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TECHNICAL MEMORANDUM:

REOPENING AND ASSESSMENT OF THE GLENGARRY MINE IN 2001
AND
ASSESSMENT OF THE GLENGARRY DUMP AS POTENTIAL BACKFILL

Prepared for:

Bob Kirkpatrick

USDA Forest Service

15 November 2001

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TECHNICAL MEMORANDUM

To: Bob Kirkpatrick

From: Henry Bogert

Date: November 15, 2001

Re: Reopening and Assessment of the Glengarry Mine in 2001 and Assessment of the Glengarry Dump as Potential Backfill

CC: F. Ehernberger
M. B. Marks
M. Cormier
A. Kirk

Executive Summary

The Glengarry tunnel and raises have been rehabilitated to a point where the underground conditions could be adequately assessed. The underground workings were rehabilitated to provide access to measure water flow, to sample water inflows, and for detailed planimetric and geologic mapping. Additionally, the second raise was renovated from the collar down to a level below all significant water inflow and well below the lower contact of the mineralized Meagher Limestone. This is the expected location of a raise plug, should plugging be selected as part of the closure plan. During the assessment phase of reopening the Glengarry Mine, the data necessary to evaluate the effectiveness and cost of various closure options and alternatives was collected.

The water inflow rate and chemistry data shows that the water flowing along the colluvial/bedrock contact in the Como Basin and then down the second raise contributes the most acidic and metal laden water entering the Glengarry. This near surface water contributes iron, sulfate, and several orders of magnitude more copper than all other water flowing into the mine. Other inflow sources also contribute significant amounts of iron and sulfate to the outflow, but have very low base-metal concentrations.

The material contained in the waste rock dump at the portal of the Glengarry tunnel was assessed for its potential use as cemented backfill aggregate for possible closure options for the Glengarry Mine. The 7/8 inch minus fraction with 10 percent cement was found to be suitable for pumping and strength requirements. The 7/8 minus fraction of the waste rock dump represents about 28 percent of the total material in the dump and could be used to backfill approximately 1200 linear feet of workings. The waste rock material is potentially acid-generating, and ABA testing results indicate that a cement content of 16 percent by weight would be adequate for neutralizing the acid generation potential of this material (this

includes a 1.25 safety factor for inhomogeneous mixing). The Glengarry mine waste is therefore considered useable as a cemented backfill material. It is recommended that a 20 percent cement mix be used to insure a significant neutralization buffer is present in the final backfill.

Introduction

The Glengarry Mine consists of 3,060 feet of drifting and two nearly vertical raises. The tunnel and raises were driven in the 1920's and 1930's and were reportedly last used for mining in the 1950's. One of the raises extends 425 upward and surfaces in the Como Basin at the foot of the north flank of Fisher Mountain. The top of the raise passes through the Meagher Limestone formation, one of the principal host rocks for massive sulfide replacement mineralization in the district.

From the Glengarry portal, 23 to 57 gallons per minute of low pH, iron-, zinc-, and copper-bearing water discharges via a short ditch into Fisher Creek. The Glengarry Mine was targeted for assessment and remediation under the New World District Response and Reclamation Project (administered by the USDA Forest Service) because it is one of the principal sources of metals loading in the headwaters of Fisher Creek.

The Glengarry Tunnel was reopened for assessment in September and October 2000 by Pony Mining Contractors under the supervision of H. Bogert, a subcontractor to Maxim Technologies Inc. During this phase of reopening and assessment, accumulated debris and ferricrete mud two to five feet deep were removed from the tunnel beginning at the portal and extending back to a "Y" intersection 1540 feet in from the portal. The two branches of the "Y" were made accessible, but debris and ferricrete were not removed from them. The Glengarry Tunnel was surveyed and a planimetric map produced (Figure 1).

In the heading extending southwest from the "Y" intersection, two raises are present. At 1,875 feet in from the portal, a three compartment timbered raise extending vertically upward was encountered. The inside dimensions of each compartment were 4.5 feet by 4.5 feet. The center compartment originally had ladders and landings in it. Each of the side compartments was an orepass lined with two inch thick timber. Timber debris cluttered the bottoms of the raise compartments and approximately 18 gallons per minute of water flowed down the raise, making entry all but impossible during the assessment. A map dating from the 1930's shows this raise extending upward approximately 50 feet.

At the end of the southwest heading, 2,150 feet in from the portal, a timbered two compartment raise extending vertically upward was encountered. Approximately one to two gallons per minute of water were observed flowing from the bottom of this second raise. A substantial air flow came down the raise on warm days. Access into the bottom of the raise was blocked by timber lagging as well as sand and gravel five feet deep in the drift. The map dating from the 1930's shows the second raise extending vertically to the surface.

In the Como Basin, a drift connecting to the second raise 20 feet below the surface was dug out in October 2000. H. Bogert and A. Kirk entered the top of the raise far enough to determine that reopening the raise from the top was a far simpler task than reopening it from the bottom. Conditions at the top of the raise are shown in Figure 2. Due to the on-set of winter, reopening the raise was scheduled for 2001.

Reopening the Second Raise Beyond the "Y"

In June 2001, Pony Mining Contractors was contracted to reopen and repair the second raise from the surface in the Como Basin down to a point well below the base of the Meagher Limestone. The contractor mobilized on 20 July 2001 and completed the project in seven weeks.

The second raise consisted of two square-set compartments, each 4.5 feet by 4.5 feet, inside dimensions. Measured from center-to-center, the vertical distance between timber sets was about 6.5 feet. The timbers were peeled logs nine to twelve inches in diameter with well-crafted interlocking joints. The top 20 feet of the raise had collapsed due to rotting timbers; however, the raise timbers below 20 feet were in very good condition. The north compartment contained ladders, landings, and a timber slide, all in disrepair. The south compartment was mostly lined with two inch thick timber and built as an orepass.

A hole, centered on the raise, was dug from the surface down 20 feet to remove the collapsed debris and expose the solid raise timbers beneath. Three 10" x 10" timbers were then laid across the hole directly over the old horizontal timbers. The 10" x 10"s extended across the uppermost timbers and out onto bedrock on the floor of the excavation, thus providing a foundation upon which the new timber would bear (Figure 3). Building upward from the 10" x 10" timber foundation, the raise was cribbed with 6" by 8" timber stacked skin-to-skin (Figure 4). The hole around the cribbing was back filled with clayey overburden, compacted, and graded so that surface water drains away from the raise and into an existing diversion ditch constructed around the Como raise collar (Figure 5 and Figure 6).

Old ladders and debris were removed from the north compartment. New ladders and landings were installed down to a depth of 215 feet below the surface (Figure 7). Three separate short horizontal workings were encountered in the Meagher Limestone at 35, 75, and 100 feet below the surface (Figure 8 and Figure 9). A typical view of a horizontal level is shown in Figure 10. At 100, 150 and again at 215 feet down, the raise was offset horizontally to the southeast, presumably to lessen the impact of falling rock dumped down the orepass. A small room with two pneumatic hoists was also encountered at 215 feet down. One hoist pulled materials up from the tunnel to the hoist room; the other pulled materials from the hoist room to the top of the raise. The hoist room is 120 feet below the base of the Meagher Limestone, and no significant water inflows were encountered below the middle of the Meagher. Therefore the reopening and assessment work was terminated at 215 feet below the collar.

Each horizontal level and the raise down to 215 feet were surveyed and the geology was mapped. Water inflows were measured and sampled at the collar of the raise and at each horizontal level during July and August 2001. Water was also sampled at the contact of overburden with bedrock (Park Shale) in the exposed wall of the excavation during re-construction of the raise collar.

Locking doors were installed on the collar cribbing and in the raise six feet below the collar. Upon completion of the assessment, the raise was secured for the winter (Figure 11). In its present condition, the raise should remain accessible for many years; however, the condition of the steel spikes attaching the ladders to the raise sets should be verified before trusting the ladders in future years.

Reopening the First Raise Beyond the "Y"

Initial speculation was that the first raise beyond the "Y" in the Glengarry was connected to the second raise by horizontal workings. The rehabilitation work in the second raise proved that there was no connection within at least the top 215 feet of the second raise. A. Kirk and H. Bogert climbed a short distance up into the orepasses to visually determine the vertical extent of the first raise. Bulkheads of six to eight inch diameter logs were seen approximately 40 feet above each of the ore chutes (Figure 12). Due to debris and the absence of ladders, the center compartment could not be entered.

Pony Mining Contractors was contracted to remove debris and install temporary ladders up the middle compartment. The purpose of this work was to determine whether the top of the raise was open or if it extended beyond the 50 feet shown on the 1930's map. Debris were removed, and aluminum ladders were nailed in place extending approximately 25 feet up the center compartment. From there, up through the rain, a round timber bulkhead was seen at the same elevation as the other two bulkheads in the adjacent compartments. Removing the bulkheads to determine what was above them or to identify the source of the water inflow was considered too dangerous to pursue.

Survey, Mapping, and Geology

The second raise was surveyed to a depth of 215 feet using plumb bobs and measuring vertical distances with a 200 foot tape. The horizontal levels were surveyed with a Brunton compass and tape. Figure 8 and

Figure 9 were compiled based on this survey data and projections to depth connecting the raise down to the southwest leg of the "Y".

Geologic structures were mapped on the horizontal levels and in the raise where bedrock was visible through spaces between the lagging. This data together with the geologic logs of adjacent exploration holes drilled by Crown Butte Mines, Inc, was used to develop a model of the geology around the raise. At least two intrusions and two faults within close proximity to the raise were identified and can be correlated both vertically and laterally. Cross sections looking north and looking west depict the geology around to the raise (Figure 13).

Summary of Water Flow and Quality in the Glengarry Mine

Water quality and quantity entering the Glengarry Mine has been measured for over a year at various underground sample locations. The results of the water sampling chemistry is summarized on a schematic long-section through the Glengarry Mine in Figure 14.

The water flowing into the Glengarry Mine comes from essentially three point sources and one more diffuse source. The point sources are a major roof leak 1050 feet in from the portal, the bulkheads at top of the first raise about 40 feet above the tunnel level, and the top of the second raise where it collars in the Como Basin. The diffuse source is a collection of small fracture controlled roof leaks developed in the bedrock between the portal and the major roof leak at 1050.

The second raise, which collars in the Como Basin, contributes 2 to 10 gallons per minute of inflow. During the snow melt, most of the flow is derived from water traveling through the colluvial material exposed at the surface in the Como Basin and drains into and down the raise. The seasonal water flow is characterized by a pH of 2.5, 100 to 400 milligrams per liter (mg/l) iron, and 10 to 40 mg/l copper.

The short first raise has a fairly constant flow in the range of 10 to 20 gallons per minute with the lowest flow occurring in the spring. The water is characterized by a pH of 3.2 to 3.3, 75 to 85 mg/l iron, and 0.015 to 0.032 mg/l copper.

The major roof leak at 1050 feet from the portal varies seasonally from 3 to 13 gallons per minute and is characterized by a pH of 4 to 5, 25 to 110 mg/l iron, and 0.004 to 0.05 mg/l copper.

The diffuse roof leaks virtually dry-up in the winter, but during the snowmelt season they collectively contribute up to 15 gallons per minute. They are characterized by a pH of 5 to 6, 2 to 10 mg/l iron, and 0.001 to 0.006 mg/l copper.

Thus, as can be seen from this data the Glengarry Tunnel receives several orders of magnitude more copper loading from the top of the Como raise than from all the other in-flow sources combined. In addition, the two raises and the 1050 roof leak each contribute at least an order of magnitude more iron loading than do the diffuse roof leaks.

Suitability of Glengarry Dump for Use as Mine Backfill

As the Glengarry Tunnel and raises were developed years ago, waste rock was dumped outside the portal creating a waste rock dump approximately 80 feet across at the top. Assuming that all of the Glengarry tunnel and raise development waste rock was deposited on the dump, the volume would be about 175,000 cubic feet. Approximately 40 percent would be Fisher Mountain Intrusive, 45 percent would be Precambrian Granite, and 15 percent would be Wolsey Shale or Meagher Limestone. The Fisher Mountain Intrusive and the Meagher Limestone both carry significant disseminated and fracture fill pyrite; therefore, half the dump material is likely to have a significant acid-generating potential.

The Glengarry Dump material was assessed as a potential backfill source for use in some of the Glengarry underground remediation alternatives. Under these backfill scenarios, a pump outside the portal would pump cemented backfill through a pipe into the Glengarry Tunnel. Assuming a 1,500 linear feet pumping distance through a 6-inch diameter pipe, a backfill with four to six inches slump could be handled by a modest sized concrete pump.

During the 2001 field season, the waste rock dump was sampled to determine the particle size distribution and to collect a representative sample for laboratory test work to assess the pumpability, strength, and acid generating potential of the fill. Data from this test work would be used to determine the feasibility of making backfill from the dump material and pumping it into the mine.

A settling pond, built in 2000 for sediment control during dewatering and renovation of the Glengarry Mine, currently occupies most of the top of the Glengarry waste rock dump. Two test pits, one north of the pond and the other south of the pond, were dug to depths of 5.5 feet, and the material dug from each hole was windrowed beginning with the near surface material on one end and finishing with the bottom-most material at the other. At each test pit, the windrow was photographed and the material sampled at 1.5 foot intervals beginning one foot below the surface. The north pit contained predominantly Fisher Mountain Intrusive and the south pit contained predominantly Precambrian Granite. Thus the samples, when combined, are expected to be representative of the overall dump material.

The photographs were analyzed to determine the particle size distribution of material that would be retained on a 2.60 inch sieve. The particle size distribution of passing 2.60 inch material was determined by dry sieve analysis to 0.0165 inches and by wet sieve analysis from 0.0165 to 0.0017 inches. Thus the dump particle size distribution was measured from boulders to clay sized material. This data is summarized in Figure 15.

Typical six inch concrete pumps are designed to handle aggregate with one inch maximum particle size. Therefore, it was conservatively assumed that the material from the Glengarry dump passing a 7/8-inch sieve could be used as aggregate in cemented backfill. This size range of material represents about 28 percent of the dump volume. Assuming a ten percent swell factor between in place rock and backfill, 1,200 linear feet of tunnel could be backfilled with the screened 7/8 inch minus size portion of dump material. If additional backfill is required, a crushing and screening plant will be needed to produce this material, or alternatively, another source will have to be found.

Size analysis of the portion of the dump passing the 7/8 inch screen shows that seven percent of the volume is clay or silt, with the remaining 93 percent evenly split between sand and gravel sizes (Figure 15). This aggregate deviates significantly from ASTM specified aggregates; however, the higher fines content will improve pumpability.

To determine the feasibility of using cemented backfill with a high fines content, backfill was batched in the laboratory with ten percent cement by dry weight, mixed, and wetted to achieve a four inch slump. Three test cylinders were cast. A second batch was mixed, wetted to 6.5 inch slump, and three more cylinders cast. The cylinders were capped, cured for 27 days, and tested in uniaxial compression. The four inch slump batch averaged 709 pounds per square inch (psi) strength, while the 6.5 inch slump batch averaged 474 psi strength. The test results are summarized in Table I. These strengths are very reasonable when compared with a maximum hydrostatic pressure of 196 psi at the portal if the mine were to be filled with water to the top of the second raise.

A passing 7/8 inch screen-composite sample was split and sent to Northern Analytical Laboratories for acid-base accounting (ABA) analysis. Based on the measured acid-generation potential, this sample required a lime amendment of 16 percent by weight, assuming a 1.25 correction factor to address mixing problems (verbal communication, L.Kirk, 31 Oct 2001). A mix containing 20 percent portland cement is recommended for future backfill work at the Glengarry Mine, thus providing an additional four percent excess neutralization potential.

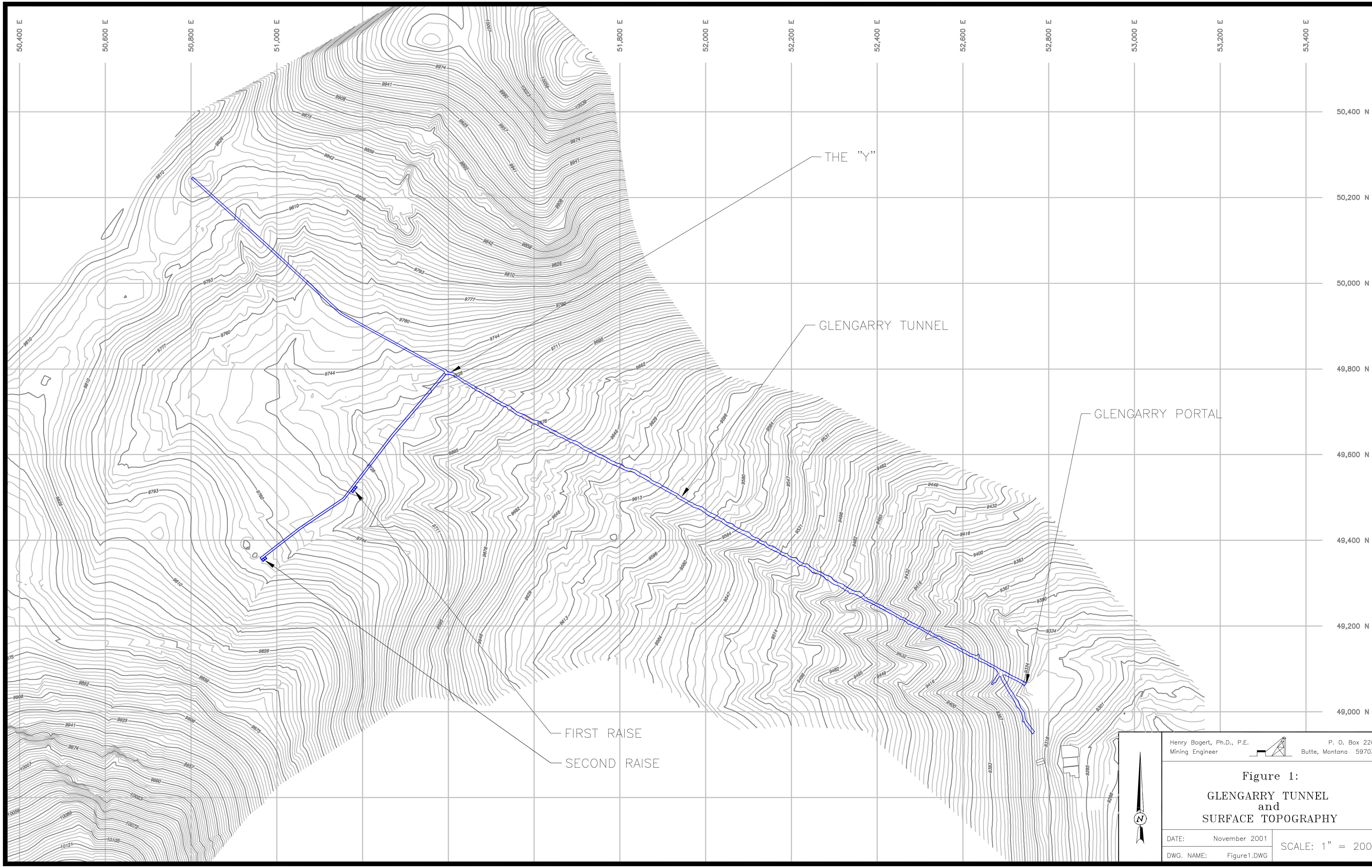

Figure 1:
GLENGARRY TUNNEL
and
SURFACE TOPOGRAPHY

Figure 2:

Top of Glengarry Raise
12 October 2000

Figure 3:

10” x 10” Bearing Set

10” x 10”s

Figure 6:

Cribbing and Site Grading Complete

Existing Diversion Ditch

Figure 7:

New Ladders and Existing Timber Sets

Figure 4:

6” x 8” Cribbing

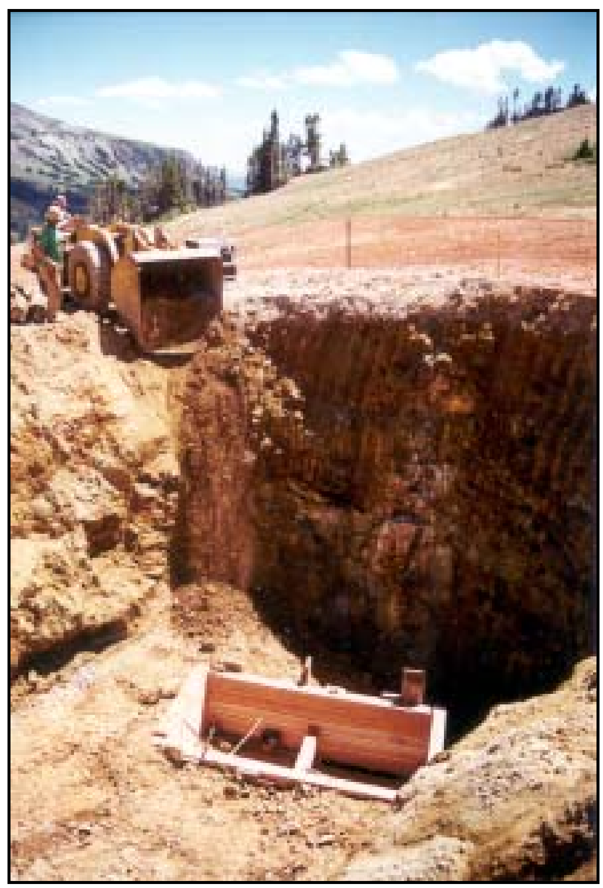

Figure 5:

Backfilling Around Cribbing

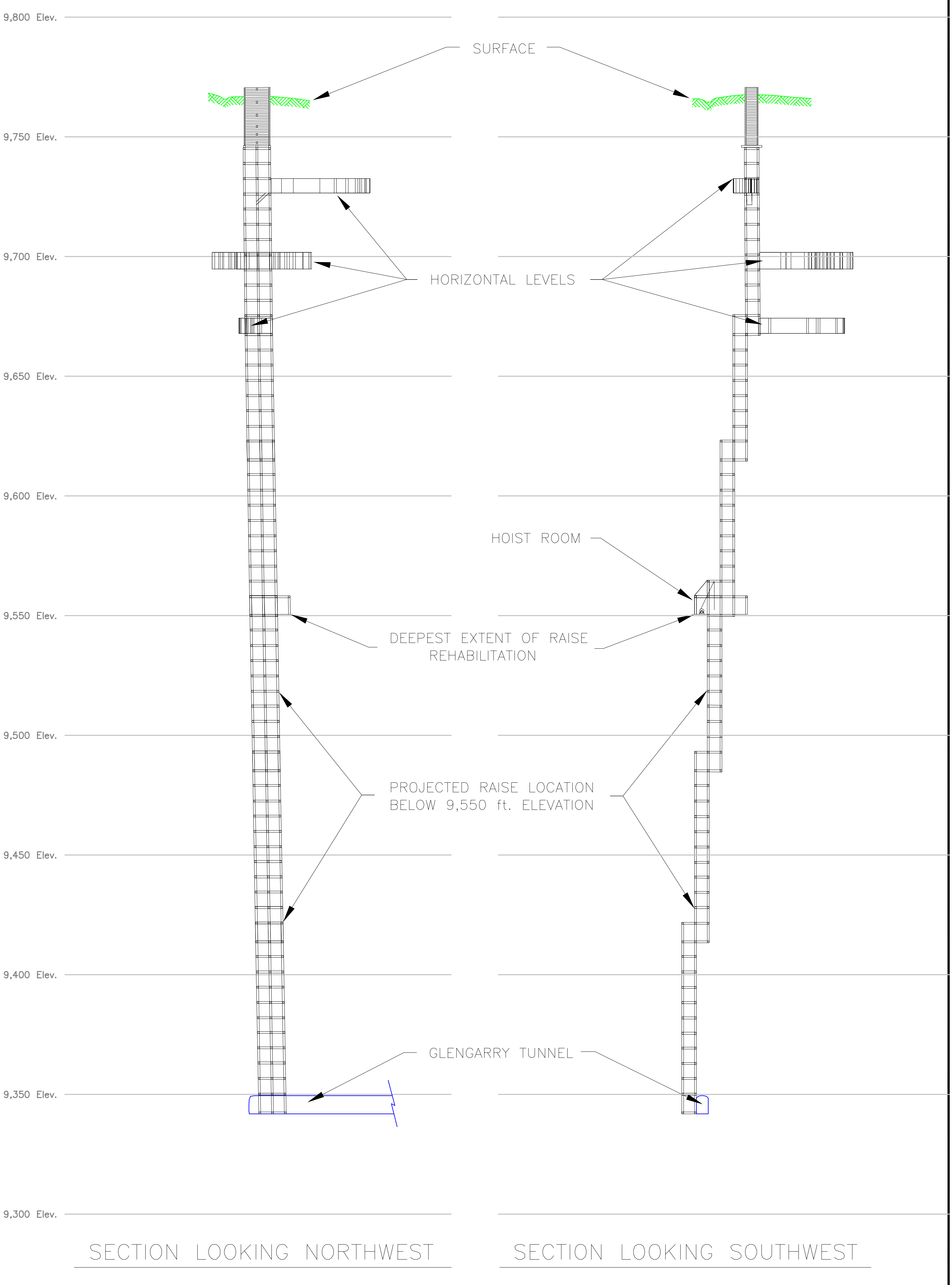

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Figure 8:

SECOND GLENGARRY RAISE

DATE: November 2001
DWG. NAME: Figure8.DWG
SCALE: 1" = 40'

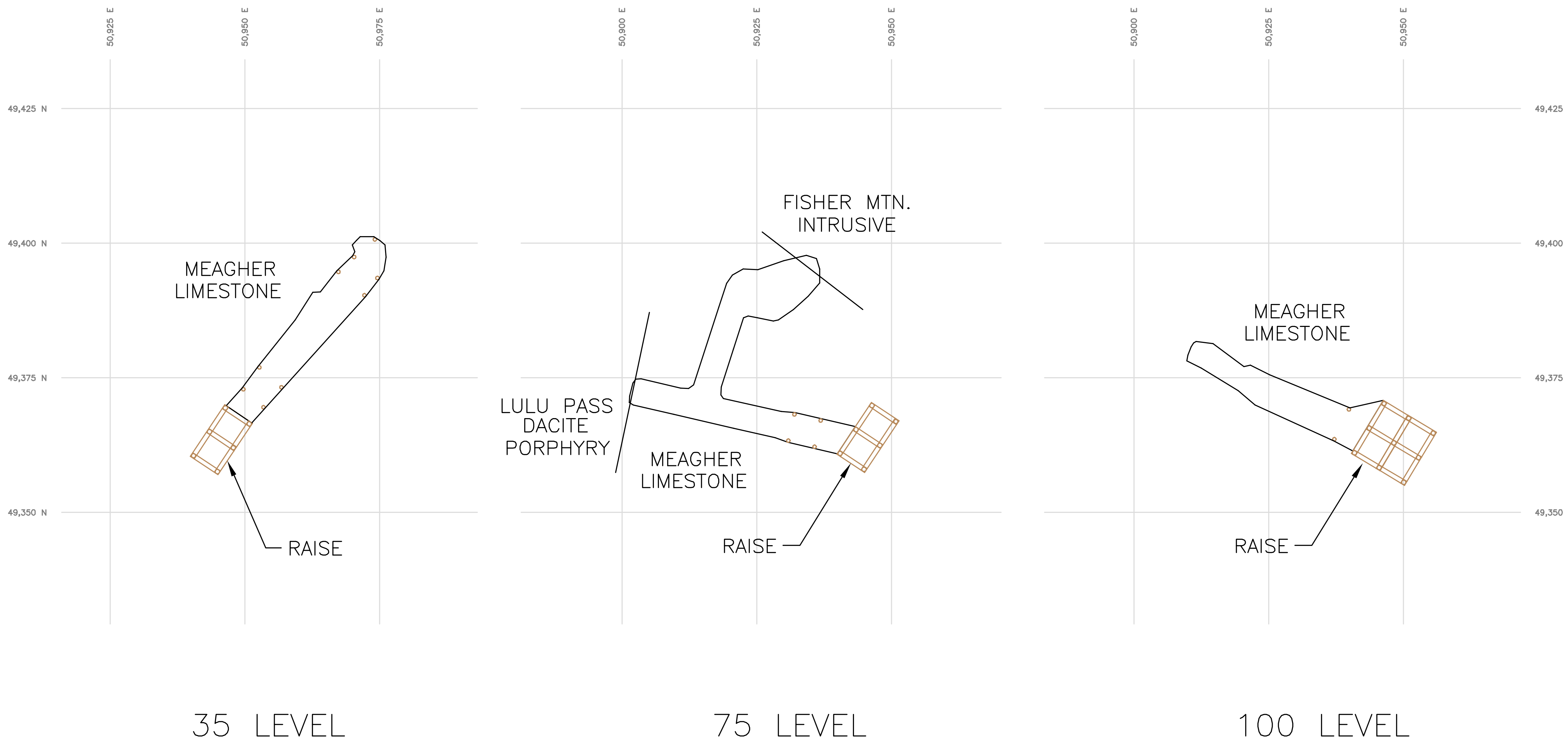

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Figure 9:

PLAN VIEWS of HORIZONTAL LEVELS

DATE:	November 2001
DWG. NAME:	Figure9.DWG

SCALE: 1" = 20'

Figure 10:

Typical Horizontal Level in the Meagher Limestone

Figure 11:

Raise Secured for Winter

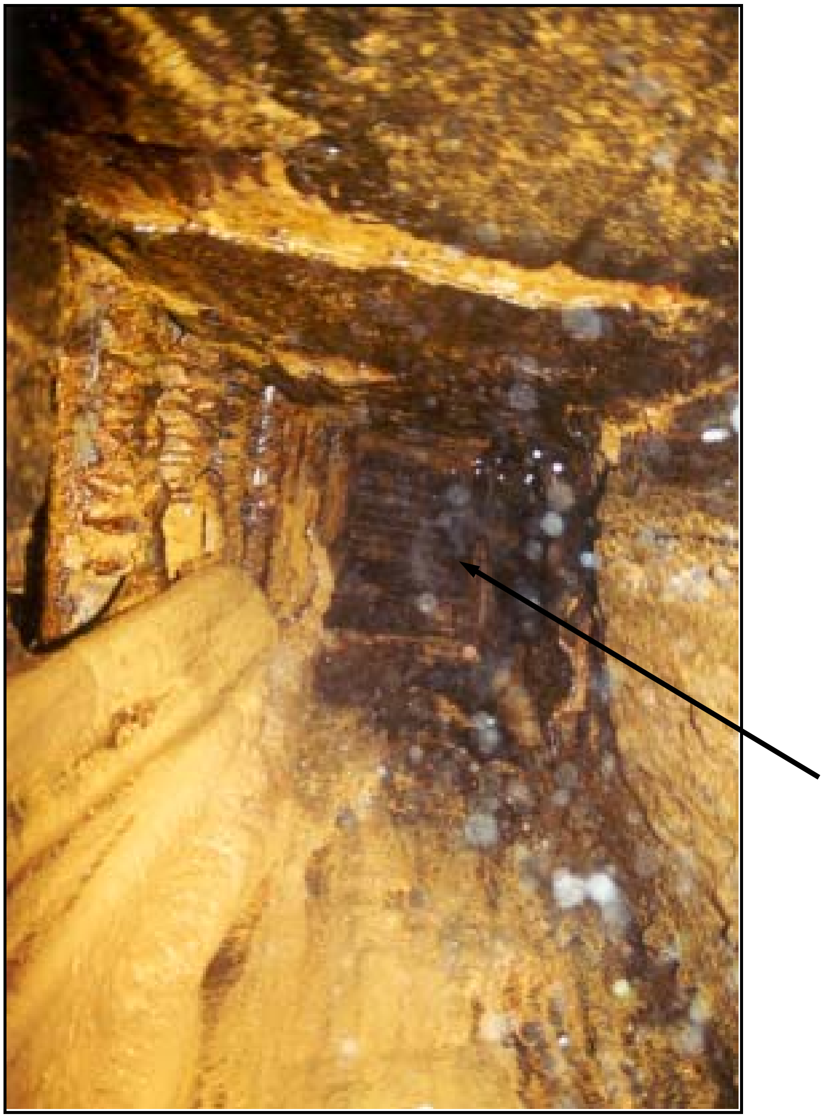

Figure 12:

Log Bulkhead in First Raise
(Looking Up Orepass)

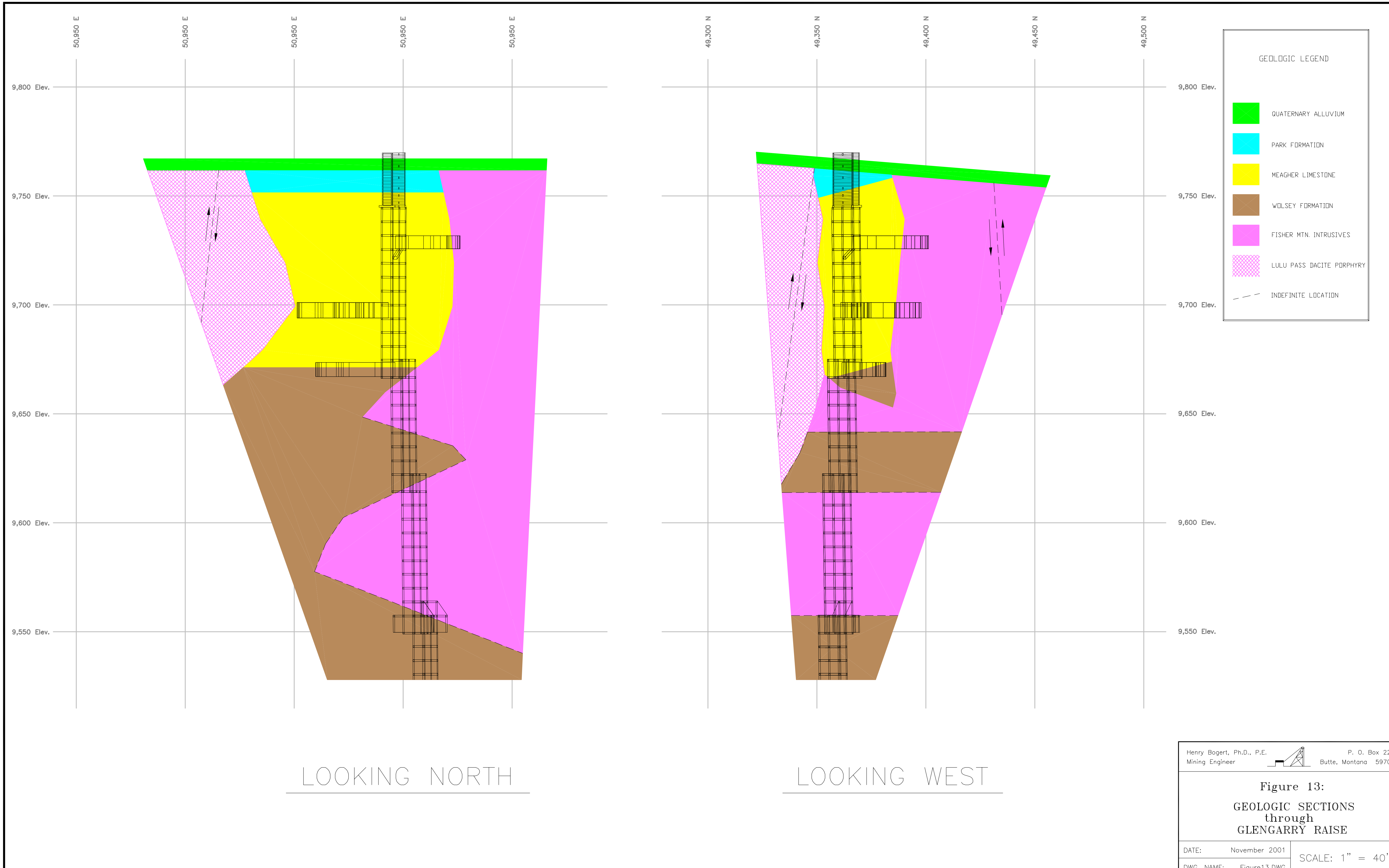
50,950 E
50,950 E
50,950 E
50,950 E
50,950 E
49,300 N
49,350 N
49,400 N
49,450 N
49,500 N
9,800 Elev.
9,750 Elev.
9,700 Elev.
9,650 Elev.
9,600 Elev.
9,550 Elev.
GEOLOGIC LEGEND
QUATERNARY ALLUVIUM
PARK FORMATION
MEAGHER LIMESTONE
WOLSEY FORMATION
FISHER MTN. INTRUSIVES
LULU PASS DACITE PORPHYRY
INDEFINITE LOCATION
LOOKING NORTH
LOOKING WEST
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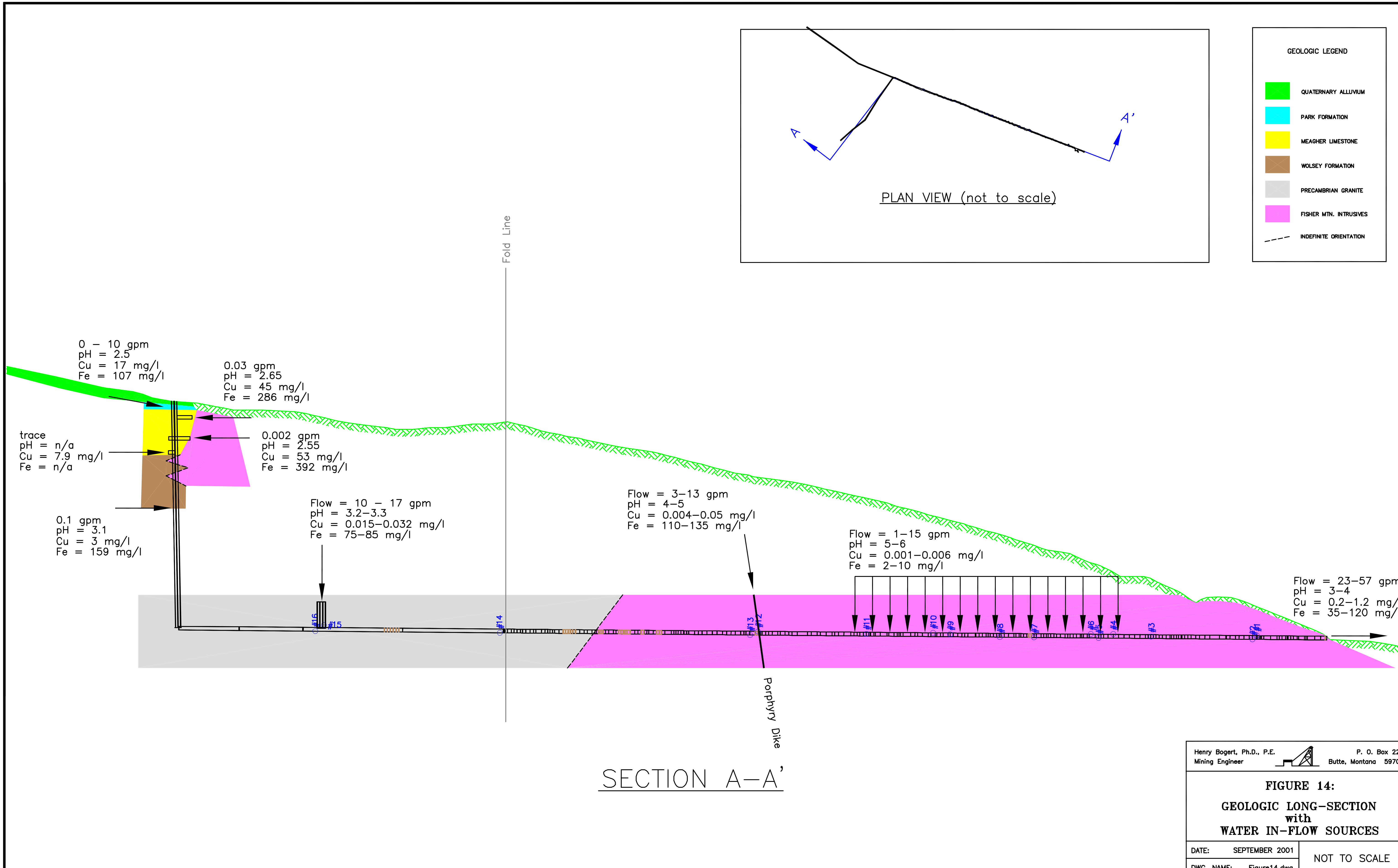
Figure 13:
GEOLOGIC SECTIONS
through
GLENGARRY RAISE
DATE: November 2001
DWG. NAME: Figure13.DWG
SCALE: 1" = 40'



PLAN VIEW (not to scale)
A
A'
GEOLOGIC LEGEND
QUATERNARY ALLUVIUM
PARK FORMATION
MEAGHER LIMESTONE
WOLSEY FORMATION
PRECAMBRIAN GRANITE
FISHER MTN. INTRUSIVES
INDEFINITE ORIENTATION
Fold Line
0 – 10 gpm
pH = 2.5
Cu = 17 mg/l
Fe = 107 mg/l
0.03 gpm
pH = 2.65
Cu = 45 mg/l
Fe = 286 mg/l
trace
pH = n/a
Cu = 7.9 mg/l
Fe = n/a
0.002 gpm
pH = 2.55
Cu = 53 mg/l
Fe = 392 mg/l
0.1 gpm
pH = 3.1
Cu = 3 mg/l
Fe = 159 mg/l
Flow = 10 – 17 gpm
pH = 3.2–3.3
Cu = 0.015–0.032 mg/l
Fe = 75–85 mg/l
Flow = 3–13 gpm
pH = 4–5
Cu = 0.004–0.05 mg/l
Fe = 110–135 mg/l
Flow = 1–15 gpm
pH = 5–6
Cu = 0.001–0.006 mg/l
Fe = 2–10 mg/l
Flow = 23–57 gpm
pH = 3–4
Cu = 0.2–1.2 mg/l
Fe = 35–120 mg/l
#16
#15
#14
#13
#12
#11
#10
#9
#8
#7
#6
#5
#4
#3
#2
#1
Porphyry Dike
SECTION A–A'
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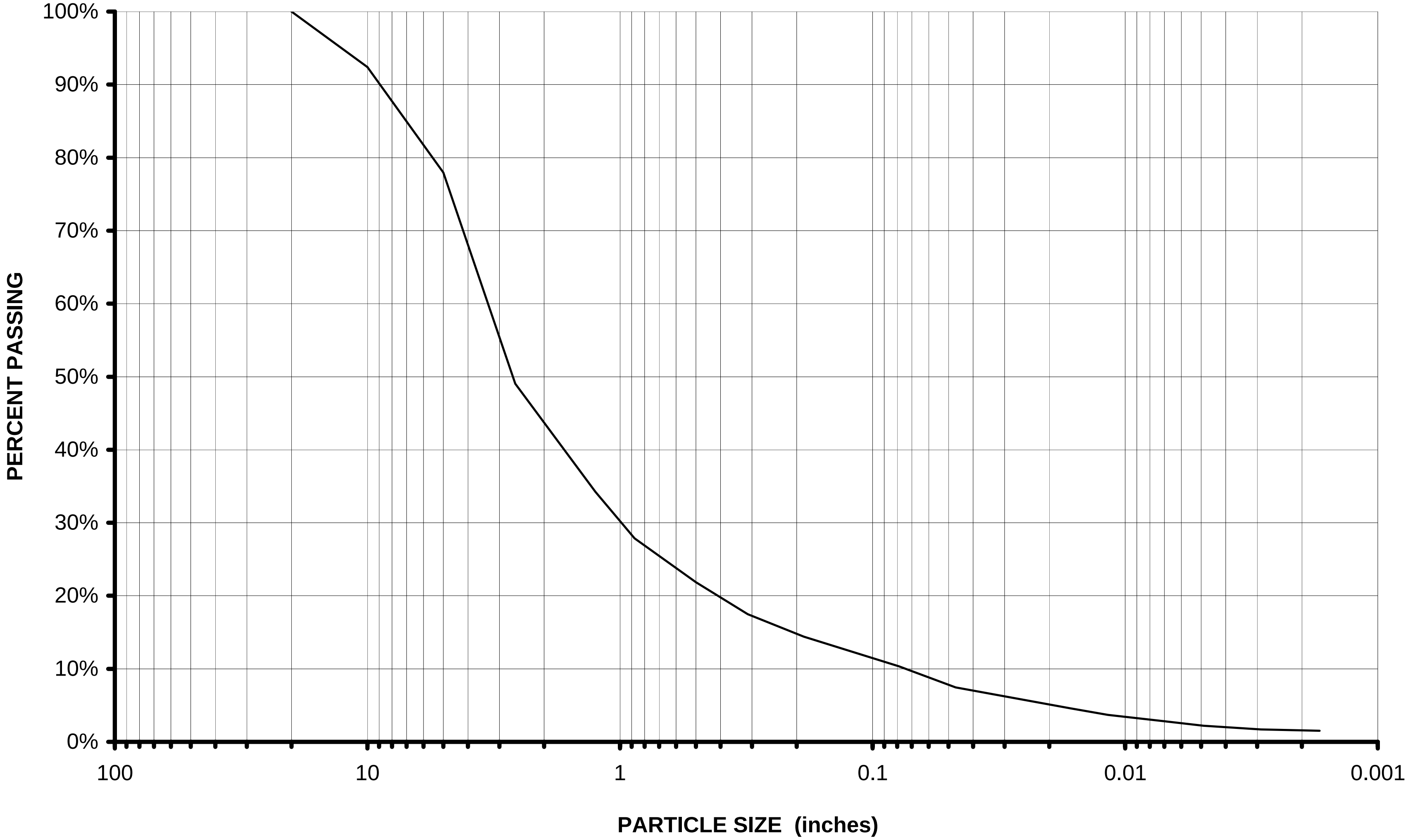
FIGURE 14:
GEOLOGIC LONG–SECTION
with
WATER IN–FLOW SOURCES
DATE: SEPTEMBER 2001
DWG. NAME: Figure14.dwg
NOT TO SCALE

Figure 15: GLENGARRY DUMP SIZE DISTRIBUTION



Passing 2.60 inch by sieve analysis of samples 1,4,7,10,11,14,17, and 20.
Greater than 2.60 inch by photo analysis of test pit muck piles.

Figure 16: 7/8" MINUS SIZE DISTRIBUTION

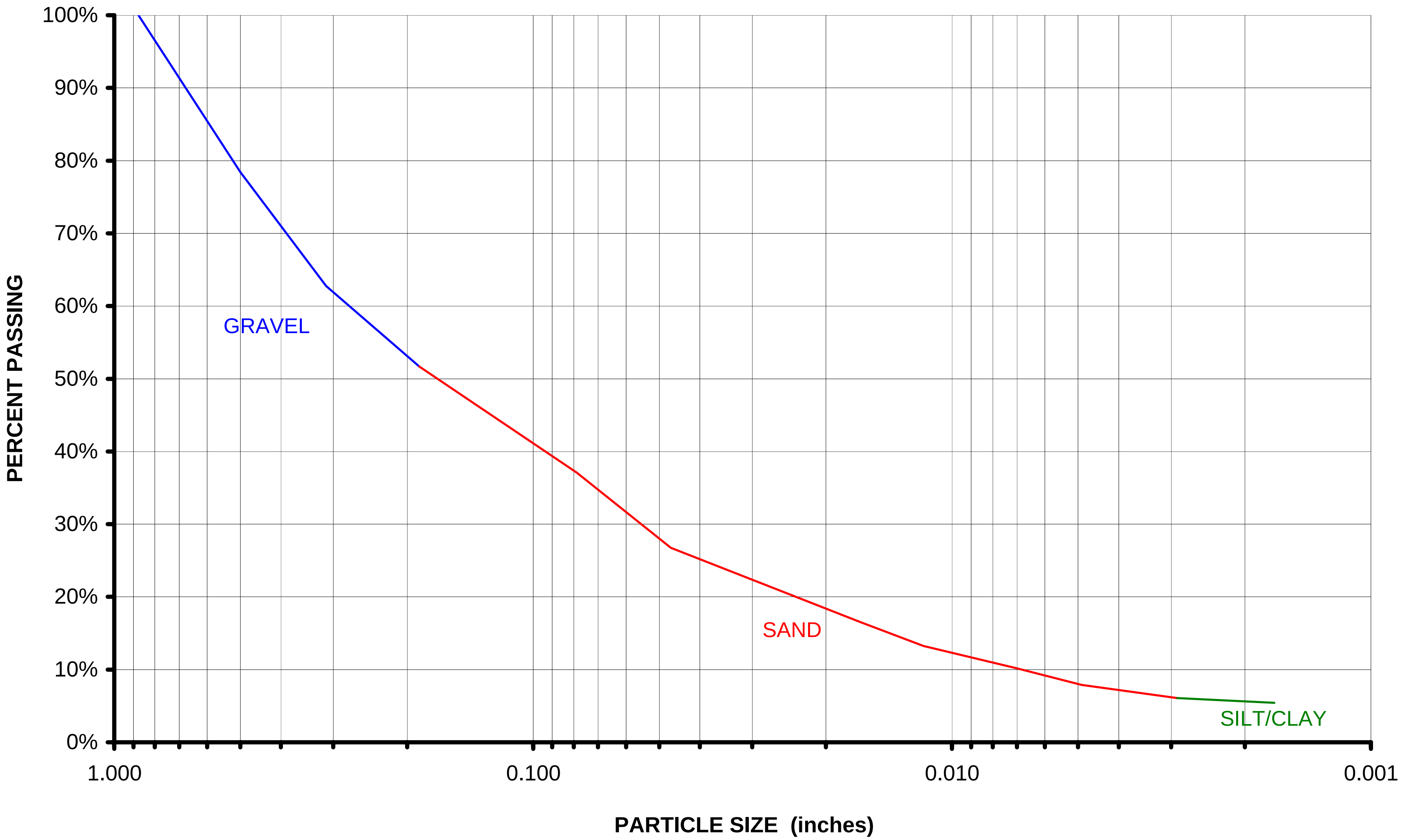


Table I: CEMENTED 7/8" MINUS DUMP MATERIAL BACKFILL ASSESSMENT

SUMMARY of CONSTITUENTS and TEST RESULTS

SAMPLE NUMBER	CEMENT CONTENT (lbs)	-0.875"/+0.500" CONTENT (lbs)	-0.500"/+0.312" CONTENT (lbs)	-0.312"/+0.187" CONTENT (lbs)	-0.187"/+0.0787" CONTENT (lbs)	-0.0787"/+0.0469' CONTENT (lbs)	-0.0469" CONTENT (lbs)	WATER CONTENT (lbs)	PERCENT ROCK and FINES IN SOLIDS (%)	PERCENT CEMENT IN SOLIDS (%)	PERCENT SOLIDS IN BACKFILL (%)	PERCENT WATER IN BACKFILL (%)	WATER-TO-CEMENT RATIO	SLUMP (inches)	SPECIMEN DIAMETER (inches)	PERCENT SHRINKAGE (lbs)	LOAD AT FAILURE (lbs)	UNIAXIAL COMPRESSIVE STRENGTH (psi)	CURING TIME (days)
1, 2, and 3	10.000	19.406	14.097	9.980	13.122	9.329	24.066	16.000	90.0%	10.0%	86.2%	13.8%	1.60	1.75	n/a	n/a	n/a	n/a	n/a
1, 2, and 3	10.000	19.406	14.097	9.980	13.122	9.329	24.066	17.300	90.0%	10.0%	85.3%	14.7%	1.73	3.00	n/a	n/a	n/a	n/a	n/a
1, 2, and 3	10.000	19.406	14.097	9.980	13.122	9.329	24.066	17.800	90.0%	10.0%	84.9%	15.1%	1.78	4.00	n/a	n/a	n/a	n/a	n/a
4, 5, and 6	10.000	19.406	14.097	9.980	13.122	9.329	24.066	18.700	90.0%	10.0%	84.2%	15.8%	1.87	6.50	n/a	n/a	n/a	n/a	n/a
1	10.000	19.406	14.097	9.980	13.122	9.329	24.066	17.800	90.0%	10.0%	84.9%	15.1%	1.78	4.00	5.81	0.0%	18,200	686	27
2	10.000	19.406	14.097	9.980	13.122	9.329	24.066	17.800	90.0%	10.0%	84.9%	15.1%	1.78	4.00	5.82	0.0%	18,850	709	27
3	10.000	19.406	14.097	9.980	13.122	9.329	24.066	17.800	90.0%	10.0%	84.9%	15.1%	1.78	4.00	5.87	0.0%	19,800	733	27
4	10.000	19.406	14.097	9.980	13.122	9.329	24.066	18.700	90.0%	10.0%	84.2%	15.8%	1.87	6.50	5.85	0.7%	12,550	468	27
5	10.000	19.406	14.097	9.980	13.122	9.329	24.066	18.700	90.0%	10.0%	84.2%	15.8%	1.87	6.50	5.86	0.8%	12,650	469	27
6	10.000	19.406	14.097	9.980	13.122	9.329	24.066	18.700	90.0%	10.0%	84.2%	15.8%	1.87	6.50	5.85	0.8%	13,050	486	27