RECLAMATION OF THE BLOCK P MILL SITE[1]

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Abstract. The Block P Mill Site is located approximately 18 km east of Monarch, Montana in the Barker-Hughesville Mining District of the Little Belt Mountains. Mining and milling of lead, zinc, and silver ores between approximately 1880 and 1930 led to the presence of unvegetated acidic mill tailings and degraded surface and ground water quality. Between 1998 and 2001, The Doe Run Company prepared an engineering evaluation / cost analysis (EE/CA) as a means of characterizing the magnitude and extent of soil and groundwater contamination and identifying potential options for reducing the risk posed to human health and the environment by conditions at the site. In 2002, the USDA-FS and the USEPA approved the EE/CA and selected a removal action alternative calling for onsite consolidation of the mill wastes and construction of a geosynthetic clay cap to minimize infiltration through the repository. In addition to the waste consolidation, the reclamation work will also reestablish stable stream channels and native vegetation to previously disturbed areas along Galena Creek and Dry Fork Belt Creek. Construction is expected to begin in 2004 and be completed in 2005.

Additional Key Words: EE/CA, lead, zinc, repository

Introduction

The Block P Mill site (the Site) is located in the Barker-Hughesville Mining District of Cascade County, Montana, approximately 65 km miles southeast of Great Falls. The Site falls within the Lewis and Clark National Forest, approximately 18 km east of the town of Monarch in the Little Belt Mountains (Fig. 1).

Mining activities in the area date back to 1879, when the discovery of rich lead-silver ores was made near the headwaters of Galena Creek. Activity in the Galena Creek valley rose and fell in the following years as the easily mined ores were depleted and miners were forced to

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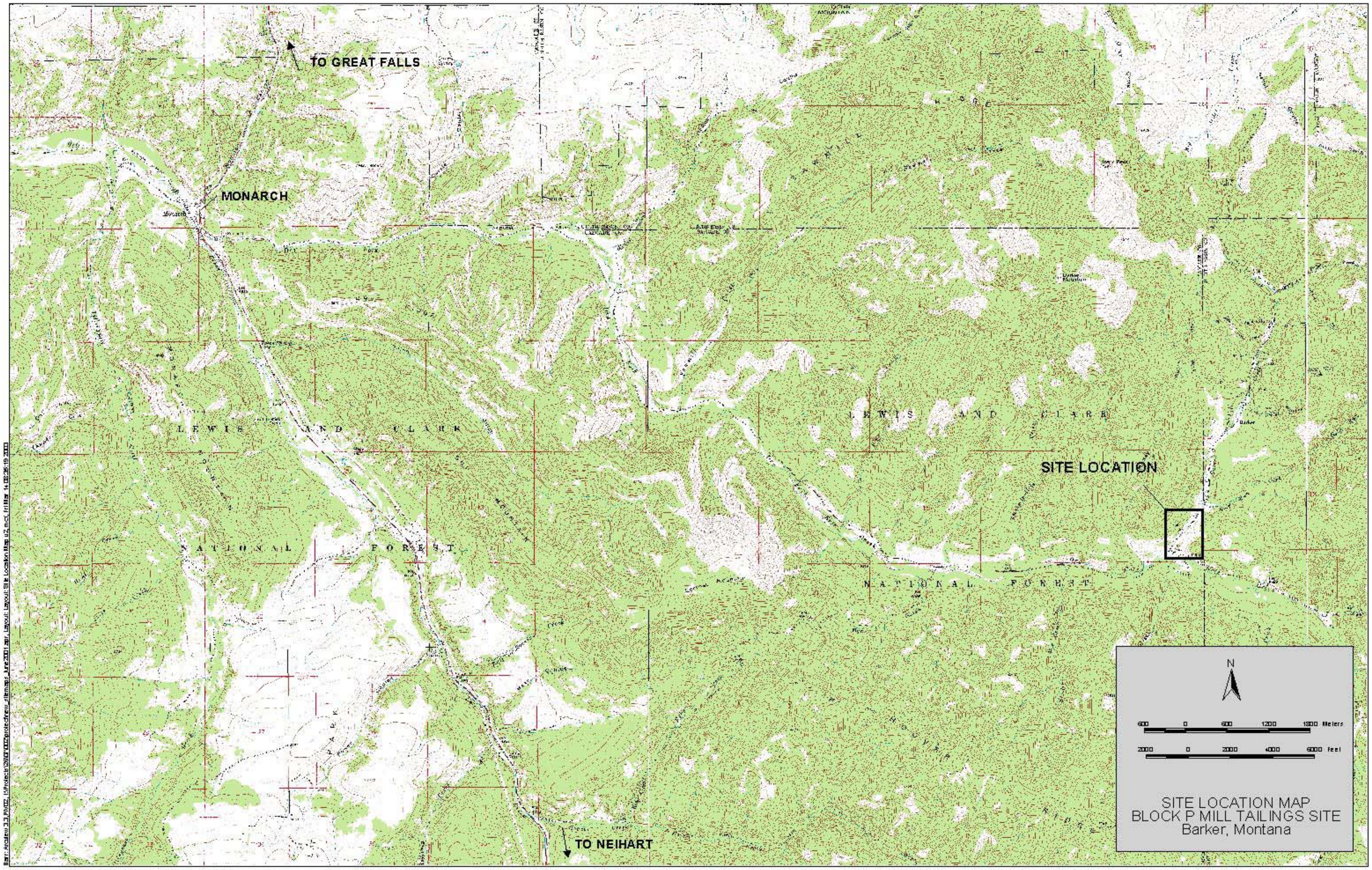
follow the mineral-bearing strata into the surrounding mountains. Montana businessman T.C. Powers consolidated several mining properties under the name Block P in 1900. In 1927, the Block P properties were purchased by the St. Joseph Lead Company (a predecessor to The Doe Run Company). St. Joseph undertook several improvements to the properties, including advancement of the main shaft of the mine to nearly 425 m below ground surface and construction of a 3,125 m long aerial tramway to carry ore from the mine to a new mill that was built near the confluence of Galena Creek and Dry Fork Belt Creek. By early 1929, the Block P mill was the largest individual producer of lead concentrate in Montana (MSE, 1991). The onset of the Great Depression forced the mine and mill to close by mid-1930. The mine and mill were operated briefly from 1941 to 1943 in support of the war effort, but once again were closed at the request of the War Production Board. The mill was dismantled shortly thereafter and production from mines in the Galena Creek valley has been virtually nonexistent since that time.

This paper presents a summary of the environmental data collected as part of the EE/CA and describes the removal action alternatives considered for implementation. The work described in this paper was initiated prior to the NPL designation for the mining district.

Site Setting

The Block P Mill site is approximately 5.3 hectares in size and consists of the mill foundation and two (upper and lower) tailings basins (Fig. 2, 3). For the purposes of the EE/CA, an additional area of tailings-like material previously identified in the riparian zone of Dry Fork Belt Creek approximately 2.4 km downstream of its confluence with Galena Creek also are included in the site definition (Fig. 4). The area immediately surrounding the former mill foundation is owned by a third party while the tailings basins and riparian tailings are located primarily on USDA-FS property. It is estimated that approximately 115,000 cubic meters of mill tailings are located at the Site with an additional 8,000 cubic meters of riparian tailings along Dry Fork Belt Creek.



Basemap: Monarch Quadrangle, Barker Quadrangle, Mixes Baldy Quadrangle (Montana), 1967.

Figure 1. Site location map

Figure 2. Block P Mill Site (from the west).

Figure 3. Lower tailings basin (looking north).

The elevation of the Site ranges from 1650 to 1690 m above mean sea level. Annual precipitation in the area ranges from 63 to 76 cm. Spruce-fir forests grow in most of the Galena Creek valley. There are no year-round residents in the valley, but there are numerous recreational cabins. Logging and grazing activities are common in the Galena Creek and Dry Fork Belt Creek watersheds.

As discussed in Weed (1900), Witkind (1971), and Baker (1991), the following geologic units are present beneath the Site: Wolsey Shale, Meagher Limestone, Park Shale, and Pilgrim Limestone (Cambrian). Under the tailings basins, the Tertiary-age Wolf Porphyry and chocolate-brown porphyry are intruded into the Wolsey Shale.

The upper tailings basin is underlain by up to 8 m of a combination of colluvium, terrace deposits, and weathered porphyry over bedrock. The lower tailings basin is located in the floodplain of Galena Creek and underlain by 1 to 2 m of sand and gravel alluvium over bedrock. Discussions with area residents suggest that the stream channel was realigned to facilitate construction of the mill and tailings basin (McBride, personal communication).

Previous Site Work

The Montana Department of Natural Resources and Conservation (MDNRC) conducted several streamflow and water quality studies in Galena Creek between 1973 and 1977 (MDNRC, 1977). These studies identified the Block P mine dump and the Block mill site as major sources of pollution to Galena Creek and Dry Fork Belt Creek.

In 1979, the Montana Department of State Lands (MDSL) conducted additional water quality studies in the two streams that ultimately led MDSL to recommend a cleanup plan for the mill site in 1988 (MDSL, 1988). This cleanup plan was not funded by the Montana legislature. In 1991, MDSL funded both an Environmental Assessment (MSE, 1991) and a Preliminary Project Assessment Report (Chen-Northern, 1991) for the Block P Project Site. Both reports again identified the Site as a significant contributor to the degradation of water quality in Galena Creek and Dry Fork Belt Creek.

In 1995, USDA-FS undertook a time-critical removal action at the Site in an effort to reduce amount of erosion from the tailings basins into Galena Creek and reduce the volume of water that infiltrated through the tailings. The work consisted of constructing a ditch along the

Figure 4. Riparian tailings along Dry Fork Belt Creek.

entire uphill length of the Site and installation of a culvert to route clean run-off from the hillside above the Site directly to Galena Creek, as well as installation of emergency overflow culverts to prevent a catastrophic failure of the lower tailings basin.

Finally, at the request of the Montana Department of Environmental Quality (MDEQ), The Doe Run Company (Doe Run) conducted an assessment of water quality in 1997 at selected surface water stations and groundwater discharge locations in the Galena Creek and Dry Fork Belt Creek watersheds, publishing a Revised Water Quality Assessment Report in July 1998 (Barr, 1998).

Doe Run, USEPA, and USDA-FS signed an Administrative Order on Consent in 1998 requiring Doe Run to prepare a non-time critical EE/CA as the means of determining the appropriate removal action for the Block P Mill site.

Results of EE/CA Investigation

The purpose of the EE/CA investigation was to characterize the magnitude and extent of soil and groundwater contamination associated with the Site and to sufficiently characterize the tailings to allow evaluation of removal action alternatives.

In support of this objective, 13 permanent monitoring wells were installed at the Site and sampled between 1998 and 2001. More than 50 samples of soils and tailings were collected from additional selected areas and two lysimeters were installed and sampled to assess the leachate quality attributable to both the upper and lower tailings. Ten surface water sampling stations were established on Galena Creek and Dry Fork Belt Creek to aid in the evaluation of potential removal action alternatives. To aid in planning for permanent site revegetation, tailings samples also were collected in support of a greenhouse study that evaluated the effects of various amendment rates on plant growth and vigor.

Figure 5 shows a site plan with selected sampling locations. The following paragraphs summarize the data collected for the EE/CA.

Tailings

The physical and chemical characterization of the tailings varies by location and depth (Table 1). In general, the tailings are extremely fine grained, with nearly 50 percent of the material passing a 400-mesh sieve. The upper tailings basin (as shown by data from MW98-2 and MW98-3) shows evidence that the tailings have established layers of oxidized and reduced conditions, while the elevation of the lower tailings basin (data from MW98-4 and MW98-5) causes the water table to frequently rise up into the waste. Tailings that have been eroded and redeposited elsewhere (Galena 1 and SS1 through SS5) appear to have less acid generating potential due to their greater weathering and sorting.

Table 1. Selected tailings characterization data collected as part of the EE/CA from sampling locations shown on Fig. 4 (Barr, 2001).

	MW 98-2	MW 98-3	MW 98-4	MW 98-5	Galena 1	SS1	SS2	SS3	SS4	SS5
pH	1.38	1.66	1.79	1.58	--	--	--	--	--	--
SMP Buffer	33.9	28.8	28.5	22.2	13.6	5.7	5.0	7.3	15.2	13.6
As	682	773	232	265	1,110	658	450	948	3400	1,520
Cd	3.9	3.3	4.4	0.28	2.0	7.6	15.0	17.6	2.3	4.7
Cu	103	296	81.9	48.1	243	250	293	398	338	344
Pb	361	14,100	1,500	1,880	16,000	7,050	6,710	16,100	14,900	8,710
Zn	766	803	711	89	534	1,610	3,130	2,980	737	970

Notes: pH in standard units, SMP Buffer in T CaCO3/Kt, all others in mg/kg
Surficial tailings samples collected at locations of monitoring wells and from riparian deposits

Groundwater

As expected, the direction of groundwater flow at the Site is generally downslope toward the bottom of the Galena Creek valley and then down-valley toward the mouth of Galena Creek. Groundwater quality as measured in monitoring wells installed through the upper tailings basin (MW98-2, MW98-3, MW12, and MW13) appears free of tailings related impacts, while the groundwater quality observed in monitoring wells installed through or adjacent to the lower tailings basin show varying degrees of contamination (MW98-4, MW98-5, MW98-6, MW98-7, MW98-8, and MW98-9). The data suggest that contaminants originating in the lower tailings basin have leached to groundwater and are migrating toward Galena Creek and Dry Fork Belt Creek (Table 2).

Figure 5. Block P Mill site layout.

Table 2. Selected groundwater quality data collected as part of the EE/CA from sampling locations shown on Fig. 4 (Barr, 2001).

	MW 98-1	MW 98-2	MW 98-3	MW 98-4	MW 98-5	MW 98-6	MW 98-7	MW 98-8	MW 98-9	MW 10	MW 11	MW 12	MW 13
pH	7.54	8.99	7.87	2.95	3.06	7.50	7.14	5.98	2.80	3.58	6.41	8.06	7.14
Sulfate	35	63	35	3,320	4,850	60	298	1,040	4,060	2,710	816	159	64
Al	<20	<20	<20	18,600	44,500	<20	<20	<20	113,000	55,500	200	<20	<20
As	<2	<2	<2	1,120	2,380	<2	<2	<2	<20	22	<2	<10	<10
Cd	<0.5	<0.5	<0.5	116	419	<0.5	3.5	11.8	501	71	54	<2	<2
Cu	<1	<1	<1	1,600	6,990	1	1	17	8,360	1,990	<1	<3	<3
Fe	<20	<20	<20	395,000	964,000	<20	<20	68,300	343,000	138,000	12,600	<20	<20
Pb	<1	<1	<1	15	<50	<1	<1	<1	376	16	<1	<5	<5
Zn	<5	<5	7	29,400	82,700	44	1,200	10,300	71,100	32,400	12,500	<5	<5

Note: pH in standard units, sulfate in mg/L, all others in µg/L.

Soil

In an effort to determine native soil quality immediately under tailings and how soil quality varied with depth at the Site, multiple soil samples were collected during monitoring well installation and via hand augers. Soil quality directly under tailings is generally poor, with acidic pH values and elevated metals concentrations (Table 3). Under the upper tailings basin, soil quality generally improves with depth, showing evidence that contaminant migration toward the water table is retarded by changes in soil chemistry. Under the lower tailings basin and in locations where eroded tailings have been redeposited, soil quality remains poor down to the water table.

Table 3. Selected soil quality data collected as part of the EE/CA from sampling locations shown on Fig. 4 (Barr, 2001).

	MW 98-2	MW 98-3	MW 98-4	MW 98-5	SS1	SS2	SS3	SS4	SS5
	9-11' bgs	19-21' bgs	6-8' bgs	14-16' bgs					
pH	7.41	4.37	3.05	5.63	5.64	2.97	2.52	3.31	3.16
As	2.97	13.3	914	1040	140	4,270	3,810	217	2,290
Cd	0.056	0.205	0.08	0.44	168	2.57	3.02	2.33	2.50
Cu	4.94	16.7	44.1	70.5	919	207	174	180	188
Pb	126	63.5	618	112	1,080	1,880	11,900	1,520	1,950
Zn	78.7	309	110	244	4,060	372	719	401	552

Note: pH in standard units, all others in mg/kg.

Development of Removal Action Alternatives

Prior to collection of additional environmental data at the Site, the USDA-FS and USEPA established four objectives for the removal action to be conducted. They were:

- Remediate the Block P tailings area to attain a degree of cleanup of hazardous substances that assures protection of public health, safety, and welfare and the environment
- Reduce water movement through the tailings to the extent that groundwater and surface water quality are not impacted by the addition of dissolved and total metals, reduce stream sedimentation attributed to erosion from the tailings, and to support beneficial uses within the drainage
- Reduce the risk of movement of tailings offsite, to remove tailings from the floodplain, and to achieve revegetation of the Site
- Implement a reclamation that requires as little maintenance as possible and is sustainable over the long-term.

Based on those objectives, eight removal action alternatives were evaluated based on effectiveness, implementability, and cost. The options were:

- No Action
- Consolidation with Soil Cover

- Consolidation with Geosynthetic Clay Cover
- Consolidation with Geomembrane Cover
- Consolidation and placement in an Onsite Isolation Vault
- Excavation for Offsite Disposal
- Onsite Stabilization
- Tailings Reprocessing.

The no action alternative and the tailings reprocessing alternative were both found to fail based on a low probability of effectiveness. Based on conceptual design plans and assumptions regarding construction methods, the cost to implement each of the remaining alternatives was estimated (Table 4).

Table 4. Removal action alternative cost estimates prepared as part of the EE/CA (Barr, 2001).

Alternative Number	Alternative Description	Total Estimated Cost
1	No Action	NA
2	Consolidation w/ Soil Cover	$1,706,000
3	Consolidation w/ GCL Cover	$2,438,000
4	Consolidation w/ Geomembrane Cover	$2,627,000
5	Consolidation into Onsite Isolation Vault	$4,469,000
6	Excavation for Offsite Disposal	$39,915,000
7	Onsite Stabilization	$5,465,000
8	Tailings Reprocessing	NA

NA = not applicable.

Based upon the estimated implementation costs, Excavation for Offsite Disposal and Onsite Stabilization also were deemed unsatisfactory. One of the remaining key factors differentiating each of the various "consolidate and cover" alternatives was the estimated amount of precipitation that might be expected to percolate through the Site in the future under the various cover scenarios. Based on conceptual cover designs and site specific soil and tailings permeability data, percolation rates were estimated using the HELP model (Schroeder, et al, 1994)(Table 5).

Table 5. Estimated percolation rates using the HELP model (Barr, 2001).

Alternative Description	Estimated Percolation Rate (cm/year)	Metals Loading Reduction Relative to No Action (Percent)
No Action	9.4	--
Consolidation w/ Soil Cover	1.57	83.2
Consolidation w/ GCL Cover	0.61	93.5
Consolidation w/ Geomembrane Cover	0.043	99.5
Consolidation into Onsite Isolation Vault	0.0014	99.98

-- = not analyzed.

The output of the HELP model provided support for USDA-FS and USEPA to then weigh the added cost and increased complexity of synthetic covers against the potential reduction in future risk to the environment.

Conclusion

The USDA-FS and USEPA reviewed the EE/CA as published by Doe Run in June 2001 (Barr, 2001) and issued their approval of the document in September 2001. In May 2002, the USDA-FS and USEPA issued an Action Memorandum selecting consolidation with a geosynthetic clay cover as the recommended removal action alternative (USDA-FS, 2002). With the issuance of the Action Memorandum, the EE/CA is complete. Negotiations between Doe Run, USDA-FS, and USEPA are currently underway to determine the schedule for implementation of the recommended removal action. At this time, it is expected that final design will take place in 2003, with construction anticipated to begin in 2004 and finish in 2004.

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