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Red Ledge Mine

Water Quality Report for Deep Creek PNRS 912 Headwaters to the Snake River

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TABLE OF CONTENTS

ABSTRACT

Deep Creek, in northwestern Adams County, is a perennial stream entering the Snake River just below Hell's Canyon Dam. Deep Creek is located on the eastern edge of the Blue Mountains Eco Region. Deep Creek was listed as a Stream Segment of Concern because of its importance to resident and anadromous fish. Deep Creek has also been listed as a Water Quality Limited Segment on the U.S. Environmental Protection Agency's (EPA) 303 (d) list for Idaho. Deep Creek and the Snake River are being impacted by heavy metals from historical mine workings at the Red Ledge Mine, and may be impacted by sediment from logging. Concerns for the mining impacts and proposed timber operations has increased awareness and concern for Deep Creek.

Corrective actions for acid mine drainage were implemented by the Alta Gold Company (aka Silver King Mines Inc) in 1992. Previous attempts at corrective actions have failed to reduce metals and sulfate loading. Reconnaissance level monitoring indicates corrective actions have decreased metals loading of Deep Creek by as much as 83%.

INTRODUCTION

Deep Creek is a perennial stream entering the Snake River just below Hell's Canyon Dam in northwestern Adams County, Idaho (Location Map). Although flows may exceed 50 cubic feet per second (cfs) they are rarely less than 10 cfs (Sanders 1991). Deep Creek flows northward through a deeply incised canyon which drops between 800 and 1,000 feet per mile (Sanders 1991). Deep Creek was listed as a Stream Segment of Concern because of its importance to resident and anadromous fish. Deep Creek is also listed as a Water Quality Limited Segment on the U.S. Environmental Protection Agency's (EPA) 303 (d) list for Idaho.

Deep Creek does not have designated beneficial uses listed in Idaho's "Water Quality Standards and Waste Water Treatment Requirements". Macroinvertebrate and fish surveys indicate, however, that Deep Creek does sustain cold water biota, and salmonid spawning and rearing. Historically, Deep Creek has been used for both primary and secondary contact recreation above the Red Ledge Mine. Chemical analyses of water samples collected below the Red Ledge Mine suggest that Deep Creek could not sustain cold water biota or salmonid spawning and rearing. Specimens of cold water species of insecta have been found below the Red Ledge Mine, and may be indications that aquatic communities are reasserting themselves. Fish and macroinvertebrate surveys continue to support the conclusion that Deep Creek below the Red Ledge Mine does not fully support the beneficial uses of "Cold Water Biota" and Salmonid Spawning".

Although Deep Creek joins the Snake River in the very arid Hell's Canyon, Deep Creek is bordered by a deep conifer forest. Distinguishing between riparian and upland habitat is very difficult as douglas fir and yellow pines encroach the stream bed, and typically riparian and wetland species such as ferns and sedges may be found high up on the flanks of the canyon where springs erupt.

Water quality in Deep Creek may be effected by both logging and mining activities. Historically, precious metals mines in the drainage were developed and produced both gold and silver from copper rich ores. Deep Creek and the surrounding watershed contains large stands of old growth Douglas Fir and Yellow Pine which have been logged. Mineral and timber developments may contribute heavy metals, sediment, and petrochemicals, such as oil, diesel fuel, hydraulic fluids, and antifreeze, to surface and ground waters. If mineral and timber continue to be developed in this drainage it will be necessary to implement best management practices and continue water quality monitoring.

Prominent features of the Deep Creek watershed include the Red Ledge Ore Body and Mine. It is important to note that these two features are identified separately. The importance lies in the fact that the exposure of the Red Ledge Ore Body, by itself, would contributed large quantities of metals to Deep Creek, which traverses the ore body. Development of the Red Ledge Mine workings are, however, believed to have accelerated the degeneration of the sulfide ore, and hence, significantly increased the metals loading of Deep Creek. One must, therefore, consider the natural versus manmade causes for metals loading of Deep Creek. Indeed, biological data indicates that aquatic communities are impaired where Deep Creek first enters the ore zone, which is considerably above the surface exposure of mine workings.

Effluent from both the ore body and mine, more specifically called acid rock drainage (ARD) and acid mine drainage (AMD) respectively, has been subject of considerable debate since the early 1970's when Idaho Power was identified alternatives to mitigate adverse effects to the anadromous fisheries, which occurred subsequent to construction of the Hell's Canyon Dam. Debates have focused on the amount of metals loading attributed to these two features.

Corrective actions for AMD were implemented by Alta Gold Company (aka Silver King Mines Inc) in 1992. Previous attempts at corrective actions have failed to reduce metals and sulfate loading. Reconnaissance level monitoring indicates the corrective actions have reduced metals loading of Deep Creek by up to 83%. The objective of the corrective action is to reduce metals loading to a natural rate. It would be a bonus, if this rate is actually conducive to the beneficial uses of "cold water biota", and "salmonid spawning".

HISTORY OF THE RED LEDGE MINE

Early explorers of the Hell's Canyon began locating precious and industrial minerals prior to the turn of the century. The Red Ledge Ore Deposit was located in the 1880's in accordance with the Federal Mining Law of 1872. From the time of its location until 1919, the Red Ledge Mine was owned and operated by individuals who developed over 800 feet of underground workings and drilled approximately 1,000 feet of exploration holes. The exploration and development work at the Red Ledge Mine has resulted in the location of twenty-three patented lode claims, seventy-one unpatented claims, and twenty-seven millsites (Sanders 1991). The status of the unpatented claims was not verified for this report.

Early delineation of the Red Ledge Ore Deposit resulted in significant interests by investors. Subsequent promotions lead to the mine's acquisition and turnover by many different mining companies. Between 1919 and the present, both small and large mining companies have attempted to bring the ore deposit under production. Previous interests have included; Butler Ore Company, ASARCO Minerals, Hecla Mining Company, Cities Services Exploration Company, Texasgulf Western, and Birch Creek Resources Company. Current ownership is held by Alta Gold Company (aka Silver King Mining Company), of Salt Lake City, Utah.

The development of the Red Ledge Ore Deposit over the course of 110 years is extensive. Over 64,000 feet of exploration drilling has lead to the delineation of approximately 42 million tons of sulfide ore containing copper, cadmium, silver, zinc, lead and trace amounts of gold and platinum. Two mine adits and levels were developed with approximately 2,175 feet of tunnels and a raise. Several cabins are located at the site for staff housing (Sanders 1991). Mine waste dumps in excess of 1,000 tons also remain on site.

The mine had been accessed by two overland routes which begin at Eagle Bar on Hell's Canyon Reservoir, and at the Peacock Mine in the head waters of Copper Creek. A third route had been planned by early mine developers, it consisted of a tunnel from Eagle Bar to beneath the ore deposit. Originally being utilized by a narrow gauge railroad and pack trains, the route from Eagle Bar over the mountain and up Deep Creek is now treacherous even to experienced hikers. The trail from Eagle Bar is the route most traveled and is approximately eleven miles round trip.

During the 1977 and 1978 FERC hearings on Hell's Canyon Dam corrective actions at the Red Ledge Mine had been considered as one of the possible mitigatory actions for construction of Hell's Canyon Dam. The mitigation would, supposedly, offset adverse effects the dam's construction would have on anadromous fisheries. One idea for mitigation included: Constructing a holding facility at the mouth of Deep Creek for salmon and steelhead where they could be trapped and or allowed to spawn. Another idea for mitigation included habitat enhancement on Deep Creek since Deep Creek had been considered, prior to the FERC hearings, as a final destination of some of the anadromous fish. It was argued, therefore, that the effects that metal laden waters from Deep Creek would have adverse effects on both of these concepts for mitigation, and therefore, the Red Ledge Mine was pertinent to the mitigation hearings. These arguments led to water quality monitoring in Deep Creek and characterization of the Red Ledge Mine to determine the amount of metals loading to Deep Creek, the necessary dilution required at the mouth to circumvent acute and chronic effects to aquatic communities, and to assess the previous impacts on aquatic communities in Deep Creek.

Water quality monitoring in Deep Creek above and below the Red Ledge Mine during 1977 and 1978 established baseline data. Data generation was, at times, a cooperative effort of Idaho Power, Butler Ore Co. and associates, the U.S. Forest Service, Idaho Department of Fish and Game, and Division of Environmental Quality (DEQ). Frequency of water quality sampling was almost completely abandoned after 1978 due to a lack of interest and resources.

In 1991 DEQ and Alta Gold Company began negotiations for corrective actions relative to the AMD. In 1992, a consent order was entered by both parties, and corrective actions were implemented according to an approved plan. Since the installation of mine and drill hole plugs, and stabilization of the dumps, DEQ has been monitoring water quality to determine the effectiveness of the action.

ISSUES

Acid Mine Drainage (AMD) from the Red Ledge Mine and Acid Rock Drainage (ARD) from the Red Ledge Ore Deposit are responsible for the delivery of large quantities of sulfuric acid and heavy metals to Deep Creek approximately two miles upstream from the Confluence of Deep Creek and the Snake River. Concentrations of these contaminants have exceeded recommended criteria by the U.S. Environmental Protection Agency which were established as protective of cold water biota. Water quality monitoring which included biological surveys confirmed that there are no resident species of salmonids present in Deep Creek below the mine, and that macroinvertebrate populations are impaired below the mine.

ARD and AMD reactions require several conditions. These conditions include: the presence of sulfide, which is the source of sulfate and heavy metals; oxygen, which reacts with and changes the molecular structure of the sulfide to sulfate; and water, which supplies hydrogen and oxygen, dissolves the sulfates, and acts as the transport mechanism for sulfuric acid and heavy metals. Elimination of sulfides, sulfate, oxygen or water will stop an acid generating process. In the environment, however, complete elimination of any of these factors is near impossible, and therefore methods of reducing the presence or reactivity of these substances is considered.

Relative to the Red Ledge Mine several concerted actions were negotiated to remediate AMD. These included drilling and pressure creting secondary fractures caused by blasting during tunnel constructions, installation of acid resistant plugs in both the mine portals and exploration drill holes, and installation od a geotextile fabric and riprap to stabilize mine dumps. Pressure creting and installation of mine plugs may reduce the transmissivity of the ore body in proximity to the underground workings. A reduction of transmissivity should cause a flooding of mine workings, which reduces availability of atmospheric oxygen, and a reduction of ground water flow through the ore body. Reduced transmissivity may reduce availability of dissolved hydrogen and oxygen and the volume of water which acts as the transport mechanism. Stabilizing mine dumps may temporarily reduce erosion and sediment delivery. In June, 1992, DEQ and Alta Gold Company entered into a consent order. The Consent Order outlined DEQ's authorities for the protection of water quality, and outlined a course of corrective action design and implementation by Alta Gold Company. As of August, 1992 corrective actions to reduce the impact of mine drainage were designed, approved and implemented. DEQ has determined that it is necessary to qualify the effectiveness on the mine plugs prior to acknowledging full execution of the consent order.

The Red Ledge Mine's location in pristine wilderness was a factor in determining what actions could be taken, and consequently what equipment could, practically, be taken into the mine. Development of access other than by air would result in greater loses to stream, riparian and upland habitat. Given the constraints of air support, corrective actions had to be designed which minimized the use of large equipment and depended greatly on hand labor.

WATER QUALITY MONITORING AND ANALYSES

Since 1974, fourteen water quality monitoring sites have been surveyed in Deep Creek. Site station numbers, descriptions and analytical parameters are listed in TABLE 1. These stations have been monitored sporadically, and until the last four years, no attempt had been made to sustain an annual monitoring program. Furthermore, Deep Creek's and the Red Ledge Mine's remote location make it difficult to monitor more than once annually. Three stations have been located on Deep Creek in the headwaters, which will have reconnaissance levels monitoring done approximately every five years.

Two instream stations were used as sites for beneficial use reconnaissance surveys. Habitat and biological scores were determined from data collected by staff and DEQ modifications of habitat and biological scoring systems, where 180 and 60 are, respectively, the highest possible scores possible.

Water Chemistry

Chemical analyses has been done at five of the sites listed in TABLE 1, including two sites located in the workings of the Red Ledge Mine. Overall the analyses shows a direct correlation between the high concentrations of heavy metals and the workings of the Red Ledge Mine from which Acid Mine Drainage (AMD) is draining.

Analyses of water chemistry of samples collected at Station 1, approximately 50 feet upstream from the Red Ledge Mine, has been done sporadically. Analyses has shown an occasional kick in total metals concentrations (Appendix B). Although metals concentrations indicate a natural influence by the ore body, they do not appear significant enough to cause acute or chronic reactions in the aquatic community.

Sample Station 2 and Sample Station 3 are located at the Upper Portal and the Lower Portal, respectively. Samples of mine effluent have consistently been found to contain concentrations of arsenic, cadmium, copper, iron, lead and zinc which are four (4) to one hundred (100) times the U.S. EPA's Criteria for Water Quality (1986) for cold water biota (Appendix B), and would, therefore, almost certainly cause acute and chronic effects in aquatic species unless significantly diluted by Deep Creek. Since the closure of the mine workings and exploration drill holes, however, combined flow of effluent from the two adits has dropped dramatically from approximately 20 gallons per minute (gpm) to approximately 8 gpm. Flows were measured by channeling the mine effluent into a flume and then into a five gallon bucket. Times were recorded for the interim necessary to fill the five gallon bucket, and then calculated to the one minute equivalent.

TABLE 1. Monitoring Stations and Analytical Parameters for Deep Creek and the Red Ledge Mine, Adams County, Idaho.

Station I.D.	Locations	Analytical Parameters
Station 5 Ralston 7	50 meters Above Confluence of Deep Cr. and Snake R.	Arsenic*, Copper, Cadmium, Iron, Manganese, Mercury, Silver, Zinc, pH, macroinvertebrates.
Ralston 6	150 meters Above Confluence of Deep Cr. and Snake River	Arsenic*, Copper, Cadmium, Iron, Manganese, Mercury, Silver, Zinc, pH, macroinvertebrates.
Station 4 (aka 93SWIRO42)	Deep Creek at Lower Crossing Approx. 1,000' Below Red Ledge Mine	Arsenic*, Copper, Cadmium, Iron, Manganese, Mercury, Silver, Zinc, NO_3, pH, macroinvertebrates, pool/riffle ratio, canopy, interstitial space.
Ralston 5	Deep Creek 250 meters Below Red Ledge Mine	Macroinvertebrates.
Ralston 4	Deep Creek 125 meters Below Red Ledge Mine	Macroinvertebrates.
Ralston 3	Deep Creek 50 meters Below Red Ledge Mine	Macroinvertebrates.
Station 3	Lower Red Ledge Portal	Arsenic*, Copper, Cadmium, Iron, Manganese, Mercury, Silver, Zinc, pH.
Station 2	Upper Red Ledge Portal	Arsenic*, Copper, Cadmium, Iron, Manganese, Mercury, Silver, Zinc, pH.
Station 1 (aka 93SWIRO43)	Deep Creek at Upper Crossing approx. 50' Above Red Ledge Mine	Arsenic*, Copper, Cadmium, Iron, Manganese, Mercury, Silver, Zinc, pH, NO_3, macroinvertebrates, pool/riffle ratio, canopy, interstitial space.
Ralston 2	Deep Creek 50 meters Above Red Ledge Mine	Macroinvertebrates
Ralston 1	Deep Creek 200 meters Above Red Ledge Mine	Macroinvertebrates
93SWIRO32 (aka 94SWIROA49)	Deep Creek Below Copper Creek	Macroinvertebrates, pool/riffle ratio, canopy, interstitial space.
93SWIRO33	Deep Creek Below Lake Creek	Macroinvertebrates, pool/riffle ratio, canopy, interstitial space.
94SWIROA48	Deep Creek Below Ritchie Gulch	macroinvertebrates, pool/riffle ratio, canopy, interstitial space.

* Total Metals Speciation are quantitatively analyzed according to approved EPA methods.

Although flow from the adits, Stations 2 and 3, has been substantially decreased, metals concentrations remain very high they have dropped from approximately 300,000 ppb to approximately 170,000 ppb (calculated as an average of all Total Metal concentrations from 1991 through 1994). This apparent decrease is not, as yet, statistically viable given the number of data, it does, however, give some glimmer of hope that the remediation has possibly had a significant effect on metals loading from the manmade workings.

Chemical analyses of samples collected at Station 4, approximately 1,000' below the Red Ledge Mine, show that cadmium, copper, and zinc concentrations (Appendix B) may have significantly dropped post mine closure. Concentrations of metals, particularly copper, remain significantly high enough to cause acute or chronic reactions in cold water biota. These high concentrations, however, may not have actually caused the expected reactions, which will be discussed further in the biological monitoring section of this report. There are several possible sources or reasons for the continued presence of high metals concentrations at Station 4. These possible sources almost certainly exist and effect Deep Creek in concert, but the amount of metals loading attributed to each will most likely never be determined.

Closure of the mine workings and exploration drill holes will not completely stop the interaction of ground and surface water and the sulfide bearing ore body. Although the corrective actions will have significantly reduced secondary fractures caused by drilling and blasting, there will have been no appreciable change in primary joints and fracture systems which are natural to the host rock. There will, because of the complex nature of the structural geology of the ore body, be a continuous influence by surface waters on the ore body. That influent will, as ground water, provide some dissolved oxygen and hydrogen to drive the ARD process, and will continue to flow down gradient to become effluent lower in the hydrologic system. Metals loading of Deep Creek will, therefore, continue to be influenced by ground water which passes through the ore body regardless of any manmade modifications of the hydrology.

A tremendous amount of metals precipitates have built up on and in the substrate in Deep Creek below the mine. These precipitates have deeply penetrated the substrate and may have become so substantial that three years is not a sufficient enough time for Deep Creek's flow to flush and scour the substrate. It may, therefore take several more years of scouring to dissipate the precipitates, and results to be seen in water chemistry.

The Red Ledge Ore Deposit has a very large surface exposure where massive sulfides are continuously leached by natural weathering processes, which include the rapidly down-cutting Deep Creek. Because of the intimate proximity of Deep Creek and the Red Ledge Ore Deposit, the two could never be prevented from having a substantial influence upon each other. There will, therefore, always be an appreciable metals loading occurring as a result of this intimate relationship.

At the mouth of Deep Creek, Station 5, only copper concentrations have exceeded acute or chronic criteria. Metals concentrations are lower at this station primarily because the volume of flow is greatly enhanced by Oxbow Creek, whose watershed is well below, hydrologically, the Red Ledge Ore Body. Other factors may also be pertinent to the lower metals concentrations, these include precipitation of metals as they are transported below Station 4, and natural uptake or attenuation of metals by floral communities growing in and along Deep Creek. Station 5 has not been monitored regularly since access for the station is considerably different than that for the other monitoring stations.

Biological Monitoring

Twelve biological and habitat monitoring sites have been located in Deep Creek since 1978. Six of the sites are located above the Red Ledge Mine, and six are located downstream from the Red Ledge Mine. Macroinvertebrates were collected at seven sites by Ralston and Katz in 1978. Both physical and biological data were collected at five other sites by beneficial use reconnaissance personel (BURP) of DEQ. Although Ralston and Katz did not collect three macroinvertebrate samples from each of their sites, as did BURP, their collection and identification protocols were similar enough to DEQ protocols to enable comparison of the data sets. It should be noted that although general analogies are made, there is substantial time differences between the studies, and the depth of the data sets do not necessarily substantiate the analogies statistically.

Reconnaissance level monitoring indicates that Deep Creek above the Red Ledge Mine has excellent habitat for aquatic communities, and that macroinvertebrates are both numerous and diverse. Extensive data collected in 1974, 1977 and 1978 that shows a near normal balance in species diversity and number of resident fish and macro-invertebrates above the Red Ledge Mine (Platts 1974, Ralston and Katz 1978, Botz 1978). Although the Idaho Fish and Game documented the presence of Red Banded Trout in Deep Creek above the Red Ledge Mine (Appendix B), no recent surveys have been done below the mine. Habitat and biological scores, 120 and 54 respectively, were determined for this site based on 1993 beneficial use reconnaissance surveys. Although water chemistry indicates that there may be some influence from the adjacent ore, biological data suggest it is relatively insignificant.

Platts, Ralston and Katz all reported that they observed a sharp decline in numbers of macro-invertebrates immediately adjacent to the ore body. They also observed, however, that diversity remains somewhat the same as above the mine. Given the rapid drop of Deep Creek and the constant state of scouring to which the substrate must be subjected, some of the individuals may surely be attributed to drift from above the mine.

Approximately 250 meters where total mixing should be complete virtually no fish or macro-invertebrates were recovered (Platts, 1974). A few specimens which were collected, at approximately 1,600 feet below the Red Ledge Mine, have been attributed to drift from communities above the impacted segment (Ralston and Katz, 1978).

Specimens collected at two locations near the mouth of Deep Creek indicate imbalanced communities, which was due to a reduction in more sensitive predacious species (Ralston and Katz, 1978). It was also observed that individual sizes were notably smaller below the Red Ledge Mine than above.

CONCLUSIONS

With few exceptions, water quality in Deep Creek does not appear to have significantly improved. One must remember, however, that water quality monitoring in Deep Creek occurs once annually, and that statistical analyses of the limited data is most likely not viable at this time. Regardless, several conclusions might be drawn from the limited data.

Although flow from the adits has been substantially decreased, ground water would naturally seek to bypass the mine plugs and continue down gradient. This diverted ground water would pass through the ore body and continue to load Deep Creek with dissolved metals. The densely fractured ore body and steep hydrologic gradient for both surface and ground waters will make additional diversions of ground waters nearly impossible.

A tremendous amount of metals precipitates have built up on and in the substrate in Deep Creek below the mine. These precipitates may have become so substantial that two years is not a sufficient enough time to flush and scour the substrate. It may, therefore take several more years of scouring to dissipate the precipitates, and results to be seen in water chemistry.

The Red Ledge Ore Deposit has a very large surface exposure where massive sulfides are continuously leached by natural weathering processes, which include the rapidly down-cutting Deep Creek. Because of the intimate proximity of Deep Creek and the Red Ledge Ore Deposit, the two could never be prevented from having a substantial influence upon each other. There will, therefore, always be a sizable metals loading occurring as a result of this intimate relationship.

There appears to be a lack of correspondence between macroinvertebrate population data and the biological and habitat ratings for sites. This might be explained by the lack of consideration for water chemistry, particularly metals. In order to characterize the ability of stream segments to support beneficial uses, it may be necessary, particularly in mining districts, to develop a third axis or set of factors relating chemistry to support.

RECOMMENDATIONS

In order to make a determination of the effectiveness of corrective actions at the Red Ledge Mine and the reestablishment of beneficial uses in lower Deep Creek monitoring should continue. Due, however, to the lack of consistency in the water chemistry data, it is recommended that water chemistry samples be taken twice annually.

If monitoring does not indicate a substantial change in water quality within the next five years DEQ should consult with Alta Gold Company to develop and implement a contingency plan. Although there are several possible courses of action to take, technology in ARD remediation is advancing so rapidly, that projecting best technology currently available for possible actions in the future would be ludicrous.

REFERENCES CITED

Botz, Maxwell K. 1978. TRANSCRIPT OF PERSONAL TESTIMONY FROM OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 1-11 pp.

Botz, Maxwell K. 1978. TRANSCRIPT OF PERSONAL SUPPLEMENTAL TESTIMONY FROM OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 855-895 pp.

Chapman, Gary A. 1978. TRANSCRIPT OF PERSONAL TESTIMONY FROM OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 1-5 pp.

Chapman, Gary A. 1978. TRANSCRIPT OF PERSONAL SUPPLEMENTAL TESTIMONY FROM OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 1-5 pp.

Juhas, Allan P. 1978. TRANSCRIPT OF PERSONAL TESTIMONY FROM OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 1-18 pp.

Juhas, Allan P. 1978. TRANSCRIPT OF PERSONAL SUPPLEMENTAL TESTIMONY FROM OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 1509-1562 pp.

Platts, William S., 1974. ENVIRONMENTAL INFLUENCES ON DEEP CREEK, FROM THE RED LEDGE MINE, PAYETTE NATIONAL FOREST. Progress Report, Payette National Forest, McCall, Idaho. 1-4 pp.

Ralston, Gene l. and Katz, Max, 1978. A SURVEY OF WATER QUALITY, FISH, AND AQUATIC INVERTEBRATES OF DEEP CREEK, ADAMS COUNTY, IDAHO. Idaho Power Company, Boise, Idaho. 4-13 pp.

Sanders, D. 1991. Red Ledge Mine Site Assessment. Idaho Department of Health and Welfare-Division of Environmental Quality.

______. 1991. RED LEDGE MINE, Site Assessment. Alta Gold Company, Salt Lake City, Utah. 2-30 pp.

______. 1979. OFFICIAL STENOGRAPHER'S REPORT BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION. Idaho Power Company DOCKET NO. E-9579, Settlement Conference. Portland Oregon. 1768-1789 pp.

Deep	Creek	At Lower	Crossing	To Mine		
DATE FROM TO	CADMIUM TOTAL MG/L	COPPER TOTAL MG/L	IRON TOTAL MG/L	LEAD TOTAL MG/L	MANGANES TOTAL MG/L	ZINC TOTAL MG/L
73/12/19			0.01		0.03	
77/09/21	0	0.2	0.56	0	0.04	0.131
77/10/18	0.005	0.01	0.4	0.005	0.02	0.16
78/01/25	0.005	0.2	0.4	0.005	0.03	0.16
78/03/28	0	0.09	0			0.054
78/08/19	0.0005	0.1		0.0008		0.057
78/08/25	0.002	0.1	0.0005	0.005		0.076
78/09/28	0.01	0.14			0.02	0.11
87/08/04	0.001	0.15	0.66	0		0.112
91/02/12	0.0096	1.13	1.59	0		0.554
91/07/25	0.096	0.155	0.39	0.025	0.021	0.079
91/11/14	0.005	0.184	0.15	0.025	0.025	0.176
92/5/21	0	0.03	0.22			
92/09/02	0.0029	0.78	0.9			0.416
92/11/6	0.0043	0.7	1.04		0.01	0.452
93/7/20	0.001	0.13	0.35		0.01	0.079
94/4/6	0.002	0.26	0.87			0.175

Red Ledge Upper Portal WQ

Red	Ledge	Mine's	Upper	Portal		
Date	CADMIUM	COPPER	IRON	LEAD	MANGANE	ZINC
	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL
	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
73/12/19	0.046	13.3	60	0	0.95	6.5
77/09/21	0.075	10.85	76	0	1.1	7.24
87/08/04	0.9	13.8	82.5	0.13		0.14
91/02/12	1.1	184	259	0.17	22	98.8
92/09/01	0.43	106	176			53.6
92/11/9	0.308	72	171		1.23	40.1
93/7/20	0.28	48	138.5		1.16	26.25
94/4/6	0.18	20.4	115			14.65
95/8/23	0.13	13.5		0.1		10.6

Red	Ledge	Mine's	Lower	Portal		
Date	CADMIUM TOTAL MG/L	COPPER TOTAL MG/L	IRON TOTAL MG/L	LEAD TOTAL MG/L	MANGANE TOTAL MG/L	ZINC TOTAL MG/L
73/12/19	0.045	13.5	61	0	1	6.6
77/10/18	0.054	12	70	0.018	1.1	7
78/01/25	0.07	13	39	0.028	1.1	8.1
78/03/28	0	70		0.04		38
78/05/08	0.06	13.6	95			7.51
78/08/25	0.086	16	79	0.055		8.3
78/09/27	0.07	16			1	8
87/08/04	0.9	13.8	82.5	0.13		9.14
89/12/19	0.084	10.9	68.3	0.052		7.1
91/02/12	0.29	60.8	133.5	0.03		23.2
91/07/25	0.321	36.9	118	0.15	1.26	17.9
91/11/14	0.157	38.82	98.03	0.51	0.349	26.41
92/05/21	0.12	18	103		22	
92/09/01	0.42	102	276			45.2
92/11/6	0.189	55.5	103.8		2.39	24.4
93/7/20	0.12	31.5	109		1.66	13.4
94/4/6	0.15	14.8	110.5			10.63

Red Ledge Lower Portal WQ

Deep DATE	Creek CADMIUM TOTAL MG/L	Above COPPER TOTAL MG/L	Red IRON TOTAL MG/L	Ledge LEAD TOTAL MG/L	Mine At MANGAN. TOTAL MG/L	Bridge ZINC TOTAL MG/L
73/12/19	0.0002	0	0	0	7	0
77/09/21	0	0	0.01	0	0	0.001
78/01/25	0.005	0	0	0	1.5	0.01
78/08/19	0.0002	0		0	1.2	0.009
78/08/26	0.0002	0		0	1.2	0.005
78/09/28	0.001	0.18			1.6	0.13
87/08/04	0	0	0.06	0		0.045
91/02/12	0	0.01	0.11	0.031		0.014
91/07/25	0.106	0.015	0.15	0.025	1.11	0.002
91/11/14	0.005	0			1.423	0.025
92/05/21	0.0014	0.2	1.25			
92/09/01	0		0.05			0
92/11/6	0	0	0.04		0	0.004
93/7/20	0	0	0.09		0	0
94/4/11	0	0.01	0.07			0.016
95/7/23	0	0		0		0