DEERE & AULT
CONSULTANTS, INC.

MEMORANDUM

TO: Joe Shields P.E., HDR
Joy Jenkins Ph.D., P.E, US EPA

FROM: Christoph Goss, Ph.D., P.E.
Bence Close, P.E.

DATE: March 13, 2018

RE: Commodore 5 Tunnel Rehabilitation Concept; Creede, Colorado;
D&A Job No. CG-0547.002.00

This updated memorandum is in response to your request of November 29, 2017 to describe a rehabilitation concept for the Commodore 5 Tunnel near Creede, Colorado which could be implemented as a time critical removal action (TCRA). This rehabilitation would complement the Flow Control Interim Action and other options evaluated in the *Focused Feasibility Study for Flow Control; Nelson Tunnel/Commodore Waste Rock Pile NPL Site* by HDR and Deere & Ault Consultants Inc. dated March 27, 2017. The goal of this rehabilitation would be to maintain access from the portal to the Del Monte Shaft, secure the ground to keep material from impounding water in the Commodore 5, and maintain access to the Nelson Tunnel until the longer-term remediation is implemented (assumed to be within 15 years). This memo is intended to be the first step in developing plans for the rehabilitation of the Commodore 5 Tunnel as a TCRA.

This memo is a significant update and replacement of our Commodore 5 Tunnel Rehabilitation Concept memo dated December 13, 2017. It incorporates observations and measurements made during our site visit on January 30 and 31, 2018. Photos from the site visit are found in **Appendix 1**. **Table 1** has been updated to reflect quantities measured in the field. Since the ground support needs have been refined, costs in it have been updated to reflect recent projects. The figures have also been updated to reflect a new geologic map provided by DRMS and the area around the Bachelor Shaft.

Background

The Nelson Tunnel is a National Priorities List (Superfund) site located in the Creede Mining District in Mineral County, Colorado (**Figure 1**). A primary feature within the Creede Mining District is the Nelson Tunnel, which was constructed to access and dewater the underground mines along the highly productive Amethyst vein and to provide a haulage route for ore from operating mines (**Figures 2**, **3**, and **4**). The Nelson Tunnel (including the Wooster and

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Humphries extensions) is approximately two miles long and was constructed between 1893 and 1902. The Nelson Tunnel is the lowest tunnel constructed along the Amethyst vein system and functions as a drain for the underground workings that are connected via winzes and raises. The collapsed tunnel portal is located on the west side of West Willow Creek about one-mile north of the City of Creede.

There are three known and primary collapses within the Nelson Tunnel, forming three distinct mine pools, referred to as the Nelson Portal Pool, Lower Mine Pool, and Upper Mine Pool (**Figure 3**). Volumes of water stored behind collapses and in each of these pools are estimated by DRMS to be 1.2 million gallons (MG), 1.4 MG, and 19.5 MG, respectively.

At present, access to the Nelson Tunnel is through the Commodore 5 Tunnel, which was driven above the Nelson Tunnel to intersect the Amethyst vein complex and allow development of mines farther north. The portal of the Commodore 5 lies approximately 45 feet above and to the northeast of the Nelson Tunnel. The Nelson Tunnel was driven at varying gradients between one-half and one percent while the Commodore Level 5 was driven at a quarter percent or less, resulting in eventual junction at the Park Regent Mine (**Figure 3**). Portions of the Commodore 5 were rehabilitated by DRMS between 2002 and 2004. Some of these repairs now require maintenance or replacement.

Along with providing access to mine workings, the Commodore 5 serves the critical function as a water bypass or "relief valve" for the Nelson Upper mine pool. When the pool level rises above the collar of the Del Monte Raise, the water flows along the floor of the Commodore and dumps back into the Nelson at the No Name/Y02 Winze. If there were additional collapses in the Nelson Tunnel, the Commodore could serve a similar bypass function through the Daylight Winze. Hence, it is critical to keep the Commodore 5 open and accessible.

Rehabilitation

We have divided the rehabilitation into five segments. The first is the portal area including access across West Willow Creek. The second segment is the Commodore 5 Cross cut to the Daylight Corner (0+00 to 22+10). The third is the Daylight Corner intersection and Daylight Winze (22+10 to 23+10). The fourth the McClure Cross cut and Bachelor Shaft (**Figure 5**). The fifth segment is the Commodore 5 from the Daylight Winze to the Del Monte Raise (23+10 to 53+27. Segments one through four are needed no matter what action is taken in the future and require relatively little effort. Segment five will require significant effort and should only be undertaken if a long-term solution is deemed to be many years out. Detailed descriptions of observed ground conditions and recommended rehabilitation by station are found in **Table 1**. Survey spad locations and elevations are listed for reference. Selected photographs of each segment are found in **Appendix A**.

Segment 1: Portal Area

At this time, work in the portal area will be limited to activities the contractor will need for access and staging during construction. The key issue is that the existing bridge is narrow with

aging wooden planks. Access to the bridge is a narrow trail, inadequate for equipment larger than a small skid steer loader. The contractor should install a temporary bridge of appropriate size and capacity for their equipment and to accommodate seasonal creek flow changes. Other portal area work such as installing generators, lights, storage, offices, etc., would be included in a mobilization cost. See **Photos 1-4**.

Segment 2: Commodore 5 Cross Cut Portal to Daylight Corner 0+00 to 22+10

Segment 2 consists of the cross cut adit from the portal to the Daylight Corner where the adit intersects the Amethyst Vein. The first half of the segment was driven through slabby, closely spaced vertically jointed rhyolitic tuff. The second half is in a much more densely welded and massive rhyolitic tuff that eventually becomes the footwall of the Amethyst Vein (specifically the Willow Creek Member of the Bachelor Mountain Tuff). See the Geologic Map in **Figure 6**. Both areas were dry during our site visit. No ground support is currently installed. The track was generally in good shape after the first 200 feet. Several gallons per minute of water flowed through a ditch at the side of the track. See **Photos 5-11**.

Rehabilitation in this segment will consist of scaling, mucking, debris removal, ditch cleaning, track repair, replacement of the portal gate, and the installation of two air doors. The Manhattan Drift and another smaller room, near station 12+00, can serve as storage during construction.

Segment 3: Daylight Corner Intersection and Daylight Winze 22+10 to 23+10

Segment 3 consists of a small but critical area where the Commodore 5 turns and starts drifting on the vein. Here it is almost directly above the Nelson Tunnel where they connect through a collapsed raise and the Daylight Winze. This segment also includes the intersection with the McClure Cross cut. See **Photos 12-19.**

While the rock is generally good, the large span of the intersection and importance of keeping this area accessible leads us to recommend scaling, pattern bolting (6’ long), and installing wire mesh. The same applies at the wide section where the collapsed raise from the Nelson intersects the floor (22+10). Two small but high stopes in the middle of this segment should have steel sets, lagging, and foam installed underneath them to limit raveling.

Significant work is also needed at the Daylight Winze and the raise above it. Due to its importance of acting as the last drain into the Nelson Tunnel, the Daylight Winze should be fully rehabilitated by scaling, bolting, and installing new ladders and landings made of non-decaying or corroding material such as fiber reinforced plastic (FRP). This work would take place above the Nelson Tunnel without impacting the impounded mine pool areas. A cover capable of supporting vehicle traffic and allowing water inflow should also be installed. We anticipate the cover consisting of a concrete collar with coated steel beam supports and grated FRP cover.

Segment 4: McClure Cross Cut to Bachelor Shaft 22+68 to 28+68 (separate stationing)

The rock in the McClure Crosscut, in the hanging wall, consists of massive rhyolitic tuff, specifically the Campbell Mountain Member of the Bachelor Mountain Tuff. It was dry during our site visit and contained some ore chutes from upper levels. No ground support was noted but there was a moldy wood canopy possibly providing protection from small debris. See **Photos 20-31.**

Based on our observations, only minimal cleanup work will be required in the McClure Cross Cut area. The moldy canopy may have to be removed and replaced with bolts and wire mesh, depending on the ground conditions behind it. The bulk of the work will be in the Bachelor Shaft where the untreated wood ladders and landings should be replaced with fiber glass reinforced plastic ladders and landings, anchored into the rock wall. **Figure 5** shows the Bachelor Shaft in cross section. Note that the work would be limited to the Bachelor Shaft and landing, without impacting or accessing the Nelson Tunnel.

Segment 5: Daylight Winze to Del Monte Raise 23+10 to 53+27

From the Daylight Winze to the Commodore Shaft, the Commodore Level 5 main haulage tunnel generally follows the Amethyst Vein. While mined in some areas, the Amethyst Vein is often visible as hard, silicified breccia with altered, clayey gouge material near its edges. The hanging wall and foot wall are well defined in many areas and dip steeply to the West. Occasional roof falls are visible and range in volume from a few cubic feet to a few cubic yards. During our site visit, the tunnel was moist with water visible as minor pools behind collapses and dipping from various stopes and the Archimedes Raise. Timber ground support was failing at various stopes.

The Commodore Shaft area consists of two large underground chambers, neither of which had any ground support. This demonstrates the generally good rock quality in the foot wall in this area. North of the Commodore Shaft, the ground becomes blockier and weaker. A large roof fall by the 44 Raise caused mine pool two to three feet deep to build up behind it. At various locations, the tunnel curves around sections of bad ground where the main drive had been abandoned. North of the No Name (Y02) Winze, iron staining is visible on the floor. When the Upper Mine Pool elevation exceeds that of the Del Monte Raise collar, the mine water flows from the Del Monte Raise to the No Name Winze where it drops back into the Nelson Tunnel. See **Photos 32-62**.

Rehabilitation work in this segment will require considerable time, cost, and effort. While the removal of the wood and rock debris from the floor is a significant undertaking, the main cost will be in the installation of steel stulls and steel sets. At numerous locations, the back has been stoped up and supported with timber posts. Most of these are rotting and need to be replaced. Removing and disposing of the timber will also be a major cost factor, particularly if they must be removed from site. There are also several raises that ravel down material. For safety and to keep the Commodore 5 open, these areas will need lagged steel sets with foam backfill across the openings. For safety, this work will have to be carried out sequentially from the Daylight Winze to the Del Monte Raise.

An item of note is the pool behind the 44 Raise debris pile. To avoid interfering with the work, prior to removing the debris this pool should be pumped out into the nearby Commodore Shaft, allowing it to flow into the mower mine pool. Given the quantity and buffering effect of the Nelson mine pools, this is unlikely to have a significant impact on the flow out of the Nelson Tunnel. If needed, caustic could be added to the 44 Raise pool prior to pumping.

The area of greatest concern for keeping the "overflow" from the Del Monte Raise to the No Name/Y02 Winze open is a section of clay gouge between stations 47+10 and 47+40. It is supported by rail posts, rail lagging, and wood lagging. If the lagging fails in this area, the drift would likely be blocked, leading to higher water pressures and water volume in the upper mine pool.

Due to its importance of acting as the overflow for the upper mine pool, the No Name/Y02 Winze should be fully rehabilitated by scaling, bolting, and installing new ladders and landings, much like the Daylight Winze. This work would take place above the Nelson Tunnel without impacting the impounded mine pool areas. A cover capable of supporting vehicle traffic and allowing water inflow should also be installed. We anticipate the cover consisting of a concrete collar with coated steel beam supports and grated FRP cover.

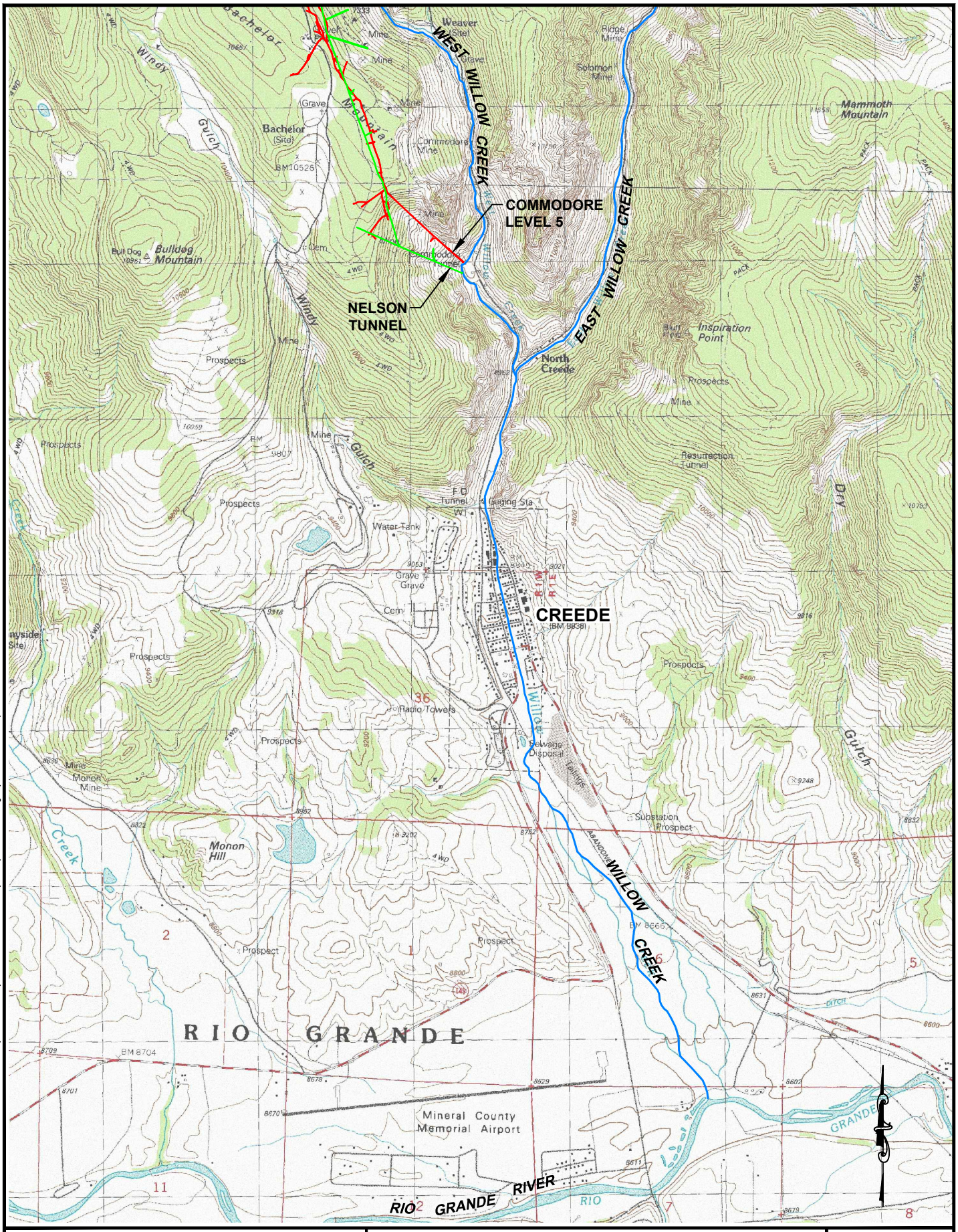
The collar at the Del Monte Raise should have an elevated platform installed above the high water line to allow safe and efficient sampling without hindering the flow of the mine pool. This platform would also be made of FRP or similar material.

Cost Summary and Assumptions

Table 1 provides unit prices and estimated costs for the various rehabilitation tasks defined. It is important to understand that the costs provided in **Table 1** are for direct costs and do not include indirect tasks, overhead costs, and contingency for completion of a project. Major assumptions used to develop **Table 1** include:

- For Segment 1-4, there is adequate room to store muck, timbers, and other debris that needs to be removed to complete the rehabilitation within the mine complex. Costs for disposal or materials outside the mine are not included.
- For Segment 5, there is adequate room to store muck and debris within the mine complex but, given the large quantity, timbers will have to be disposed of offsite.
- Work within the mine can be completed without the use of air purifying or air supplying respirators.
- Pricing is based on engineering judgment and experience at recent projects.
- Assumes work will be initiated in 2018.
- Costs for handling water are not included in the estimate. It is assumed work between the No-Name/Y02 Winze and the Del Monte Raise will be completed when the water Level in the Upper Mine Pool is below Commodore Level 5.
- Local mine rescue team

FIGURES



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NELSON TUNNEL	FIGURE NO.
VICINITY MAP	1
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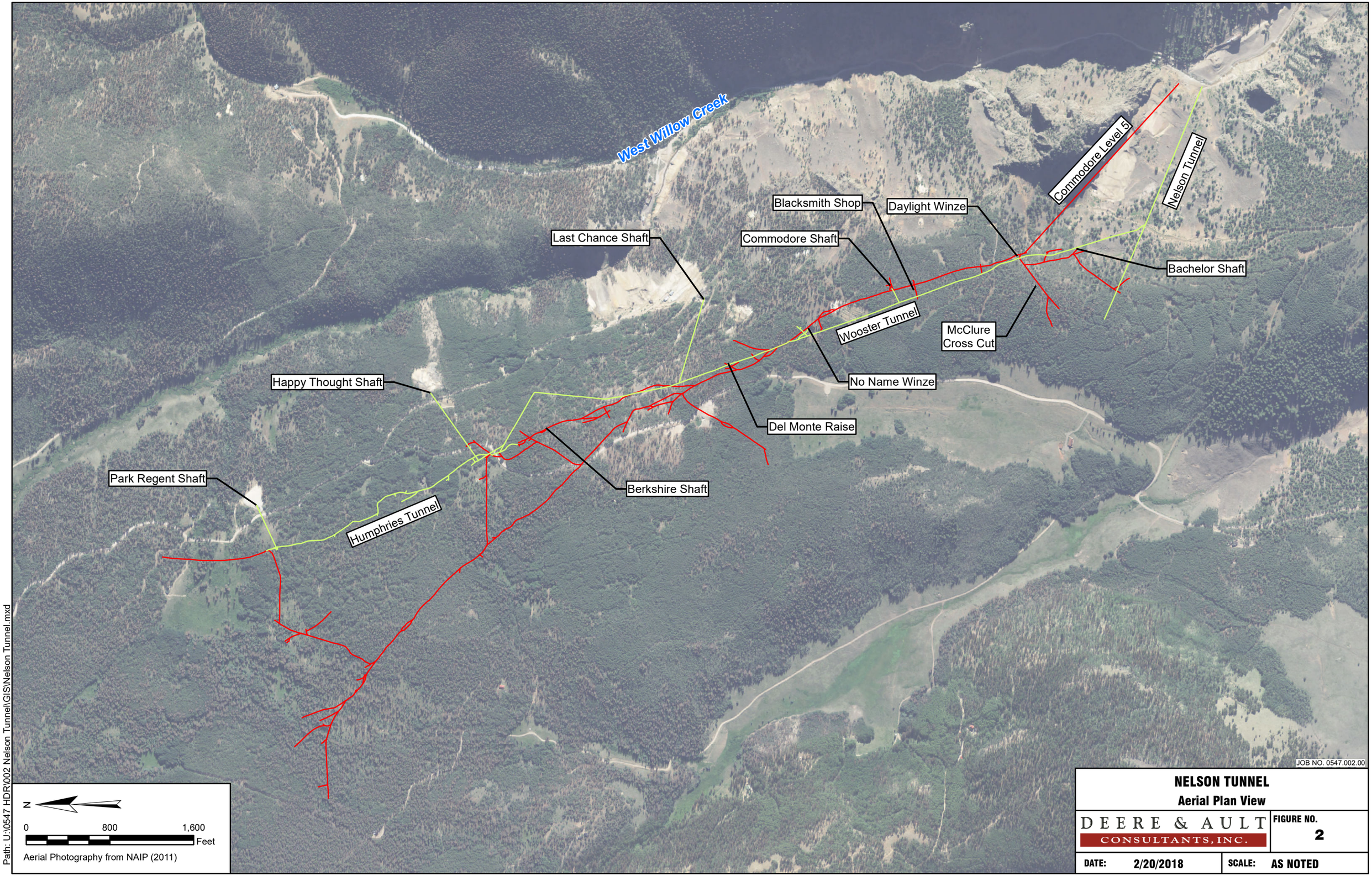

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NELSON TUNNEL

Aerial Plan View

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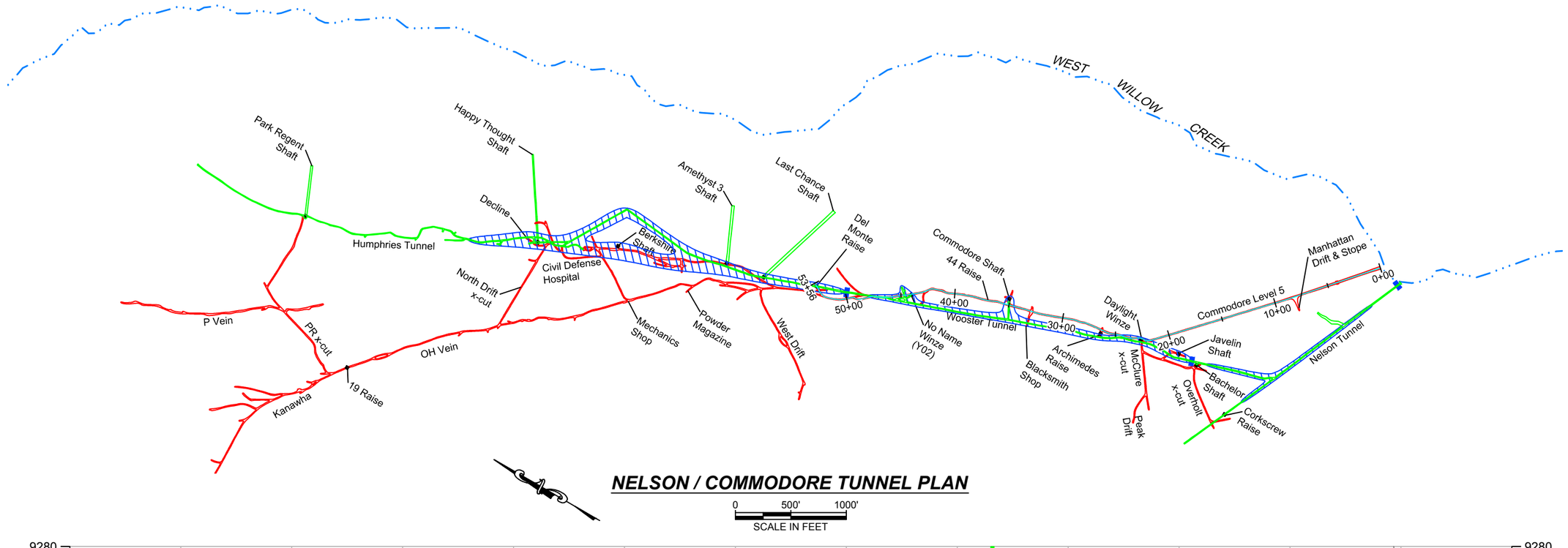
FIGURE NO. **2**

DATE: **2/20/2018**

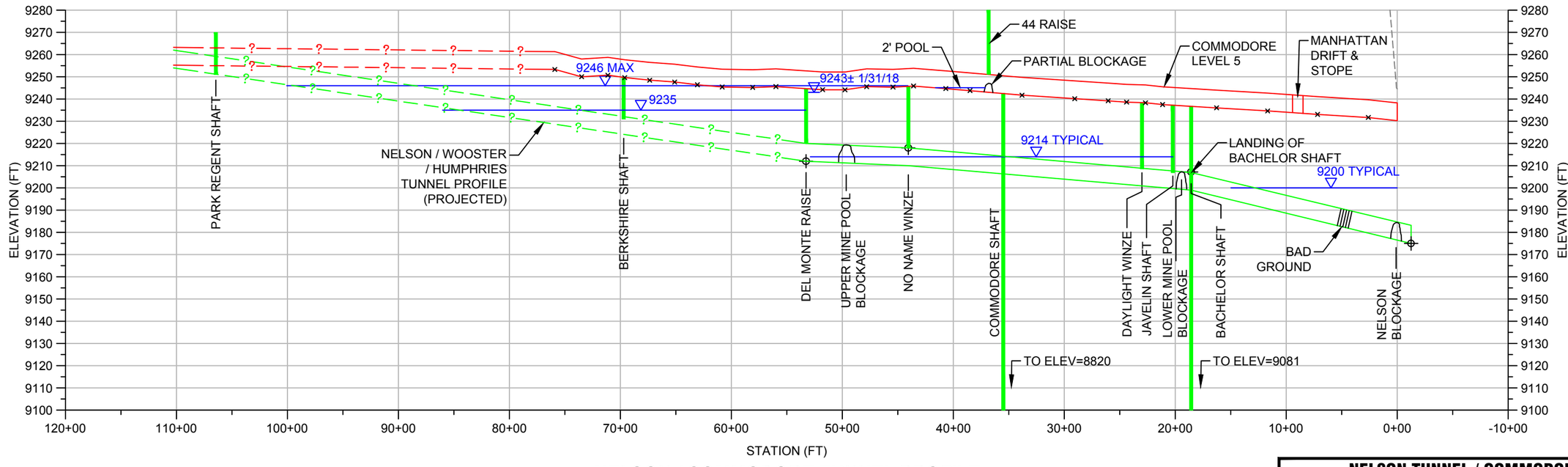
SCALE: **AS NOTED**



NELSON / COMMODORE TUNNEL PLAN

0 500' 1000'

SCALE IN FEET



NELSON / COMMODORE TUNNEL PROFILE

Vertical Scale (FT) 0 25' 50'

Horizontal Scale (FT) 0 500' 1000'

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NOTES:

BASE MAP BY CDRMS

× COMMODORE TUNNEL ELEVATION SURVEY POINTS

⊕ NELSON TUNNEL ELEVATION SURVEY POINTS

NELSON TUNNEL / COMMODORE 5

PLAN & PROFILE

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FIGURE NO. 3

DATE: MARCH 2018

SCALE: AS NOTED

WEST WILLOW CREEK

Amethyst 3 Shaft

Last Chance Shaft

Del Monte Raise

Commodore Shaft

44 Raise

Wooster Tunnel

No Name Winze (Y02)

West Drift

Blacksmith Shop

Archimedes Raise

Daylight Winze

McClure x-cut

Peak Drift

Overholt x-cut

Bachelor Shaft

Corkscrew Raise

Javelin Shaft

Commodore Level 5

Manhattan Drift & Stope

Nelson Tunnel

53+56

50+00

45+00

40+00

35+00

30+00

25+00

20+00

15+00

10+00

5+00

0+00

- SEGMENT 1 - PORTAL
- SEGMENT 2 - 0+00 - 22+10
- SEGMENT 3 - 22+10 - 23+10
- SEGMENT 4 - McCLURE CROSS CUT & BACHELOR SHAFT
- SEGMENT 5 - 23+10 - 53+56

0 200' 400'
SCALE IN FEET

JOB NO. 0547.002.00

NELSON TUNNEL / COMMODORE 5

PLAN VEIW

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FIGURE NO. 4

DATE: MARCH 2018

SCALE: AS NOTED

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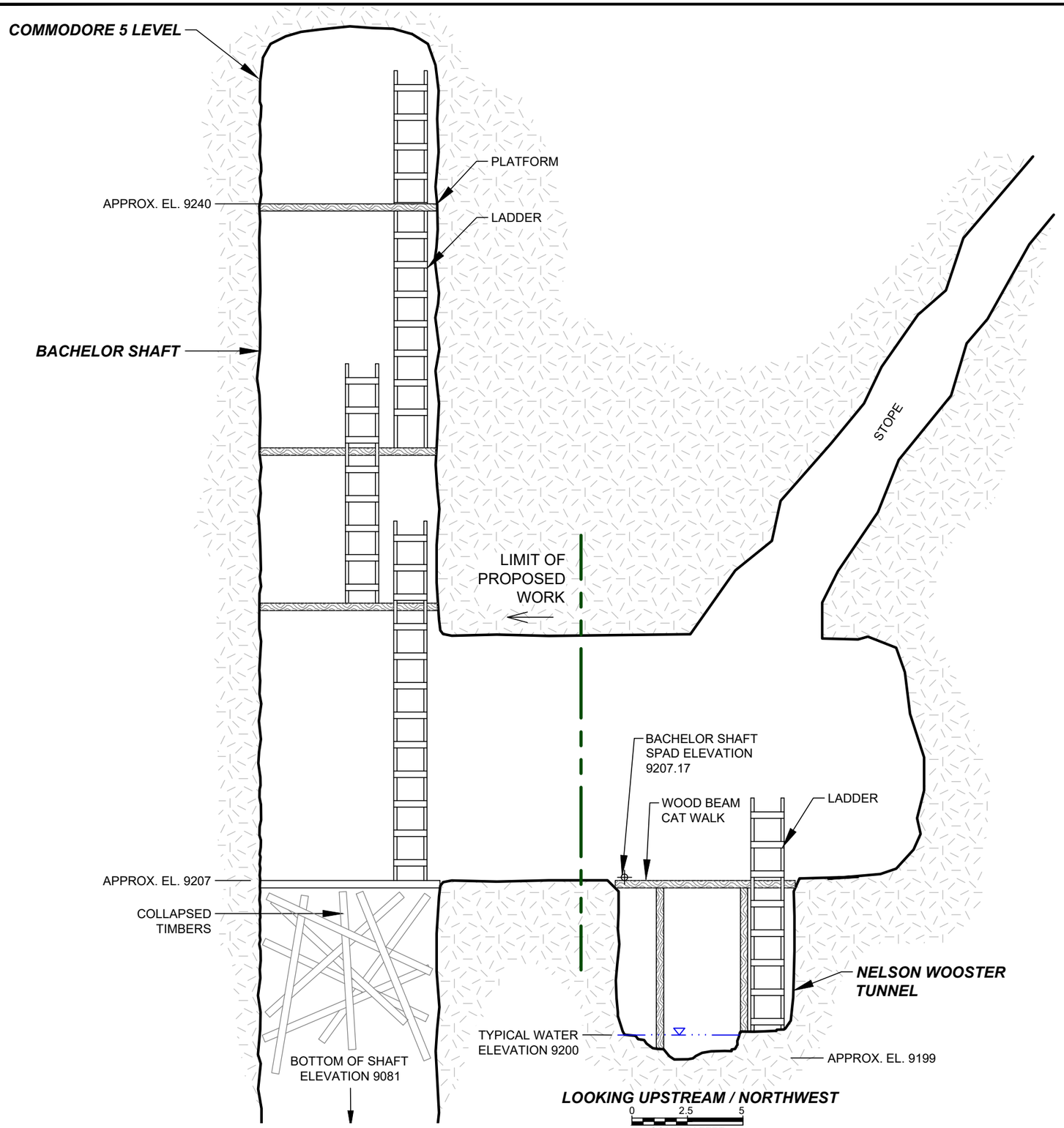

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NELSON TUNNEL / COMMODORE 5

BACHELOR SHAFT CROSS SECTION

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FIGURE NO. **5**

DATE: **FEB. 2018**

SCALE: **AS NOTED**

-1000N

-2000N

-3000N

-4000N

Symbols

- Tbw - Willow Creek Rhyolite
- Tbc - Campbell Mountain Rhyolite
- Tunnel Walls
- Vein, with strike & dip (arrow indicating dip direction)
- Shaft or Raise

Abbreviations

BR	Breccia
Fe/FeOx	Iron or Iron Oxide
GO	Gouge
IRR	Irregular
MIN	Mineralization
SH	Shear
SULF	Sulfidization
VIS	Visible
WK	Weak

Approx. elev. at portal 9220'

Daylight Winze

Bachelor Shaft

STOPED IRR. UP 60-75' OVER 2-4' WIDTH. OPEN DOWN 20' TO HUMPHREY TUNNEL (?) WATER FILLED

IRR. STOPING UP 15-60', DOWN 20-40' OVER 2-4' WIDTHS.

OPEN DOWN 40' ±

1-2" GO & SH.

Tbw

Tbc

2-3" BR, FeOX

3-6" IRR, BR FeOX

2-7" IRR. SH. BR & GO. NO VISIBLE SULF.

6" SH WITH MnO

2-6" HIGHLY BR.ROCK

OVERHOLT X-CUT

McCLURE X-CUT

1-2" WK. SH.

5' COARSE BR. WITH 6" FINE GO. ON H.W.

ARCHIMEDES RAISE

LAGGED IN BACK

COMMODORE SHAFT

LAGGED

4-6' COARSE BR. NO VIS. MIN.

12-18" GO. & BR. WK. MIN.

1-5' SH. & GO. NO VIS. MIN.

8' IRR. BR. & GO. FeOX

2-12" IRR. SH. & GO.

CAVED

TELLER DRIFT

Blacksmith Shop

2-3" WK. IRR. SH.

IRR. STOPED 2-4' WIDE

2-6" SH. & OPEN FRAC.

No Name Winze

BR. & GO. OVER WIDTH OF DRIFT - NOT HIGHLY MIN.

Del Monte Raise

STOPED AREA CAVED

CAVED

CAVED

IRR. STOPING OVER 4-8' WIDTHS

STOPED 4-5' WIDE STONG Fe STAINED GO. ZONE FAIR TO GOOD SULF. VIS.

2" IRR. FRAC. WK. MIN.

4-18" WK. SH. & GO.

RAISE UP 50' ±

2-6" SH. - WK. MIN.

2" IRR. FRAC. WK. MIN.

CAVED - OPEN FRAC. OPEN UP 40± 2-6' WIDE

Source: Unknown

DRAFT

JOB NO. 0547.002.00

COMMODORE 5

GEOLOGIC MAP

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FIGURE NO. 6

DATE: FEBRUARY 2018

SCALE: AS NOTED

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APPENDIX A
SELECTED PHOTOGRAPHS FROM SITE VISIT
JANUARY 30-31, 2018

Photo 1: Commodore Levels 3, 4, and 5 Portal Area with Willow Creek in front

Photo 2: Willow Creek at portal looking upstream; Note small bridge and path for access

Photo 3: Nelson Tunnel and Commodore Level 5 Portal; Note steep grading left of portal

Photo 4: Commodore 5 Portal Area close up

Photo 5: Portal Gate to be replaced

Photo 6: First Air Door to be replaced

Photo 7: Floating rail ties and poor drainage near 1+00

Photo 8: Typical rail, ditch, and invert in Commodore 5 Cross Cut

Photo 9: Manhattan Drift

Photo 10: Underground storage chamber along Commodore 5 Cross Cut

Photo 11: Typical conditions in Commodore 5 Cross Cut

Photo 12: Daylight Corner with collapsed raise from Nelson Tunnel in left rib

Photo 13: Close up of collapsed raise from Nelson Tunnel

Photo 14: Intersection with McClure Cross Cut to left; Daylight Winze to right

Photo 15: Looking up stope at Daylight intersection

Photo 16: Overview of Daylight Winze; Note decayed wood cover

Photo 17: Daylight Winze with rotten wood cover

Photo 18: Looking down Daylight Winze: Note smooth footwall, ladder, and landing

Photo 19: Raise above Daylight Winze: Note Amethyst Vein in center

Photo 20: McClure Cross Cut with debris

Photo 21: Moldy canopy in McClure Cross Cut

Photo 22: McClure Cross Cut typical view

Photo 23: McClure Cross Cut ore chute

Photo 24: Top of Bachelor Shaft

Photo 25: Looking down into Bachelor Shaft; Small first landing visible

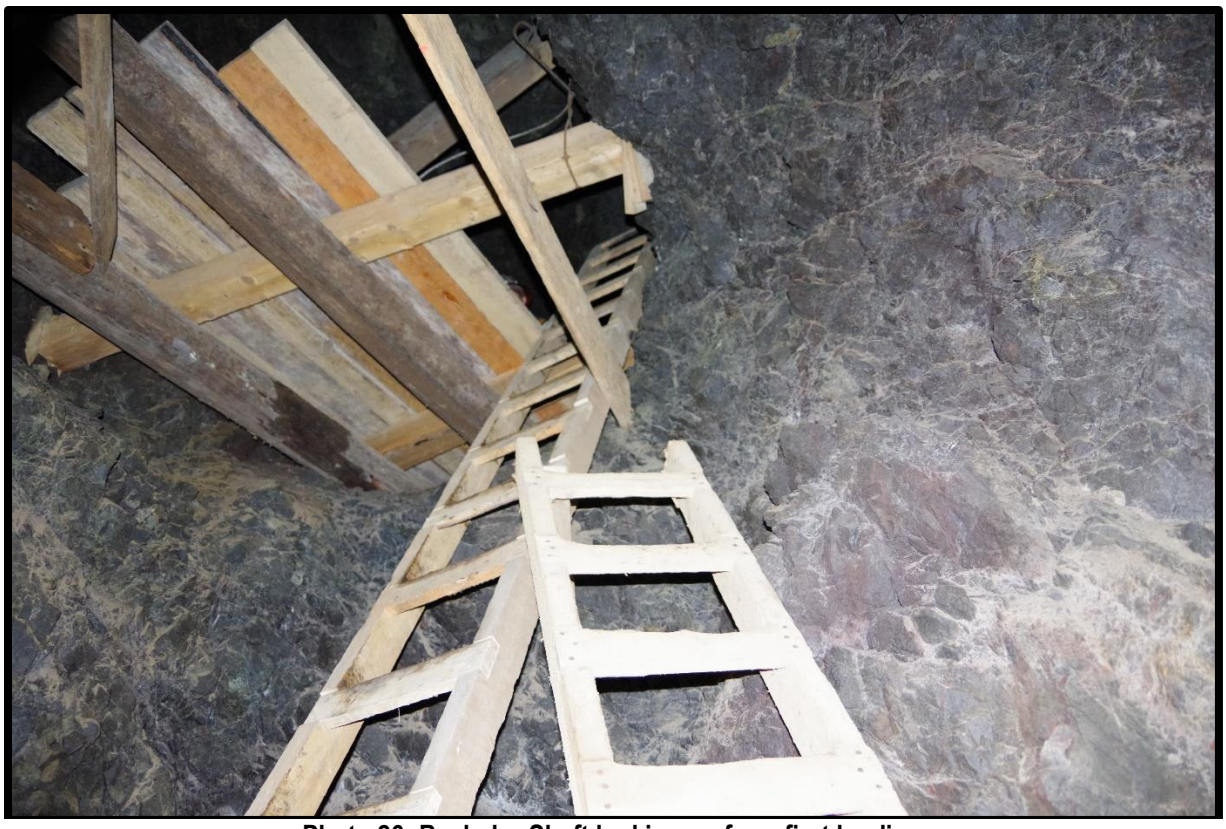


Photo 26: Bachelor Shaft looking up from first landing

Photo 27: Bachelor Shaft looking up

Photo 28: : Bachelor Shaft looking up to second landing

Photo 29: Bachelor Shaft bottom and second landing seen from far side of Nelson Tunnel

Photo 30: Bachelor Shaft at Nelson Tunnel landing

Photo 31: Collapsed Timbers at Bachelor Shaft Nelson Tunnel landing

Photo 32: Decayed rail ties near 25+00; Note staining from water

Photo 33: Measuring Archimedes Raise dimensions 26+64

Photo 34: Close up of Archimedes Raise steel posts; Note corrosion and delamination

Photo 35: Typical timber stulls; Note hanging wall, Amethyst vein, and foot wall

Photo 36: Steel rail stulls with rotten timber lagging 30+50

Photo 37: Looking up raise at 30+20

Photo 38: Debris from actively raveling raise near 32+00; Note water backed up behind

Photo 39: Steel pipe stulls near 32+20; Note pipe cribbing

Photo 40: Failed timber stulls near 32+80

Photo 41: Debris pile at very active 44 Raise 36+82

Photo 42: Debris pile at 44 Raise 36+82 looking outby; Note water ponded behind pile

Photo 43: Steel rail stulls and rotten wood lagging near 37+50

Photo 44: Large loose slabs in hanging wall near 38+10; View is outby

Photo 45: Raise with steel sets and rail near 38+70

Photo 46: Abandoned heading near 41+00; Drift moves into foot wall

Photo 47: Sealed opening in left rib near 41+50; Loose debris is behind it

Photo 48: Large chamber and drift in left rib near 42+79

Photo 49: Large chamber and drift in left rib near 42+79 looking outby; Note timber and other debris

Photo 50: Cathedral near 43+50; Note loose muck in right rib and rotten timber lagging

Photo 51: Raise with steel rail, wood posts, and rotten cribbing near 44+00

Photo 52: Looking up raise near 44+00

Photo 53: No Name/Y02 Winze 44+60

Photo 54: Looking down No Name/y02 Winze

Photo 55: Drip pan in back near 45+45

Photo 56: Area of clay gouge in left rib near 47+10

Photo 57: Area of clay gouge in left rib near 47+10; Note heavy steel rail lagging

Photo 58: Area of clay gouge in left rib near 47+10 looking outby; Note timber lagging

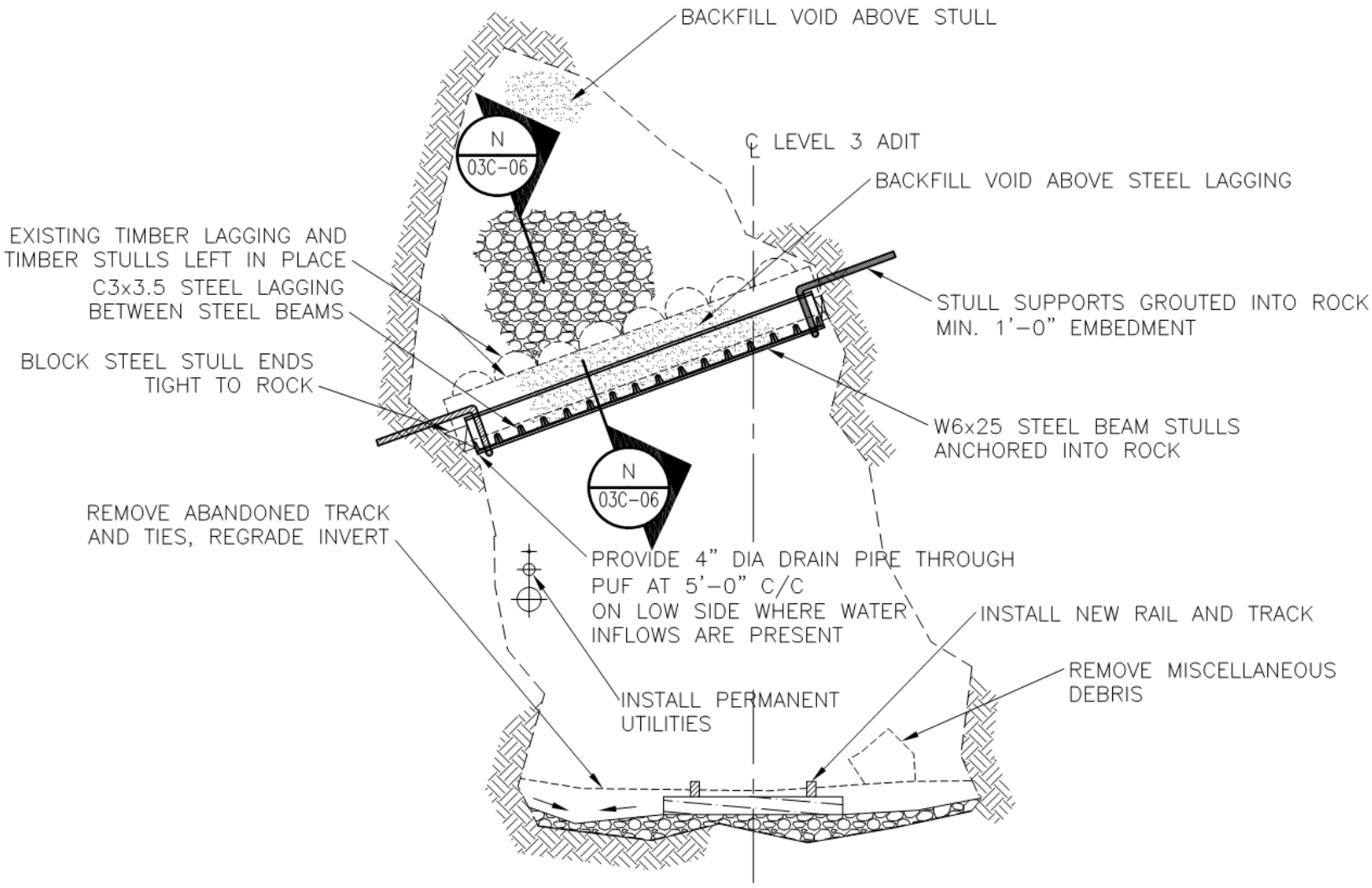
Photo 59: Typical draft near 50+00; Note high water line from upper mine pool overflow

Photo 60: Del Monte Raise 53+15; Note sampling platform

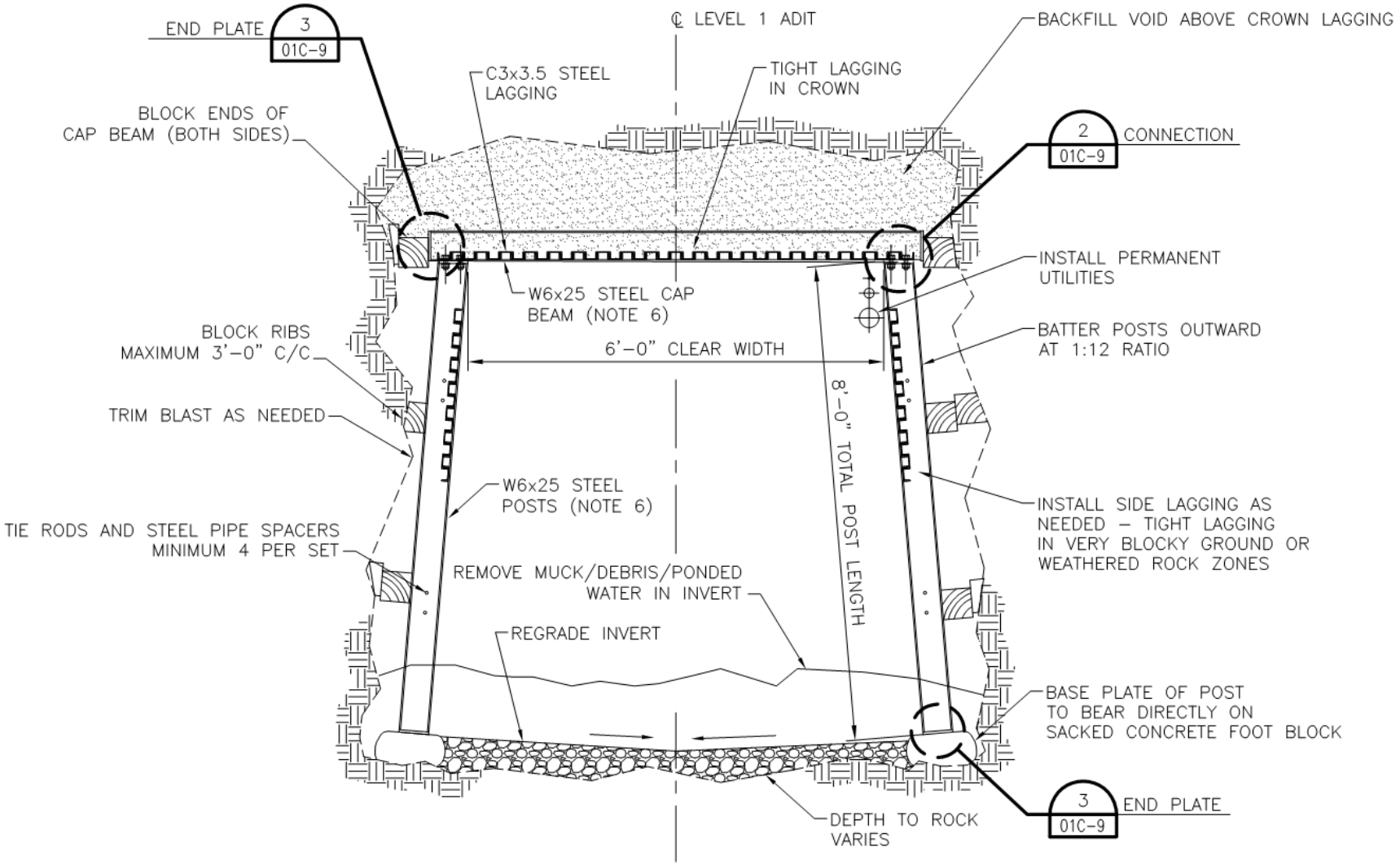
Photo 61: Del Monte Raise 53+15; Note clear water

Photo 62: Del Monte Raise 53+15 looking down

APPENDIX B
TYPICAL SUPPORT DETAILS



Typical Stulls (Courtesy of HDR-Standard Mine)



Typical Steel Sets with Backfill (Courtesy of HDR-Standard Mine)