Underground Investigation of Standard Mine Level 2, Gunnison County, Colorado

Submitted To:

Colorado Department of Public Health and Environment
HMWD
4300 Cherry Creek Drive South
Denver, CO 80246

And

U.S. EPA Region VIII
1595 Wynkoop Street (5144)
Denver, CO 80202-1129

By:
Colorado Division of Reclamation, Mining & Safety
1313 Sherman Street, Suite 215
Denver, CO 80203

Prepared By:
Jeff Graves

October, 2009

Table of Contents

	Page
Introduction	4
Project Location and Background	4
Geologic Setting	6
Underground Infrastructure	6
Underground Reconnaissance	8
Underground Workings	15
Mine Geology	16
Underground Hydrology	17
Recommendations for Source-Water Control Approaches	19
Recommendations for Future Work	21
Summary	21
References	23

List of Figures

Figure Number		Page
1.	Location of the Standard Mine, Gunnison County Colorado.	5
2.	Mapped workings for Levels 2 and 3 with aerial photo.	6
3.	Timbered platform at Center Raise.	7
4.	Ladders descending Center Raise.	8
5.	View down first raise from Level 2 to 1.	9
6.	Second raise with railed grizzly.	10
7.	Personnel in main drift just beyond railed grizzly.	11
8.	Collecting water at sample location #1.	11
9.	Flowstone deposits at sample location #2.	12
10.	View down back raise.	13
11.	Ore chute and flowstone at sample location #4.	14
12.	Collecting water at sample location #3.	15
13.	Footwall and ore chute near sample location #6.	16
14	Fracture controlled groundwater inflows.	18

List of Tables

Table #1.	Water sample location descriptions.	19

List of Plates

Plate 1	Standard Mine, Level 2 Map, Plan View
Plate 2	Standard Mine, Cross Section Map, Area Investigated
Plate 3	Standard Mine, Cross Section Map, Water Flow

Introduction

This report summarizes the results of an underground assessment of the Standard Mine, Level 2, conducted by the Colorado Department of Natural Resources, Division of Reclamation, Mining and Safety, Inactive Mines Reclamation Program, (DRMS) at the request of the United States Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). The report includes descriptions of the underground workings that were explored, and presents an interpretation of the geology and mine-groundwater interactions, with specific recommendations for further work associated with potential remediation alternatives.

Field work was conducted at the site the week of July 20th, 2009. DRMS staff completed installation of access infrastructure to Level 2, and conducted exploration of Level 2. Water samples were collected for United States Geological Survey (USGS) personnel from Level 2 for further evaluation.

The project work was designed to:

1. Provide reasonably safe access to Level 2 for exploration and sample collection;

2. Map all accessible mine workings on Level 2 specifically noting mine layout, vertical connections, and water flow paths;

3. Assist USGS personnel by collecting water quality samples at appropriate locations on Level 2.

The results of the subsurface investigations will be used to assist EPA in decision making regarding future mine drainage remediation work at the Standard Mine site.

Project Location and Background

The Standard Mine is located approximately 4.5 miles northwest of the town of Crested Butte in Gunnison County, Colorado. The mine is situated in Elk Basin, a high mountain valley on the southerly flank of Scarp Ridge. Scarp Ridge extends easterly from the Ruby Range. Elevations at the site range from 11,000 feet to 11,560 feet above MSL. The Standard Mine lies in the Ruby Mining District of central Colorado. Previously known as the Micawber Mine, it developed a silver-zinc-lead vein, and was worked intermittently from 1950 until 1969 (Ludington and Ellis, 1983).

The term “Standard Mine” is applied to a series of interconnected underground mine levels located in Elk Basin. The mine openings are located within a roughly linear twelve acre northeasterly trending area bounded at the southwest at latitude north 38^0 52’ 46.5”, longitude west 107^0 04’ 25” and at the northeast at latitude north 38^0 52’ 59.0”, longitude west 107^0 04’ 07.4”.

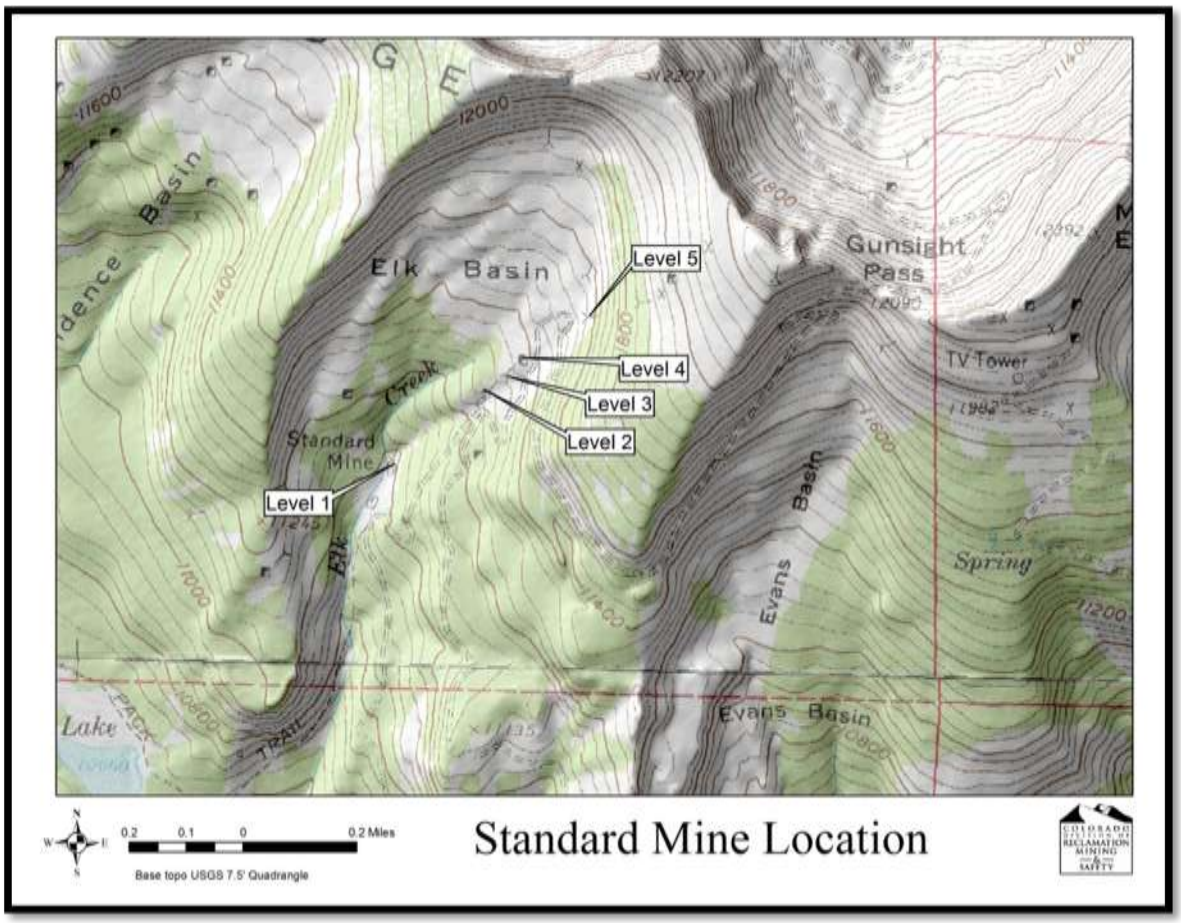


Figure 1. Location of the Standard Mine Surface Openings in Elk Basin, Gunnison County, Colorado. Base from USGS 7.5 min. *Oh-Be-Joyful* Quadrangle Map.

The five openings consist of four adits and the remnants of a twin compartment shaft (Figure 1). At Levels 3 and 5, the adits provide access to mine workings that are open essentially for their entire extent. The Level 1 adit is caved tight less than one hundred feet from the portal. The Level 2 adit is caved at the portal. The twin compartment vertical shaft, shown as Level 4 on Figure 1 is also caved tight approximately fifteen feet below the surface. This shaft originally connected the surface to the underlying Level 3. Figure 2 depicts the mapped location of underground workings for Levels 2 and 3 projected onto an aerial photo of the site.

This report refers to the mine workings by the discreet mine level number (1, 2, 3 etc.). With Level 1 being the lowest and Level 5 being the highest in elevation. This system corresponds to that used by the EPA on their Standard Mine web site (http://www.epa.gov/region8/superfund/co/standard/photos.html).

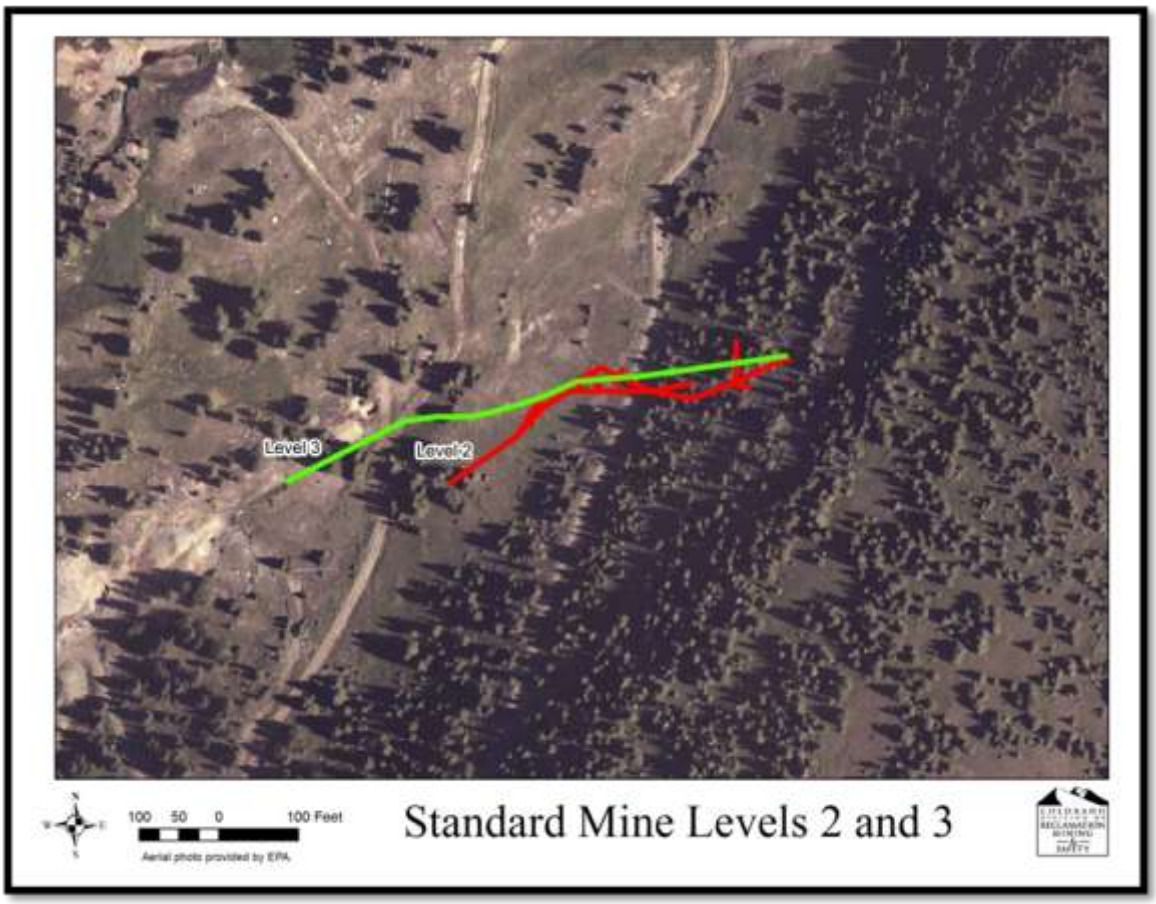


Figure 2. Location of mapped workings for Levels 2 and 3 relative to aerial photograph.

Geologic Setting

Site geology will not be covered in this report since no new geologic mapping was conducted. The reader is referred to previous reports for site geology including: Caine, etal., 2009; Gaskill, 1967; Ludington and Ellis, 1983; Socolow, 1955; Wood and Oeter, 2007.

Underground Infrastructure

Following underground investigations completed during the summer of 2006 by DRMS personnel, it was proposed to EPA that Level 2 could be safely investigated from Level 3 with minor infrastructure improvements. Access to Level 2 would be from Level 3 through the Center Raise. The Center Raise is a partially timbered raise/stope that descends approximately 70 feet to Level 2. No ladders are present within the raise, and substantial muck and debris has accumulated along the sill pillar just above Level 2.

To safely access Level 2 through the raise, a method of entry and exit other than ropes had to be established. Previous investigations indicated that sufficient timber and lagging remained within the raise to allow for a ladder and platform combination to provide

access. Installation of electrical power and surface communications would also be necessary to install the ladders and access Level 2 safely.

During the spring and early summer of 2009, DRMS personnel obtained the necessary infrastructure components, and arrived onsite the week of July 20th to begin installation. Electrical power was provided within the mine by underground cabling from a gas powered generator placed outside the portal. Communications were established with self-powered hard line phones placed at the portal and at the head of the Center Raise. A timbered platform and anchored tie-off (Figure 3) was constructed above the Center Raise to provide a safe entry point into the raise.

Figure 3. Timbered platform and anchored tie-off above Center Raise.

Various lengths of aluminum ladder were placed within the lagged section of the raise in an alternating zigzag pattern descending through the timbering. The bottom section of lagging within the raise was suspended approximately 40 feet above the sill pillar muck pile, and opened into a large stoped room. Ladders were anchored to the ribs and pieces of timber to descend the remaining 40 feet to the muck pile (Figure 4). At the bottom of the muck pile a ladder was placed through a small opening to descend the remaining 12 feet to Level 2. Safety rope was installed that allowed personnel to move up and down the ladders while still on belay to prevent falls.

Figure 4. Ladders descending Center Raise stoped section.

Underground Reconnaissance

Upon completion of the access infrastructure DRMS personnel began reconnaissance of Level 2 by descending the Center Raise from Level 3. All areas that were observed are shown on Plate 2 in cross section and Plate 1 in plan view. As previously described the Center Raise was partially timbered near the top and opened into a large stoped out room just above the sill pillar for Level 2. Along the southeast face of the Center Raise stope a small scram drift was opened approximately 15 feet from the top of the sill pillar. The scram drift was completely collapsed within 7 feet of the brow. It appeared that the drift had been cut and exposed during stoping along the side of the Center Raise. Substantial muck, roof fall and timber debris covered the sill pillar just above the draw point entry into Level 2. Level 2 was accessed through a 3 ft by 4 ft opening within an ore chute that dropped down about 12 feet into Level 2.

Level 2 was flooded to a height of 3 feet at the entry point and in some places the floor was also covered with up to 1 foot of clayey muck and iron precipitate. Temperatures were cold and humidity was nearly 100% as evidenced by visible water vapor. Numerous ore chutes with extensive back timbering were noted as progress was made northeasterly. Approximately 40 feet from the entry point a muck pile was encountered that was

responsible for creating the mine pool at the entry point. Some water was moving over and through the muck pile to the northeast.

The head of a large twin compartment raise was encountered to the south that appeared to be the first Level 1 to 2 raise shown on the Carpenter, 1958 cross section. The raise was 5 feet by 10 feet with a laddered man way, and open skip way. Figure 5, is a photograph looking down the first raise. Approximately 3 gallons per minute (gpm) of water was cascading down the open raise, and significant iron flowstone deposits were observed on the raise collar. No attempt was made to descend the raise due to the unstable nature of the existing ladder. Across the raise to the south, another drift was noted that appeared to parallel the current heading.

Figure 5. View down first raise from Level 2 to Level 1.

The head of another raise was encountered approximately 15 feet northeast of the first raise. The second was likely the second raise shown on the Carpenter, 1958 cross section providing access from Level 2 to Level 1. The raise was approximately 18 feet by 18 feet and was covered by a railed grizzly for rock screening as seen in Figure 6. A large iron flowstone deposit was visible across the raise likely having been formed by the 2 gpm of water cascading down the side. The raise was open to the extent visible, and was likely used as an ore pass between Level 2 and 1.

Figure 6. Second raise with railed grizzly.

Beyond the second raise the drift began heading to the southeast. The foot of a twin compartment raise was encountered with an intact ladder. No exploration was made up the raise due to the unstable nature of the ladder. Just past the raise doghole drifts on either side of the main drift were observed. This section of the mine was significantly drier with very little dripping from the back or pooled water on the floor as seen in Figure 7. A large four-way junction was encountered just beyond the dry section.

One drift proceeding from the junction continued to the southeast and appeared to be the main drift. The drift heading to the west was likely the previously observed drift across the first raise. Finally, a 40 foot dead end drift proceeded to the northeast. The center pillar separating the west drift was observed to be heavily silicified with some minor mineralization. Water sample #1 (USGS EC-MSTDL21) was collected from a weeping drill hole along the south rib, shown in Figure 8. The drill hole and surrounding fractures were producing less than 2 gpm, but had resulted in moderate iron flowstone deposits along the rib and floor.

Figure 7. Personnel proceeding along main drift just beyond raise with grizzly.

Figure 8. Collecting water at sample location #1 (USGS EC-MSTDL21)

Sample #2 (USGS EC-MSTDL22) was collected from fracture seepage along the north rib of the northeast trending drift from the four-way intersection. There was approximately 3 gpm of diffuse discharge emanating from fractures within this drift, all along the north rib. Extensive iron flowstone deposits had developed along the rib and floor below these fractures as seen in Figure 9.

Figure 9. Flowstone deposits along rib at sample location #2 (USGS EC-MSTDL22)

Continuing southeast from the four-way intersection the drift began to dry substantially. No mineralization was evident along this section of drift suggesting that this was a runaround heading. After the drift began heading to the northeast, a three-way intersection was encountered. The head of a raise with observable sublevel drifting occupied the center of the intersection. This raise is not shown on the 1958 Carpenter cross section indicating that additional mining occurred within the Standard Mine Complex after completion of the 1958 map. Drifting began approximately 30 feet below Level 2 and appeared to continue both east and west. It was difficult to tell if the raise continued to descend beyond the 30 foot sub level. A wooden ladder was precariously attached to a timber post supporting lagging above the raise (Figure 10). The raise was not accessed due to the unstable nature of the ladder. Approximately 3 gpm was cascading down the raise from the north drift of the three-way intersection.

The north drift from the three-way intersection continued 50 feet to an abandoned working face. Along this drift the foot of a two compartment raise was encountered that

likely coincides with the back raise connecting Levels 2 and 3 shown on the Carpenter, 1958 cross section. The raise was timbered and had a deteriorating ladder ascending the man way. No effort was made to ascend the man way. Water sample #3 (USGS EC-MSTDL23) was collected from the nearly 3 gpm discharge descending the raise.

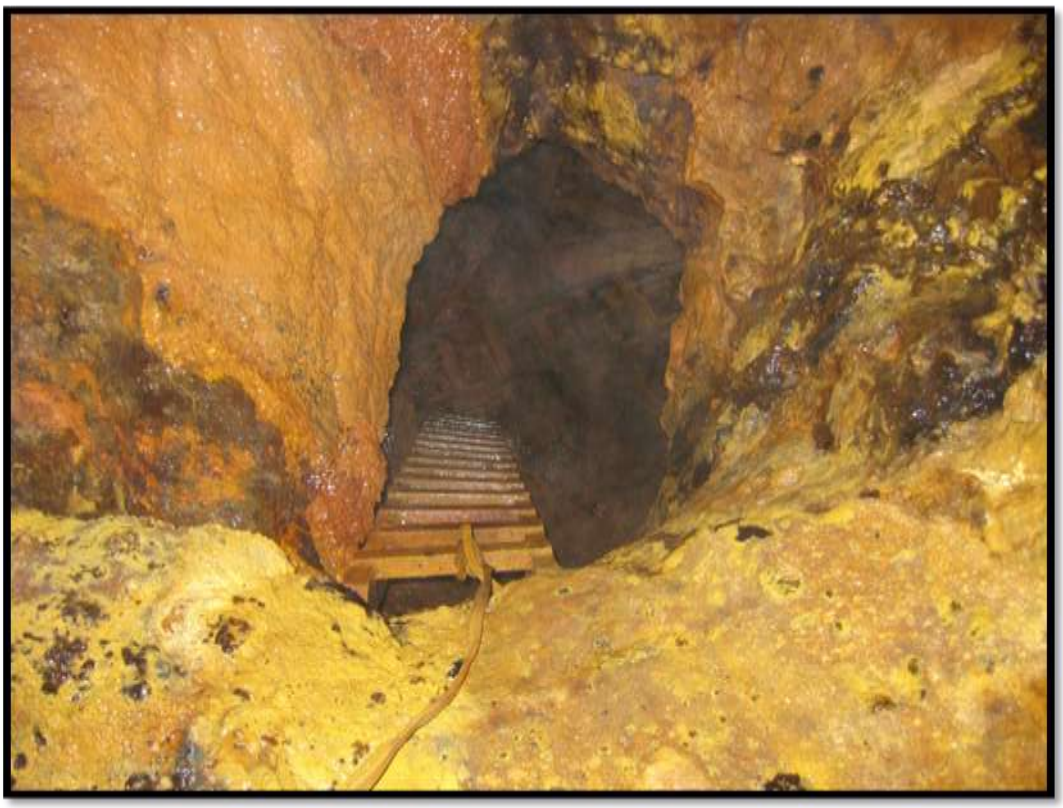


Figure 10. View down back raise with visible sub level.

The main drift continued northeast from the three-way intersection, but was not explored due to unstable timber and potential roof fall. The drift continued nearly 65 feet before appearing to turn to the east. No water was visible along the floor or dripping from the back for the observable length of the drift. No exploration was conducted farther east than this point.

Personnel returned to the four-way intersection and proceeded along the west heading. A number of dripping ore chutes with extensive flowstone deposits were encountered in the vicinity of raises one and two. Sample #4 (USGS EC-MSTDL24) was collected from an ore chute closest to the second raise (grizzly raise). The ore chute and associated flowstone deposit are shown in Figure 11.

Pooled water was encountered just beyond the first raise as personnel continued southwesterly along the drift. A stoped but untimbered area was encountered beyond the first raise. Eventually the drift intersected the main drift that had already been explored northeasterly. Sample #5 (USGS EC-MSTDL25) was collected from diffuse dripping along the back at the intersection. Substantial diffuse dripping was apparent all along the main drift in this area.

Figure 11. Ore chute and flowstone at sample location #4 (USGS EC-MSTDL24)

As reconnaissance continued southwest along the drift numerous ore chutes were observed. Most of the ore chutes still contained material and were providing a conduit for water movement. Diffuse dripping was noticeable all along this section of drift and may have amounted to 5 gpm in aggregate. Much of the back in this area was timbered preventing visible inspection of stoped areas. Mine pool depth progressively rose until further reconnaissance along the drift became impossible. Visible observation down the drift indicated that the mine pool continued to approach the back. Ore chutes and back timbering continued down the drift. This point was the farthest west that exploration was conducted. Sample #6 (USGS EC-MSTDL26) was collected from dripping timber along the back as seen in Figure 12.

More detailed mapping of the already observed workings was not conducted due to the apparent onset of hypothermic symptoms in DRMS personnel. The cold temperatures, high humidity and partially submerged workings likely contributed to the early onset of hypothermia. DRMS personnel returned to the entry chute and exited Level 2.

Figure 12. DRMS personnel collecting sample #6 (USGS EC-MSTDL26)

Underground Workings

Over 825 feet of workings on Level 2 were explored during the investigation, of which nearly 300 feet had pooled water in excess of 1 foot. The drifts averaged 6 feet in width and 8 feet in height. Some sections of the drifts, specifically the intersections were in excess of 10 feet width. Where drifts ran parallel, stoping appeared to take place along the northern drift as indicated by numerous ore chutes and timbering. Timbering was confined to ore chutes and areas of stoping, and appeared to not be required for general ground support. Areas of back stoping were typically timbered and not visible. Minor and sporadic amounts of roof fall were visible along the floor with most muck directly correlated to ore chutes or zones of collapsed lagging. All observed ore chutes had not been fully drawn, and had visible ore filling the chutes.

Some original mine infrastructure was present on Level 2. Both mine rail and rigid airline was observed along most of the workings investigated. One ore/skip car was noted at the head of the first raise. No hoisting works or associated infrastructure was observed at the head or foot of any raises. One stick of dynamite was visible on top of mine timbers near the four-way intersection. Additionally, a deteriorated cardboard dynamite box was located near the ore car. Extra care was taken not to disturb any of the explosives.

No oxygen deficient environments were encountered during the reconnaissance. Overall, the workings on Level 2 appeared to be stable and well ventilated allowing for relatively safe and unrestricted access for the extent of the investigation.

Mine Geology

Geology on Level 2 was not well documented due to a number of factors. Much of the back and ribs on Level 2 was either timbered or heavily coated with flowstone and other precipitate making rock type identification difficult. In addition, DRMS personnel cut the investigation short for safety reasons.

Of the geology that was observed, it appeared to be consistent with geology on Level 3 with Ohio Creek formation occupying the footwall while Wasatch formation was present in the hanging wall. The majority of ore emplacement and subsequent stoping occurred around the center raise and towards the portal. The well defined fault zone present on Level 3 was not as evident on Level 2, partially due to extensive timbering. Neither the hanging wall nor footwall surfaces of the fault were prominently exposed, except along the main drift where sample #6 was collected (Figure 13). Figure 13 shows a near vertical dip of the footwall. A near vertical structure/vein approximately 1 foot in width was observed along the back of the west heading drift from the four-way intersection. The vein was heavily silicified with sparse mineralization. Other obvious vein/fault structures were not readily exposed or noted.

Figure 13. Footwall and ore chute near sample location #6.

Overall very little in-place mineralization was observed due to the extensive stoping and subsequent timbering. It appeared that a poorly defined or bounded structure was responsible for the parallel drifting, dogholes and wandering character of the drifts. The most well defined portion of the structure began near the ore chute entry point and extended to the southwest along the main drift. Some sulfide mineralized ore along with waste rock was noted in many of the undrawn ore chutes.

Underground Hydrology

A major portion of the Level 2 investigation revolved around understanding water movement and water quality within the mine complex since it is a critical component of decision making regarding remedial action. As previously discussed in CDRMS, 2007, groundwater flow appeared to be fault and mine controlled, with Level 3 intercepting relatively "near" surface groundwater and directing it down through the open workings to eventual discharge out the Level 1 portal. Some question also remained as to the source and extent of a previously observed mine pool on Level 2. Finally, as Manning, etal. reported in 2007, the source of metals loading to the Level 1 discharge had not been found on Level 3 suggesting that Level 2 might provide that source.

Water movement on Level 2 and 3 is shown in Plate 3, and is consistent with what was expected. The vast majority of water was moving into Level 2 from open stopes and timbered areas between Levels 2 and 3, specifically from the Center Raise towards the portal. Flow through most stopes was diffuse and defined by consistent dripping except for flow within the Center Raise and entry ore chute to Level 2, where flow was streaming. Flow was also observed to be streaming down the back raise from Level 3 to 2. Most streaming flows from Level 3 to 2 were between 2 and 3 gpm, with individual drips not exceeding 0.5 gpm. No individual water flows were observed to exceed 3 gpm. Roughly 80% of inflows into Level 2 appeared to be through stopes and raises tied to Level 3. Quantification of all flows during the investigation was by visible estimation.

The remaining 20% or so of inflows appeared to be from the surrounding rock. These inflows were strongly preferential to joints and fractures as seen in Figure 14. The areas of most intense groundwater inflows coincided with drifts driven towards or along the probable fault footwall and the Ohio Creek formation. Some diffuse inflows were however observed from the hanging wall and Wasatch formation. Varying amounts of iron flowstone were present below most groundwater inflows suggesting enrichment in iron from previous contact with pyrite. Both Ohio Creek and Wasatch formation inflows formed iron flowstone.

Water was leaving Level 2 from at least 3 discreet locations. The locations are shown in Plate 3, and consisted of all 3 raises from Level 2 to Level 1. Most water flowing down the last/back raise on Level 2 was coming directly from the back raise to Level 3. Water flowing down the grizzly raise was coming from rock formations and ore chutes to the east. The majority of water flowing down the first raise was backflow from the mine

pool which was being fed predominately by drips and streams through stopes and ore chutes.

Figure 14. Fracture controlled groundwater inflows.

The previously observed mine pool on Level 2 was being formed on one side by a muck pile consisting of collapse debris approximately 35 feet northeast of the entry chute. No collapse on the west end of the mine pool was observable prior to the water reaching the back. It is possible that collapse material at the portal of Level 2 or at the first raise from Level 3 could be responsible for the mine pool seen on Level 2. The investigation clearly showed that the mine pool on Level 2 was not due to a backup of water from Level 1. No mine pools were observed to the east of the raises from Level 2 to 1.

To help determine loading from Level 3 to Level 2, 6 water samples were collected from various locations in Level 2 and analyzed by the USGS. Results from the samples are detailed in Verplank, etal. 2009. Table #1 describes the 6 sample locations. Results from Level 2 water sampling suggest that water movement between Levels 3, 2 and 1 could account for the metal loading seen at Level 1 portal discharge (Verplank, etal., 2009). Most likely, water movement from Level 3 to Level 2 through open stopes, raises and filled ore chutes is accumulating metals, and is responsible for the metal concentrations seen on Level 2. Water flow along the floor in Level 2 through muck, containing sulfide ores provides additional leachable metals. The mine pool located on Level 2 compounds loading by providing additional residence time for leaching. Some metals loading to Level 2 is occurring from formation water entering the mine through fractures and along

or adjacent to the fault/vein structure, but likely does not account for a large percentage of the load.

Table #1. Water sample location descriptions from Level 2, Standard Mine.

Sample ID	Sample Location Description
#1 (USGS EC-MSTDL21)	Level 2, drill hole, south rib, Wasatch Formation
#2 (USGS EC-MSTDL22)	Level 2, fracture inflows, north rib, Ohio Creek Formation
#3 (USGS EC-MSTDL23)	Level 2, stream from raise, Level 3 to 2
#4 (USGS EC-MSTDL24)	Level 2, drips from ore chute
#5 (USGS EC-MSTDL25)	Level 2, drips from back
#6 (USGS EC-MSTDL26)	Level 2, through timbered stope

Recommendations for Source-Water Control Approaches

Specific recommendations for source-water control approaches were outlined in a previous report by CDRMS, 2006. Additional information collected during this investigation and other investigations since 2006 have provided useful information for better source control selection. Previously mentioned source control methods included the following: Hydrologic barriers; Up slope groundwater diversions; Modify hydrologic behavior of the fault structure; Dewater fault; Surface water diversions; Minimize flow between mine levels.

Source Control Methods

Previous and current investigations continue to indicate that water movement from Level 3 through Level 2 to Level 1 is responsible for the majority of metal loading seen in Level 1 discharge. Thus, controlling the amount of water that enters Level 3 and migrates to Level 2 is an essential component to any successful source control remedy. Water quality data gathered during this investigation highlights the amount of loading occurring just between Levels 2 and 3 as water passes through stopes, raises and ore chutes. Additional loading is likely taking place as water moves from Level 2 to Level 1, and during impoundment behind the Level 1 collapse.

The following is a short summary of source control methods provided in the 2006 CDRMS report:

> Hydrologic Barriers – Installation of grout curtains or other groundwater pathway modification techniques along or adjacent to the fault zone that restrict groundwater movement.
>
> Up Slope Groundwater Diversion – Installation of horizontal dewatering wells or the use of Level 5 as an up gradient groundwater intercept and diversion, thereby reducing groundwater available down gradient.

Modify Hydrologic Behavior of the Fault Structure – Modify hydraulic conductivity of fault zone through the injection of grout or other flow restricting media to reduce the water delivering capacity of the fault zone.

Dewater Fault – Installation of gravity draining wells into the fault zone between Levels 1 and 5 thereby reducing water inflow into the mine workings from the fault zone.

Surface Water Diversion – Install surface water diversions including French drains and berms up gradient of the fault zone and workings to reduce infiltration and eventual inflow into the mine workings.

Minimize Flow Between Mine Levels – Install flow barriers within the mine complex to reduce movement of water between levels and areas of mineralization.

A successful source control remedy at the Standard Mine will likely involve the use of multiple source control measures in a phased fashion allowing for scope modifications based on observed success. As a result of work completed this summer by Caine, etal., and Minsley, etal. it appears that the fault may function more as a flow barrier than a conduit, and that the down thrown side of the Micawber Fault consisting of the Ohio Creek formation exposed at surface and in the mine has a relatively high hydraulic conductivity. This helps to explain the observed confinement of groundwater infiltration to the footwall within the mine workings.

If the fault truly functions as a barrier to flow, then installation of hydrologic barriers or modification of the fault structure to impede flow is not necessary. Installation of Surface water diversions will have a more limited impact if the majority of groundwater is supplied to the mine through an extensive area of the Ohio Creek formation. The installation of up slope groundwater diversions in conjunction with fault zone and Ohio Creek formation dewatering would help to reduce the amount of water inflow into the mine workings. These groundwater diversions could be modified to intercept Ohio Creek formation water from Level 3 using horizontal wells, or from surface horizontal wells parallel to the workings. This intercepted water could then be collected and possibly discharged from Level 3 without treatment. If water was not sufficiently clean to discharge, it could be collected and conveyed to the bioreactor at Level 1.

Minimization of water movement between levels within the Standard Mine, specifically between Levels 2 and 3 would be the most successful in reducing metals loads at Level 1 discharge based on the data collected thus far. Reduction of water movement between Level 3 and 2 could be accomplished with the use of impermeable barriers covering open stopes and raises, and all along the floor of Level 3. Impermeable barriers could consist of polyurethane foam, grout, flow fill or some other impermeable medium. Installation of in mine source water controls will require some level of rehabilitation to provide a safe working environment. The level of rehab will be dictated by the extent and location of source control implementation. Serious consideration should be given to exploring remote, source control installation options.

A phased approach involving reduction of mine level flow through, formation dewatering, and surface water diversions would provide a comprehensive solution and would be most likely to succeed. Phasing the approach to source control will allow for scope modification based on observed successes of individual components.

In addition to the above summarized source control methods, consideration should also be given to installation of a bulkhead on Level 1. The collapse on Level 1 is currently functioning as an un-engineered bulkhead and as such has an unknown factor of safety regarding permanence. Previous investigations have indicated that water discharging from Level 1 has not been stored within the mine pool for very long suggesting minimal head behind the collapse (Manning, etal., 2007). Even the blowout of an 8 foot head could result in a substantial downstream impact. The installation of an engineered bulkhead would reduce any blowout concerns and allow for metering or elimination of discharge from the portal.

Recommendations for Future Work

Current and previous investigations have provided a substantial amount of information for remedial alternative selection and should make the need for additional investigatory work relatively limited. Continued monitoring of existing discharges and groundwater wells should be continued on a regular basis. The installation of additional groundwater wells might be necessary within the Ohio Creek formation to better establish direction of groundwater movement to assist in formation dewatering and surface diversion installation. Additional underground investigations from Level 3 are not recommended due to safety concerns and lack of potentially useful new data. Future work should include an investigation and feasibility of Level 1 collapse removal and bulkhead installation. Consideration could also be given to opening up Level 2 so that the cause of pooled water could be determined and remedied.

Summary

The Colorado Division of Reclamation, Mining and Safety performed reconnaissance of Level 2 of the Standard Mine the week of July 20th, 2009. The purpose of the investigation was to establish access to Level 2 from Level 3, map accessible portions of Level 2, and collect samples for water quality analysis. Remediation alternatives were summarized along with specific recommendations based on the data collected.

Investigation of Level 2 determined that most water entering Level 2 was moving through stopes, raises and ore chutes connected to Level 3. This water was then being directed from Level 2 down to Level 1 through a series of raises. It was determined that the collapse on Level 1 was not responsible for pooling water on Level 2, and that collapses on Level 2 were responsible for the pooling.

Water quality samples collected from Level 2 confirm that water is degraded as it moves from Level 3 to Level 2. Water degradation appears to be associated with movement through stopes, raises and ore chutes filled with sulfide rich ore.

Source control measures should focus on reducing the amount of water entering Level 3 and moving to Level 1 through Level 2. A phased approach of surface water diversions, flow through restrictions on Level 3, and Ohio Creek formation dewatering should be considered as source control alternatives.

Future work should focus on installation of source control remedies and continued monitoring of existing data points. Investigation into Level 1 blockage removal and bulkhead installation should also be considered.

References

Caine, J.S., Manning, A.H., Berger, B.R., Kremer, Y., Guzman, M.A., Eberl, D.D., and Schuller, K., 2009, Characterization of Geologic Structure and Host Rock Properties Relevant to the Hydrogeology of the Standard Mine in Elk Creek Basin, Colorado: U.S. Geological Survey Scientific Investigations Report, 2009.

Carpenter, C.D., 1958, Micawber Mine cross section: Standard Uranium Corp. unpublished map, Office of Surface Mining files, Docket #403817.

Colorado Division of Reclamation, Mining, and Safety, 2007, Draft underground assessment, Standard Mine Superfund site, Gunnison County, Colorado: Denver, Colorado, 37 p.

Gaskill, D. L., Godwin, L. H., Mutschler, F. E.,1967, Geologic map of the Oh-Be-Joyful Quadrangle, Gunnison County, Colorado: .U.S. Geological Survey Map GQ- 578, scale 1:24,000.

Ludington, S., and Ellis, C.E., 1983: Mineral resource potential of the Oh-Be-Joyful Wilderness Study Area, Gunnison County, Colorado: U.S. Geological Survey Miscellaneous field studies map MF-1582-A, scale 1:24,000.

Manning, A.H., Verplanck, P.L., Mast, M.A., and Wanty, R.B., 2007, Hydrogeologic investigation of the Standard Mine vicinity, upper Elk Creek basin, Colorado: U.S. Geological Survey Scientific Investigations Report, 2007.

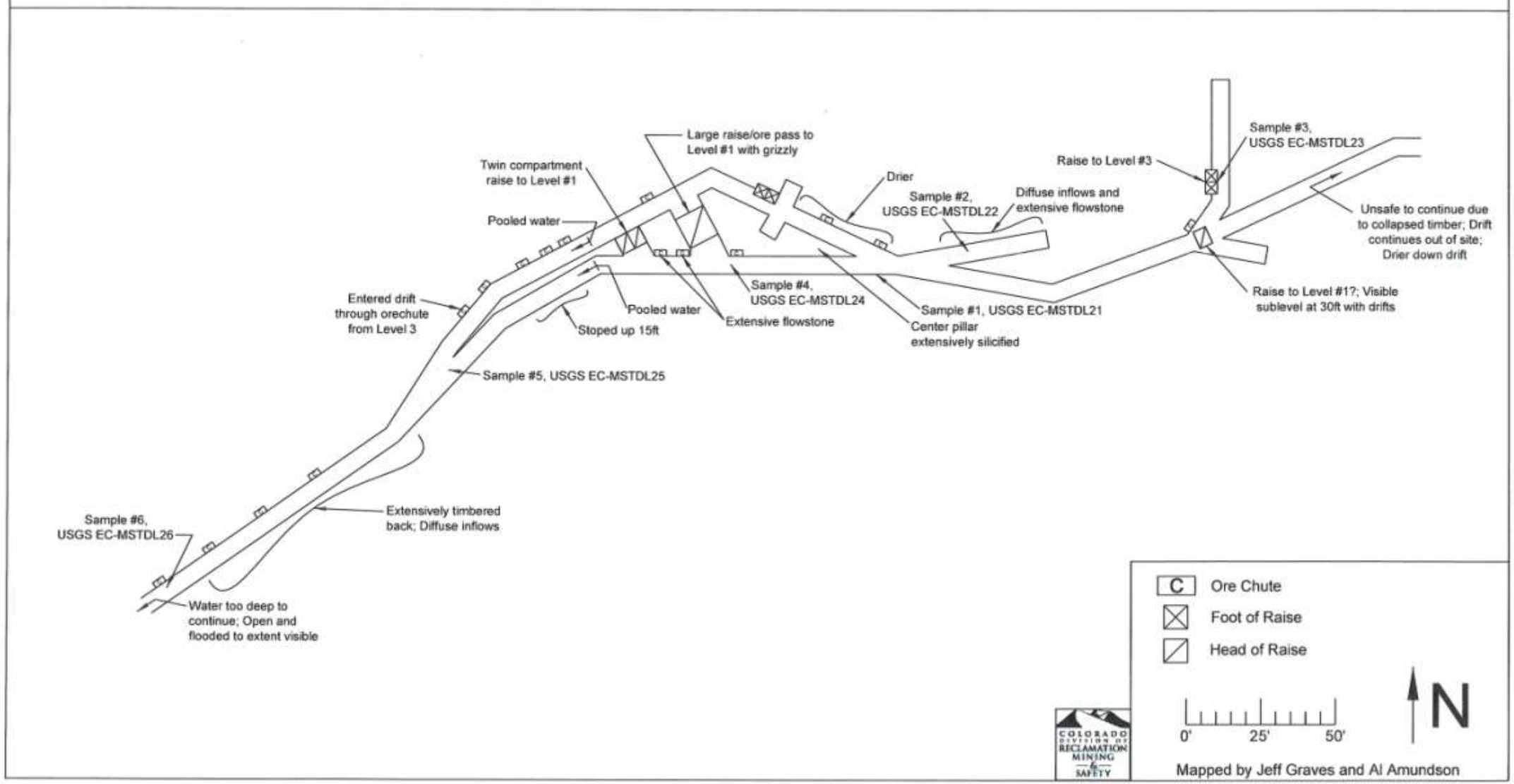
Minsley, B.J., Ball, L.B., Burton, B.L., Caine, J.S., Curry-Elrod, E., and Manning, A.H., 2009, Geophysical characterization of subsurface properties relevant to the hydrology of the Standard Mine in Elk Creek Basin, Colorado: U.S. Geological Survey Open-File Report 2009.

Socolow, A.A., 1955, Geology of the Irwin district, Colorado: Columbia University, PhD dissertation, 97p.

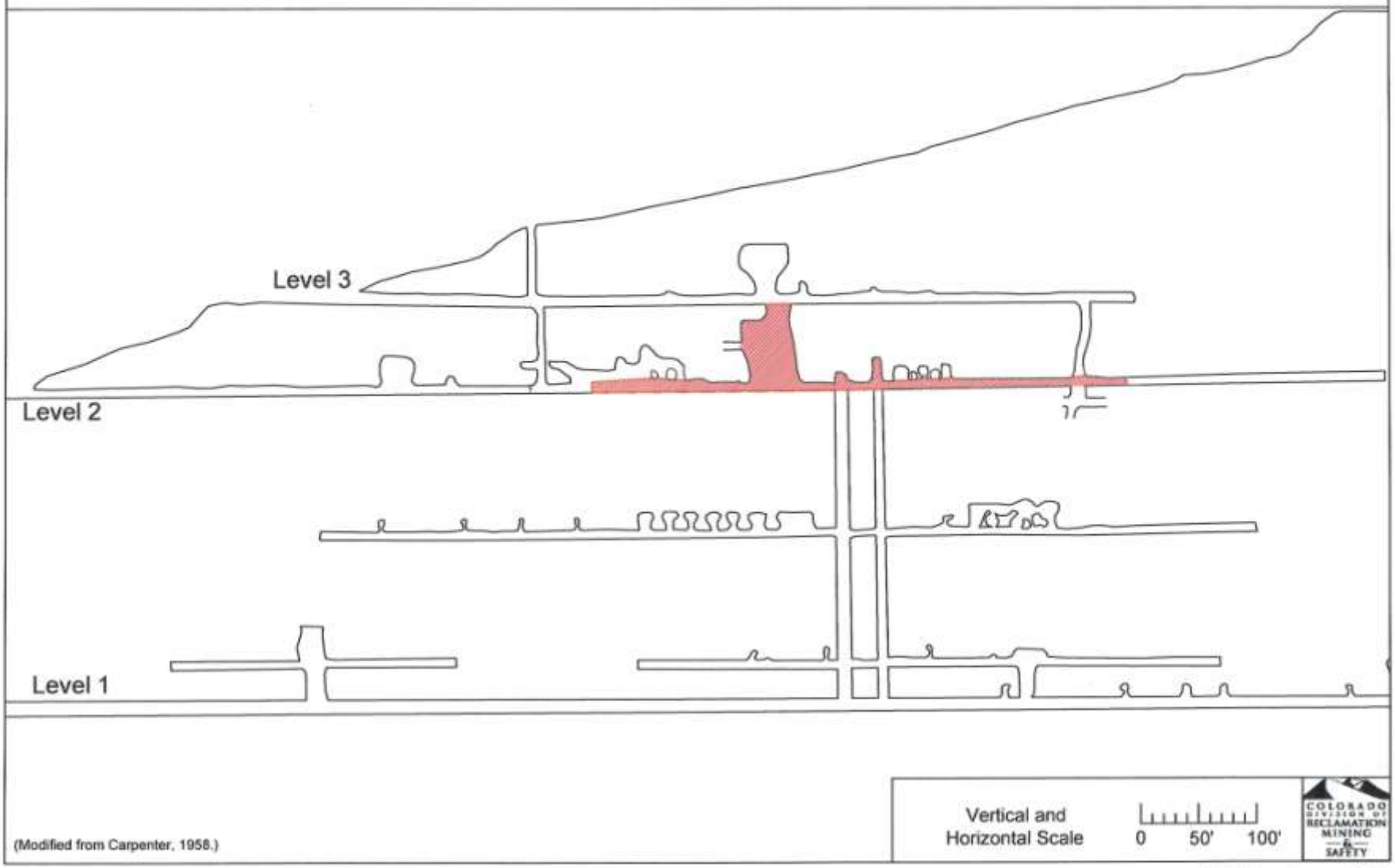
Verplanck, P.L., Manning, A.H., Graves, J.T., McCleskey, R.B., Todorov, Todor, and Lamothe, P.J, 2009, Geochemistry of Standard Mine Waters, Gunnison County, Colorado, August 2009: U.S. Geological Survey Open-File Report 2009.

Wood, R.H. II, and Oerter, E.J., 2007, History, geology, and environmental setting of the Micawber Mine and Elk Load in the Ruby Mining District, Gunnison National Forest, Gunnison County, Colorado: Colorado Geological Survey Open-File Report 08-10.

Standard Mine Level 2



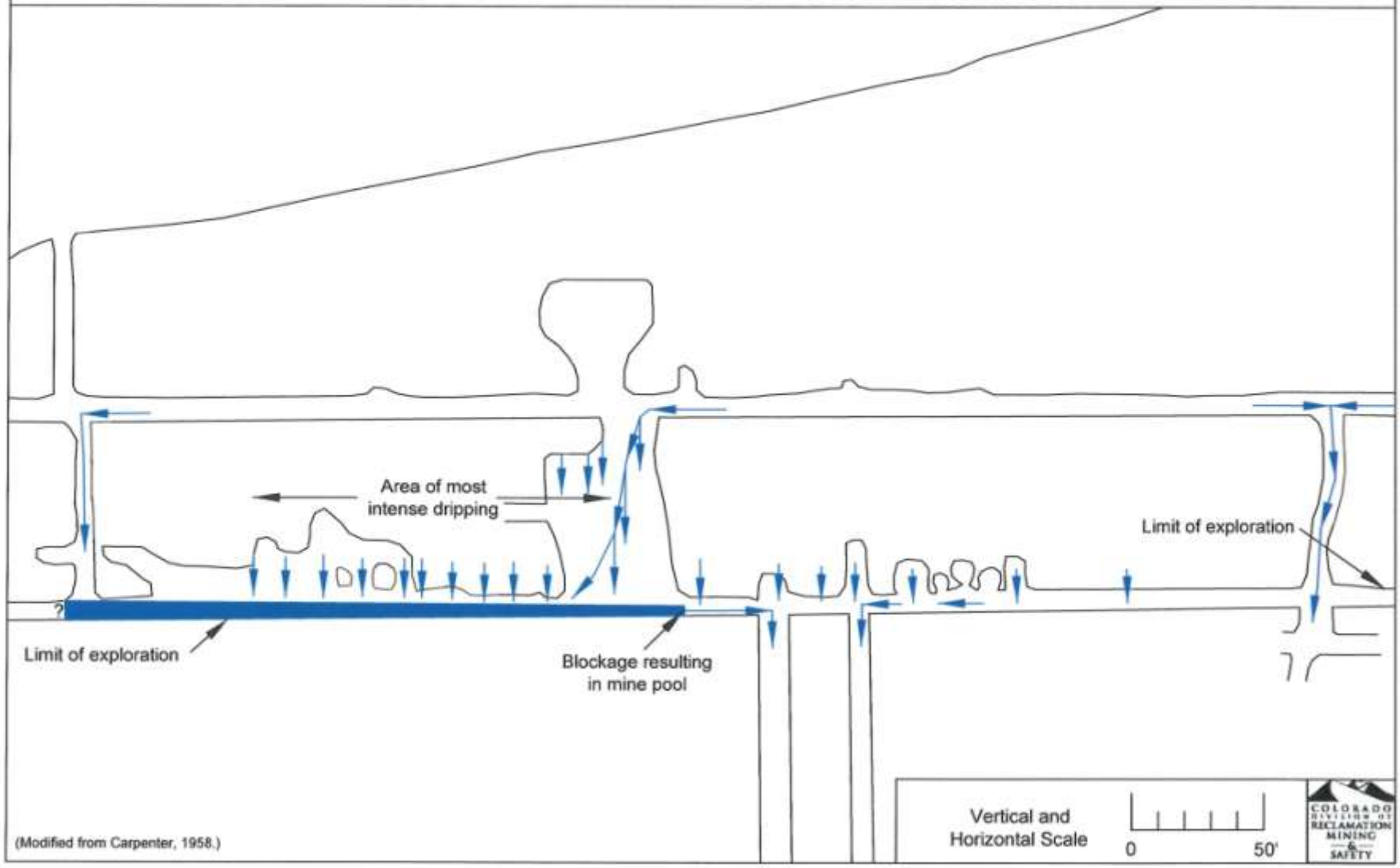
Standard Mine Area of Investigation



(Modified from Carpenter, 1958.)

Plate 2

Observed Water Flow Between Standard Mine Levels 2 and 3



(Modified from Carpenter, 1958.)

Plate 3