START 3

Superfund Technical Assessment and Response Team 3 – Region 8

United States
Environmental Protection Agency
Contract No. EP-W-05-050

FIELD ACTIVITIES REPORT
Mine Adit Entry

RED AND BONITA MINE SITE
Silverton, San Juan County, Colorado

TDD No. 1008-01

January 20, 2012

URS
OPERATING SERVICES, INC.

In association with:
Garry Struthers Associates, Inc.
LT Environmental, Inc.
TechLaw, Inc.
Tetra Tech EMI
TN & Associates, Inc.

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1.0 INTRODUCTION

URS Operating Services, Inc. (UOS), was tasked by the Environmental Protection Agency (EPA), under Superfund Technical Assessment and Response Team 3 (START) contract # EP-W-05-050, Technical Direction Document (TDD) No. 1008-01, to provide technical support to the Region 8 On-Scene Coordinator (OSC) at an abandoned mine site near Silverton, San Juan County, Colorado. Specifically, START was tasked to develop a scope of work and obtain a contractor to perform work activities to rehabilitate the collapsed mine portal at the Red and Bonita mine, and to perform oversight activities during the performance of the mine portal activities. Field activities followed the applicable UOS Technical Standard Operating Procedures (TSOPs) and the Emergency Response Program generic Quality Assurance Project Plan (UOS 2005a,b).

Field activities to reveal the collapsed mine adit and install a new mine portal structure were performed during August 24 to October 13, 2011. Weather conditions included sunshine, rain, and snow. The Red and Bonita Mine site is located along Cement Creek, approximately 10 miles north of the town of Silverton, Colorado, centered near 37.897236° north latitude and -107.64382° west longitude (Figure 1).

2.0 BACKGROUND

2.1 RED AND BONITA MINE

The Red and Bonita Mine is in the Cement Creek watershed, which is a component of the upper Animas River watershed. These watersheds were the focus of both large- and small-scale mining operations that flourished beginning in 1871 and lasting until as late as 1991 (U.S. Geological Survey [USGS] 2007). Though this region has been extensively studied, including geologic, hydrologic, and geochemical studies in the evaluation of metals contamination and acid mine drainage (AMD), limited documentation exists on the Red and Bonita Mine specifically, likely because it resides on private land (USGS 2007). However, recent studies have indicated that the mine is releasing a significant load of contaminants to the Animas River. Photo documentation is included in Appendix A.

The Red and Bonita mine site consists of approximately 1.25 acres of waste rock and suspected tailings material, a collapsed but flowing mine adit, and accompanying debris including the site of a former smelter on the north side of the mine dump (Figure 2). The mine is located on the west-facing slope, east of Cement Creek, approximately 200 vertical feet above the creek. The slope of the mountainside on which the mine is located has an average 44 percent grade; i.e., a 23.75

degree slope (100 percent grade equals 45 degrees). The talus slope immediately above the mine was measured by START to be 81 percent; i.e., 39 degrees.

The adit at the Red and Bonita Mine has been collapsed/covered for an unknown number of years and is currently releasing acid mine drainage (AMD) at a rate observed to range from 0.4 cubic foot per second (cfs) (180 gallons per minute [gpm]) in April 2010 to 0.749 cfs (336 gpm) in May 2009 (Table 4). The covered adit dimensions were difficult to distinguish by viewing the hillside, although red ferric hydroxide (iron hydroxysulfate); i.e., yellow boy, staining precipitated by AMD flowing from the collapsed adit was visible in an area approximately 7 feet across and to 7 feet above the top of the mine dump. These dimensions were later observed to reasonably reflect the actual adit dimension, indicating that the portal collapse material was porous; i.e., AMD did not flow around the collapse, but rather flowed predominantly through the collapse. Observations and effort performed during the summer of 2011 to remove collapsed material at the mine portal to reveal the mine adit are described herein.

The surveyed location of the mine adit inby where water flows from the slope was poorly constrained, and is shown in a map produced in 1899 that was obtained from the State of Colorado Division of Reclamation, Mining, and Safety (DRMS). This map shows an adit survey conducted in 1899 and depicts the Red and Bonita adit as a single tunnel with a dogleg to the right. Based on the 1899 map, the first 50 feet inby trends to the east at N61ºE, and at 50 feet the adit direction changes to S79ºE inby. A structural geologic investigation was performed at the Red & Bonita mine area by the DRMS in 2007, their reporting is included in appendix C. The investigation included structural and geotechnical observations with regard to emplacement of an interior bulkhead, as well as future study needs (DRMS 2007).

A groundwater monitoring well, RB-1, was drilled and installed in September 2010 at a location above the mine dump into what was then suspected to be the mine adit. The well was later visually confirmed to be completed in the mine adit upon removal of the collapsed portal in September 2011. The well, located approximately 25 feet inby of the portal area, was used to observe static water changes within the adit during removal of the adit blockage. Static water level measurements are included on Tables 1 through 3. Also, days prior to adit entry activities, a dissolved oxygen measurement was obtained from well RB-1 and from AMD effluent water on the top of the mine dump. Results indicated that dissolved oxygen within adit water behind the collapsed portal was slightly greater than that outside of the collapsed portal in ambient conditions; i.e., 7.87 milligrams per liter (mg/L, or 93.1 percent) versus 7.21 mg/L (87 percent).

2.2 SITE ACCESS

Activities at the Red and Bonita mine, including road access, incorporated several mine claims: the American Eagle Mill Site, Success Placer, Sampson Mill Site, Belcher, Letter B, and the American Eagle. Site access agreements were managed by EPA. Road access is via County Road (CR) 110 from the town of Silverton to CR53 located at the abandoned town site of Gladstone. CR53 continues northward up the Cement Creek valley to other mines and also passes the base of the Red and Bonita mine (Figure1). The mine is accessible during non-snow months of the year, typically late June through early October.

Access to the top of the mine dump is via an earthen road that intersects CR53 approximately 1,000 feet north of the mine site, and which crosses private and Bureau of Land Management (BLM) land. This “north access road” required improvement in order to mobilize heavy equipment to the adit area, as well as routine access by workers (Figure 2). An attempt was made to make minimal improvements, such as limited widening to 10 feet (excavator tracks overlapped the downslope road edge), and re-grading only when necessary. Minor rough grading was required to reduce road rolls and deep tracks that caused high-center problems, as well as downslope dips that caused vehicles to slip downslope when the road was wet. It is anticipated that road restoration activities will take place upon completion of site activities.

Also, an original road (“south access road”) accessing the mid-portion of the mine dump intersects CR53 approximately 250 feet south of the mine. Minimal restoration was performed on this road, as it was not used for site access. However, water springing from the mountainside along the road-cut flowed along the road and caused downgradient water flooding issues. Water bars were placed on the road to divert the water. The lower portion of the south road was utilized as a large equipment storage area where metal culvert and an equipment trailer were staged.

The top surface of the mine dump was capped with talus overburden material derived from the monitoring well RB-1drill pad located above the mine dump, constructed in September 2010. The dump was resurfaced to allow for equipment access and for excavation activities at the collapsed mine portal, and was required due to a thick sequence of soft yellow boy fines on the dump surface. Yellow boy fines were not allowed to release to areas below the dump pad. In addition, a basin was constructed below the AMD outflow from the adit to control and divert adit flow while work progressed to expose the adit portal.

3.0 FIELD METHODS

3.1 DESIGN AND WORK CONSIDERATIONS

Several consultant and regulatory entities were consulted by EPA and START during informal and formal inquiries regarding safety issues and design considerations inherent in removing a collapsed mine portal that is holding back a volume of water, as well as the physical removal and handling of materials at the mine site to achieve the site goal of accessing the mine adit and replacing the mine portal. The approach to remove the collapsed material at the mine portal, handle AMD water flowing from the collapsed portal while not releasing additional impacts to Cement Creek, and construct a new secure mine portal, were primarily designed and performed by the Frontier Environmental Services Company (Frontier), Arvada, Colorado. Heavy equipment used by Frontier while on site included a CAT 325 excavator, a CAT 950 front end loader, a CAT D-5G dozer, and a Goodwin impeller pump with a 1,000 gpm capacity.

3.2 WORK PAD AND SOUTH DITCH CONSTRUCTION

The top surface of the roughly level mine dump is approximately 2,400 square feet in size. AMD effluent water flows from the collapsed mine portal toward the face of the mine dump via an alternating channel where it then flows toward Cement Creek approximately 200 feet below. The natural deposition/movement of the channel of AMD from the mine during the past several years has resulted in deposition of an approximately 10-inch thick layer of yellow boy fines onto 75 percent of the dump surface. The yellow boy fines form an armored surface but are saturated and become “pudding-like” when disturbed; therefore, the surface was reinforced to allow work activities to take place (Photo 16).

Rock debris from the site consisting mostly of loose talus material ranging in size from 1-inch pebbles to 12-inch cobbles was placed over the yellow boy fines to add support to the unstable mixture. A 7-ounce non-woven geotextile underlayment fabric was then placed onto the yellow boy/talus material to inhibit any upward migration or leakage of yellow boy fines (Photo 17). An additional 6- to 12-inch layer of talus material was then placed upon the fabric. Additional talus material derived from the adjacent mountain slope and work area was added to the working surface of the mine dump as required to perform operations.

A drainage ditch (south ditch) was constructed adjacent to the south side of the mine dump and was used to divert AMD effluent from the collapsed portal, away from the work area on the dump surface, and ultimately into the previously established ditch system below the mine dump that conveyed water into Cement Creek (Figure 2, Photo 13). The ditch was constructed to a shallow depth, less than 2 feet, because a very hard ferricrete rock formation was encountered under near-surface sediments and dump material (Photo 14).

Ferricrete is a deposit of alluvial material (sediments transported by water forces) or colluvial material (land-derived sediments) cemented together by iron hydroxysulfate material. Colluvial ferricrete deposits are either wet or dry and are formed on hill slopes and in narrow debris channels where rock and soil can accumulate in colluvium, talus, and alluvial fan deposits. Ferricrete deposits are massive to weakly stratified and are typically sub-parallel to the current slope, or drape existing topography. They will form in surficial deposits that are adjacent to, or that overlie, mineralized faults and veins and pervasively altered bedrock (USGS 2007). Typical precious metal occurrence within mountainous terrain is within faults and fractures where hydrothermal fluids once migrated. Precious metals are dropped from the fluids as they cool, thus creating mineralized zones that are the focus for mining. Ferricrete is also formed where fluids carrying iron hydroxysulfate cementing agent are released, e.g., from faults and fractures which release outward onto mountain slopes. This appears to be the case at the Red and Bonita mine where a shallow deposit of ferricrete is present under the mine dump and within the adjacent mountain slope to an undetermined lateral extent.

Evidence of the existence of ferricrete south of the mine site lies in the fact that when water flowed within the south ditch (i.e., on top of the ferricrete), three seeps were observed to form within hours of water placement into the ditch at locations downgradient (south) of the ditch, likely indicating flow along the impervious ferricrete plane. Seep flow ceased when water was diverted from the ditch. Two seeps were newly created while one existing seep appeared to have an enhanced flow. The seeps were located approximately 50 feet, 115 feet, and 170 feet south of the south ditch, each in subsequently hydraulically lower locations, and flowed at visual estimates of 0.5 gpm, 2 gpm, and 5 gpm, respectively, for short distances before re-entering the ground. Water flow observed below the seeps from the upgradient bank of the south access road-cut flowed at a visually estimated rate of 1 gpm prior to diverting flow into the south ditch, but increased to approximately 25 gpm during periods of water flow within the south ditch.

3.3 AMD WATER DIVERSION

AMD effluent water from the collapsed mine portal was captured into an approximately 10-foot diameter sump (Photo 22) constructed from talus material near the mine portal where it could be diverted to one of two locations, dependent upon need:

1) During periods of inactivity, when the AMD effluent water did not carry any visible suspended load from the adit, the water was routed from the sump through a 12-inch diameter polyvinyl chloride (PVC) under-pipe to an 8-ounce non-woven geotextile fabric "Dandy De-Watering Bag®" (filter bag) located south of the adit work area on the dump surface (Photo 23). Dimensions of all filter bags were15 feet by 15 feet with no side walls. The filter bag was intended to act as a filter before releasing AMD water into the south ditch.

2) During all active excavation activities at the collapsed mine portal, AMD effluent was pumped from the sump to a series of filter bags located at the toe of the dump (Photo 24). Flocculent was added to this flow to avoid plugging the filter fabric and to aid in dropping out solids inside the filter bag prior to releasing back into the road ditch system. Additionally, a filter bag was placed within the road ditch system at the outflow end of the culvert pipe located under CR53 before passing onto Cement Creek.

The filter bag on the PVC under-pipe at the dump surface, as well as the filter bag at the culvert pipe under CR53, were not intended to be primary filters for the AMD water, but were placed as a precautionary measure to capture possible sediment movement. In addition, these filters provided a backup to the primary filter system, if needed.

3.4 AMD WATER FILTRATION

The adit discharged AMD at a rate of approximately 250 to 300 gpm and needed to be managed during operations to reduce the release of sediment and yellow boy iron precipitation accumulated in the adit. AMD water was filtered during all collapsed mine portal excavation activities via a filter bag manifold system located at the north toe of the mine dump adjacent to CR53 within the road right-of-way. The filter bag manifold system was located at the toe of the dump due to space limitations near the mine portal. AMD water was directed from the sump (located at the collapsed mine portal) to a series of four filter bags. Water was typically pumped at a rate of 300 to 450 gpm through 6-inch PVC piping to the filter bag manifold system. Because water flow could be manipulated at each filter bag via dedicated valving, specific flow to each filter bag could be adjusted to achieve uniform dispersion among the four filter bags. An aluminum sulfate flocculent was also added to the AMD water through tubing installed in the PVC piping at a point on top of the dump, allowing for thorough mixing within the piping prior to entry into the filter bags below (Photo 34). Flocculent was required to coagulate yellow boy fines into larger masses so as to not saturate the filter bag walls and cause a “blinding” effect that prevented water from draining. The liquid flocculent was metered into the PVC piping by a peristaltic pump at an approximate flow rate of 30 to 100 gallons per day (gpd), adjusted based on visual observation of filtered water releasing through the walls of the filter bags. Filter bags were replaced as needed. Spent filter bags do not pose any hazards and are currently safely stored at the site awaiting final disposition. AMD water analytical data is included on Tables 4 and 5.

3.5 COLLAPSED PORTAL EXCAVATION DESIGN

The approach employed to safely excavate collapsed material from the mine portal area was to first construct benches on either side of the portal area from which to stage the excavator (Photo 28). Abundant talus material was present on the mountainside at the work area which was used to construct the benches, which were built to a height equal to the upper level of water flowing from the collapse. This configuration allowed access by the excavator to both sides of the collapsed portal to safely remove material while remaining out of a potential adit blow-out flow path in front of the collapse. During excavation activities, yellow boy fines typically washed from the disturbed collapse material by the flowing AMD effluent water. The flow was captured within the sump located below the collapsed adit and pumped to the filter bag manifold apparatus located at the toe of the mine dump where suspended solids were captured.

Once the mine adit outline within competent rock was established by removal of much of the collapsed material, a 40-foot long, 6-inch diameter steel pipe was inserted into the mine adit through the remaining portal collapse (Photo 33). The pipe was used to pump water from the adit in order to reduce head pressure on the remaining portal collapse so additional excavation could be performed safely. The pumping rate through the pipe was monitored to gain insight regarding the potential of additional blockages inby of the mine portal by observing water extraction and recharge rates.

The pipe was inserted into the adit at an approximate angle of 19.5 degrees, as measured from the top of the collapse, and did not encounter resistance until approximately 20 feet of pipe was in the adit. Resistance was very firm and is believed to have been caused by the floor of the adit. The pipe continued to slide along the resistance, pushed by the excavator, to its terminal point of 37 feet inby. The full adit blockage at the adit portal was eventually removed and AMD effluent water now flows freely from the adit along the adit floor. Tables 1 thru 3 include AMD water pumping data.

4.0 FIELD ACTIONS AND OBSERVATIONS

4.1 PORTAL / ADIT EXCAVATION

Loose talus material that had collapsed over the Red and Bonita mine portal was removed by using an excavator accessing the portal area from either side of the collapse. The material was placed onto the mine dump surface. Approximately 10.5 vertical feet of material was eventually removed at the portal area to reveal the outline of the mine adit within a deposit of ferricrete. During the process of portal excavation, approximately 10 pieces of narrow gauge railroad track material 5 to 8 feet in length were encountered, along with deteriorated wood debris. The rail is believed to have been used as spiling for the roof (back) of the portal, as the pieces were cut to a point on one end so that they could be driven into the mountainside. Wood debris included a few pieces of planking and larger beams that had become dislodged through the years.

During excavation activities, AMD effluent water was observed to flow through the collapsed material from a distinct upper horizontal limit, as determined by yellow boy staining. This upper limit line coincided with the current adit flow, and was later discovered to coincide with some of the rail spiling. Upon additional excavation it was determined that AMD effluent water was releasing from the adit at the roof elevation. The mine adit outline was eventually observed to be easily distinguished from the mountainside and was encountered within a few horizontal feet of the slope surface (Photo 30). The adit entrance was discovered to be contained within a resistant ferricrete formation of undetermined thickness and lateral extent. Apparently, because of the steep 44 percent slope, loose talus material was able to slide down-slope over an unknown number of years to collapse and fill the mine portal area.

A ferricrete brow forming the top of the adit portal was readily distinguished and outward sloping ferricrete formed the sides of the adit in wedge shapes, apparently formed as the adit was cut into the sloping ferricrete formation (Photo 39). The ferricrete formation at the adit entrance appears to have formed at a slope angle similar to the existing mountainside slope. An approximate 2-foot thickness of material, mostly fines apparently transported by out-flowing AMD, was observed on the adit floor at the entrance, and the fines are suspected to become thinner with further entry into the adit, as the adit floor is declined to promote outward water flow. Approximately 4 feet of void space was measured from the fines on the floor to the adit roof. A timber set is observed an estimated 80 feet inby, as well as remnant material including a wood wedge still intact on the right rib near the entrance (Photo 44).

Ferricrete walls inside the adit are stained red, orange, and white (Photo 45). The various colors are likely due to differing metals (likely predominantly iron and aluminum) dropping out of solution onto the rock walls. Apparent integrity of the adit seems to be very good as little collapse material could be discerned on the adit floor, and the adit walls and roof do not seem to be malformed from excessive caving.

An entry attempt by EPA and DRMS was abandoned when oxygen meters indicated a depleted (19 percent) oxygen content within 30 feet of the adit portal. Carbon monoxide was not detected, nor was hydrogen sulfide. There also was no discernable air movement from the adit, indicating a lack of communication with an open air source.

4.2 PORTAL INSTALLATION

In order to install the new corrugated galvanized metal culvert portal structure as closely to the adit opening as possible, a minor amount of ferricrete had to be broken from the outwardly sloping side walls using the excavator. The ferricrete was very hard and difficult to break from the mountainside (Photo 41). A 10- foot horizontal section of 10-foot diameter culvert pipe was placed to within approximately 3 feet of the top of the sloping ferricrete adit entrance, although the lower half of the culvert pipe fit snugly against the ferricrete rock face where it had been broken out (Photo 42). Douglas fir timber roof supports were bridged from the top of the metal culvert to the ferricrete rock face and covered with loose talus material. A wood timber set was also placed under the roof support at the ferricrete rock face for added support (Photo 43). An additional 5-foot section of galvanized metal culvert pipe was also spliced to the original 10-foot section for a final portal length of 15 feet, leaving sufficient area to access the remaining dump pad. The portal structure rests on a ferricrete floor and, therefore, could not be lowered.

A 12-inch diameter PVC pipe was placed inside the bottom of the culvert structure and covered with talus material to create a walking surface. The PVC pipe directs free-flowing AMD effluent water into an open ditch located at the entry to the portal structure, which leads to the face of the mine dump. The AMD effluent water then spills over the mine dump in the same fashion and location as it did prior to adit entry activities. A locking, secure, metal barrier was constructed and welded into place inside the metal culvert structure. The metal barrier is constructed of a 1-inch wide metal grid reinforced with angle iron. A 6-foot locking metal door was fitted into the barrier. The mine portal is currently secure and draped with a tarp for protection from the elements.

4.3 OBSERVATIONS

The newly exposed adit opening was large enough to enter via the new portal, and existing timber sets inby the portal approximately 80 feet were visible. A mine inspection has not occurred; however, it appears plausible that the Red and Bonita mine adit was advanced through a thick deposit of ferricrete that is likely in contact with crystalline andesitic rock. Based on the 1899 map of the mine workings, the point where the mine adit turns approximately 45 degrees to the southeast (approximately 250 inby of the portal) may indicate the contact plane between the ferricrete and the crystalline rock that forms the mountain. This scenario would, however, require a very thick deposit of ferricrete. The turn-in the adit appears to coincide with the crystalline rock outcrop visible in the field and in aerial photography.

The ferricrete visible at the mine portal appears to be massive and mostly intact with little deterioration. The crystalline andesitic rock forming the mountain is a massive, regionally extensive formation, which is extremely hard and resistant. Fracturing and jointing are, however, present within the crystalline rock as evidenced by historical water movement (ferricrete deposition) and mineralization where mining took place.

Other openings into the mine are not apparent on aerial photography at this time, also evidenced by the fact that the air within the adit did not seem to be moving during adit excavation and portal construction activities. Additionally, low oxygen levels were observed during an attempt to enter and inspect the adit. It is, however, possible that oxygen amounts are consumed within the adit in chemical reactions. Regardless, air within the adit appears to not be moving and may require ventilation before interior work may take place.

Groundwater in the form of AMD flows from the adit at a typical rate of approximately 300 gpm. This flow rate indicates that some prolific fractures, joints, contact planes, other workings, etc. are present within the adit in some form. It may be possible that there is only one major water source, with other minor sources contributing. Geologic mapping of the adit should be performed to better understand the groundwater flow.

Large volumes of water were removed (multiple times) from the adit during activities to remove the blockage and appeared to flow from an unobstructed adit in relatively short time frames. There were no apparent pauses in water extraction rates, or pulsing water flow indicated by sporadic pump operation. Also; during pumping operations a water volume of 27,000 gallons was observed to re-fill the mine adit within a 90 minute time span based on an in-flow rate of 300 gpm. The 27,000-gallon volume is also in agreement with the estimated pump discharge volume for that event. The static level inside the adit was observed to rise 2.39 feet during that recharge period. Assuming a 5-foot wide adit (as appears to be the approximate case by visual observation at the mine portal), the volume of water would fill a space approximately 304 feet long. By these observations a complete adit collapse within 304 feet inby the portal is not likely. There could, however, possibly be a partial collapse that is not observable via the existing observation point near the portal. Groundwater is currently flowing from the mine adit at a constant rate, unchanged from the flow rate prior to adit entry activities.

A pressure transducer was placed into the mine adit via well RB-1 in October 2010, and removed in September 2011 pursuant to adit entry activities. The transducer was calibrated to log temperature, specific conductivity, and water depth. Data is presented in Appendix B. Because of accumulation of yellow boy precipitate onto the transducer, some measurements are suspect.

5.0 SUMMARY

Future entry and inspection for water resources and rock structure relative to potential bulkhead placement will require ventilation and adit rehabilitation with placement/replacement of timber sets and clean-out of residual precipitation solids from the adit floor. Because the adit maintains a perennial flow of AMD, some water handling inside the adit would also be required. The base area around the mine portal will require modification to allow for reasonable access into the mine by personnel and equipment; e.g., the AMD flow will likely need to be placed into a buried outflow pipe so that a level working surface outside of the portal may be constructed. Well RB-1, which was installed into the mine adit in 2010 from a bench above the mine portal, should be abandoned as it is no longer useful. Pending work on the mine adit rehabilitation, site restoration work will be performed. As the site is located at an elevation of 11,000 feet, it receives ample snowpack and is accessible typically during July through September; therefore, work seasons are short.

6.0 REFERENCES

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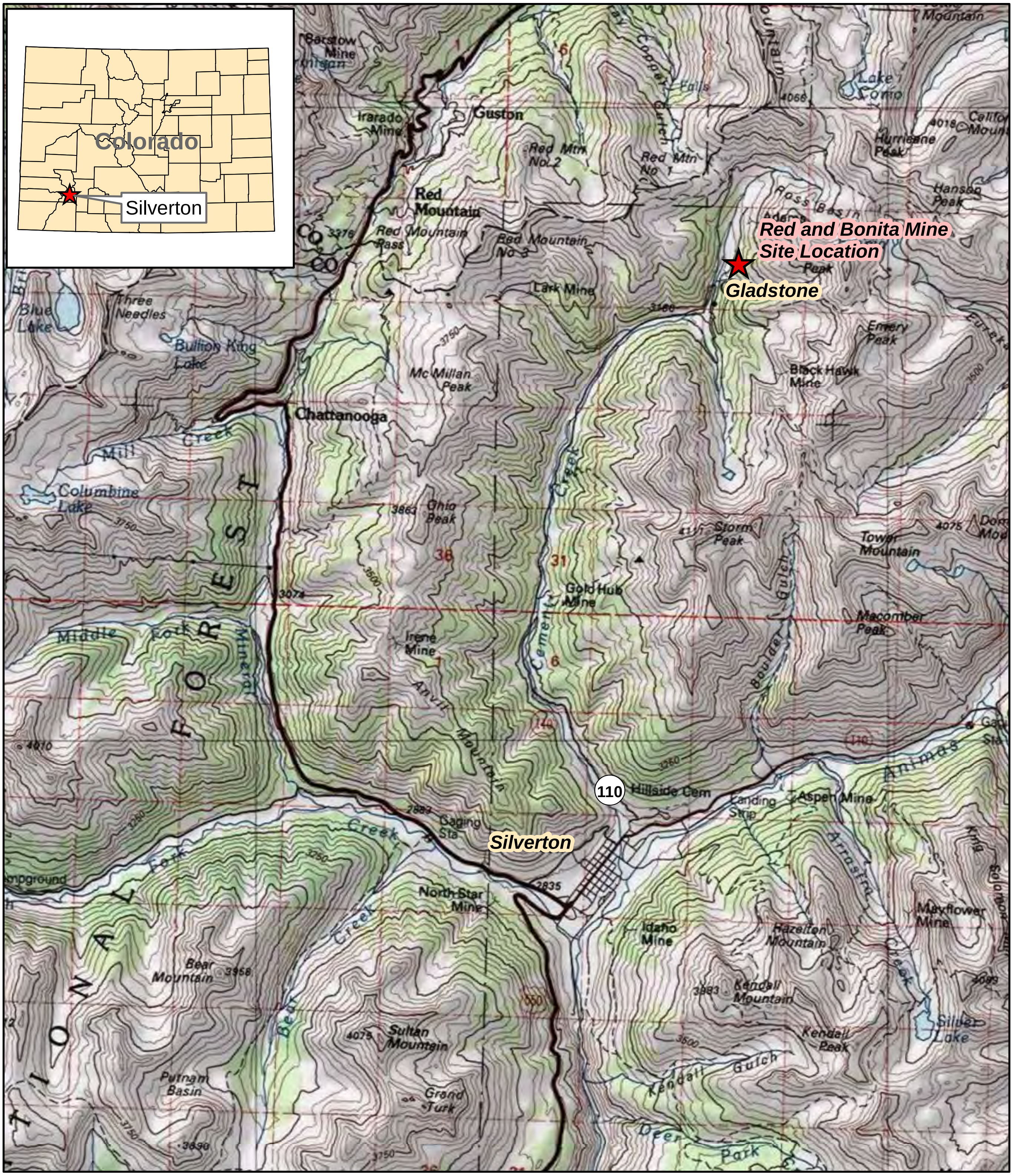

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Projection System: NAD 1983 UTM Zone 13N Page Size: 11x17	TDD Title: **Red and Bonita Mine and Mill** Figure: 2	Sources: Bing Maps© Aug - Sept 2011 Aquisition National Hydrography Dataset Field Observations
N Feet 0 62.5 125 250	Figure Title: Site Features TDD County: SAN JUAN TDD State: CO TDD: 1008-01 Date: 01/2012	URS OPERATING SERVICES UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Table 1
AMD Water Pumping Data - Well RB-1*

Time	Static (ft bgs)	Comment
9-27-2011		
08:35		Filter bags at manifold slightly used during portion of prior work day.
09:15	29.88	No pumping, static equilibrium.
10:17		Pump from sump to check strength of collapse material in adit. Pumping all water produced by adit. Rpm = 1100, estimate 300 gpm.
10:40		Pump off.
11:00		Begin pumping from adit. 1500 rpm = estimate 450 gpm. Flocculent added at 30 gpd.
11:13	30.49	
11:10		All flow from adit stop. Decrease rpm=1400.
11:21	30.68	Rpm=1400.
11:31	30.92	Rpm=1400.
11:43	31.34	Rpm=1400.
11:51		Visual flow estimate in ditch 600 gpm. Possibly 15,000 gal. pumped.
11:53	31.95	Rpm=1400.
11:56		Abundant yellow boy fines appear at filter bags, likely pumping solids from adit.
12:00	32.30	Pump off. Static has lowered accumulative 2.42 ft. Rpm=1400. Pumped estimated 25,000 gal.
12:15	32.56	Pipe is siphoning water from adit.
12:30	32.94	Pipe is siphoning water from adit.
12:35		Recharged water in adit appears to be clear, visual observation with light.
12:45	33.12	Break siphon by detaching in-line floc tubing on pipe to filter bags, water flow stop. Siphon lowered static 0.82 ft. Static has lowered accumulative 3.24 ft.
13:00	32.51	Adit recharging.
13:30	31.71	Adit recharging.
		Excavate at portal collapse to ferricrete invert. Adit width approx. 5 ft., height approx. 7 ft.
13:45	31.25	Adit recharging.
14:00	31.0	Adit recharging.
14:15	30.73	Adit recharging. Static recovered 2.39 ft in 1 hr 30 min.
		Note: assume adit recharge rate = 300gpm via prior ditch flume measurement. [300gpm (90min recharge) = 27,000gal.] And Static recovery of 2.39ft per 27,000gal water, using 5ft wide adit dimension, and assuming invert slope is negligible; Extent of water pool influence inby the adit = approx. 304 ft. Also Assuming 2% invert slope (arctan 2% = 1.1°) and static at top of 7ft high adit, the extent inby of water pool influence = 364 ft.

bgs below ground surface gpm gallons per minute rpm revolutions per minute
gpd – gallons per day. AMD – acid mine drainage. * - Well RB-1 is completed approx. 25ft from adit portal.

Table 2
AMD Water Pumping Data - Well RB-1*

Time	Static (ft bgs)	Comment
9-28-2011		
09:12	30.49	Adit at equilibrium. Flow from adit via left rib.
09:14		Begin pumping from sump.
09:30	30.54	Pump off, sump empty. Position hose onto pipe to pump from adit.
10:30	30.63	Pump on. Begin pumping from adit. Rpm = 950. Adding flocculent at 80 gpd.
10:38		Rpm = 1100, estimate 300+ gpm.
10:45	31.13	Rpm = 1100. Visually clear water exiting filter bags.
11:00	31.71	Rpm = 1100. Visually clear water exiting filter bags.
11:15	32.65	Rpm = 1100.
11:30	34.06	Rpm = 1100.
11:45	34.91 suspect measurement	Pump off. Appears water level instrument responding to yellow boy accumulation in bottom of well. No water in well. Abundant yellow boy at filter bags, water was clear at 11:35 hours. Water apparently derived from adit floor where yellow boy resides.
12:40	32.49	Recharging.
12:45	32.37	Recharging.
13:00	31.90	Recharging.
13:15	31.57	Recharging.
13:30	31.22	Recharging.
14:00	30.70	Recharging. Additional collapse material removed. Adit flow bypass portal collapse via a side channel in left rib.
14:15	30.54	Recharging.
14:30	30.49	Recharging.
14:45	30.45	Recharging.
16:05	30.49	Static equilibrium.

bgs below ground surface gpm gallons per minute rpm revolutions per minute
gpd – gallons per day. AMD – acid mine drainage. * - Well RB-1 is completed approx. 25ft from adit portal.

Table 3
AMD Water Pumping Data - Well RB-1*

Time	Static (ft bgs)	Comment
9-29-2011		
08:30		Replaced filter bags at manifold.
09:15	30.49	Pump on. Pumping from pipe in adit. Rpm = 1100. Estimate 300 gpm. Pipe also has siphon effect through pump. Flocculent added at 80 gpd. Filtered water is visually clear.
09:30	30.92	Rpm = 1000.
09:45	31.36	Rpm = 1000.
09:50		Begin removing front portion of portal collapse material for new culvert portal structure.
10:00	31.95	Rpm = 1000.
10:15	32.58	Rpm = 1000.
10:25	33.03	Pump off. Siphon broken, no water extraction.
10:45	32.37	Recharging.
11:07		Recharging. Removed approx. additional 2ft height of collapse dam.
11:15	31.76	Recharging. Adit flow over lowered collapse dam into sump. Adding flocculent to sump by hand.
11:28		Recharging. Adit releasing approx. 6 inches of head over lowered collapse dam.
11:52	31.95	Static flow from adit.
11:58	31.95	Pump on. Rpm = 1100. Flocculent at 80 to 100 gpd.
12:15	33.03	Rpm = 1000.
12:25	33.71	Rpm = 1000.
12:30	34.06	Pump off. Do not want to pull yellow boy off floor through system. Continue removing collapse material from adit entrance area for new portal structure.
12:45	34.25	Remove additional collapse dam material. Collapse dam height approx. 4ft below adit brow (approx. 2 ft above adit floor).
13:02		Begin pulling pipe from adit. Static flow from adit into sump.
14:40	34.39	Static water flow from adit.
14:54	34.39	Pump on. Rpm = 1000. Pumping from sump, add flocculent to sump.
15:14	34.77approx. measurement	Pump off. Much yellow boy in water. Water level instrument responding to yellow boy accumulation in bottom of well. No water in well. Adding flocculent to sump by hand. Cease activities, allow adit water to settle overnight.
9-30-2011		
09:18	34.37	Adit at equilibrium. Water running visually clear, is flowing through sump to south ditch. Typical flow volume as measured by gauge at underflow pipe to south ditch, i.e., 300gpm. Current static is above the reduced collapse dam height in adit. Adit flow held back by rock dam forming sump. Continue to chip away ferricrete rock face of adit for close fit of new culvert portal structure.

bgs below ground surface gpm gallons per minute rpm revolutions per minute
gpd – gallons per day. AMD – acid mine drainage. * - Well RB-1 is completed approx. 25ft from adit portal.

Table 4
AMD Water Parameters

Location Date Collected Parameter	CC03D 5/19/2009	CC03D 6/17/2009	CC03D 7/14/2009	CC03D 8/18/2009	CC03D 9/22/2009	CC03D 11/18/2009	CC03D 2/18/2010
pH	5.86	6.40	6.50	6.22	6.35	5.95	5.44
Temperature (°C)	9.17	8.28	8.15	6.08	3.89	2.09	3.22
Total Organic Carbon (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	--	--
Flow (cfs)	0.749	0.699	0.664	0.676	0.749	--	--
Chloride(mg/L)	<0.5	<2.5	<0.5	<1.0	<0.5	<0.5	<0.5
Specific Conductance (EC) (µS/cm)	2,070	2,050	2,090	2,100	2,110	2,170	2,181
Sulfate as SO4 (mg/L)	1,370	1,150	68.2	1,400	1,370	1,460	1,430
Dissolved Organic Carbon (mg/L)	<0.50	0.52	<0.50	0.52	<0.50	--	--
Dissolved Oxygen (mg/L / %)	7.1	7.6	8.1	7.8	9.5	9.1	8.7
Salinity (ppt)	--	--	--	--	--	--	--
Total Dissolved Solids (ppm)	--	--	--	--	--	--	--

% Percent
°C Degrees Celsius
EC Electrical Conductance
mg/L milligrams per Liter
cfs cubic feet per second
ppm parts per million
ppt parts per thousand
µS/cm microseiverts per centimeter
AMD Acid Mine Drainage

Table 4, cont.
AMD Water Parameters

Location / Date Collected / Parameter	CC03D 3/18/2010	CC03D 4/14/2010	CC03D 6/2/2010	RBSW01 6/15/2010	UAAD003 10/28/2010	Behind Adit Collapse 8/25/2011	Outside Adit Collapse 8/25/2011
pH	5.76	5.94	5.94	5.66	6.32	4.68	5.48
Temperature (°C)	6.85	9.40	6.83	12.8	5.5	6.2	6.0
Total Organic Carbon (mg/L)	--	--	--	--	--	--	--
Flow (cfs)	--	0.403	0.488	0.59	--	--	--
Chloride(mg/L)	<0.5	<1.0	<0.5	--	--	--	--
Specific Conductance (EC) (µS/cm)	2,207	2,288	2,207	1,575	2,200	45.4	1,995
Sulfate as SO4 (mg/L)	1,450	1,550	1,420	--	--	--	--
Dissolved Organic Carbon (mg/L)	--	--	--	--	--	--	--
Dissolved Oxygen (mg/L / %)	7.9	7.5	7.9	--	--	7.87/93.1%	7.21/87%
Salinity (ppt)	--	--	--	956	--	--	--
Total Dissolved Solids (ppm)	--	--	--	1.11	--	--	--

%	Percent
°C	Degrees Celsius
EC	Electrical Conductance
mg/L	milligrams per Liter
cfs	cubic feet per second
ppm	parts per million
ppt	parts per thousand
µS/cm	microseiverts per centimeter
AMD	Acid Mine Drainage

Table 5
AMD Water Laboratory Analysis
µg/L (ppb)

Analytes	Sample Location / Sample Collection Date	CC03D 5/19/09	CC03D 6/17/09	CC03D 7/14/09	CC03D 8/18/09	CC03D 9/22/09	CC03D 11/18/09	CC03D 2/18/10	CC03D 3/18/10	CC03D 4/14/10	CC03D 6/2/10	RBSW01 6/15/10
Aluminum	Dissolved	3,320	1,840	2,000	2,640	2,440	3,270	3,920	2,690	2,280	2,770	3,100
	Total	4,030	3,040	3,380	3,500	3,520	3,780	4,410	3,960	3,820	3,850	3,200
Antimony	Dissolved	-	-	-	-	-	-	-	-	-	-	0.14 U
	Total	-	-	-	-	-	-	-	-	-	-	1 J
Arsenic	Dissolved	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	3.3 J
	Total	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	3.5 J
Barium	Dissolved	-	-	-	-	-	-	-	-	-	-	14
	Total	-	-	-	-	-	-	-	-	-	-	15
Beryllium	Dissolved	5.93	5.33	5.45	5.8	6.2	6.9	7.2	6.4	6.3	6.2	7.5
	Total	7	6	6	6.6	7.0	7.4	7.4	7.6	7.4	7.1	9.1
Cadmium	Dissolved	33.1	34.4	34.5	34.5	37.5	37.3	38.1	36.5	40.9	38.6	32
	Total	33.3	34.8	34.9	34.6	35.9	37.7	37.5	37.6	37.3	40.4	35
Calcium	Dissolved	395,000	382,000	405,000	408,000	415,000	425,000	457,000	411,000	430,000	398,000	400,000
	Total	-	-	-	-	-	-	-	-	-	-	390,000
Chromium	Dissolved	<2.00	<2.00	<2.00	<2.0	<2.0	<2.0	<2.0	3.3	<2.0	<5.0	1 U
	Total	<2	<2	<2	<2.0	<2.0	<2.0	3.2	3.5	2.5	<5.0	0.66
Cobalt	Dissolved	-	-	-	-	-	-	-	-	-	-	110
	Total	-	-	-	-	-	-	-	-	-	-	110

Table 5, cont.
AMD Water Laboratory Analysis
µg/L (ppb)

Analytes	Sample Location Sample Collection Date	CC03D 5/19/09	CC03D 6/17/09	CC03D 7/14/09	CC03D 8/18/09	CC03D 9/22/09	CC03D 11/18/09	CC03D 2/18/10	CC03D 3/18/10	CC03D 4/14/10	CC03D 6/2/10	RBSW01 6/15/10
Copper	Dissolved	41.1	<3.0	3.5	4.5	<3.0	8.9	41.8	11.2	13.8	10.7	1.5 J
	Total	50.6	4.5	6.2	6.9	4.1	8.6	47.1	14.2	18.0	14.3	2.9 J
Fluoride	Dissolved	6.73	5.60	0.45	6.03	6.69	6.67	<0.20	6.73	15.4	7.2	
Iron	Dissolved	80,500	81,200	85,800	85,800	94,100	91,600	83,100	85,600	87,100	83,100	100,000
	Total	86,700	76,700	87,700	88,000	96,700	96,100	82,300	93,500	97,600	89,400	100,000
Lead	Dissolved	8.1	4.1	7.6	9.1	15.4	4.6	4.3	3.6	2.1	8.9	79
	Total	71.2	39.5	36.5	34.0	41.4	37.2	47.2	58.7	55.3	57.7	90
Magnesium	Dissolved	26,400	25,600	26,200	26,600	27,300	28,400	29,500	27,000	27,300	25,900	24,000
	Total	-	-	-	-	-	-	-	-	-	-	26,000
Manganese	Dissolved	32,300	30,800	32,100	32,700	33,700	35,000	35,200	32,900	32,500	31,700	33,000
	Total	33,200	27,900	32,300	32,500	34,600	35,700	34,100	35,100	36,300	33,000	30,000 B
Mercury	Dissolved	-	-	-	-	-	-	-	-	-	-	0.027 JB
	Total	-	-	-	-	-	-	-	-	-	-	0.027 U
Nickel	Dissolved	51.9	47.7	47.9	50.4	55.5	57.3	59.4	55.9	54.7	48.5	56
	Total	52	44	50	52.5	53.8	57.1	56.9	59.1	56.5	55.1	60
Potassium	Dissolved	1,690	1,880	1,740	1,820	1,770	1,830	1,680	1,930	1,580	1,880	1,700 J
	Total	-	-	-	-	-	-	-	-	-	-	2,100 J
Selenium	Dissolved	1.5	1.3	1.1	1.3	1.5	1.6	1.6	1.5	1.2	1.6	1.8 J
	Total	1.7	1.3	1.4	1.5	1.3	1.1	1.7	1.8	1.1	1.8	3.5 U

Table 5, cont.
AMD Water Laboratory Analysis
µg/L (ppb)

Analytes	**Sample Location** **Sample Collection Date**	**CC03D** **5/19/09**	**CC03D** **6/17/09**	**CC03D** **7/14/09**	**CC03D** **8/18/09**	**CC03D** **9/22/09**	**CC03D** **11/18/09**	**CC03D** **2/18/10**	**CC03D** **3/18/10**	**CC03D** **4/14/10**	**CC03D** **6/2/10**	**RBSW01** **6/15/10**
Silver	Dissolved	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.93 U
	Total	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	0.12 J
Sodium	Dissolved	8,730	9,070	8,850	8,680	8,940	9,450	8,830	9,360	8,680	8,330	9,800
	Total	-	-	-	-	-	-	-	-	-	-	11, 000 B
Thallium	Dissolved	-	-	-	-	-	-	-	-	-	-	0.16 JB
	Total	-	-	-	-	-	-	-	-	-	-	0.3 J
Vanadium	Dissolved	-	-	-	-	-	-	-	-	-	-	0.28 J
	Total	-	-	-	-	-	-	-	-	-	-	0.28 U
Zinc	Dissolved	14,300	13,600	15,000	15,000	16,100	16,400	16,900	15,500	14,200	14,700	14,000
	Total	15,600	13,600	15,500	15,800	16,400	17,400	16,000	16,500	17,500	15,500	15,000

ppb — parts per billion
µg/L — micrograms per liter
J — The associated numerical value is an estimated quantity because quality control criteria were not met. Presence of the element is reliable.
U — The analyte was not detected at or above the Contract Required Detection Limit (CRDL).
B — The analyte was detected in the blank.
AMD — Acid Mine Drainage

APPENDIX A

Photolog

PHOTO 1 8-23-2011
Field conditions prior to adit entry activities. South view along CR 53. Toe of dump on left. See also Photo 2.

PHOTO 2 10-13-2011
Field conditions after adit entry. View south along CR53, toe of dump on left. See also Photo 1.

PHOTO 3   8-23-2011

Field conditions prior to adit entry activities. View northward on CR53, toe of dump on right. See also Photo 4.

PHOTO 4   10-13-2011

Field conditions after adit entry. View north on CR53, manifold filter bag area on right. See also Photo 3.

PHOTO 5 8-23-2011
Field conditions prior to adit entry activities. Northward view along CR53, north of mine site. See also Photo 6.

PHOTO 6 10-13-2011
Field conditions after adit entry. Water bar on CR53, north of mine site. North access road on level behind two trees on right. See also Photo 5.

PHOTO 7 8-23-2011
Field conditions prior to adit entry activities. Southward view on north access road, south of gate. See also Photo 8.

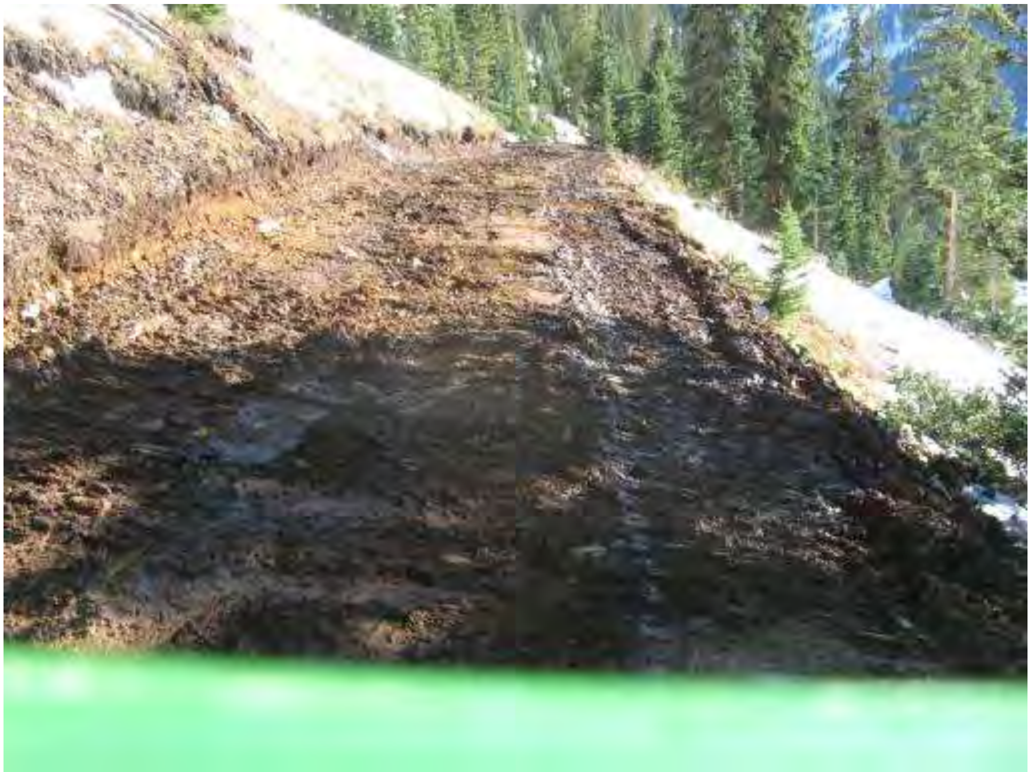


PHOTO 8 10-13-2011
Field conditions after adit entry. Southward view on north access road, south of gate. See also Photo 7.

PHOTO 9 8-24-2011
Field conditions prior to adit entry activities. CR53 north of the mine, below the north access road intersection. See also Photo 10.

PHOTO 10 10-13-2011
Field conditions after adit entry. CR53 north of the mine, below the north access road intersection. See also Photo 9.

PHOTO 11   8-23-2011
Field conditions prior to adit entry activities. Top of mine dump visible at end of road.

PHOTO 12   8-24-2011
Field conditions prior to adit entry activities. AMD flowing from mountain side at apparent adit location.

PHOTO 13 8-29-2011
Initial diversion flow from adit into south ditch. Red color derived from ditch sediments washing out.

PHOTO 14 8-30-2011
South ditch flow temporarily diverted. Red-colored resistant ferricrete underlying thin soil and dump material.

PHOTO 15   8-30-2011
Decanting water from yellow boy solids on dump surface. Temporary underflow pipe diverting adit water to north side of dump.

PHOTO 16   8-31-2011
Talus material placed over geotextile fabric that was placed over base talus material on dump surface. AMD discharge from collapsed portal in lower right, under-piped to south ditch. See also Photo 17.

PHOTO 17 8-31-2011
Geotextile fabric placed between layers of talus material on mine dump.

PHOTO 18 8-31-2011
Constructing pad for filter bag on dump surface.

PHOTO 19 9-6-2011
Red and Bonita Mine. AMD cascading down portal collapse at top left of dump into the south ditch on right. Red and Bonita Mill debris in area on left side of dump above vehicles.

PHOTO 20 9-8-2011
Toe of prepared dump surface at head of dump face. Note geotextile fabric liner exposed under talus, and armored yellow boy surface on dump face.

PHOTO 21   9-10-2011
Valve and filter bag manifold apparatus. Unused bags.

PHOTO 22   9-10-2011
Koir-Logs®, filter barrier, and pump at sump below the adit outflow. Twelve-inch PVC pipe under Koir-Logs® directs water to south ditch when not being pumped to manifolded filter bag apparatus at toe of dump. Pipe can be plugged with stopper, stored on Koir-Log® in photo center.

PHOTO 23   9-10-2011
Geotextile filter bag at diverted adit AMD outflow. Flowing into south ditch.

PHOTO 24   9-11-2011
Geotextile fabric filter bags filtering AMD water at location below working surface at adit level. Flow releasing into road ditch system.

PHOTO 25 9-11-2011
Excavated approximately 3 feet of collapsed talus material from portal area. Note yellow boy-coated talus material and small piece of horizontal lagging at yellow boy horizon.

PHOTO 26 9-13-2011
Geotextile fabric water filtering bags passing filtered AMD water.

PHOTO 27 9-11-2011
Geotextile fabric filter bags at toe of mine dump slowly decanting after use.

PHOTO 28 9-13-2011
Collapsed portal work area. Removed approximately 6 feet of talus material from in front of adit to level where workman is standing. Top of red staining at dig face indicates upper AMD flow level. Note talus sloughing due to steep slope.

PHOTO 29   9-13-2011
Slope failure at bench above excavation area at collapsed portal. Note water level indicator tool in well.

PHOTO 30   9-13-2011
Collapsed portal work area. Dark red ferricrete formation becoming apparent at dig face, visible above right of AMD outflow. Line of red staining in photo top indicates AMD flow level and deposition of yellow boy.

PHOTO 31 9-13-2011
Excavation activities at collapsed portal.

PHOTO 32 9-15-2011
View of operations on top of dump. Collapsed portal behind nearest workman's back out of view in foreground, AMD water flowing through temporary rock dam (nearest workman standing on) to sump where Koir-Logs® are located, under-piped to geotextile filter bag in background (behind stacked piping) where water is filtered prior to release to the south ditch out of view. AMD water flows through stressed vegetation zone in photo background to Cement Creek.

PHOTO 33 9-22-2011
Schedule 40, 6.63-inch OD, flush-threaded steel pipe. Assembled during placement into mine adit. Used to pump AMD water from adit in controlled conditions.

PHOTO 34 9-22-2011
Liquefied aluminum sulfate flocculent pumped from blue poly drums (photo right) into drain pipe directing flow to geotextile fabric filter bags located at dump toe.

PHOTO 35 9-27-2011
Pumping water through hose from sump at excavated portal. Steel pipe placed in adit is visible resting on header above current collapse blockage.

PHOTO 36 9-27-2011
AMD water pumping operations from steel pipe in adit. Water is piped to geotextile fabric filter bags located at toe of mine dump.

PHOTO 37 9-27-2011
Invert of adit on solid ferricrete formation under standing water in photo. Note wood debris. Portion of red ferricrete wall visible on right of excavation.

PHOTO 38 9-29-2011
Removing upper portion of remaining collapse material to allow AMD water to flow out of adit.

PHOTO 39   9-29-2011
AMD water flowing from adit.

PHOTO 40   9-29-2011
Left rib of adit. Abundant collapse/fines/yellow boy material.

PHOTO 41   9-30-2011
Excavator having difficulty breaking well-cemented ferricrete rock from portal face to accommodate new portal structure.

PHOTO 42   9-30-2011
Placing portion of new portal structure. Ten-foot diameter galvanized steel culvert pipe.

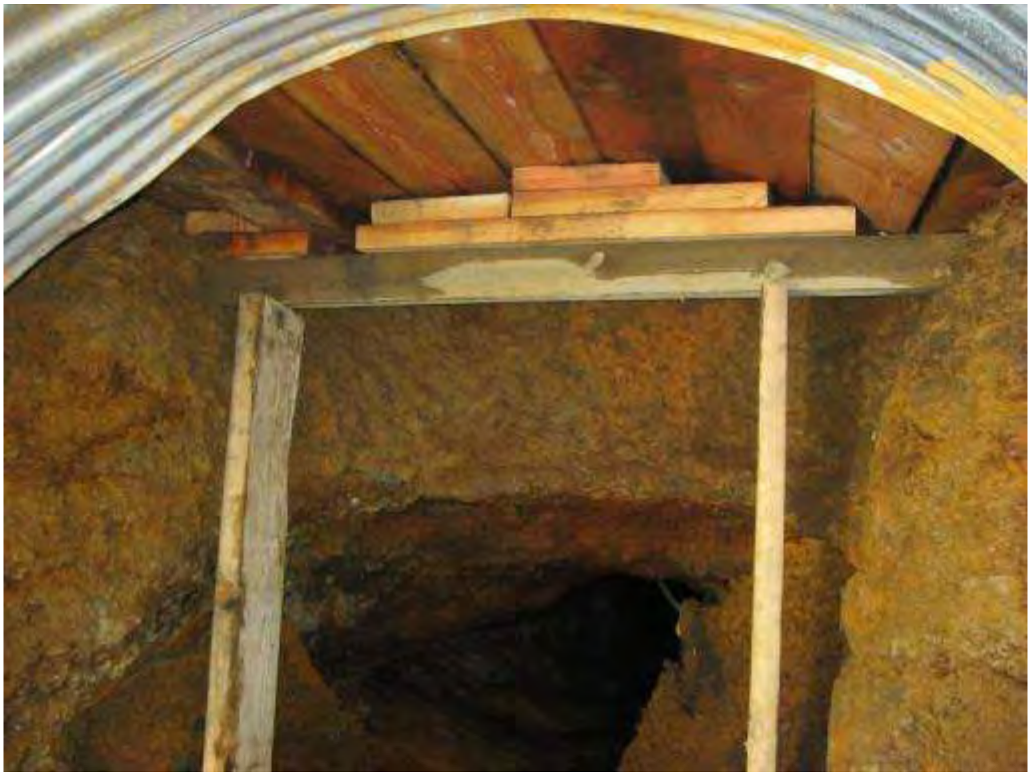


PHOTO 43   10-12-2011
Lagging and bracing between culvert pipe and ferricrete rock at portal.

PHOTO 44   10-11-2011
View into adit from portal. Sediment material on floor in photo foreground is 2 feet thick, approximately 4 feet of open space to adit back. AMD water draining down center. PVC monitoring well pipe is visible in adit. Note timber set visible behind PVC well.

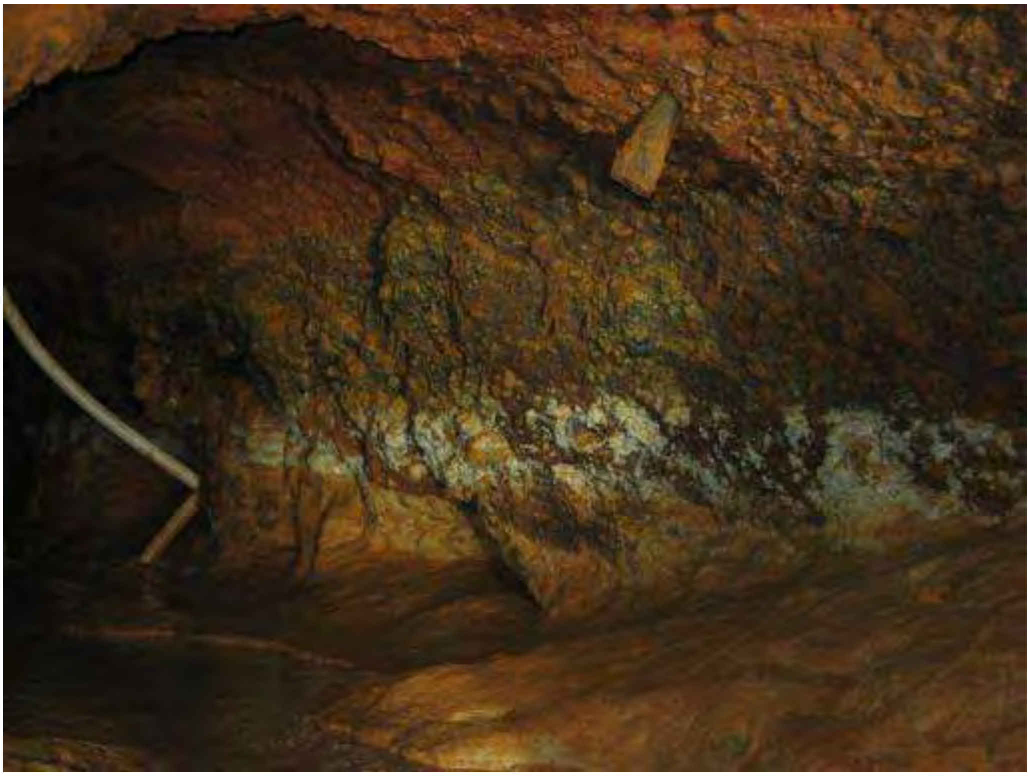


PHOTO 45 10-12-2011

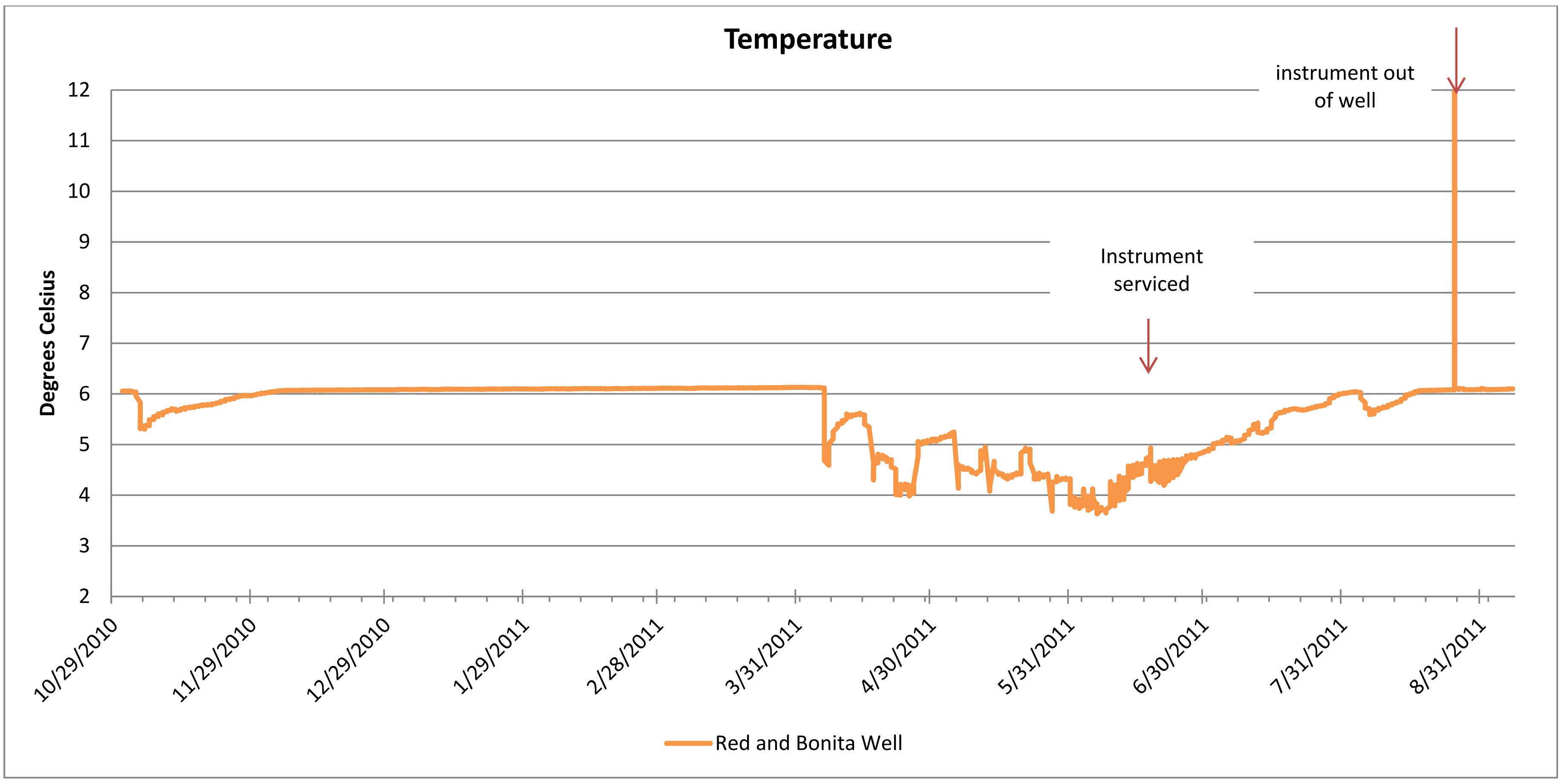
Right rib of adit near portal showing various stained horizons on ferricrete formation. Orange-colored yellow boy fines on adit floor, light grey (aluminum hydroxide?) material on wall above yellow boy material, dark red iron oxide staining on back of adit. PVC well pipe in photo left, wood remnant wedge still intact in adit back.

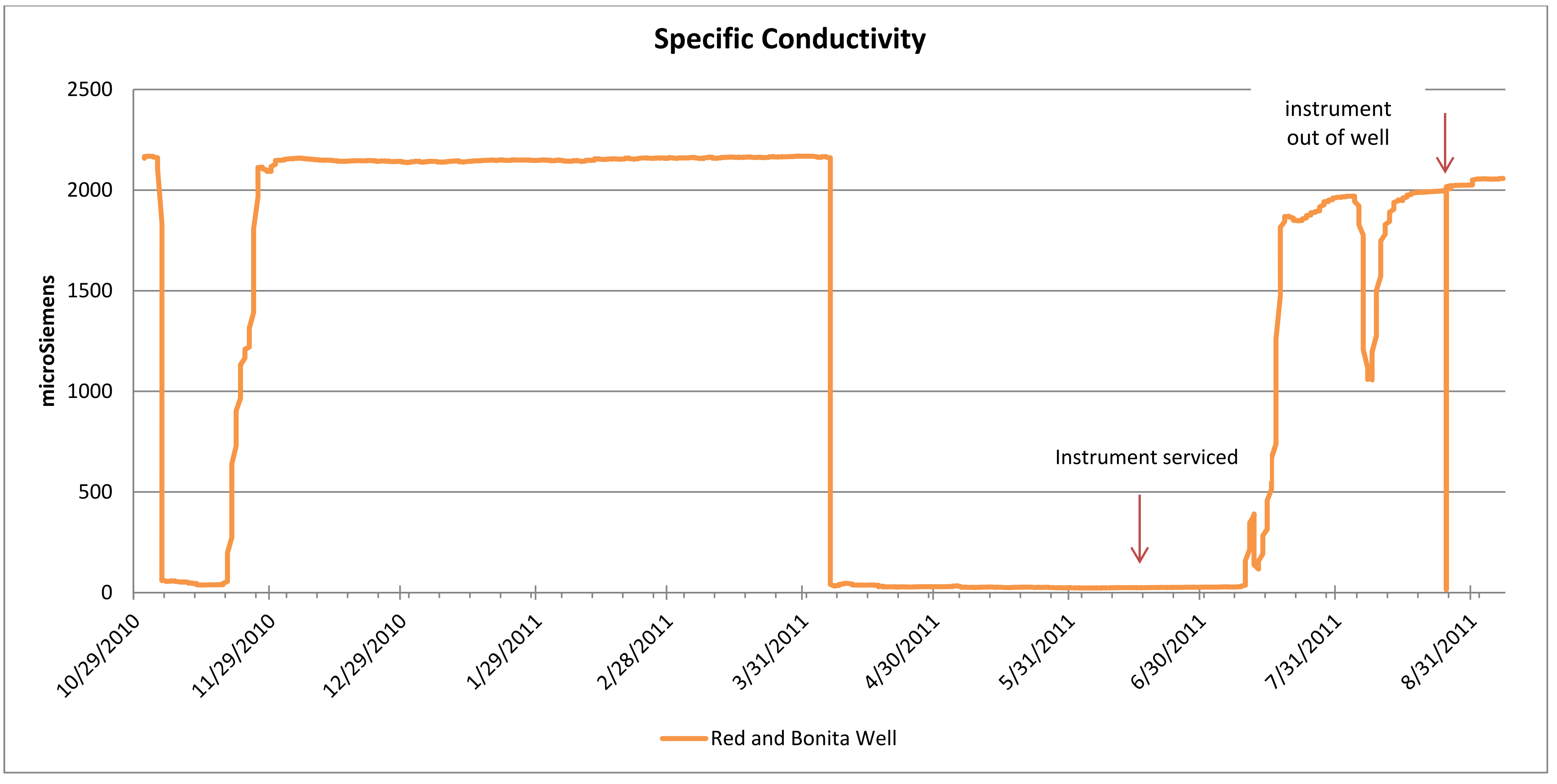
PHOTO 46 10-13-2011

AMD effluent from the adit via PVC pipe at the base of the portal structure. Water is directed to the flow location over the dump face that was in place prior to site activities.

APPENDIX B

Mine Adit Effluent Transducer Data





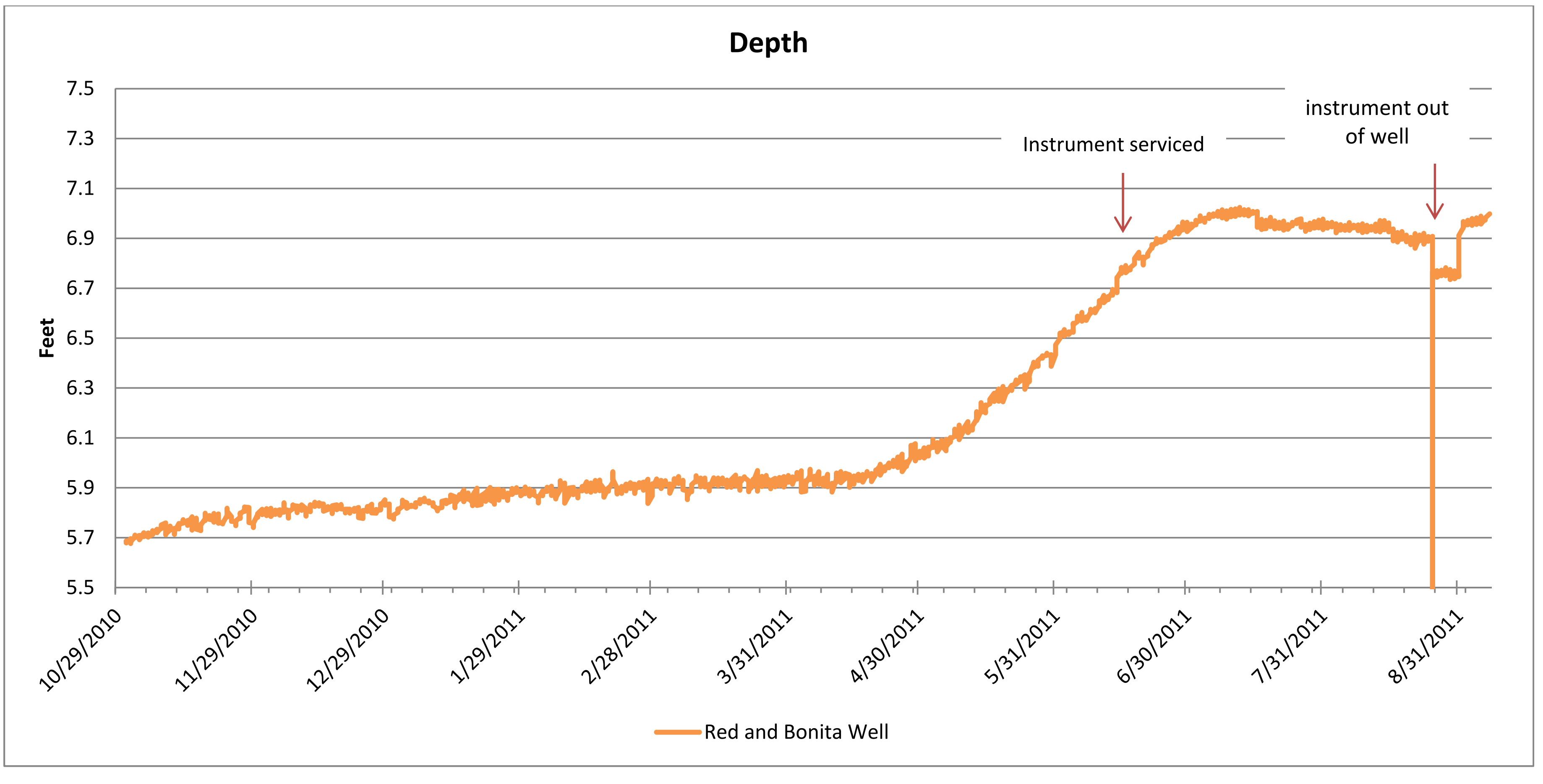


CHART 1
Upper Animas River, Cement Creek Watershed Mine Adit Effluent Transducer Data
Red and Bonita Mine
October 29, 2010 to September 7, 2011

APPENDIX C

Report of Structural Geologic Investigation – Red & Bonita Mine

Report of Structural Geologic Investigation

Red & Bonita Mine

San Juan County County, Colorado

August, 2007

Prepared for

Animas River Stakeholders Group

Prepared by

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Red & Bonita Mine

Structural Geologic Investigation

Introduction and Background

The Animas River Stakeholders (ARSG), Bureau of Land Management (BLM) and the U.S. Environmental Protection Agency (EPA), are cooperating in an investigation of reclamation options for controlling or eliminating acid mine drainage at the inactive Red & Bonita Mine (R&B), on upper Cement Creek, in San Juan County, Colorado. The overall goal of the work is to reduce heavy metal loading in Cement Creek and the Animas River, as measured below Silverton. The R&B portal and dump are located about ½-mile above Gladstone on the east side of Cement Creek at an elevation of 10,960 feet (Lat. N37° 53'51.3", Long. W107° 38'34.9") (Figure1). The portal is located on the "Letter B" claim, M.S.No.2045. At present, the R&B adit portal is caved at surface, and is discharging an estimated 300gpm of mine drainage. The drainage is contributing an un-quantified but significant metals load to Cement Creek.

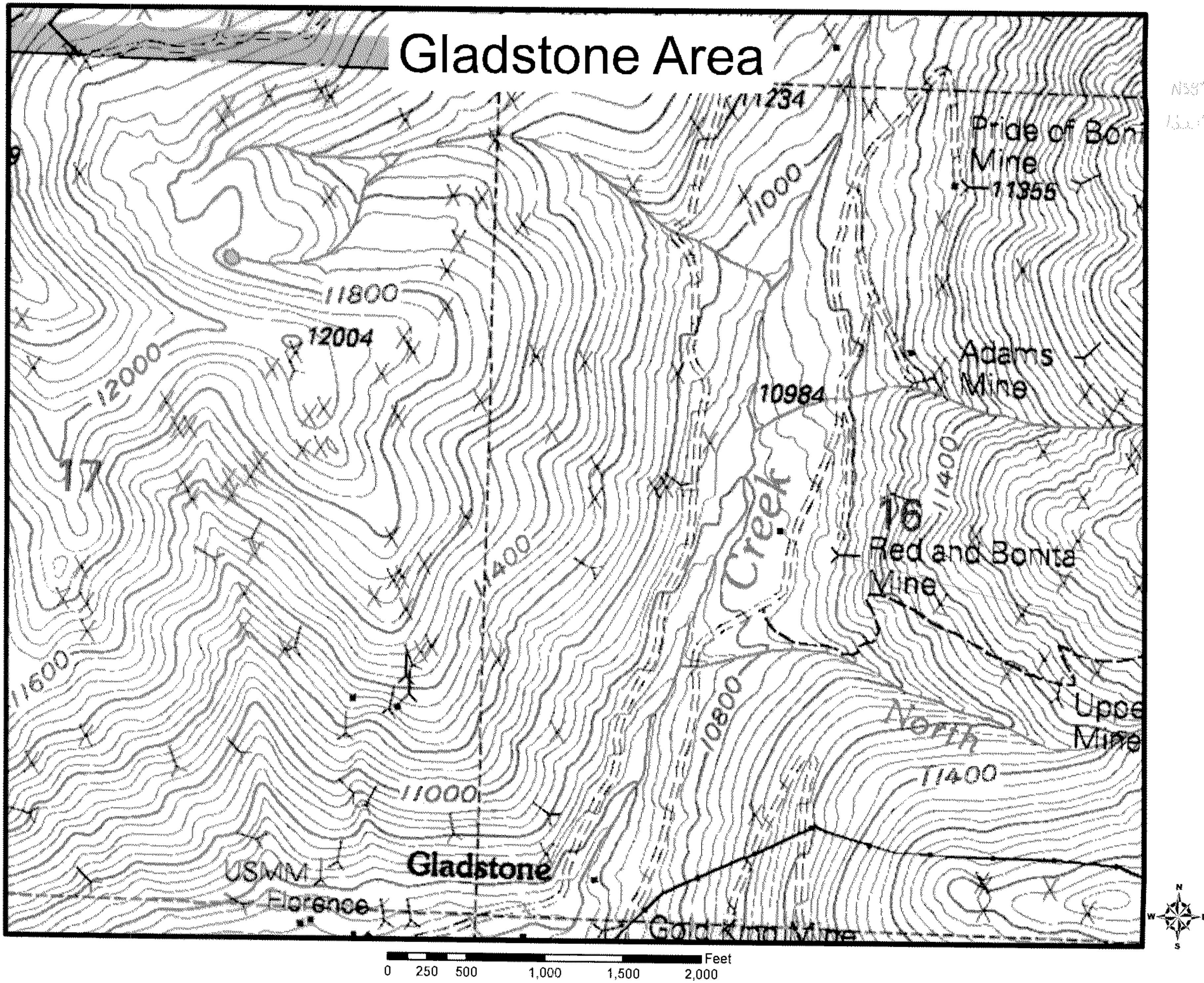
Project Objective and Methodology

One of the options being considered for water quality improvement is a subsurface hydrologic bulkhead constructed in the R&B adit to prevent acid mine discharge from the mine portal. The focus of this report is to make a preliminary assessment of the geotechnical suitability of the bedrock along the R&B cross-cut as a potential location for a bulkhead closure. Surface geologic structural analysis work was conducted at the mine in June 2007. This included analysis of joints, faults, and rock fabric associated with the bedrock in which the workings are driven, as well as a review of the available information on underground workings. Surface geologic investigations concentrated on the slopes above the workings, and in the adjacent section of the north fork of Cement Creek below the Gold King Mine. Rock structural discontinuities were located and strikes and dips of these features measured and plotted to develop a preliminary structural analysis of the bedrock. The strike and dip of joints and planar flow structure were measured in the field and analyzed using a computer program to determine if there were any preferred structural orientations in the bedrock, (anisotropy), that might create a permeability "short-cut" that could compromise the integrity of an underground bulkhead at the Red & Bonita site. A topographic transect was also reviewed to determine if a sufficient depth of cover along the adit crosscut would allow for consideration of a bulkhead approach.

Description of Geologic Units

The Red & Bonita Mine site is located entirely within Tertiary-aged rocks of the Silverton Volcanic sequence. The Silverton Volcanics is a sequence of predominantly intermediate composition lava flows and related volcaniclastic rocks that were extruded onto the underlying Eureka Tuff in later Oligocene time. These volcanic flows have been subdivided into the mapable formations exposed at the R&B site (Figure 2, Burbank and Luedke, 1964). The R&B workings are driven in the Burns Member, a sequence of light to dark-gray, thin to thick, intertounging flows and domes of porphyritic dacite and rhyodacite that crops out throughout the study area. These rocks have been propyliticaily altered throughout the watershed. The only other geologic units at the site consist of aprons of talus, and colluvium. The R&B portal is

FIGURE 1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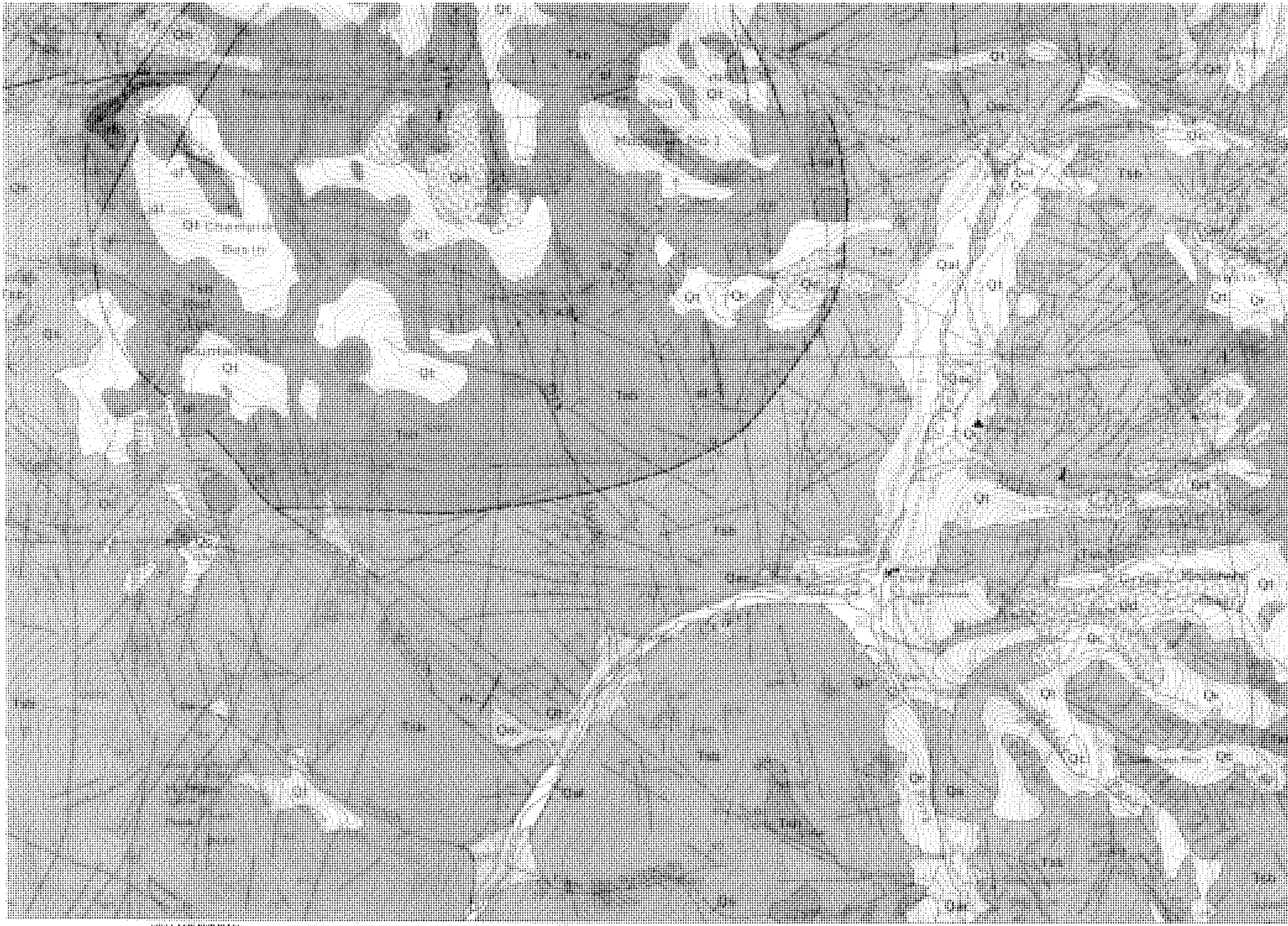

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FIGURE 2. SURFACE GEOLOGIC MAP, RED & BONITA MINE AREA.
▲ INDICATES MINE LOCATION

Geology by W. S. Burbank, assisted by M. G. Barclay, F. M. Chace, M. G. Dings, R. S. Duce, E. B. Eckel, E. N. Goddard, V. C. Kelley, C. F. Park, Jr., 1929–38; V. C. Kelley, assisted by Caswell currently blocked at surface by caved talus and colluvial materials, loosely cemented by iron hydroxide precipitates.

Structural Geology

Structurally, the Red & Bonita workings lie entirely within the Burns Member described above. The Gold King Vein system lies 2,200 feet east of the portal, and the Bonita Fault lies 3,600 feet east of the portal (Figure 2). At least four other un-named but mapped mineralized fissures striking roughly NE-SW occur in the ground between the portal and the Gold King vein structure (Burbank and Luedke, 1964). There are also five localized, mineralized fissures exposed in the gulch below the Gold King waste dump, however, these do not appear to continue farther north into the R&B ground, and there was no evidence they are the locations of surface groundwater discharge.

Joints and flow structure (crude bedding) were identified and measured at surface on cliff faces and at the portals of adjacent prospects and mines (Table 1). The structural data was analyzed using Rock Pack III software at the Colorado Geological Survey (Figures 3 and 4). As shown in Figure 3, two preferential joint trends were detected.

TABLE 1
RED & BONITA STRIKE AND DIP DATA

Structure Type	Feature No.	Strike Azimuth°	Dip Angle°	Dip Azimuth°
Minor Joint	1	279	79	9
Minor Joint	2	275	85	5
Minor Joint	3	276	86	6
Minor Joint	4	5	81	95
Minor Joint	5	136	89	226
Minor Joint	6	40	84	130
Minor Joint	7	263	59	353
Minor Joint	8	325	84	55
Minor Joint	9	271	62	1
Minor Joint	10	41	86	131
Minor Joint	11	261	82	351
Minor Joint	12	332	76	62
Minor Joint	13	295	75	25
Minor Joint	14	275	70	5
Minor Joint	15	278	82	8
Minor Joint	16	302	84	32
Minor Joint	17	30	90	120
Minor Joint	18	115	79	205
Minor Joint	19	54	82	144
Flow Structure	1	130	33	220
Flow Structure	2	123	33	213
Flow Structure	3	134	11	224

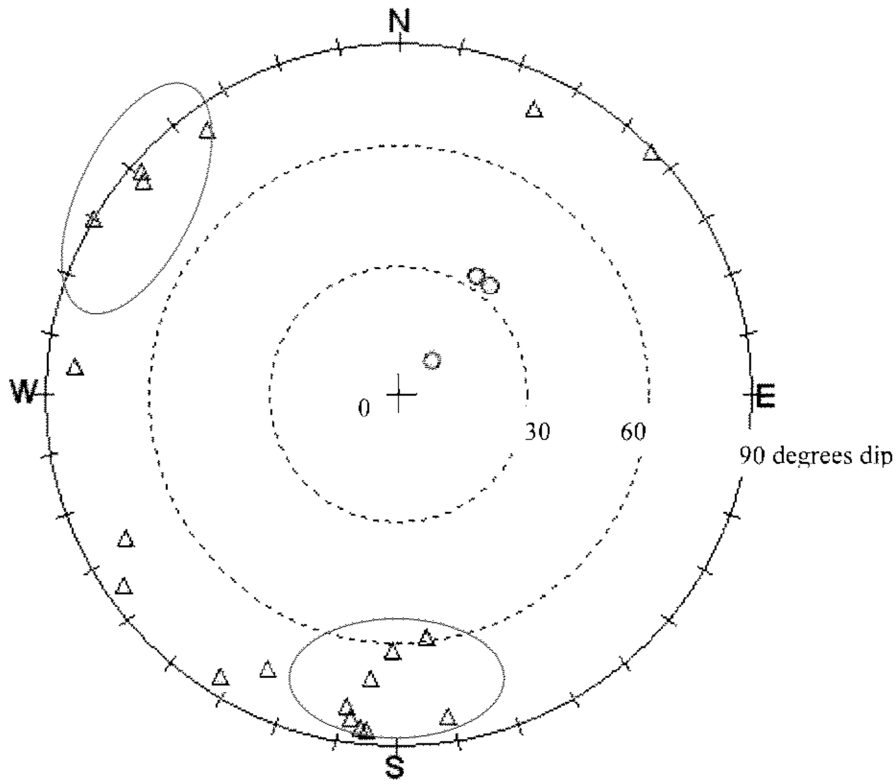


Figure 3. Pole plot of surface planar discontinuities measured around the Red & Bonita Workings. Triangles indicate poles of minor joints; circles indicate poles of flow laminations in andesite rock. The plot shows a cluster of poles to the south and a weaker set in the northwest sector, indicating two trends of anisotropy in the surface bedrock.

The southern pole cluster represents a set of joints trending roughly east-west, with dips of 60 to 89 degrees to the north. The northwest pole cluster represents joints striking roughly northeast-southwest, dipping steeply southeast. These orientations are similar to the dominant northeast-southwest anisotropy noted in the Simon Hydrosearch report prepared for the Sunnyside Mine (Stock, et. al, 1992,1993). They reported permeability greater in a northeast-southwest direction due to the dominant fracture orientation within this section of the Eureka Graben. The structural discontinuities measured in this study tend to agree with the direction of structural anisotropy as shown on published geologic maps and reports for this area near the Eureka Graben. Flow structure (crude bedding) in the andesite strikes south-east and dips gently southwest.

Rock exposed in adjacent mine workings and prospect adits is highly jointed near the portal, becoming tighter with increased distance from surface. This is common in hard rock workings in the San Juan Mountains. Rock near surface is subjected to severe chemical and physical weathering (freeze-thaw, surface infiltration). Release of overburden pressure through erosion, coupled with glacial scouring effects, normally increases fracturing and jointing of the rock mass near surface. As distance from the surface increases, joints generally become fewer and tighter with depth due to overburden pressure. This is important, because the dominant trend of anisotropy is roughly parallel to the trend of the workings in the R&B. Although the structural measurements in this study were collected from surface outcrops, they are believed to be analogous to rock fabric underground in the cross-cut section of the R&B workings. If overburden pressures are not enough to close the minor joints at mine level, a plug in the R&B workings could be "short-circuited" by filling of these steeply dipping pathways until they "spill over" and discharge back into the workings on the other side of the bulkhead.

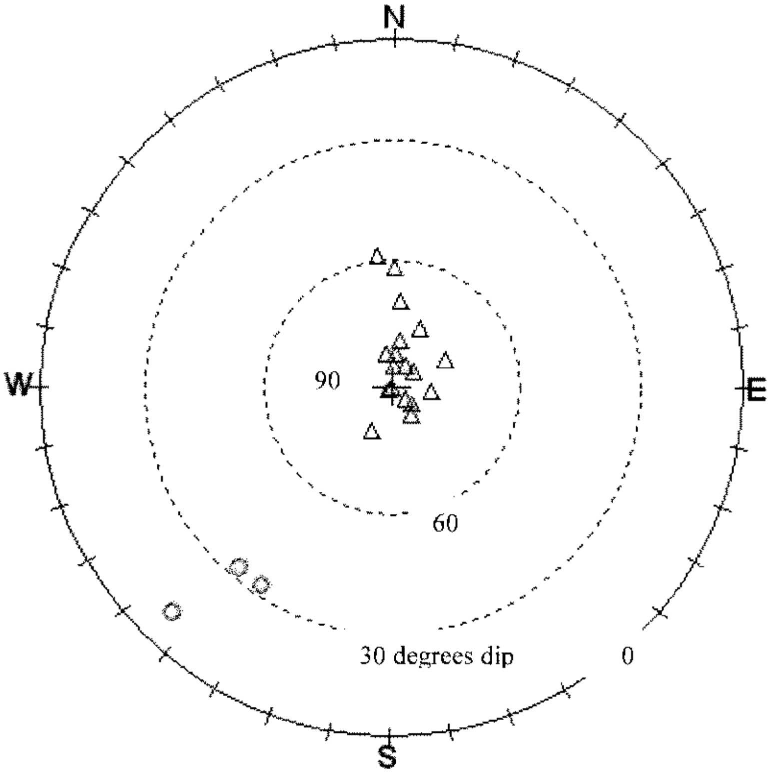


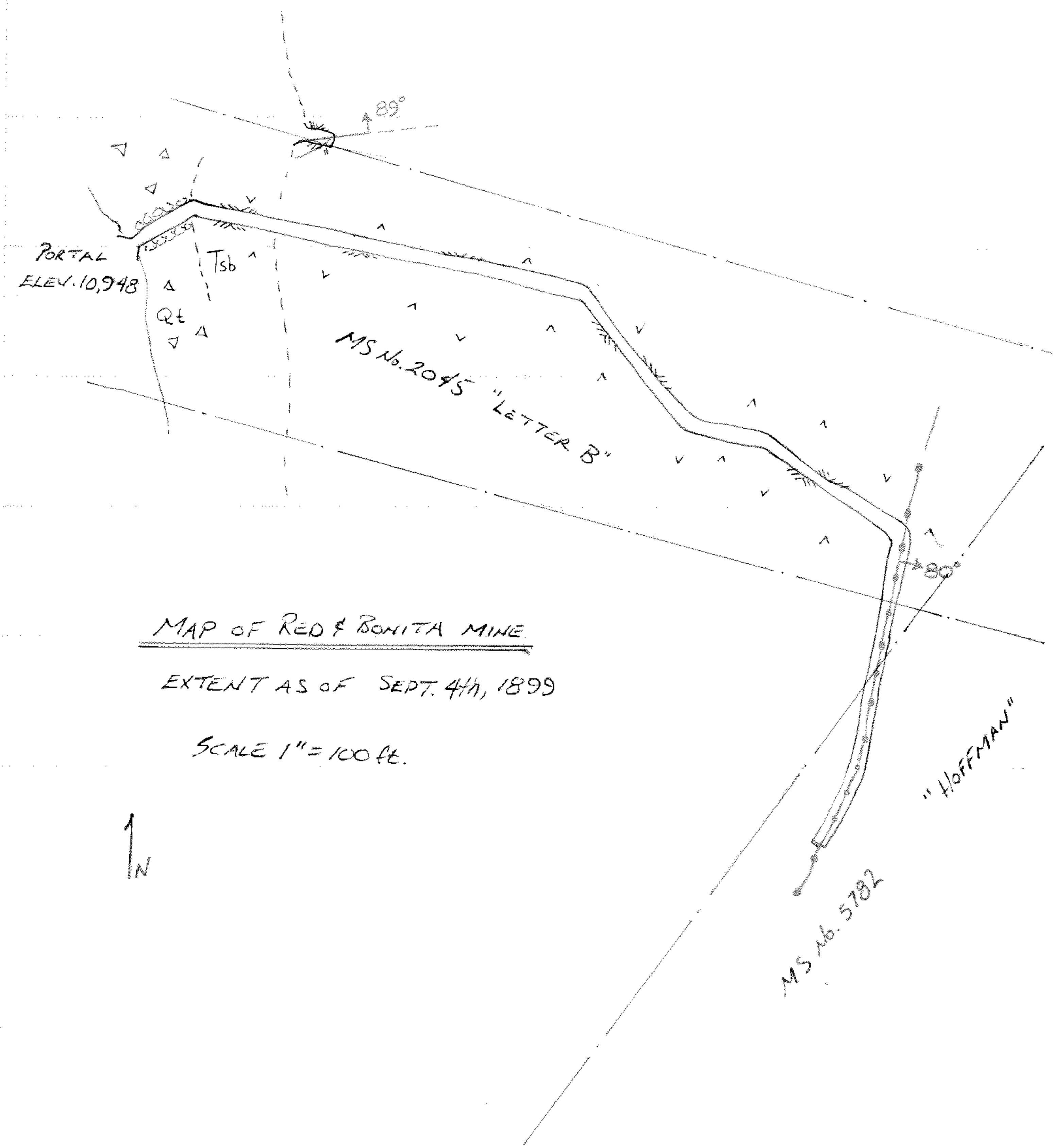
Figure 4. Dip vector plot for planar discontinuities measured on surface around the Red & Bonita workings. Triangles indicate dip of minor joints; circles indicate dips of flow laminations in andesite rock. Most joints are steeply dipping, while flow structure has shallow dips.

Mine Workings

A rudimentary layout of the R&B workings is available from an 1899 mineral survey for the adjacent American Eagle Mill Site (Fearn Engineering Services, personal communication, 2007). Based on geologic maps and the 1899 representation of the workings, the R&B adit appears to be a crosscut driven entirely in Burns Formation dacite on a roughly east-south east heading for approximately 665 feet (Figure 5). At 665 feet from the portal, the heading is believed to have intersected a mineralized fissure vein trending NE-SW on the Hoffman Lode. The workings turn abruptly SW and drifted on this structure for approximately 230 feet.

Although the 1899 map shows a total of only 895 lineal feet of workings, the size of the main dump indicates the eventual underground configuration of the mine was much more extensive. The waste dump survey completed by DMG in 1998 (Herron, et, al, 1998), estimated there were approximately 6,000 cubic yards of materials left at the portal. Back-calculating the extent of underground void from this volume using a reasonable bulking factor indicates the waste represents at least 3,560 lineal feet of 5ft. x 7ft. workings. This estimate does not include the volume of ore that was either hauled off or run through the mill. Based on these rough calculations, it is highly probable that the R&B workings were driven much farther east-ward, intersecting deeper groundwater-bearing structures between the Gold King 7-level above and the American Tunnel level below. This conjecture is supported by the fact that, after the American

FIGURE 5.



RED & BONITA ABOVE GLADSTONE, SAN JUAN Co. CO MAIN

BKS A.E. LOWE JUNE 23, 1899 1in = 100 ft

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Tunnel level 331 lower than the R&B workings was bulkheaded, groundwater re-filling these deeper structures eventually increased the R&B portal discharge from approximately 5gpm in 1998 to over 300gpm at present time.

The R&B portal is currently caved at surface where it was timbered through unconsolidated scree and talus deposits. The 1899 mine map shows a distinct change in heading at 50 feet from the portal; this distance might represent the length of original timbered section through the surface talus deposit to the point where bedrock was encountered, and the heading was "squared up" to avoid a mixed-face condition when drilling started into bedrock. Based on the position of the outcropping rock above the portal, and the slope and a visual estimate of the thickness of the talus deposit, fifty feet or a little less is a good approximation of where solid bedrock is expected to be encountered beyond the portal.

There are no known records on the vertical extent of workings in the R&B mine. Based on historical accounts, ore found on the dump, and the fact that the mill operated intermittently for many years, it must be assumed that ore was extracted by stoping on the steeply dipping mineralized structures the workings encountered. The extent and heights of ore extraction are unknown but could be significant. Prior to opening the portal for underground evaluations, an appropriately cased and equipped drill hole should be extended into the workings within the bedrock section to measure the hydraulic head present behind the debris plug. If a significant head pressure is found, it can be bled-off by opening the pressure valve on the probe hole or drilling additional pressure-relief probe holes into the workings. Following decanting of the impounded mine pool, underground mapping is needed in the cross cut section of the workings to identify any discrete structural discontinuities, rock quality, mineralized structures, and locations of water inflow prior to any final feasibility analysis or bulkhead design.

Hydrology

The R&B site lies along the valley floor of Cement Creek, and is in an area identified as a zone of groundwater discharge to Cement Creek (Stover, 1999, Herron et al, 1998, Stock et. al, 1992, 1993,). Extensive aprons of native ferricrete deposits lie below the site on the banks of Cement Creek, indicating that groundwater with elevated iron and other metals discharged in this area long before mining occurred. Since plugging of the American Tunnel, natural springs and seeps have begun to reappear along the valley foot slopes. At present, the R&B workings are short-circuiting groundwater from the natural fracture systems they intersect directly to surface through the mine. If the R&B adit were bulkheaded deep enough such that overburden pressures are great enough to seal minor joints, it is expected the restoration of natural groundwater flow paths would result in discharge from reactivated springs and seeps in this area along Cement Creek.

Fracture permeability in the crystalline volcanic bedrock generally decreases with depth. As depth below surface increases, minor joints and fractures are made progressively tighter by increasing overburden pressure. As generally observed in the San Juans, the deeper mine workings penetrate below surface, the more likely groundwater tends to be present only where major structures are encountered. Closer to the portal, decreasing overburden pressure allows minor joints and fractures to transmit water, as is evident by the drips and drizzles entering most adits within the first couple hundred feet of surface. This near-surface "aquifer" thus consists of water-bearing interconnected fractures and joints in the andesite bedrock beneath the surface of the study area. It will be important to select any proposed bulkhead location in the R&B well beyond the zone of the near-surface saturated fractured-rock aquifer, where overburden pressures are high enough to seal minor joints from transmitting groundwater.

Depth of Cover

A preliminary cross section along the R&B workings was constructed as part of the bulkhead feasibility consideration (Figure 6). Due to the extremely steep valley walls along Cement Creek there are 400 feet of overburden at 400 feet in from the portal, and 600 feet of depth at 1,000 feet from the portal. A final bulkhead design must take into account the expected pressure head and depth of overburden available to prevent hydro-fracturing of the rock around the bulkhead. In the case of the R&B workings, it appears that sufficient cover exits to continue consideration of a bulkhead if this approach is chosen.

Conclusions

This surface geologic investigation did not indicate any significant structural or undesirable geotechnical conditions that would preclude further consideration of a bulkhead closure approach for discharge control at the Red & Bonita Mine. The bedrock in this area has dominant structural anisotropy (preferred orientation of permeability and flow direction) trending northeast-southwest dipping steeply southeast, and east-west dipping steeply north. The preferred overall groundwater flow direction is thus predicted to be toward the main Cement Creek valley, parallel to the trend of the workings, and generally not toward the adjacent lower section of the gulch below the Gold King Mine. Localized structures and joints do exist that strike in many other directions, making it imperative that a thorough structural analysis of rock exposed in the mine workings be conducted prior to a final bulkhead feasibility analysis. Additionally, if overburden pressure is not sufficient to close minor joints parallel to the trend of the workings at the selected bulkhead location, it could be "short-circuited" by filling of these steeply dipping pathways until they "spill over" and discharge back into the workings on the other side of the plug. A through investigation of formation permeability at selected plug locations should be included in any underground evaluation.

The Red & Bonita workings are driven in similar ground and structural conditions to those encountered in the American Tunnel, where bulkheads were successfully installed. The significant depth of the workings below surface at this site should provide sufficient overburden pressures for a bulkhead. The bulkhead would eliminate the present "short-circuit" movement of groundwater through the mine workings and force it back into pre-mining natural pathways. Groundwater is expected to recharge these fracture pathways and eventually find its way to surface in the valley of Cement Creek, reactivating the springs and seeps which existed prior to mining. Flooding of the R&B workings is expected to minimize ARD formation by establishing essentially anoxic conditions in mineralized areas of the mine, significantly reducing formation and transport of dissolved zinc, copper and cadmium from the mined ore bodies to surface waters.

One major concern is the unknown groundwater inter-connectivity between the R&B workings and the nearby Gold King Mine. Although there are no known man made connections such as drill holes, raises or stopes, without direct knowledge of the final extent and configuration of the workings, these types of connections could exist. It is more likely that there are at least a few deep, discrete groundwater-bearing structures that are intersected by both mines, and therefore it is possible that plugging the R&B adit level could force the local groundwater system to refill and rise high enough along these pathways such that discharge increases at the Gold King Portals.

Recommendations

Based on available underground information and surface structural observations, the following

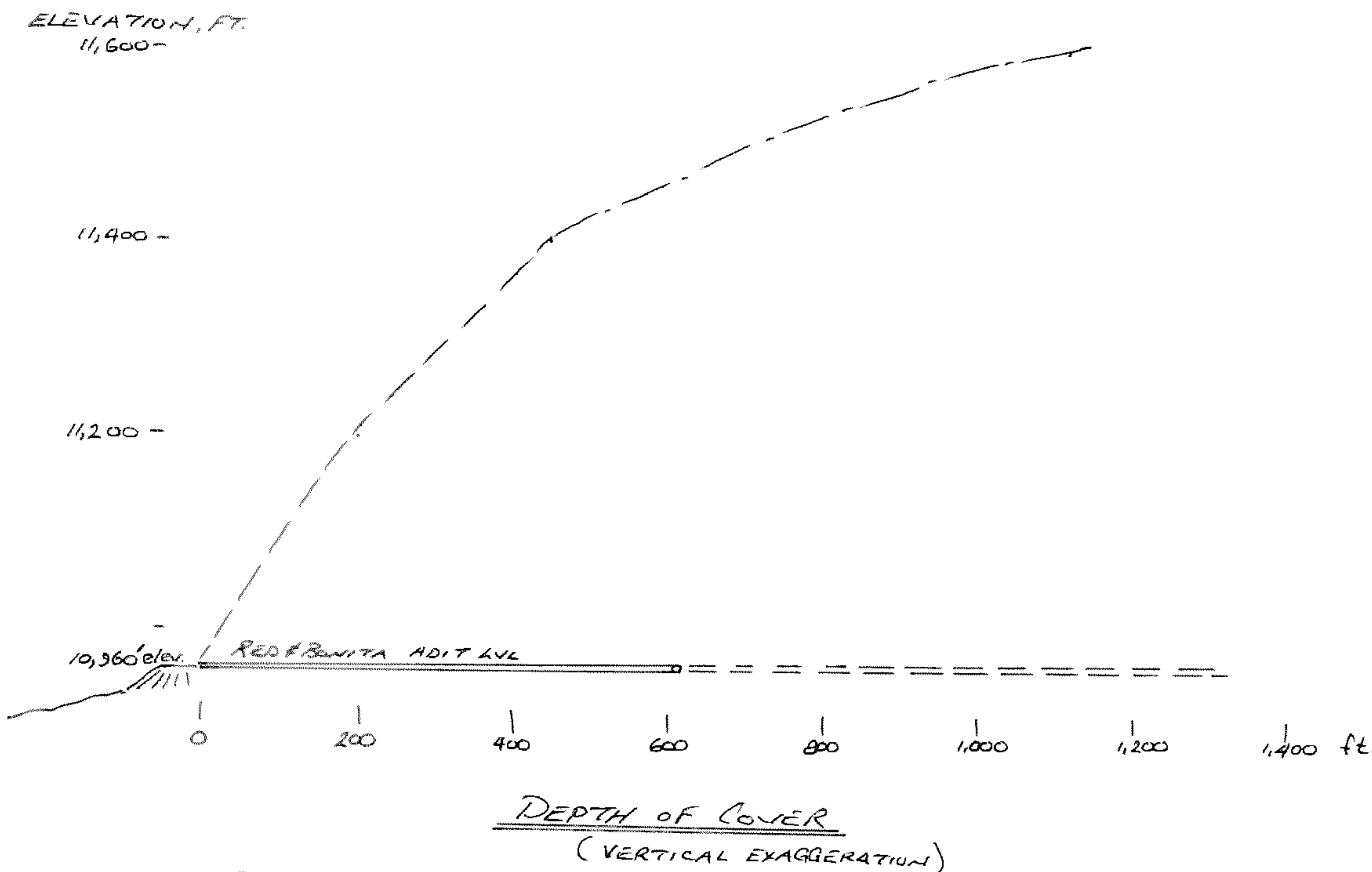

FIGURE 6. DEPTH OF COVER PROFILE ABOVE RED & BONITA ADIT

recommendations are provided for consideration in underground source control and bulkhead feasibility investigations:

1. The head pressure behind the surface portal collapse should be determined prior to any attempt to remove the portal blockage. This can be accomplished by directional drilling into the adit in the bedrock crosscut section using appropriate drill tooling, packers and pressure control methods.

2. Once the portal is opened and the mine pool decanted, a thorough geotechnical and hydrologic investigation of the underground workings should be conducted to determine an appropriate mitigation approach. Other source controls methods could include diverting any clean inflows entering the workings away from ore bodies and contaminate sources in the mine, and local controls to prevent discrete inflows from entering the workings.

3. The location of any bulkhead should be as far back from the portal and shallow fractured rock aquifer as possible, while avoiding the altered rock zones adjacent to mineralized veins. A through investigation of formation permeability at selected plug locations should be included in any underground investigations. This will determine the formation (curtain) grouting needed to seal the rock around the bulkhead. If the bulkhead is placed too close to surface, a great deal more grouting will be required to isolate the impounded water from communicating with the near-surface fractured rock aquifer, and there is a higher degree of risk that water will find a pathway around the bulkhead.

4. If a high-head condition is predicted for a bulkhead, it might be more cost effective to consider the "multiple leaky plugs" approach to save drilling and curtain grouting costs.

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