

CASE STUDY

Argo Tunnel Site Clear Creek, Colorado

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**Prepared by
The Interstate Technology & Regulatory Council
Mining Waste Team**

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ARGO TUNNEL SITE, CLEAR CREEK, COLORADO

1. SITE INFORMATION

1.1 Contacts

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1.2 Name, Location, and Description

The Argo Tunnel is located in Idaho Springs, Clear Creek County, Colorado, approximately 30 miles west of Denver (Figure 1-1). The tunnel was constructed to provide drainage and transportation for several connected gold mines. The tunnel continues to drain acidic mine water at an average rate of 280 gallons per minute. The location is at a latitude of 39°44'37" N and longitude of 105°30'28" W. The media affected is surface water and, to a much lesser extent, groundwater.

2. REMEDIAL ACTION AND TECHNOLOGIES

The Argo Tunnel is part of the Central City/Clear Creek Superfund Site. Under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act, a conventional lime water treatment plant was constructed in 1998 and has been operating continuously.

Primary contaminants include acidity and a host of heavy metals, including aluminum, copper, iron, manganese, and zinc. Site cleanup goals are based on the mitigation of human health risk and mitigation of ecological risk.

A pilot treatment system was operated and studied periodically from 2004 through 2007 by the U.S. Geological Survey (USGS) Leetown Science Center. The pilot used a pulsed limestone bed treatment system. Up to 60 gallons per minute was treated using limestone and carbon dioxide. A polymer is added in a low dose (2–3 ppm) to effect flocculation. The solution overflows into a high-rate lamella clarifier, where the solids drop to the bottom of the tank and the clarified water flows off the top. After a final pH adjustment back to neutral, the treated water is discharged to Clear Creek.

The underflow solids from the clarifier are contained in a liquid sludge and pumped to a plate and frame filter press for dewatering.



Figure 1-1. Areal view of the Argo Tunnel area. (Map created with ESRI ArcView software using Microsoft Bing maps.)

3. PERFORMANCE

The Argo water treatment facility (WTF) was originally designed to use sodium hydroxide as the alkali source. The treatment process was able to remove over 99.9% of the metal contaminants by treating at a pH of 9.9. The treatment pH was determined by the necessity to remove manganese while still removing other metals to low concentrations.

Performance criteria included measuring the contaminant concentrations in water, the amount of chemical consumption, and sludge production. During the various tests, the pilot system raised the pH from 3.1 to 5.1–7.3. Alkalinity was increased from undetectable to 210 mg/L CaCO₃. Metal removal efficiencies varied depending on the effluent pH but ranged from less than 10% for manganese, to 5%–65% for zinc, to 50%–99% for copper, and greater than 98% for aluminum and iron.

In 2004, the treatment process was modified to use hydrated lime as the alkali source, largely due to cost considerations, with lime being more economical than sodium hydroxide. The modification also had the added benefit of increasing hardness in the receiving stream. Using hydrated lime, the treatment system continues to be able to remove over 99.9% of the metal contaminants. However, the treatment pH had to be increased to 10.1 due to the lower rate of reaction for the lime.

The treatment process obtains standard discharge limits for all metals. The 30-day average discharge limits are as follows:

Cadmium	3 ppb
Copper	17 ppb
Iron	15,800 ppb
Lead	4.8 ppb
Manganese	800 ppb
Nickel	850 ppb
Silver	0.02 ppb
Zinc	225 ppb

The treated discharge also passes Whole Effluent Toxicity testing for ceriodaphnia and fathead minnows and is nontoxic.

The solid filtercake contains approximately 15%–20% solids and passes testing of the Toxicity Characterization Leaching Procedure (TCLP). It is therefore characterized as a nonhazardous waste and is disposed of in a municipal landfill.

4. COSTS

The Argo WTF had a cost of construction of approximately \$5 million. Ongoing operation and maintenance costs are approximately \$900,000 per year. O&M costs are largely dependent on

treatment flow rates. Roughly 40% of the O&M costs is for labor, which includes five full-time employees. The plant is staffed 10 hours per day, 7 days per week.

5. REGULATORY CHALLENGES

None encountered.

6. STAKEHOLDER CHALLENGES

None reported.

7. OTHER CHALLENGES AND LESSONS LEARNED

The State of Colorado and the Environmental Protection Agency (EPA) currently operate an acid neutralization plant to treat the Argo Tunnel discharge. Recently, the U.S. Geological Survey Leetown Science Center, in partnership with the EPA, State of Colorado, and the Colorado School of Mines transported a portable pulsed limestone bed (PLB) AMD treatment system to the site for evaluation and demonstration as a possible lower-cost alternative to the current process (Sibrell et al. 2005).

Preliminary tests were conducted in late summer 2004 and indicated that reagent costs could be cut considerably by pretreatment of the water with the system. A full suite of tests was conducted during summer 2005 to investigate the effects of water treatment rate and carbon dioxide addition on acid neutralization, metal removal, and sludge generation. The treatment system increased the pH of the water from 3.2 in the influent to 5.1–7.3 in the process effluent. Alkalinity was increased from 0 to as high as 210 mg/L as CaCO₃, depending on operating conditions. Metal removal depended on the pH of the product water and varied from greater than 98% for iron and aluminum, 50%–99% for copper, 5%–65 % for zinc, and less than 10% for manganese. Although the process produced water with net alkalinity, the process effluent required post-treatment with lime to raise the pH high enough to remove zinc and manganese to dischargeable levels (Sibrell et al. 2005).

Pilot-scale post-treatment tests with lime showed that the PLB/lime sludge settled faster and resulted in sludge volumes that were 60% of the lime treatment alone. These results confirm that treatment costs at the Argo plant could be significantly reduced by pretreatment with the PLB system.

8. REFERENCES

Sibrell, P. L., T. R. Wildeman, M. Frienmuth, M. Chambers, and D. Bless. 2005. “Demonstration of a Pulsed Limestone Bed Process for the Treatment of Acid Mine Drainage at the Argo Tunnel Site.” Abstract. www.asmr.us/Portals/0/Documents/Conference-Proceedings/2005/1068-Sibrell.pdf