

# Underground Assessment Of The Standard Mine Superfund Site Gunnison County, Colorado

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## ***Introduction***

This report summarizes the results of an underground assessment of the Standard Mine 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 to refine the preliminary understandings developed from this assessment. A number of potential remediation alternatives are also discussed.

Field work was conducted at the site the week of August 14, 2006. DRMS staff, accompanied by EPA and CDPHE staff explored Levels 1, 2, 3 and 5 of the Standard Mine, to the extent that they were safely accessible. The United States Geological Survey (USGS) was also present during part of the investigation, and collected water quality samples and water flow data from the significant mine inflows that were identified.

The underground assessment work was designed to accomplish three major goals. These were:

1. Determine the extent of the accessible parts of the mine on the various working levels, and map the accessible areas noting important mining related features and conditions likely to effect water quality improvement alternatives;
2. Map subsurface geology (structure, lithology, fracturing and faulting), and water inflow points and water impoundments in the accessible areas;
3. Assist USGS personnel in collecting water quality and quantity data from the underground inflows located during the assessment.

The results of the subsurface investigations were used to develop recommendations for 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  $38^{\circ} 52' 46.5''$ , longitude west  $107^{\circ} 04' 25''$  and at the northeast at latitude north  $38^{\circ} 52' 59.0''$ , longitude west  $107^{\circ} 04' 07.4''$ .

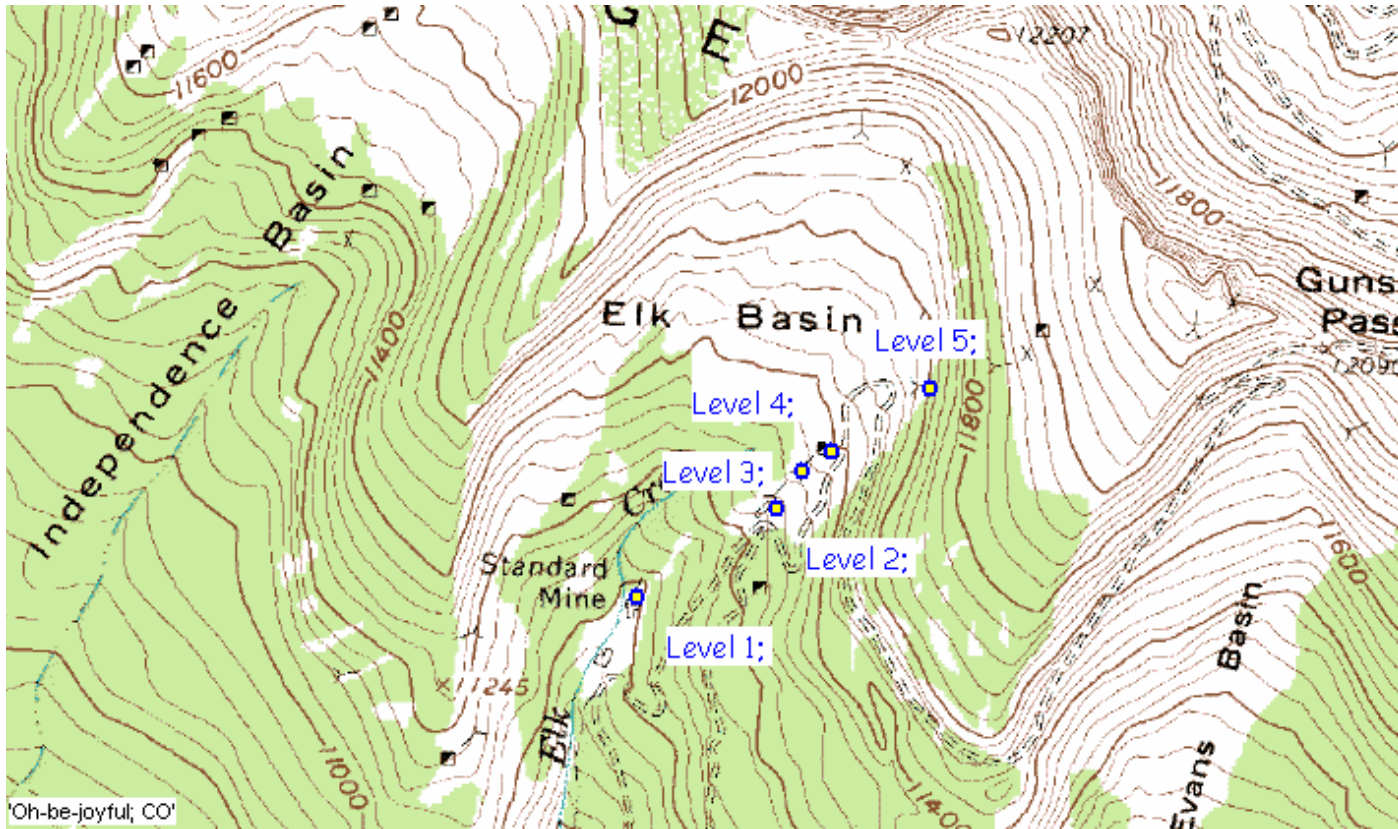


Figure 1. Location of the Standard Mine Surface Openings in Elk Basin, Gunnison County, Colorado. Base from USGS 7.5 min. Oh-Be-Joyful Quadrangle Map.

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.

The Colorado Geological Survey (CGS) (Bird and Wood, undated) provided an annotated history of the Standard Mine site. As with many sites, the name of the mine has changed over time. The change of names is further complicated by the use of a numeric coding system which assigns a unique inventory number to the various mine openings.

In order to eliminate confusion regarding mine feature nomenclature, Table 1 correlates the various mine opening names.

**TABLE 1**

<b>Mine Name</b>	<b>CGS Inventory Code Number</b>	<b>Adit Elevation</b>	<b>Mine Level As Referred To In This Report</b>
Standard Mine	319-4305-2-100	11,000	1
Micawber Mine	319-4305-3-103	11,240	2
	319-4305-3-104	11,320	3
	319-4305-5-103	11,560	5

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>).

The CGS report provides an interpretation of historic mine development and production data associated with the abandoned mine entries. The report indicates that the Level 2 adit was the original Micawber Mine entry developed in Elk Basin. The Level 3 adit was later driven above Level 2 as development continued. These two levels were eventually connected by intervening raises. It is unclear from the CGS report when the Level 5 adit was developed, however it does note that nearby adits and shafts were driven on the same vein as Levels 2 and 3 subsequent to their development.

The Level 1 portal, depicted on the USGS Oh-Be-Joyful Quadrangle Map as the Standard Mine, was developed in 1958. The Level 1 workings were eventually connected to Levels 2 and 3 above by two raises. The development of this lower level allowed for easier transport of waste and ore from the upper levels of the mine to a mill facility constructed outside Level 1.

The CGS report indicates that a cross cut was driven at least 2,000 feet easterly from the “main drift”, however it is not clear if this refers to Level 1, or Level 2. This cross cut may have been an attempt to intersect the Keystone vein that lies east of the Micawber vein under Gunsight Pass (Figure 2, Ludington and Ellis, 1983.) The crosscut could not be verified during underground reconnaissance due to the inaccessibility of Level 1 and most of Level 2.

### ***Geologic Setting***

Elk Basin is underlain primarily by Cretaceous and Tertiary sedimentary rocks that are intruded by a series of Oligocene and Miocene intrusive sills (Ludington and Ellis, 1983). The oldest exposed rocks belong to the Tertiary Wasatch Formation, a series of alternating shales, marine and continental sandstones, and conglomerates (Figure 3). Overlying the Wasatch is the Ohio Creek Formation, also of Tertiary age. Its basal section as exposed in Elk Basin consists of thick to massive beds of light-gray to white

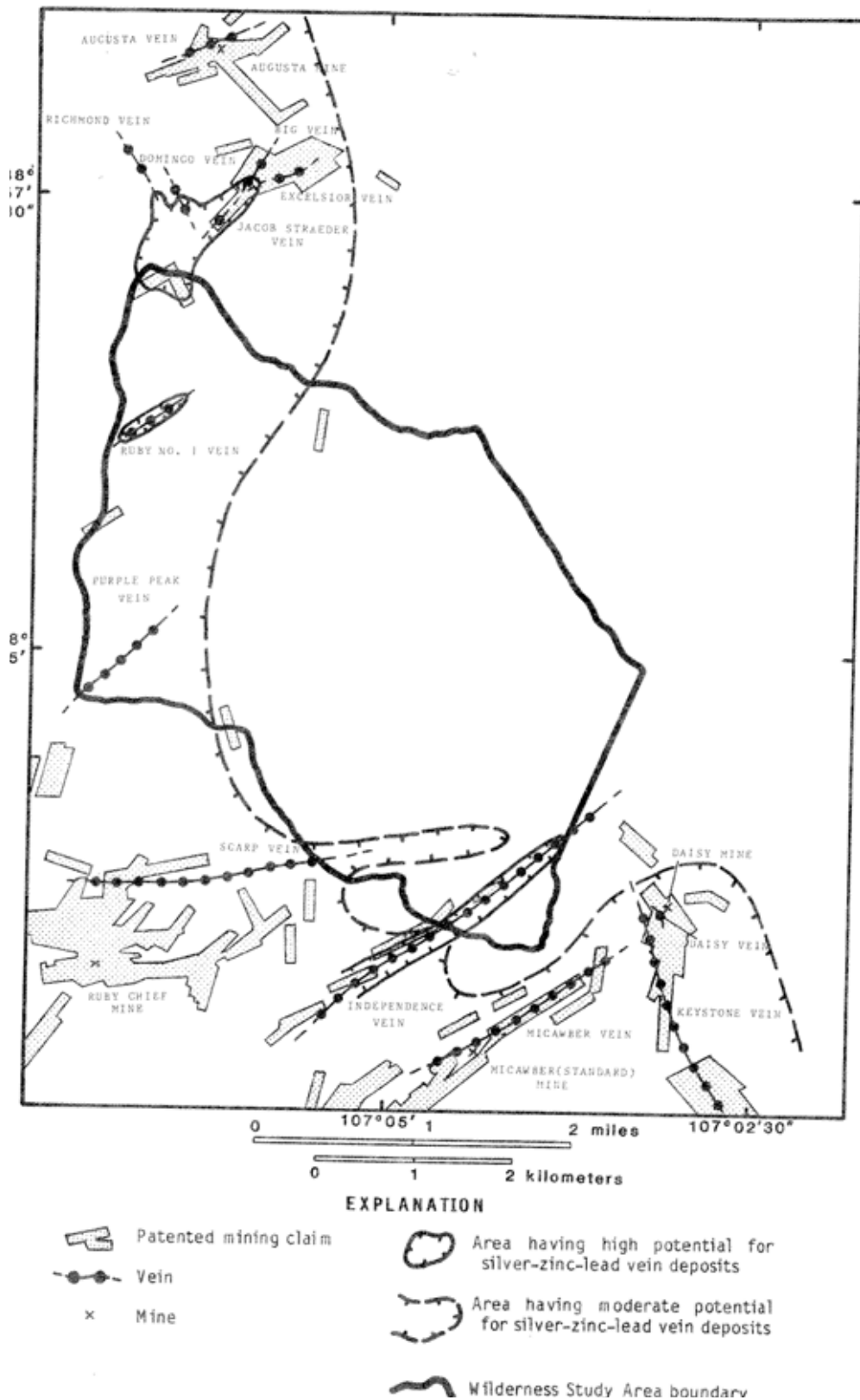


Figure 2. Silver-Lead-Zinc Veins, Showing Micawber Vein (Standard Mine) and Keystone Vein. From Ludington and Ellis, 1983, Mineral Resource Potential of the Oh-Be-Joyful Wilderness Study Area.

feldspathic sandstone that locally contains pebble lenses, and subordinate interbeds of sandy siltstone, silty shale, and carbonaceous shale (Gaskill, et.al, 1967), The Wasatch formation is intruded by a prominent sill of quartz-monzonite-porphyry that is Oligocene in age. The Cretaceous Mesaverde formation lies beneath the Wasatch section, but is not exposed in Elk Basin. Unconsolidated surface deposits include landslide debris, talus, and glacial debris that overlie bedrock around the margins of the basin.

Subsequent to the volcanic intrusion of the porphyry sill, the entire region was broken by a period of normal faulting. The faults exposed in Elk Basin trend east and northeast, and are of generally small displacement. Some of the faults are mineralized and contain epithermal vein deposits of silver, zinc, and lead. Some of the faults also contain porphyry dikes, intruded into the fault system (Ludington and Ellis, 1983).

The Standard Mine developed a mineralized normal fault known as the Micawber vein, which strikes northeasterly, obliquely across Elk Basin, and dips steeply southeast (Ludington and Ellis, 1983, Figure 2). The mineralized fault has a few hundred feet of right-lateral movement which offsets the Ohio Creek Formation, exposed to the northwest side of the fault (footwall), against the underlying Wasatch exposed on the southeast side of the fault (hanging wall), (Ludington and Ellis, 1983, Gaskill et.al 1967).

Observations made within the mine workings and on the ground surface indicate that a generally distinct lithologic change is observed across the fault trace. Lithology of the Ohio Creek formation in the footwall side of the fault is mostly siltstones, mudstones and other relatively fine grained sandstone interbedded with pebbly conglomeratic sequences. The down-dropped side of the fault is predominantly a silicified siltstone-sandstone sequence. Although periodically present, conglomeratic sequences are less prevalent. Intrusive porphyry dike-like masses were also noted within parts of the fault.

#### *Mineralization*

The Micawber vein produced silver and base metals from a vein that continues northeastward and intersects the Redwell Basin stock-work molybdenum deposit, just north of the summit of Mount Emmons (Ludington and Ellis, 1983). The vein does not expose molybdenite mineralization. It is mineralogically similar to the Keystone vein directly to the east, and continues southwest where it may become the same structure as the vein at the Forest Queen mine. The Micawber vein is composed of iron-rich sphalerite, pyrite, galena, chalcopyrite, banded and vuggy quartz, rhodochrosite, and rhodonite (Ludington and Ellis, 1983). The mineralization fills open spaces along the normal fault. Farther southwest at the Forest Queen mine, mineralization consists of native and ruby silver, in a quartz and arsenopyrite gangue. Galena and sphalerite are present, but only in small quantities (Socolow, 1955). Ludington and Ellis, 1983, state that “if the correlation of the Micawber and Forest Queen structures is valid, the vein is clearly mineralogically zoned away from a source within the Redwell Basin molybdenite deposit”.



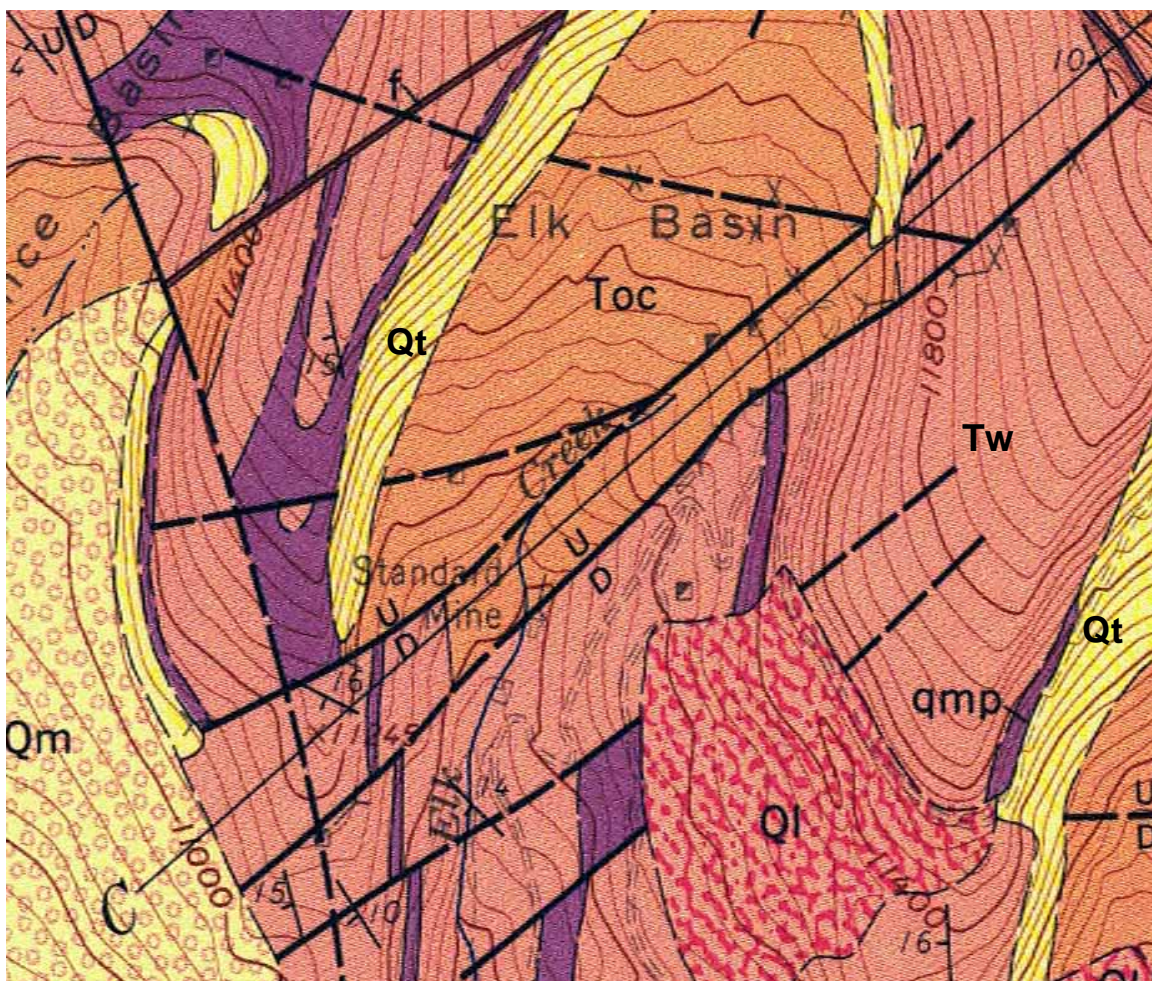


Figure 3. Geologic Map of Standard Mine Vicinity (from Gaskill et al, 1967).  
(See Text for descriptions of rock units.)

Surficial Deposits

*Qm* - Glacial debris

*Qt* - Talus deposits

*Ql* - Landslide deposits

Intrusive Rocks

*Qmp* - Quartz-monzonite porphyry sill

Sedimentary Rocks

*Toc* - Ohio Creek Formation

*Tw* - Wasatch Formation

Fault, dashed where inferred



### *Underground Reconnaissance*

Field investigations were conducted the week of August 14, 2006 by DRMS, EPA and CDPHE personnel. During the latter phases of the underground work, DRMS accompanied USGS personnel into Levels 3 and 5 to collect water quality samples and flow data at identified inflow locations.

The crew was equipped with the necessary mine safety and underground mapping equipment to conduct a preliminary reconnaissance of underground workings. Specific additional safety and climbing equipment necessary to explore the workings was acquired after the initial reconnaissance.

At the time of the field visit, the Level 1, 3 and 5 adits were open and accessible. Level 2 and Level 4 (the twin compartment shaft) were not immediately accessible. The Level 2 adit had collapsed at the portal, and the twin compartment shaft was caved 15 feet below the collar.

#### *Level 1*

Level 1 was the first adit entered for reconnaissance. The portal was draining approximately 11 gpm at the time of the site visit. The USGS had previously collected water quality and quantity data from the portal discharge, however this data is not yet available and could not be included in this report.

The Level 1 drift was blocked by what appeared to be a substantial roof fall approximately eighty feet from the portal. The collapsed debris blocks the drift from rib to rib and from floor to back. The ribs and back are timbered from the portal to the collapse, and rail is present on the floor. Water drains from the caved material, and can be heard cascading through the debris pile. The volume of fall material appears to be substantial, given the nature of the material, and the length of the plug. Hand excavation of the blockage was not a viable option, and further exploration of Level 1 was not possible.

#### *Level 3*

Reconnaissance moved next to the Level 3 portal following abandonment of Level 1 exploration. This level is open and readily accessible via an open collapse immediately beyond the original portal. The ground above the drift just beyond the portal appears to have collapsed, blocking the original portal entry. Erosion, or potentially people with shovels, breached through the collapsed debris at a timber set beyond the original mine entrance, allowing entry to the workings. Once inside, the drift is open and relatively free of blockages. Water enters the drift at many areas on this level along the mineralized vein it follows. The vein structure appears to act as a conduit for groundwater movement downward into the mine workings. The water intercepted on this level flows down raises to Level 2 below. Following the initial reconnaissance, Level 3 was mapped in detail (Plate 1).

Exploration of Level 3 encountered several raises between levels, however only one could be safely entered. The first raise was encountered 142 feet beyond the portal. This raise, located on the north side of the drift, passes from surface through Level 3 and likely to Level 2, 80 feet below. Water from this section of Level 3 drains into this open raise. The raise continues upward and is believed to coincide with the collapsed twin compartment shaft located on surface farther upslope from the Level 3 portal. Significant diffuse seepage, visually nearly equal in volume to the drainage on the floor of the drift, runs down the shaft from above and continues down the raise.

The foot of a second raise was encountered 196 feet farther in (338 feet from the portal) on the north side of the drift. It was timbered, extended upwards 40 feet, and appeared to possibly contain a manway and adjacent loaded ore pass. Relatively fine-grained material fallen from the ore pass forms a pile that partially blocks the drift at this location, but it can be climbed over with little trouble.

Beyond the second raise is a third raise, 360 feet from the portal, passing through the level. It was likely used to pass ore from Level 3 and the stope above down to Level 2. While some timbering remains in this raise, it is not stable. The head of the raise down to Level 2 has collared out much of the floor of the drift at this point. Rails and timber span the enlarging opening. This raise is shown on the Cross Section (Figure 4) as a stope-like feature extending upward from Level 2 and through Level 3. The raise compartment is vertical and has two timber sets at the top, and a bald section with two timber sets located at the bottom. Just above Level 2, the raise compartment opens into a large stope, mined on both sides of the timbered raise compartment. DRMS staff latter rappelled down this raise and explored part of what is believed to be Level 2 (see Level 2 description, below).

Moving inward beyond the head of this raise on Level 3, overhand stoping on the vein was observed in several locations. Ore was mined from the vein in the back to a height of 15 to 18 feet above the drift, over a vein width of 1.5 to 2 feet.

A fourth raise was encountered 610 feet in from the portal near the end of the drift workings on Level 3. Figure 4 indicates that this raise passes down only to Level 2. The head of the raise is collared on the south (right) side of the drift, and is inclined from the horizontal approximately 60° to follow the vein structure. It contains rotting ladders in very poor condition. The raise is not timbered and is in satisfactory condition; however access into Level 2 from this connection is prevented by a large rock jammed near the foot of the raise just above Level 2.

### *Level 2*

DRMS staff latter rappelled down the third raise located 360 feet beyond the Level 3 portal and explored part of what is believed to be Level 2. Level 2 was accessible through a hole in a timber bulkhead on the outby side at the foot of this raise. Figure 4 shows that this raise terminates at Level 2, but it also indicates that the heads of two other raises on Level 2 are located immediately beyond its foot. These raises both descend 240 feet to Level 1, passing through two intermediate sub-levels on the way.



Safety considerations prevented substantial exploration of Level 2. Approximately two feet of water over muck and debris on the floor of the drift potentially obscured the two mapped raises which extend to Level 1. Because these raises might have been timbered over, a potential fall hazard existed, thus discouraging DRMS staff from exploring more than 20 feet in either direction from the foot of the access raise. The section of Level 2 observed in the vicinity of the foot of the access raise was heavily timbered and in good condition. Draw points were observed in place about every 20 feet along the drift, suggesting that a good ore shoot existed in this section of the vein.

#### *Level 5*

The Level 5 adit was open and easily accessible (Plate 2). A small sill of debris slightly restricts the drift and acts as a dam for water accumulated on the floor of the drift. Water was discharging from the portal at an estimated 3 gpm at the time of investigation.

As with Level 3, Level 5 appears to generally follow the strike of the Micawber vein in upper Elk Basin. Water accumulates on the floor of the drift, with high water marks noted at approximately three feet above the floor. Few notable inflows were observed, thus, it is assumed that water within the drift can be attributed to diffuse seepage of seasonal precipitation from the surface. The drift runs fairly straight for approximately 250 feet, where it then branches into right (south) and left (north) headings (see Plate 2).

The north drift generally follows the strike of the Micawber fault-vein structure, turning slightly north of strike for the first 250 feet of this branch. The structure is un-mineralized, consisting of a barren fault that is somewhat difficult to trace in locations, and it rolls flatter (decrease in dip), and splits. The fault structure is not as well defined as was observed in Level 3, leading to the slight meanders noted in the workings. At approximately 300 feet in from the branch on this level, the north drift is blocked by a substantial collapse. The collapse acts as a dam, as a small quantity of water flows into Level 5 from near the top of the collapse material.

The first 80 feet of the south drift on Level 5 generally follows the same northeast strike as the main drift before the branch point. A discontinuous fault trace is present in the back and ribs along this section of the south drift to a point where it turns abruptly southeast. The workings continue southeast in barren ground with no evidence of a fault or vein structure, ending approximately 200 feet beyond the branch point on the main drift entry. A 6-inch to 10-inch wide un-mineralized fault re-appears at the face of the heading. No evidence of water inflow was observed in the south drift.

#### *Level 2 Portal Excavation*

An attempt to open and enter through the collapsed Level 2 portal was made in an effort to evaluate the original Micawber Mine level. The EPA contractor on site mobilized a tracked excavator to the Level 2 portal. The excavator was positioned on top of the collapse material, and began to remove material from the collapsed portal location. After considerable excavation, the mine was opened to a point where timber posts and caps supporting the back of the drift were visible. An initial evaluation of the exposed drift

indicated that another partial collapse existed immediately beyond the timbering, with more of the drift visible beyond that collapse. Water was observed impounded in the drift to an unknown depth.

Preliminary assessment of the exposed drift workings indicated that the potential to enter Level 2 from the portal was feasible. Additional excavation and scaling of the highwall created by excavation of the portal was resumed in order to facilitate entry. However, following continued excavation and scaling operations, there remained some uncertainty regarding the stability of the ground immediately above the new access point to the drift. Because of this safety concern, further attempts to enter Level 2 from the original portal during this phase of work were abandoned.

DRMS recommended that a large diameter corrugated metal culvert pipe (CMP) fitted with a lockable grate be positioned into the newly exposed Level 2 drift. A grated CMP closure would safely facilitate future Level 2 access, allow for water sampling, and promote natural mine ventilation while preventing public access to the mine. The CMP was to have been placed from just beyond the brow of the drift opening to the original ground surface. Backfilling around the CMP from the brow to the ground surface would complete the closure. Unfortunately, construction of the CMP access alternative was not possible at the time due to budget considerations. The excavated portal area was backfilled without providing for future access.

### ***Underground Workings Description***

The following tables provide an annotated description of the Level 3 and 5 surveys. Mine condition, pertinent features and geologic data are presented.

**TABLE 2**

#### ***Level 3***

<b>Distance From Portal (Ft.)</b>	<b>Mine Features</b>	<b>Geologic Information</b>	<b>Dimensions (Width x Height; Ft.)</b>	<b>Notes</b>
0 - 162	Trends N 63 <sup>0</sup> E	Ohio Creek Formation	6' x 7' @162'	
132 - 140	1 <sup>st</sup> inby raise / shaft			Center of raise at 140', collared on north side of drift
132				USGS sample MSTDL3-1
145				USGS sample MSTDL3-2
162 – 205	Trends N 83 <sup>0</sup> E	Intercept fault at 160'	6' x 6' @200'	
195	Stulls in back support fault zone			
200		Fault zone 4.5', Mineralized zone at 1.5'. Fault near vertical		Mineralization within fault zone
227		Exit fault, drift in hanging wall		
205 - 242	Trends N 90 <sup>0</sup> E		6' x 6' @242'	
260		Encounter fault. Fault at 2.5 – 3'; indistinct mineralized zone. Fault strikes N 80 E, dips 52 <sup>0</sup> S		
267 – 313	Trends N 75 <sup>0</sup> E	Fault at 5'; mineralized zone at 1 – 2'		
270	Open stopes at 15' tall			
313 - 338	Trends N 73 <sup>0</sup> E			

**Level 3 (continued)**

<b>Distance From Portal (Ft.)</b>	<b>Mine Features</b>	<b>Geologic Information</b>	<b>Dimensions (Width x Height; Ft.)</b>	<b>Notes</b>
327				USGS sample MSTDL3-3
340				Powder box on floor is empty
338 - 343	Foot of 2 <sup>nd</sup> Raise / loaded ore pass on north side of drift	Fault at 6' – 7'		Slough material from ore pass constricts drift. Ladder rotting.
353 – 362	Head of 3 <sup>rd</sup> Raise collared on south side of drift			Timber supports rail, bridges head of raise
369	Stope on north side		Stope dimension 4' x 5' x 15'	Loaded drill hole in stope
338 - 386	Trends N 65 <sup>0</sup> E		6' x 6' @ 338'	
374 - 391		Drift moves left and right of fault plane		
386				USGS sample MSTDL3-4
391		Drift on fault. Galena-rich mineralized zone		
386 - 476	Trends N 85 <sup>0</sup> E		6' x 6' @ 386'	
400 - 410	Stope in back on vein, north side. Rock fall on floor	Fault zone is 5' wide at 400' from portal; mineralized zone at 1.5' – 2.0' wide. Variable 0' – 2.0' at 400' – 476'		Diffuse water inflow from fault exposure, north side (Footwall) through segment
425 - 430		Copper precipitate on back. Fault strikes N 80 <sup>0</sup> E, dip 65 <sup>0</sup> S / SE		



*Level 3 (continued)*

<b>Distance From Portal (Ft.)</b>	<b>Mine Features</b>	<b>Geologic Information</b>	<b>Dimensions (Width x Height; Ft.)</b>	<b>Notes</b>
450		Fault strikes N 85 <sup>0</sup> E, dip 55 <sup>0</sup> SE. Wasatch bedding strikes N 25 E, dip 11 <sup>0</sup> W		
470 – 486		Fault branches and splits (horsetails)		
476 - 576	Trends N 82 <sup>0</sup> E		6' x 6' @ 476'	
576		Fault at 4'; mineralized zone at < 1'	6' x 8'	
590		Fault at 4'; mineralized zone indistinguishable		
607 - 614	Head of 4 <sup>th</sup> raise on south side of drift	Raise driven in hanging wall	Raise dimension 4' x 7'	
576 - 652	Trends N 82 <sup>0</sup> E			
639				USGS Sample MSTDL3-5
652	End of drift	Neither fault nor mineralized zones are identifiable	6' x 4' @ 640'	

*Level 5*

<b>Distance From Portal (Ft.)</b>	<b>Mine Features</b>	<b>Geologic Information</b>	<b>Dimensions (Width x Height; Ft.)</b>	<b>Notes</b>
0 - 200	Trends N 76 <sup>0</sup> E			
0 - 190		Wasatch Fm. No fault visible. Little inflow noted in back		Standing water
180		Drift intercepts fault in south rib		
193		Fault crosses to north rib, 9" – 12" wide, clay gauge zone; no mineralization		No significant inflow noted
200 - 228	Trends N 56 <sup>0</sup> E			
200			6' x 8'	
210		Fault strikes N65 <sup>0</sup> E, dip65 <sup>0</sup> S		
228				USGS sample @ back seep; water appears under pressure MSTDL5-1 NO.*
250	Drift branches right (south) and left (north)		13' x 7'	
253	Begin North Drift: Trends N 66 <sup>0</sup> E	Drift to south of fault	6' x 8'	<b>Begin North Drift</b>
260		Intersect fault; strikes N62 <sup>0</sup> E, dip 80 <sup>0</sup> S		
263 - 300		No mineralization noted in fault zone		Seepage from north rib on fault
332 - 409	Trends N 81 <sup>0</sup> E			
325		Drift crosses to south of fault		

\* It is unclear if this is the correct USGS sample number.

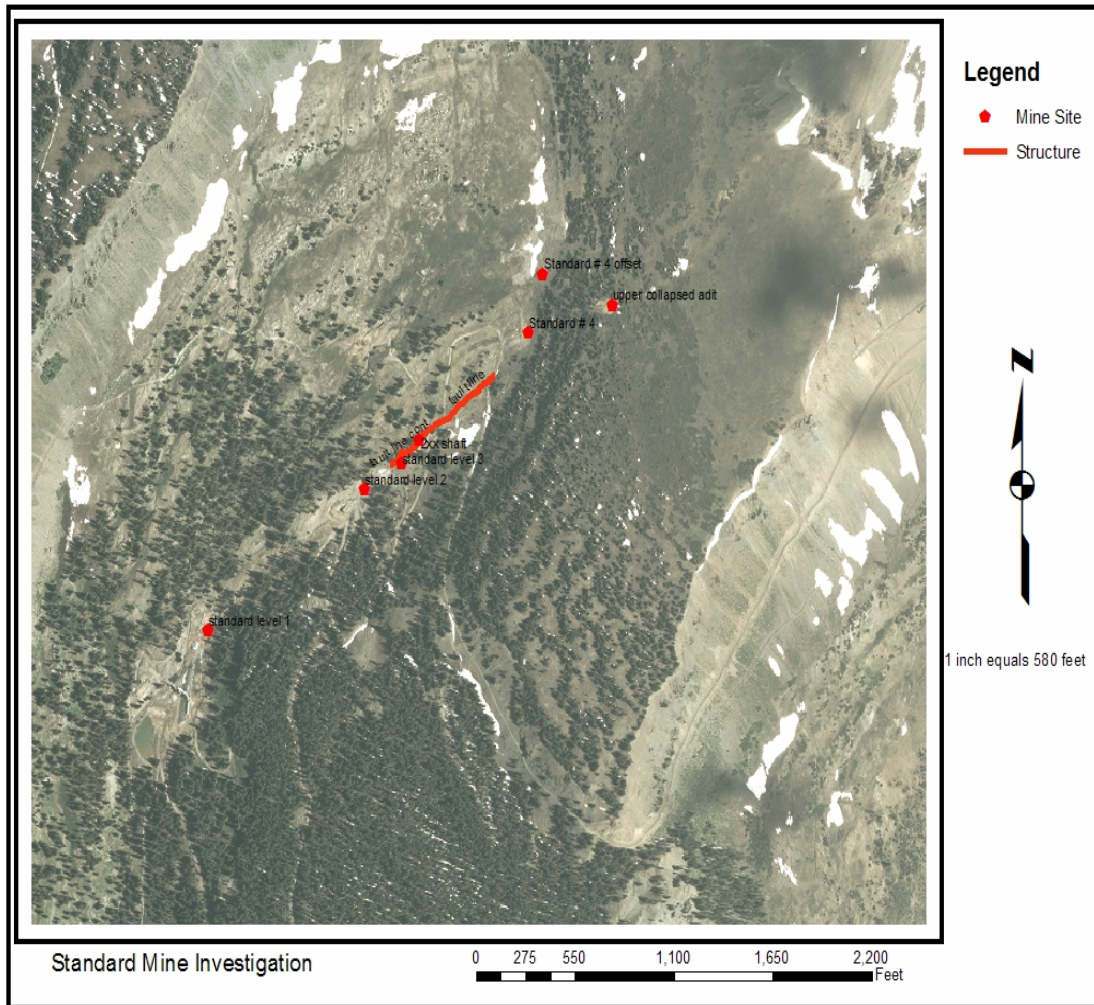
*Level 5 (continued)*

<b>Distance From Portal (Ft.)</b>	<b>Mine Features</b>	<b>Geologic Information</b>	<b>Dimensions (Width x Height; Ft.)</b>	<b>Notes</b>
338		Drift crosses to north of fault. Fault zone 3.5' – 4'. Distinct zoned mineralization 0.5'		
363		Indistinct fault zone. No mineralized zone		
367		Iron stain on rib, back	5' x 7'	Inflow from north
409 – 484	Trends N 71 <sup>0</sup> E			
409	Minor stoping in back			Inby left rib wet
490 - 512		Fault appears to split and dip rolls toward horizontal		
500	Small cutout in north rib			5'w x 6'h x 10' long '
514 - 530		Fault trace apparent in back, no mineralization observed		
530 - 542		Fault dip rolls steeper		
546			5' x 7'	USGS sample M116001 NO. *
553		Fault nearly vertical; diverges into left and right splays		
563	Drift caved tight.			Water flows into drift from near top of collapse

\* It is unclear if this is the correct USGS sample number

*Level 5 (continued)*

<b>Distance From Portal (Ft.)</b>	<b>Mine Features</b>	<b>Geologic Information</b>	<b>Dimensions</b>	<b>Notes</b>
250	Main Drift branches right (south) and left (north)		13' x 7'	
250 - 333	Begin South Drift. Trends N58 <sup>0</sup> E			<b>Begin South Drift</b>
333		Fault visible in back and south rib. Passes out of rib 4.5' above floor. Strikes N60 <sup>0</sup> E, Dip 79 <sup>0</sup> S / SE	6' x 8'	
333 - 384	Trends S 66 <sup>0</sup> E		6' x 8'	Abrupt change in heading to SE
384 – 447	Trends S54 <sup>0</sup> E		5' x 7'	
447	End of heading	Fault zone 6" – 10" in face, no mineralization	5' x 7'	



*Figure 5. Aerial Photograph of Standard Mine Vicinity with Mine Entries and Visible Fault Trace Depicted.*

### ***Mine Geology***

The mine workings on all levels explored consisted of drifts driven northeastward on the Micawber vein structure. The Micawber vein is a mineralized normal-fault, dipping steeply southeast. The fault is generally observable in the back, and along the footwall on the north side of the drift on Level 3. A clayey, very plastic gouge material is visible in many places within the fault zone between the hanging and footwalls. This sheared zone between the hanging and footwalls was observed to vary from between 1.5 and 5 feet in width, normal to the dip of the fault plane, with typical widths being near the lower value.

Mineralization occurs as a discreet zone (vein) within the fault zone. Although the vein is sometimes indistinct within the fault zone, it varies from between 0.5 and 2 feet in

width. Mineralization is weak on Level 5, and much of the fault structure there is barren, accounting for the lack of significant development (stopes, raises etc) on this level.

The footwall side of the structure is sharply defined at many locations on Level 3, and to a lesser extent on Level 5. The rock structure and texture in the footwall side of the fault zone is markedly different than the hanging wall. The footwall (north side) is characterized as a fairly continuous, smooth and planar surface in more massive rock strata that transmits water down the exposed fault contact. Strata in the hanging wall are much less massive in structure, exhibiting more distinct jointing and bedding. This rock is finer grained, often clayey, and appears to act as a barrier to groundwater movement. Rock along the hanging wall is texturally and structurally distinctive from other exposures of Ohio Creek or Wasatch Formations that have not been faulted or hydrothermally altered by mineralizing processes.

Water was observed to enter the Level 3 drift from numerous locations, all associated with the footwall (north) side of the fault system. Although much less significant inflow was observed at Level 5, it too was observed to enter from within the fault zone, or along the footwall side of the fault. No inflow from the hanging wall was observed on either Level 3 or 5.

Parts of the fault trace can be followed and mapped on the ground surface (Figure 5). The fault extends up the hillside above Level 5 to waste piles associated with a collapsed abandoned mine adit. Within Level 5, the fault trace was observed to be less distinct than what was observed at the ground surface overlying this drift. This raises the question of whether Level 5 workings follow the same fault structure as that observed on surface.

### ***Water Quantity and Quality***

The USGS (Manning, et al., 2007) collected samples from in-stream locations, springs and seeps, portal discharges and from points within Levels 1, 3 and 5 during the DRMS site evaluation. Water quality samples were analyzed in an effort to establish baseline data and develop correlations which may exist between sample locations and constituent concentrations in order to shed light on possible sources of the poor quality water at the Level 1 discharge. Water quality analysis included dating techniques to quantify relative water ages at various locations, and analysis for major ions and trace element chemistry. For purposes of this underground assessment, DRMS has reviewed the Manning report, and has developed an evaluation of what the data means in the context of developing preliminary source control options for the Standard Mine site.

Our interpretation of the water quality data supports the theory that the Micawber fault-vein acts as a primary conduit of travel for groundwater in the study area. With increasing water residence time in the mineralized structure, water quality is increasingly adversely affected. The water quality data also suggests that water quality diminishes as residence time increases due to the circuitous flow path from Level 3 down toward Level 1 via the inter-connecting system of raises and stopes within the mine.

Observations within the mine indicate that the majority of subsurface water enters the mine along the Micawber vein as diffuse seepage. Age dating analysis suggests that water entering the Standard Mine along the vein system is very young. Major ion and trace element chemistry indicates that elevated levels of those constituents are closely tied to sulfide mineralization, specifically the Micawber vein, and are not regional in nature (Manning, et al., 2007). Manning concluded that sampling data did not identify the primary source of metals discharging from Level 1. More accurate flow measurements from the upper levels are needed to develop a water balance, and determine the possibility of additional water inflow sources to Level 1.

Discharge from the Level 1 portal was measured by USGS at the time of the sampling event. The Level 1 portal was discharging approximately 11 gallons per minute in mid-August, 2006 (Manning, et al., 2007). Flow was also measured at certain locations within Level 3 during the underground evaluation. The discharges were measured at points immediately above raises where the water cascaded downward to a lower mine level. The total discharge measured on Level 3 is estimated to not exceed two gallons per minute (Manning, et al., 2007). No water discharged from the Level 3 portal at the time of the site evaluation.

At Level 5, a maximum discharge of three gallons per minute was observed from the portal, with no more than two to three gallons per minute observed discharging from all measured interior sample points (Manning, et al., 2007).

Level 1 may be making water from inflow sources other than direct communication with Level 3. Additional flow data from the various mine levels is required to make a definitive water balance accounting. There is still an un-characterized inflow to the system between the observed flows on Level 3 and Level 2, which appears in the total flow and chemistry discharging from Level 1. The source of additional water may be from the Micawber structure that is up gradient of the extent of Levels 2 and 3, or possibly as a result of inflow from the 2,000 foot-long cross cut noted in the Bird and Woods report (undated).

#### *Isotopic Age Dating and Source Control Implications*

The USGS has concluded that the water entering the Standard Mine along the Micawber fault-vein structure is less than one year old. This suggests that the major source of the water within the Standard Mine is directly tied to relatively recent surface precipitation events. While there may be some potential of a deeper, more regional groundwater source of high concentration and minimal flow, it is likely that such a source would not only be minimal, but could also be undetectable due to mixing with the younger, near surface groundwater. The most significant source of young, near surface groundwater is from the infiltration of rainfall and snowmelt. It is likely that meteoric water drives a near surface groundwater system that moves through the hydraulically conductive fractured zone along the Micawber vein, and into the Standard Mine.

While it is probable that topography controls the general direction of movement of the shallow groundwater regime in Elk Basin, the Micawber vein may significantly impact lateral groundwater movement. Observations within the mine workings of extensive clayey gouge material and silicification along the fault-vein suggests that lateral movement of groundwater across the structure is significantly impeded and may be preferentially directed parallel to and downward along the fault plane, where it is eventually intercepted in the mine workings. Addressing surface water infiltration along the Micawber vein structure may be the best strategy for water quality improvement, since a deep groundwater source does not appear to be a significant factor at the site. Similarly, interrupting or diverting groundwater flow from along the fault structure may also be a viable component of a source control plan.

#### *Water Quality Data and Source Control Implications*

The Level 3 water sample analyses indicate that at least two metals are present with concentrations elevated above drinking water standards. The data also indicates that the quality of water within Level 5 is substantially better than that in Levels 1 or 3. Water quality degradation occurs down gradient of Level 5 within the fault structure, suggesting that groundwater moving along the Micawber vein degrades in quality with residence time in the more highly mineralized parts of the fault-vein structure. This theory could be evaluated by completing groundwater monitoring wells within the fault and in the surrounding country rock between Levels 3 and 5. It is also possible that Level 5 may have no direct hydrologic communication to the lower level workings.

Water quality results also indicate that after the fault-controlled water enters the mine workings, it becomes substantially more degraded upon contact with the exposed ore body and mineralized materials. A sample collected on Level 3 downstream from the fault seep sample locations had a metals concentration approximately seven times higher than that of the seep water inflow itself. This data suggests that water moving along the floor of the drift workings and through accumulated broken ore and mineralized waste material quickly leaches metals, further diminishing the quality of the water as it moves through the mine. The ready leaching of metals from mineralized waste material is supported by sampling of the water seeping from mine waste dumps at the site. Surface water quality data from the Levels 2 and 5 waste dumps showed water moving through the material quickly picks up very high metals concentrations. The movement of water downward from Level 3, through Level 2 and sublevels to Level 1, all through ore-laden stopes and ore passes, could account for the much higher metals concentrations observed in the Level 1 discharge. Exploration of Level 2 in conjunction with water sampling could potentially confirm that water moving from Level 3 to Level 2 becomes more degraded.

The USGS (Manning, et al; 2007) and DRMS conclusion that near surface groundwater is the primary source of mine related inflow strongly suggests that source control efforts should be focused on minimization of inflows, and reduction of inter-level water movement. Efforts focused on reducing surface water infiltration into the fault system, reducing groundwater movement along the fault-vein into the workings, and preventing any remnant water within Level 3 from flowing to the lower levels could significantly



improve water quality. The concept of underground segregation of clean inflows from those with high metal concentrations as a means of reducing treatment quantity appears unworkable at this site, due to the limited observed volume of any clean background inflows into Level 3.

### ***Hydrologic Assessment***

Due to the inaccessibility of Levels 1 and 2, only a limited hydrologic assessment of the underground workings of Standard Mine was possible. In order to completely understand the interaction of the geology, hydrology and mine workings, an evaluation of Levels 1 and 2 needs to be made. The observations made primarily on Level 3 during this study provide what is likely to be a useable initial hydrologic model of the effects of the Micawber vein structure and its past mining development to the groundwater regime in Elk Basin. This Initial model can help refine development of preliminary remediation approaches for the Standard Mine.

Observations made within the Level 3 drift, and to a lesser extent at Level 5, clearly indicate that the fault zone is the most significant hydro-geologic control within the study area, and that this structure will directly impact remediation alternatives. The fault trace can be followed on surface, extending from Level 1 northeasterly to the base of an abandoned mine dump located approximately 2,000 feet northeast of the portal. It is assumed that the entire length of the fault above Level 1 is an area of relatively high permeability and porosity, that intercepts and channels surface precipitation and shallow groundwater into and down along the structure itself. The various interconnected mining levels drifted along and developed ore bodies within the fault-vein. The mine workings intercept groundwater as it flows vertically along the fault plane, acting as a significant pathway for rapid movement of water both horizontally and vertically along and between mine levels.

Water quality data developed during this study tends to confirm that water quality becomes degraded as a function of the downward movement of water along the Micawber vein structure. This process likely occurs both within the un-mined parts of the structure, as well as within the mine workings themselves. Water quality degrades as groundwater moves within the fault structure from the upper portions of the basin toward the lower portions of the basin. This degradation initially occurs as a result of naturally occurring mineralization within the fault. The naturally degraded groundwater is then intercepted by the mine workings, where it is exacerbated by exposure to oxygen and subsequent bacteriological oxidation reactions with sulfide mineralization. Level 3, and undoubtedly the underlying levels contain substantial remaining ore and mineralized waste rock. Some of the raises that convey groundwater from upper to lower levels consist of loaded ore passes. Thus, the potential for groundwater to move through the mine workings while picking up and transporting metals is very high. This mechanism could, in large part, be responsible for the increase in metals loading observed at the Level 1 discharge, when compared to the Level 3 water quality data.

The degree of interconnection between Levels 1 and 2 is unknown, but will likely be a significant factor when designing a hydrologic water quality remediation plan. During the limited exploration of Level 2 conducted near the foot of the raise to Level 3, water estimated at two feet depth was encountered. Interestingly, the Cross Sectional view of the Standard Mine Complex (Figure 4) indicates that the heads of two raises are located in very close proximity to the section of Level 2 that was accessible. If these vertical connections exist, it begs the question of why water was standing within Level 2 at that location, rather than draining down these raises to Level 1.

Two theories have been advanced to explain the existence of standing water at a location so close to the heads of the raises on Level 2. The first is that a substantial cave or collapse exists, either between the foot of the raise to Level 3 and the head of the twin raises on Level 2, or within the raises themselves. A collapse or plug in either location would tend to impound water flow, leading to the standing pool as observed.

A second possibility is that there is a collapse on Level 1 downstream from the foot of the twin raises. A significant plug here could have created a substantial pool of water that backed upward into Level 2. If this is the case, the impounded water would have 242-feet of head pressure (~100 psi/ 14,000 psf) at the blockage on Level 1. The implications of this possibility, if correct, will greatly affect any potential remediation strategy. Given the limited scope of this assessment, it is impossible to know at this point which of these or other possibilities may explain the standing water observed on Level 2 near the heads of the twin raises that supposedly connect to Level 1.

### ***Recommendations for Source- Water Controls Approaches***

Specific recommendations for methods to address the impacts of mine drainage at the Standard Mine are difficult to make because the character of other water inflows to Level 1 are unknown. Since the hydrologic behavior of the fault-vein system and inter-level connectivity are supported by the underground assessment and the data available, we can make some general source control recommendations. These are generally focused on reducing the volume of water requiring treatment and on improving the quality of the water that eventually reaches Level 1 via Level 3. These source control approaches can be refined into remediation plans as the hydrology of the Standard Mine is further defined.

#### ***Source Control Methods***

The Micawber vein appears as the primary conduit for movement of water into the Standard Mine complex. Controlling the volume of water reaching the mine workings developed in the vein could be an opportunity to minimize the quantity of discharge requiring perpetual treatment at Level 1. The analysis of the water quality data collected in the mine has resulted in a preliminary model of where and how metals are transported within the mine. Data shows it is likely that the fault-vein system provides most of the water available to the mine system, and that the mine workings act as a conduit for water migration between Levels 3 and 1. It also appears that as water migrates from the upper

to lower levels, the quality of the water is degraded as a result of contact with ore and waste materials located within the mine complex.

Hydrologic Barriers- Grout curtains or other groundwater pathway modification techniques could be strategically placed into or along the fault structure to impede or divert water movement. In conjunction with angled dewatering wells, perimeter grout curtains or grouting of the fault structure itself could reduce the amount of water that moves along the structure into the workings below. The use of surface drainage control techniques such as permanent diversion structures could also play a role in minimizing water infiltration into the fault system.

The increase in metals concentrations between Levels 3 and 1 could be reduced by controlling water pathways between the levels. Hydrologic barriers could be constructed in Level 3 to prevent the downward movement of water to the levels below. Placement of concrete or grout linings or aprons along the floor in Level 3 would reduce water infiltration and contact with mineralized material. A drain could be installed within the Level 3 floor lining to divert water out of the level before it can move downwards into the lower workings in the vein. Water thus diverted out of Level 3 is expected to have better quality than if it were allowed to continue through the workings to Level 1. This approach would also reduce the flow at Level 1 potentially resulting in opportunities for alternative treatment strategies.

Up Slope Diversion – The Micawber vein has been observed to extend well up slope of Level 5. Observations indicate that the fault-vein structure is the major source of water entering the mine workings. The Level 5 workings might be used as a “horizontal well” to intercept water produced from the fault structure up slope of that elevation. A system to move intercepted water out of this level quickly could be developed in order to minimize residence time and the potential to infiltrate into the fault structure in the floor of the drift workings. The diverted water would be treated if necessary and released via a diversion that would route water well away from the associated mine dump and the fault structure down slope.

Modify Hydrologic Behavior of the Fault Structure – Minimization of water movement to Levels 1, 2 and 3 should be part of any source control strategy employed at the site. One minimization strategy is to reduce the volume of water that the fault is capable of moving by reducing the permeability and transmissivity of the structure itself. This could be accomplished by grouting the structure above the underground workings. A series of grout injection holes that intersect and run down through the fault zone could be developed. A variety of grouting methods, including hot bitumen, hot wax, bentonite, other types of clay, or chemical grouts can be used to augment cementitious grout to reduce the permeability of the fault structure. These grouts would be injected under pressure into the fault zone so that a continuous impermeable barrier is formed from the base of Level 5 to above Level 1, diverting groundwater away from and out of the fault structure.

Dewater Fault – There may be some potential to partially dewater the fault structure between Levels 5 and 1. This would be accomplished by installing a relatively shallow dewatering drill hole network in the fault zone. Drill casing would be completed and screened within the fault zone to intercept water that moves along the fault plane. Dewatering wells would be drilled so that they are sloped to allow gravity drainage of the fault water. The water will have been in contact with relatively un-oxidized mineralized material, and might not need to be treated upon discharge at the surface.

Surface Water Diversion – Snowmelt runoff is probably the largest contributory source of water to the fault structure. Moving snowmelt and rainfall runoff away from the surface expression of the fault could lead to a reduced volume of water infiltration. A series of surface diversion ditches could be constructed over and adjacent to the surface expression of the fault structure. These ditches would intercept surface water runoff and convey it down slope of the fault expression in order to minimize overland flow across the fault trace.

Minimize Subsurface Water Migration – The raise complexes between Levels 3, 2 and the sub-level immediately below Level 2, if it exists, could be sealed using concrete plugs. Sealing of these features would divert the direct vertical movement of water between the individual levels and keep the water away from stopes, ore passes, and other mineralized material.

In order to minimize contact time between groundwater and remnant ore or waste rock on the mine floors, a concrete lining such as shotcrete or grout could be placed along the bottom of each accessible level. The concrete would seal the fault exposure as well as waste and ore materials that have fallen there. Isolation of these materials should result in improved quality of water that runs along the floor. A plastic piping and collection system to convey water out of the individual drifts quickly would need to be developed in conjunction with any subsurface water diversion scheme, in order to better ensure the long term success of this approach.

Assuming that the quality of water is better at the upper levels than at the lower levels, the remaining water at the lower levels would be treated if necessary prior to release, while the cleaner water discharging from the upper levels might potentially be released without need of treatment.

### ***Recommendations for Future Work***

In order to develop a comprehensive water quality improvement plan for the Standard Mine complex, a more thorough understanding of the inter-connected underground mine workings is needed. It would be difficult to design an encompassing remediation plan without understanding in more detail how the local hydrologic system interacts with the various levels in the mine workings. This interaction involves not only potential water flow patterns, but the chemistry of water moving within the identified fault zone pathway and its associated mineralization.

Future investigations recommended include:

- Determine the quantity of water movement from Level 3 through discharge at Level 1;
- Determine the change in chemistry as water moves from Level 3 through Level 1;
- Utilize tracers/dyes to establish connectivity of workings and the fault structure. Additionally, tracers can be used to establish loading data based on dilution of tracer concentrations;
- Install a few relatively shallow groundwater monitoring wells on both sides of the fault. These monitoring wells would be used to help determine groundwater flow direction in the vicinity of the fault and to characterize groundwater quality before and after it interacts with the mineralized fault structure.

To accomplish some of this work, it will probably be necessary to gain access to Level 2, to determine its connections with Levels 1 and 3. A logical initial point to access Level 2 is the raise located 360 feet in from the Level 3 portal. If further consideration is given to entering Level 2 from this point, aluminum ladders, wooden landings and some timber work should be installed in the raise between these levels. This raise can be restored to useful access for a relatively small investment. Alternatively, or possibly in conjunction with this work, the Level 2 portal could be excavated and fitted to allow access, as was previously described above. Once access is established, Level 2 should be mapped to the extent it is accessible, and water quality and quantity data gathered.

The cause of the standing water pooled on Level 2 near the heads of the raises to Level 1 should be determined. It is possible that the blockage 80 feet inside Level 1 is the reason for the standing water seen on Level 2. If the plug on Level 1 is causing water to back 240 vertical feet up into Level 2, additional work will be required to eliminate this condition. A catastrophic failure of such a plug resulting in a sudden blow out could cause serious environmental damage, destroy any type of constructed treatment system, and potentially risk human injury or death. An initial assessment of the cause of the standing water could be made from Level 2. It may, however, be necessary to carefully evaluate, drain, and remove the caved blockage 80 feet in on Level 1 and further evaluate that drift for additional blockage.

Bird and Woods (undated) describe a 2,000 foot- long cross cut that apparently connects to the Level 1 drift at an unknown point. The existence of this cross cut remains unverified, but should be determined through further research. This could potentially entail entering Level 1 after the 80-foot collapse is removed, or if additional mine mapping and information from the adjacent Keystone workings can be obtained, it might be possible to target a bore hole to intercept the cross cut, allowing sampling of the water and assessment of the head pressure that may exist in the workings.

If the cross cut exists, it may be a source of water inflow to the Level 1 discharge. The quantity and quality of this water could either help or hinder site remediation. The characteristics of any water discharging from the cross cut to Level 1 could influence the selection of a treatment alternative.

Due to heavy public usage and traffic on the area's roads and trails, it is recommended that secure safeguards be placed on all the open Standard Mine entries. This is particularly true of Levels 1 and 3. While there is some risk of further collapse inside Level 1, the open raise 140 feet inside Level 3 presents a possibly fatal hazard to the unwary visitor who enters this level.

There does not appear to be any remaining value in leaving the Level 4 twin compartment shaft open for further evaluation. This feature should be backfilled to ground level using locally obtained clean rock or fill.

General construction guidelines for each closure type are provided in Appendix 2, Closure Construction Plans.

### ***Summary***

The Colorado Division of Reclamation, Mining and Safety evaluated the Standard Mine during the week of August 14, 2006. The purpose of the investigation was to evaluate the underground workings of the mine in order to quantify its physical characteristics, and pertinent hydrologic and geologic features. Preliminary remediation recommendations were developed from that underground investigation.

Site evaluation has determined that Level 3 and 5 are generally accessible, while Levels 1, 2, and 4 are not. Level 4 is a twin compartment shaft caved just below surface, and no further evaluation of that feature was conducted or is recommended. Only very limited parts of Levels 1 and 2 were accessible during this investigation.

The underground assessment and literature research indicate mining followed a mineralized fault zone known as the Micawber vein. The fault structure was observed to be a significant pathway of water movement between the ground surface and Level 3. It is believed that with time, water continues to move downward along this structure until it intersects Level 2 and ultimately Level 1. Water was also found moving downward between levels through raises and stopes that connect the various levels. Open mine workings between Levels 1 and 3 likely provide the major pathways for water movement resulting in discharge at the Level 1 portal.

Water moving within the mine degrades in quality with increased residence time. This occurs as a result of the interaction between the water and remnant ore and mineralized waste materials found within the workings.

Source control remediation techniques could reduce the quantity of water which discharges from Level 1, and could potentially improve the quality of the discharging water, possibly leading to significant long term operation and maintenance cost-savings. Most of the recommended source control techniques involve interception or diversion of groundwater prior to its interaction with the subsurface mine workings.

A number of recommendations for future work are discussed. Additional underground reconnaissance work should be conducted at Level 2 and possibly at Level 1 as well. These efforts are necessary to more fully understand the nature of the mine-groundwater hydrology interactions at the Standard Mine. Finally, open mine entries should be fitted with safety closures to prevent public ingress while allowing site access by authorized personnel.

## *Glossary*

Adit	A horizontal or nearly horizontal opening driven from the surface to work a mine.
Back	The roof or overhead surface of a horizontal mine working.
Bald	Without framing, timbering or other ground support.
Cross cut	A horizontal opening driven at an angle across the trend of a vein, or across the general direction of the main workings.
Drift	A horizontal opening driven in or near an ore body and parallel to the course of the vein or long dimension of the ore body.
Footwall	The upper or hanging surface above an inclined fault plane or vein.
Gouge	The clay or clayey material in a fault zone.
Hanging wall	The bottom, or lower surface of an inclined fault plane or vein.
Inby	Toward the working face, or interior, of the mine; away from the mine portal.
Lagging	To secure the back and ribs behind the timber or steel sets with short lengths of timber planking, thus securing loose rock.
Manway	A vertical or steeply incline passage, often a compartment in a shaft or raise, equipped with ladders and landings for miners to move between various levels in the mine.
Outby	Nearer to the mine portal, away from the face. The opposite of inby.
Portal	Surface entrance or opening in the hillside (beginning of the adit or drift).
Raise	A vertical or nearly vertical opening in a mine driven upward from one level to connect with the level above. The “head” of the raise is the upper end, and the “foot” is the lower end, from which it was driven
Stope	An excavation from which ore has been removed in a series of steps, usually applied to inclined or vertical mining.
Winze	A vertical or nearly vertical opening in a mine, distinguished from a raise only by its being driven downward from one level to connect with the level below.



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## Appendix 1, Annotated Survey Notes

### *Summary of Level 3 Notes*

Distances / locations inby from portal

- Ohio Creek Formation from portal to 140 feet. Bearing is N630E.
- At 132 feet USGS sample point MSTDL031.
- At 140 feet, winze drops downward from main. Water cascades into winze inby far edge. Collapsing timber above winze in back could indicate communication with twin compartment shafts at ground surface. Winze dimensions: 16 feet parallel with main by average 8 feet perpendicular to main by unknown depth. Dimension of main is 6 feet wide by 7 feet high.
- At 145 feet USGS sample point MSTDL032.
- At 195 feet, quartzite inby left and siltstone right. Fault appears left of the main at this location; workings in the hanging wall. Stalls on fault.
- At 200 feet, fault rolls in vertical plane, with gauge material apparent in back. Fault zone is 4.5 feet wide, with interior mineralized zone at 1.5 feet wide. Dimension of main is 6 feet wide by 6 feet high.
- At 210 feet, workings appear to cross through the fault zone.
- At 227 feet, main exits fault, and is driven into hanging wall.
- At 245 feet, cross cut started on left side, dimensions estimated at 4 feet by 5 feet by 10 feet deep. Strike and dip on rib of main are N80°E / 52° S respectively.
- At 250 feet water from bedding on left.
- At 260 feet, main intersects fault, with hanging wall present on right and footwall on the left. Fault varies between 2.5 and 3 feet wide. Mineralized zone is indistinct.
- At 265 feet, quartzite is present on the right, and predominates with siltstone pinching out. Little, if any, fault gauge is observable.
- At 270 feet, 15 feet tall stope into back. Fault zone is approximately 5 feet wide, while the mineralized zone varies from one to two feet wide. Timbered back begins here and extends to 305 feet. Silt stone apparent at beginning of timber set, with igneous contact observable immediately inby the timber set. Apparently igneous material / intrusive observable at this section. Material is very hard, massive with no apparent dip or structure. Fault gauge in back, thus necessity of timber set.
- Altered section appears to heavily impact the section between 270 and 385 vicinity. This coincides with area of most apparent inflows.
- At 300 – 310 siltstone material present on right.
- At 315 feet stope in back is 12 feet by 18 feet.
- Stope in back ends at 319 feet.
- At 320 to 330 feet water is produced.
- At 327 feet USGS sample point MSTDL033.
- At 338 feet, a timbered raise with remnants of a ladder are present on the left. Estimated dimensions are 4 feet by 6 feet by 40 feet visible height. A loaded

- timbered feature located immediately adjacent to the raise may be an ore pass from an upper elevation sub level(s). Fault zone here is six to seven feet wide.
- At 350 feet a timber set inclined at approximately 45 degrees located in the back.
  - At 355 feet a stope is located on the left, with estimated dimensions of 4 feet by 8 feet by 40 feet in height. Timber set, presumably an ore pass remnant, is located on the outby side of the stope. Material from the timber set is piled across the floor of the main, inhibiting ingress.
  - At 360 feet a winze is located on the floor of the workings. The winze is overlain by planks which provide rail and foot access inby the feature. Majority of the winze opening is located to the right. Surface dimensions of the winze are estimated at 8 feet by 12 feet. The winze appears to be a twin compartment providing access to lower levels at an estimated vertical distance of 75 feet.
  - At 370 feet a stope on left with dimensions estimated at 4 feet by 15 feet by 15 feet. A loaded, un-shot drill hole is located on the inby side of the stope approximately 8 feet above the floor.
  - At 374, main moves into footwall, and back into the hanging wall at 391 feet.
  - At 381 feet, strike and dip on rib are N75°E / 45° S. Dimension of main is 6 feet wide by 6 feet high. USGS sample point MSTDL033.
  - At 385 feet, the workings bend to the right, and appear to shift from the hanging wall to the foot wall, and then bending back to intersect the hanging wall. The fault zone also appears to bend in this vicinity. At 390 feet an igneous intrusion appears on the right, approximately perpendicular to trend of workings. This dike-like intrusion cross cuts bedding, but is not apparent in the back.
  - At 386 feet USGS sample point MSTDL034.
  - At 391 galena rich material.
  - At 400 – 410 feet back is stoped, estimated to be no taller than 18 feet above the floor. Fall material from stope on floor here. Fault zone is 5 feet wide with mineralized zone being approximately 2 feet wide.
  - At 400 to 476 feet, diffuse water inflows occur from the footwall exposure of the fault (left side).
  - At 425 feet, strike and dip on rib are N80°E / 65° S-SE.
  - At 425 – 430 feet copper precipitate is present on the left occurring in quartzite. Altered siltstone on the right. Vein structure is 6 inches to 8 inches wide, and pinching out. Good fault exposure.
  - At 450 feet, strike and dip on rib are N85°E / 55° SE. Inflows are consistently from the left, along the fault. Siltstone on the right likely confines flow, forcing water to flow downwards along the fault plane.
  - At 460 feet, siltstone / quartzite / conglomerate sequence as fault begins to horsetail. Splitting of the fault is observed on the right at this location.
  - At 460 – 500 feet a good fault exposure is visible on the right. Horsetail-like fault exposures develop along the fault as well. Sandy conglomeratic materials exposed on the right.
  - At 511 feet flow stone development on right with likely inflows at this location.
  - At 576, dimension of main is six feet wide by eight feet high. Fault zone is 4 feet wide, mineralized zone is less than 1 foot wide.

- At 590 feet, fault zone is three feet wide, mineralized zone is a discontinuous set of stringers.
- At 610 feet, a winze is located on the right. Dimensions are 7 feet parallel with main by 4 feet perpendicular to main. Estimated depth is 50 feet.
- At 639 feet USGS sample point MSTDL035.
- At 645, floor rises and back falls to end of mining at 652 feet.
- At 652 feet mine ends. Neither the fault zone nor the mineralized zone is discernable at this location. Dimension of main is 6 feet wide by 4 feet high.

### *Summary of Level 5 Notes*

#### Distances/ locations in by from portal

- 0 to 100 feet bearing N76<sup>0</sup>E. In Wasatch Formation; silicified siltstone in rib. No fault zone discernable. Water standing on floor, but little water seepage from ribs or back observed.
- At 180 feet, fault zone encountered on right. Zone is 1 foot wide or less, with clay gouge material present. No significant inflows noted.
- At 190 feet fault crosses to left; strikes at N72<sup>0</sup>E / 86<sup>0</sup> dip.
- At 200 feet, dimension of main is 6 feet wide by 8 feet high.
- At 210 feet, fault gauge is 8 inches wide, but does not contain a discernable mineralized zone.
- At 228 feet, USGS samples inflow from back; sample number unknown. Inflow is a constant stream of water from back.
- At 250 feet, mine splits right and left.

#### Left Drift

- At 235 feet, main in hanging wall of fault zone, with fault zone likely right of drift.
- At 260 feet, main intersects fault zone. Water seeps into main from footwall (left) side of fault at 263 feet. Fault strikes N62<sup>0</sup>E and dips 80<sup>0</sup>.
- At 267 feet hanging wall is on the right with footwall on the left. Small volume of seepage from footwall through 300 feet.
- At 300 feet there is no discernable fault or mineralized zones; fault may roll flat at this location.
- At 325 feet fault exposure located on the left.
- At 338 feet fault exposure located on the right. Fault zonation widens to 4 feet, with 6 inch mineralized zone observable.
- At 363 feet fault and mineralized zones are nearly not discernable.
- At 367 feet inflow from left. Iron staining on rib and floor. Footwall of fault apparent on left. Dimensions of main at this location are 5 feet wide by 7 feet high.

- At 409 feet foot wall is on the left. Minor stopping in back. Fault width estimated at 4feet.
- At 490 feet fault appears to begin to split and roll flatter to a horizontal inclination.
- At 500 feet is a cross cut measuring 5 feet wide, 6 feet high and 10 feet deep.
- At 514 feet to 530 feet the fault appears to roll flatter, appearing in back. No mineralization apparent.
- At 530 feet to 542 feet fault begins to steepen.
- At 546 feet USGS sample location M116001.
- At 553 feet fault splits in back to right and left components.
- At 563 feet mine collapse, end of ingress. Water inflow into mine from top of collapse.

#### Right Drift

- At 333 feet fault face on inby right. Fault strikes N60<sup>0</sup>E, dips at 79<sup>0</sup>. Slickenside in back trend approximately parallel with strike of mine.
- At 447 mining ends. Dimension of main at this location is 5 feet wide by 4.5 feet high. Fault structure is 6 to 10 inches wide at this location, with no discernable mineralized zone.

## *Appendix 2, Closure Construction Plans*

### **1 BACKFILL CLOSURE**

#### **1.1 DESCRIPTION**

This work shall consist of backfilling mine openings with on-site or imported fill materials and revegetation of disturbed areas, as designated in the specifications or by the PROJECT MANAGER.

#### **1.2 MATERIALS**

Backfill Materials shall be on site common fill or other materials as designated by the PROJECT MANAGER.

Riprap shall be minimum of two-foot (24") diameter, hard, durable and well graded in order to eliminate the presence of large voids when placed.

Drain Pipe shall be six-inch (6") SDR-35 or schedule 40 perforated PVC, ABS or HDPE drain pipe.

Cement shall be Type II Portland cement, conforming to ASTM C150.

#### **1.3 EXECUTION**

##### **Shaft, Stope, and Subsidence Feature Backfilling**

Prior to backfilling a shaft, stope or subsidence feature, all wood, garbage, cribbing or other materials, as directed by the PROJECT MANAGER, shall be removed from the mine opening. All trash and debris shall be hauled to a county-approved disposal site, as directed by the PROJECT MANAGER.

Shafts, stopes and subsidence features shall be backfilled using a graded backfill technique. First, riprap a minimum of two feet (2') in diameter shall be placed in the opening to a minimum thickness of twelve feet (12'). In deep openings or water filled openings, riprap a minimum of two feet (2') in diameter shall be placed in the opening until visible from the edge of the opening. The remaining fill shall be graded and may be obtained on site as directed by the PROJECT MANAGER. The final one foot (1') of fill material shall be comparable to surrounding surface material and shall be suitable for plant growth. The CONTRACTOR may use on-site riprap materials if permission is obtained from the landowner by the CONTRACTOR and with the approval of the PROJECT MANAGER. The final surface of the backfilled opening shall be mounded a minimum of three feet (3') above the original ground level to allow for settlement.

Material used for backfilling shall be compacted as directed by the PROJECT MANAGER using multiple passes with available heavy equipment. A new, six foot (6')

long, three inch (3") I.D. (inside diameter) galvanized steel pipe shall be installed at the center of each backfilled feature. The lower two feet (2') of pipe shall be set in concrete a minimum one foot (1') diameter and the upper one foot (1') minimum, two feet (2') maximum, of the pipe shall extend above grade. Alternatively, a minimum one foot (1') diameter 3/8-inch thick galvanized steel plate may be welded perpendicular to the bottom end of the pipe to act as an anchor, in place of the concrete. A brass cap shall be grouted flush to 1/4" below the top of the pipe by the CONTRACTOR using a non-shrink grout, such as Moly Parabond, Pour Rock, or Kwik Crete. The brass caps will be supplied by the OWNER.

## **2 ADIT DOOR CLOSURE**

### **2.1 DESCRIPTION**

This work shall consist of installing a grated steel door within an adit including clearing and grubbing, excavation of loose material, trimming of adit, and furnishing, securing and welding of steel grate work in accordance with Standard Drawing Number 7 and these specifications.

### **2.2 MATERIALS**

Steel Grating shall be a minimum of 1-1/4" by 3/16" bearing bars on 1 3/16" centers. Cross bars shall be resistance welded at right angles to the bearing bars and spaced 4 inches center to center, (bar as manufactured by AMICO type 19-W-4-53, or equivalent).

Cement-grout shall consist of commercially available sand and cement mix with a minimum rated compressive strength of 3,500 psi at 28 days.

Structural Steel shall conform to the requirements of ASTM A-36, all-purpose steel.

Drain pipe shall be six-inch (6") SDR-35 or schedule 40 ABS, or HDPE pipe.

Rock bolts shall be expansion type with a minimum pullout strength of 2,000 pounds at an embedment depth of 4.5 inches. The rock bolts shall be Hilti Heavy-Duty Expansion Anchor, Kwik Bolt or equivalent.

Anchor Bars shall be Number 6 (3/4") rebar in accordance with ASTM A 615, grade 60, anchored to a minimum depth of eight inches (8") into competent rock with Moly Parabond epoxy capsule or equivalent, or with an interference fit in drilled holes in solid rock.

Durable Rock shall consist of locally-available durable rock, which gives a ringing sound when struck with a hammer.

## **2.3 EXECUTION**

### **Fabrication**

The door grating shall be welded to a L 2" x 2" by ¼" angle iron framework. The grate framework is to be attached with six-inch (6") extra heavy hinges to a L 2" x 2" x ¼" angle iron door frame which will be securely anchored to the perimeter of the opening with rock bolts or anchor bars in the roof and floor, and a steel grating. All field welds shall be in accordance with the requirements of the American Welding Society AWS D1.1.

### **Clearing and Grubbing**

The work site shall be cleared and grubbed of debris, loose rocks and other items which interfere with construction, as approved by the PROJECT MANAGER. All trash and debris shall be disposed of at a county-approved disposal site, as approved by the PROJECT MANAGER.

### **Excavation and Installation**

The door shall be set into the adit at a stable location a minimum of five feet (5') and a maximum of ten feet (10') from the opening or as directed by the PROJECT MANAGER. The foundation must be excavated to bedrock. The adit opening shall be cleaned of loose rock and trimmed as needed to accommodate the door framework.

The door frame shall be secured to the internal adit surface on the sides by rock bolts or anchor bars on twelve-inch (12") centers. The rock bolts or anchor bars shall be anchored eight-inch (8") minimum embedment depth into the drilled holes such that an interference fit is obtained. Swaged bar embedments will be allowed only in competent rock. No rock bolts or anchor bars are required on the top or bottom unless the space between the door frame and the adit exceeds eighteen (18") inches.

If the rock is soft, excessively fractured, or generally incompetent, a minimum anchoring depth of eighteen inches (18") shall be required, and anchoring shall be by Moly Parabond epoxy capsules (or equivalent epoxy capsules).

The ends of the anchors at the door frame will be welded to the door frame. Welding shall be made on both sides of the anchors.

The spaces between the adit and the angle-iron doorframe be covered with grating identical to that of the door. This alternative requires that anchor bars must be placed around the entire perimeter of the door frame. The grating shall be trimmed, framed, attached, and installed around the perimeter of the adit in accordance with the specifications for the grated adit closure, (11.0), as shown in Standard Drawing No. 7.

L 2" x 2" x ¼" stiffeners installed from roof to floor must be used to support the L 2" x 2" x ¼" angle iron door frame as shown on Standard Drawing No. 7. Bolt protection plates, as shown on Standard Drawing Number 6, are required at the edges of the perimeter grate frame.



If there is any mine drainage, a twelve inch (12") thick, twelve inch (12") tall concrete footer must be poured. A six inch (6") diameter SDR or schedule 40 ABS pipe must be placed near the bottom of the footer. The concrete footer must be anchored into the floor with rock bolts or anchor bars on twelve inch (12") centers. The steel grating or door frame must extend into the concrete a minimum of two inches (2"). If the door frame is cast into the concrete footer, the top of the angle iron must be flush with the top of the concrete footer.

# LEVEL 3 STANDARD MINE

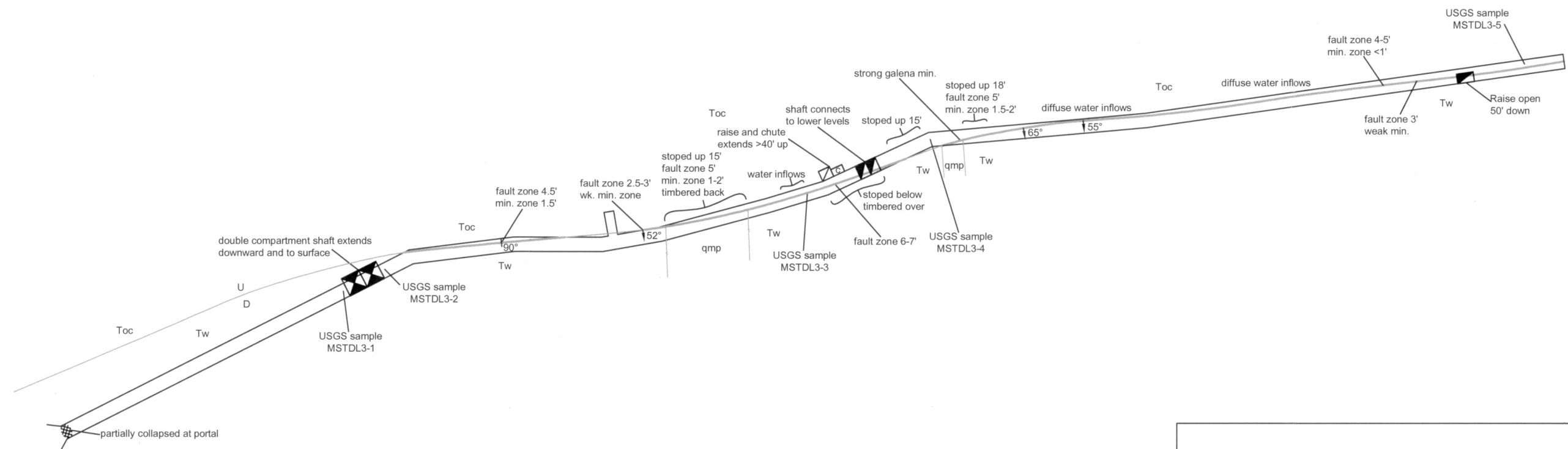
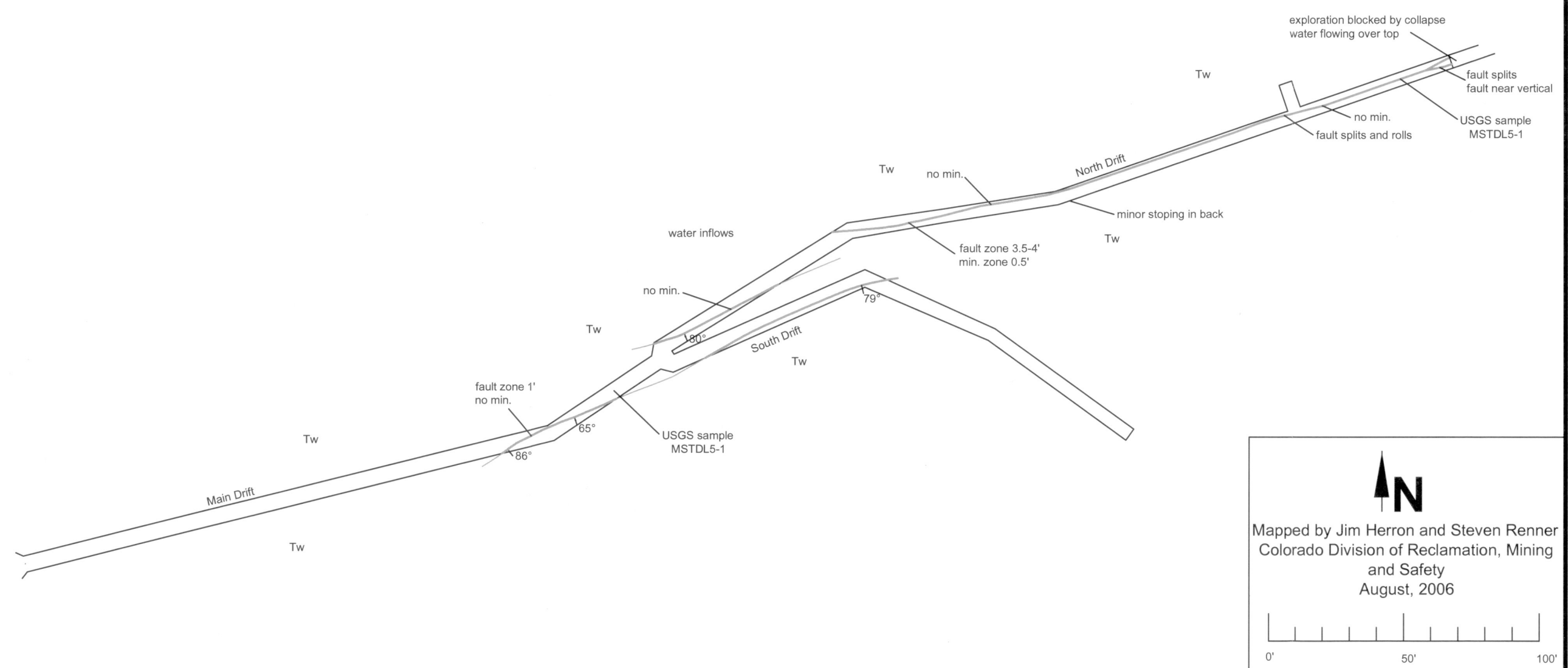


PLATE 1

Mapped by Jeff Graves and Steve Renner  
Colorado Division of Reclamation, Mining  
and Safety  
August, 2006

- ▣ Shaft/Raise extending through level
- ▣ Head of raise
- ▣ Foot of raise
- ▣ Ore chute
- $\frac{U}{D}$  Fault - U, upthrown side; D, downthrown side
- $\nabla 50^\circ$  Fault dip - direction and magnitude
- qmp Quartz Monzonite Porphyry
- Toc Ohio Creek Formation
- Tw Wasatch Formation

# LEVEL 5 STANDARD MINE



**N**

Mapped by Jim Herron and Steven Renner  
Colorado Division of Reclamation, Mining  
and Safety  
August, 2006

0' 50' 100'

PLATE 2

50° Fault- dip direction and magnitude indicated  
Tw Wasatch Formation