segment 2 were consistent with Segment 1 above.

3.2.2.4 Liner

Findings within Segment 2 were consistent with Segment 1 above.

3.2.3 Geotechnical Assessment

3.2.3.1 Foundation Stability

No foundation stability issues were identified within Segment 2.

3.2.3.2 Erosion

Erosion of surface soils was observed near several seasonal draws along the segment. These areas should be monitored for future erosion.

3.2.3.3 Slope Stability

No slope stability issues were identified within Segment 2.

3.2.3.4 Rock Fall

No rock fall issues were identified within Segment 2.

3.3 Segment 3

Segment 3 extends from Bear Valley Spillway at Sta 119+40 to the beginning of the wood box flume at Sta 129+90. The segment consists of Concrete Bench Flume that was a replacement of the historic wood box flume at some point after the 1940s.

3.3.1 General Assessment

3.3.1.1 Access Points

Access to Segment 3 is via Bear Valley Spillway Road. Similar to Segment 2, staging areas are limited along the flume, but there are locations for truck turnaround.

3.3.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates ranged from 18 inches to 24 inches.

3.3.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 3.

3.3.2 Structural Assessment

There were no raised structures within Segment 3. No liner issues were observed within the segment.

3.3.3 Geotechnical Assessment

3.3.3.1 Foundation Stability

No foundation stability issues were identified within Segment 3.

3.3.3.2 Erosion

No erosion issues were identified within Segment 3.

3.3.3.3 Slope Stability

No slope stability issues were identified within Segment 3.

3.3.3.4 Rock Fall

No rock fall issues were identified within Segment 3.

3.4 Segment 4

Segment 4 extends from the end of the Segment 3 concrete box flume at Sta 129+90 to Telephone House Flume at Sta 191+95. The segment consists of wood box flume. Cape Horn Spill was located within Segment 4.

3.4.1 General Assessment

3.4.1.1 Access Points

Access to Segment 4 is limited to pedestrian access at the upstream end of the segment and along the top of the flume. Telephone House Road (from Lowell Hill Road) provides access to the downstream end of the segment. Due to the terrain, there are no staging areas along the segment. There are potential staging areas along Lowell Hill Road, but access to the flume alignment is limited.

3.4.1.2 Hydraulic Analysis (Freeboard)

Freeboard measurements ranged from 15 to 18 inches along the segment and approximately 24 inches at the transition to wood box flume.

3.4.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 4.

3.4.2 Structural Assessment

3.4.2.1 Superstructure

Findings within Segment 4 were consistent with Segment 1 above.

3.4.2.2 Substructure

Findings within Segment 4 were consistent with Segment 1 above. In addition, a portion of the flume was out of plumb, likely due to the undocumented nature of the footings.

3.4.2.3 Foundation

Findings within Segment 4 were consistent with Segment 1 above.

3.4.2.4 Liner

Findings within Segment 4 were consistent with Segment 1 above.

3.4.3 Geotechnical Assessment

3.4.3.1 Foundation Stability

A portion of the flume within Segment 4 was founded on undocumented concrete material and was observed to be out of plumb.

3.4.3.2 Erosion

No erosion issues were identified within Segment 4.

3.4.3.3 Slope Stability

No slope stability issues were identified within Segment 4.

3.4.3.4 Rock Fall

No rock fall issues were identified within Segment 4.

3.5 Segment 5

Segment 5 includes Telephone House Flume from Sta 191+95 to 206+80. The flume is a half round canal supported on a timber structure.

3.5.1 General Assessment

3.5.1.1 Access Points

Access to Segment 5 is available from Telephone House Road, which spurs from Lowell Hill Road and ends near the upstream side of the segment. Flume End Spur extends from Telephone House Road to the flume at the downstream end. There is a clearing near Flume End Spur that could be used for staging.

3.5.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates ranged from 16 to 23 inches along the segment.

3.5.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 5.

3.5.2 Structural Assessment

3.5.2.1 Superstructure

Findings within Segment 5 were consistent with Segment 1 above.

3.5.2.2 Substructure

Findings within Segment 5 were consistent with Segment 1 above.

3.5.2.3 Foundation

Findings within Segment 5 were consistent with Segment 1 above.

3.5.2.4 Liner

Findings within Segment 5 were consistent with Segment 1 above.

3.5.3 Geotechnical Assessment

3.5.3.1 Foundation Stability

No foundation stability issues were identified within Segment 5.

3.5.3.2 Erosion

No erosion issues were identified within Segment 5.

3.5.3.3 Slope Stability

No slope stability issues were identified within Segment 5.

3.5.3.4 Rock Fall

No rock fall issues were identified within Segment 5.

3.5.3.5 Field Testing

No geotechnical field testing was performed within Segment 5.

3.6 Segment 6

Segment 6 extends from the end of Telephone House Flume at Sta 206+80 to Little Tunnel at Sta 319+60. The segment consists of gunite lined canal. Little Tunnel Spill is located within Segment 6. A short section of Lennon Flume is located near Little Tunnel (Flume 7/1).

3.6.1 General Assessment

3.6.1.1 Access Points

Access to Segment 6 is via Telephone House Road, Upstream Little Tunnel Spill Road, Levy Ditch Camp Road, Downstream Little Tunnel Canal Spill, Upstream Little Tunnel Spill Canal Spur, and Little Tunnel Inlet Road, all of which extend from Lowell Hill Road to the System.

3.6.1.2 Hydraulic Analysis (Freeboard)

The average field freeboard estimate was approximately 20 inches, with the majority of the segment above 24 inches.

3.6.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 6.

3.6.2 Structural Assessment

Flume 7/1 is a Lennon flume with half round metal canal and timber substructure, constructed in 1994. There were no issues identified with the flume. Minor erosion was observed behind the liner and minor cracking of the gunite was identified.

3.6.3 Geotechnical Assessment

3.6.3.1 Foundation Stability

No significant foundation stability issues were identified within Segment 6. The inspection team observed cracking in the soils at the foundation of Flume 7/1, and evidence of additional supports constructed on the flume. This area should be monitored for future signs of movement.

3.6.3.2 Erosion

Minor erosion and voids were observed at several areas of the bench on the downslope side of the System and behind the canal liner.

3.6.3.3 Slope Stability

A small area upstream of Little Tunnel was observed to have separation of the bench from the canal liner with lateral offset. In addition, PG&E identified two locations upslope of the System that were potential landslide areas.

3.6.3.4 Rock Fall

No rock fall issues were identified within Segment 6.

3.7 Segment 7

Segment 7 consists of Little Tunnel. See Section 4 below for the tunnel condition assessment.

3.8 Segment 8

Segment 8 extends from Little Tunnel at Sta 323+70 to the 2017 landslide repair at Sta 370+00. The segment consists of gunite-lined canal with two Lennon flumes that have replaced portions of canal impacted by landslides (Flumes 8/2 and 8/4).

3.8.1 General Assessment

3.8.1.1 Access Points

Access to Segment 8 is via Lowell Hill Road and Downstream Little Tunnel Lower Spur at the upstream end and an unnamed forest service road that leads to the lower end. Potential staging areas are located near Little Tunnel and at the 2017 landslide repair (Segment 9).

3.8.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates averaged approximately 20 inches, with the majority of the segment greater than 24 inches.

3.8.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 8. Large stumps were observed in the canal bench that should be monitored.

3.8.2 Structural Assessment

Flumes 8/2 and 8/4 were both constructed in 1994 and appeared to be in good condition during the inspection.

3.8.2.1 Superstructure

No superstructure issues were identified within Segment 8.

3.8.2.2 Substructure

No substructure issues were identified within Segment 8.

3.8.2.3 Foundation

No foundation issues were identified within Segment 8.

3.8.2.4 Liner

No liner issues were identified within Segment 8.

3.8.3 Geotechnical Assessment

3.8.3.1 Foundation Stability

No foundation stability issues were identified within Segment 8.

3.8.3.2 Erosion

No erosion issues were identified within Segment 8.

3.8.3.3 Slope Stability

Historic landslides were observed downstream of Little Tunnel, where the canal has been replaced by Flumes 8/2 and 8/4. Slumps were observed in the bench in two locations along the segment that should be monitored. A landslide repair was observed at the Little Tunnel outlet where a MSE wall was constructed along the access road.

3.8.3.4 Rock Fall

No rock fall issues were identified within Segment 8.

3.9 Segment 9

3.9.1 General Assessment

Segment 9 includes the 2017 landslide repair, from approximate Sta 370+00 to Sta 372+40. The segment includes a timber flume on mud sill foundations.

3.9.1.1 Access Points

Vehicle access to the bench is available above the segment and pedestrian access available at the downstream end of the segment. The bench above the segment could likewise be used for staging.

3.9.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates averaged approximately 17 inches.

3.9.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 9.

3.9.2 Structural Assessment

3.9.2.1 Superstructure

No superstructure issues were identified within Segment 9.

3.9.2.2 Substructure

No substructure issues were identified within Segment 9.

3.9.2.3 Foundation

No foundation issues were identified within Segment 9.

3.9.2.4 Liner

No liner issues were identified within Segment 9.

3.9.3 Geotechnical Assessment

3.9.3.1 Foundation Stability

No foundation stability issues were identified within Segment 9.

3.9.3.2 Erosion

Erosion was observed in the bench supporting the timber flume that could impact the System.

3.9.3.3 Slope Stability

No slope stability issues were identified within Segment 9.

3.9.3.4 Rock Fall

No rock fall issues were identified within Segment 9.

3.10 Segment 10

Segment 10 extends from the 2017 landslide at Sta 372+40 to Steep Hollow #1 Flume at Sta 425+10. The segment consists of gunite-lined canal. 9½ Mile Spill is located within Segment 10.

3.10.1 General Assessment

3.10.1.1 Access Points

Access is limited to pedestrian access at the upstream end. Steep Hollow #1 Inlet Spur extends to the downstream end, accessible from Steep Hollow #1 Access Road. There are limited staging opportunities near Steep Hollow #1 access road.

3.10.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates averaged approximately 16 inches.

3.10.1.3 Vegetation Threat Analysis

Three hazard trees were identified at 9½ Mile Spillway where a fallen tree could impact the spillway and canal.

3.10.2 Structural Assessment

There were no raised structures within Segment 10. No erosion issues were identified within Segment 10.

3.10.3 Geotechnical Assessment

3.10.3.1 Foundation Stability

Foundation stability issues were identified by PG&E within Segment 10 at two locations.

3.10.3.2 Erosion

No erosion issues were identified within Segment 10.

3.10.3.3 Slope Stability

PG&E identified potential slope stability hazards within Segment 10.

3.10.3.4 Rock Fall

No rock fall issues were identified within Segment 10.

3.11 Segment 11

Segment 11 consists of Steep Hollow #1 Flume and extends from Sta 425+10 to 427+40. The flume is a half round canal with steel structure.

3.11.1 General Assessment

3.11.1.1 Access Points

Access to Segment 11 is available via Steep Hollow #1 Inlet Spur, accessible from Steep Hollow #1 Access Road. There are limited staging opportunities near Steep Hollow #1 access road.

3.11.1.2 Hydraulic Analysis (Freeboard)

Freeboard was not directly measured in the field but based on field notes and photographs, it was deemed to be sufficient.

3.11.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 11.

3.11.2 Structural Assessment

3.11.2.1 Superstructure

No superstructure issues were identified within Segment 11.

3.11.2.2 Substructure

No substructure issues were identified within Segment 11.

3.11.2.3 Foundation

No foundation issues were identified within Segment 11

3.11.2.4 Liner

No liner issues were identified within Segment 11

3.11.3 Geotechnical Assessment

3.11.3.1 Foundation Stability

No foundation stability issues were identified within Segment 11.

3.11.3.2 Erosion

No erosion issues were identified within Segment 11.

3.11.3.3 Slope Stability

No slope stability issues were identified within Segment 11.

3.11.3.4 Rock Fall

No rock fall issues were identified within Segment 11.

3.12 Segment 12

Segment 12 extends from Steep Hollow #1 Flume at Sta 427+40 to Hickman Spill at Sta 481+80. The segment includes gunite-lined canal.

3.12.1 General Assessment

3.12.1.1 Access Points

Access to Segment 12 is via Downstream Steep Hollow #1 Access Spur, which runs along the north side of the System.

3.12.1.2 Hydraulic Analysis (Freeboard)

The minimum field freeboard measurement was approximately 16 inches.

3.12.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 12.

3.12.2 Structural Assessment

There were no raised structures within Segment 12. No liner issues were observed within Segment 12.

3.12.3 Geotechnical Assessment

3.12.3.1 Foundation Stability

Foundation stability issues were observed at Hickman Spill, within Segment 12. See Section 5 below for further details.

3.12.3.2 Erosion

Erosion issues were observed at Hickman Spill, within Segment 12. See Section 5 below for further details.

3.12.3.3 Slope Stability

Slope stability issues were observed at Hickman Spill, within Segment 12. See Section 5 below for further details. In addition, potential slope movement was observed with separation of the liner near Steep Hollow #1 Flume.

3.12.3.4 Rock Fall

No rock fall issues were identified within Segment 12.

3.13 Segment 13

Segment 13 extends from Hickman Spill at Sta 481+80 to Excelsior Spill at Sta 554+35. The segment consists of gunite-lined canal with three short reaches of Lennon Flume.

3.13.1 General Assessment

3.13.1.1 Access Points

Access to Segment 13 was via Downstream Steep Hollow #1 access road.

3.13.1.2 Hydraulic Analysis (Freeboard)

The minimum measured freeboard within Segment 13 was 16 inches.

3.13.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 13.

3.13.2 Structural Assessment

Structural features within Segment 13 includes Flumes 11/1, 11/1A, and 11/2, which were constructed in areas where landslides impacted the canal.

3.13.2.1 Superstructure

No superstructure issues were identified within Segment 13.

3.13.2.2 Substructure

No substructure issues were identified within Segment 13.

3.13.2.3 Foundation

No foundation issues were identified within Segment 13.

3.13.2.4 Liner

Several reaches of the canal were in need of repair and patching.

3.13.3 Geotechnical Assessment

3.13.3.1 Foundation Stability

No foundation stability issues were identified within Segment 13.

3.13.3.2 Erosion

No erosion issues were identified within Segment 13.

3.13.3.3 Slope Stability

Potential landslides were observed in three locations within Segment 13.

3.13.3.4 Rock Fall

No rock fall issues were identified within Segment 13.

3.14 Segment 14

Segment 14 extends from Excelsior Spill at Sta 554+35 to the wood box flume at Sta 605+00.

3.14.1 General Assessment

3.14.1.1 Access Points

Access to Segment 14 is via Excelsior Spill Road. Limited staging areas were available near the segment.

3.14.1.2 Hydraulic Analysis (Freeboard)

Field estimates of freeboard within Segment 14 were greater than 24 inches.

3.14.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 14.

3.14.2 Structural Assessment

There were no raised structures within Segment 14. No liner issues were observed within Segment 14.

3.14.3 Geotechnical Assessment

3.14.3.1 Foundation Stability

No foundation stability issues were identified within Segment 14.

3.14.3.2 Erosion

No erosion issues were identified within Segment 14.

3.14.3.3 Slope Stability

Two potential landslide areas were identified within Segment 14.

3.14.3.4 Rock Fall

No rock fall issues were identified within Segment 14.

3.15 Segment 15

Segment 15 includes a wood box flume extending from 605+00 to 606+90.

3.15.1 General Assessment

3.15.1.1 Access Points

Access to Segment 15 is via 13 Mile Spill Road or unnamed forest service roads.

3.15.1.2 Hydraulic Analysis (Freeboard)

Field freeboard measurements were greater than 24 inches.

3.15.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 15.

3.15.2 Structural Assessment

3.15.2.1 Superstructure

Similar to Segment 1, the superstructure was highly weathered and showing signs of distress.

3.15.2.2 Substructure

The timber substructure had several observed locations of crushed girders and posts.

3.15.2.3 Foundation

No foundation issues were identified within Segment 15.

3.15.2.4 Liner

No liner issues were identified within Segment 15.

3.15.3 Geotechnical Assessment

3.15.3.1 Foundation Stability

No foundation stability issues were identified within Segment 15.

3.15.3.2 Erosion

Minor erosion was ongoing at the foundation of the timber flume.

3.15.3.3 Slope Stability

A potential landslide was observed upslope of the flume.

3.15.3.4 Rock Fall

No rock fall issues were identified within Segment 15.

3.16 Segment 16

Segment 16 extends from the wood box flume at 606+90 and Boot Road Flume at Sta 625+60. 13 Mile Spill is located within Segment 16.

3.16.1 General Assessment

3.16.1.1 Access Points

Access to Segment 16 is via 13 Mile Spill Road.

3.16.1.2 Hydraulic Analysis (Freeboard)

Field measurements of freeboard averaged 22 inches.

3.16.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 16.

3.16.2 Structural Assessment

Structural features within Segment 16 includes Flume 13/2.

3.16.2.1 Superstructure

No superstructure issues were identified within Segment 16.

3.16.2.2 Substructure

No substructure issues were identified within Segment 16.

3.16.2.3 Foundation

No foundation issues were identified within Segment 16.

3.16.2.4 Liner

No liner issues were identified within Segment 16.

3.16.3 Geotechnical Assessment

3.16.3.1 Foundation Stability

No foundation stability issues were identified within Segment 16.

3.16.3.2 Erosion

No erosion issues were identified within Segment 16.

3.16.3.3 Slope Stability

No slope stability issues were identified within Segment 16.

3.16.3.4 Rock Fall

No rock fall issues were identified within Segment 16.

3.17 Segment 17

Segment 17 extends from Sta 625+60 to 637+75 and includes Steep Hollow #2 Flume and Boot Road Flume.

3.17.1 General Assessment

3.17.1.1 Access Points

Access to Segment 17 was available at the downstream end via a dirt access road for Boot Road Flume. Staging areas along the access road were limited.

3.17.1.2 Hydraulic Analysis (Freeboard)

Field freeboard was measured to be approximately 16 inches in one location, with most of the canal greater than that.

3.17.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 17.

3.17.2 Structural Assessment

3.17.2.1 Superstructure

Findings within Segment 17 were consistent with Segment 1 above.

3.17.2.2 Substructure

Findings within Segment 17 were consistent with Segment 1 above.

3.17.2.3 Foundation

Findings within Segment 17 were consistent with Segment 1 above.

3.17.2.4 Liner

Findings within Segment 17 were consistent with Segment 1 above.

3.17.3 Geotechnical Assessment

3.17.3.1 Foundation Stability

No foundation stability issues were identified within Segment 17.

3.17.3.2 Erosion

No erosion issues were identified within Segment 17.

3.17.3.3 Slope Stability

No slope stability issues were identified within Segment 17.

3.17.3.4 Rock Fall

No rock fall issues were identified within Segment 17.

3.18 Segment 18

Segment 18 extends from Boot Road Flume at Sta 637+75 to Big Tunnel at Sta 712+90. The segment includes gunite-lined canal with four short segments of Lennon Flume. 14 Mile Spill is located within Segment 18.

3.18.1 General Assessment

3.18.1.1 Access Points

Access to Segment 18 was available at the upstream end via an unnamed access road on the north side of the System. Additional access roads were visible on aerial photography along the flume. Access at the downstream end was available via the Big Tunnel access road. Several cleared areas that could be suitable for staging were observed on aerial photography.

3.18.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates ranged from 14 inches to 16 inches.

3.18.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 18.

3.18.2 Structural Assessment

Structural features within Segment 18 includes 14 Mile Flume, Cement House Flume 14/2, Flume 15/2, Flume 15/3, and Flume 15/4.

3.18.2.1 Superstructure

No superstructure issues were identified within Segment 18.

3.18.2.2 Substructure

No substructure issues were identified within Segment 18.

3.18.2.3 Foundation

No foundation issues were identified within Segment 18.

3.18.2.4 Liner

Potential leakage of the gunite liner was observed within Segment 18.

3.18.3 Geotechnical Assessment

3.18.3.1 Foundation Stability

No foundation stability issues were identified within Segment 18.

3.18.3.2 Erosion

No erosion issues were identified within Segment 18.

3.18.3.3 Slope Stability

Slumps were observed in the canal bench that could indicate slope instability.

3.18.3.4 Rock Fall

No rock fall issues were identified within Segment 18.

3.19 Segment 19

Segment 19 consists of Little Tunnel. See Section 4 below for the tunnel condition assessment.

3.20 Segment 20

Segment 20 extends from Big Tunnel at Sta 748+30 to 755+60 and consists of concrete box flume.

3.20.1 General Assessment

3.20.1.1 Access Points

Access to Segment 20 is available at the upstream end via Big Tunnel Outlet Road. Limited staging areas are available along the access road.

3.20.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates averaged approximately 16 inches.

3.20.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 20.

3.20.2 Structural Assessment

There were no raised structures within Segment 20. No liner issues were observed within Segment 20.

3.20.3 Geotechnical Assessment

3.20.3.1 Foundation Stability

No foundation stability issues were identified within Segment 20.

3.20.3.2 Erosion

No erosion issues were identified within Segment 20.

3.20.3.3 Slope Stability

No slope stability issues were identified within Segment 20.

3.20.3.4 Rock Fall

No rock fall issues were identified within Segment 20.

3.21 Segment 21

Segment 21 extends from the end of the concrete box flume at Sta 755+60 to the 1993 landslide repair at Sta 857+10. The segment consists of gunite-lined canal with five short Lennon Flume segments (Flume 0/3, Sand Bunker Flume, Chalk Bluff 1/1, Sand Settler Flume, and an unnamed flume).

3.21.1 General Assessment

3.21.1.1 Access Points

Access to Segment 21 is available via an unnamed access road that runs along the south side of the System, though direct access from the road to the flume was limited. Access to the downstream end was available via Slide Road. Potential staging areas along the segment were generally limited based on a review of aerial photographs, though a large clearing was observed near Sand Bunker Spill that may be suitable.

3.21.1.2 Hydraulic Analysis (Freeboard)

Field freeboard estimates averaged approximately 13 inches.

3.21.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 21.

3.21.2 Structural Assessment

3.21.2.1 Superstructure

No superstructure issues were identified within Segment 21.

3.21.2.2 Substructure

No substructure issues were identified within Segment 21.

3.21.2.3 Foundation

No foundation issues were identified within Segment 21.

3.21.2.4 Liner

Potential voids were observed behind the gunite liner in two locations.

3.21.3 Geotechnical Assessment

3.21.3.1 Foundation Stability

No foundation stability issues were identified within Segment 21.

3.21.3.2 Erosion

Minor scour was observed at Sand Bunker Spill, and there was an apparent void in the liner near Chalk Bluff 1/1.

3.21.3.3 Slope Stability

No slope stability issues were identified within Segment 21.

3.21.3.4 Rock Fall

No rock fall issues were identified within Segment 21.

3.22 Segment 22

Segment 22 extends from Sta 857+10 to 863+50 and includes the 1993 landslide repair. The segment consists of gunite-lined canal with a freestanding wall on the downslope side.

3.22.1 General Assessment

3.22.1.1 Access Points

Access to Segment 22 is available via Slide Road.

3.22.1.2 Hydraulic Analysis (Freeboard)

Freeboard was not directly measured in the field but based on field notes and photographs, it was deemed to be sufficient.

3.22.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 22.

3.22.2 Structural Assessment

There were no raised structures within Segment 22. No liner issues were observed within Segment 22.

3.22.3 Geotechnical Assessment

3.22.3.1 Foundation Stability

No foundation stability issues were identified within Segment 22.

3.22.3.2 Erosion

No erosion issues were identified within Segment 22.

3.22.3.3 Slope Stability

No slope stability issues were identified within Segment 22 other than the 1993 landslide.

3.22.3.4 Rock Fall

No rock fall issues were identified within Segment 22.

3.23 Segment 23

Segment 23 extends from the 1993 landslide at Sta 863+50 to the end of the project at Sta 914+70. The segment includes gunite-lined canal.

3.23.1 General Assessment

3.23.1.1 Access Points

Access to Segment 23 is available at the downstream end through Deer Creek Forebay. Access along the flume is available from Slide Road and Deer Creek Forebay Road. Potential staging areas would be located within the Deer Creek Forebay facility and a large clearing near Slide Road at the 1993 landslide repair.

3.23.1.2 Hydraulic Analysis (Freeboard)

Freeboard was not directly measured in the field but based on field notes and photographs, it was deemed to be sufficient.

3.23.1.3 Vegetation Threat Analysis

No vegetation issues were identified within Segment 23.

3.23.2 Structural Assessment

There were no raised structures within Segment 23. No liner issues were observed within Segment 23.

3.23.3 Geotechnical Assessment

3.23.3.1 Foundation Stability

No foundation stability issues were identified within Segment 23.

3.23.3.2 Erosion

Minor erosion and potential void were observed near the standpipe on the bench downstream hinge point.

3.23.3.3 Slope Stability

No slope stability issues were identified within Segment 23.

3.23.3.4 Rock Fall

No rock fall issues were identified within Segment 23.

4. Tunnel Condition Assessment

Tunnel inspections were completed on November 4, 2020. Detailed reports for both Little Tunnel and Big Tunnel are included in Appendix C. There were no significant findings associated with the tunnel inspection, with minor observations noted as summarized in the following bullet list:

- Minor erosion/scour of the liner was observed at three locations within Little Tunnel. These areas should be monitored for future erosion.
- Minor erosion/scour of the liner was observed at five locations within Big Tunnel. These areas should be monitored for future erosion.

5. Spillway Condition Assessment

The following sections describe specific findings for each spillway as observed in the field. Photographs of representative observations are included in Appendix D.

5.1 YB-139

The YB 139 spillway is a primary release point and spill for flow regulation. The facility is a concrete vertical drop box to channel below. This drop box is within a Lennon flume section. A cross gate and an outlet gate regulate flow split. The gates are electrically actuated with SCADA. The spill outflows to a concrete chute outlet structure with a drop of several feet into a rock-lined channel. Gage YB31A is located immediately downstream.

It is unclear whether this facility will continue to be operated and maintained by PG&E, as it is a critical release point.

5.1.1 Structural

The cast-in-place concrete junction structure, discharge chute, and gate supports are aging but in serviceable condition. Minor concrete surface erosion exists. No major cracking is evident.

The metal stairs, platforms, walkways and supports are in good condition with fresh paint.

The structure appears to be stable with no visible undermining. The narrow vertical shape of the structure makes it susceptible to significant earthquake loading, but seismic review is beyond the scope of this assessment.

5.1.2 Handrails

Stair railings and platform guardrails are properly configured and in good condition.

5.1.3 Retaining Walls

There were no retaining walls identified at this site.

5.1.4 Geotechnical

The receiving channel is rip-rap lined with minor vertical drop from the end of concrete discharge chute. The channel receiving pool is currently stable; however, it is evident that the rock lining has required some prior maintenance and should be monitored.

5.1.5 Hydraulic

The structure is well configured for flow regulation and release. The concrete junction structure appears to have adequate freeboard based upon watermarks, with walls at or above the top of the upstream flume.

Debris in the canal could easily disrupt flows due to the in-line vertical drop.

5.1.6 Mechanical/Electrical

The aluminum gates with electric actuators are in excellent condition and appear new. Electrical gate actuators have a manual override with two-inch square operating nut. Removable handwheels are likely stored on site in a lock box but were not verified. The grout pads and seals for wall mounting are in good shape, but the sealing required to retrofit the gates is complex. The grouting and seals will require routine inspection to maintain.

The electrical equipment appears new and is well enclosed. Equipment and metalwork appear grounded, but no electrical safety assessment was conducted.

5.1.7 Maintenance Access

The structure is directly accessible. Overall maintenance access is very good. The access stairs, platforms, and guardrails are properly configured for worker access.

Electrical equipment is at proper height and configured to provide best available clearances, but clearance is limited by available space. As a result, power should be locked out during maintenance.

There is a plank footbridge at the discharge chute with no fall protection; see photos. This publicly accessible access does not appear to be necessary and should be removed or replaced with proper walkway.

5.1.8 Assessment Summary

Based upon our assessment, the top three concerns at the YB 139 spillway are these:

1. Rock lining at discharge chute outlet should be monitored
2. Debris in the canal could disrupt hydraulic flows
3. No fall protection present at discharge chute plank footbridge

5.2 Bear Valley Spill

The Bear Valley spillway is at a canal access point, located in a transition from a Lennon flume to a concrete bench flume. The facility is a concrete vault with a manually actuated cross gate and outlet gate regulating the flow split. This site is a gaging point with solar powered telemetry and SCADA. Spill is provided by a concrete chute outlet structure with a moderate shotcrete-lined drop into a rocky channel.

5.2.1 Structural

The cast-in-place concrete junction structure, gate supports, and ditch transition structures were aging, but in serviceable condition and well maintained. No major cracking was evident. The shotcrete lining on right bank of spill was cracking and will need replacement in the intermediate term to avoid undermining the bench flume.

The metal stairs, platforms, walkways, bridges, and supports were in good condition with mostly fresh paint. Repainting of flume walkways, some handrail posts, and some support members will be required in the intermediate term.

5.2.2 Handrails

Bridge access and platform guardrails were post and cable, well configured, and in good condition.

5.2.3 Retaining Walls

There were no retaining walls identified at this site.

5.2.4 Geotechnical

The receiving channel, after a minor drop from the end of concrete discharge chute with rubble for energy dissipation, was rocky and appeared stable within visible downstream reach.

The spill structure appeared to be founded on a relatively stable bench with no visible undermining.

5.2.5 Hydraulic

The structure was well configured for flow regulation and release. The concrete junction structure had more than adequate freeboard, based upon watermarks, with walls at the top of upstream flume.

While debris in the canal could disrupt flows, the downstream gate allows overtopping and, due to site conditions, short-term spills would not be particularly damaging. There was no evidence of the facility being undersized for current use.

5.2.6 Mechanical/Electrical

The timber slide gates with manual hand crank actuators were aged equipment but serviceable. The timber for slides was in good condition but aging. The timber support angles were uncoated but bolting (which is the weak link) was galvanized and in good condition. The gate slide slots in concrete were in good condition. The manual crank actuators appeared to be original equipment and although serviceable were a potential failure point unless well maintained. Gate cranks were chain locked. These gates, although serviceable and relatively simple technology, are outdated equipment and depending upon the criticality of this spill point should be scheduled for replacement.

The electrical equipment was limited to flow gaging, appeared new, and was well enclosed

5.2.7 Maintenance Access

The structure is at a canal access point and is relatively accessible. Overall maintenance and equipment access is good. The access bridge, platforms, and guardrails are properly configured for worker access. Gate hand cranks are at an ergonomically proper height; however, the hand cranks projecting into the walkway narrow the walk space.

The electrical panel is at the proper height with good accessibility and is configured to provide proper maintenance clearance.

5.2.8 Assessment Summary

Based upon our assessment, the top three concerns at the Bear Valley spillway are:

1. Gate timber slides require near term replacement
2. Gate metalwork requires recoating
3. Gate hand crank is aging equipment

5.3 Cape Horn Spillway

Cape Horn Spillway was constructed in 1952 as part of the wood flume replacement. The spillway was side spill from a wooden sheet-lined bench flume of all timber construction. The cross gate and spill gate were manually actuated timber slides. A short side box flume ended with a large vertical drop onto solid rock sited on a steep slope.

5.3.1 Structural

The all-timber construction was well maintained with a significant amount of new timber. However, the rails supporting the gate slide and actuator were aging and deteriorating. These are the most significantly loaded timbers, critical to operation, and will require near-term replacement. Select additional timbers should also be replaced. Uphill debris buildup against the side of flume has been kept relatively cleared out but should be monitored to minimize loading.

Wood flume steel linings were well maintained with recent seals.

5.3.2 Handrails

Wooden handrails were well-configured and well-maintained. Wood handrail condition requires regular focused monitoring for safety, as it is subject to rapid deterioration.

5.3.3 Retaining Walls

There were no retaining walls identified at this site.

5.3.4 Geotechnical

The spill dropped onto a solid rock face and appeared stable with surrounding mature vegetation. As with the rest of this canal reach, it was benched into an area with a steep uphill rock face and was subject to rock fall damage. Debris buildup against uphill side of wood flume has been kept relatively cleared out but should be monitored to minimize loading.

The structure appeared to be founded on a relatively stable bench.

5.3.5 Hydraulic

The structure was well configured for flow regulation and release. The spill as configured would provide full canal capacity. While debris loading could disrupt flows, the spill allows for overtopping.

5.3.6 Mechanical/Electrical

The timber slide gates with manual hand crank actuators were aged equipment but serviceable. The side spill gate slide and guides have been recently reconditioned, but the cross gate would require near-term replacement of wood. The side slots arrangement for gate slides support and guide was not ideal, as it projects into flow. The cross gate had a seat only (i.e., slide is not sandwiched between two vertical guide timbers). During rehabilitation of cross gates, a better guide arrangement should be considered.

The manual crank actuators appeared to be original equipment and although serviceable are a potential failure point unless well maintained. Gate cranks were chain locked. The gate cranks, although serviceable and relatively simple technology, were outdated equipment. Depending upon gearing condition, the actuator could be replaced.

The electrical equipment was limited to flow gaging, appeared new, and was well enclosed.

5.3.7 Maintenance Access

The structure was only accessible on foot via the flume walkways, and materials would likely be helicoptered in. Otherwise, access for maintenance and to equipment was good. The access bridge, platforms, and guardrails were properly configured. Gate hand cranks were at an ergonomically proper height; however, the hand cranks projecting into walkway narrowed the walk space.

5.3.8 Assessment Summary

Based upon this assessment, the top three concerns at the Cape Horn Spillway are:

1. Gate lift timber headrail requires near-term replacement
2. Monitor debris against uphill side of word flume
3. Gate hand crank is aging equipment

5.4 Little Tunnel Spill

The Little Tunnel spillway was located in a concrete lined channel canal reach at a canal access point. The cross gate was a handwheel operated slide gate with timber slide. The side spill entered a multi-channel concrete flume. The spill gate was chain hoist hand crank operated, undershot radial gate. Adjacent to cross gate was a stoplog passive overflow to spillway, which may also serve as a trash chute. Both channels converge into a single chute, with a moderate drop into a mildly sloped, well-vegetated channel. However, the plunge pool was erodible and was undermining the chute.

There was a powered gaging station with solar backup and remote communication. The equipment was within a locked building on the canal bank.

5.4.1 Structural

The cast-in-place concrete gate headwall and supports as well as the spillway flume headwall and supports were aging, but serviceable condition. No major cracking was evident. The concrete spillway flume was very thin-walled, aged concrete. A minor crack in the discharge chute left wall may be attributable to undermining. Unmanaged vegetation growth could further damage concrete flume. Stoplog slots in concrete of spill chute headwall are in good condition.

Anchorage of radial gate pivot appeared to be old and is of questionable capacity in thin wall concrete.

A combination of wood planking over spillway and metal plank bridge over canal as well as its steel guardrail are in relatively good condition.

The metalwork for upstream steel bridge to Little Tunnel Alarm Building was in fair condition with some attention to coatings required.

5.4.2 Handrails

Handrails were painted steel with mechanical fittings. The bridge across the spillway had no downstream handrail. Fall protection was marginally provided by the radial gate's chain rail but was otherwise exposed. The narrowness of the spillway bridge walk increases risk.

The upstream canal bridge includes properly configured steel handrails.

5.4.3 Retaining Walls

There were no retaining walls identified at this site.

5.4.4 Geotechnical

The receiving channel was erodible, and the receiving pool at drop was backcutting and undermining the concrete discharge chute. Stabilization is required and possibly a structural fix to incorporate a drop structure. An access road upstream, with a temporary canal crossing could be used as access for a major retrofit. The downstream channel appears to be stable and vegetated within the visible reach.

The canal upstream and downstream of sill appeared to be currently stable, but continued backcutting of spill over the long term could threaten the canal.

5.4.5 Hydraulic

The structure was generally well configured for flow regulation and release. The cross gate was of limited height and did not appear to allow for blockage of full depth canal flow (i.e., when fully seated, the canal flow will overtop). The operation was unclear and should be verified. The outlet chute appears to provide significant spill capacity.

There was no evidence of the facility being undersized for current use. The passive spill over stoplogs would not exceed downstream chute capacity, but whether it is sufficient for needs should be determined prior to any major rehab. The concrete junction structure and radial gate had more than adequate freeboard, based upon high watermarks.

It appears that the spill radial gate has not been operated for some time due to sediment buildup. It is likely curtailed due to downstream erosion. As the spill capacity is significant, the effects of high releases further downstream in the spill watershed should be reviewed, particularly if flow has been curtailed for an extended period of time.

While debris in the canal could disrupt flows, the downstream cross gate and passive side spill allow for significant overtopping.

5.4.6 Mechanical/Electrical

The radial spill gate had new sheeting and chains. Radial gate steel framing, connectors, and hoist were aged and required recoating at a minimum. The pivot was anchored to thin walled concrete and appeared to be original. The manual crank actuators appeared to be original equipment and although serviceable are a potential failure point unless well maintained. Gate cranks were chain locked. These actuators, chain rail bearings, and pivot bearings were critical to operation of radial gate and dated. An operational test should be conducted. Depending upon the criticality of this spill point, a major upgrade to radial gate mechanical features should be scheduled.

The cross gate was timber slide gate and handwheel operated. The handwheel was chain locked. The timber slides were of limited height and did not appear to allow for blockage of full depth of flow (i.e., when fully seated, the canal flow will overtop). The operation was unclear and should be verified. The timber for the slides was in good condition but aging. There was no bracing of timber slides, which would prevent pivoting. The gate slide slots were steel angles and require recoating, and the fit of timber in slots was poor. Reconditioning and improvements of the timber slides is recommended in the near term.

The upstream gaging station equipment was not reviewed but is well secured with a building and readily accessible.

5.4.7 Maintenance Access

The structure was at a canal access point and relatively accessible. An access road into the canal and canal bridge was located immediately upstream. Overall maintenance and equipment access was fair. The access bridge, platforms, and guardrails were properly configured. Gate hand cranks were at an ergonomically proper height; however, the hand cranks projecting into walkway narrowed the walk space.

The major deficiencies were the narrowness of the walkway over spill channel and the lack of sufficient railing (as discussed above) at this location. The hand crank projects into the narrow walkway. As this is a canal access point, improvements to spill crossing should be considered.

Due to its placement, the upstream walkway bridge configuration also severely restricts equipment movement along canal banks.

5.4.8 Assessment Summary

Based upon this assessment, the top three concerns at the Little Tunnel Spill are:

1. Spill receiving pool is backcutting and undermining outlet chute
2. Spill radial gate is aging and appear to be infrequently used (spillway may be abandoned) and should be tested prior to return to service
3. Walkway over spill channel is narrow with inadequate fall protection on downstream side

5.5 9½ Mile Spill

The 9½ spillway is located in a gunite-lined canal reach. The facility includes manually actuated cross and spill outlet gates with headwalls to regulate the flow split. Spill is provided by a concrete lined chute outlet with a moderate shotcrete-lined drop into highly fractured rock pool, which immediately outlets into a broad well vegetated and moderately sloped plain.

A siphon pipe immediately upstream provides additional emergency release in the event of high canal levels.

5.5.1 Structural

The cast-in-place concrete headwalls, gate supports, and ditch transition structures were well maintained. The inspection team observed evidence of recent patching of surface spalls. No major cracking was evident. The concrete lining of spill chute was aged with no major cracking, although left bank lining was undermined at top. Backcutting could undermine chute if not anchored properly. A large redwood on the right toe of the spillway chute provided stability but presents a risk of significant damage in the event of treefall. The health of this tree should be evaluated.

The metal stairs, platforms, walkways, bridges, and supports were in good condition with fresh galvanizing or paint.

The walkway over the upstream siphon was supported on aging timber that requires near-term replacement; see photos.

5.5.2 Handrails

Bridge access and platform guardrails were steel, well configured, and in good condition.

5.5.3 Retaining Walls

There were no retaining walls identified at this site.

5.5.4 Geotechnical

The receiving pool, after a significant drop from the end of concrete lined discharge chute was fractured but solid rock and appeared stable. Further inspection after significant spill events is warranted. The rock drop pool outlets into a broad, well vegetated, and moderately sloped plain without evidence of erosion within visible limits.

The spill structure appeared to be founded on a relatively stable bench with no visible undermining.

5.5.5 Hydraulic Analysis

The structure was well configured for flow regulation and release. The concrete junction structure had more than adequate freeboard level with the top of the canal.

While debris in the canal could disrupt flows, the downstream cross gate and side spill outlet gate allowed for significant overtopping prior to excessive canal levels. There was no evidence of the facility being undersized for current use.

5.5.6 Mechanical

The manually actuated timber slide gates were of new construction. The wood for slides was recently replaced, with new bolting. The timber support angles were galvanized with dissimilar metal isolation from stainless stems. The gate slide slots in concrete were in good condition. The manual actuators were new construction (2016) with removeable handwheels in a lock box onsite and chain locks if needed. The handwheel shaft did not include an operating nut for portable drive, but adapters were available, if not already in onsite lock box.

5.5.7 Maintenance Access

Overall maintenance and equipment access were good. Platforms/walkways were good width and well supported. The access bridge, platforms, and guardrails were properly configured for worker access. Gate handwheels were at an ergonomically proper height.

5.5.8 Siphon Pipe

Upstream of this spill is a siphon pipe that automatically engages when canal levels become excessive. The siphon pipes are a good safety feature that moderate unexpected canal rise resulting from excessive side inflows during rainfall event. The siphon operation was mechanical; raising waters trip the mechanism in the siphon barrel to initiate flow release and require reset after use. The capacity of siphons was limited and dependent upon both pipe size and downstream vertical drop.

Visible portions of the siphon system were in good condition. Visible required maintenance includes painting and securing the loose trash screen. The condition of the siphon barrel components was not a visible part of the inspection and should be reviewed with PG&E operators. An interior camera inspection of the piping may also be warranted. An operating procedure should be developed from discussions with PG&E operations staff, as the setup and post flood reset are complex.

5.5.9 Assessment Summary

Based upon this assessment, the top three concerns at the 9 1/2 Mile Spill are:

1. The receiving pool at spillway outlet has undermined the outlet chute, but the downstream rock channel appears stable.
2. A large tree at end of the spill chute threatens stability and the health of tree should be reviewed.
3. The siphon pipe is aged, and its operation is uncertain. The operating procedures and maintenance should be reviewed.

5.6 Hickman Spill

Hickman Spillway is at a walkable canal access point in a concrete lined canal reach. The facility is limited to an approximately 36-inch-wide stoplog controlled side spill with no canal cross gate. A short concrete lined chute leads to a significant drop into a large glory hole. The facility appears abandoned but may act as a passive spill with stoplogs six inches below the top of the canal bank.

5.6.1 Structural

The concrete lined chute was intact but severely undermined at outlet. Concrete lining appeared fresh and joints had been sealed indicating recent work; however, the chute was presently unstable and not suitable for use. The spill chute cut through canal bank was near vertical with thin concrete lining and unknown reinforcement.

The wooden walkways, bridges, and supports were in fair condition and would require routine maintenance. Bridge handrailing was new steel. Wood railing for spill bridge was recent and should be regularly inspected and maintained.

5.6.2 Handrails

Canal access and spill bridge railings were well configured and in good condition; however, no canal side railing was provided on spill bridge.

5.6.3 Retaining Walls

There were no retaining walls identified at this site.

5.6.4 Geotechnical

The receiving channel was highly erodible as evidenced by the large glory hole that had developed. The glory hole has destabilized the slopes downhill of canal, particularly left of spill. Further site-specific geotechnical evaluation is recommended.

5.6.5 Hydraulic Analysis

The structure apparently was used as a passive side spill and possibly a canal drainage point. It was configured as a passive spill with boards set approximately 12 inches above operating level and six inches below the top of the canal. In its present condition, its use is not recommended and the ability to spill elsewhere or an alternative spill arrangement should be considered.

The stoplogs had some visible leakage, and it is recommended that even this small release be curtailed.

5.6.6 Mechanical/Electrical

There were no mechanical/electrical features at this site.

5.6.7 Maintenance Access

The canal access was narrow, but since it is only a footpath may be acceptable. The canal bank bridge was a wide wooden plank bridge (five to six feet). It is unclear whether ATV access was intended for this bridge; the width was wide enough, but a structural capacity check is required.

Stoplog removal with gig pole was accessible, but there was no canal side fall protection.

5.6.8 Assessment Summary

Based upon this assessment, the top three concerns at the Hickman Spill are:

1. The spill receiving channel is highly erodible and spills have resulted in a large glory hole destabilizing the left canal bank.
2. The spill channel chute is unstable and not suitable for use (spill appears to be abandoned).
3. Leakage through spillway stoplogs should be sealed if spill in abandoned to minimize further deterioration of downstream drop pool and bank.

5.7 Excelsior Point Spill

The Excelsior Point Spillway contains two separate spill structures in a concrete lined canal reach: an upstream stoplog weir side spill and a gated spill downstream. The gated spillway assessment is covered in the next section. The weir is a long (20 to 25 feet) multi-bay stoplog weir. The concrete crest is about canal operating level with a single stoplog for freeboard. The multiple bays converge rapidly to a head box with a cast-in-place concrete structure. The box outlets to a large diameter CMP (48 to 60 inches) with a moderate slope down to a rocky stable channel.

A siphon pipe immediately upstream provides additional emergency release in the event of high canal levels.

5.7.1 Structural

The cast-in-place concrete spillway structure was very thin-walled, aged concrete but where visible was in good condition. No major cracking was evident. Observed some surface erosion of concrete weir and damage to the left flashboard concrete slot requiring repair. The headbox for culvert was covered with wood debris and not available for inspection. This should be reviewed, as the wood covering alone may not provide a safe hole covering.

The wooden plank walkway is aging and will require replacement in the intermediate term. Handrails are robust and relatively new and will require routine inspection.

The CMP from exterior view appears to have remaining useful life, but interior inspection and inspection of joint at concrete inlet is recommended.

The walkway over upstream siphon is steel plank with wood timber supports and in good condition.

5.7.2 Handrails

Wooden handrails are well-configured and in good condition. Wood handrail condition requires regular focused monitoring for safety, as it is subject to rapid deterioration. There is no canal side railing.

Similar conditions exist at the upstream siphon bridge.

5.7.3 Retaining Walls

There were no retaining walls identified at this site.

5.7.4 Geotechnical

The receiving channel is rocky and appears stable. The spill structure appears to be founded on a relatively stable bench with no visible undermining.

5.7.5 Hydraulic Analysis

The structure is well configured for significant spill. The stoplogs may need improvement for operating at higher canal levels as they are fairly loose fit.

5.7.6 Mechanical/Electrical

There are no mechanical or electrical features at this site.

5.7.7 Maintenance Access

The wooden pathway is good width at about three feet.

Stoplog removal with gig pole is accessible, but there is no canal side fall protection.

5.7.8 Siphon

Upstream of this spill is a siphon pipe that automatically engages when canal levels become excessive, as further discussed for the 9½ mile siphon above.

Visible portions of the siphon system are in good condition but require painting. The downstream pipe is aged. The condition of the siphon barrel components was not a visible part of the inspection and should be reviewed with PG&E operators. An interior camera inspection of the piping may also be warranted. An operating procedure should be developed from discussions with PG&E operations staff, as the setup and post flood reset are complex.

5.7.9 Assessment Summary

Based upon this assessment, the top three concerns at the Excelsior Point spillway are:

1. The concrete headbox at CMP entrance is covered with debris and should be inspected.
2. The spill weir stoplog fit is loose with minimal freeboard, that would restrict increase in canal levels.
3. The siphon pipe is aged, and its operation is uncertain. The operating procedures and maintenance should be reviewed

5.8 Excelsior Spillway (Gated Spill)

The Excelsior Point Spillway, gated spill point is located in a concrete lined channel canal reach. The facility includes a timber slide cross gate and a radial spill gate, both manually actuated, to regulate the flow split. Spill enters a thin-walled cast-in-place concrete lined flume chute outlet with a minor drop to a rocky channel.

There is a powered gaging station (Excelsior Alarm Building) with solar backup and remote communication downstream of this site. The equipment is within a locked building on the canal bank.

5.8.1 Structural

The cast-in-place concrete gate headwall and supports are aging, but in serviceable condition. Patching of surface spalls to restore section is evident. The concrete spillway flume is very thin-walled, aged concrete, but remains in good condition with only minor cracking and minimal non-structural top of wall damage. Some backcutting exists at flume end, but support is adequate for the time being. Unmanaged vegetation growth could further damage the concrete flume, which has a large rotting trunk against the right side.

Anchorage of radial gate pivot appears to be old and is of questionable capacity in thin-walled concrete.

The metal walkway bridges, over spill channel and canal, as well as the post and cable railing are in good condition.

Immediately upstream of the spillway, a bridge crossing exists over the wood over-shot flume. The steel planking and wood supports are in relatively good condition, but wooden supports and railings should be subject to frequent inspection.

5.8.2 Handrails

Walkway railing is provided by post and cable on one side and gate top rails on the other side.

5.8.3 Retaining Walls

There were no retaining walls identified at this site.

5.8.4 Geotechnical

The receiving channel is rocky and well vegetated with relatively flat slope and appears stable. The drop pool appears to have been subject to some backcutting overtime and should be stabilized and restored in the near term. The spill structure appears to be founded on a relatively stable bench with no visible undermining.

5.8.5 Hydraulic Analysis

The structure is well configured for flow regulation and release. The outlet chute appears to provide significant spill capacity and there is no evidence of the facility being undersized for current use.

While debris in the canal could disrupt flows, the spillway radial gate allows for significant overspill prior to excessive canal levels.

5.8.6 Mechanical/Electrical

The radial spill gate has relatively new sheeting and chains. The radial gate steel framing, connectors, and hoist are aged and require recoating at a minimum. The pivot is anchored to thin-walled concrete and appears to be original. The manual crank actuators appear to be original equipment and although serviceable are a potential failure point unless well maintained. Gate cranks are chain locked. These actuators, chain rail bearings, and pivot bearings are critical to operation of radial gate and are dated. An operational test should be conducted. Depending upon the criticality of this spill point, a major upgrade to radial gate mechanical features should be scheduled.

The cross gate is timber slide gate, handwheel operated. The handwheel is chain locked. The timber for the slides is in good condition but aging. The bolting and bracing for timber slides as well as the gate frame are in good condition. The gate slide slots are steel angles and require recoating.

The downstream gaging station equipment was not reviewed but is well secured with a building and readily accessible.

5.8.7 Maintenance Access

Overall maintenance and equipment access is good. Platforms/walkways are good width and well supported. The access bridge, platforms, and guardrails are properly configured for worker access. Gate handwheels are at an ergonomically proper height.

5.8.8 Assessment Summary

Based upon this assessment, the top two concerns at the Excelsior Gated Spillway are:

1. Minor backcutting at end of discharge flume and vegetation management in flume should be addressed.

2. Spill radial gate is aging and appear to be infrequently used should be tested

5.9 13 Mile Spill

The 13 Mile spillway is located in a transition from a concrete bench flume to a Lennon Flume, just upstream of a canal footpath access. The facility includes manually actuated cross and spill outlet gates with headwalls to regulate the flow split. Spill is provided by a cast-in-place thin-walled concrete flume with a concrete support down to rock. Spill enters a mildly sloped channel after a short drop from the chute.

There appears to be an abandoned long weir passive spill immediately upstream with stoplogs installed and backfill placed on the downhill side.

5.9.1 Structural

The cast-in-place concrete headwalls, gate supports, and ditch transition structures are aging but well maintained. No major cracking is evident. The spill gate headwall was submerged and not fully visible for inspection. Gate mounts and grouting should be reviewed when visible. The spill gate corbel has some concrete deterioration that should be addressed in the intermediate term.

The flume spill chute concrete is aged but in good condition with no visible cracking. Concrete footing at spill chute outlet is intact with no apparent contact with foundation. The support is at risk of undermining if further backcutting occurs. Backcutting could undermine chute if not anchored properly. Some vegetation management is recommended to avoid significant growth that could threaten structure.

The metal plank walkways and tube steel rails are in good condition.

The walkway upstream approaching the spillway is mounted on exterior wall of the thin-walled concrete bench flume. The brackets are uncoated and partially buried. The brackets are also supported on posts embedded within thin-walled concrete. Downhill side pipe handrails appear to be buried. This walkway should be considered for an upgrade in the intermediate term or, at a minimum, a more detailed evaluation and recondition.

The abandoned passive spill immediately upstream has stoplogs installed in steel posts that are old and not well fit and could fail or generated significant leakage at higher canal levels. Proper abandonment is recommended in the intermediate term.

5.9.2 Handrails

Spillway headworks and canal gate headwall guardrails are square HSS tubing and are well configured and in good condition.

The upstream walkway handrail is galvanized steel pipe of questionable support, as discussed above. No handrail is provided on the canal side, and the walkway is narrow.

5.9.3 Retaining Walls

There were no retaining walls identified at this site.

5.9.4 Geotechnical

The receiving pool, after a minor drop at end of chute appears to be moderately erosive, but minimal backcutting/downcutting has occurred. The adjacent slope on the left side has been shotcrete lined, indicating some previous issues that could include toe erosion. Due to the critical support of the discharge chute, it is recommended that the channel immediately below the chute be stabilized in the immediate term. Measures could include rock slope protection, energy dissipation, rebuild and shotcrete line, or cast-in-place concrete/rubble walls with cutoff. More detailed geotechnical review is recommended to develop a specific plan. The pool discharges moderately sloped ditch without evidence of erosion within visible limits.

The spill structure appears to be founded on a relatively stable bench with no visible undermining.

5.9.5 Hydraulic Analysis

The structure is well configured for flow regulation and release. The concrete junction structure had adequate freeboard level with top of canal. However, the canal wall upstream of this point is low with stoplogs providing added freeboard. This appears to be an abandoned passive overflow that has been backfilled. A more permanent abandonment is recommended.

The spill has limited capacity based upon its size. Unlike many of the other spills, there is no passive overflow, particularly in light of upstream spill abandonment. Debris could disrupt the ability to pass water through or out of this site, as the submerged spill slide gate does not appear to allow for overtopping.

Depending upon the criticality of this spill point, a supplemental passive chute may be warranted. Further review of the spillway capacity needs and historical operations is recommended.

5.9.6 Mechanical

The canal cross gate is a manually actuated timber slide gate. The wood is aging, the steel angles are unpainted and exhibit some minor corrosion, and the bolting is in good condition. The guides are embedded in concrete and in good condition where visible. Reconditioning of the wood and recoating of steel in the near term is warranted. The hand crank actuator is of modern construction with some aging but appears well maintained. Cranks are removed and were not visibly stored onsite, but the other gate’s crank could be used.

The spill slide gate was underwater and not visible. Due to facility configuration, it is assumed to be a wall mounted slide gate (unlike remaining gates, which are timber weir type allowing overflow). When visible, the seals and grouting as well as the fasteners and coatings should be inspected and rehabilitated. The hand crank actuator is of modern construction with some aging. Recoating is recommended in the near term. The crank is removed and chained to the operator.

The wood for slides was recently replaced, with new bolting. The timber support angles are galvanized with dissimilar metal isolation from stainless stems. The gate slide slots in concrete are in good condition. The manual actuators are of new construction (2016) with removeable handwheels in a lock box onsite and chain locks if needed. The handwheel shaft does not include an operating nut for portable drive, but adapters are available if not already in onsite lock box.

5.9.7 Maintenance Access

Overall maintenance and equipment access is good. Platforms/walkways are good width and well supported. The access bridge, platforms and guardrails are properly configured for worker access. Gate hand cranks are at an ergonomically proper height.

The upstream walkway is narrow and does not include a canal side guardrail.

5.9.8 Assessment Summary

Based upon this assessment, the top three concerns at the 13 Mile Spill are:

1. The receiving pool downstream of spillway chute is backcutting and requires stabilization.
2. The upstream passive spill weir is abandoned due to erosion and facility has no passive overflow provision (spill release is through a headwall mounted gate).
3. The upstream approach walkway is narrow and of questionable structural integrity.

5.10 14 Mile Spill

The 14 Mile Spillway is passive side spill in a concrete lined canal reach with a steep downhill drop off. The canal downhill side transitions to a vertical concrete wall immediately upstream with a reduced freeboard. The cross gate has been removed, and the timber slide spill gate appears abandoned, essentially acting as stoplogs. The top of the stoplogs is set approximately six inches above maximum operating canal level. A short concrete chute leads to a short drop onto the canal bank, which is a tall steep bank with rock scattered along the slope.

5.10.1 Structural

The cast-in-place concrete transition structure is thin-walled and aging but in good condition where visible. The chute is a short rectangular flume built into a window in the flume wall and is in good condition with no visible cracking. Concrete gate supports are aging with visible patching to restore the section.

The plank grating steel walkways and supports are in good condition. The canal walkway is supported by relatively new steel bracket supports that are uncoated. Brackets are designed as hanging on top of thin-walled concrete with bolts to cinch against side walls and also support handrails. The bracket design requires further review for anticipated loading, particularly rail loading. The bracket supports, if found sufficient, will require recoating in the intermediate term. Handrails are post and cable and in good condition.

The canal bridge, at the abandoned cross gate, is supported by timbers with moderate aging but in good condition.

5.10.2 Handrails

Canal walkway handrail is post and cable with no canal side railing on narrow walkway. The canal walkway bridge has upstream timber railing, in good condition. However, the downstream gate has been mostly removed, leaving only the top rail for gate hoist with a good deal of exposure below.

It is recommended that the canal bridge be removed, if no longer required for gate access, to reduce fall hazard. The bridge is not an access point across the canal, as there is no uphill access.

5.10.3 Retaining Walls

There were no retaining walls identified at this site.

5.10.4 Geotechnical

The receiving channel after a short drop from the chute is a steep hillside below the canal bench. The area has been protected somewhat by placement of rock over the years, but some loss of canal support bank is evident. While the discharge chute is partially undermined, the design does not rely heavily on foundation support.

The structure, including upstream and downstream transition walls are perched above a steep slope. The use of this spillway has to some extent degraded this slope that provides support for the entire structure.

It is evident this spill is not frequently used. There is vegetation growth and log debris downstream of the outlet. The area adjacent to walls upstream and downstream is also rocked and partially degraded, which could be an indication of past overflow. Return to use is not recommended at this point without further evaluation. Due to slope degradation, additional geotechnical review may be warranted to verify the canal stability.

5.10.5 Hydraulic Analysis

The canal transition to the spill structure results in a velocity increase but with no apparent negative consequences. The old cross gate slot frames are abandoned in place and could be removed to reduce flow disruption.

While the canal has sufficient freeboard for normal operation through this reach, the side wall is lower than the upstream and downstream banks. As a result, for uncontrolled canal flows, the wall will be overtopped first. It should be evaluated as to whether this is the appropriate overtopping point and if not, the wall may warrant raising.

5.10.6 Mechanical

The cross gate has been removed at this site with the top rail (yoke) and steel gate slots remaining. Full removal is recommended in the intermediate term.

The spill gate is a timber slide with a gear head manual crank that is locked with a chain. The timber slides are aging and do not have any steel bracing (essentially stop logs). The wood should be replaced in the near term. The top rail is damaged, most likely from rock fall, but still intact. The geared head actuator has no cover and is a potential pinch point if operated in current condition. The hand crank actuator is old and evidently not operating. This gate should not be brought into service without a complete overhaul. If abandoned, the stoplogs should be more permanently installed or the chute should be otherwise bulkheaded.

5.10.7 Maintenance Access

The canal access walkway is narrow, but since it is only a footpath may be acceptable. The hand crank projects into pathway and should be removed. Access is available for removal of stoplogs (if implemented). The canal bridge serves no purpose and should be removed.

5.10.8 Assessment Summary

Based upon this assessment, the top three concerns at the 14 Mile Spill are:

1. The spill gate should be reconditioned if restored to use (damaged top rail, exposed gearing on hand crank actuator, deteriorating timbers.)
2. The canal left bank adjacent to the spillway structure is partially degraded and should be monitored.
3. The upstream approach walkway is narrow and of questionable structural integrity.

5.11 Big Tunnel Upstream Spill

The Big Tunnel spillway contains two separate spill structures. This section covers the gated side spill, known as the Big Tunnel Spill. The next section covers the Big Tunnel Spillway, which is a major release point.

The Big Tunnel Spill is located in a concrete lined channel canal reach. The facility includes manually actuated cross and spill outlet gates to regulate the flow split. The cross gate is a timber slide, and the spillway control is provided by a radial undershot gate. Spill is conveyed through a concrete chute outlet with a sharp drop off into a canyon. The spill appears abandoned, as the cross gate operating platform is removed with the gate retracted and chain locked; the radial gate hoist chains are disconnected, the chain hoist was removed, and the spill chute contains debris and vegetation growth.

5.11.1 Structural

The cast-in-place concrete headwalls, gate supports, and ditch transition structures are aging but in serviceable condition. The concrete spill chute is old and thin walled with some minor cracking. The retained height along chute walls is minimal.

The canal walkway/spill chute crossing metal planking and handrails are new, and the walkway is well supported.

5.11.2 Handrails

The canal walkway/spill chute crossing has guardrails on both sides.

5.11.3 Retaining Walls

There were no retaining walls identified at this site.

5.11.4 Geotechnical

The downstream conditions were not visible, but a large drop off is evident. The canal banks are wide in this area with a long spillway chute.

The spill structure appears to be founded on a relatively stable bench with no visible undermining.

5.11.5 Hydraulic Analysis

The structure is well configured for flow regulation and release. However, it is likely abandoned due to steep drop off at the end of spillway chute. The abandoned structure does not result in any canal flow disruption.

It is recommended that the spill chute be more permanently blocked at the entrance, if abandoned.

5.11.6 Mechanical

The handwheel actuated timber slide gates are in good condition but no longer in use.

The radial spill gate is original equipment and deteriorating. The pivot is anchored to thin-walled concrete and appears to be original. The chain hoist has been removed. The radial gate is a potential failure point unless well maintained. The pivot hinge post has questionable load capacity and gate steel frame is deteriorating. It is recommended that a more permanent method of blocking the spillway chute be implemented in the intermediate term to remove this potential point of failure.

5.11.7 Maintenance Access

The canal access bridge and guardrails are properly configured for worker access. No other maintenance access exists at this site.

5.11.8 Assessment Summary

Based upon this assessment, the top concern at the Big Tunnel Side Spill is:

1. The spillway radial gate is aging and should be reconditioned or abandoned chute otherwise sealed.

5.12 Big Tunnel Outlet Spill

The Big Tunnel spillway is major spillway in the approach to the entrance to Big Tunnel. The entire spillway was recently reconstructed, from the Lennon Flume outlet through to the cross gate. The cross gate is a manually operated slide gate with a timber slide. The side spill enters a multi-channel concrete flume. The spill gate was chain hoist hand crank operated, undershot radial gate. Adjacent to the cross gate is a stoplog passive overflow to spillway chute that serves as a trash chute. Upstream of the spill gate is a long concrete crested passive overflow weir. The crest channels converge into a single concrete chute, and the channel opens into a wide pool adjacent to the spillway crest with vertical wall and retaining wall on the uphill side.

There is a powered gaging station with solar backup and remote communication at this site. The equipment is within a locked building on the left canal bank.

No drawings were available at the time of this review but should be available and will be reviewed prior to finalizing this assessment.

5.12.1 Structural

The cast-in-place concrete approach channel, spillway pool right wall, spillway crest, and crest divider walls are of new construction and in generally good condition. Wall expansion joints have fresh seals. The concrete wall of approach channel shows some minor cracking and effervescence that should be monitored but with no appreciable leakage. The design appears to be in accordance with modern concrete practices.

The cast-in-place concrete spillway chute, after a short converging section, drops into a concrete lined spill channel, both of new concrete construction. The upper chute concrete is moderately inclined and in good condition; however, jointing is limited. As such, future cracking is likely and should be monitored and sealed as soon as they develop. Joints between the drop walls and the lower chute are freshly sealed.

The lower chute is steeply inclined large concrete placement with curving alignment to redirect flow prior to a drop into the receiving channel. There is minimal jointing, no evidence of underdrains, and potentially no anchorage. The downstream edge is undermined and actively backcutting, as further discussed in the Geotechnical section below. While the chute has minimal cracking, it would be expected to deteriorate somewhat over time. As such, cracking should be closely monitored, and crack sealing should be conducted each fall before high spill events. It is critical to maintain integrity, as water entry into the subgrade has the potential to create a sudden massive failure.

Various shotcrete placements downstream of the spill chute have been installed to arrest erosion and appear new. Further review of channel stability is required to evaluate the long-term stability of these repairs.

The walkways are generally metal planking with steel supports. Some rusting is evident on galvanized and painted members with normal maintenance required. Handrails are generally post and cable with pipe rails used at spillway crossing. Normal touch-up painting of railings is also required. Timber supports for the metal plank walkway above the concrete bench flume approach are all of new construction.

The spillway radial gate was salvaged during the major spillway rehabilitation. Anchorage of radial gate pivot, which is a point of high stress, was replaced during the spillway rehabilitation. The remainder of the gate and hoist framing is aging but in good condition. Steel will require repainting in the intermediate term.

The grizzly bear rack in front of cross gate is lightweight but apparently adequate for expected loading. The carbon steel rack has thin paint coatings and should be monitored for corrosion and recoated as needed.

5.12.2 Handrails

Handrails are generally post and cable and well configured. The cabling in some areas could be retightened. Similar to other facilities, there is no canal side railing for the spillway crest bridge, but walkways are wide.

The alarm building fronts the canal with no water side guardrail. This is most likely due to use of this area to walk trash from the rack to trash chute. The operators should use caution in this area.

5.12.3 Retaining Walls

There is a modern precast block retaining wall on the uphill side of the canal across from the alarm building with rock slope protection above. There is no evidence of significant movement of this wall, but its age is uncertain. The wall should be visually monitored for signs of displacement and soil movement, particularly after heavy rainfall events. A geotechnical engineer should be consulted if anomalies are identified.

5.12.4 Geotechnical

The receiving channel is erodible, and it is evident that significant effort has been made to stabilize the spillway and receiving pool. The slopes immediately downstream of the chute are destabilized by erosion. Erosion is beginning to undermine the end of the spillway chute. It is also possible other runoff sources are contributing to erosion, as the bank on the right side of spillway is eroding at the drop off to the channel below chute.

Given the complexity and the urgent need to address undermining and backcutting, a more detailed geotechnical evaluation is needed. The geotechnical evaluation should be prepared along with a hydraulic evaluation, as discussed below, to understand the mechanisms.

The reach of the canal in which the spillway is located, including upstream bench flume areas, appear stable. The uphill slope has been recently stabilized opposite the Big Tunnel alarm building and remains in good condition.

5.12.5 Hydraulic Analysis

The structure is generally well configured for flow regulation and release at the crest. The spillway hydraulic capacity is significant. The outlet chute also appears to provide significant spill capacity. The flow is complex with rapid redirection of flow that could create significant runup and overtopping; however, no evidence of chute wall overtopping exists. The operating experience should be reviewed with PG&E. Unless the spillway has experienced a severe event with witness of satisfactory flow conditions, further analysis may be needed to understand flow behavior.

After exiting the chute, there are a series of drops to the receiving channel without energy dissipation, resulting in serve erosion. The erosion is discussed further in the section above.

Given the significant overflow spillway, debris at this location should not create detrimental disruption, and there is more than adequate freeboard at this site.

5.12.6 Mechanical

The radial spill gate steel framing, connectors, and hoist are aged and require recoating at a minimum. The pivot pins were recently replaced. The chain has been replaced by new wire rope, which should be monitored for deterioration over time. The manual crank actuators appear to be original equipment. The geared actuator is not enclosed and is potential pinch point. A new shield should be installed in the near term. The gate crank is chain locked. These actuators, chain rail bearings, and pivot bearings are critical to operation of radial gate and are dated. An operational test should be conducted. An upgrade to radial gate mechanical features should be considered.

The cross gate is timber slide gate with an aging pedestal geared actuator. The crank was not found but could be stored in the adjacent building. The timber for the slides, uncoated steel bracing, and bolting are new, and the gate is well fit.

The gaging station equipment was not reviewed but is well secured in a building and readily accessible. The approach slab to building entrance is partially undermined overhanging canal, but stable.

5.12.7 Maintenance Access

The structure is at a canal access point and readily accessible. Overall maintenance and equipment access is good. The access bridge, platforms, and guardrails are properly configured. Gate hand cranks are at an ergonomically proper height. The walkways and bridges are generally new construction and wide.

The trash rack at the cross gate is readily accessible for cleaning, although the angle is relatively flat. The canal escape stairs are on the rack and could interfere with cleaning but block only a minor amount of available rack area. An adjacent trash chute in spillway is useful for maintenance.

5.12.8 Assessment Summary

Based upon this assessment, the top three concerns at the Big Tunnel Spillway are:

1. Significant erosion in the channel downstream of spillway undermining shotcrete lining of the spill channel.
2. No energy dissipation in steep, converging spillway chute, with minimal jointing in concrete and no evidence of underdrains.
3. The geared actuator for spillway radial gate is not enclosed and is a potential pinch point.

5.13 Sand Bunker Spillway

Sand Bunker spillway is located on a concrete lined channel canal reach at a canal access point. The cross gate was a handwheel operated slide gate with a steel slide. The side spill was a passive overflow stoplog structure with an adjacent manual slide gate. Spill enters a short concrete chute that makes a 90-degree bend before discharging a small drop to a stable, well-vegetated channel.

5.13.1 Structural

The cast-in-place concrete gate headwall and supports as well as the spillway headwall and supports were aging and in serviceable condition but require some repairs. The concrete spillway had some spalling with exposed reinforcement at the corner of the stoplog slot member that should be repaired in the near term. Stoplog slots in concrete of spill chute headwall were in good condition.

A metal planking stairs and bridge over canal as well as steel guardrail were in relatively good condition with some rusting that requires recoating in the intermediate term.

5.13.2 Handrails

Handrails were painted steel with mechanical fittings in good condition. The bridge across the canal did not have an upstream handrail where the gate structure provides barrier from falling into the canal.

5.13.3 Retaining Walls

There were no retaining walls identified at this site.

5.13.4 Geotechnical

The receiving channel was rocky and appeared stable. The spill structure appeared to be founded on a relatively stable material with no visible undermining.

5.13.5 Hydraulic Analysis

The structure was well configured for flow regulation and release. The concrete junction structure had adequate freeboard level with top of canal. The cross gate as positioned was below the top of stoplog elevation but could be raised if necessary.

At the base of the stoplogs there was visible leakage into the spill chute near the areas of the concrete spalling.

5.13.6 Mechanical

The cross gate was a steel slide gate, handwheel operated. The handwheel was chain locked. The steel for the slide was in good condition but aging with signs of corrosion. The gate slide slots were steel angles on the downstream side. The upstream side of the slot was concrete, and the fit of slide in slots was poor. The gate and components require recoating in the intermediate term.

The spill slide gate was not visible, but there were obvious signs of moderate leakage. The actuator was an old a geared crank and is chain locked. The actuator gearing was not enclosed, which creates a pinch point that should be corrected. The gate requires inspection and rehabilitation in the intermediate term, including the seals and possibly a new actuator.

5.13.7 Maintenance Access

The structure was at a canal access point is easily accessible by vehicle. A canal bridge exists as part of the structure. Overall maintenance and equipment access was good with access to the spillway side of the structure more challenging. The access bridge, platforms, and guardrails were properly configured. Gate handwheel at an ergonomically proper height.

The spillway stoplogs have no access platform and are pulled using ropes from each side. There is separate access to each side making access for the stoplog adjustments awkward and cumbersome.

A metal planking stairs and bridge over canal as well as steel guardrail were in relatively good condition with some rusting that requires recoating in the intermediate term.

5.13.8 Assessment Summary

Based upon this assessment, the top three concerns at the Sand Bunker Spill are:

1. The spillway slide gate may require new seals and the replacement of the actuator or correction to actuator to enclose gearing
2. Minor concrete spalling with exposed reinforcing at the spillway stoplog requires repair.
3. The spillway stoplogs have no access platform and are pulled using ropes from each side, on two different platforms.

5.14 Sandsettler Spillway

The Sandsettler Spillway is located on a concrete flume canal reach. The cross gate is a manually operated radial gate. The side spill is a passive stoplog overflow to spillway chute, with an adjacent manual slide gate. The stoplogs extend to approximately 18” below the top of canal lining. Spill is conveyed through the concrete chute outlet with a moderate drop into a mildly sloped poorly vegetated channel. The plunge pool is erodible and is starting to undermine the chute.

A siphon pipe immediately upstream provides additional emergency release in the event of high canal levels.

5.14.1 Structural

The cast-in-place concrete gate supports, and spillway chute are well maintained. No major cracking is evident. The concrete lining of spill chute is old, with no major cracking, although left bank lining is under mined at toe

The metal stairs, platforms, walkways, bridges, and supports are in good condition.

The walkway over the spill is supported off of timber that is in fair condition but requires maintenance and monitoring to prevent deterioration.

5.14.2 Handrails

Wooden handrails are well-configured and well-maintained, in fair condition. Wood handrail condition requires regular-close monitoring for safety, as it is subject to rapid deterioration. No canal side railing is provided on spill bridge.

5.14.3 Retaining Walls

No retaining walls at this site.

5.14.4 Geotechnical

The receiving channel is erodible, and the receiving pool at drop is back cutting and is starting to undermine the concrete chute discharge chute. The spill after drop pool impinges against the toes of an erodible steep bank that has been partially shotcrete lined. However, the bank perched above the lining is near-vertical and unstable. The downstream channel shows signs of erosion and is poorly vegetated within the visible reach. This spill should be used with caution and inspected after each passive spill event due to erosive potential. The downstream channel should be stabilized, if intent is to re-establish a gated spill release.

5.14.5 Hydraulic

The structure is generally well configured for flow regulation and release. The outlet chute appears to provide significant spill capacity.

The passive spill over stoplogs would not exceed downstream chute capacity. The concrete junction structure and radial gate have more than adequate freeboard, based upon high watermarks.

While debris in the canal could disrupt flows, the downstream radial gate is not sensitive to debris loading and the passive side spill allows for significant overtopping.

5.14.6 Mechanical

The radial cross gate has new seals. Radial gate steel framing, sheeting, connectors, and hoist are aged and require recoating at a minimum. The pivot is anchored to thin walled concrete and appears to be original. The manual crank actuators appear to be original equipment and although well maintained are a potential failure point. The gate cranks are chain locked. An operational test should be conducted. Depending upon the criticality of this spill point a major upgrade to radial gate mechanical features should be scheduled. The actuator gearing is not enclosed, which creates a pinch point that should be corrected.

The spillway is gated with timber stoplogs. The stoplog slots are block outs in the concrete chute sidewalls. There is visible seepage at the base of the stoplogs into the chute. Reconditioning and improvements of the timber stoplogs is recommended in the near term.

The spill slide gate was not visible, but there are obvious signs of moderate leakage. The actuator is an old a geared crank and is chain locked. The actuator gearing is not enclosed, which should be corrected. The gate requires inspection and rehabilitation, include the seals and possibly a new actuator, in the intermediate term. The extent of rehab would depend upon intended use, but leakage and structural integrity should be restored.

5.14.7 Maintenance Access

The structure is at a canal access point is relatively accessible. A canal bridge exists immediately upstream of the structure. Overall maintenance and equipment access is fair. The access bridge, platforms and guardrails are properly configured. The spill slide gate headwall is missing grating cover over the air vent, and this tripping hazard should be resolved in the near-term. The radial gate hand crank is at a relatively low height but easily accessible.

5.14.8 Siphon Pipe

Upstream of this spill is a siphon pipe that automatically engages when canal levels become excessive. The siphon pipes are a good safety feature that moderate unexpected canal rise resulting from excessive side inflows during rainfall event. The capacity of siphons is limited and dependent upon both pipe size and downstream vertical drop.

Visible portions of the siphon system are in serviceable but poor condition, required maintenance includes painting. The concrete intake is old but with no signs of cracking. The siphon barrel is in the canal pathway, limiting walking space and creating a tripping hazard. These access issues should be addressed in the near-term. The condition of the siphon barrel components was not a visible part of the inspection and should be reviewed with PG&E operators. An interior camera inspection of the piping may also be warranted. The siphon barrel is access points are partially buried and should be corrected along with access improvements.

5.14.9 Assessment Summary

Based upon this assessment, the top three concerns at the Sandsettler Spillway are:

1. The drop pool at the end of spillway chute is backcutting under spill chute and downstream channel banks are eroding.
2. The geared actuator for spillway radial gate is not enclosed and is a potential pinch point.
3. The siphon pipe is aged, and its operation is uncertain. The operating procedures and maintenance should be reviewed

5.15 Yunk's Spill

The Yunk's Spillway was a side spill from a concrete lined canal reach that has been abandoned. The facility was limited to an approximately 36-inch-wide stoplog controlled side spill with no canal cross gate. At present the stoplogs had been removed and the spillway was sealed off just beyond the stoplog slot. A short, sheet-lined wood box flume chute led to a drop to unimproved hillside.

5.15.1 Structural

The sheet-lined wood box flume chute was intact but wooden members were severely deteriorated, and the structure had undermining at the toe. The spill chute cut through the canal bank was near vertical with deteriorating wooden framing. The box flume should be removed from the canal bank cut or otherwise stabilized in the near term due to stability concerns.

The wood plank walkway and supports were in fair condition and would require routine maintenance. Wood railing for spill bridge was recent and should be regularly inspected and maintained.

A complete replacement would be required prior to restoring to service.

5.15.2 Handrails

Spill bridge wooden railings were well configured and in good condition. However, the walkway was narrow with no canal side railing. The wood railing had been moved waterward due to unstable conditions of the box flume cut through the canal bank.

5.15.3 Retaining Walls

There were no retaining walls identified at this site.

5.15.4 Geotechnical

The receiving channel was unimproved hillside. The spill structure was founded on soil and appears to have some undermining at the toe of the spill. As the drop off is not significant, the channel could be stabilized if the structure is restored to service.

5.15.5 Hydraulic Analysis

The structure apparently was used as a passive side spill and possibly a canal drainage point. It was configured as a passive spill currently sealed off to approximately the top of canal lining. In its present condition, its use is not recommended.

Prior to re-engaging the spillway, if desired, a review of the downstream channel is recommended to identify any vulnerable new encroachments installed since abandonment.

5.15.6 Mechanical/Electrical

There were no mechanical or electrical features at this site.

5.15.7 Maintenance Access

The wooden pathway was narrowed with no canal side fall protection. The access should be improved by removing the box flume or otherwise stabilizing the spill structure.

5.15.8 Assessment Summary

Based upon this assessment, the top three concerns at the Yunk's Spill are:

1. The abandoned wood sheet lined box flume chute is failing.
2. The wood plank spillway chute crossing is narrowed and supported by a failing wood box flume chute.
3. The spillway should be properly abandoned.

6. Geophysical Investigation

6.1 Field Investigation

Field work was completed on May 4, 2021 within Segment 15 along the existing timber raised flume and 13 Mile Spill Road to determine the characteristics of the observed landslide. Geophones were set up at 10-foot intervals and energy sources were placed between every other geophone. A total of four lines were collected in the field, as summarized below:

- RS Line 1 was located on the south side of the flume and consisted of 15 active stations

- RS Line 2 was located on the north side of the flume and consisted of 15 active stations
- RS Line 3 crossed under the flume and intersected both RS Line 1 and RS Line 2. This line had 12 active stations.
- RS Line 4 was located along the 13 Mile Spill access road above the flume. The line had 24 active stations.

The locations of each geophone were recorded with global position system equipment. Both horizontal and vertical locations were obtained in the field.

6.2 Analysis Results

The results of the geophysical survey are included in Appendix E. In general, surficial loose soils were observed to trend to the southwest, indicating that the sliding mass extend 10 to 20 feet below existing grade in some areas. The soil profile along 13 Mile Spill Road was similar to these findings with low-velocity soils in the upper 10 feet. These findings suggest the sliding mass is relatively shallow and mitigation for it can be incorporated into the design of the replacement flume. Additional geotechnical information will be required to confirm the findings of the geophysical survey as part of correlating the data to physical soil samples.

7. Risk Matrix

7.1 Risk Matrix Methodology

Ratings were applied to the observations summarized above ranging from 1 to 5. Features assigned a rating of 1 are higher priority items that should be addressed as soon as possible, as there may be a threat to the System if the issue is not resolved. Features assigned a rating of 5 are in good condition and no action is required or minimal action may be needed as part of current maintenance activities.

In addition to the condition rating described above, an importance factor was assigned to each rating criteria. An importance factor of 1 was assigned to those criteria that would have more impact to the System and an importance factor of 3 was assigned to those that would have the least impact.

A weighted risk rating was calculated for each segment based on the features included. The condition rating was multiplied by the importance factor for the applicable features, and these values were averaged. Lower values reflect areas that will need focused attention.

7.2 Results of Risk Matrix

The results of the risk matrix analysis are included in Appendix F. Findings show that the following canal and flume segments have more associated risk and should be prioritized for future work and additional field testing:

- Segment 1 had a poor rating due largely to erosion of the foundation and freeboard limitations at Highway 20. In addition, the timber structure is weathered, and the liner is separated from the supports.
- Segment 9 received a poor rating largely due to the continuing erosion at the downslope side of the flume.
- Segment 12 received a poor rating due to concerns at Hickman Spill, where erosion and slope stability was a concern at the spillway discharge.
- Segment 15 received a poor rating due to the poor nature of the existing timber flume and the upslope landslide.

The spillway weighted risk ratings account for a wide range of disparate factors. The complexity of individual spillways, as well as their function in regulating the system, varies greatly. At certain sites a moderate investment can significantly improve the ratings, whereas significant investments are necessary elsewhere to make moderate risk reductions. The risk rating should be employed accordingly. Findings show that the following spillways have more associated risk:

- Big Tunnel spill received poor ratings largely due to the geotechnical conditions related to erosion and structural condition of the spillway.
- Yunk's spill had a poor rating due to failing wood box flume through the right bank of the canal at this abandoned spill.

8. Conclusions and Recommendations

The following sections provide conclusions and recommendations based on the findings of the risk assessment.

8.1 Canals and Flume

8.1.1 Freeboard

Generally, most segments appeared to operate in the 12- to 18-inch range, particularly Lennon and Wood Box Flumes. Gunite-lined canal segments often appeared to operate at greater than 18 inches of freeboard, with isolated lower measurements at transition areas.

The primary area of freeboard concern is the Lennon flume immediately upstream of the Highway 20 crossing, as well as a limited section downstream. Just upstream of Highway 20 the freeboard measured approximately 10 inches, with a further reduction immediately upstream of the headwall. Note that the System was empty at the time of inspection for this segment. Inspection indicates that the tunnel under Highway 20 was formed to the same cross sections as the Lennon flumes, with a 12-inch air gap, an angle point and an invert slope break. The estimated water level through the culvert clearly exceeded the half circle shape.

The Highway 20 crossing freeboard issues are most likely due to settlement immediately after construction. Although further review is required, crossing modifications may be too destructive.

Surface roughness improvements for the box culvert may be possible but would provide marginal capacity upgrades. Lennon Flumes by their nature do not lend themselves to modifications to increase freeboard. Additional freeboard may be achieved by partial replacement with an alternative flume type.

It should be noted that the freeboard rating is independent of spillways. Many spillways have areas set to passively spill with crests immediately above operating level. Raising canal operating levels will require some changes at spillways, such as crest raises with stoplogs, modified timber slide board heights, etc.

8.1.2 Vegetation

Hazard trees should be removed from the System footprint. Dense vegetation near the timber structures should be minimized to reduce fire danger.

8.1.3 Superstructure and Substructure

Observations of these timber structures reveal most are exceeding their useful life and should be scheduled for replacement. Only the more recent constructs are in acceptable condition. That said, we should note that the system functions and should continue to function provided the most critical defects are addressed early. Generally speaking, while all timber framed segments have the same types of defects, the worst, most-critical defects may comprise only a fraction, or sub-segment, of each segment. Focusing efforts on these areas will lower overall risk of failure.

Required repairs include, replacing split timber members, tightening bolts in hardware clips that are not fastened down, replacing hardware that does not fit with proper fitting hardware and replacing beams with splits through connectors. Beam to column steel connector hardware is deficient in that it does not provide proper bolt end and edge distances and results in splits of the timber members. These elements should be replaced with an appropriately designed piece of hardware each time a beam and or column is replaced.

These “sub-segments” when reviewed in their entirety may suggest a full structural replacement of the sub-segment will provide the best value for the repair dollar.

Longitudinal lateral bracing is a prescribed component in classic Lennon Flume construction. It seems to be largely missing in this system. Consideration should be given to installing the bracing where it is missing, and all new construction should include the bracing.

8.1.4 Foundation

Material that has accumulated at the flume foundations should be cleared away and formerly buried timber inspected for dry rot. Erosion at foundation piers should be repaired and monitored. Seasonal draws may need to be further channelized through the foundation areas to prevent further erosion.

8.1.5 Liner

Hardware supports should be replaced where the liner is not sufficiently supported on the flume substructure. The liner in the timber box flumes should be monitored for leaks and the resulting possibility of dry rot damaged lining should be repaired to ensure the flume is operating efficiently.

Minor cracking of the gunite liner should be monitored and patched as needed. If voids have formed in areas where the liner is cracked should be filled prior to patching.

8.1.6 Foundation Stability and Erosion

Foundation instability is largely related to undermining of the foundation footings as noted above. Areas where this is observed should be monitored and repaired as needed to maintain stability of the System.

8.1.7 Slope Stability

Potential landslide areas should be monitored for future movement and repaired as required. Repairs should be undertaken when slope movement is noticeable or the bench fill has separated from the liner. Mechanically stabilized earth walls have performed well historically in similar environments along steep hillsides and would provide a cost effective way to provide stability to the System.

8.1.8 Rock Fall

Areas where rock fall could impact the conveyance should be monitored. Rock fall could damage the liner, flume foundation, and other features. If potential for rock fall is observed, problematic rocks or rock fragments should be carefully removed in such a way to prevent damage to the System.

8.2 Spillways

Conclusions and recommendations for each individual spillway are included in the Assessment Summary at the end of each spillway condition assessment subsection.

8.3 Tunnel Bypass

NID has expressed interest in potential tunnel bypass options to reduce the length of the System and eliminate portions of canal that are in poor condition. Several locations along the canal appear to be suitable for tunnel bypass, as summarized below:

- 950-foot-long tunnel to connect Segments 6 and 8, which would replace Little Tunnel and approximately 5,670 feet of canal and bypass areas with potential landslide risk.
- 1,450-foot-long tunnel in Segment 13 that would eliminate 5,415 of canal that would bypass several historic and potential landslide areas.
- 1,100-foot-long tunnel in Segments 14 and 15 that would eliminate 3,800 feet of canal and flume, including the Segment 15 landslide area.

- 1,425-foot-long tunnel within Segment 21 on Chalk Bluff Canal to replace 4,420 feet of canal.

These tunnel bypass projects would be significant upgrades to the system and would bypass known problem areas that could cause issues in the future.

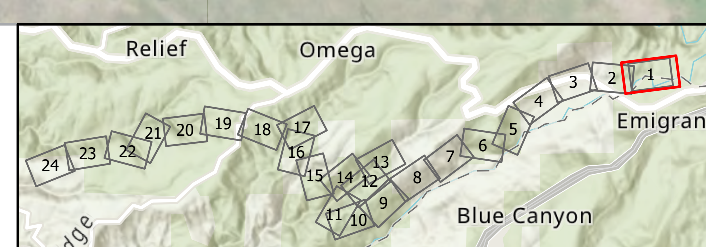
9. Limitations

The observations, findings, and recommendations made in this report are based on a limited visual inspection of the subject facility. A detailed review of plans for the facility beyond that required for a general understanding of the system was not performed. Destructive and non-destructive testing was not included in our scope of work. The subject property was not reviewed for compliance with current Code requirements. This report is intended for the exclusive use of Nevada Irrigation District. The GHD team reserves the right to revise this report should new evidence warrant. This report should be considered invalid after five years.

Appendix A
Map Book

Legend

- Lined Canal
- Lennon Flume
- Access Road
- Inspection Point
- Gaging Station
- Bridge
- Seasonal Draw
- Pedestrian Access Ramp
- Station
- Spill



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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

Project No. 11211964
Revision No. -
Date 4/16/2021

FIGURE 1

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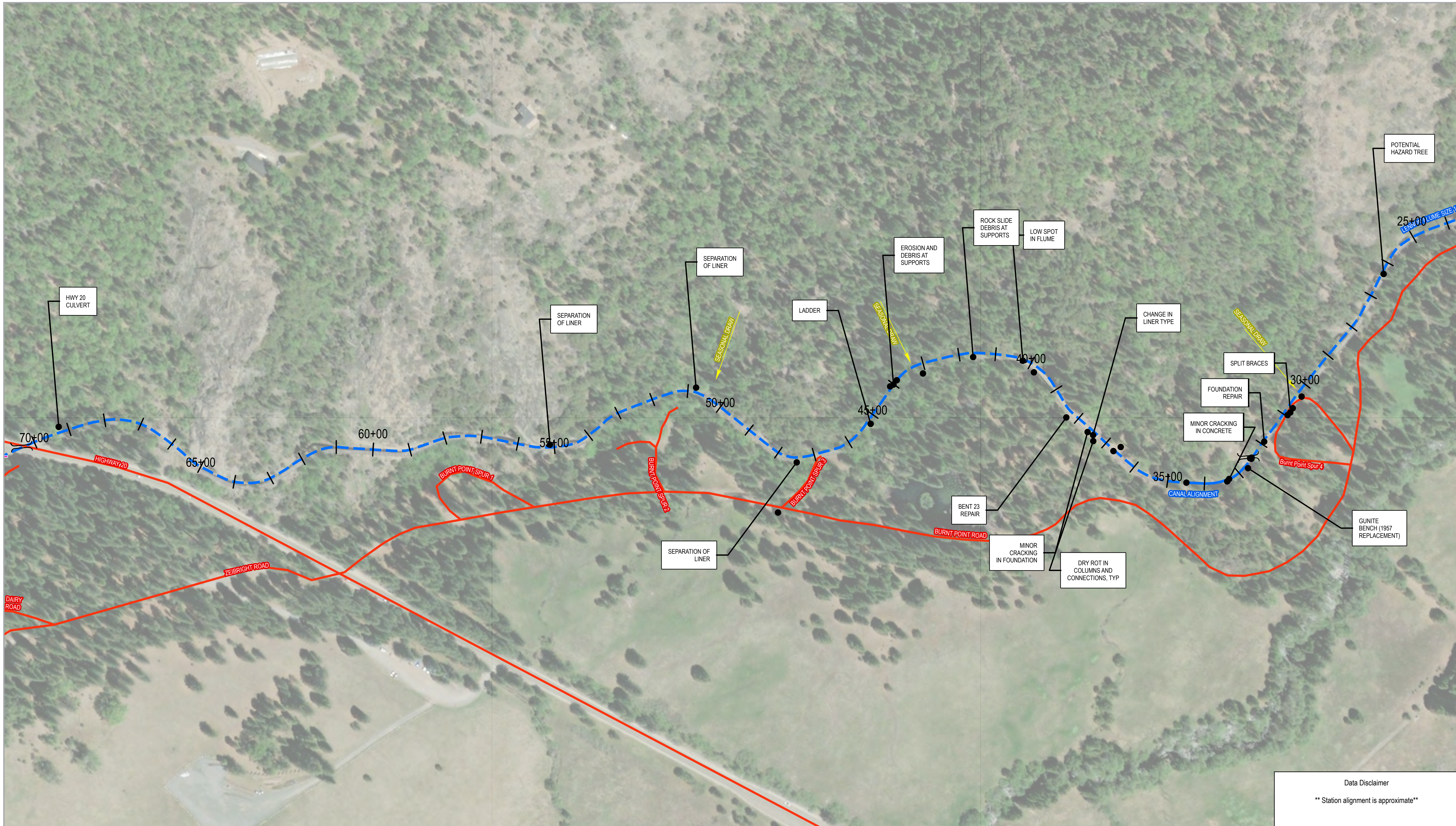
Data source: World Imagery: Maxar, Microsoft
World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

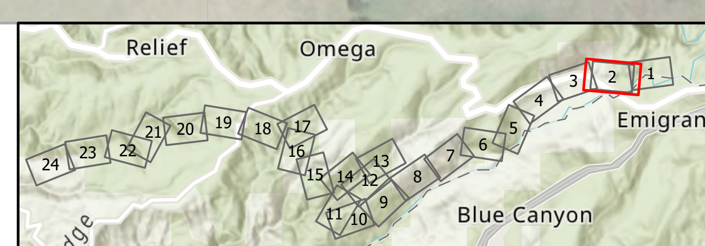


Data Disclaimer

** Station alignment is approximate**

Legend

- Lined Canal
- Lennon Flume
- Access Road
- Inspection Point
- Bridge
- Seasonal Draw
- Segment



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EVALUATION OF THE SOUTH YUBA CANAL
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FIGURE 2

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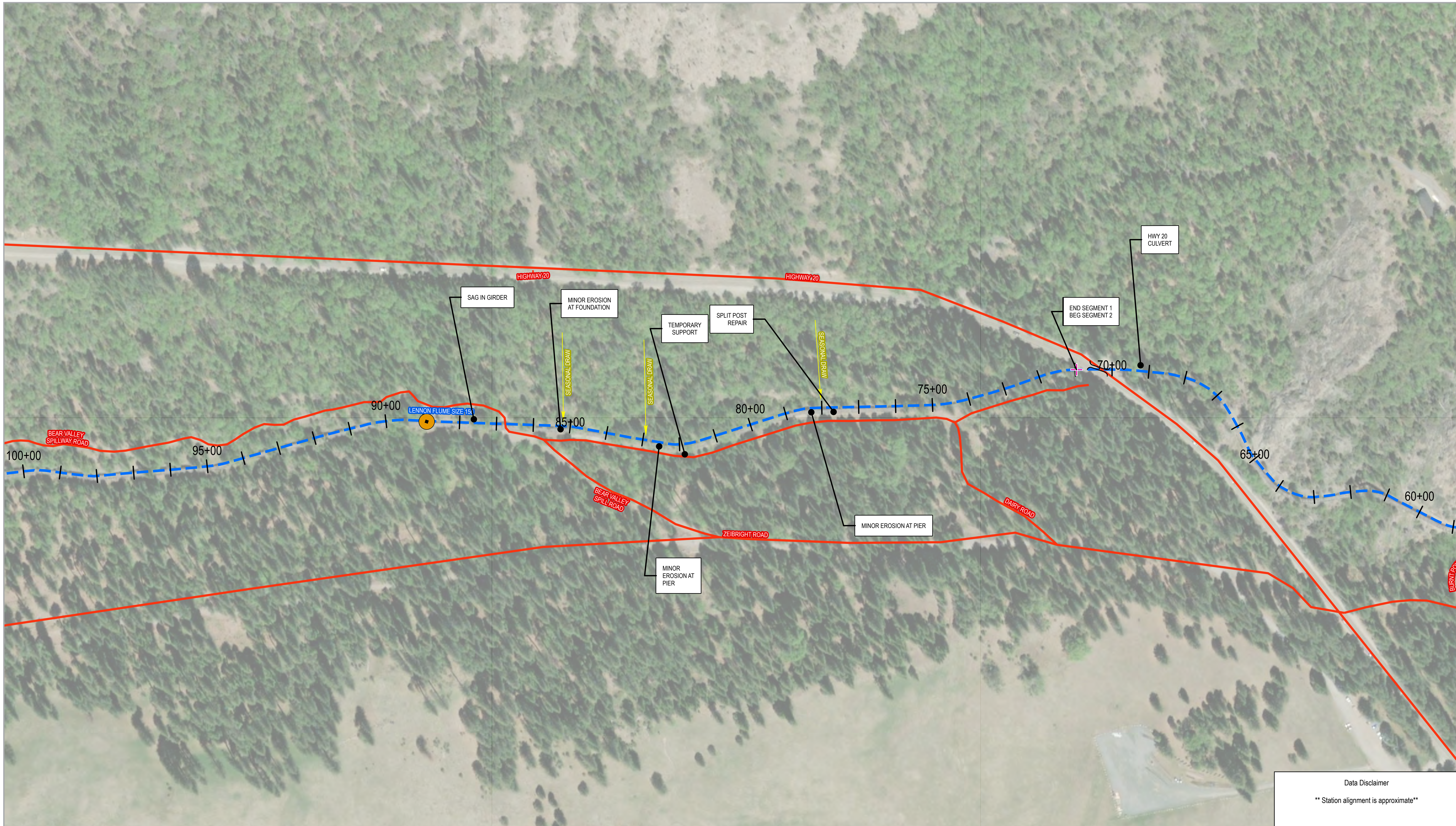
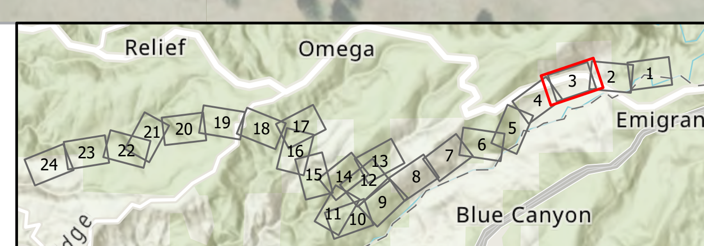


Legend

- Lennon Flume
- Inspection Point
- Segment
- Access Road
- Bridge
- Access Point
- Seasonal Draw



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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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Revision No. -
Date 4/16/2021

FIGURE 3

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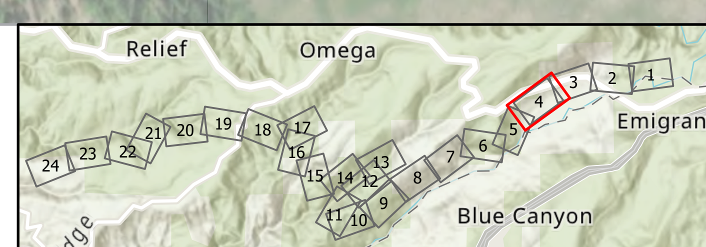
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

Legend

- Lennon Flume
- Wood Box Flume
- Concrete Box Flume
- Access Road
- Access Point
- Inspection Point
- Spill
- Segment



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EVALUATION OF THE SOUTH YUBA CANAL
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SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 4

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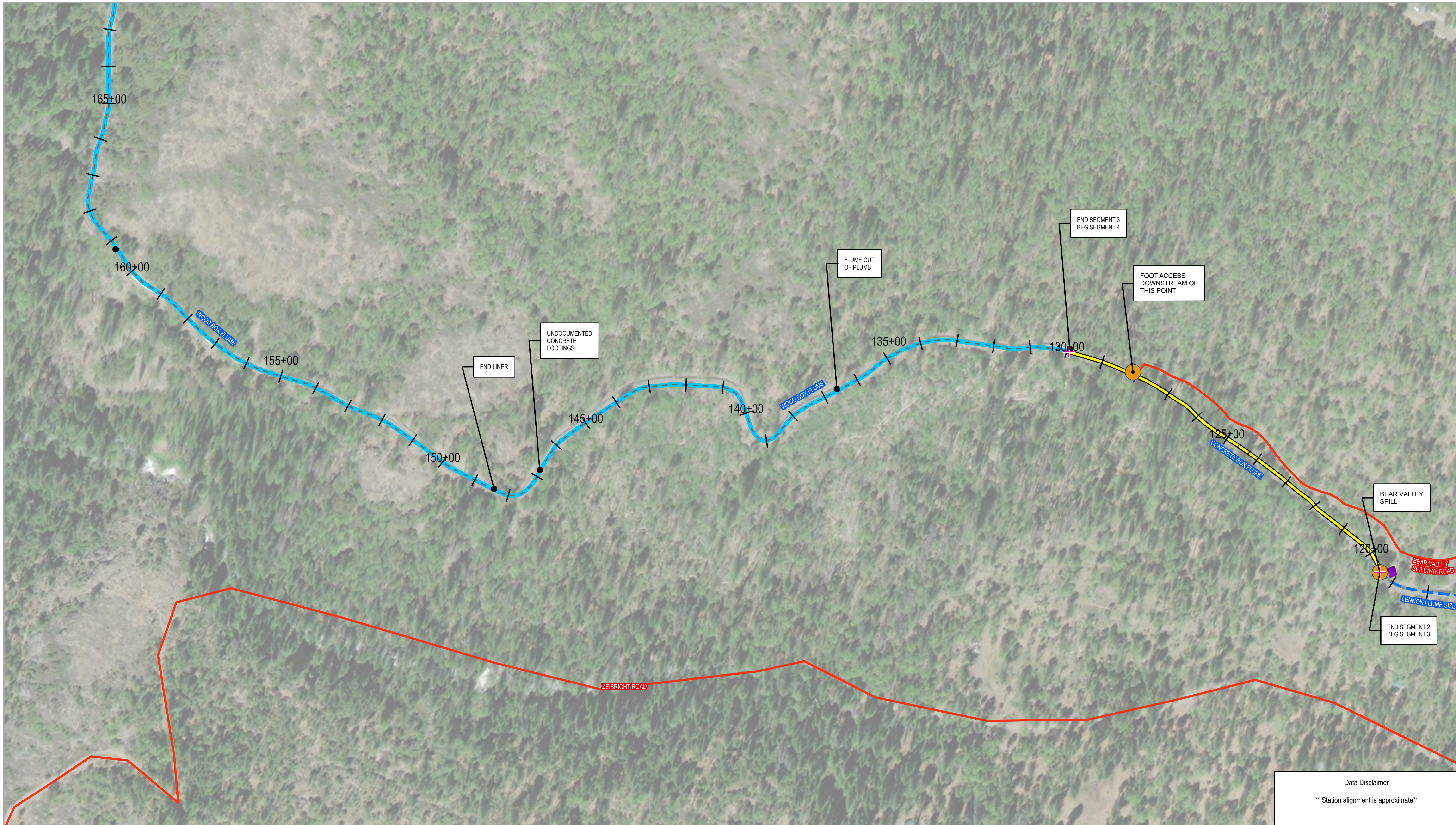

Data Disclaimer

** Station alignment is approximate**

Legend

- Lennon Flume
- Wood Box Flume
- Concrete Box Flume
- Access Road
- Access Point
- Inspection Point
- Spill
- Segment

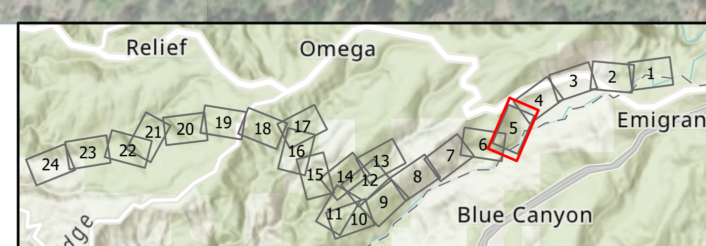

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FIGURE 5

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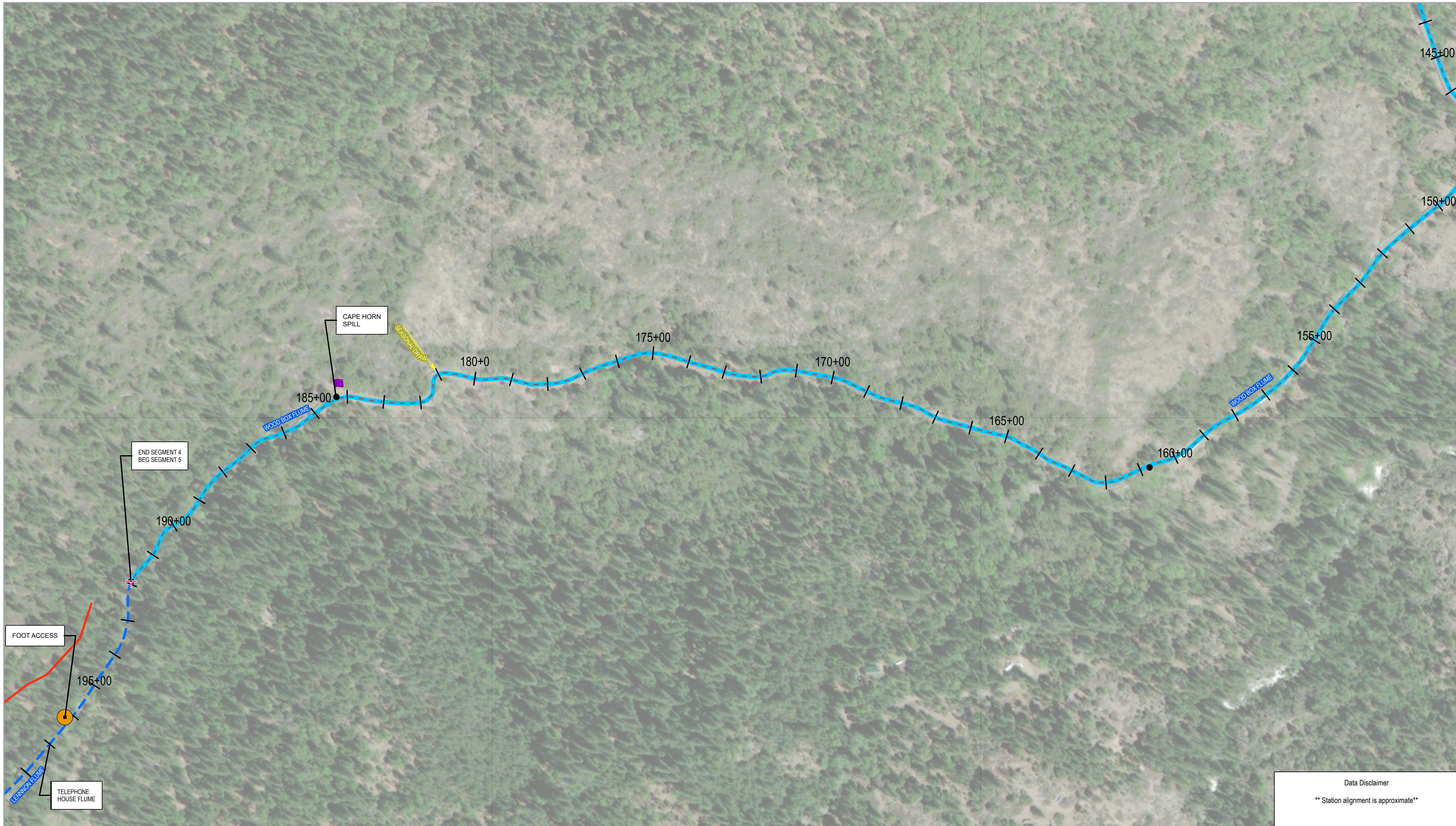
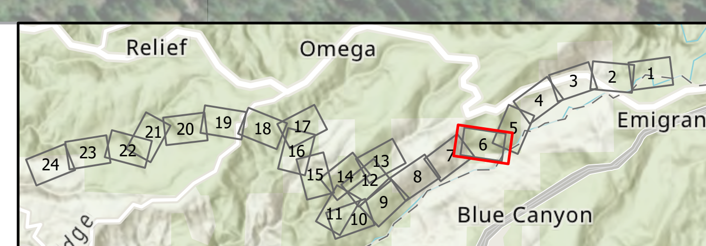


Legend

- Lennon Flume
- Wood Box Flume
- Access Road
- Access Point
- Inspection Point
- Seasonal Draw
- Spill
- Segment



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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 6

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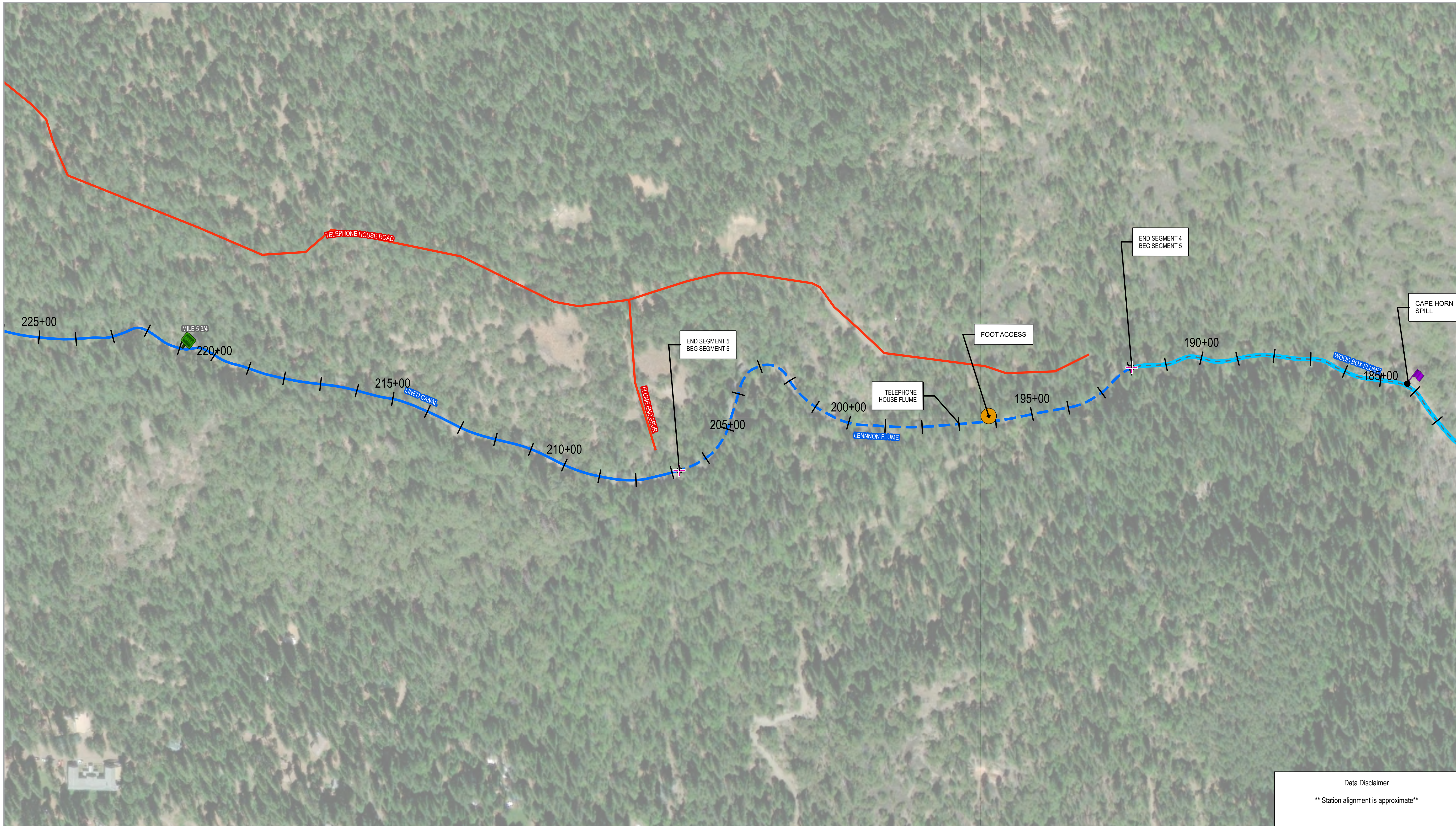
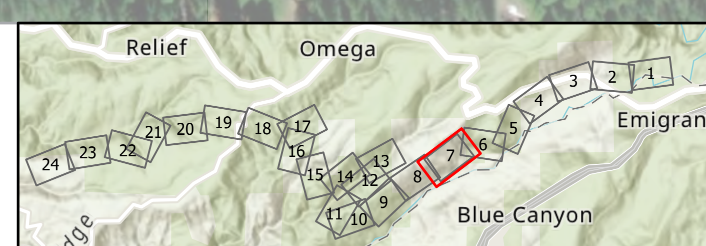


Legend

- Lined Canal
- Lennon Flume
- Wood Box Flume
- Access Road
- Access Point
- Inspection Point
- Mile Marker
- Spill
- Segment



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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

Project No. 11211964
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FIGURE 7

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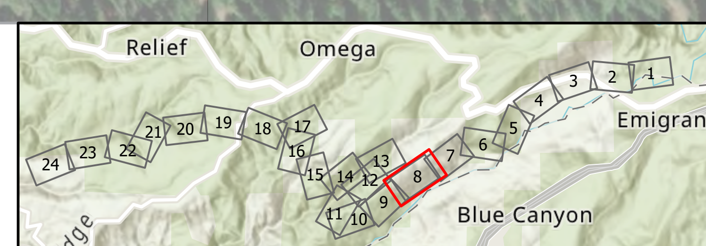
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

Legend

- Lined Canal
- Access Road
- Inspection Point
- Gaging Station
- Mile Marker



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SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 8

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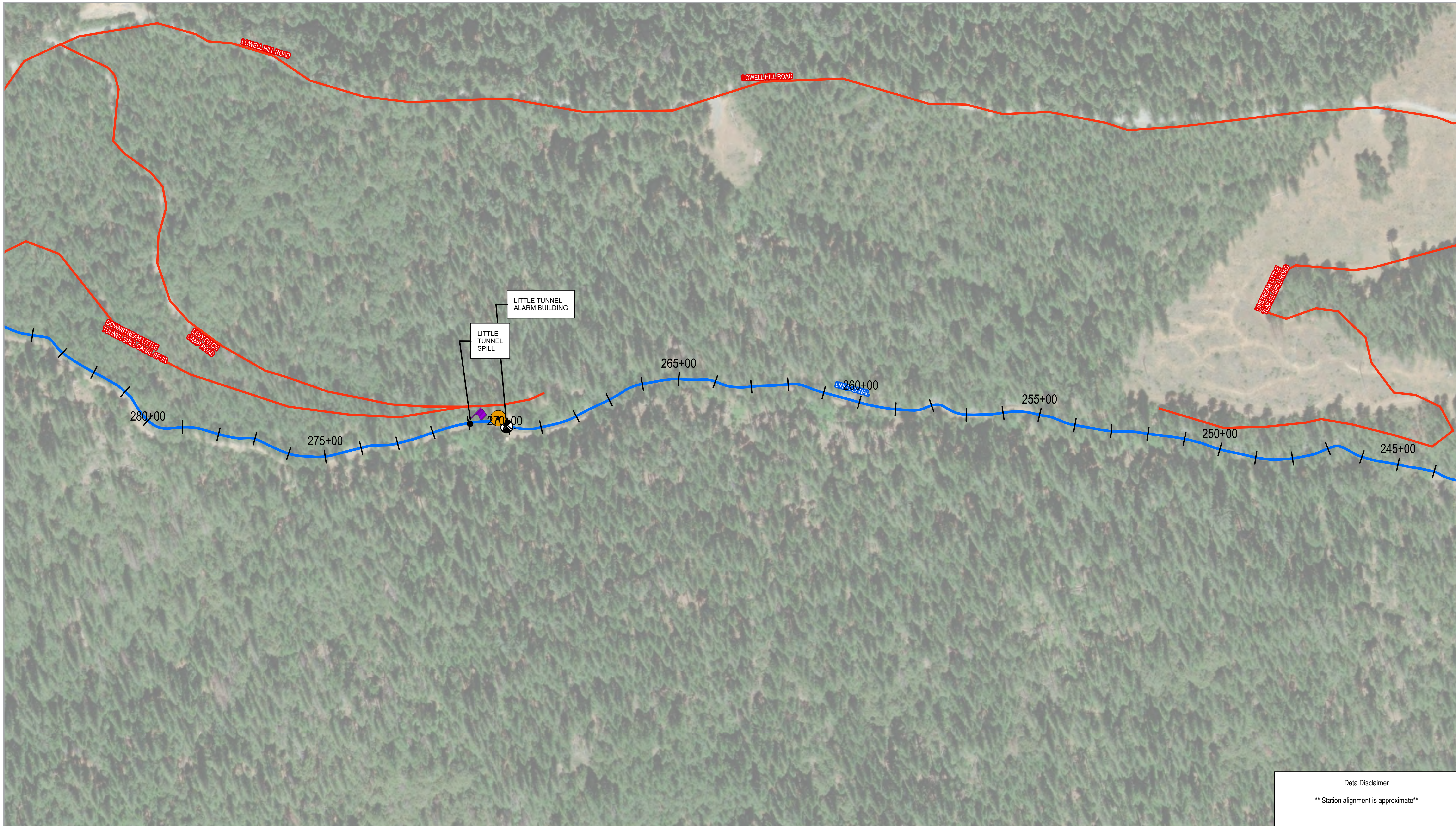
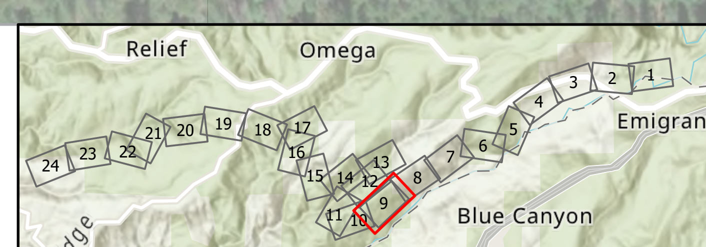


Legend

- Lined Canal
- Access Road
- Access Point
- Inspection Point
- Gaging Station
- Bridge
- Spill



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SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 9

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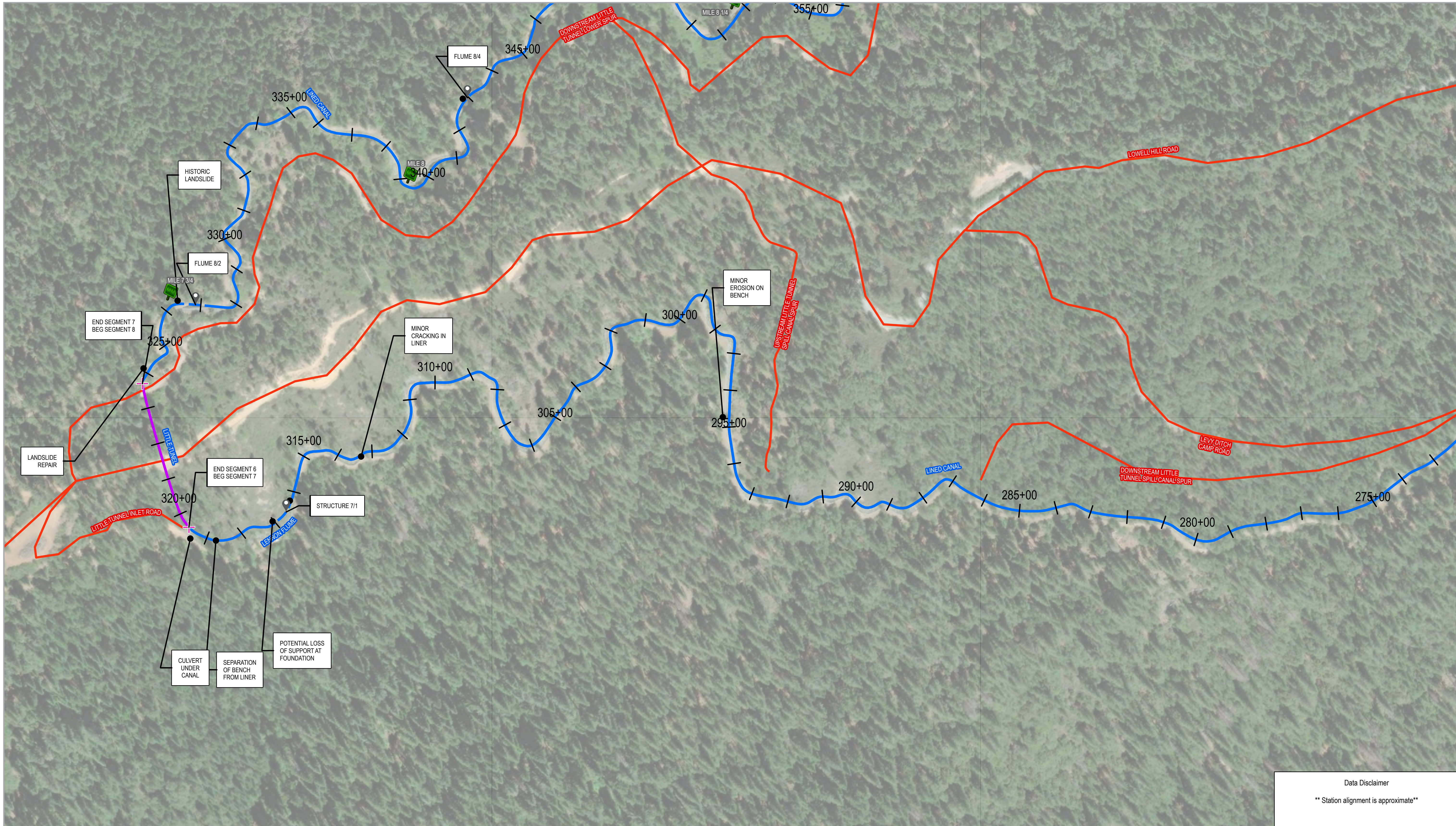
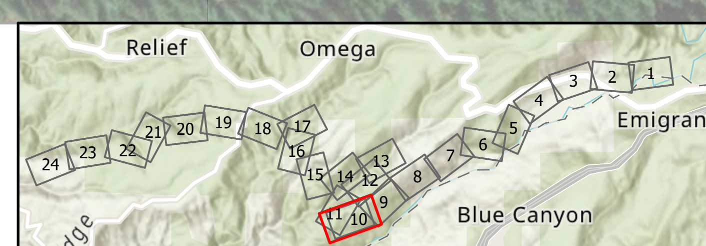


Legend

- Lined Canal
- Lennon Flume
- Tunnel
- Access Road
- Flume
- Inspection Point
- Mile Marker
- Segment



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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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Date 4/16/2021

FIGURE 10

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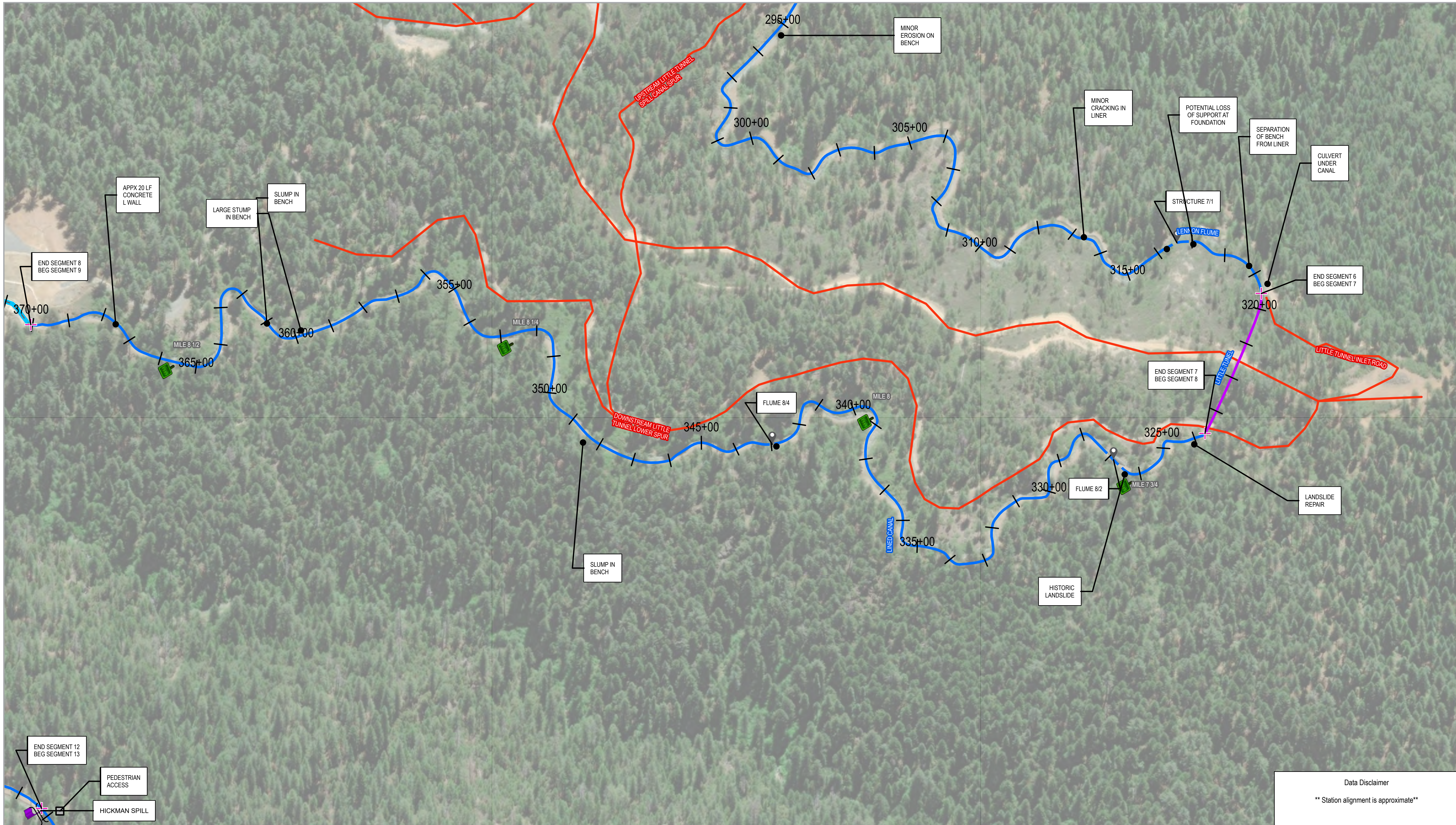
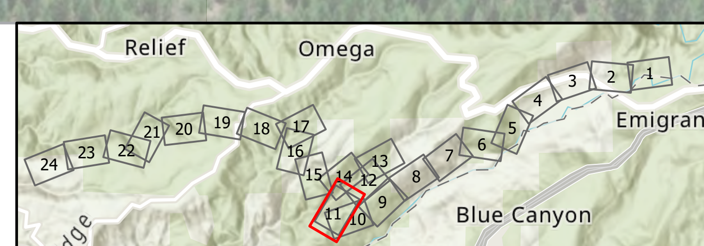


Legend

- Lined Canal
- Lennon Flume
- Wood Box Flume
- Tunnel
- Access Road
- Flume
- Inspection Point
- Bridge
- Pedestrian Access Ramp
- Mile Marker
- Spill
- Segment



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EVALUATION OF THE SOUTH YUBA CANAL
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SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 11

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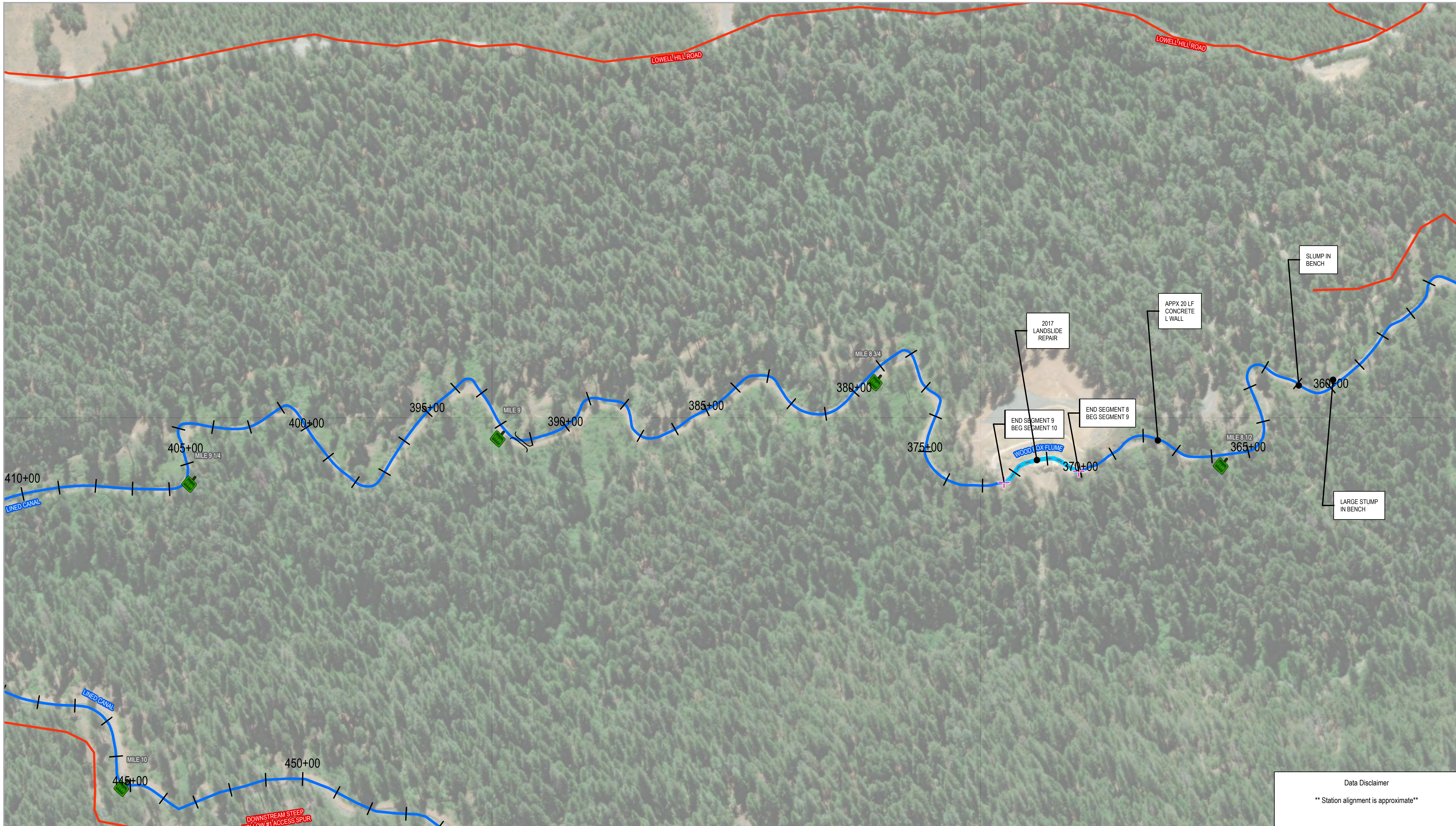
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

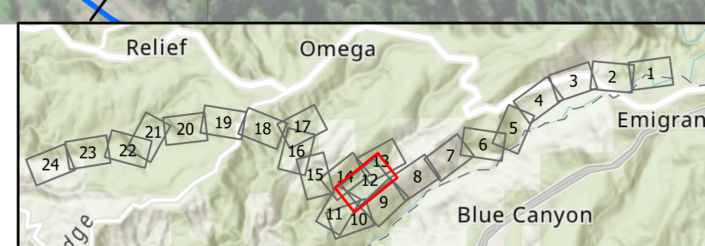


Data Disclaimer

** Station alignment is approximate**

Legend

- Lined Canal
- Wood Box Flume
- Access Road
- Inspection Point
- Bridge
- Mile Marker
- Segment



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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

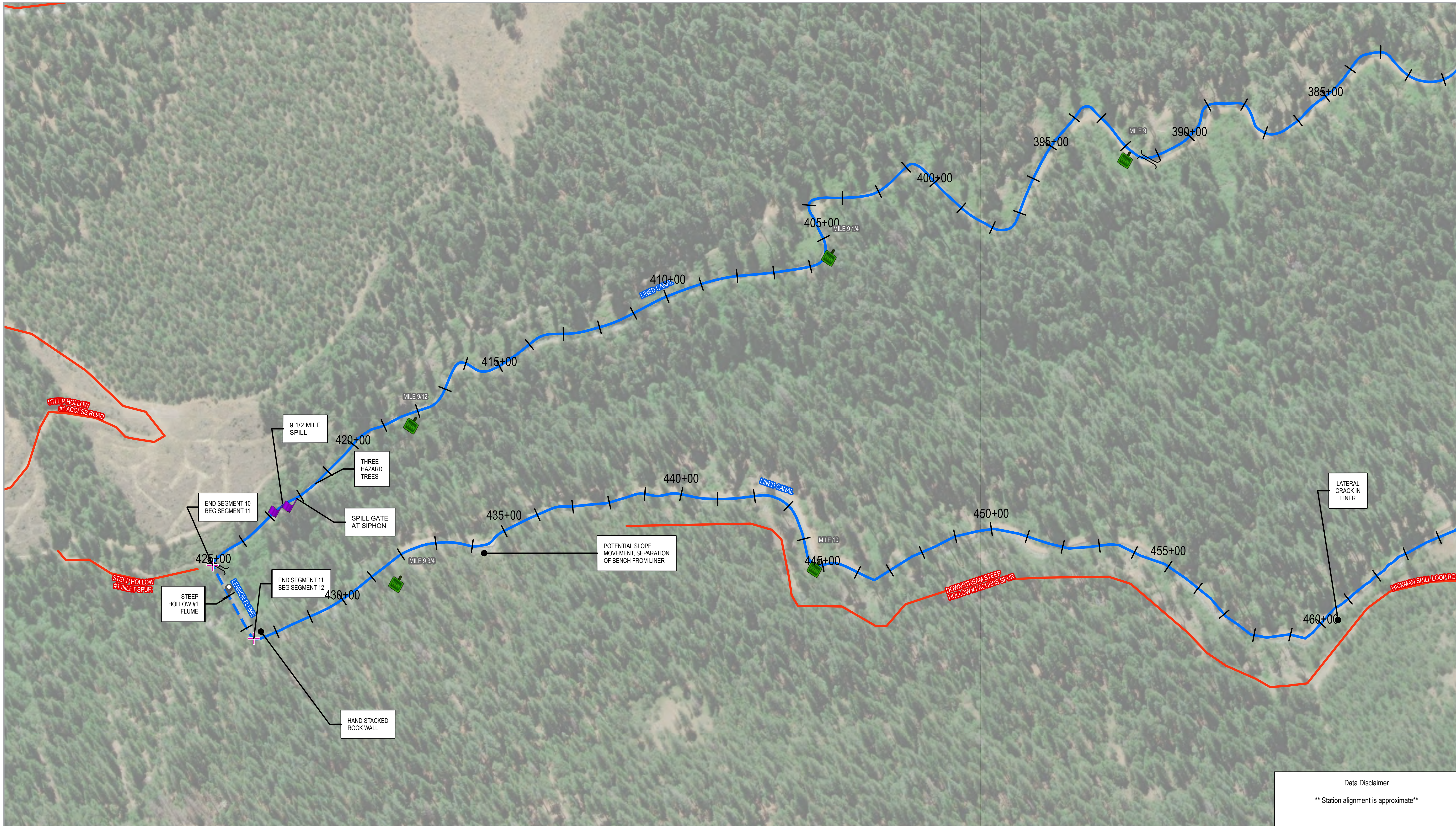
SOUTH YUBA CANAL SYSTEM MAP

Project No. 11211964
Revision No. -
Date 4/16/2021

FIGURE 12

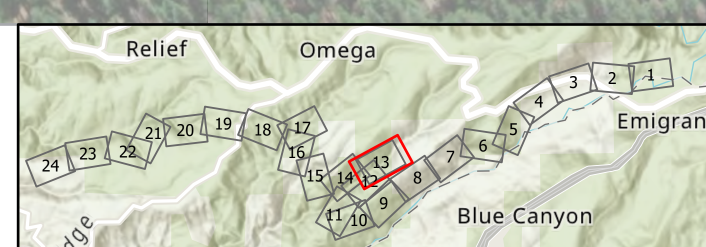
\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

- Lined Canal
- Lennon Flume
- Access Road
- Flume
- Inspection Point
- Bridge
- Mile Marker
- Spill
- Segment



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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
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SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 13

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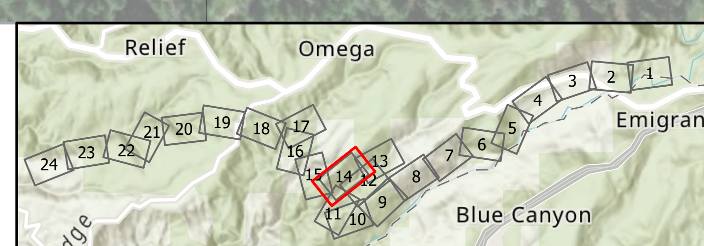
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

Legend

- Lined Canal
- Wood Box Flume
- Access Road
- Inspection Point
- Gaging Station
- Bridge
- Pedestrian Access Ramp
- Mile Marker
- Spill
- Segment



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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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Date 4/16/2021

FIGURE 14

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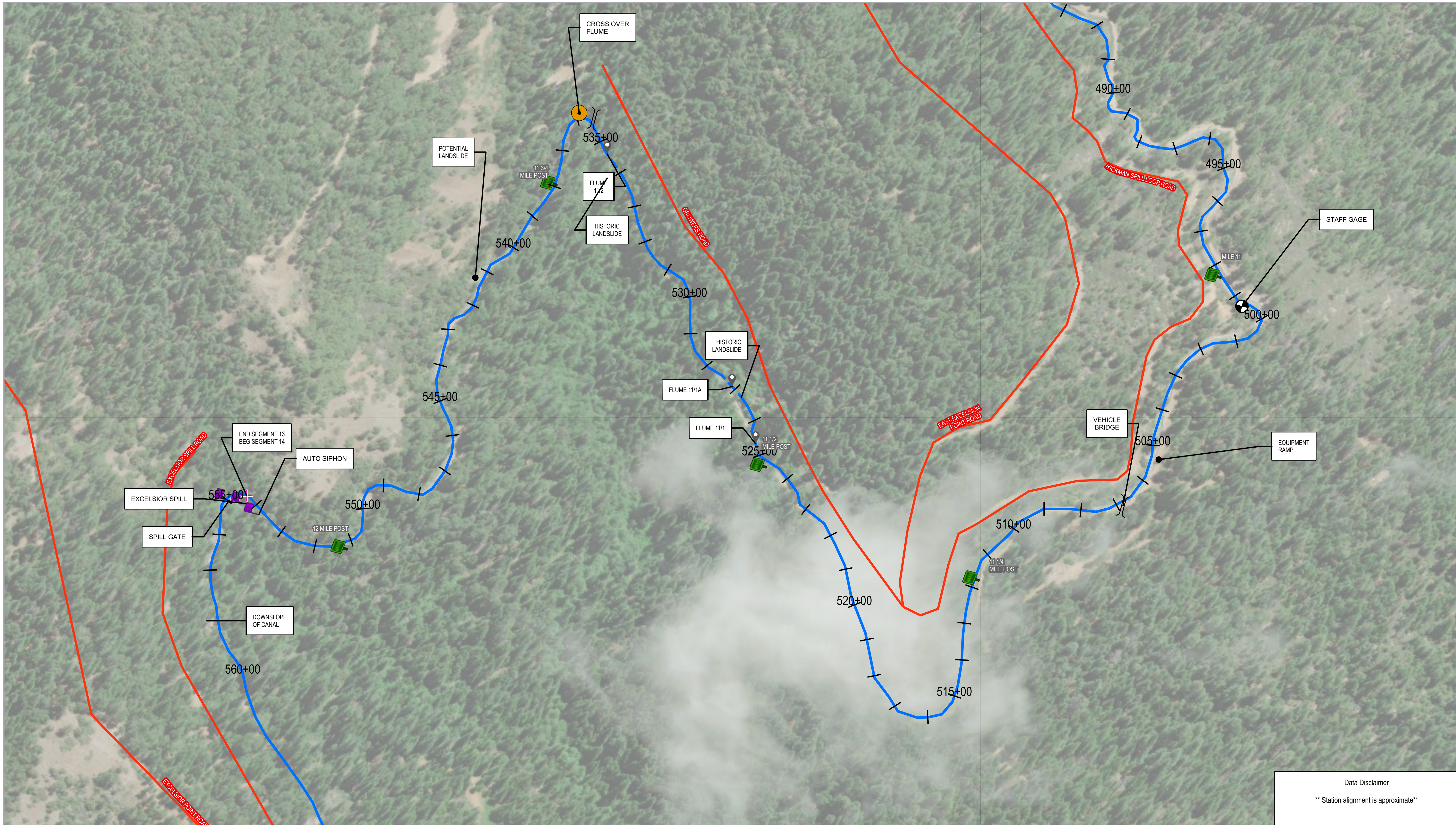
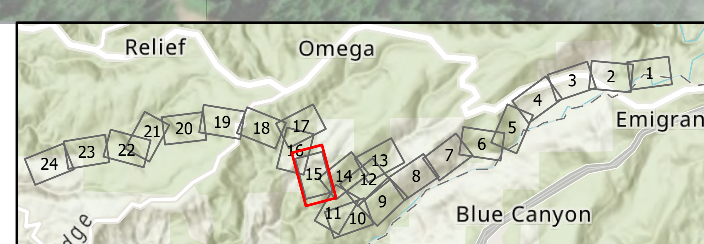
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

- Lined Canal
- Lennon Flume
- Access Road
- Flume
- Access Point
- Inspection Point
- Gaging Station
- Bridge
- Mile Marker
- Spill
- Segment



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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

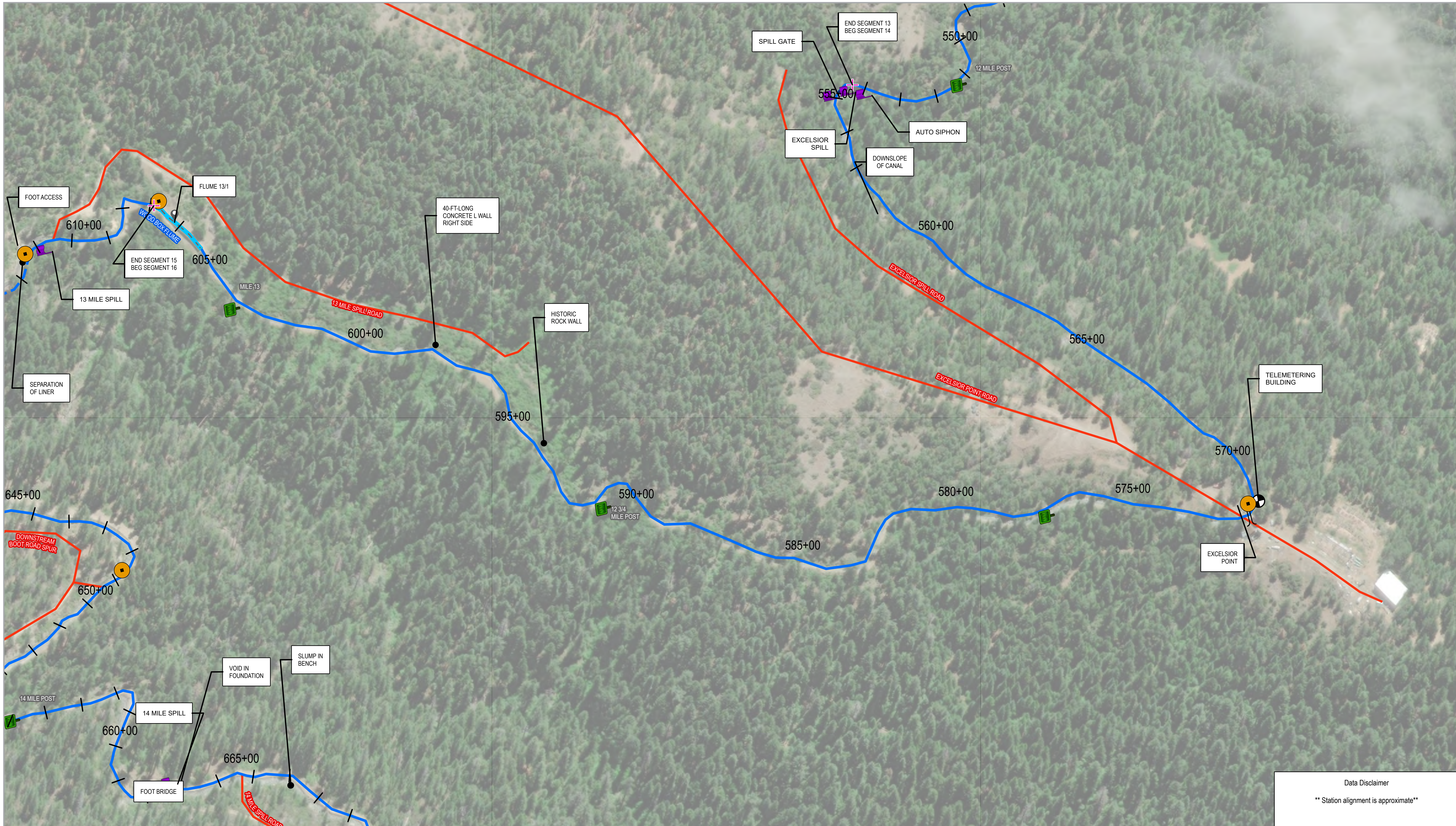
SOUTH YUBA CANAL SYSTEM MAP

Project No. 11211964
Revision No. -
Date 4/16/2021

FIGURE 15

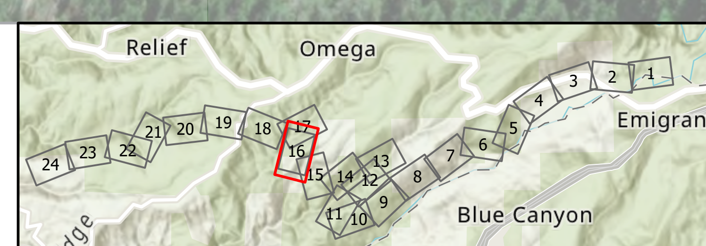
\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

- Lined Canal
- Lennon Flume
- Wood Box Flume
- Access Road
- Flume
- Access Point
- Inspection Point
- Gaging Station
- Bridge
- Mile Marker
- Spill
- Segment



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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

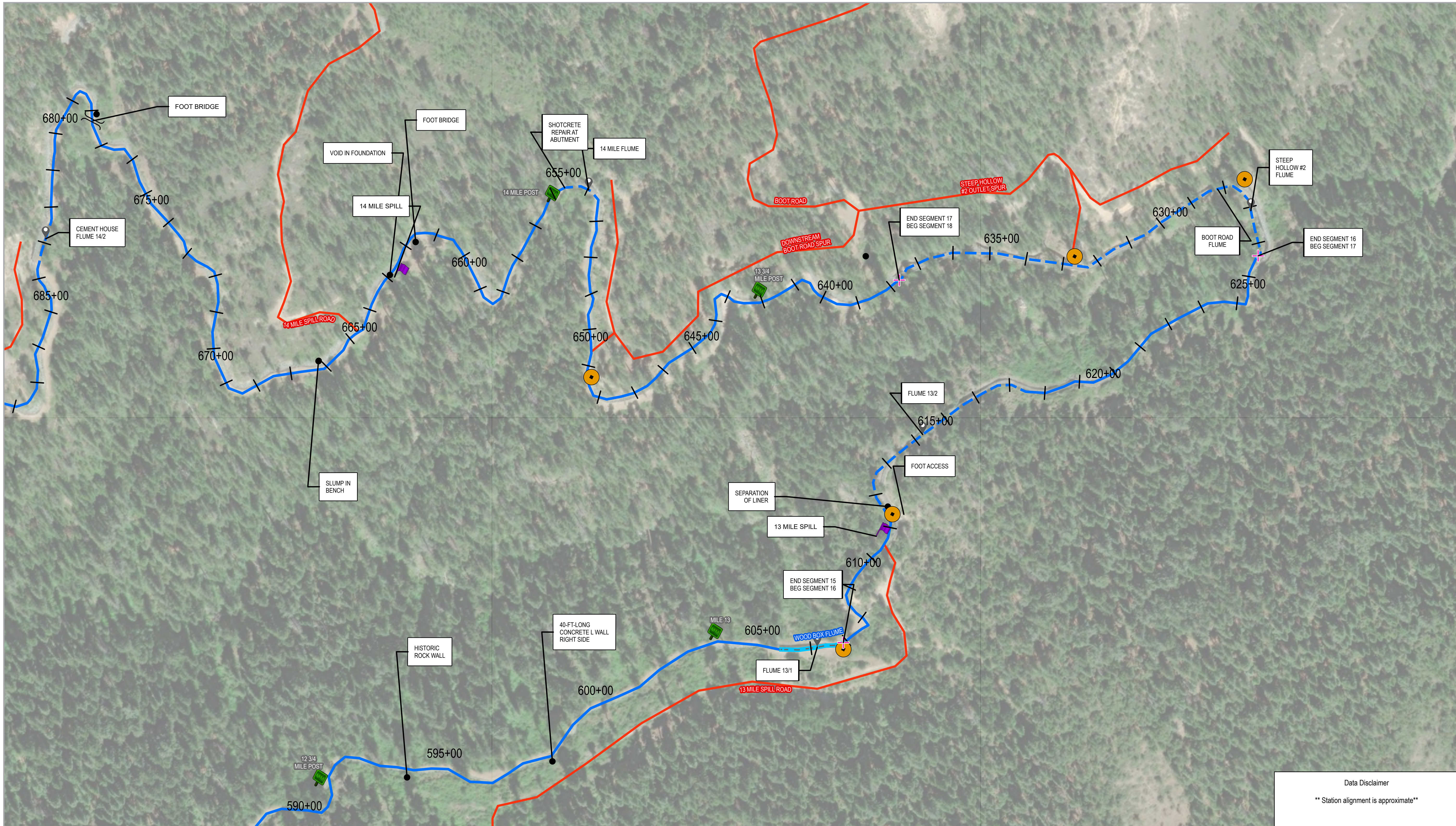
SOUTH YUBA CANAL SYSTEM MAP

Project No. 11211964
Revision No. -
Date 4/16/2021

FIGURE 16

\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

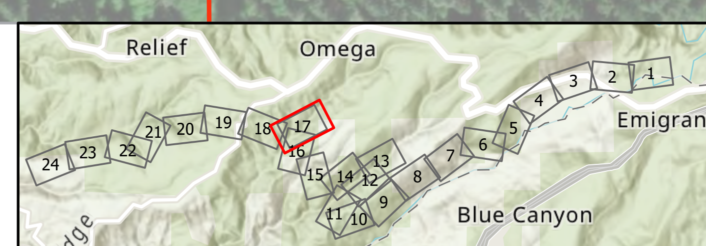


Data Disclaimer

** Station alignment is approximate**

Legend

- Lined Canal
- Lennon Flume
- Wood Box Flume
- Steep Hollow Flume
- Access Road
- Flume
- Access Point
- Inspection Point
- Bridge
- Mile Marker
- Spill
- Segment



0 70 140 210 280

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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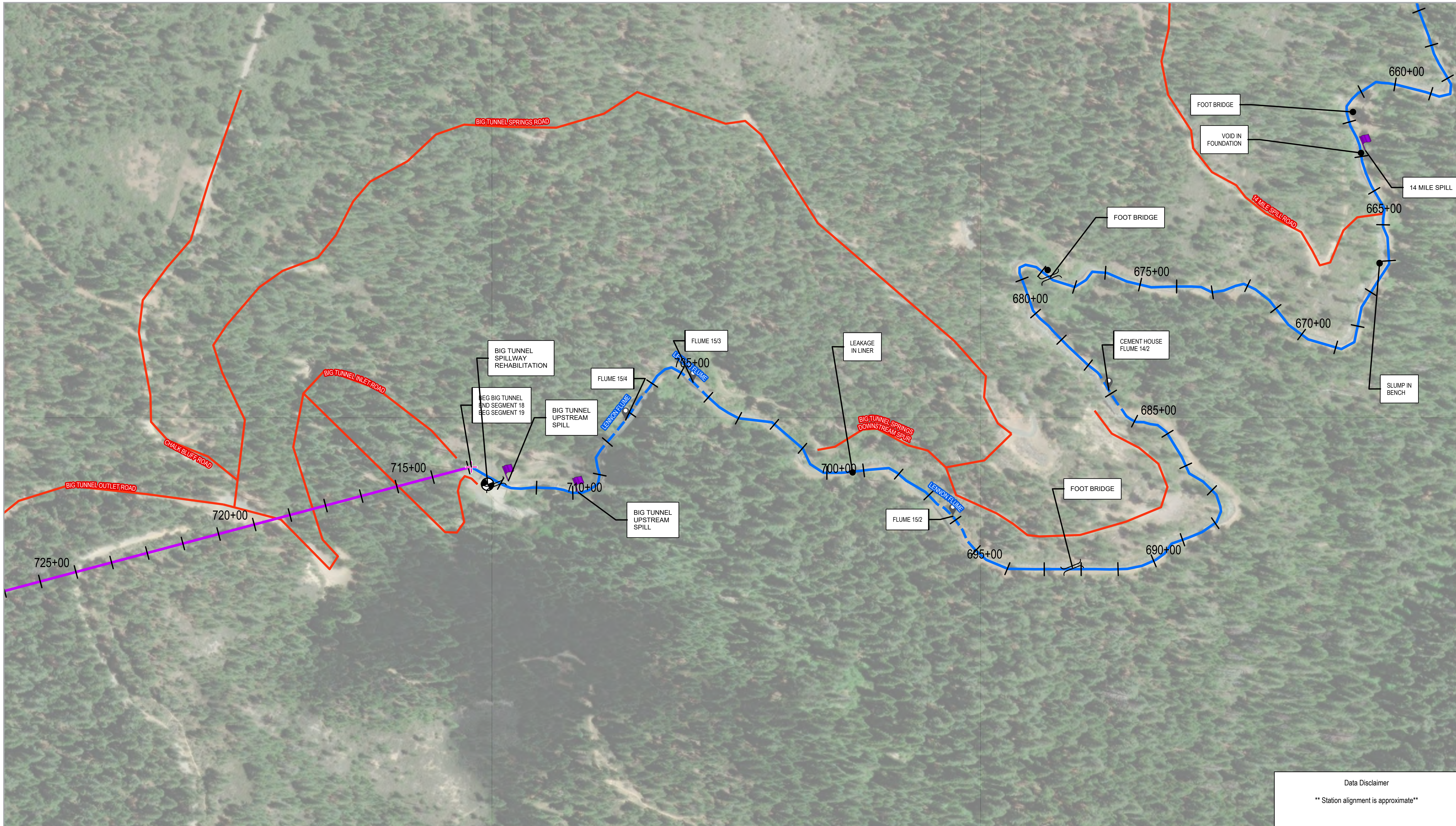
FIGURE 17

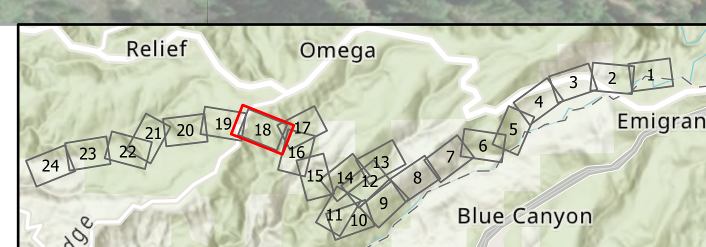
\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarrerovelliz



Legend

- Lined Canal
- Lennon Flume
- Tunnel
- Access Road
- Flume
- Inspection Point
- Gaging Station
- Bridge
- Spill
- Segment



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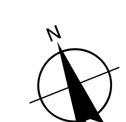

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 18

\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

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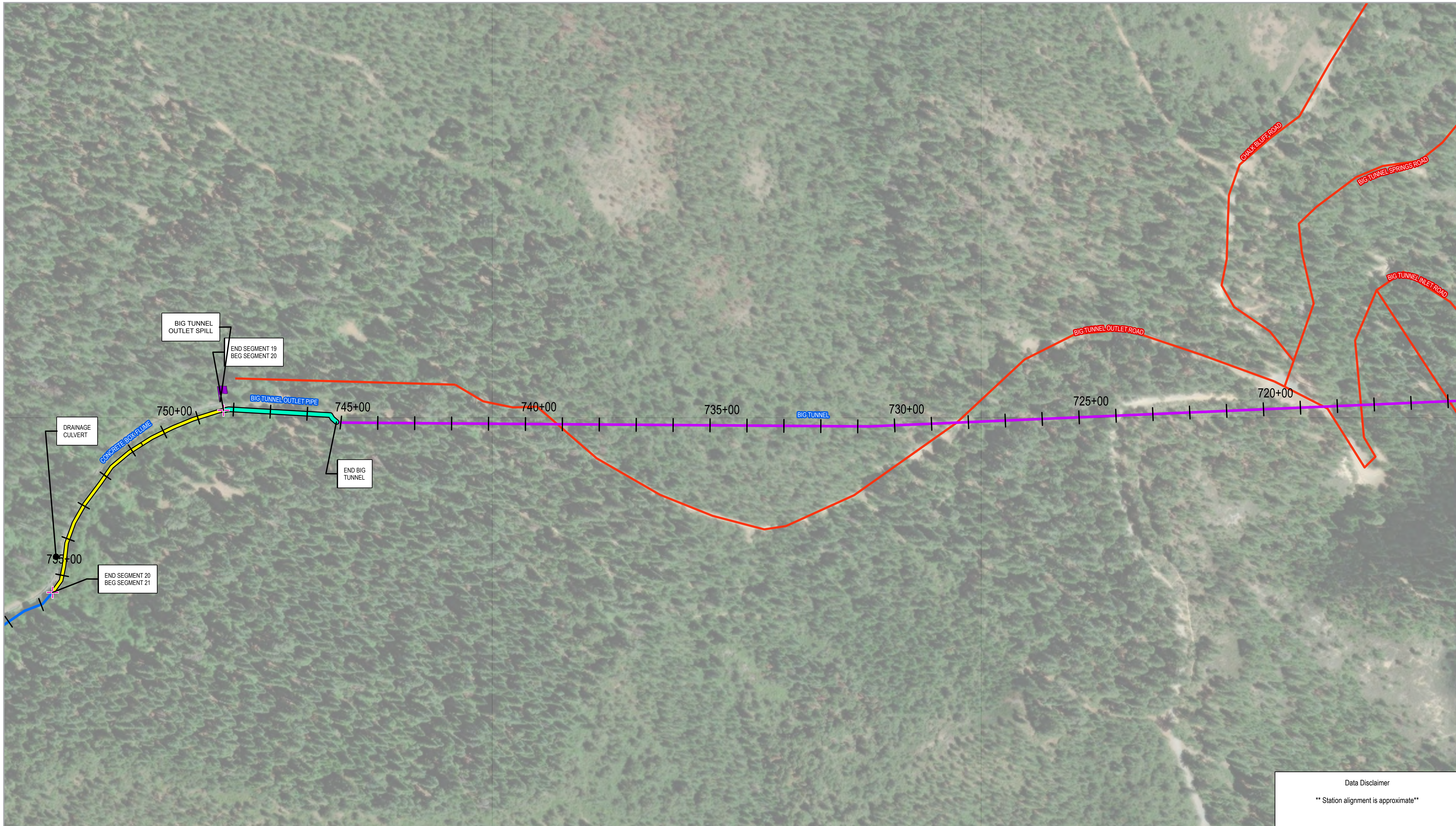
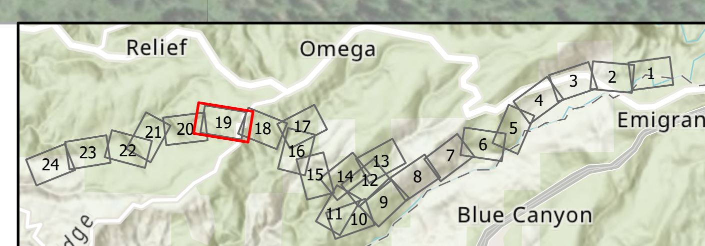
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

- Lined Canal
- Tunnel
- Concrete Box Flume
- Pipe
- Access Road
- Inspection Point
- Spill
- Segment



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Map Projection: Lambert Conformal Conic
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GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
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SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 19

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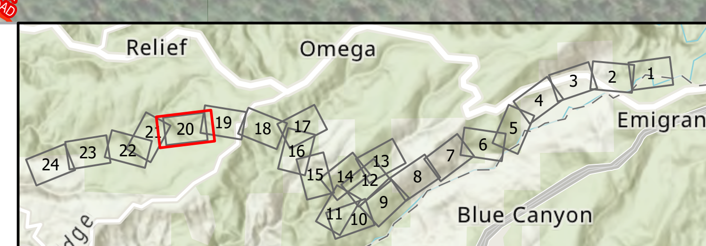
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

Data Disclaimer

** Station alignment is approximate**

Legend

- Lined Canal
- Lennon Flume
- Tunnel
- Concrete Box Flume
- Pipe
- Access Road
- Flume
- Inspection Point
- Bridge
- Mile Marker
- Spill
- Segment



0 70 140 210 280

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 20

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Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
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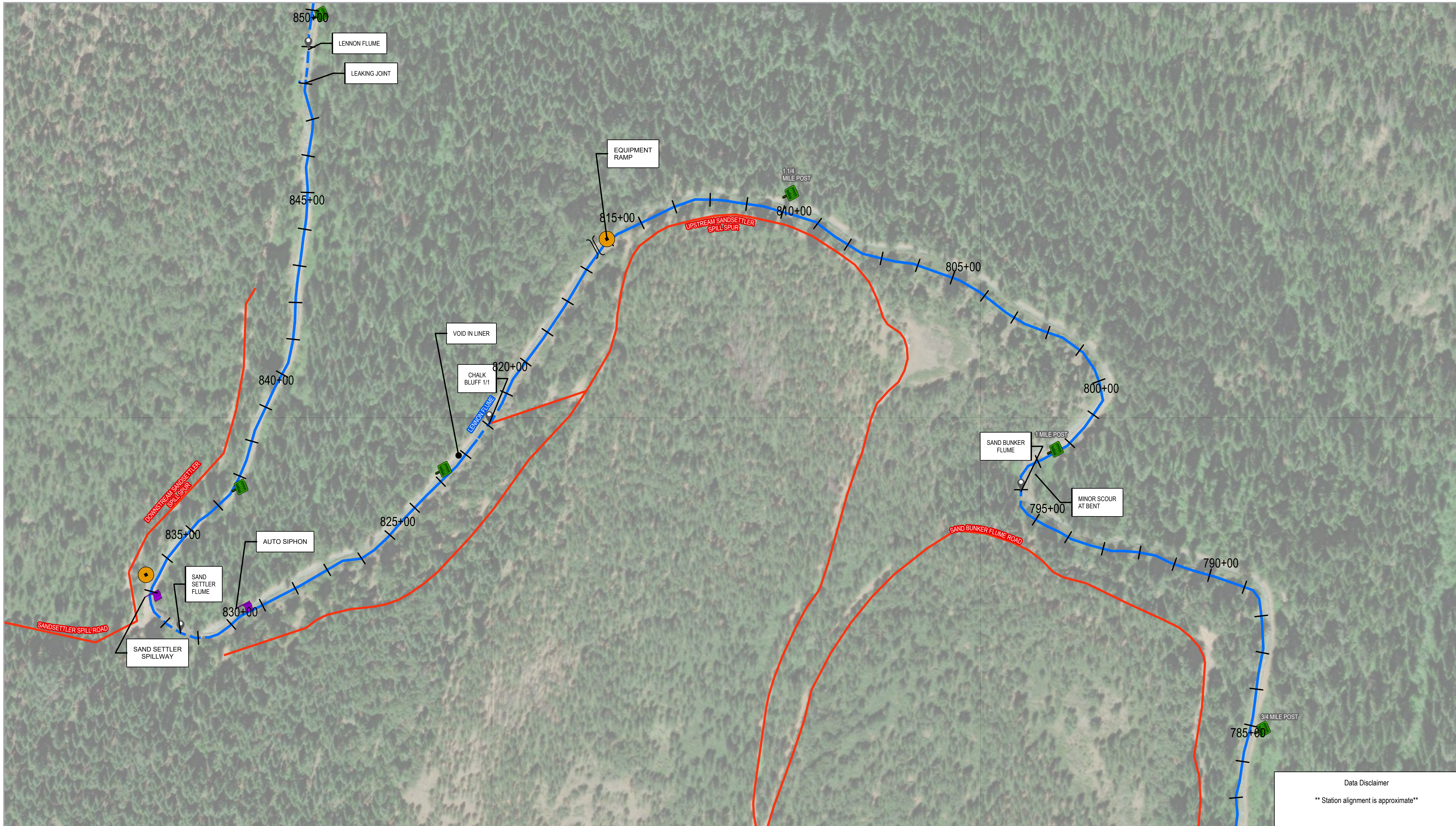
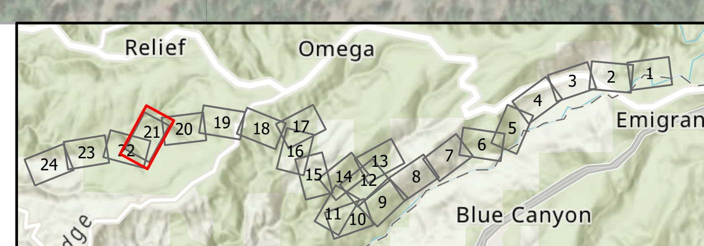
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

Lined Canal	Flume	Bridge
Lennon Flume	Access Point	Mile Marker
Access Road	Inspection Point	Spill



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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 21

\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
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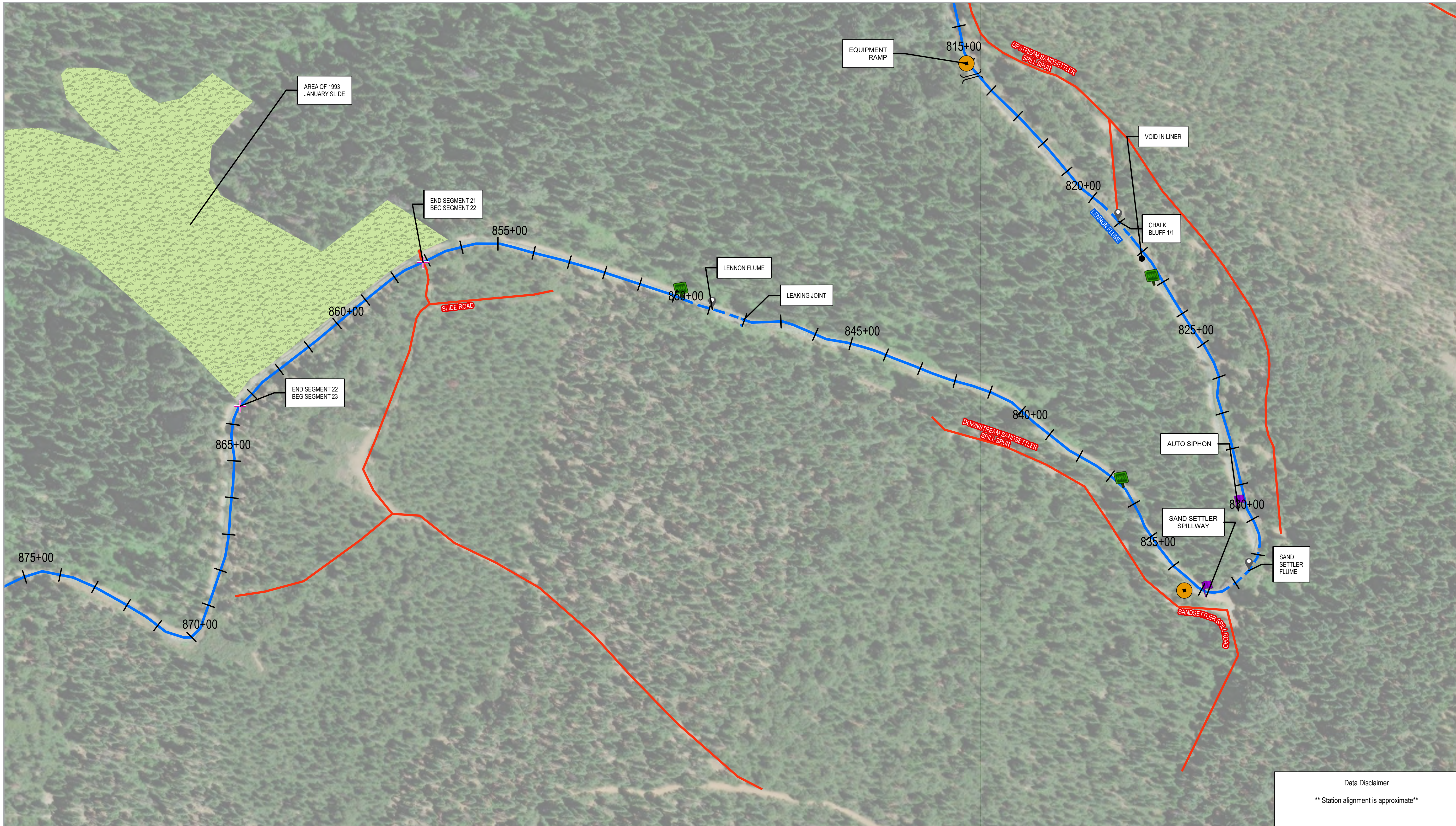
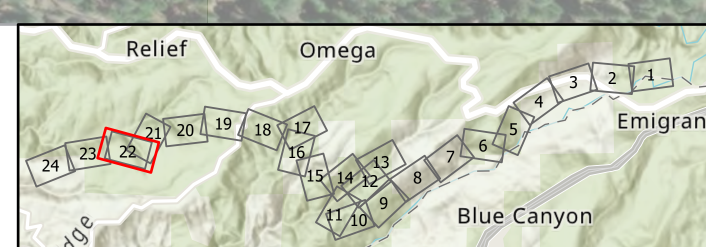
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

- Lined Canal
- Lennon Flume
- Access Road
- Flume
- Access Point
- Inspection Point
- Bridge
- Mile Marker
- Spill
- Segment
- January Slide 1993



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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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Revision No. -
Date 4/16/2021

FIGURE 22

\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

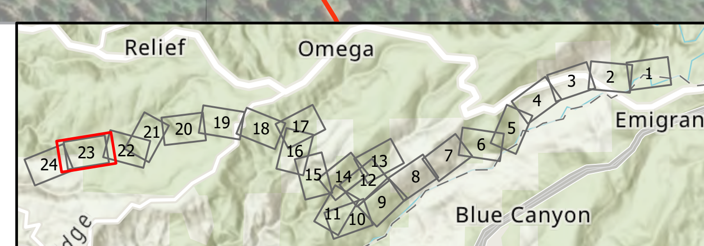
Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

Data Disclaimer

** Station alignment is approximate**

Legend

- Lined Canal
- Access Road
- Access Point
- Gaging Station
- Bridge
- Spill
- Segment
- January Slide 1993



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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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NEVADA IRRIGATION DISTRICT
EVALUATION OF THE SOUTH YUBA CANAL
REPAIRS AND UPGRADES

SOUTH YUBA CANAL SYSTEM MAP

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FIGURE 23

\\ghdnet\ghd\US\Cameron Park\Projects\561\11211964\GIS\Maps\Deliverables\11211964_S_Yuba_Canal\11211964_KeyMap_S_Yuba_Canal.aprx

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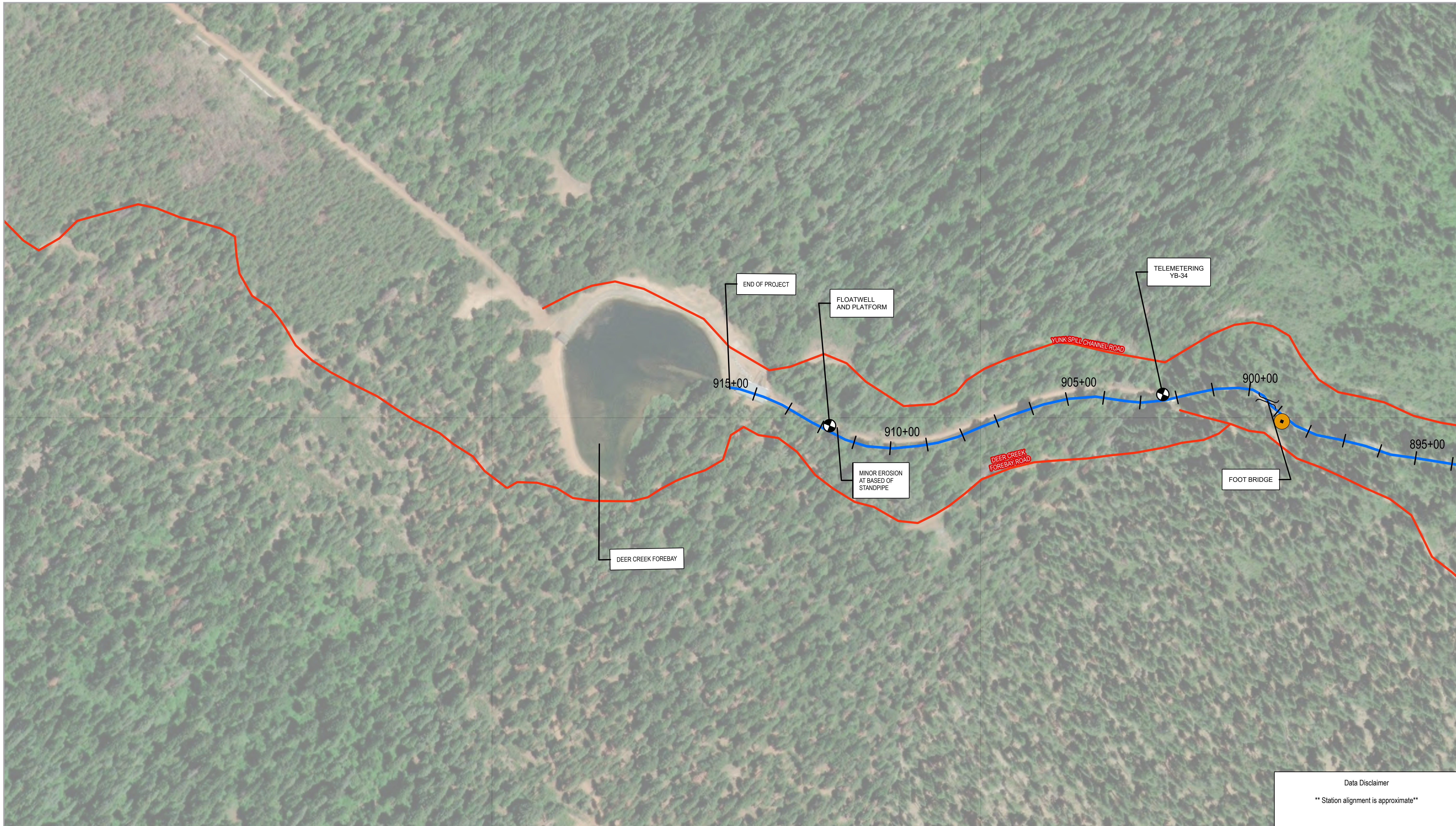
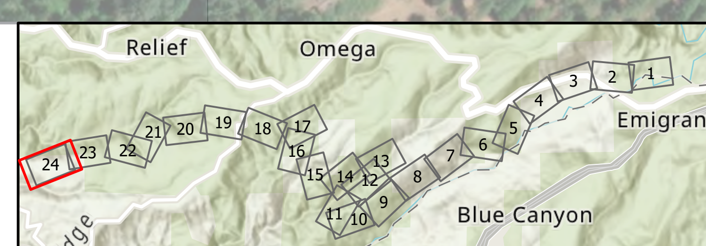
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz



Legend

- Lined Canal
- Access Road
- Access Point
- Gaging Station
- Bridge



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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
GRID: NAD 1983 StatePlane California II FIPS 0402 Feet

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EVALUATION OF THE SOUTH YUBA CANAL
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FIGURE 24

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Data source: World Topographic Map: Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA
World Imagery: Maxar
World Hillshade: Esri, NASA, NGA, USGS. Created by: kbarreroveliz

Appendix B
Site Photographs - Canal and Flume

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Site Photographs

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Site Photographs


Photo 7 Sagging Girder


Photo 8 Temporary Support


Photo 9 Minor Erosion at Foundation

Site Photographs

Segment 3

Photo 10 Typical Concrete Box

Segment 4

Photo 11 Flume out of Plumb

Segment 6

Photo 12 Minor Erosion behind Liner

Photo 13 Minor Cracking in Liner

Photo 14 Separation of Bench from Canal with Lateral Offset

Photo 15 Erosion and Voids in Bench

Site Photographs

Segment 8

Photo 16 Historic Landslide at Flume 8/2

Photo 17 Historic Landslide at Flume 8/4

Site Photographs

Segment 9

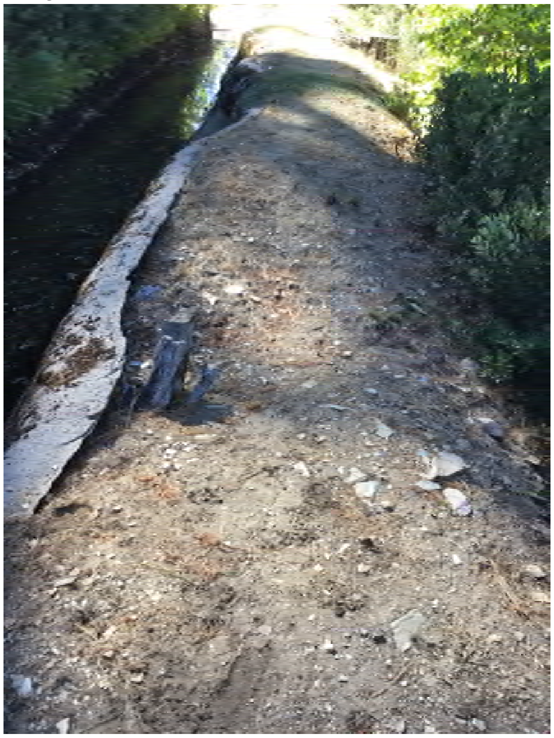

Photo 18 Slump in Bench with Cracking in Canal

Photo 19 Landslide Repair

Segment 10

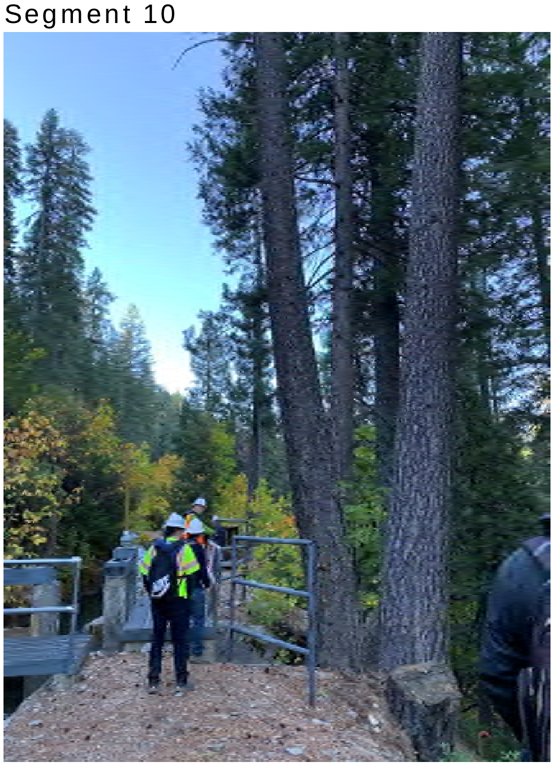

Photo 20 Hazard Trees

Segment 11

Photo 21 Steep Hollow #1 Lennon Flume

Site Photographs

Segment 12

Photo 22 Cracking in Liner

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Segment 13

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Segment 15

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Site Photographs

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Photo 30 Upslope Landslide

Photo 31 Steep Hollow #2 Lennon Flume

Segment 18

Photo 32 Leakage in Liner at Transition

Photo 33 Shotcrete Repair at Flume Abutment

Segment 21

Photo 34 Slump in Bench

Photo 35 Void in Liner

Photo 36 Potential Leak in Liner

Site Photographs

Appendix C
Tunnel Inspection

Tunnel Condition Assessment

Little Tunnel
Nevada County, California

Nevada Irrigation District

11211964 | May 2021

May 12, 2021

Nevada Irrigation District
Engineering Department
Doug Roderick
Interim Engineering Manager
1036 W. Main Street
Grass Valley, CA 95945-5424

RE: Tunnel Condition Assessment for Little Tunnel
Nevada County, California

Dear Mr. Roderick,

GHD is pleased to present the attached report containing the findings of our inspection of Little Tunnel, an approximately 351-foot-long untreated water tunnel in Nevada Irrigation District's water and hydroelectric delivery system.

Little Tunnel conveys flow from the South Yuba Canal (FERC Project 2310). The approximate 351-foot-long (nominal) is timber sets lined and spanned by reinforced concrete. Concrete thickness varies from 1/2 inch to more than 10 inches near the top. Reinforcing steel was designed with either #4 rebar or 10/10 wire mesh. Minimum design concrete strength was specified at 2,500 pounds per square inch.

Nevada Irrigation District (District) scheduled an annual maintenance outage in November 2020 to inspect Little Tunnel and to construct improvements. The tunnel inspection occurred on November 4, 2020. Overall, the condition of the portals and tunnel is good.

Tunnel inspection photographs are presented in Attachment A, and a detailed Inspection Record is presented in Attachment B.

If you have any questions regarding the information contained in this report, or if we may be of further assistance, please do not hesitate to contact us.

Sincerely,
GHD

David B. Jermstad, P.G., C.E.G.
Senior Project Manager

PROFESSIONAL GEOLOGIST
DAVID B. JERMSTAD
No. E.G. 1727
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

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Attachment Index

1. Tunnel Inspection Overview

The South Yuba Canal and Chalks Bluff Canal are part of Pacific Gas & Electric Company's Drum-Spaulding Project, Federal Energy Regulatory Commission (FERC) Project No. 2310. These canals deliver water from Lake Spaulding in eastern Nevada County to Deer Creek Forebay east of Nevada City, a distance of about 19 miles. Little Tunnel, one of two tunnels in the system, is located within the South Yuba Canal. A separate inspection report has been prepared for Big Tunnel and will be submitted under separate cover.

Little Tunnel was inspected on November 4, 2020. The inspection team entered the intake portal, walked the tunnel in the downstream direction, and exited the downstream portal. The GHD inspection team was accompanied by Nevada Irrigation District (NID) staff and Pacific Gas and Electric (PG&E) staff for the duration of the inspection. For the purposes of the inspection and this report, Station 0+00 was set at the inlet portal and Station 3+51 was set at the downstream portal.

2. Tunnel Inspection Safety

2.1 Identified Hazards and Mitigation Measures

Safety was a high priority for the tunnel inspection. Three primary hazards common to all tunnel inspections were identified: tunnel instability, atmospheric hazards immediately dangerous to life or health (IDLH), and operational hazards. Steps were taken to mitigate the risks associated with each of these hazards.

2.1.1 Tunnel Instability

GHD's trained inspectors watched for localized tunnel instability throughout the inspection. The absence of hydraulic anomalies in the tunnel suggested that the tunnel cross section was stable and no immediate need for scaling was observed.

2.1.2 Atmospheric Hazards

Little Tunnel is constructed in Tertiary-age volcanic formations consisting of volcanic ash deposits (Valley Springs, Tvs), and mud flows and Lahar (Mehrten, Tm). Organic deposits are rare in these formations. Atmospheric hazards include unsafe oxygen and hydrogen sulfide levels. Throughout the inspection, the atmosphere was monitored for unsafe levels of oxygen and hydrogen sulfide along with carbon monoxide and explosive gases (4-gas meter). At no point during the inspection did air monitors indicate a potentially hazardous atmosphere.

2.1.3 Operational Hazards

The most significant operational hazard during the inspection of Little Tunnel was the potential for flooding. Flooding was prevented through a lock-out-tag-out (LOTO) protocol that isolated Little Tunnel from the rest of the system. Two forms of LOTO exist in most agencies: physical and administrative. Administrative LOTO places a clearance tag or man-on-line tag (typically paper) on equipment control surfaces. Operators are trained not to place equipment in service if a tag is present. Physical LOTO requires that equipment be temporarily disabled or prevented from operating. A combination of administrative and physical LOTO methods was used during Little Tunnel outage. The LOTO actions were effective and provided a safe work environment for the inspection.

2.1.4 Biologic Hazards

The tunnel back above normal flow line was colonized by spiders in localized areas.

2.2 Applicable Safety Regulations

There are no specific tunnel safety regulations covering the inspection of in-service water tunnels in the state of California. A combination of California Code of Regulations Subchapter 7, General Industry Safety Orders and Subchapter 20, Tunnel Safety Orders was applied to the inspection.

2.3 Safety Preparations

2.3.1 Communication

Communication between the surface support team and tunnel entrants is difficult during tunnel inspections. During the inspection, the team checked in and out with PG&E and NID personnel on the surface. The team included attendants at the tunnel adit that could be sent for help if needed. Fortunately, emergency communication was not necessary.

2.3.2 Personal Protective Equipment

Personal protective equipment (PPE) for the tunnel entrants was selected to protect against the identified hazards, including these:

- Hard hat
- Helmet mounted light
- Flashlight and spare batteries
- Back-up flashlights
- Safety glasses
- Atmospheric monitoring 4-gas meters, one per inspection team
- Gloves
- Thermal shirt
- Water repellant jacket
- Walking sticks
- Waders and sturdy boots
- Emergency whistle

- First aid kit, one per inspection team (safety representative)
- Water and snacks

2.3.3 Safety Instruction

On the morning of November 4, 2020, the tunnel entrants and support team participated in an extended safety tailboard conducted by PG&E. The agenda included the topics discussed below.

- Overview – Purpose of inspection, access, anticipated conditions, safety procedures, and emergency procedures.
- Safety Instruction – Recognition and avoidance of hazards, awareness of other work going on at/near Little Tunnel, air monitoring, illumination, communication, flooding, LOTO, use of PPE, fire prevention and control, emergency procedures, evacuation, and personal accountability requirements.
- Biologic – Recognition and avoidance of spiders.
- Confined Space – Recognition and protective measures for confined space entry.

2.3.4 Pre-entry Activities and Monitoring During Inspection

Prior to entry, the entry permit was updated with information from the hazard assessment, incident action plan, communication plan, LOTO procedures, personnel accountability plan, PPE list, and atmospheric monitoring equipment list. On the surface, the standby rescue team monitored surface conditions.

3. Inspection Methodology

The objective of the inspection was to visually inspect and evaluate the current condition of Little Tunnel. To achieve this objective, the inspection party performed the following activities: geologic interpretation of the tunnel condition, identification of anomalies, measurement of cross-sectional dimensions, measurement of seeps and water inflow, and photographic documentation of conditions.

4. Observations and Recommendations

4.1 Observations

A measuring wheel was utilized for relative stationing referenced in the following observations. A date stamp above the back of the tunnel inlet portal reads “1966.” Unconfined compressive strength was estimated using a calibrated rebound hammer (ASTM C805) to 8,500 pounds per square inch.

- Station 0+97, approximately 2 1/2 feet above springline on the left rib is a scour exposing 10/10 wire mesh.

- Station 1+66 from invert to springline the liner is missing over a width of eight to 10 inches on the right rib, exposing the timber support.
- Station 1+85 at invert on the right rib and two feet above invert is a scour exposing 10/10 wire mesh. Shotcrete was observed less than one inch thick over timber support (as originally designed).
- Station 2+87, from invert and 2 1/2 feet above invert is a very thin section of shotcrete separating over a width of 10 inches.
- The tunnel is full lined with shotcrete to the downstream portal. The tunnel was essentially dry with a total estimated inflow of less than one gallon per minute.

Photographs are presented in Attachment A. A detailed Inspection Record is presented in Attachment B.

4.2 Recommendations

GHD recommends continued monitoring of the eroded thin liner sections discussed above. The original design called for thin shotcrete cover over old timber sets.

Within approximately five years, we anticipate that “dental” localized repair work may be needed in the eroded liner sections. Other than eroded liner sections, no evidence of structural distress was observed.

Based on the existing information, GHD recommends that Little Tunnel be inspected annually by NID personnel to compare conditions to those described in this report. Additionally, an inspection of the tunnel by a licensed professional is recommended every five years.

5. Summary

The following table summarizes the pertinent recommendations based on the field inspection.

Table 5.1 Summary of Recommendations

Priority	Reach	Description	Impact
Low	Stations 0+97, 1+66, 1+85, 2+87	Eroded/scoured thin liner over supporting timber sets	Continued erosion and scour could eventually result in localized tunnel instability.

6. Limitations

This Tunnel Condition Assessment Report (“Report”):

- Has been prepared by GHD for the Nevada Irrigation District (NID) under the professional supervision of those senior partners and/or senior staff whose seals and signatures appear herein

- May only be used and relied on by NID, which is responsible to ensure that all relevant parties to the project, including designers, contractors, subcontractors, etc., are made aware of this report in its entirety
- Must not be copied to, used by, or relied on by any person other than NID without the prior written consent of GHD
- May only be used for the purpose of engineering design of the proposed structures at the project site described in this report (and must not be used for any other purpose)

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than NID arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties, and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report:

- Were limited to those specifically detailed in sections one through five
- Did not include GHD undertaking testing at some parts of the site

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report (“Assumptions”), including (but not limited to):

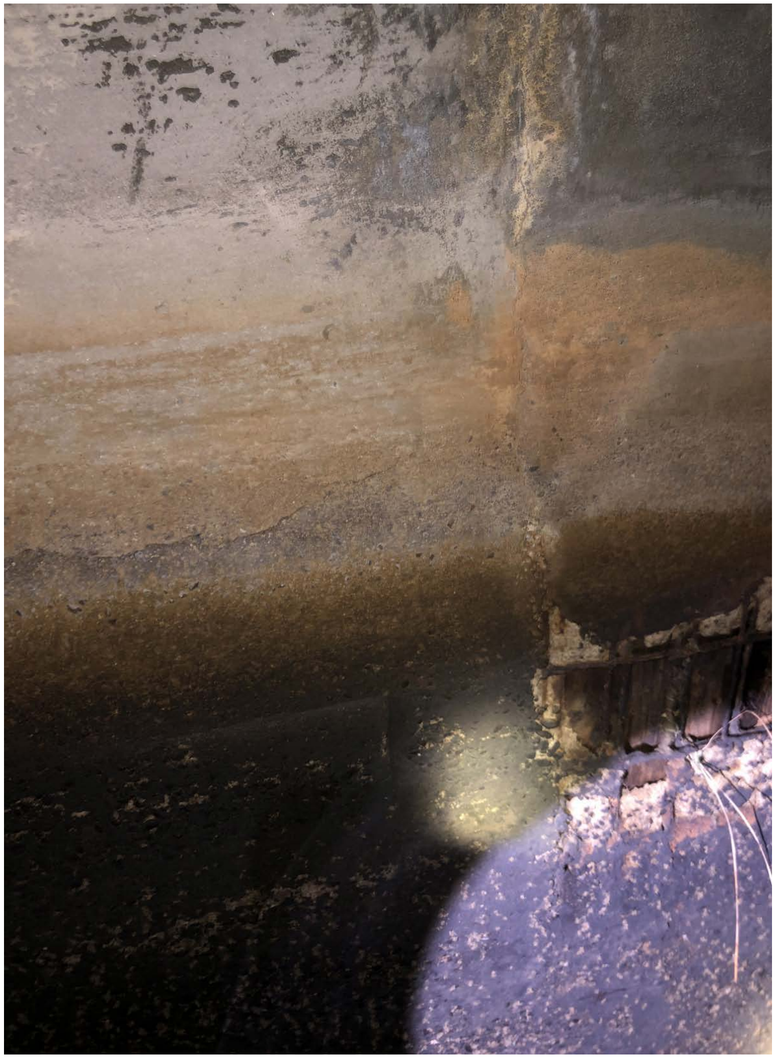
- The condition has remained essentially unchanged since our site visit

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions, and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until one year from the date of the report after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions, and any recommendations

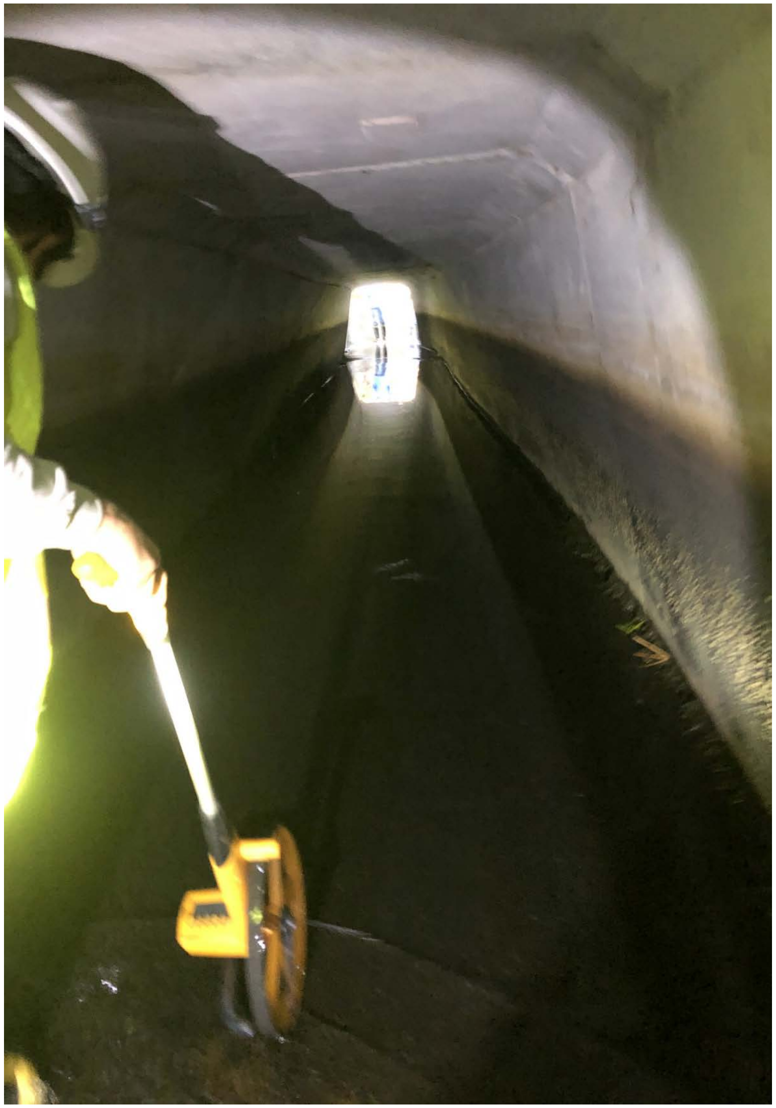
.

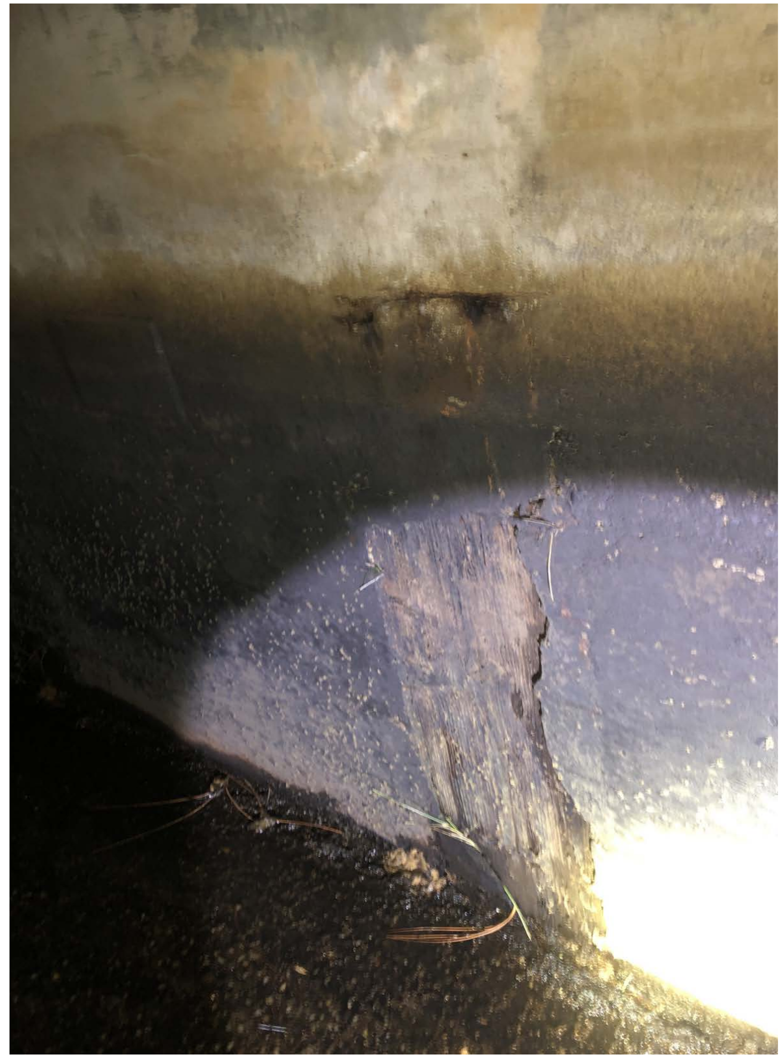
Attachment A
Photographs



Little Tunnel Liner Thin Cover On Timber

Little Tunnel Upstream Portal


Little Tunnel Liner


Little Tunnel Liner Thin Cover On Timber1


IMG_4442

Little Tunnel Liner 3+60

Little Tunnel Downstream Portal (2)

Little Tunnel Liner 3+60 (2)

Little Tunnel Liner 3+60 (3)

Little Tunnel Downstream Portal1

Little Tunnel Downstream Portal

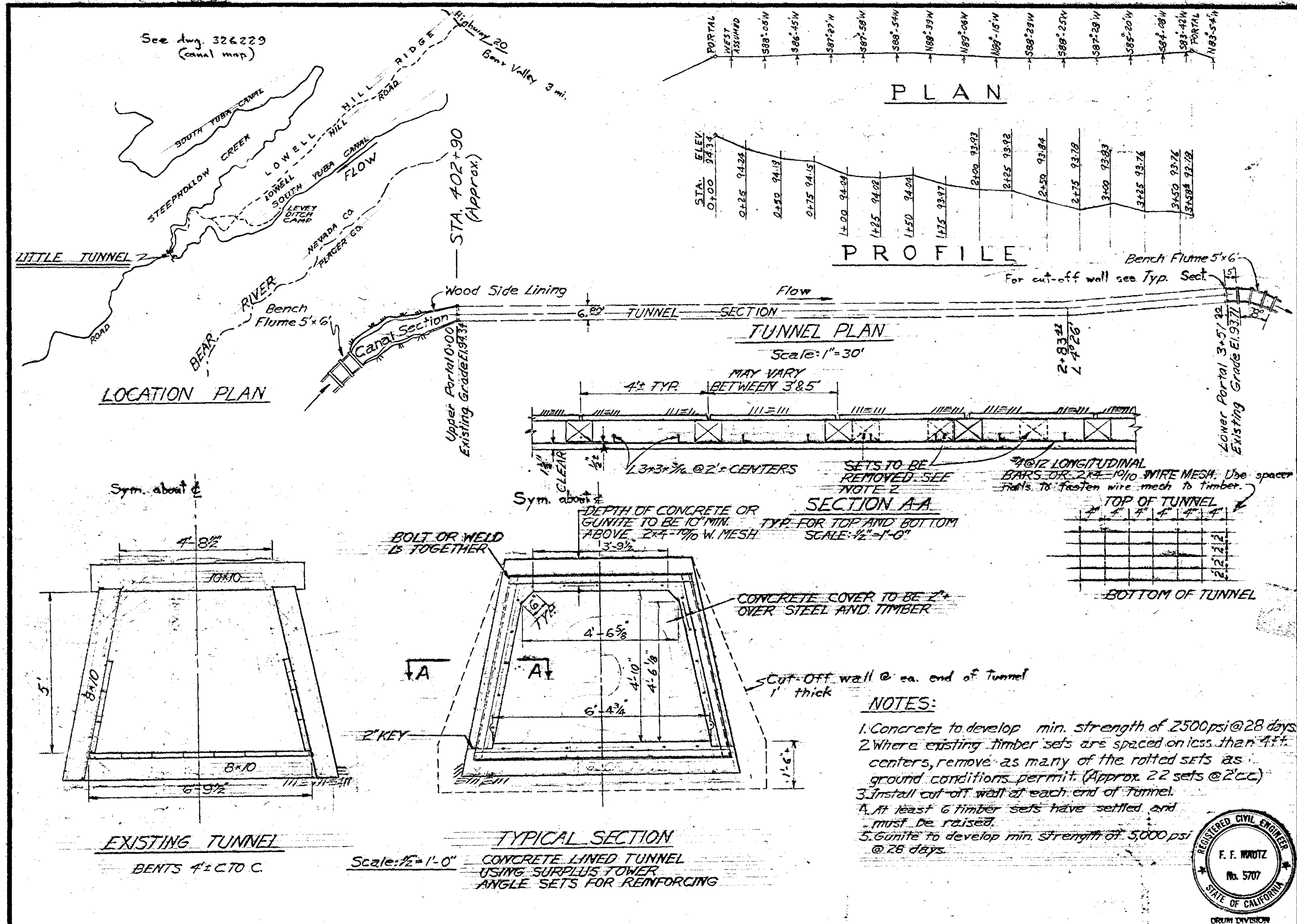
Little Tunnel Liner 3+60 (4)

Attachment B
Inspection Record

Little Tunnel

little tunnel upstream portal date stamp 1966 on the portal. UCS was 8500 psi.
Station 0+97 left rib just at spring line up about 2 1/2 feet there's exposed WIRE reinforcing and Wood back in just a little scour area.
Station 1+66 right rib from belly up to spring line 8 to 10 inch section exposing wood. The shot Crete shell is gone exposing wood.
Station 1+85 right rib about spring line 2-feet off belly exposed reinforcing wire mesh. thin shot Crete shell less than 1 inch thick over old timber posts.
Station 2+87 left rib, belly to spring line up about 2 1/2 feet high section of separating shot Crete with linerboard very thin section approximately 10 inches wide and no signs of distress and back looks competent.

214745



NO.	DATE	DESCRIPTION	GM	BY	CH.	APRD.
2	7-27-66	PLAN, PROFILE & DIM., As Built		V.B.		
1	1-6-66	APPROVED FOR CONSTRUCTION				

TABLE OF CHANGES

APPROVED BY	GM 63542
SUPERV. BY	Vasconcelos
DSGN.	B. Neff
DR.	B.N.
CH.	
O.K.	
DATE	12-4-64
SCALE	As Noted

CONCRETE LINING
LITTLE TUNNEL
SOUTH YUBA CANAL

DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

BILL OF MATERIAL	
DRAWING LIST	
SUPERSEDES	
SUPERSEDED BY	
SHEET NO. 1	SHEETS
DRAWING NUMBER 214745	CHANGE 2

SCAN 2

Pacific Gas and Electric Company

Inspection Procedures

FOR

SOUTH YUBA CANAL

BIG & LITTLE TUNNEL INSPECTIONS

BY

Hydro Generation

November 2020

Table of Contents

South Yuba Big & Little Tunnels Inspection Procedures

1.0 Tunnel Owner:

Pacific Gas and Electric Co.

Company Rep: Chris Brewster: Drum Area Manager.

Address: 12840 Bill Clark Way.
Auburn CA 95602
Cellular Phone: (530)-906-3584

2.0 CONTRACTOR:

PACIFIC GAS & ELECTRIC CO.

PE&C Work Supervisor:
Keith Rowland: Asset Management Engineer.
Office 12840 Bill Clark Way.
Auburn, 95602
Cellular phone: (530)-320-2581

O&M Work Supervisor:
Mike Robinson: Alta Water Crew Foreman
Alta Office, (530) 3465958
Address:
Cellular phone, (530)-906-2751

Main Field Office Physical Address: 33995 Alta Bonnie Nook Rd.
Alta CA 95701

Main Field Office Phone Numbers: Co. #, 734-5247, PT&T #, (530) 389-2202

Field Office Contact:
Kristi Hoisington - Field Clerk
Alta Office, (530)-346-5958

3.0 PG&E SAFETY REPS:
Bob Raibley
Auburn Office: (530)-889-6449
Cellular Phone:(530)-906-3280

4.0 TUNNEL LOCATION / CONTACTS

4.1 CONTACTS:

Contact	Name	Radio / Freq.	Telephone	Cellular Phone
Drum PH		**KMH 404 / 158.130**	**(916)389-2551**	**Co. # 734-5000**
Area Manager	Chris Brewster		(530)-889-3370	(530)-906-3584
Water Foreman	Mike Robinson		(530)389-2202	(530)-906-2751
AM Engineer	Keith Rowland		(530) 889-3381	(530)-320-2581
Inspection	Bob Raibley		(530) 889-6449	(530) 906-3280
Field Office			(530)-389-2202	

4.2 SOUTH YUBA CANAL TUNNELS LOCATION:

South Yuba Canal Big and Little Tunnels are located in the Bear Valley area of eastern Placer County California.

Big Tunnel: Located in T16N R11E, on the center of section 4.

Little Tunnel: Located in T17N R11E on north line of section 31.

4.3 JOB ACCESS ROADS:

Big Tunnel:
From Auburn take Interstate 80 east toward Reno 40 miles to the intersection of Hwy 20. Turn north on Hwy 20 toward Grass Valley Ca. Travel 10.8 miles to Chalk Bluff Road. Turn left on Chalk Bluff "dirt road" and travel 1.5 miles to a four way intersection, turn left and travel .4 miles to the up stream portal.

Little Tunnel:
From Auburn take Interstate 80 east toward Reno 40 miles to the intersection of Hwy 20. Turn north on Hwy 20 toward Grass Valley Ca. Travel 7.3 miles to Lowell Hill Road. Turn left on Lowell Hill "dirt road" and travel 2.8 miles to a four way intersection, turn left to the upstream portal of the tunnel.

4.4 HELICOPTER MEDI VAC. PAD_

Big Tunnel: N 39* 18' 04" W 120* 46' 16"
Little Tunnel: N 39* 16' 52" W 120* 45' 04"

5.0 DURATION OF JOB:

Both tunnels will be inspected on November 3rd & 4th 2020.

6.0 SOUTH YUBA BIG & LITTLE TUNNELS PHYSICAL INFORMATION:

6.1 Description:

Big Tunnel is 3,250 feet long and is 67% lined. The tunnel is concrete lined in four locations a total of 1970 feet with an average cross section of 6 feet wide by 5.5 feet high. The tunnel is timber lined in 8 locations a total of 205 feet with an average cross sections of 7 feet wide by 6.5 feet high. The tunnel is unlined for 1075 feet with an average cross section of 8 feet wide by 10 feet high.

Little Tunnel is 372 feet long and is 100% lined. Average cross section is 6 feet wide by 5 feet high.

6.2 Underground Gas Classification:

These tunnels have been classified by Cal Osha as a “Non Gassy” tunnel.

6.3 Tunnel Access:

Big Tunnel:
The inspection team will enter the upstream portal of the tunnel and proceed downstream exiting at the downstream portal.

Little Tunnel:
The inspection team will enter through the upstream portal of the tunnel and proceed downstream exiting at the downstream portal.

7.0 Scope of work:

7.1 Illumination:

All entrants must have 2 sources of light. The main source must be a cap mounted light and a backup hand light for Emergency escape should the cap lamps fail, "two sources of light required".

7.2 Communication:
Because Little Tunnel is very short, verbal communication will be adequate. At Big Tunnel the inspection team will communicate to the portal attendants by radio. However, air horns will be on site and utilized for emergency notification if it becomes necessary to evacuate the tunnel. Signals will be as follows.

1. One blast - ignore, could be accidental
2. Series of two short blasts, - Need help in the tunnel non emergency
3. Series of three short blasts - Evacuate the tunnel
4. Series of four short blasts - Need help in the tunnel - emergency

7.3 Ventilation:
The inspection will be performed under natural air flow, no forced air ventilation is planed for this inspection.

7.4 Inspection:

Dewatering: The tunnels will be dewatered on morning of 11-03 as follows. YB 244 Gate closed tagged danger, dissipater drain valve open tagged danger. YB 116 Cross Gate closed tagged danger, YB 116 Cross Gate ac breaker open tagged danger. YB 116 spill open tagged danger, YB 116 spill gate ac breaker open tagged danger. The clearance will be held by Dave Snyder, Alts water crew lead. Dave must report on the clearance before tunnel entry and confirm all personnel clear of the tunnels before reporting off.

Create Safe Access:
Ladders used to access the tunnels must be secured and extend at least 3 feet above landings or decks.

Tunnel Inspections:
A 5 to 7 person inspection team will enter the tunnels and split into two, teams and be separated by a short distance. Separation of team members helps assure that someone will be able to escape to summon help in the event of an emergency. The team will look for defects and signs of distress in the lined and unlined portions of the tunnels. In each entry the inspection team will give a definite time of exit to the portal safety person. Upon exiting the tunnel the inspection team will notify the attendant. If the specified exit time is

exceeded the attendant will initiate the emergency response plan. It is the responsibility of the inspection team to exit the tunnel before the specified time elapses, even if it means exiting and reentry.

8.0 AIR FLOW & TESTING FOR HARMFUL GASSES:

8.1 Testing Personnel and Procedures:

A qualified trained person will test the atmosphere, and will continuously monitor the air during the time of the inspection. The minimum volume of air shall not be less than 60 lfm or 200 cfm per man, which ever is greater. The air will be monitored for percent oxygen and L.E.L along with parts per million carbon monoxide and hydrogen sulfide. Limitations are presented in the table below:

Oxygen	Carbon Monoxide	Explosive Limit	Hydrogen Sulfide
19.5% to 22%	20 PPM	5% LEL	10 PPM

The tunnel shall be evacuated if the above standards are not met. The certified tester shall be immediately notified. The owner and engineer will then review the alternatives before work resumes.

8.2 Testing Equipment

1. An Alnor velometer Jr. will be used for measuring the velocity of air flow.

2. An Industrial Scientific MX6, and/or a MSA Passport will be used to monitor air quality.

9.0 ENTRY PROCEDURES:

9.1 Entrants and Attendant:

Each individual entering & exiting the tunnel is to report their name and time entering and exiting the tunnel to the designated safety attendant stationed at the tunnels portal. The safety attendant shall then log this information in the log book. The entrants shall not travel to locations other than the specified work area

9.2 Working Alone Under Ground.

No one individual shall work underground alone. A crew member must be accompanied by at least one other crew member at all times.

10.0 ACCIDENT PREVENTION PROGRAM:

* Code of Safe Practices & Procedures
* Tunnel Safety Orders
* PG&E Accident Prevention Rule Book
* Electrical Safety Orders
* Pre-Job Safety Plan
* New Hire Indoctrination
* E. A. P. & First Aid Stations
* Pre-Job Crew Indoctrination
* M.S.D.S'S on Site
* 10 Day extended Tailboard
* Job Site Posting Area
* Quality Air Testing
* Quarterly Safety Meetings
* Daily Tailboards
* First Aid Training
* Weekly Safety Audits
* P G & E Injury & Illness Prevention Program

11.0 TUNNEL PORTAL SAFETY REQUIREMENTS:

11.1 PORTAL SAFETY ATTENDANT:

A minimum of one person shall be outside the tunnel entrance at all times while men are underground. This person shall have radio contact with Drum Power House. This individual shall remain at the portal with sole duties of monitoring the tunnel entrance. This individual shall be familiar with the Tunnel Safety Orders and ERP.

11.2 POSTING REQUIREMENTS:

The following items shall be available at the tunnel entrance:

1. Tunnel classification
2. ERP
3. Trauma kit
4. Stokes litter
5. Eye wash station
6. Air horn

12.0 MINE RESCUE TRAINING:

Trained Emergency tunnel Rescue Units:

LASSEN COUNTY SEARCH AND RESCUE TEAM
P.O. Box 171
Susanville, CA 96130
530-257-5756

Our team resources provide: Field tracking, technical rescue, search dogs, MSHA certified mine rescue, dive rescue/recovery, medical response units, and mobile command center.

President: Bob Trussell
Commander: Leonard Potter
Captains: Terrie Trussell-Ginder, Larry Dahlen
Lieutenants: Laurie Karikka, Doug Hutchinson,
Sergeants: Tim Williams, Sue Bonham,
Tim Hinman, Marcus Pacheco,
Jay Bishop, Nora Bishop,
Justin Ginder, Lori Powers,
Rob Sears, Chris Moberg

13.0 EMERGENCY RESPONSE PLAN & PROCEDURES:

Will be available at all tunnel access manhole. If it becomes necessary to evacuate the tunnel, evacuate to the nearest and safest exit. Sign out of the tunnel, by radio if necessary. Verify that all personnel have evacuated the tunnel while initiating the emergency response plan. ***Contact Lassen County Search and Rescue only if underground rescue is necessary.***

14.0 RESCUE EQUIPMENT:

14.1 Self Rescuers:

Not required for this entry.

14.2 Emergency Rescue Equipment:

As supplied by trained rescue crews in section 14.

15.0 PROTECTIVE EQUIPMENT:

Two sources of light
Hard hats
Safety glasses
Leather gloves
Chest Waders

Power Generation

Job Safety Analysis (JSA) Worksheet

Submitted to centralized data base ☐

Date: November 3rd 2020	**Job / Task: Inspect the SYC Big and Little Tunnels**	
JSA Reference #:	**Location: Job Sites off HWY 20**	**S/EC & Phone #:**
Prepared By: Raibley	**Department: Hydro**	**ERP Location: In job Book**
SW CTR and Phone #: Drum SC. 530-3892551	**Job Order #**	
Gen Supervisor: Adam Merschel Cell 916-316-2175	**Exempt Foreman: Robert Raibley Cell 530-906-3280**	**Water Crew Foreman: Mike Robinson Cell 530-906-2751**

Task Steps	Hazards	Controls	Reference Documents	F*	S*	P*
Drive to Project	Traffic on road, Animals, unfamiliar area.	Inspect vehicles daily prior to use, follow defensive driving techniques (Smith techniques) at all times and watch for errant third party vehicles “lane-sharing”, etc. on mountain roads. Maintain safe speeds – numerous blind turns and can also encounter range cattle along roads. Close and lock all access gates upon entry and exit.		X		

Task Steps Hazards Controls Reference
Documents

Parking	**Backing, traffic congestion**	**Get assistance when backing, stay alert of your surroundings. Take vehicle keys and personnel belongings with you.(a vehicle was broken into on prior inspection) Back in vehicles to avoid blocking entry/exit way to powerhouse(s) and use spotter when available.**		**X**		
PPE	**Overhead clearance, foreign objects in eye, cuts and abrasions**	**Hard Hat, ANSI Approved safety glasses, Felt Soled Boots, Wadders, Gloves, Two sources of light, walking stick(if needed), outer most layer reflective (traffic vest)**		**X**		
Miscellaneous safety Items	**Insect/snake bites Poison Oak.**	**Job site awareness & attitude. Avoidance & use of pre-exposure creams**		**X**		

Task Steps Hazards Controls Reference
Documents

Miscellaneous safety Items	**Dehydration/heat illness/heat exhaustion**	**Multiple water jugs & sports drinks available – consume frequently to stay properly hydrated and avoid heavy use of caffeinated drinks. Tunnel crew will pack water in their backpacks**		**X**		
Clearance	**Working under clearances – SYC System Ditches**	**Follow LOTO PG-1404P-01 energy control procedure & walk down clearance boundary weekly. Hydro Crew Foreman Dave Snyder to be primary clearance holder for all water conveyance clearances. After walking down all energy isolation and control points, GC, I&C and all contract employees to lock-on as secondary/additional clearance holders using green/blue locks.**		**X**		

Task Steps Hazards Controls Reference
Documents

ERPs	**Emergency Response Plans - confusion who to call for assistance**	**Updated ERP's in trucks, trauma kits @ SJ#2 & #3 powerhouses. Inspector with Tunnel Inspection group will carry an ERP and radio. GC crew will monitor groups movement thru tunnels via radio communication.**		**x**		
Entering the Tunnels	**Slips, Trips, and Falls, ladder not secured properly.**	**Secure ladder prior to use, ensure ladder extends 36" over access,**		**x**		
Tunnel Entry	**Medical Emergencies**	**Identify rescue personnel and responsibilities. Be sure that all numbers and emergency contacts are listed in EAP. Inspector will have Trauma kit on his person during Inspection.**		**X**		

Task Steps Hazards Controls Reference
Documents

Air Monitors	**Out of calibration, wrong bump gas.**	**Inspector will have two air monitors with him during tunnel inspection. One will be on at all times. The second is a back up. All monitors will be calibrated and bump tested prior to entry. Tunnel will be tested by qualified personnel prior to entry. Data will be collected and relayed to tunnel attendant.**				

Task Steps	Hazards	Controls	Reference Documents			
Tunnel Attendants	**Miss communication between tunnel inspection group and attendants, outside air contaminants, unauthorized personnel entering tunnel.**	**Attendants: A minimum of one person shall be outside the tunnel entrance at all times while men are underground. This person shall have radio contact with Drum Switching Center and Tunnel Inspection Group. This individual shall remain at the portal with sole duties of monitoring the tunnel entrance. Once section of tunnel has been inspected. Inspection group will communicate to attendants that it is safe to move to next portal. This individual shall be familiar with the Tunnel Safety Orders and ERP.**				
Concluding Inspection	**Not contacting Drum SC when complete, Inaccurate head count.**	**Ensure all personnel have exited the tunnel, ensure that attendants have signed them out, ensure that attendants contact Drum SC at the conclusion of Inspection.**				

GHD

4080 Plaza Goldorado Circle
Suite B
Cameron Park, CA 95682 USA
T: 1 530 677 5515

Tunnel Condition Assessment

South Yuba Canal Big Tunnel
Nevada County, California

Nevada Irrigation District

11211964 | May 2021

May 12, 2021

Nevada Irrigation District
Engineering Department
Doug Roderick
Interim Engineering Manager
1036 W. Main Street
Grass Valley, CA 95945-5424

RE: Tunnel Condition Assessment for Big Tunnel
Nevada County, California

Dear Mr. Roderick,

GHD is pleased to present the attached report containing the findings of our inspection of Big Tunnel, an approximately 3,242-foot-long untreated water tunnel in Nevada Irrigation District's water and hydroelectric delivery system.

Big Tunnel conveys flow from the South Yuba Canal (FERC Project 2310). The tunnel is lined with timber sets and spanned by reinforced concrete. Concrete thickness varies from three inches to more than 10 inches near the top. Reinforcing steel was designed with #5 rebar. Minimum design concrete strength was not specified on drawing 208339 reviewed.

Nevada Irrigation District (NID) scheduled an annual maintenance outage in November 2020 to inspect Big Tunnel and to construct improvements. The tunnel inspection occurred on November 4, 2020. Overall, the condition of the portals and tunnel is good.

Tunnel inspection photographs are presented in Attachment A, and a detailed Inspection Record is presented in Attachment B.

If you have any questions regarding the information contained in this report, or if we may be of further assistance, please do not hesitate to contact us.

Sincerely,
GHD

David B. Jermstad, P.G., C.E.G.
Senior Project Manager

PROFESSIONAL GEOLOGIST
DAVID B. JERMSTAD
No. E.G. 1727
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

GHD | 4080 Plaza Goldorado Circle Suite B Cameron Park, CA 95682

Table of Contents

Table Index

Attachment Index

1. Tunnel Inspection Overview

The South Yuba Canal and Chalk Bluff Canal are part of Pacific Gas & Electric Company's Drum-Spaulding Project, Federal Energy Regulatory Commission (FERC) Project No. 2310. These canals deliver water from Lake Spaulding in eastern Nevada County to Deer Creek Forebay east of Nevada City, a distance of about 19 miles. Big Tunnel, one of two tunnels in the system, is located between the South Yuba Canal and Chalks Bluff Canal. A separate inspection report has been prepared for Little Tunnel and will be submitted under separate cover.

Big Tunnel was inspected on November 4, 2020. The inspection team entered the intake portal, walked the tunnel in the downstream direction, and exited the downstream portal. The GHD inspection team was accompanied by Nevada Irrigation District (NID) staff and Pacific Gas and Electric (PG&E) staff for the duration of the inspection. For the purposes of the inspection and this report, Station 795+64 was set at the inlet portal and Station 828+06 was set at the downstream portal.

2. Tunnel Inspection Safety

2.1 Identified Hazards and Mitigation Measures

Safety was a high priority for the tunnel inspection. Three primary hazards common to all tunnel inspections were identified: tunnel instability, atmospheric hazards immediately dangerous to life or health (IDLH), and operational hazards. Steps were taken to mitigate the risks associated with each of these hazards.

2.1.1 Tunnel Instability

GHD's trained inspectors watched for localized tunnel instability throughout the inspection. The absence of hydraulic anomalies in the tunnel suggested that the tunnel cross section was stable and no immediate need for scaling was observed.

2.1.2 Atmospheric Hazards

Big Tunnel is constructed in Tertiary-age volcanic formations consisting of volcanic ash deposits (Valley Springs, Tvs), and mud flows and Lahar (Mehrten, Tm). Organic deposits are rare in these formations. Atmospheric hazards include unsafe oxygen and hydrogen sulfide levels. Throughout the inspection, the atmosphere was monitored for unsafe levels of oxygen and hydrogen sulfide along with carbon monoxide and explosive gases (4-gas meter). At no point during the inspection did air monitors indicate a potentially hazardous atmosphere.

2.1.3 Operational Hazards

The most significant operational hazard during the inspection of Big Tunnel was the potential for flooding. Flooding was prevented through a lock-out-tag-out (LOTO) protocol that isolated Big Tunnel from the rest of the system. Two forms of LOTO exist in most agencies: physical and administrative. Administrative LOTO places a clearance tag or man-on-line tag (typically paper) on equipment control surfaces. Operators are trained not to place equipment in service if a tag is present. Physical LOTO requires that equipment be temporarily disabled or prevented from operating. A combination of administrative and physical LOTO methods was used during Big Tunnel inspection. The LOTO actions were effective and provided a safe work environment for the inspection.

2.1.4 Biologic Hazards

The tunnel back above normal flow line was colonized by spiders in localized areas.

2.2 Applicable Safety Regulations

There are no specific tunnel safety regulations covering the inspection of in-service water tunnels in the State of California. A combination of California Code of Regulations Subchapter 7, General Industry Safety Orders and Subchapter 20, Tunnel Safety Orders was applied to the inspection.

2.3 Safety Preparations

2.3.1 Communication

Communication between the surface support team and tunnel entrants can be difficult during tunnel inspections. During the inspection, the team checked in and out with PG&E and NID personnel on the surface. The team included attendants at the tunnel adit that could be sent for help if needed. Fortunately, emergency communication was not necessary.

2.3.2 Personal Protective Equipment

Personal protective equipment (PPE) for the tunnel entrants was selected to protect against the identified hazards, including the following:

- Hard hat
- Helmet mounted light
- Flashlight and spare batteries
- Back-up flashlights
- Safety glasses
- Atmospheric monitoring 4-gas meters, one per inspection team
- Gloves
- Thermal shirt
- Water repellant jacket
- Walking sticks
- Waders and sturdy boots
- Emergency whistle

- First aid kit, one per inspection team (safety representative)
- Water and snacks

2.3.3 Safety Instruction

On the morning of November 4, 2020, the tunnel entrants and support team participated in an extended safety tailboard conducted by PG&E. The agenda included the topics discussed below.

- Overview – Purpose of inspection, access, anticipated conditions, safety procedures, and emergency procedures.
- Safety Instruction – Recognition and avoidance of hazards, awareness of other work going on at/near Big Tunnel, air monitoring, illumination, communication, flooding, LOTO, use of PPE, fire prevention and control, emergency procedures, evacuation, and personal accountability requirements.
- Biologic – Recognition and avoidance of spiders.
- Confined Space – Recognition and protective measures for confined space entry.

2.3.4 Pre-entry Activities and Monitoring During Inspection

Prior to entry, the entry permit was updated with information from the hazard assessment, incident action plan, communication plan, LOTO procedures, personnel accountability plan, PPE list, and atmospheric monitoring equipment list. On the surface, the standby rescue team monitored surface conditions.

3. Inspection Methodology

The objective of the inspection was to visually inspect and evaluate the current condition of Big Tunnel. To achieve this objective, the inspection party performed the following activities: geologic interpretation of the tunnel condition, identification of anomalies, measurement of cross-sectional dimensions, measurement of seeps and water inflow, and photographic documentation of conditions.

4. Observations and Recommendations

4.1 Observations

A measuring wheel was utilized for relative stationing referenced in the following observations. Relative Station 0+00 corresponds to Station 795+64 at the inlet portal, and Relative Station 32+42 corresponds to Station 828+06 at the downstream portal. Unconfined compressive strength was estimated utilizing a calibrated rebound hammer (ASTM C805); it was estimated to be on average 6,500 pounds per square inch (psi).

- Big Tunnel is lined from Station 0+00 to Station 0+79. Thin cover of the timber backing was observed in several locations.

- Metamorphic bedrock is exposed in the unlined tunnel from Station 0+79 to 1+07. Bedrock is moderately to highly weathered, closely fractured, and moderately strong. Split sets at three-foot centers and chain-link fence on the back. A void from a detached block was observed in the back with no debris in the invert; looks clean.
- Station 1+07 begin transition concrete up 4 1/2 feet both ribs.
- Station 1+54 begin full-lined tunnel.
- Station 2+43 construction joint with sealant ranges from three inches to 1/4 inch and looks tight.
- Station 3+23 construction joint erosion on the right rib down at the belly.
- Station 3+62 construction joint erosion.
- Station 4+01 construction joint with some minor inflow on right rib at 3 o'clock, less than one gallon per minute.
- Station 4+41 construction joint erosion on right rib about four inches wide and three inches deep from 3 o'clock to 5 o'clock.
- Station 4+70 construction joint tight all sides.
- Station 5+18 end lined section; begin bald section. Bedrock is metamorphic rock and moderately weathered, closely fractured, moderately strong. No debris, no fallouts, no reinforcement. Water flow line (springline) about halfway up the ribs approximately 2 1/2 feet from invert.
- Station 5+67 begin wood timber set with lagging. Posts approximately 10 inches by eight inches at approximately 5-foot centers. No evidence of crushing. Lag boards on top don't appear to be loaded, and the liner boards on left rib are falling apart. Right rib looks okay.
- Station 5+80 end wood-lined section; begin bald section. No reinforcement, no signs of distress. Bedrock is moderately weathered, moderately strong, closely fractured. No fallouts observed.
- Station 6+25 begin short timbered section, approximately four feet in length. Liner boards both ribs and back. No crushing, no distress.
- Station 6+30 end timbered short section; begin bald tunnel. Bedrock is metamorphic rock and moderately weathered, closely fractured, moderately strong.
- Station 6+57 geologic shear zone approximately 12 inches wide approximately perpendicular to the tunnel axis. Small breakout approximately 12 inches deep over one- to two-foot-wide section, no obvious continued distress.
- Station 7+00 marked on the right rib at springline.
- Station 7+40 begin timber-lined section. No lagging remains on the left rib. Right rib is lagged. Tunnel back also lagged. No signs of distress, no crushed members observed.
- Station 7+53 end lined section. Timber set on the left rib; bottom of post is tapered down from erosion but appears plumb. No evidence of taking weight.
- Station 7+53 begin bald section. Bedrock is metamorphic rock and moderately weathered, closely fractured, moderately strong.

- Station 8+00 begin fall-out section on bedrock joints. Void above the back, but no signs of continued distress were observed.
- Station 8+43 construction joint left rib eroded back exposing timber set approximately two feet in depth. Width varies from one inch to 12 inches. No signs of distress observed on liner.
- Station 9+35 begin radius turn to canal right.
- Station 9+47 end radius begin straight section, still full-lined.
- Station 10+18 begin radius left and right.
- Station 11+20 end bend canal right.
- Station 11+61 begin turn canal left.
- Station 12+00, 12+16 end left then begin straight section: bald tunnel. Tunnel back is eight to nine feet tall. Ribs look competent, no signs of distress.
- Station 13+00 begin wood-lined section. Similar construction, both ribs have liner boards. Tunnel back has lagging boards. Post and columns show no signs of distress.
- Station 13+53 end wood lined sets and begin small bald section. Unlined approximately 12 feet before another wood lined section. Section is heavily cribbed behind lagging and posts.
- Station 13+65 begin wood-lined section and end bald section. Left rib is heavily cribbed at downstream end, and right rib is cribbed with some large timber, but no liner boards. Right rib has liner boards. Timber sets show no signs of crushing and no signs of significant distress.
- Station 13+78 end liner boards. Left rib begins liner boards. Liner boards only partial on right rib and do not extend to the belly. Right rib liner missing the lower 18 inches.
- Station 13+85 coming into the shaft repair area. Timber sets are double or triple dense spacing with helper sets for nearly continuous sets with small gaps for approximately 12 feet.
- Station 14+02 end helper sets section for shaft repair. Tunnel is wood lined for another two sets.
- Station 14+10 end wood-lined section and begin bald section. No split sets, no support. Bedrock is metamorphic rock slightly to moderately weathered, moderately strong, closely fractured. No fallouts; appears competent.
- Station 14+67 begin timber-lined section. Same construction on the timbers: partial liner boards on right rib and no liner boards on left rib. No signs of distress.
- Station 14+76 end timber-lined section and begin bald section that ends at 14+95.
- Station 14+95 begin short section of timber-lined construction. Liner boards on both ribs and on back. Timbers appear similar with no signs of distress.
- Station 15+08 end timber-lined section and begin bald tunnel. Bedrock is metamorphic rock and moderately weathered, closely fractured, moderately strong. No signs of distress.
- Station 15+23 has left rib erosion approximately 2 1/2 feet wide and four feet deep, approximately four feet above invert. Right rib looks like it is not actively eroding.

- Station 15+93 begin timber-lined section. Liner boards on both ribs and on back. No signs of taking on weight; no signs of distress observed.
- Station 16+02 right and left ribs are not lagged between timber sets. Lagging on tunnel back. Ribs look competent, no signs of erosion.
- Station 16+10 diagonal shear in tunnel dipping upstream. Shear is approximately two inches wide rolling back up to six to eight inches on the right rib. Similar on the left rib. Shear obscured in tunnel back by lagging.
- Station 16+33 end timber sets. This station is approximately the area that a diagonal shear projects to intercept the back. No signs of distress. Begin bald section approximately eight feet tall with no support. Looks competent.
- Station 16+57 shear/altered bedrock zone, normal to the tunnel axis. Slight erosion in weak rock on the left rib. Right rib below springline and invert looks fine. Back looks fine.
- Station 17+10 right ribs diagonal, non-continuous void approximately four inches wide and two feet deep, probably carbonate dissolution or just erosion. Otherwise, no signs of distress. Just upstream a joint was observed on the right rib that was parallel to the rib and just downstream from this location flat joints were observed in the back. Joint spacing is approximately 12 inches.
- Station 17+28 left rib below springline a small feature approximately 2 1/2 feet wide and three feet deep apparently in quartz vein. Void cribbed up with some spare timber and other mining waste. Somewhat flat void exists on the right rib as well with similar dimensions but without timber backfill lagging; probably actively eroding, but no signs of distress.
- Station 17+83 continued flat joint on back and joints on right rib prying off. Right rib prying off approximately six to eight inches wide, otherwise looks competent.
- Station 19+18 begin short timber-lined section. Both ribs and back are lagged, and sets look good.
- Station 19+26 end timber-lined section and begin bald tunnel. No reinforcement, no support. Rock is moderately weathered, moderately fractured, and moderately strong. No signs of distress.
- Station 19+71 high springline at approximately 4 1/2 feet above invert. Manganese staining in bedrock on the tunnel back suggesting seasonal saturation.
- Station 19+91 erosional feature in a shear zone normal to the tunnel axis. Shear is approximately 12 inches wide and up to 4 1/2 feet deep. Tunnel back looks competent. Left rib is apparently a little stronger with less erosion.
- Station 20+15 begin lined section. The transition is eroded above springline on the right rib, and back has been partially filled. Looks tight, however, from springline down to belly on both left and right ribs. Vertical concrete transition exists at approximately 45° angle over distance of about 12 inches (chamfered edge).
- Station 26+14 begin full-lined section. Some rock pockets above springline. Rock pockets present tunnel back and ribs from 9 o’clock to 3 o’clock. Flow line at approximately 2 1/2 feet.

At 5 o'clock and 7 o'clock, at the interface of ribs and belly are rock pockets and slight erosion, but nothing exposing bedrock or destabilizing the tunnel.

The tunnel was essentially dry with a total estimated inflow of less than one gallon per minute. Tunnel inspection photographs are presented in Attachment A, and a detailed Inspection Record is presented in Attachment B.

4.2 Recommendations

GHD recommends continued monitoring of the eroded thin liner sections discussed above. The original design called for thin shotcrete cover over old timber sets.

Within approximately five years, we anticipate that "dental" localized repair work may be needed in the eroded liner sections. Other than eroded liner sections, no evidence of structural distress was observed.

Based on the existing information, GHD recommends that Big Tunnel be inspected annually by NID personnel to compare conditions to those described in this report. Additionally, an inspection of the tunnel by a licensed professional is recommended every five years.

5. Summary

Big Tunnel was in generally good condition. The following table summarizes the pertinent recommendations based on the field inspection and the findings described above.

Table 5.1 Summary of Recommendations

Priority	Reach	Description	Impact
Low	Sta. 0+70, 4+01, 4+41, 4+55, 4+75	Eroded/scoured thin liner over supporting timber sets	Continued erosion and scour could eventually result in localized tunnel instability.

6. Limitations

This Tunnel Condition Assessment Report ("Report"):

- Has been prepared by GHD for the Nevada Irrigation District (NID) under the professional supervision of those senior partners and/or senior staff whose seals and signatures appear herein
- May only be used and relied on by NID, which is responsible to ensure that all relevant parties to the project, including designers, contractors, subcontractors, etc., are made aware of this report in its entirety
- Must not be copied to, used by, or relied on by any person other than NID without the prior written consent of GHD

- May only be used for the purpose of engineering design of the proposed structures at the project site described in this report (and must not be used for any other purpose)

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than NID arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties, and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report:

- Were limited to those specifically detailed in sections one through five
- Did not include GHD undertaking testing at some parts of the site

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to):

- The condition has remained essentially unchanged since our site visit

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

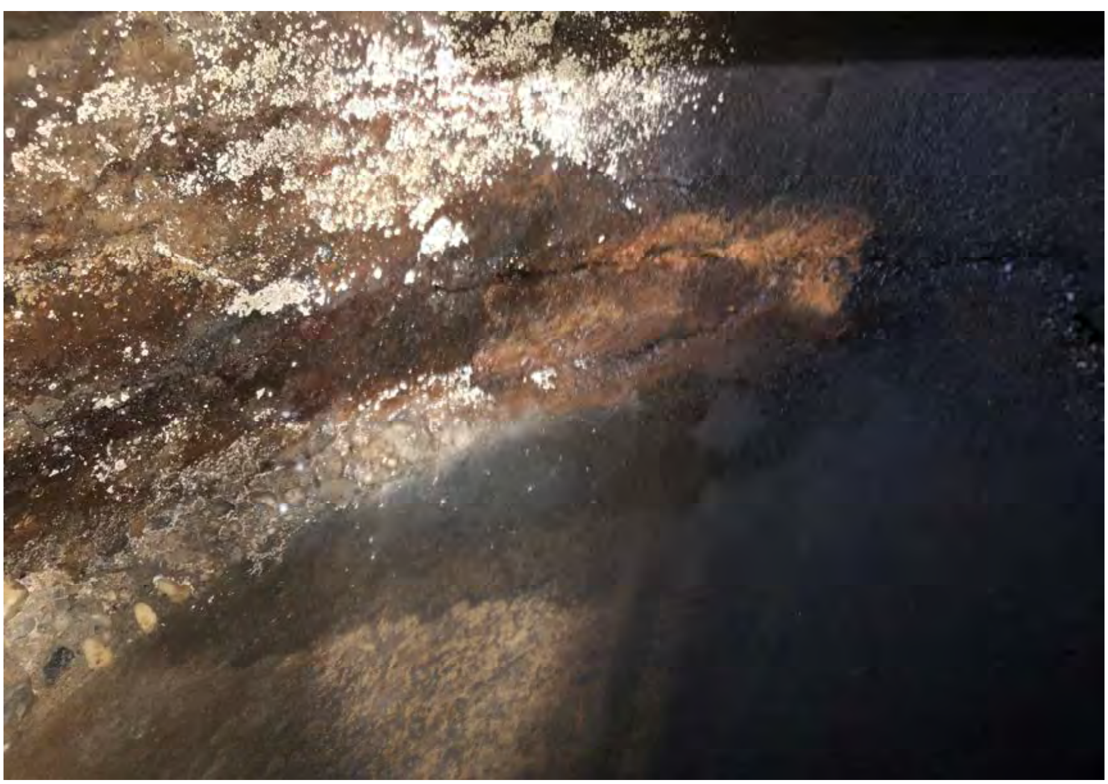
Subject to the paragraphs in this section of the Report, the opinions, conclusions, and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until one year from the date of the report after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions, and any recommendations.

Attachment A
Photographs

Big Tunnel Portal

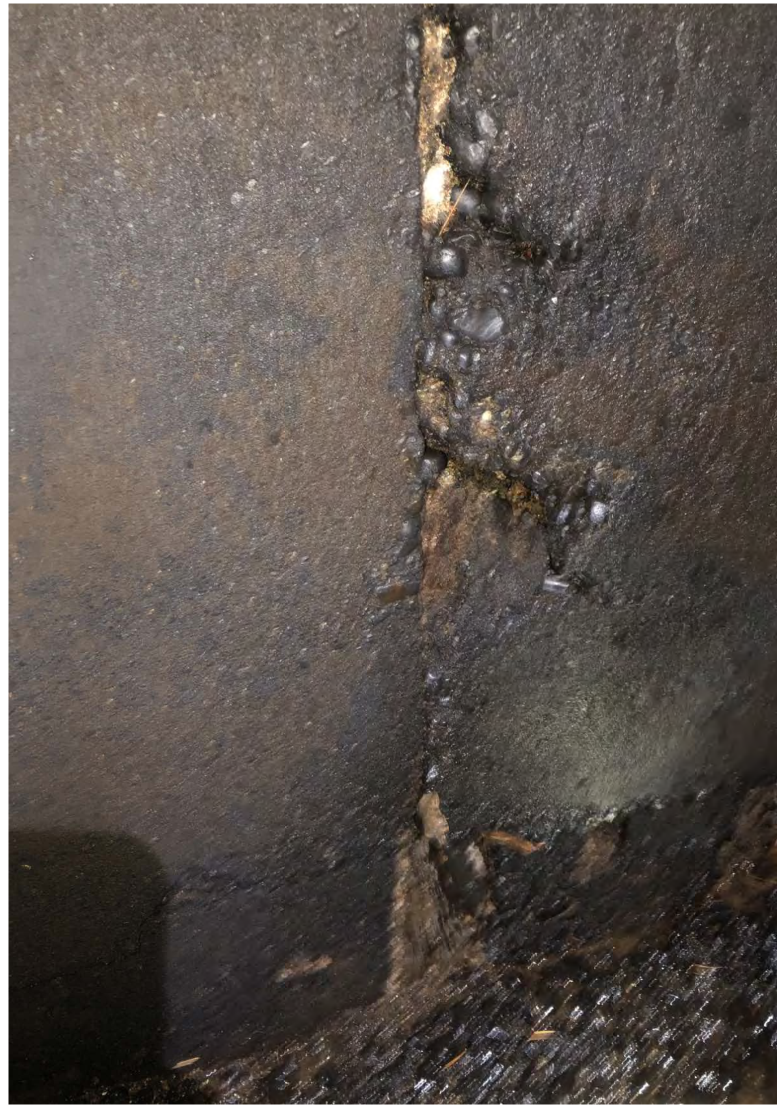
Big Tunnel Upstream

Big Tunnel 0+70 Thin Cover



Big Tunnel 0+80

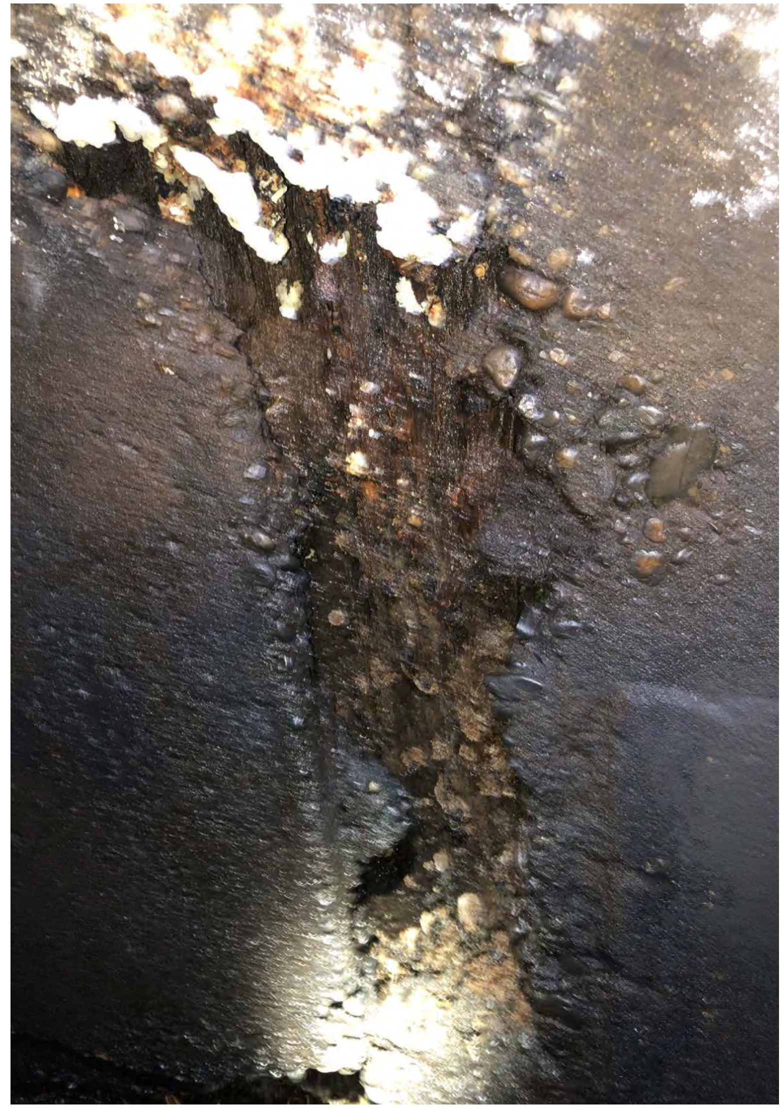

Big Tunnel Construction Joint


Big Tunnel Thin Cover On Wood


Big Tunnel Thin Cover On Wood 4+01

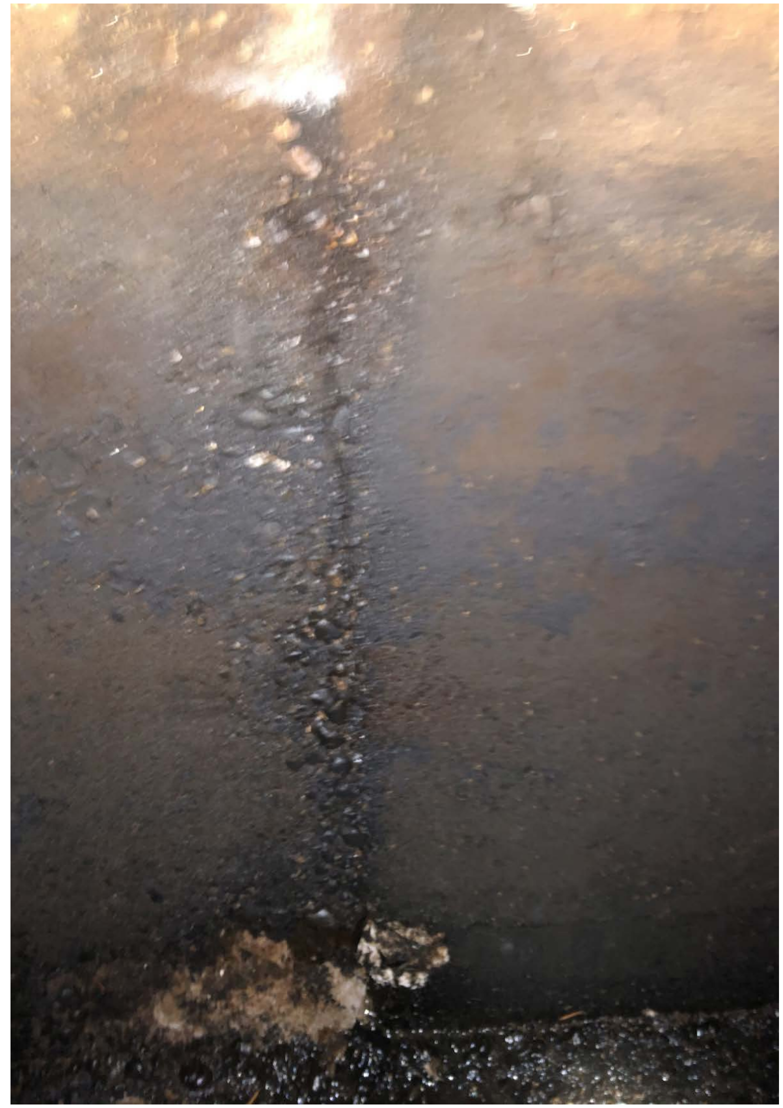

Big Tunnel Thin Cover On Wood1

Big Tunnel Thin Cover On Wood 4+55



Big Tunnel Thin Cover On Wood 4+41

Big Tunnel End Liner 5+18



Big Tunnel Thin Cover On Wood 4+75


Big Tunnel Timber Sets 5+70


Big Tunnel Timber Sets 5+67


Big Tunnel Timber Crib Above Liner


Big Tunnel Timber Crib Above Liner1

Big Tunnel 9+35

Big Tunnel Timber Crib 8+43

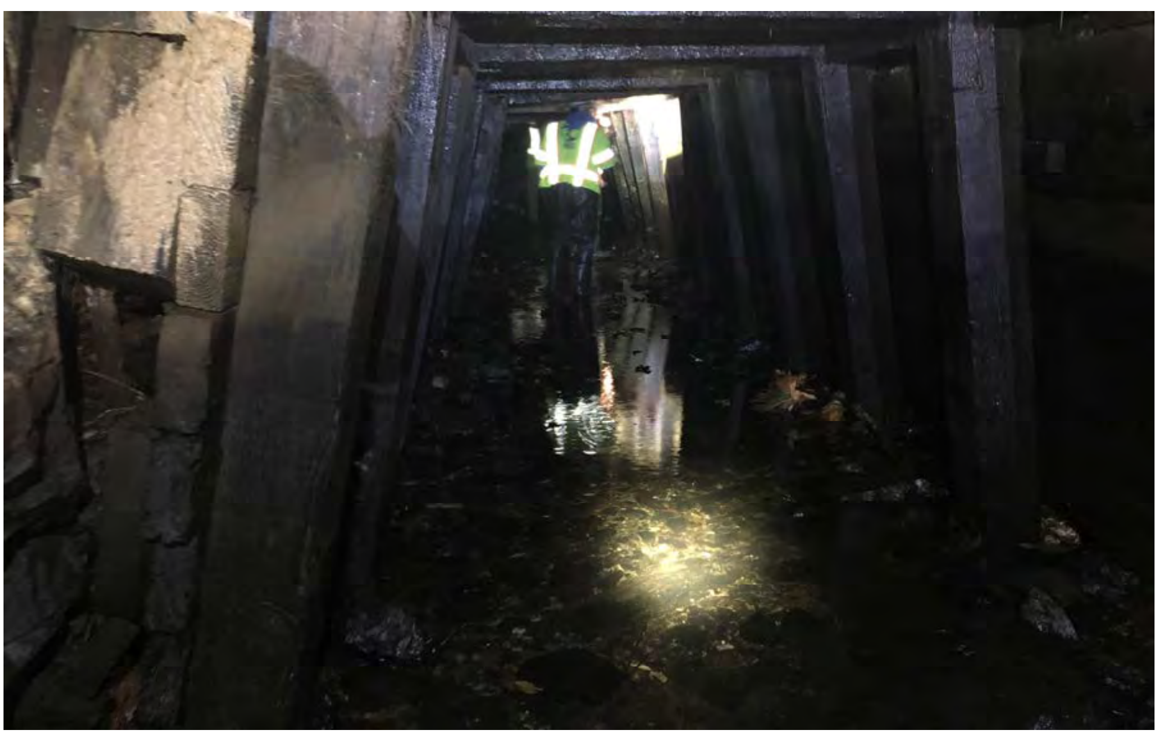

Big Tunnel 9+40


Big Tunnel 10+18


Big Tunnel 11+61


Big Tunnel 11+20

Big Tunnel 13+00



Big Tunnel 13+01

Big Tunnel 13+02

Big Tunnel 13+03

Big Tunnel 13+60


Big Tunnel 16+05

Big Tunnel 16+60

Big Tunnel 17+10

Big Tunnel 17+28

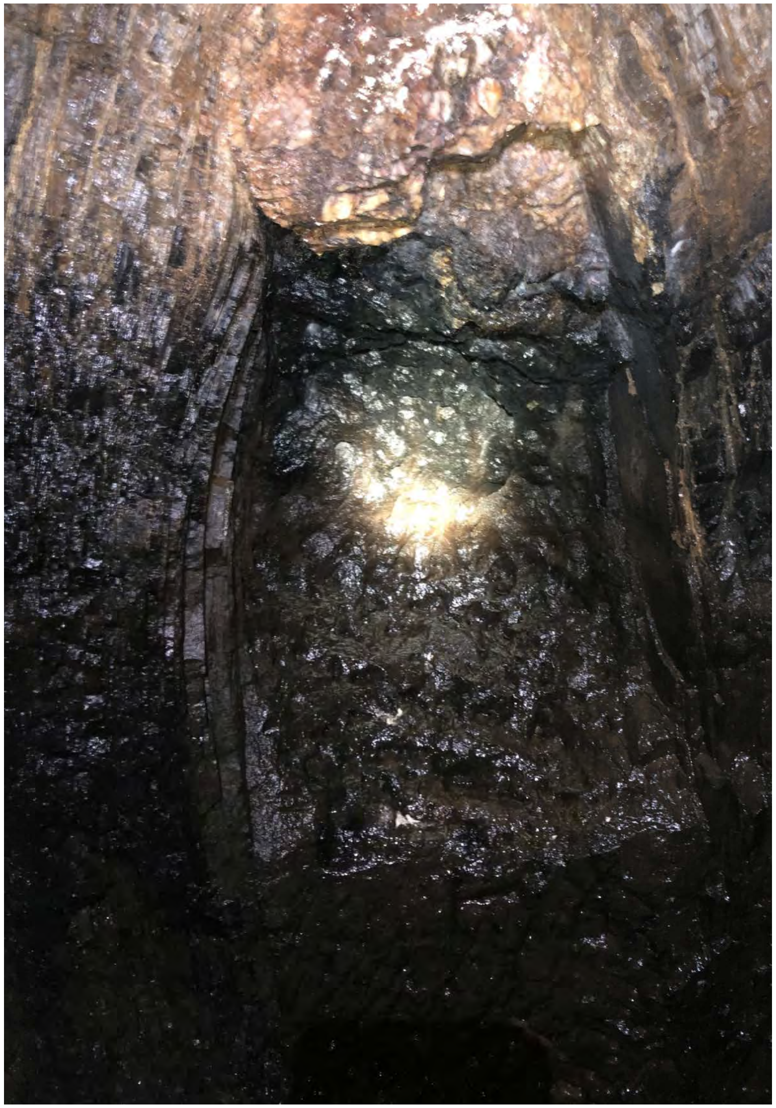
Big Tunnel 17+28 (2)


Big Tunnel 17+50

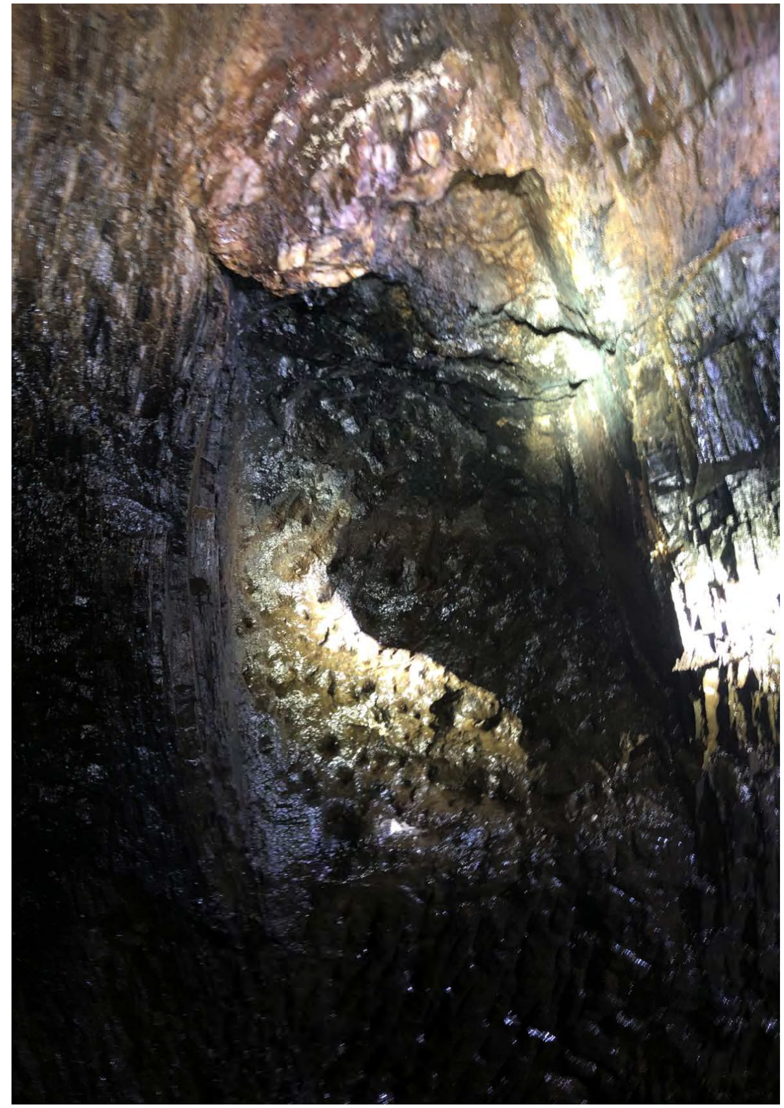

Big Tunnel 17+50 (2)

Big Tunnel 17+83

Big Tunnel 17+85

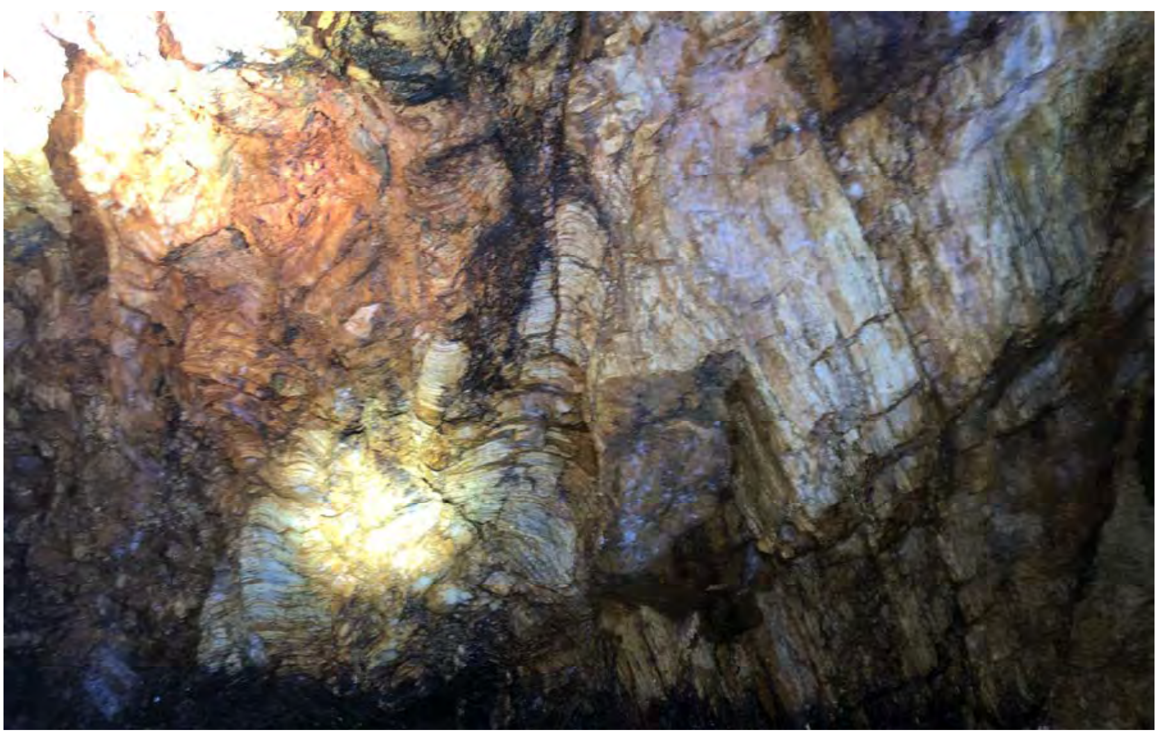


Big Tunnel 19+91 Shear4



Big Tunnel 19+91 Shear3

Big Tunnel 19+00



Big Tunnel 19+91 Shear2


Big Tunnel 19+91 Shear1


Big Tunnel 19+91 Shear

Big Tunnel 20+15

Big Tunnel 19+91 Shear5

Big Tunnel 20+15 (2)

Attachment B
Inspection Record

Big tunnel condition assessment

Lined section to station 0+79. metamorphic bed rock from 0+79. Bedrock is highly weathered, closely fractured, moderately weathered, moderately strong. Split sets at 3 foot centers and chain-link fence on the back. A void from a detached block in the back but nothing on the belly looks looks clean.

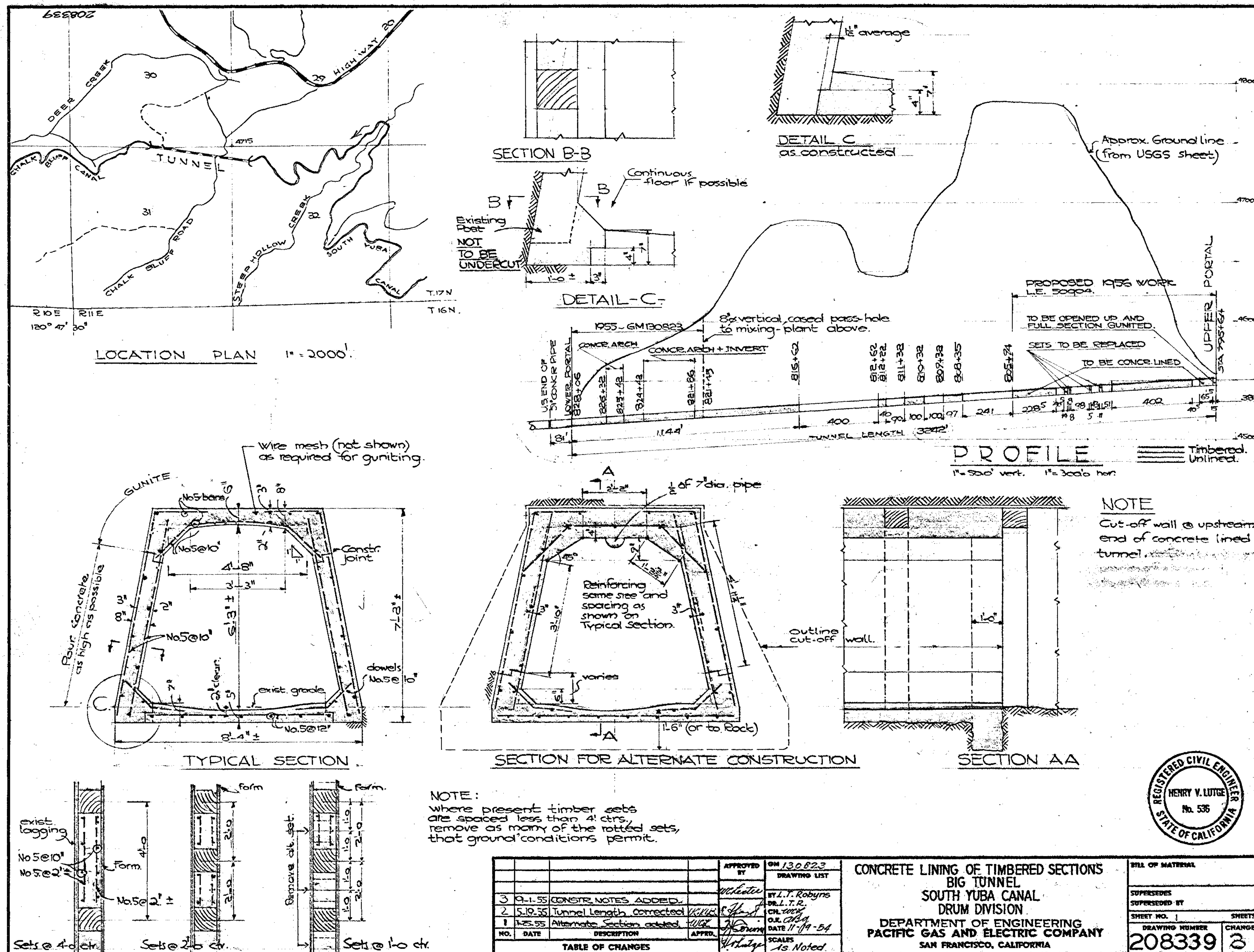
Station 1+07 began transition concrete up 4 1/2 feet both ribs.
station 1+154 lined tunnel.
Station 2+43 construction joint with sealant it's about ranges from 3 inches to 1/4 inch and looks tight.
Station 3+23 another construction joint erosion on the right rib down at the belly took photographs.
Station 3+62 another construction joint erosion. station 4+01 Another construction joint some minor inflow on right rib at 3 o'clock less than 1 gallon per minute.
Station 4+41 another construction joint erosion on right rib about 4 inches wide and 3 inches deep up two from 3 o'clock to 5 o'clock.
Station 4+? another construction joint tight all sides.
Station 5+18 end lined section begin bald section metamorphic rock and moderately weather closely fractured moderately strong no debris no fallouts no reinforcement. Water flow line about halfway up the ribs approximately 2 1/2 feet from invert.
Station 5+67 begin wood timber set with lagging. Posts approximately 10 x 8 and they're approximately 5 foot centers no crushing. the lag boards on top don't appear to be loaded and the liner boards on left rib are falling apart. right ribs looks Okay.
Station 5+80 end Wood-lined section begin bald section. No reinforcement, no signs of distress. rock is moderately weathered, moderately strong closely fractured. no fallouts observed.
Station 6+25 begin short timbered section, just a 4 foot section. liner boards both ribs and back no crushing no distress.
Station 6+30 end timbered short section begin bald tunnel same description as before moderately weathered moderately strong closely fractured.
station 6+57 structural shear zone approximately 12 inches wide pretty much normal to the tunnel and a little bit a break out approximately 12 inches deep over 1 to 2 foot wide section no obvious distress.
Station 7+00 marked on the right rib at Spring line.

Station 7+40 begin timber-lined section. no lagging remains on the left rib right rib is lagged back also lagged. no no distress no crushed members.
Station 7+53 end lined section left rib bottom of post is tapered down but appears plum. not taking weight.
Station 7+53 begin bald section similar description.
Station 8+00 begin fall-out section on the joints look fine. void above the back but everything looks stable.
Station 8+43 construction joint left rib eroded back exposing Old timber approximately 2 feet back in depth and width varies from 1 inch to 1 foot. no signs of distress on liner.
Station 9+35 begin radius turn to canal right.
Station 9+47 end radius begin straight section still full lined.
station 10+18 begin radius left and right station 11+20 and bend canal rightStation 11+61 and begin turn canal leftStation 12+00, 12+16 end left then begin straight section bald tunnel back is 8 to 9 feet tall ribs look for a competent no signs of distress.
Station 13+00 begin Wood-lined section similar construction both ribs liner boards back has lagging boards the post and columns look good no signs of distress.
Station 13+53 end wood lined set construction began small bold section approximately 12 feet to another Woodline section heavily cribbed behind lagging and posts.
station 13+65 begin wood lined section end bald section. left rib is heavily cribbed at downstream and right rib has crib with some large timber and no liner boards. right rib liner boards. the sets look good no signs of crush and no signs of significant distress.
Station 13+78 end liner boards left rib begin liner boards partial right rib although that doesn’t extend to the belly; it’s missing the lower 18 inches.
Station 13+85 coming into the shaft repair area in the timber sets are double or triple nearly continuous sets with small gaps for approximately 12 feet.
Station 14+02 end jump set section for shaft repair still timber-lined for another two sets. station 14+10 end timberline section begin bald section no split sets at no support. metamorphic rock slightly to moderately weathered, moderately strong, closely fractured. no fallouts looks competent.
Station 14+67 begin timber-lined section same construction on the Timbers a partial liner boards on right rib and nothing on left rib no signs of distress.
Station 14+76 end timberline section begin bald section that ends at 14+95.
Station 14+95 begin short section of Timber-lined construction liner boards both ribs and back Timbers look similar no signs of distress.

Station 15+08 end timberline section begin bald tunnel. similar rock no support and no signs of distress.
Station 15+23 and left rib erosion approximately 2 1/2 feet wide and 4 feet deep up approximately 4 feet above invert on left rib looks like it is not actively eroding anymore looks like it's done.
Station 15+93 begin timber-lined section liner boards both ribs and back and no signs of taking on weight no signs of distress.
Station 16+02 lright and left ribs are bare Timberset construction. lagging on back and the ribs look competent, no signs of erosion.
Station 16+10 diagonal shear in tunnel dipping upstream proximately 2 inches wide rolling back up to 6 to 8 inches on the right ribb. similar on the left rib. can't see the back because it's covered with lagging.
Station 16+33 end timber sets and approximately the area that a diagonal shear projects to intercept the back. no signs of distress. begi bald section approximately 8 feet tall no support. looks looks competent.
Station 16+57 shear, normal to the tunnel axis . slight erosion actually I think it's just a week a rock slight erosion on the left rib. right rib below spring line and invert looks fine back looks fine and left it looks fine.
Station 17+10 right ribs diagonal noncontinuous small void approximately 4 inches wide and 2 feet deep probably carbonate dissolution or just erosion? otherwise no signs of distress I'm just upstream took a picture of a joint on the right rib that was some at parallel to the rib and just downstream from this location there's some flat joints in the back joints me saying appears to be 12 inches approximately .
Station 17+28 left rib below spring line a small feature approximately 2 1/2 feet wide and 3 feet deep apparently in quartz vein. Void cribbed up with some spare timber and and other mining waste. somewhat flat void exists on the right rib as well with similar dimensions but without timber backfill lagging; probably actively eroding but no signs of distress.
Station 17+83 continued flat joint on back and joints on right rib paying off. right rib paying off approximately 6 to 8 inches wide, otherwise looks competent.
Station 19+18 begin short timber-lined section. both ribs and back are lagged and sets look good.
Station 19+26 end timberline section begin bald tunnel. No reinforcement, no support. Rock is moderately weathered, moderately fractured and moderately strong. no signs of distress.
Station 19+71 high water line or normal flow line at approximately 4 1/2 feet above invet. manganese staining in bedrock on the back.

Station 19+91 erosional feature in shear zone normal to the tunnel axis. Shear is approximately 12 inches wide and up to 4 1/2 feet deep. back looks competent. left rib is apparently a little stronger with less erosion.
Station 20+15 begin lined section. the transition is eroded above spring line on the right rib and back has been partially filled. looks tight however from spring line down to belly on both left and right ribs. a vertical concrete transition exists at approximately 45° angle over distance of about 12 inches (chamfered edge).

Station 26+14 begin full lined section. some rock pockets above spring line pretty much back and ribs from 9 o'clock to 3 o'clock flow lines at approximately 2 1/2 feet in at 5 o'clock and 7 o'clock at the interface of ribs and belly are rock pockets and slight erosion but nothing exposing bedrock or destabilizing the tunnel.



NO.	DATE	DESCRIPTION	APPRD.
3	9-1-55	CONSTR. NOTES ADDED.	
2	5-19-55	Tunnel Length corrected	
1	3-25-55	Alternate Section added	

TABLE OF CHANGES

APPROVED BY
GM 130823 DRAWING LIST
BY L.T. Robyns
DR. L.T.R.
DATE 11-19-54
SCALES As Noted

CONCRETE LINING OF TIMBERED SECTIONS
BIG TUNNEL
SOUTH YUBA CANAL
DRUM DIVISION
DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

BILL OF MATERIAL
SUPERSEDES
SUPERSEDED BY
SHEET NO. 1 SHEETS
DRAWING NUMBER 208339 CHANGE 3

105 M/M, NEG. 3

SCAN 3

Pacific Gas and Electric Company

Inspection Procedures

FOR

SOUTH YUBA CANAL
BIG & LITTLE TUNNEL INSPECTIONS

BY

Hydro Generation

November 2020

Table of Contents

South Yuba Big & Little Tunnels Inspection Procedures

1.0 Tunnel Owner:

Pacific Gas and Electric Co.

Company Rep: Chris Brewster: Drum Area Manager.

Address: 12840 Bill Clark Way.
Auburn CA 95602
Cellular Phone: (530)-906-3584

2.0 CONTRACTOR:

PACIFIC GAS & ELECTRIC CO.

PE&C Work Supervisor:
Keith Rowland: Asset Management Engineer.
Office 12840 Bill Clark Way.
Auburn, 95602
Cellular phone: (530)-320-2581

O&M Work Supervisor:
Mike Robinson: Alta Water Crew Foreman
Alta Office, (530) 3465958
Address:
Cellular phone, (530)-906-2751

Main Field Office Physical Address: 33995 Alta Bonnie Nook Rd.
Alta CA 95701

Main Field Office Phone Numbers: Co. #, 734-5247, PT&T #, (530) 389-2202

Field Office Contact:
Kristi Hoisington - Field Clerk
Alta Office, (530)-346-5958

3.0 PG&E SAFETY REPS:

Bob Raibley
Auburn Office: (530)-889-6449
Cellular Phone:(530)-906-3280

4.0 TUNNEL LOCATION / CONTACTS

4.1 CONTACTS:

Contact	Name	Radio / Freq.	Telephone	Cellular Phone
Drum PH		**KMH 404 / 158.130**	**(916)389-2551**	**Co. # 734-5000**
Area Manager	Chris Brewster		(530)-889-3370	(530)-906-3584
Water Foreman	Mike Robinson		(530)389-2202	(530)-906-2751
AM Engineer	Keith Rowland		(530) 889-3381	(530)-320-2581
Inspection	Bob Raibley		(530) 889-6449	(530) 906-3280
Field Office			(530)-389-2202	

4.2 SOUTH YUBA CANAL TUNNELS LOCATION:

South Yuba Canal Big and Little Tunnels are located in the Bear Valley area of eastern Placer County California.

Big Tunnel: Located in T16N R11E, on the center of section 4.

Little Tunnel: Located in T17N R11E on north line of section 31.

4.3 JOB ACCESS ROADS:

Big Tunnel:
From Auburn take Interstate 80 east toward Reno 40 miles to the intersection of Hwy 20. Turn north on Hwy 20 toward Grass Valley Ca. Travel 10.8 miles to Chalk Bluff Road. Turn left on Chalk Bluff "dirt road" and travel 1.5 miles to a four way intersection, turn left and travel .4 miles to the up stream portal.

Little Tunnel:
From Auburn take Interstate 80 east toward Reno 40 miles to the intersection of Hwy 20. Turn north on Hwy 20 toward Grass Valley Ca. Travel 7.3 miles to Lowell Hill Road. Turn left on Lowell Hill "dirt road" and travel 2.8 miles to a four way intersection, turn left to the upstream portal of the tunnel.

4.4 HELICOPTER MEDI VAC. PAD_

Big Tunnel: N 39* 18' 04" W 120* 46' 16"
Little Tunnel: N 39* 16' 52" W 120* 45' 04"

5.0 DURATION OF JOB:

Both tunnels will be inspected on November 3rd & 4th 2020.

6.0 SOUTH YUBA BIG & LITTLE TUNNELS PHYSICAL INFORMATION:

6.1 Description:

Big Tunnel is 3,250 feet long and is 67% lined. The tunnel is concrete lined in four locations a total of 1970 feet with an average cross section of 6 feet wide by 5.5 feet high. The tunnel is timber lined in 8 locations a total of 205 feet with an average cross sections of 7 feet wide by 6.5 feet high. The tunnel is unlined for 1075 feet with an average cross section of 8 feet wide by 10 feet high.

Little Tunnel is 372 feet long and is 100% lined. Average cross section is 6 feet wide by 5 feet high.

6.2 Underground Gas Classification:

These tunnels have been classified by Cal Osha as a “Non Gassy” tunnel.

6.3 Tunnel Access:

Big Tunnel:
The inspection team will enter the upstream portal of the tunnel and proceed downstream exiting at the downstream portal.

Little Tunnel:
The inspection team will enter through the upstream portal of the tunnel and proceed downstream exiting at the downstream portal.

7.0 Scope of work:

7.1 Illumination:

All entrants must have 2 sources of light. The main source must be a cap mounted light and a backup hand light for Emergency escape should the cap lamps fail, "two sources of light required".

7.2 Communication:

Because Little Tunnel is very short, verbal communication will be adequate. At Big Tunnel the inspection team will communicate to the portal attendants by radio. However, air horns will be on site and utilized for emergency notification if it becomes necessary to evacuate the tunnel. Signals will be as follows.

1. One blast - ignore, could be accidental
2. Series of two short blasts, - Need help in the tunnel non emergency
3. Series of three short blasts - Evacuate the tunnel
4. Series of four short blasts - Need help in the tunnel - emergency

7.3 Ventilation:

The inspection will be performed under natural air flow, no forced air ventilation is planed for this inspection.

7.4 Inspection:

Dewatering: The tunnels will be dewatered on morning of 11-03 as follows. YB 244 Gate closed tagged danger, dissipater drain valve open tagged danger. YB 116 Cross Gate closed tagged danger, YB 116 Cross Gate ac breaker open tagged danger. YB 116 spill open tagged danger, YB 116 spill gate ac breaker open tagged danger. The clearance will be held by Dave Snyder, Alts water crew lead. Dave must report on the clearance before tunnel entry and confirm all personnel clear of the tunnels before reporting off.

Create Safe Access:

Ladders used to access the tunnels must be secured and extend at least 3 feet above landings or decks.

Tunnel Inspections:

A 5 to 7 person inspection team will enter the tunnels and split into two, teams and be separated by a short distance. Separation of team members helps assure that someone will be able to escape to summon help in the event of an emergency. The team will look for defects and signs of distress in the lined and unlined portions of the tunnels. In each entry the inspection team will give a definite time of exit to the portal safety person. Upon exiting the tunnel the inspection team will notify the attendant. If the specified exit time is exceeded the attendant will initiate the emergency response plan. It is the responsibility of the inspection team to exit the tunnel before the specified time elapses, even if it means exiting and reentry.

8.0 AIR FLOW & TESTING FOR HARMFUL GASSES:

8.1 Testing Personnel and Procedures:

A qualified trained person will test the atmosphere, and will continuously monitor the air during the time of the inspection. The minimum volume of air shall not be less than 60 lfm or 200 cfm per man, which ever is greater. The air will be monitored for percent oxygen and L.E.L along with parts per million carbon monoxide and hydrogen sulfide. Limitations are presented in the table below:

Oxygen	Carbon Monoxide	Explosive Limit	Hydrogen Sulfide
19.5% to 22%	20 PPM	5% LEL	10 PPM

The tunnel shall be evacuated if the above standards are not met. The certified tester shall be immediately notified. The owner and engineer will then review the alternatives before work resumes.

8.2 Testing Equipment

1. An Alnor velometer Jr. will be used for measuring the velocity of air flow.

2. An Industrial Scientific MX6, and/or a MSA Passport will be used to monitor air quality.

9.0 ENTRY PROCEDURES:

9.1 Entrants and Attendant:

Each individual entering & exiting the tunnel is to report their name and time entering and exiting the tunnel to the designated safety attendant stationed at the tunnels portal. The safety attendant shall then log this information in the log book. The entrants shall not travel to locations other than the specified work area

9.2 Working Alone Under Ground.

No one individual shall work underground alone. A crew member must be accompanied by at least one other crew member at all times.

10.0 ACCIDENT PREVENTION PROGRAM:

* Code of Safe Practices & Procedures
* Tunnel Safety Orders
* PG&E Accident Prevention Rule Book
* Electrical Safety Orders
* Pre-Job Safety Plan
* New Hire Indoctrination
* E. A. P. & First Aid Stations
* Pre-Job Crew Indoctrination
* M.S.D.S'S on Site
* 10 Day extended Tailboard
* Job Site Posting Area
* Quality Air Testing
* Quarterly Safety Meetings
* Daily Tailboards
* First Aid Training
* Weekly Safety Audits
* P G & E Injury & Illness Prevention Program

11.0 TUNNEL PORTAL SAFETY REQUIREMENTS:

11.1 PORTAL SAFETY ATTENDANT:

A minimum of one person shall be outside the tunnel entrance at all times while men are underground. This person shall have radio contact with Drum Power House. This individual shall remain at the portal with sole duties of monitoring the tunnel entrance. This individual shall be familiar with the Tunnel Safety Orders and ERP.

11.2 POSTING REQUIREMENTS:

The following items shall be available at the tunnel entrance:

1. Tunnel classification
2. ERP
3. Trauma kit
4. Stokes litter
5. Eye wash station
6. Air horn

12.0 MINE RESCUE TRAINING:

Trained Emergency tunnel Rescue Units:

LASSEN COUNTY SEARCH AND RESCUE TEAM
P.O. Box 171
Susanville, CA 96130
530-257-5756

Our team resources provide: Field tracking, technical rescue, search dogs, MSHA certified mine rescue, dive rescue/recovery, medical response units, and mobile command center.

President: Bob Trussell
Commander: Leonard Potter
Captains: Terrie Trussell-Ginder, Larry Dahlen
Lieutenants: Laurie Karikka, Doug Hutchinson,
Sergeants: Tim Williams, Sue Bonham,
Tim Hinman, Marcus Pacheco,
Jay Bishop, Nora Bishop,
Justin Ginder, Lori Powers,
Rob Sears, Chris Moberg

13.0 EMERGENCY RESPONSE PLAN & PROCEDURES:

Will be available at all tunnel access manhole. If it becomes necessary to evacuate the tunnel, evacuate to the nearest and safest exit. Sign out of the tunnel, by radio if necessary. Verify that all personnel have evacuated the tunnel while initiating the emergency response plan. ***Contact Lassen County Search and Rescue only if underground rescue is necessary.***

14.0 RESCUE EQUIPMENT:

14.1 Self Rescuers:

Not required for this entry.

14.2 Emergency Rescue Equipment:

As supplied by trained rescue crews in section 14.

15.0 PROTECTIVE EQUIPMENT:

Two sources of light
Hard hats
Safety glasses
Leather gloves
Chest Waders

Power Generation

Job Safety Analysis (JSA) Worksheet

Submitted to centralized data base ☐

Date: November 3rd 2020	**Job / Task: Inspect the SYC Big and Little Tunnels**	
JSA Reference #:	**Location: Job Sites off HWY 20**	**S/EC & Phone #:**
Prepared By: Raibley	**Department: Hydro**	**ERP Location: In job Book**
SW CTR and Phone #: Drum SC. 530-3892551	**Job Order #**	
Gen Supervisor: Adam Merschel Cell 916-316-2175	**Exempt Foreman: Robert Raibley Cell 530-906-3280**	**Water Crew Foreman: Mike Robinson Cell 530-906-2751**

Task Steps	**Hazards**	**Controls**	**Reference Documents**	**F***	**S***	**P***
Drive to Project	**Traffic on road, Animals, unfamiliar area.**	**Inspect vehicles daily prior to use, follow defensive driving techniques (Smith techniques) at all times and watch for errant third party vehicles “lane-sharing”, etc. on mountain roads. Maintain safe speeds – numerous blind turns and can also encounter range cattle along roads. Close and lock all access gates upon entry and exit.**		**X**		

Task Steps Documents	Hazards	Controls	Reference			
Parking	**Backing, traffic congestion**	**Get assistance when backing, stay alert of your surroundings. Take vehicle keys and personnel belongings with you.(a vehicle was broken into on prior inspection) Back in vehicles to avoid blocking entry/exit way to powerhouse(s) and use spotter when available.**		**X**		
PPE	**Overhead clearance, foreign objects in eye, cuts and abrasions**	**Hard Hat, ANSI Approved safety glasses, Felt Soled Boots, Wadders, Gloves, Two sources of light, walking stick(if needed), outer most layer reflective (traffic vest)**		**X**		
Miscellaneous safety Items	**Insect/snake bites Poison Oak.**	**Job site awareness & attitude. Avoidance & use of pre-exposure creams**		**X**		

Task Steps	Hazards	Controls	Reference Documents			
Miscellaneous safety Items	**Dehydration/heat illness/heat exhaustion**	**Multiple water jugs & sports drinks available – consume frequently to stay properly hydrated and avoid heavy use of caffeinated drinks. Tunnel crew will pack water in their backpacks**		**X**		
Clearance	**Working under clearances – SYC System Ditches**	**Follow LOTO PG-1404P-01 energy control procedure & walk down clearance boundary weekly. Hydro Crew Foreman Dave Snyder to be primary clearance holder for all water conveyance clearances. After walking down all energy isolation and control points, GC, I&C and all contract employees to lock-on as secondary/additional clearance holders using green/blue locks.**		**X**		

Task Steps Hazards Controls Reference
Documents

ERPs	**Emergency Response Plans - confusion who to call for assistance**	**Updated ERP’s in trucks, trauma kits @ SJ#2 & #3 powerhouses. Inspector with Tunnel Inspection group will carry an ERP and radio. GC crew will monitor groups movement thru tunnels via radio communication.**		**x**		
Entering the Tunnels	**Slips, Trips, and Falls, ladder not secured properly.**	**Secure ladder prior to use, ensure ladder extends 36” over access,**		**x**		
Tunnel Entry	**Medical Emergencies**	**Identify rescue personnel and responsibilities. Be sure that all numbers and emergency contacts are listed in EAP. Inspector will have Trauma kit on his person during Inspection.**		**X**		

Task Steps Hazards Controls Reference
Documents

Air Monitors	**Out of calibration, wrong bump gas.**	**Inspector will have two air monitors with him during tunnel inspection. One will be on at all times. The second is a back up. All monitors will be calibrated and bump tested prior to entry. Tunnel will be tested by qualified personnel prior to entry. Data will be collected and relayed to tunnel attendant.**				

Task Steps Hazards Controls Reference
Documents

Tunnel Attendants	**Miss communication between tunnel inspection group and attendants, outside air contaminants, unauthorized personnel entering tunnel.**	**Attendants: A minimum of one person shall be outside the tunnel entrance at all times while men are underground. This person shall have radio contact with Drum Switching Center and Tunnel Inspection Group. This individual shall remain at the portal with sole duties of monitoring the tunnel entrance. Once section of tunnel has been inspected. Inspection group will communicate to attendants that it is safe to move to next portal. This individual shall be familiar with the Tunnel Safety Orders and ERP.**				
Concluding Inspection	**Not contacting Drum SC when complete, Inaccurate head count.**	**Ensure all personnel have exited the tunnel, ensure that attendants have signed them out, ensure that attendants contact Drum SC at the conclusion of Inspection.**				

GHD

4080 Plaza Goldorado Circle
Suite B
Cameron Park, CA 95682 USA
T: 1 530 677 5515

Appendix D
Site Photographs - Spillways

Photo 1 - View of YB139 Spillway

Photo 2 - View of YB139 Spillway

Site Photographs

Photo 3 - View of YB139 Spillway

Photo 4 - View of YB139 Spillway

Photo 5 - View of YB139 Spillway

Photo 6 - View of YB139 Spillway

Photo 7 - View of Bear Valley Spillway

Photo 8 - View of Bear Valley Spillway

Photo 9 - View of Bear Valley Spillway

Photo 10 - View of Bear Valley Spillway

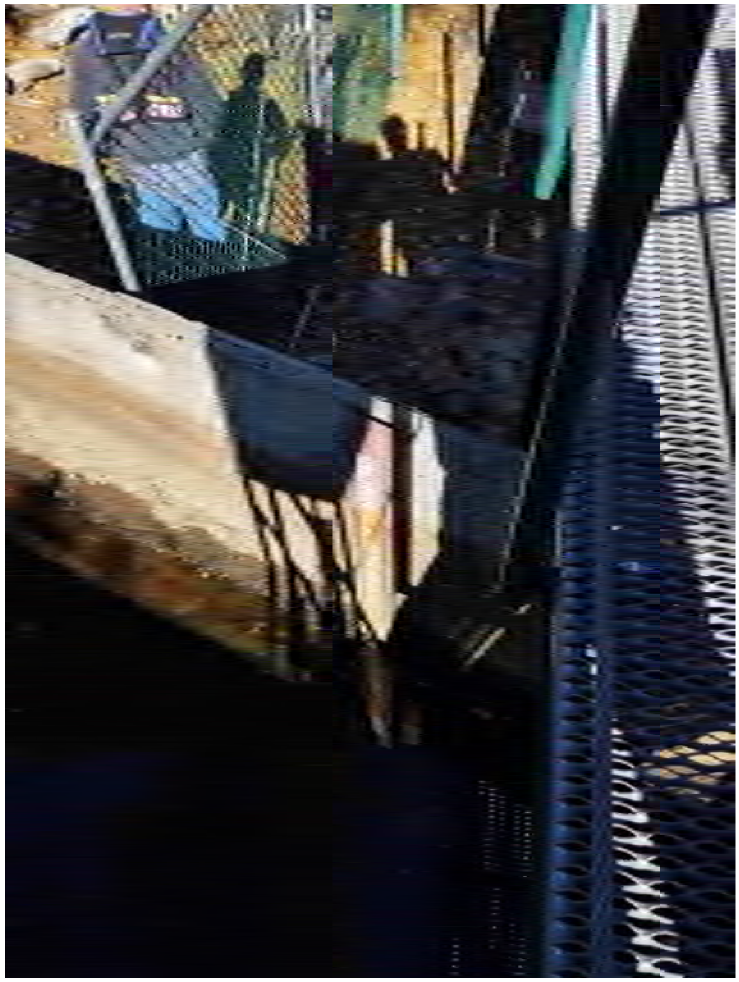


Photo 11 - View of Bear Valley Spillway

Photo 12 - View of Bear Valley Spillway

Photo 13 - View of Bear Valley Spillway

Photo 14 - View of Bear Valley Spillway

Photo 15 - View of Bear Valley Spillway

Photo 16 - View of Bear Valley Spillway

Photo 17 - View of Bear Valley Spillway

Site Photographs

Photo 18 - View of Bear Valley Spillway

Photo 19 - View of Capehorn Spillway

Photo 20 - View of Capehorn Spillway

Photo 21 - View of Capehorn Spillway

Photo 22 - View of Capehorn Spillway

Photo 23 - View of Capehorn Spillway

Photo 24 - View of Capehorn Spillway

Photo 25 - View of Capehorn Spillway

Photo 26 - View of Capehorn Spillway

Photo 27 - View of Capehorn Spillway

Site Photographs

Photo 28 - View of Capehorn Spillway

Photo 29 - View of Capehorn Spillway

Photo 30 - View of Little Tunnel Spillway

Photo 31 - View of Little Tunnel Spillway

Photo 32 - View of Little Tunnel Spillway

Photo 33 - View of Little Tunnel Spillway

Photo 34 - View of Little Tunnel Spillway

Photo 35 - View of Little Tunnel Spillway

Photo 36 - View of Little Tunnel Spillway

Photo 37 - View of Little Tunnel Spillway

Photo 38 - View of Little Tunnel Spillway

Photo 39 - View of Little Tunnel Spillway

Photo 40 - View of Little Tunnel Spillway

Site Photographs

Photo 41 - View of Little Tunnel Spillway

Photo 42 - View of Little Tunnel Spillway

Photo 43 - View of Little Tunnel Spillway

Photo 44 - View of Little Tunnel Spillway

Photo 45 - View of Little Tunnel Spillway

Photo 46 - View of Little Tunnel Spillway

Photo 47 - View of Little Tunnel Spillway

Photo 48 - View of Little Tunnel Spillway

Photo 49 - View of Little Tunnel Spillway

Photo 50 - View of 9 ½ Mile Spill

Photo 51 - View of 9 ½ Mile Spill

Photo 52 - View of 9 ½ Mile Spill

Photo 53 - View of 9 ½ Mile Spill

Photo 54 - View of 9 ½ Mile Spill

Photo 55 - View of 9 ½ Mile Spill

Photo 56 - View of 9 ½ Mile Spill

Photo 57 - View of 9 ½ Mile Spill

Photo 58 - View of 9 ½ Mile Spill

Photo 59 - View of 9 ½ Mile Spill

Photo 60 - View of 9 ½ Mile Spill

Photo 61 - View of 9 ½ Mile Spill

Photo 62 - View of 9 ½ Mile Spill

Photo 63 - View of 9 ½ Mile Spill

Photo 64 - View of 9 ½ Mile Spill Siphon

Photo 65 - View of 9 ½ Mile Spill Siphon

Photo 66 - View of 9 ½ Mile Spill Siphon

Photo 67 - View of 9 ½ Mile Spill Siphon

Photo 68 - View of 9 ½ Mile Spill Siphon

Photo 69 - View of 9 ½ Mile Spill Siphon

Photo 70 - View of 9 ½ Mile Spill Siphon

Photo 71 - View of 9 ½ Mile Spill Siphon

Photo 72 - View of 9 ½ Mile Spill Siphon

Photo 73 - View of Hickman Spill

Photo 74 - View of Hickman Spill

Photo 75 - View of Hickman Spill

Photo 76 - View of Hickman Spill

Photo 77 - View of Hickman Spill

Photo 78 - View of Hickman Spill

Photo 79 - View of Hickman Spill

Site Photographs

Photo 80 - View of Hickman Spill

Photo 81 - View of Hickman Spill

Photo 82 - View of Hickman Spill

Photo 83 - View of Excelsior Point Spill Siphon

Photo 84 - View of Excelsior Point Spill Siphon

Photo 85 - View of Excelsior Point Spill Siphon

Photo 86 - View of Excelsior Point Spill Siphon

Photo 87 - View of Excelsior Point Spill Siphon

Photo 88 - View of Excelsior Point Flashboard Weir

Photo 89 - View of Excelsior Point Flashboard Weir

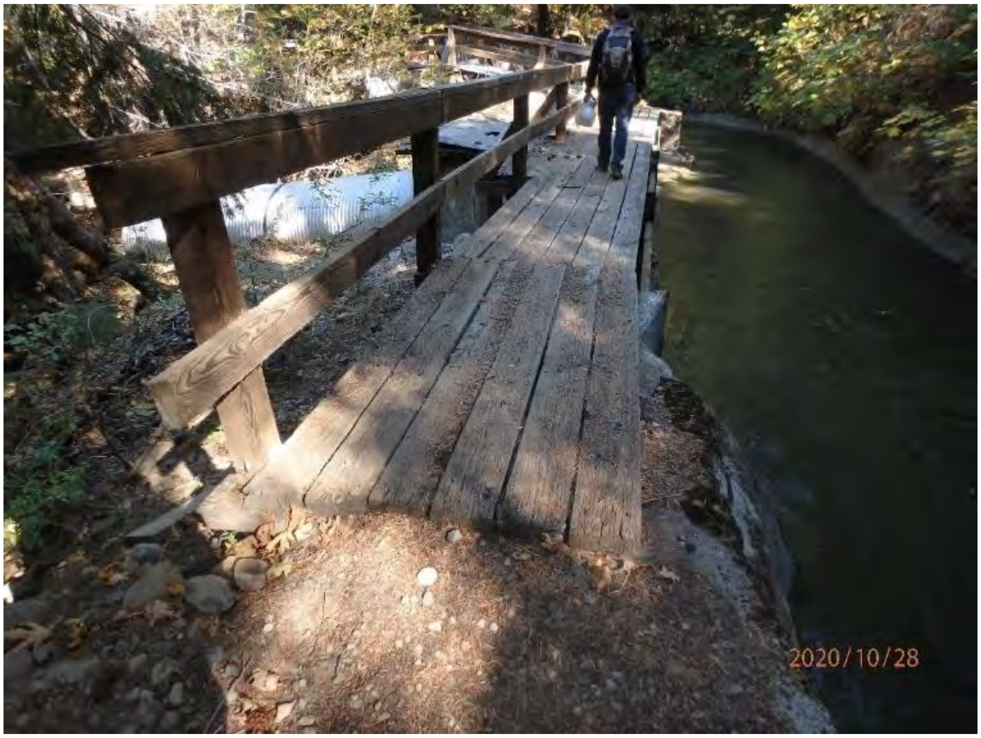


Photo 90 - View of Excelsior Point Flashboard Weir

Photo 91 - View of Excelsior Point Flashboard Weir

Site Photographs

Photo 92 - View of Excelsior Point Flashboard Weir

Photo 93 - View of Excelsior Point Gated Spillway

Photo 94 - View of Excelsior Point Gated Spillway

Photo 95 - View of Excelsior Point Gated Spillway

Photo 96 - View of Excelsior Point Gated Spillway

Photo 97 - View of Excelsior Point Gated Spillway

Photo 98 - View of Excelsior Point Gated Spillway

Site Photographs

Photo 99 - View of Excelsior Point Gated Spillway

Photo 100 - View of Excelsior Point Gated Spillway

Site Photographs

Photo 101 - View of Excelsior Point Gated Spillway

Photo 102 - View of Excelsior Point Gated Spillway

Site Photographs

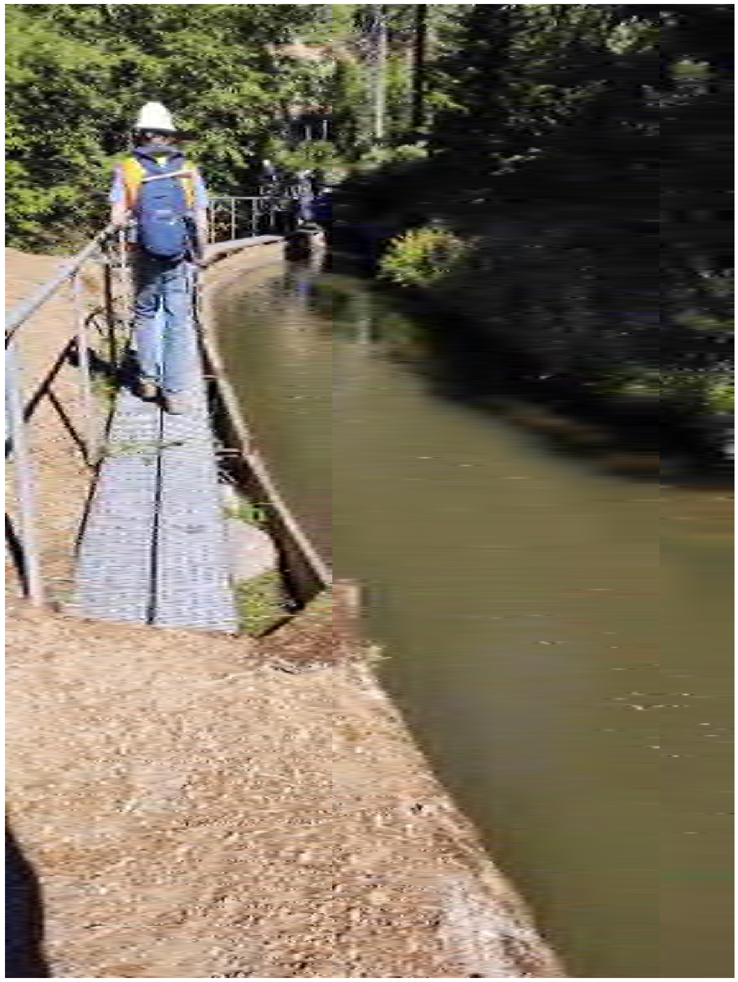


Photo 103 - View of 13 Mile Spillway

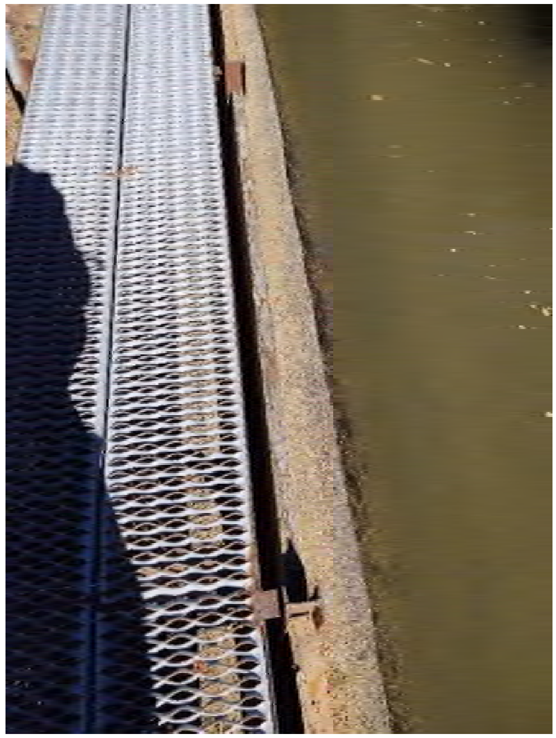


Photo 104 - View of 13 Mile Spillway

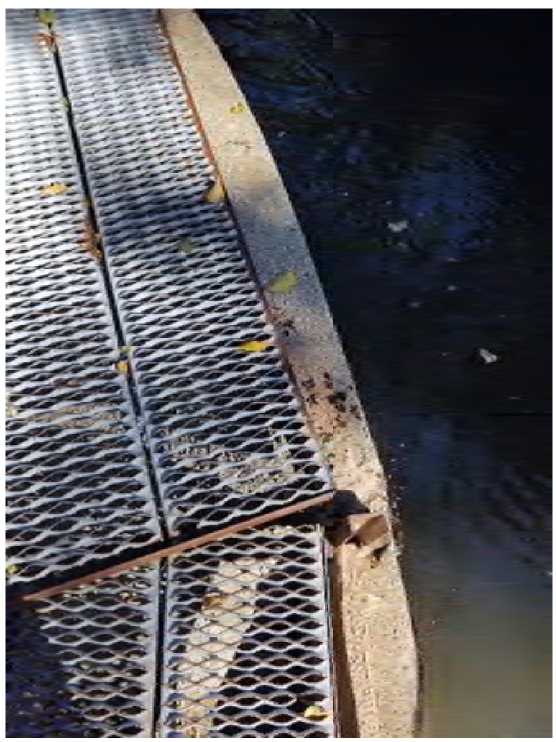


Photo 105 - View of 13 Mile Spillway

Photo 106 - View of 13 Mile Spillway

Photo 107 - View of 13 Mile Spillway

Photo 108 - View of 13 Mile Spillway

Photo 109 - View of 13 Mile Spillway

Photo 110 - View of 13 Mile Spillway

Site Photographs

Photo 111 - View of 13 Mile Spillway

Photo 112 - View of 13 Mile Spillway

Photo 113 - View of 13 Mile Spillway

Photo 114 - View of 13 Mile Spillway

Site Photographs

Photo 115 - View of 14 Mile Spill

Photo 116 - View of 14 Mile Spill

Photo 117 - View of 14 Mile Spill

Photo 118 - View of 14 Mile Spill

Photo 119 - View of 14 Mile Spill

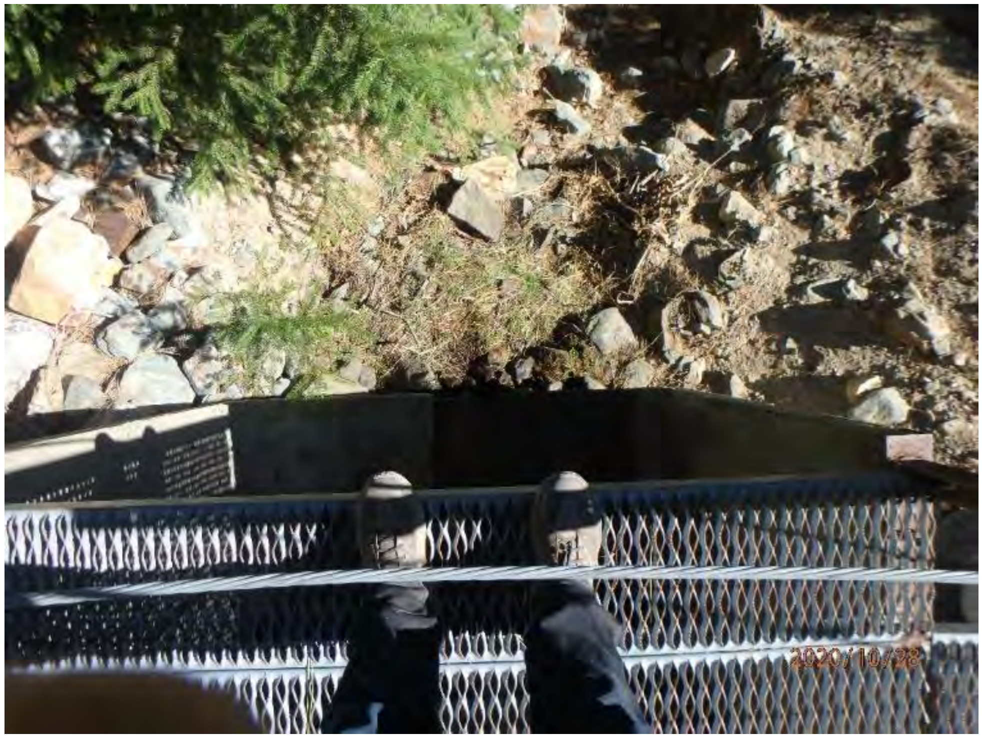


Photo 120 - View of 14 Mile Spill

Photo 121 - View of 14 Mile Spill

Photo 122 - View of Big Tunnel Side Spill

Photo 123 - View of Big Tunnel Side Spill

Photo 124 - View of Big Tunnel Side Spill

Photo 125 - View of Big Tunnel Side Spill

Photo 126 - View of Big Tunnel Side Spill

Photo 127 - View of Big Tunnel Side Spill

Photo 128 - View of Big Tunnel Side Spill

Photo 129 - View of Big Tunnel Side Spill

Photo 130 - View of Big Tunnel Spillway

Photo 131 - View of Big Tunnel Spillway

Photo 132 - View of Big Tunnel Spillway

Site Photographs

Photo 133 - View of Big Tunnel Spillway

Photo 134 - View of Big Tunnel Spillway

Photo 135 - View of Big Tunnel Spillway

Photo 136 - View of Big Tunnel Spillway

Photo 137 - View of Big Tunnel Spillway

Photo 138 - View of Big Tunnel Spillway

Photo 139 - View of Big Tunnel Spillway

Photo 140 - View of Big Tunnel Spillway

Photo 141 - View of Big Tunnel Spillway

Photo 142 - View of Big Tunnel Spillway

Photo 143 - View of Big Tunnel Spillway

Photo 144 - View of Big Tunnel Spillway

Photo 145 - View of Big Tunnel Spillway

Photo 146 - View of Big Tunnel Spillway

Photo 147 - View of Sand Bunker Spill

Photo 148 - View of Sand Bunker Spill

Photo 149 - View of Sand Bunker Spill

Photo 150 - View of Sand Bunker Spill

Photo 151 - View of Sand Bunker Spill

Photo 152 - View of Sand Bunker Spill

Photo 153 - View of Sand Bunker Spill

Photo 154 - View of Siphon Upstream of Sandsettler Spill Siphon

Photo 155 - View of Siphon Upstream of Sandsettler Spill Siphon

Photo 156 - View of Sandsettler Spillway

Photo 157 - View of Sandsettler Spillway

Photo 158 - View of Sandsettler Spillway

Photo 159 - View of Sandsettler Spillway

Photo 160 - View of Sandsettler Spillway

Photo 161 - View of Yunks Spill

Photo 162 - View of Yunks Spill

Photo 163 - View of Yunks Spill

Photo 164 - View of Yunks Spill

Photo 165 - View of Yunks Spill

Photo 166 - View of Yunks Spill

Photo 167 - View of Yunks Spill

Appendix E
Geophysical Investigation

Refraction Seismic Investigation at the NID South Yuba Canal – Segment 15 Nevada County, California

GGSI Project No. 2021-17.01

Prepared by:

Gasch Geophysical Services, Inc.
Rancho Cordova, California 95742-6576

Submitted to:

Mr. Tony Quintrall
GHD, Inc.
4080 Plaza Goldorado Circle, Suite B
Cameron Park, California 95682

May, 2021

GASCH GEOPHYSICAL SERVICES, INC.
WWW.GEOGASCH.COM Since 1969

May 8, 2021

Mr. Tony Quintrall
GHD, Inc.
4080 Plaza Goldorado Circle, Suite B
Cameron Park, California 95682

Re: Refraction Seismic Investigation at the NID South Yuba Canal – Segment 15 Project Site, Nevada County, California.
GGSI Project No. 2021-17.01
GHD Project No. 11211964, Phase 20

Dear Mr. Quintrall:

At your request and authorization, Gasch Geophysical Services, Inc. (GGSI) has completed a refraction seismic investigation at the Nevada Irrigation District's (NID) South Yuba Canal – Segment 15 Project Site in Nevada County, California (Figure 1).

Purpose

The purpose of this investigation was to determine the depth to higher velocity material and also define characteristics of the sub-surface materials at the South Yuba Canal – Segment 15 Site.

The refraction seismic (RS) method was used to evaluate the rock velocities on site, as seismic primary-wave travel times are used to quantify the rock velocities, and as a result, can determine the general competency in areas of various rock types. Higher seismic p-wave velocities (measured in feet per second, ft/s) indicate material of higher density, thus quantifying the competency or strength of the soil or rock medium beneath the RS Lines.

Method, Instrumentation and Software

The RS method measures the velocity at which a seismic wave propagates through a soil or rock medium. In this case, the primary (p-wave/compressional wave) seismic wave was measured. Higher seismic p-wave velocities (measured in feet per second, ft/s) indicate material of higher density, thus quantifying the competency, or strength, of the soil or rock medium.

GGSI's seismic data acquisition system was a Seistronix EX-6 Explorer, which is a distributed, 24-bit digital instrument with data output to electronic media for subsequent processing. Geophones were single, 10-Hz, digital grade units manufactured by OYO Geospace Corporation. Spread cables were manufactured by Pro-Seismic Services. The energy source for this project was a twelve pound sledge hammer with a hardwire connection for system triggering. All data were processed in house on our data reduction and plotting workstation.

Our refraction seismic data reduction and processing software is Rayfract® version 3.36. This refraction seismic processing software utilizes Wavepath Eikonal Traveltime (WET) tomography which models multiple signal propagation paths contributing to one first break (the Fresnel volume approach), while conventional ray tracing tomography is limited to the modeling of just one ray path per first break. The WET inversion method is founded upon a back-projection formula for inverting velocities from travel times computed by a finite-difference solution to the Eikonal equation (Qin, et al. 1992). An Eikonal solver is used for traveltime field computation which models diffraction in addition to refraction and transmission of acoustic waves. As a result, the velocity anomaly imaging capability is enhanced with the WET tomographic inversion method compared to conventional ray tomography. This software is developed by Intelligent Resources, Inc. of Vancouver, British Colombia, Canada.

A color-coded seismic velocity cross-section of the subsurface has been generated for each RS line, where cool colors (blues) indicate lower seismic velocities and warm colors (reds, purple) indicate higher velocities. Color scaling of these seismic velocity sections is based on the range of seismic velocity values calculated. Velocity scaling has been normalized on all RS velocity sections.

Data Acquisition Parameters

A total of 4 RS lines were acquired during this investigation. RS Line locations were suggested by GHD personnel and slightly adjusted in the field to allow for safe and efficient data acquisition. RS Lines 1 and 2 were acquired with 15 active geophone stations spaced at 10-foot intervals and energy source points located between every other geophone station, and off the end of the lines. Line 3 was acquired with 12 active geophone stations at 10-foot intervals with energy source points located between every other geophone station, as well as off the ends of the line. RS Line 4 utilized 24 active geophone stations spaced at 10-foot interval with energy source points located between every other geophone station, as well as off the ends of the line. A total of 700 lineal feet of data were collected for this investigation. Collection of the field data were carried out on May 4th, 2021. The field crew consisted of Professional Geophysicist Kent Gasch with additional field support from GHD and NID personnel. The location of the RS lines are presented on Figure 2.

Seismic Velocities

Generally, seismic p-wave velocities less than 3,000 ft/s indicate native soil, fill material, or highly weathered/decomposed/fractured rock, while velocities in excess of 10,000 ft/s indicate fresh (essentially non-weathered) rock. Seismic velocities between these two values typically indicate rock with varying degrees of weathering and/or fracturing. Consolidation and cementation, fracture spacing, and fracture density also affect the measured seismic velocities. Moderate velocities may indicate compacted soil, moderately weathered rock, or loosely consolidated sediment such as gravel, sand, and silt. Saturated sediment below the water table characteristically displays seismic velocities near or slightly above 5,000 ft/s.

Extremes in seismic velocities may range from below 1,000 ft/s to over 20,000 ft/s. Very low seismic velocities usually indicate highly weathered or poorly compacted material, either natural or man-made. Extremely high velocities are rare in the near-surface, and only possible in certain types of rock. Rock velocities are dependent on the physical condition of the rock masses evaluated; as a result, seismic p-wave velocities are related to both rock hardness and fracture density, as well as sediment consolidation, saturation, and cementation.

Findings

The results of this refraction seismic investigation are summarized by Figures 3 through 6. These seismic velocity sections, which were created through the inversion process, have very low error and provide a high degree of lateral definition of the seismic velocity horizons found beneath each line. The seismic velocity sections have been scaled from 1,500 ft/s to 16,000 ft/s for the velocity window. Spatial axes have been scaled to 20 feet per inch in both the horizontal and vertical.

<u>RS Line 1 (Figure 3)</u>

RS Line 1 is oriented northeast to southwest and is located approximately parallel to the existing canal on the southeast side of the canal. This Line crosses RS Line 3 near distance station 25 feet (see Figure 2). Measured seismic velocities at this location grade at a moderate rate from low velocities (1,500 ft/s) at the surface to moderate velocities (~4,000 ft/s) at depths of approximately 7 to 22 feet below ground surface (bgs). This low to moderate velocity horizon is closest to the ground surface on the northeast end of the line and dips toward the southwest. Velocities at or above the depth of the 4,000 ft/s horizon suggest native soils, fill, and/or highly weathered/fractured rock. Below the 4,000 ft/s horizon, measured seismic velocities continue to increase suggesting moderately weathered/fractured rock transitioning to more competent material near the 5,000 ft/s and continues to the maximum depth of exploration beneath this line.

<u>RS Line 2 (Figure 4)</u>

RS Line 2 is also oriented approximately southwest to northeast and is located approximately parallel to the northwest side of the existing canal. This line ties to RS Line 3 near distance station 130 feet (see Figure 2). Measured seismic velocities at this location grade at a moderate rate from low velocities (1,500 ft/s) at the surface to moderate velocities (~4,000 ft/s) at depths ranging from 26 to 33 feet bgs and generally parallels the ground surface. This low to moderate velocity horizon shows a slightly undulating nature, but flattens with depth and increase in velocity. Velocities below the ~4,000 ft/s horizon velocities increase at a slightly faster rate showing high velocity levels at the maximum depth of exploration beneath this line. Velocities above the depth of the 4,000 ft/s horizon suggest native soils, fill, and/or highly weathered/fractured rock. At velocities greater than the 4,000 ft/s horizon, measured seismic velocities suggest moderately weathered/fractured rock transitioning to slightly weathered to fresh, essentially unweathered rock at depths exceeding approximately 35 to 40 feet bgs.

<u>RS Line 3 (Figure 5)</u>

RS Line 3 is located between RS Lines 1 and 2 and crosses beneath the existing canal. This line is oriented approximately east to west and ties with Line 1 near distance station 2 feet and Line 2 near distance station 120 feet (see Figure 2). Measured seismic velocities at this location grade at a moderately fast rate from moderately-low velocities (2,000 ft/s) at portions of the ground surface to moderate velocities (~4,000 ft/s) at depths ranging from 10 feet bgs on the east end to over 30 feet on the west end of the line and shows a substantial dip from the east to the west. Velocities above the depth of the 4,000 ft/s horizon suggest native soils, fill, and/or highly weathered/fractured rock. At or greater than the 4,000 ft/s horizon, measured seismic velocities suggest moderately weathered/fractured rock transitioning to slightly weathered to fresh, essentially unweathered rock at depths exceeding approximately 25 to 30 feet bgs.

<u>RS Line 4 (Figure 6)</u>

RS Line 4 was located on the southeast side of the site access road and is oriented approximately northeast to southwest (see Figure 2). Measured seismic velocities at this location grade at a moderate rate from low velocities (1,500 ft/s) at the surface to moderate velocities (~4,000 ft/s) at depths of approximately 13 to 22 feet below ground surface (bgs) and generally follow surface topography. Velocities above the depth of the 4,000 ft/s horizon suggest native soils, fill, and/or highly weathered/fractured rock. Below the 4,000 ft/s horizon, measured seismic velocities continue to increase suggesting moderately weathered/fractured rock transitioning to more competent material near the 5,000 ft/s and continues to the maximum depth of exploration beneath this line.

Summary

This refraction seismic investigation was designed to provide a good sampling of the subsurface conditions at the South Yuba Canal – Segment 15. This investigation revealed a moderate to high degree of variation in the calculated seismic velocities of the subsurface materials, with the highest seismic velocity of greater than 14,000 ft/s measured at the maximum depth of exploration on RS Lines 2 and 3. Low velocity material was encountered in the near surface on all four lines, which suggests highly weathered/fractured rock and soil or fill, such as silts, sands, and gravels. The moderate velocity range of 3,000 ft/s to approximately 4,000 ft/s, suggests compacted soil/fill, moderately weathered/fractured rock, or moderately consolidated sediment. All four RS Lines show this low to moderate velocity section of material from surface to varying depths and higher velocity material at the maximum depth of exploration. The higher velocity horizons (4,000 ft/s and greater) suggests rock of moderate weathering and/or fractures which continues to transition to slightly weathered and/or less fractured rock at depth.

The observed geology at the site consists of surface alluvium and landslide debris above a mudflow breccia and weathered slates or shales, which are assumed to be the more competent material. The RS Line velocities, mainly on Lines 1 and 3, depict a lower velocity horizon, consistent with landslide material, dipping toward the southwest. Below this lower velocity horizon, velocities grade more rapidly and suggest competent material near the 5,000 ft/s horizon and continues to increase with depth.

Warranty and Limitations

Gasch Geophysical Services, Inc. has performed these services in a manner which is consistent with standards of the profession. Site conditions can cause some variations of the calculated seismic velocities. Refraction seismic velocities assume that velocities increase with depth; therefore, a lower seismic velocity layer beneath a higher seismic velocity layer will not be resolved. No guarantee, with respect to the results and performance of services or products delivered for this project, is implied or expressed by Gasch Geophysical Services, Inc.

We trust that this is the information you require; however, should you have comments or questions, please contact our Rancho Cordova office at your convenience. Thank you for this opportunity to again be of service.

Sincerely,

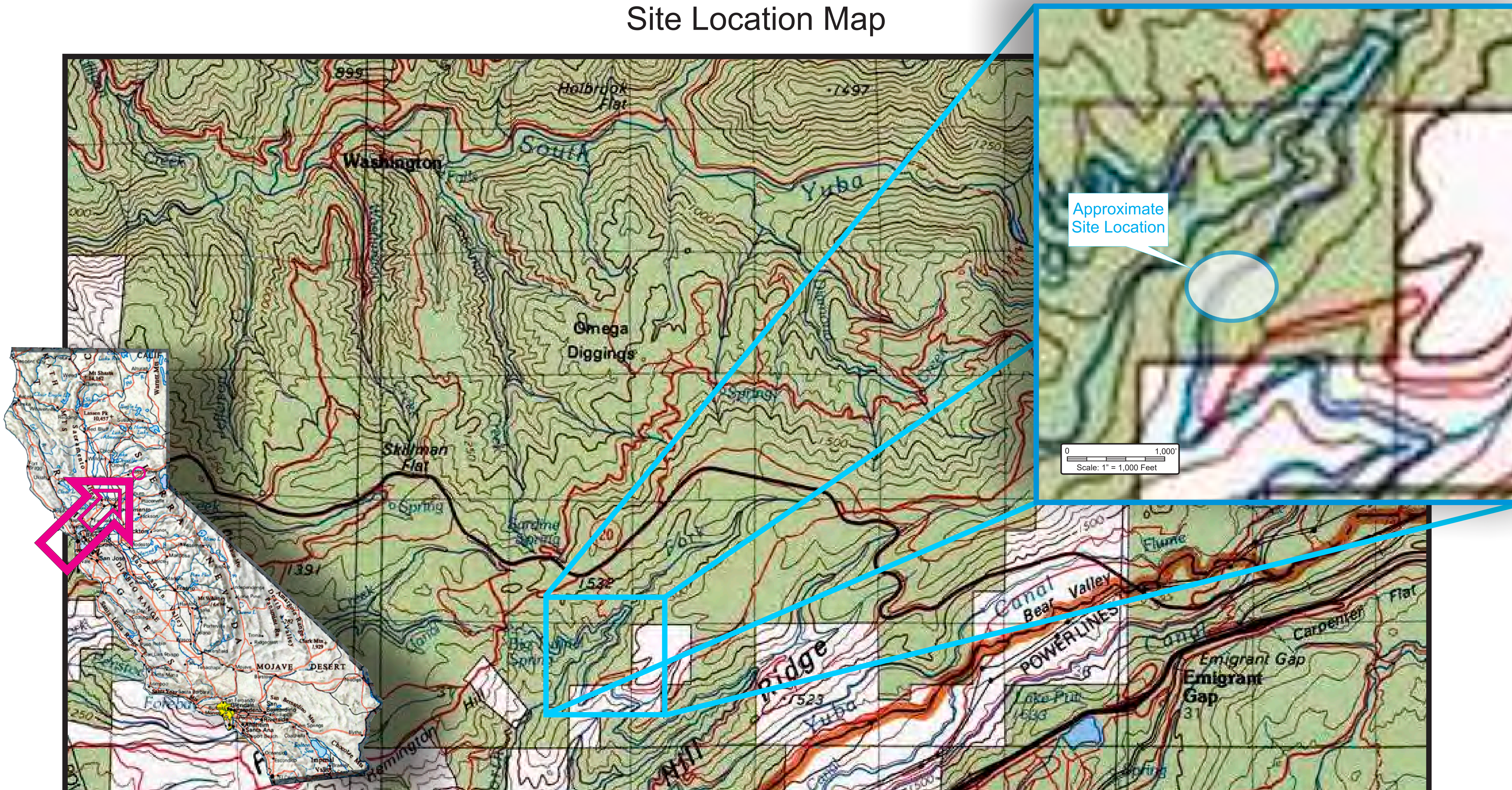
GASCH GEOPHYSICAL SERVICES, INC.

Professional Geophysicist
Kent L. Gasch
No. 1061
State of California

Expires 12/31/2021

Kent L. Gasch
Professional Geophysicist #1061

Site Location Map



Base Maps Courtesy of: USGS

0 0.5 1 1.5 2 miles
0 1 2 3 kilometers

North

Figure 1

G²S Consultants in Geophysics for the Engineering, Groundwater, Oil & Gas and Blasting Industries
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www.geogasch.com

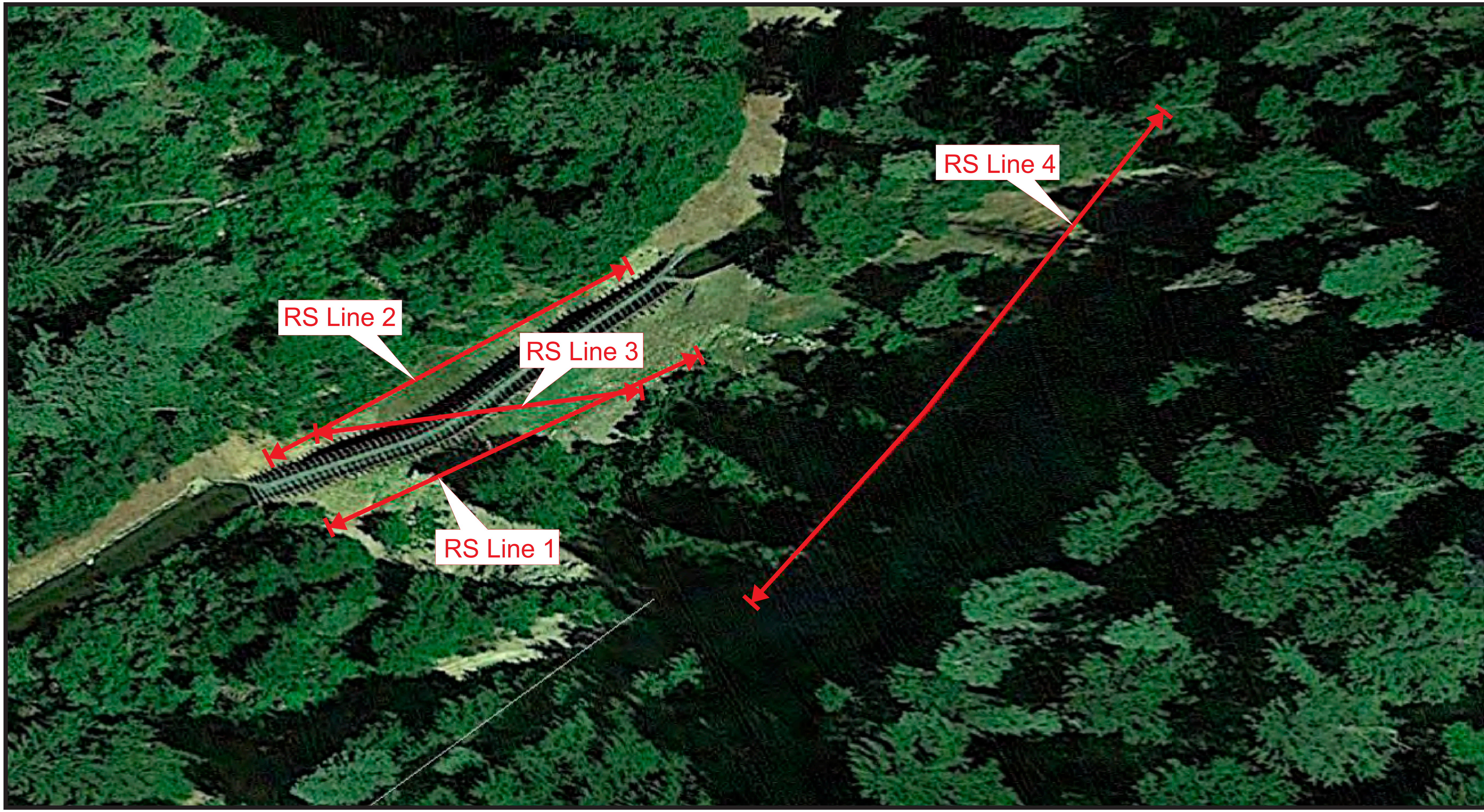
3174 Luyung Drive, Building #2
Rancho Cordova, California 95742 U.S.A.
(916) 635-8906 • FAX (916) 635-8907

Refraction Seismic Investigation:
NID South Yuba Canal - Segment 15

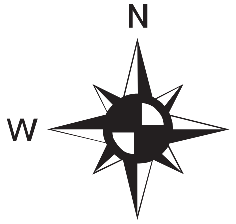
***Prepared for:* GHD, Inc.**

Project Number: 2021-17.01 ***Date:*** May, 2021

RS Line Location Map



Base Map Courtesy of Google Earth Pro, dated 6/26/2018



0' 40' 80'
Scale: 1 inch = 40 feet

Figure 2

Consultants in Geophysics for the Engineering, Groundwater, Oil & Gas and Blasting Industries

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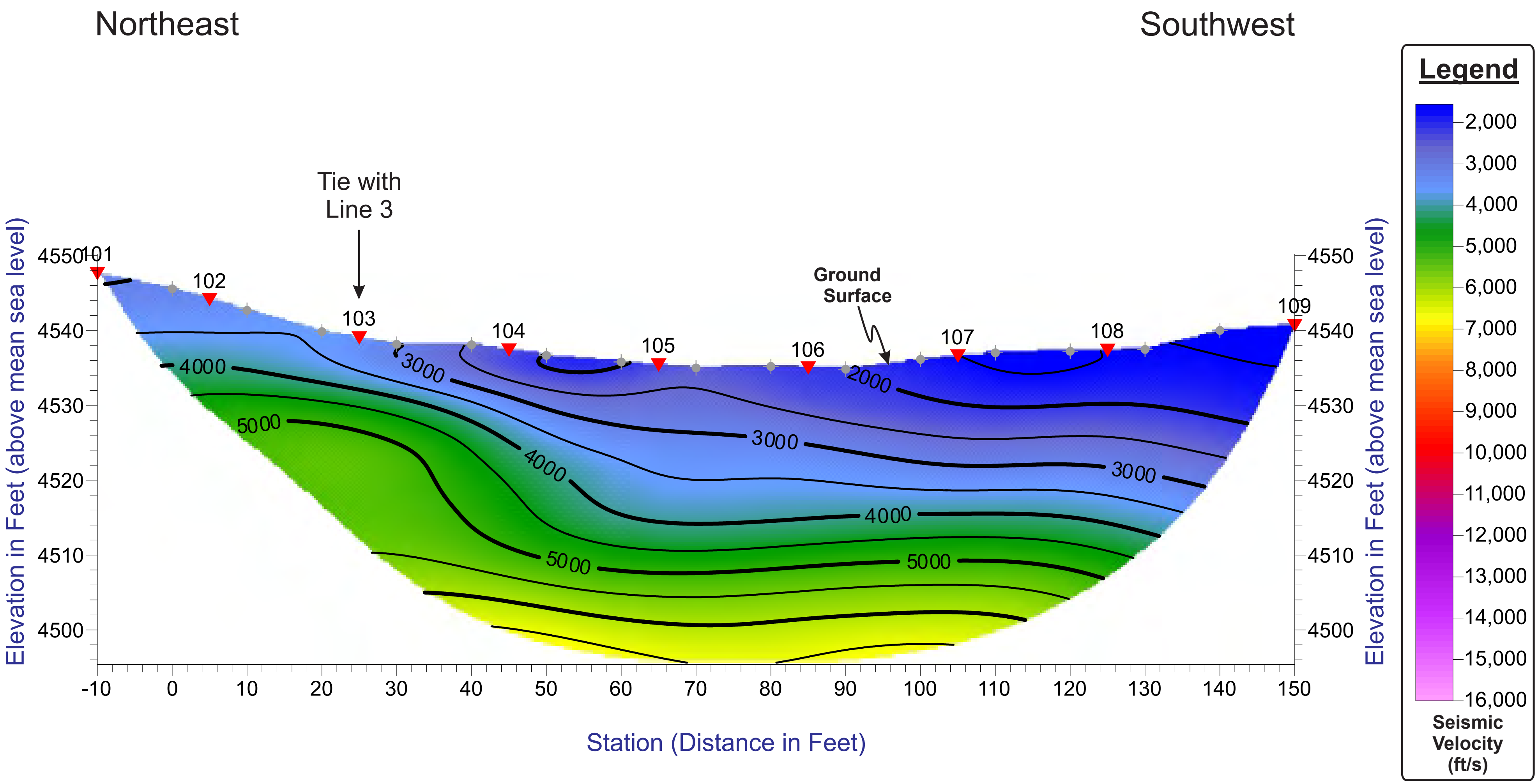
Seismic Velocity Section • RS Line 1



Scale:
Horizontal: 1” = 20’
Vertical: 1” = 20’

Legend

Geophone Station

101 Energy Source Locations

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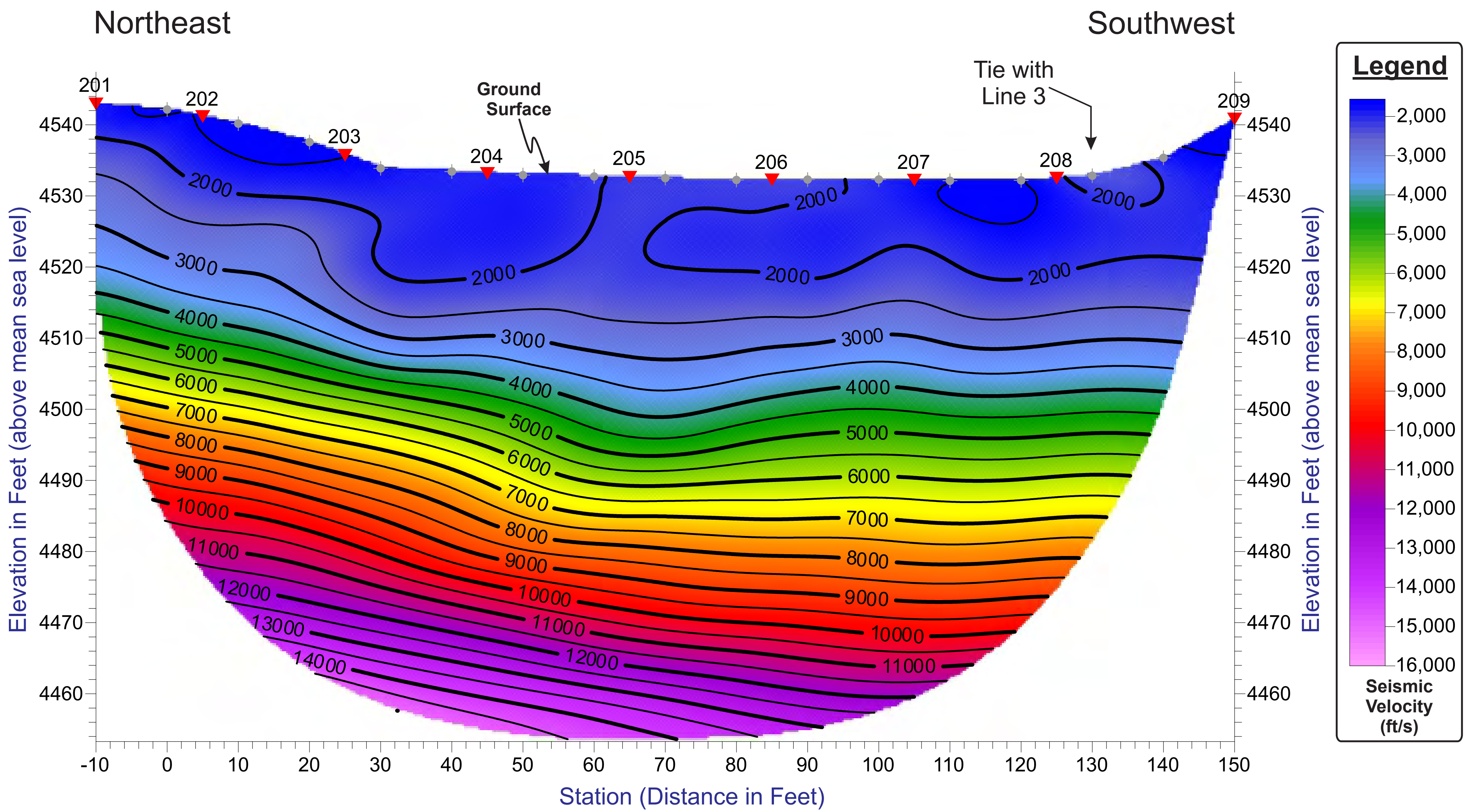
Figure 3

Refraction Seismic Investigation:
NID South Yuba Canal - Segment 15

Prepared for: GHD, Inc.

Project Number: 2021-17.01 ***Date:*** May, 2021

Seismic Velocity Section • RS Line 2



Scale:
Horizontal: 1” = 20’
Vertical: 1” = 20’

Legend
Geophone Station
201 Energy Source Locations

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Figure 4

Refraction Seismic Investigation:
NID South Yuba Canal - Segment 15

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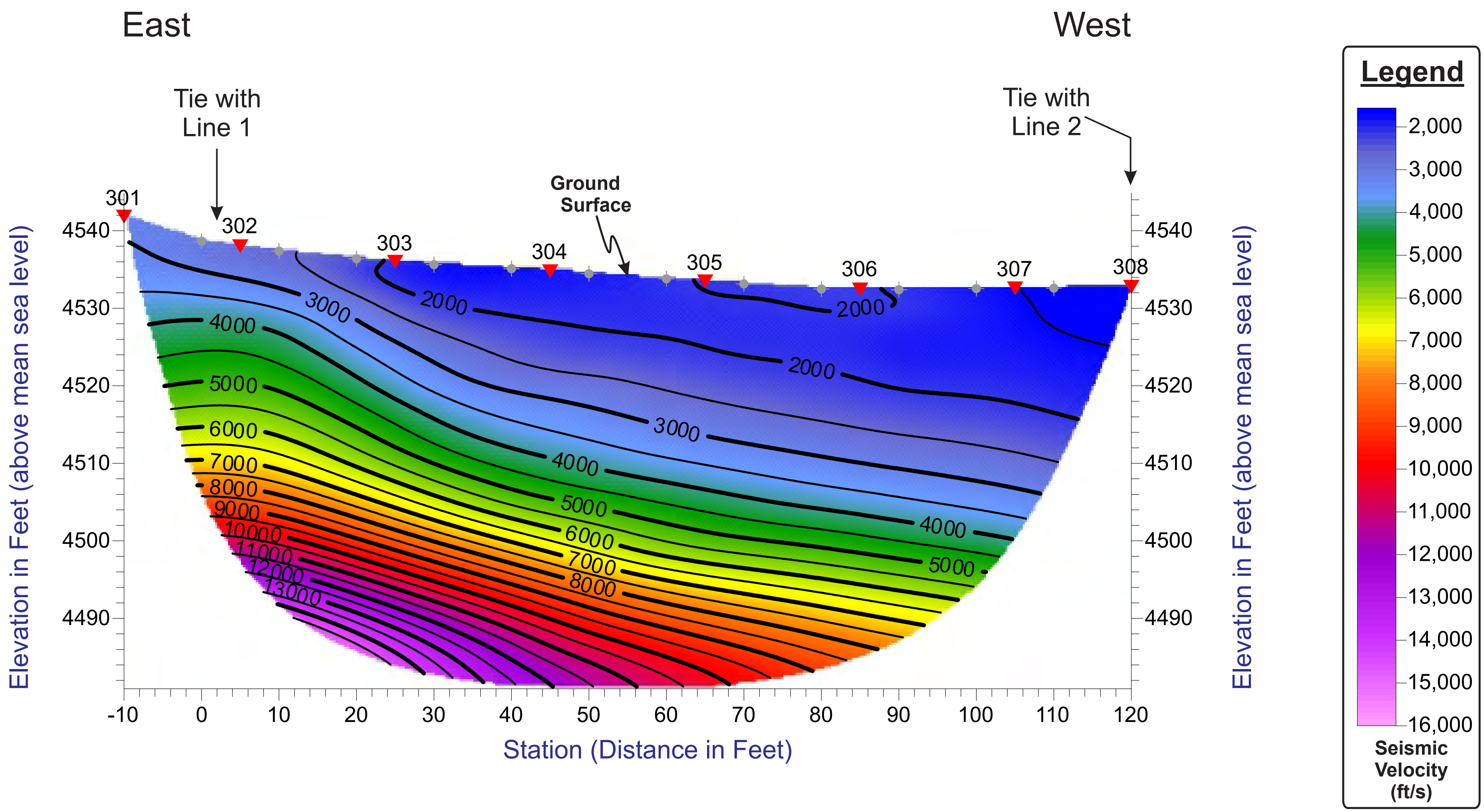
Seismic Velocity Section • RS Line 3



Scale:
Horizontal: 1" = 20'
Vertical: 1" = 20'

Legend
Geophone Station
301 Energy Source Locations

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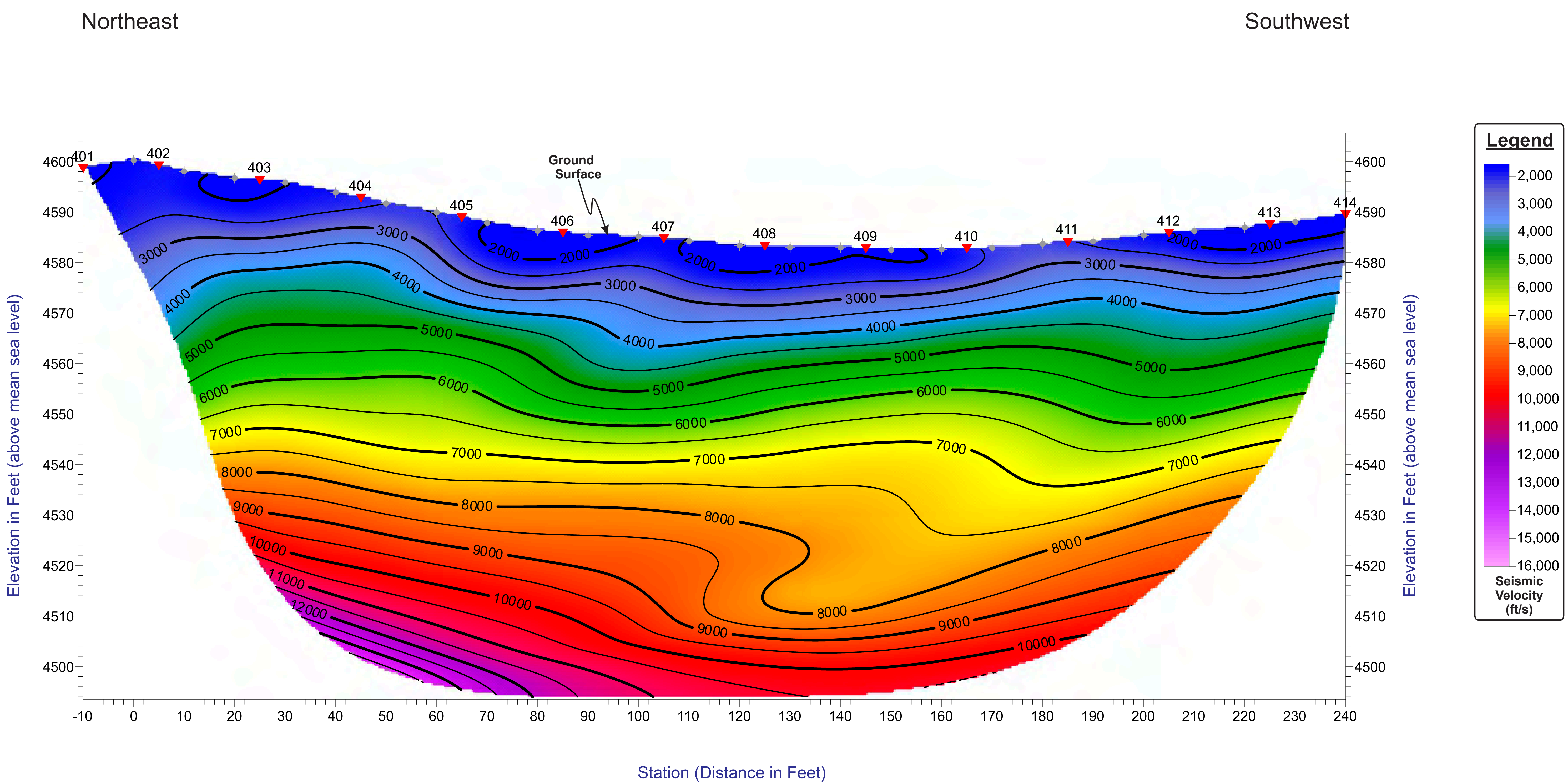
Figure 5

Refraction Seismic Investigation:
NID South Yuba Canal - Segment 15

Prepared for: GHD, Inc.

Project Number: 2021-17.01 ***Date:*** May, 2021

Seismic Velocity Section • RS Line 4



Scale:
Horizontal: 1” = 20’
Vertical: 1” = 20’

Legend
Geophone Station
401 Energy Source Locations

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Figure 6

Refraction Seismic Investigation:
NID South Yuba Canal - Segment 15

Prepared for: GHD, Inc.

Project Number: 2021-17.01 ***Date:*** May, 2021

Appendix F
Risk Matrix

	Appx PG&E Sta		Current Sta				General			Structural				Geotechnical						
Segment	Beg Sta	End Sta	Beg Sta	End Sta	Length	Structure Type	Access	Freeboard	Vegetation	Superstructure	Substructure	Foundation	Liner	Foundation Stability	Erosion	Slope Stability	Rock Fall	Weighted Risk Rating	Access Notes	Condition Rating Notes
1	87+23	155+86	0+00	70+80	7,080	Lennon Flume	5	2	4	2	2	4	3	3	2	5	3	6.5	Bowman Lake Road, access through Bear Valley Yard. Access downstream through Burnt Point Road and its spurs, largely pedestrian Access along flume on metal grates	Separation of liner from timber beams Substructure shows signs of distress, split braces, dry rot. Hazard trees within segment Minor erosion at foundation near seasonal draw Freeboard ranges from 10" just upstream of Hwy 20, to 18" at the greatest. Freeboard of 11"-12" at YB139 and 1 other point along segment. Culvert under Hwy 20 inlet controlled. Drainage culvert at Hwy 20 erosion. Headwall cracked at 156+10 & 158.97. Rocks and debris at supports.
2	155+86	203+57	70+80	119+40	4,860	Lennon Flume	5	3	5	2	2	4	3	5	3	5	5	7.8	Zeibright Road to Dairy Road and Bear Valley Spillway Road	Sagging in top of flume, timber post repairs. Minor erosion at pier foundation in several locations. Freeboard measurements range from 15"-20".
3	203+57	214+05	119+40	129+90	1,050	Concrete Box	4	4	5	NA	NA	NA	5	5	5	5	5	9.5	Zeibright Road to Bear Valley Spillway Road	Foot access throughout along walking planks Freeboard appears to be 18"-24". 24" measured near transition to wood box flume.
4	214+05	274+38	129+90	191+95	6,205	Wood box flume	3	3	5	2	2	4	3	3	5	5	5	7.5	Limited to foot access upstream, from Telephone House Road downstream	Freeboard measurements ranged from 15"-18" along segment. 24"+ at transition to wood box flume. Portion of flume on mudsill, leaning and out of plumb.
5	274+38	289+10	191+95	206+80	1,485	Lennon Flume	5	3	5	2	2	4	3	5	5	5	5	8.2	Telephone House Road from Lowell Hill Road	Freeboard measurements range from 16"-23"
6	289+10	403+05	206+80	319+60	11,280	Lined Canal Flume 7/1	5	4	5	4	4	3	4	3	4	3	4	8.2	Lowell Hill Road to spur roads	Minor erosion on bench. Minor cracking in liner. Potential loss of support at Flume 7/1 Foundation. PG&E identified slope stability and rockfall potential. Slump in bench near Little Tunnel inlet. Freeboard measurement ~20", much of canal appears to be 24"+
7	403+05	406+67	319+60	323+70	410	Tunnel	See Tunnel Condition Assessment												Little Tunnel Road	See tunnel inspection report
8	406+67	453+26	323+70	370+00	4,630	Lined Canal Flumes 8/2 and 8/4	4	4	4	2	2	4	5	5	5	3	5	7.9	Lowell Hill Road to spur roads	Slumps in bench, PG&E identified landslide risks. Two documented landslide repairs with flumes. 20" measured along short flume section lined canal segments looked to be 24"+
9	453+26	455+33	370+00	372+40	240	Wood Box Flume	4	3	5	2	2	3	4	3	2	3	5	7.0	Lowell Hill Road, limited to pedestrian access	Replaced in 1992 and repaired in 2017. Erosion in bank undercutting and de-stabilizing bench. Freeboard measured approximately 17"
10	455+33	508+40	372+40	425+10	5,270	Lined Canal	4	3	3	NA	NA	NA	5	5	4	4	5	8.3	Downstream Steep Hollow #1 Access Road	Freeboard measurement of 16", much of the canal looks to have more. Minor erosion on bench. Hazard trees observed at 9 Mile Spill.
11	508+40	510+54	425+10	427+40	230	Lennon Flume	5	4	5	2	2	4	4	5	5	5	5	8.5	Downstream Steep Hollow #1 Access Road	No direct freeboard measurement but sufficient freeboard based on photo review.
12	510+54	564+69	427+40	481+80	5,440	Lined Canal	5	3	5	NA	NA	NA	5	2	1	2	5	8.0	Excelsior Point Road	16" minimum freeboard occurs at short flume section. Severe erosion de-stabilizing bench near Hickman Spill. PG&E identified landslide risks at one location within segment.
13	564+69	636+79	481+80	554+35	7,255	Lined Canal Flumes 11/1, 11/1A and 11/2	4	3	5	2	2	4	3	5	5	3	5	7.7	Excelsior Point Road	16" minimum freeboard occurs at short flume section. PG&E identified slope stability issue risks at three locations within segment.
14	636+79	687+62	554+35	605+00	5,065	Lined Canal	4	5	5	NA	NA	NA	4	5	5	3	5	9.1	Excelsior Point Road	Lined canal appears to also have 24" freeboard from photos. Potential landslide area. PG&E identified moderate landslide risk.
15	687+62	689+50	605+00	606+90	190	Wood Box Flume	4	5	5	2	2	3	3	4	3	2	5	7.2	13 Mile Spill Road	Active landslide Aging timber structure 24.5" freeboard measured at box flume section
16	689+50	709+38	606+90	625+60	1,870	Lined Canal	4	4	5	2	2	4	5	5	5	3	5	8.2	13 Mile Spill Road	Freeboard measured at 22" at end of flume. PG&E identified moderate to high landslide risk.
17	709+38	722+24	625+60	637+75	1,215	Lennon Flume	4	3	5	2	2	4	3	5	5	4	5	7.8	13 Mile Spill Road	One measurement of 16", much of canal appeared to have greater freeboard. PG&E identified moderate landslide risk.
18	722+24	797+17	637+75	712+90	7,515	Lined Canal 14 Mile Flume, Cement House Flume, Flumes 15/1, 15/2, 15/3 and 15/4	4	3	5	2	2	4	3	5	5	3	5	7.7	Big Tunnel Road	Slump in canal bench Leakage in liner Freeboard measurements ranged from 14"-16" along flume. PG&E identified moderate to high landslide risk throughout segment.
19	797+17	3+32	712+90	748+30	3,540	Tunnel and Pipe	See Tunnel Condition Assessment												Big Tunnel Road	See tunnel inspection report
20	3+32	12+14	748+30	755+60	730	Concrete Bench	3	3	5	NA	NA	NA	4	5	5	5	5	8.8	Deer Creek Forebay Road	~16" Freeboard measurement.
21	12+14	112+13	755+60	857+10	10,150	Lined Canal Flume 0/3, Sand Bunker Flume, Chalk Bluff Flume 1/1, Sandsettler Flume, Lennon Flume	3	3	5	2	2	4	3	5	4	3	5	7.3	Deer Creek Forebay Road	13" Freeboard measurement at Lennon flume Voids behind liner. Leakage from liner. PG&E identified high landslide risk in several locations.
22	112+13	117+59	857+10	863+50	640	Lined Canal	3	4	5	NA	NA	NA	5	5	5	4	5	9.0	Deer Creek Forebay Road	Jan 1993 Slide Repair Freeboard not measured, sufficient based on photos
23	117+59	168+79	863+50	914+70	5,120	Lined Canal	5	4	5	NA	NA	NA	4	5	4	5	5	9.4	Yunk Spill Channel Road at DS end Slide Road at US End	Minor erosion or settlement at standpipe Freeboard not measured, sufficient based on photos
Importance Factor (1 to 3)							3	1	3	2	2	2	2	1	2	1	3			

Notes
1. Rating 1 = Immediate Attention Required, Rating 5 = Repaired or replaced as needed by annual maintence crews.
2. Importance Factor 1 = More Important, 3 = Less Importan
3. Freeboard Rating uses Following System:

1	<6"
2	6"-12"
3	12"-18"
4	18"-24"
5	>24"

4. NA = Not Applicable to this Segment

Spillway	Current Sta	Structure Type	Structural	Handrails	Retaining Walls	Geotechnical	Hydraulic	Mechanical	Maintenance Access	Weighted Risk Rating	Access	Notes
YB-139	0+00	Automated spill with Cross Gate and Spillgate to control release	3	5	NA	5	5	5	5	9.8	Good access platforms and guardrail arrangement. Footboard across chute potential fall hazard. Equipment accessible safely, and stair to discharge channel. Electrical equipment appears well contained with grounding and clearances for maintenance access, but electrical safety not evaluated	Receiving channel is rip-rap lined with minor drop from end of concrete discharge chute. Currently stable, but evident that rock lining has required some maintenance and should be monitored. Cast-in-place concrete junction structure in Lennon Flume showing some aging with minor surface erosion, but currently sound. Replacement or rehab of concrete for critical facility in the long term. Overall excellent condition of metalwork, gates and actuators. Aluminum gates, electrically actuated. No electrical condition assessment but work appears new.
Bear Valley Spill	119+50	Cross Gate with Gated Side Spill within Concrete Lined Ditch in transition to Lennon flume Gaging point with telemetry. Canal access point.	3	4	NA	4	5	4	4	8.5	Good access platforms and guardrail arrangement. Equipment accessible safely with gate actuators at proper height; however handwheel narrows walk space. Electrical panel working clearance provided.	Receiving channel is stone and rubble lined for energy dissipation with minor drop from end of concrete discharge chute. Currently stable within visible downstream reach. Shotcrete in immediate vicinity of discharge chute cracking (deteriorating). Cast-in-place concrete junction structure is aged but no visible deterioration. Ditch transition to concrete is good. Overall excellent condition of metalwork Gates are aging but serviceable, will require near term replacement of wood slides.
Cape Horn Spill	184+50	Cross Gate with Gated Side Spill from Box Flume All wood.	3	4	NA	4	5	3	4	8.2	Good access platforms and guardrail arrangement. Equipment accessible safely with gate actuators at proper height; however handwheel narrows walk space.	Large drop to rock receiving channel at spill outlet. Appears sound within visible limits. Wood platforms and guardrails, as well as flume serviceable with regular maintenance. Sheet lining is well maintained with recent seals. Gates are aging but serviceable, will require near term replacement of wood slides. Spill gate actuator support beam requires replacement with visible deterioration that could compromise strength. Similar with cross gate, except wood beams are sound but aging.
Little Tunnel Spill	271+00	Cross Gate with Gated Side Spill from concrete lined ditch. Side spill with undershot radial gate and chain hoist, with flash boarded trash chute. Wood slide cross gate.	4	5	NA	3	4	3	4	8.2	Walkway across channel and spill chute. Wood railing and Equipment safely accessible with gate actuators at proper height.	Receiving channel appears erodible, but spill is low energy with slight drop off from chute. Channel is gradually back cutting under concrete chute and requires stabilization.. Cast-in-place concrete junction structure and spillway chutes are aged but no significant deterioration. Chute walls are thin with minimal strength capacity, but only minor cracking visible. Ditch transition to concrete is good. Wood walkways and steel guardrails are in good condition. Cross gate is aging but serviceable, wood slides. Trash chute wood flashboards aging. Radial gate is metal with new sheeting, rusting arms. Anchorage is questionable at attachment to thin section. Radial gate chain hoist is aged but serviceable. Chains are in good condition.
9 1/2 Mile Spill	422+50	Cross Gate with Gated Side Spill within Concrete Lined Ditch. Siphon pipe immediately upstream.	4	5	NA	3	4	5	5	9.0	Good access platforms and guardrail arrangement. Equipment accessible safely with gate actuators at proper height	Ditch lining interface in good condition. Significant drop with large glory hole at outlet to downstream spill channel. Appears to drop into rock channel, but channel should be reviewed and monitored for back cutting, particularly after releases. Minor undermining of concrete lining top edge at spill chute. Aged concrete, but well maintained. Overall good condition of metalwork, gates and actuators. Wooden gate slides are new. Tool box on site appears to be for removable gate handwheels.
Hickman Spill	482+00	Passive side spill with flashboards from concrete lined ditch. Canal access point	3	4	NA	2	4	3	5	7.0	Wooden walkway and railing across spill chute. Metal canal bridge and guardrail.	Passive spill only. Significant drop into glory hole at terminus of spill chute. Significant back cutting with concrete lining beginning to undermine. Requires more geotechnical review to evaluate stabilization. Overall minor capacity spill. Transition to concrete lined ditch in good condition, spill chute gunite is undermining and cracking. Spill flashboards channels are embedded in thin concrete.
Excelsior Point Spill (Spill to CMP)	555+00	Side Spill with Long Flashboard Weir transition to CMP pipe. Siphon pipe upstream of this site.	4	4	NA	4	4	3	4	8.3	Walkway over outlet weir. Stoplogs readily accessible from walkway.	Passive weir multiple stoplog bays with Steel I-Beam stoplog supports. Thin wall concrete transition to CMP inlet. Low energy drop into stable vegetated channel. Cast-in-place concrete junction structure is aged, thin walled, but sound condition Wooden plank walkway and wood guardrail aging but robust. Wood cover over CMP inlet box covered with debris, requires inspection. CMP appears from exterior view to have remaining useful life, but interior inspection and inspection of joint at concrete inlet recommended.. Support at end of pipe to be verified..
Excelsior Spillway (Gated Spill)	555+00	Cross Gate with Gated Side Spill, Concrete-Lined Ditch. Wood flume drainage overcrossing just upstream.	4	3	NA	4	4	4	4	8.3	Metal plank walkway over spillway chute and flume with wood railing, Separate metal plank platform with wire rope railing for Spillgate access. Steel walkway over canal for cross gate access. Equipment accessible safely with gate actuators at proper height.	Low energy drop into rocky, heavily vegetated, receiving channel. Currently stable within visible downstream reach. Minor backcutting under concrete outlet chute to be monitored.. Cast-in-place concrete junction structure and concrete gate support piers are aged good condition. Platform and railing metal work in good condition with moderate rusting. Wood railing for walkway over wood flume crossing and spill channel is aging and will require regular inspection due to safety risk. Cross gates are well maintained, wood slide in good condition. Radial Spillgate with chain hoist aging but serviceable, moderate to heavy rusting, anchor points to thin-walled concrete questionable.

Spillway	Current Sta	Structure Type	Structural	Handrails	Retaining Walls	Geotechnical	Hydraulic	Mechanical	Maintenance Access	Weighted Risk Rating	Access	Notes
13 Mile Spill	611+00	Cross Gate with Gated Side Spill, Concrete-Lined Ditch Transitions to Lennon Flume	4	3	NA	4	4	3	4	8.0	Good access platforms and guardrail arrangement, transitions to flume walkway is narrow. Equipment accessible safely with gate actuators at proper height.	Ditch lining interface in good condition. Minor drop at outlet flume end to downstream spill channel, with left side wing walls. Receiving channel appears stable downstream of outlet, outlet flume support foundation appears stable. Monitored for back cutting, particularly after releases. Aged concrete but well maintained. Overall good condition of metalwork, gates and actuators. Wooden gate slides are in relatively good condition (some minor corrosion and wood aging). Removable gate handwheels did not appear to be onsite.
14 Mile Spill	662+50	Passive side spill with flashboards from concrete lined ditch.	3	2	NA	4	4	3	4	7.2	Walkway across channel and spill chute. Wood railing and frame for guardrail for canal bridge. Wire rope railing on downhill side for chute crossing.	Passive spill only. Cross gate removed, spill gate inactive. Boards set to passively over top to spill channel. Minor drop to stone lined outlet with sharp drop off down step bank. Downstream channel condition visible to toe of embankment and in serviceable condition. Concrete and transition to concrete lined ditch in good condition. Wire rope railing on downhill side for chute crossing warrants some minor maintenance (loose posts and wire).
Big Tunnel Upstream Spill	708+50	Cross Gate with radial gate side spill, Concrete-lined ditch	3	5	NA	3	4	3	3	7.5	Metal walkway and railings across spill chute. No equipment access or cross canal access.	The cast-in-place concrete headwalls, gate supports, and ditch transition structures are aging but in serviceable condition The concrete spill chute is old, thin walled, with some minor cracking The canal walkway/spill chute crossing metal planking and handrails are new, and the walkway is well supported The handwheel actuated timber slide gates are in good condition, but no longer in use The radial spill gate is original equipment and deteriorating
Big Tunnel Outlet Spill	711+00	Cross Gate with Massive Gated/Passive Side Spill. Gaging point with telemetry. Canal access point	3	4	4	2	3	3	4	6.1	Walkway across channel and spill chute. Equipment accessible safely with gate actuators at proper height. Wide trashrack decking. Electrical equipment in building not accessed for clearances.	Significant drop with large glory hole at outlet to downstream spill channel. Concrete in spill chute significantly undermined and rock slope protection failed. New concrete work in channel transition and spill weir in good condition. Overall good condition of metalwork, gates and actuators, although new handrail is already rusting and metal coatings (e.g. gate frames) are not very robust. Wood slide cross gate recently rehabbed. Trashrack grizzly in good condition, with canal escape stairs however may be difficult to clean at flat angle. Trash chute adjacent to rack. Spillway radial gate with chain hoist salvaged during rebuild. Unclear if bearings replaced, but metal recoated and seals replaced with minimal leakage.
Sand Bunker Spill	795+50	Cross Radial Gate with Flashboard and Gated Side Spill upstream of Concrete Flume Canal	3	5	NA	4	3	3	2	7.5	Walkway across canal steel platforms with guardrails. No walkway over stoplog slots not safely accessible, ropes tied to stoplogs with each end only accessible from 2 different platforms. Manual gate actuators safely accessible at proper height.	Low energy drop into heavily vegetated, stable receiving channel. Currently stable within visible downstream reach. . Cast-in-place concrete junction structure is aged and thin walled. Minor damage stoplog slots, but still serviceable. Transition of concrete structure to downstream ditch concrete is deteriorating, with some seepage and cracking, minor undermining, but serviceable. Platform and stair metal work in good condition with moderate rusting, but walkway support for crossgate platform is anchored to thin concrete of questionable quality. Cross gates are aging but serviceable, with good operator access. Spillgate appears inoperable with primary spill through stoplog bay and is aged and leaking. Stoplogs have no direct access. Operation appears to be with pull ropes and each end of stop logs is pulled from two different platforms.
Sand Settler Spill	831+50	Cross Gate with Flashboard Side Spill within Concrete Flume Canal Siphon Pipe upstream at this site.	4	3	NA	2	5	3	3	7.2	Walkway across spill chute, metal plank with wood supports and wood railing on downhill side. Equipment accessible safely with radial gate handwheel lower than ergonomically correct height.	Low energy drop into erodible channel, channel immediately downstream with shotcrete bank for erosion mitigation, risk of backcutting undermining outlet chute without maintenance. Cast-in-place concrete junction structure is aged, but sound condition Transition of concrete structure is sound. Wooden plank support and handrail aging and will require replacement in near term (railing is high risk if not well maintained). Cross gates are radial gates with chain hoist, aging but serviceable, new seals, moderate rust., Handcrank for chain hoist is low appears to have been designed for operation at lower standing level (top of ditch bank, not top of walkway), ergonomically awkward but usable. Spill stoplogs have moderate leakage.
Yunk's Spill	886+50	Abandoned Side Spill Box Flume from Concrete Lined Canal	3	4	NA	2	2	NA	4	6.2	Wooden walkway over stoplog chute with wood railing on downhill side.	Abandoned. Significant drop into erodible channel, with backcutting undermining chute. Although abandoned risk of chute failure remains. Downstream channel beyond immediate drop is stable. Box flume chute wood is deteriorating and undermined side (retaining) walls unstable in present state. Wooden plank walkway is aged but heavy duty. New wood rails have been moved toward canal to prevent access to portion of walkway over unstable wood chute, resulting in narrow walk space.
		Importance Factor (1 to 3)	3	2	1	3	2	2	1			

Notes
1. Rating 1 = Immediate Attention Required, Rating 5 = Long Term Inspection and Maintenance
2. Importance Factor 1 = High Risk, 3 = Low Risk
3. NA = Not Applicable to this Spillway

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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