

Mammoth Mine Pilot Plant Operation  
Acid Mine Drainage  
Shasta County, California  
1999



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## Pilot Plant Site

In October, 1999, we contacted representatives from Mining Remedial and Recovery Corporation (MRRC) and requested their authorization to set up and operate a pilot plant Acid Mine Drainage (AMD) operation at Mammoth Mine Complex in Shasta County, California.

The Mammoth complex is located approximately 15 miles northwest of Redding, on the west side of Lake Shasta at an elevation of approximately 2500 feet and includes several old copper mines discovered and developed around the turn of the century.

During peak production years, 2300 people were employed at the mine sites, as well as the smelter operations in nearby Kennet There are many other mines in the region, including Iron Mountain Mines (Iron Mt.), Balakalala Keystone, Afterthought, and others located on the range of mountains north and west of Lake Shasta.

The Mammoth complex was selected for the pilot plant operation due to access available to various portals and willingness of the owner, MRRC, to permit the operation of a pilot plant at the site.

## Objectives of the Pilot Plant Operation

The primary objective of the pilot plant operation was to treat an AMD influent stream from the Mammoth Mine complex. Our focus was to prove it's technologies were able to continuously treat such a waste stream; ascertain energy, equipment, and chemical costs; determine the level at which dissolved metal could be removed; and produce effluent of a quality that met or exceeded MRRC discharge standards.

Secondary objectives included, but were not limited to, the following:

- (1) Determine production flow rates that could be anticipated from the existing pilot plant and determine design criteria for a plant capable of higher flow rates.
- (2) Ascertain preliminary approximations of operating was of plant, chemicals, labor, fuel, etc. that could eventually be developed into a basic formula for "cost per gallon" or "cost per day" of treatment.
- (3) Develop test protocol whereby dam generated by the bench scale test can be equated to on-site operation costs and water discharge quality expectations.

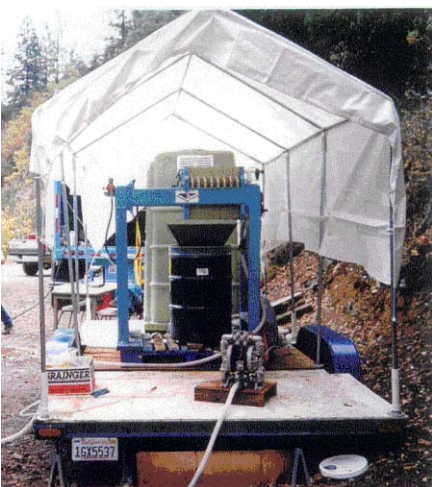
## History of the Area

The history of the area surrounding Mammoth Mine is significant, for it highlights the vast sums of dollars which have been expended as a consequence of the many years of mining and smelter operations throughout the region. Extensive mining has occurred in the area since the late 1800's.

In addition to copper, concentrations of zinc, cadmium, gold and silver were found. Smelters were located at Keswick (for the Iron Mountain Mines), Coram (for the Balakalala Mines), and Kenner (now under Lake Shasta, for the Mammoth Mines).

The last mine to operate was Iron Mountain and discontinued operations until the 1950's. Due to its extremely heavy concentrations of metal laden waters discharged into tributaries of the Sacramento River, this site was designated an Environmental Protection Agency (EPA) Superfund Site and has been involved with a myriad of remediation activities over the last 25 years.

The operation of these old mines, coupled with usage of the large number of smelters, caused immense environmental devastation. This included total loss of vegetation on extremely steep and rugged terrain, causing continuing erosion and runoff, exacerbated by the AMD conditions which exist throughout this region. Annual precipitation often exceeds 100 inches per year. Tributaries to the Sacramento River that contain the known contaminants have long been a serious problem. This has caused great concern to a number of regulatory agencies (including state and federal EPA, State Water Resources Control Board, and State Department of Fish & Game), present-day mine





owners, local communities, residents, fishermen and many other downstream users of Sacramento River Basin water.

It must also be noted that AMD from each source has its own, "personalized" characteristics. Each site produces a unique version of AMD, generating a family of dissolved metal with different levels of concentrations and features that will require its own specialized treatment. Tests performed at the Berkeley Pit in Butte, Montana, Leviathan Mine in Alpine County, Iron Mt. Mine, and many others reinforce the need to develop a treatment protocol which generates an equation between bench scale testing and the anticipated treatment results and costs of a particular site.

## Pilot Plant Pre-Operation Activities

Prior to mobilization, samples were taken at the Balakalala Drain Portal and the Friday Loudon Portal; both portals had been plugged by concrete bulkheads. It was possible to operate at either site with a pilot plant, although access and site constraints at the Balakalala were more challenging than the Friday Loudon. Consequently, the decision to set up at the Friday Loudon portal permitted tapping of the 5 inch pipeline, which extends 800 feet from the bulkhead to the portal.

Mobilization occurred Tuesday, November 2, 1999, with two large (35 foot and 40 foot) moving vans containing the plant, clarifiers, reactors, tools, piping, compressors, tanks, and a small 20 foot trailer with filter press and miscellaneous sludge handling equipment. The first two days were occupied with plumbing, pipe connections in the mine, generator and electrical hookups, with the first run occurring Thursday, November 5, 1999 and continuing on November 6.

Several small incompatibilities were encountered which necessitated a change to some of our tanks and chemical handling equipment. Following these modifications, the system was; much easier to start up and equalize.

Samples were pulled Monday, November 8, 1999 and delivered to Columbia Analytical Services Laboratory in Redding on Tuesday, November 9, 1999. Results were analyzed on Thursday, November 19 and are reported in Table No. 1 at the conclusion of this report.

## Plant Operation Overview

Our AMD treatment technology, called the Ionic State Modification Process (ISM), provides the means to alter ionic structures of contaminant material in acidic waste stream in a manner that allows all the metal contaminants to be precipitated out of the AMD. This process extracts all of the heavy metals while producing a relatively small volume of metal hydroxide sludge. Since our inception, we have focused our research and development of technologies on the provision of answers for those environmental industries responsible for the remediation of AMD and other water pollution conditions that exist today,

The pilot test at the Mammoth Mine treated approximately 100,000 gallons of AMD and produced approximately 150 gallons of de-watered metal oxide sludge that was removed from the initial test site. Initial lab analysis revealed sulfate levels of 1600 mg] in the untreated AMD. With this new process, the sulfates were removed with the metal cake. The sulfate level of the treated AMD showed sulfates below 500 ppm. When there are higher concentrations of sulfates, they are removed as anhydrous calcium sulfate cake. This metal-free cake will have some value as a building material or soil amendment.

Our process allows the configuration of the treatment plant to be established on a relatively small and restricted site. Since the plant can be built to operate at varying flow rates, and does not use a lime treatment process that requires large storage areas for sludge handling, most mines and portal areas can accommodate a plant operation. Depending on the concentrations of metal contaminants, power requirements can vary considerably. At the Friday Loudon Portal, commercial power was not available, so a portable 25 kW generator was utilized. Commercial power costs, if it was available, were computed to be less than \$1.72 per hour for treatment rates of 20 to 35gpm.





Initial plans for treatment of the Balakalala Drain Portal AMD and AMD from other mine portals at the Mammoth complex were not carried out. It was concluded that the efficacy of the bench test would be duplicated by a pilot run like the one at the Friday Loudon Portal. Additionally, the time and expense necessary to set up such a duplicative pilot plant would be excessive considering its low flow rate.

All laboratory testing was performed by independent third parties, including Basic Laboratory and Columbia Analytical Laboratory in Redding, and BSK Laboratory in Fresno, California. Chain of Custody documents from the sampler to the lab are available upon request. It should be further noted that the Maximum Contaminant Level (MCL) for drinking water standards governing Copper, Cadmium, Lead, Zinc, Aluminum heavy metals are also listed in the Appendix, Table 3. This table shows that the treated effluent exceeded drinking water standards for metals.

**BENCH SCALE TREATMENT  
(BSKANL LAB)**

**SAMPLES FROM FRIDAY LOUDON PORTAL, TREATED WITH LAB TEST  
UNITS ON OCTOBER 19, 1999**

TEST	UNITS	UNTREATED	TREATED
Aluminum	ug/l	58000	620
Cadmium	ug/l	110	ND> I
Copper	ug/l	5100	95
Lead	ug/l	41	NC>5
Manganese	ug/l	4400	20
Zinc	ug/l	26000	240
Sulfate	mg/l	1600	460