Report for 2002MT4B: Recharge Assessment of the Anaconda Mine near Belt, Montana

- Conference Proceedings:
  - Reddish, Shawn. 2003. A continued study of the hydrogeologic characterization of AMD production along Belt Creek near Belt, Montana. Poster Presentation, American Water Resource Association annual Montana Conference October 2, 2003, Livingston, Montana.
  - Reddish, Shawn. 2004. Age dating of the aquifers in the Belt area. Poster Presentation, American Water Resource Association annual Montana Conference October 20, 2004.
- Other Publications:
  - Duaime, Ted, Sandau, Ken, Vuke, Susan, Hanson, Jay, Reddish, Shawn, and Reiten, Jon. 2004. Reevaluation of the Hydrogeological system in the vicinity of the Anaconda Coal Mine at Belt, Cascade County, Montana. MBMG Open File Report 504.

Report Follows

ABSTRACT

Decades of underground coal mining have resulted in acid mine drainage (AMD) that has contaminated ground-water and surface-water resources in Belt, Montana. The AMD has lowered the pH of Belt Creek and increased trace metals concentrations in the stream. The overall goal of work in the Belt area was to define the hydrogeologic regime in the vicinity of Belt so that recharge to old mine workings, the source of acid mine drainage, can be delineated with a reasonable level of certainty. This Water Center project provided seed funding for additional work funded by the Montana Department of Environmental Quality MDEQ 319 Program and the MDEQ Remediation Division-Abandoned Mine Lands.

This project consisted of a phased approach to define and mitigate water quality problems in Belt Creek near the town of Belt, which is 23 miles southeast of Great Falls. Phase 1 is a hydrogeologic investigation to determine contaminant sources and their relative contributions, and to identify and evaluate mitigation measures. Phase 2 will be based on a later proposal to apply specific measures to reduce recharge to the Anaconda Coal Mine and monitor their success.

Work conducted by Shawn Reddish, under the supervision of Jon Reiten has documented hydrogeologic conditions surrounding the abandoned Anaconda Coal Mine (ACM) near Belt. Specific tasks included inventorying, sampling for water quality and collecting samples for age dating water from wells, springs, adits and seeps. These tasks were conducted to determine if the recharge to the mine workings is local or regional. The inventory process included collecting GPS coordinates of pertinent locations, measuring specific conductivity, pH, oxidation-reduction potential, dissolved oxygen; and determining the geologic source of water in the well. These field data were then evaluated to screen for the most useful sampling sites; all information was entered into a database accessible by the public.

Water levels at 31 wells and discharges at 3 springs were measured monthly for about 2 years to monitor the fluctuations of local aquifers. Several of these wells and springs have been sampled for tritium, helium-3/tritium and chlorofluorocarbons (CFC) to determine the age of the water. All sampled wells have tritium concentrations greater than background pre-nuclear testing levels. This suggests a modern (post nuclear testing) age for ground water in the alluvial, Kootenai, Morrison, Swift, and Madison aquifers. CFC samples also indicated that all of the recharge is relatively recent. Several samples from the Madison aquifer were supersaturated with CFC's, but the cause of this

supersaturation is unknown. The results of helium-3/tritium dating of two water samples also confirms the relatively young age of water in aquifers near Belt.

Stream flows at 9 sites were also measured monthly in the study area. Differences in flows between measuring sites were used to evaluate gaining or losing reaches of the streams. Field parameters, including specific conductivity, pH, oxidation-reduction, and dissolved oxygen were measured at each site. The AMD discharge was monitored at 5 sites on a monthly basis for about 2-years, the measurements included flow and field parameters. In addition to monthly measurements, an H-flume set up with a pressure transducer recorded the AMD discharge from the mine adit. Based on this work and other ongoing MBMG research, the direct loading to Belt Creek from AMD was estimated to be 94,500 pounds per year of iron and 59,279 pounds per year of aluminum. Indirect loading to the Creek from other AMD sources that moves through alluvial sediments before reaching Belt Creek was estimated to be 48,880 pounds per year of iron and 25,254 pounds per year of aluminum. The main direct source of AMD is the discharge from the ACM that averages about 132 gpm or about 213 acre feet per year. The primary purpose of this work has been to identify the source of water recharging the mine workings and recommend methods to reduce the recharge which would decrease or possibly eliminate the AMD loading to Belt Creek.

Several possible sources of recharge were suggested when this project started and others developed as new information became available. The possible sources include 1) recharge from regional aquifers such as the Madison aquifer 2) upward seepage from deep aquifers along fault planes 3) localized recharge from precipitation directly overlying the mines, or up-gradient recharge areas 4) water loss from Box Elder Creek, and 5) focused recharge through shallow depressions overlying the mines. Water-level data from wells completed below the mine workings and in areas surrounding the mine, in the Madison aquifer, indicate the static water level in the Madison aquifer is about 400 feet below the mine voids. Therefore, the Madison aquifer is not hydrologically connected to the workings nor is it a likely source of recharge to the mines. Other regional aquifers do not appear to be likely sources although these have not been completely ruled out. Upward seepage along fault planes does not appear to be a likely source of recharge based on the downward hydraulic gradients. Box Elder Creek is at a higher elevation than the mine workings and therefore has a potential for losses to the mine. Flow data along Box Elder are currently inconclusive to document stream losses. The most likely source of recharge

to the mines is infiltration of precipitation on the land surface overlying the mine workings, including up-gradient areas that recharge the localized Kootenai aquifer system.

Based on initial interpretations, a significant source of water to the Anaconda Coal Mine appears to be from the overlying Kootenai Formation which is about 260-feet thick in the Belt area. Figure 1 is a surficial geologic map of the area above and adjacent to the Anaconda mine.

A potentiometric-surface map of the Kootenai Formation was constructed based on well inventory and monitoring measurements. This map was contoured using measurements from 44 wells and springs near the mine. The Kootenai potentiometric surface map combines head data from aquifers in both the Sunburst and Cutbank Members of the Kootenai Formation. As a result, this map shows only general water-level conditions in the mapped area. Additional wells at critical locations will be needed to accurately depict ground-water flow. Figure 2 is a 3-dimensional view of the predominant recharge area to the mine. Ground water is interpreted to flow from a divide located about 3.5 miles south of the ACM. The ground-water divide south of the mine appears to be both topographically and structurally controlled. The topographically high area forming the ground-water divide is located just north of a paired anticline-syncline structure that trends north 45 degrees east. Only precipitation falling north of this divide has the potential to move towards the mine. Once recharge infiltrates vertically to the saturated zone, ground-water flow is generally to the north perpendicular to the potentiometric contours depicted in Figure 2. The upland area between Belt Creek and Box Elder Creek is highly dissected by tributaries of the two streams. These tributaries plus the main stems of the two streams are discharge areas for ground water moving out of the Kootenai Formation. The potential recharge area covers about 2,100 acres overlying and up gradient of the mine. The highly dissected nature of the upland appears to cause much of the precipitation falling on the upland to recharge a shallow ground-water flow system and discharge to the surface water drainages as seeps and springs in the valley walls. Several of the springs coincide with the contact of the Sunburst Sandstone Member (aquifer) and the underlying unnamed fine-grained unit (aquitard).

A final report is currently being prepared. Based on the data collected it appears that recharge to the ACM is likely locally derived. As a result, the volume of AMD discharging from the mine may be able to be reduced or possibly eliminated by changing land use in the recharge area. Growing alfalfa or other water consumptive crops would have the potential to reduce infiltration and possibly decrease the AMD.

Publications/Citations-

Duaime, Ted, Sandau, Ken, Vuke, Susan, Hanson, Jay, Reddish, Shawn, and Reiten, Jon, 2004, Reevaluation of the Hydrogeological system in the vicinity of the Anaconda Coal Mine at Belt, Cascade County, Montana, MBMG Open File Report 504.

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Student Support – Shawn Stevens, MSU-B Environmental Studies student.

Additional Funding Sources- The Montana Department of Environmental Quality provided most of the funding for work in the Belt area through the MDEQ 319 Program and several Task orders through the MDEQ Remediations Division-Abandoned Mine Lands Bureau.

Figure 1: Geologic Map of the Anaconda Mine Area, Belt Montana

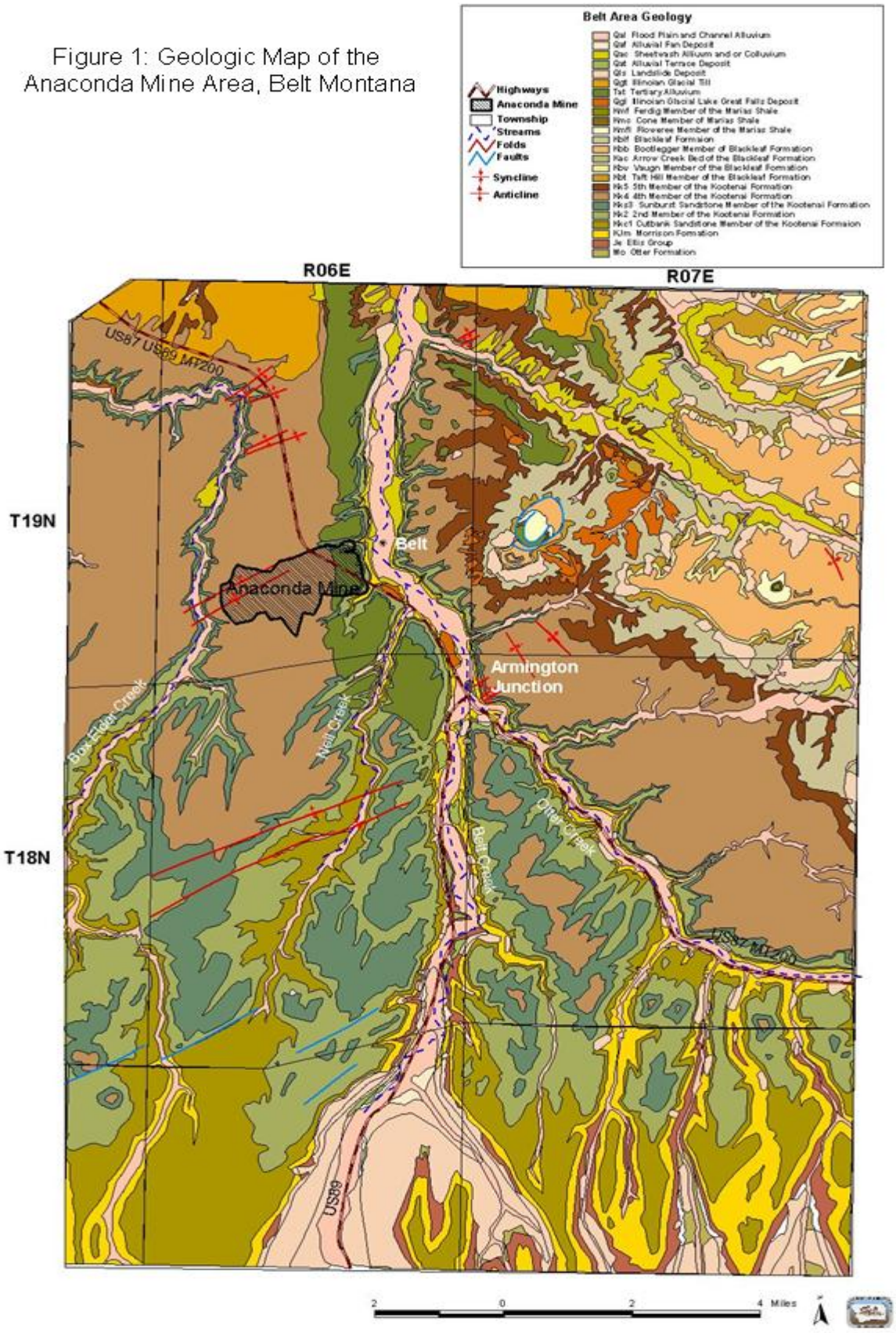
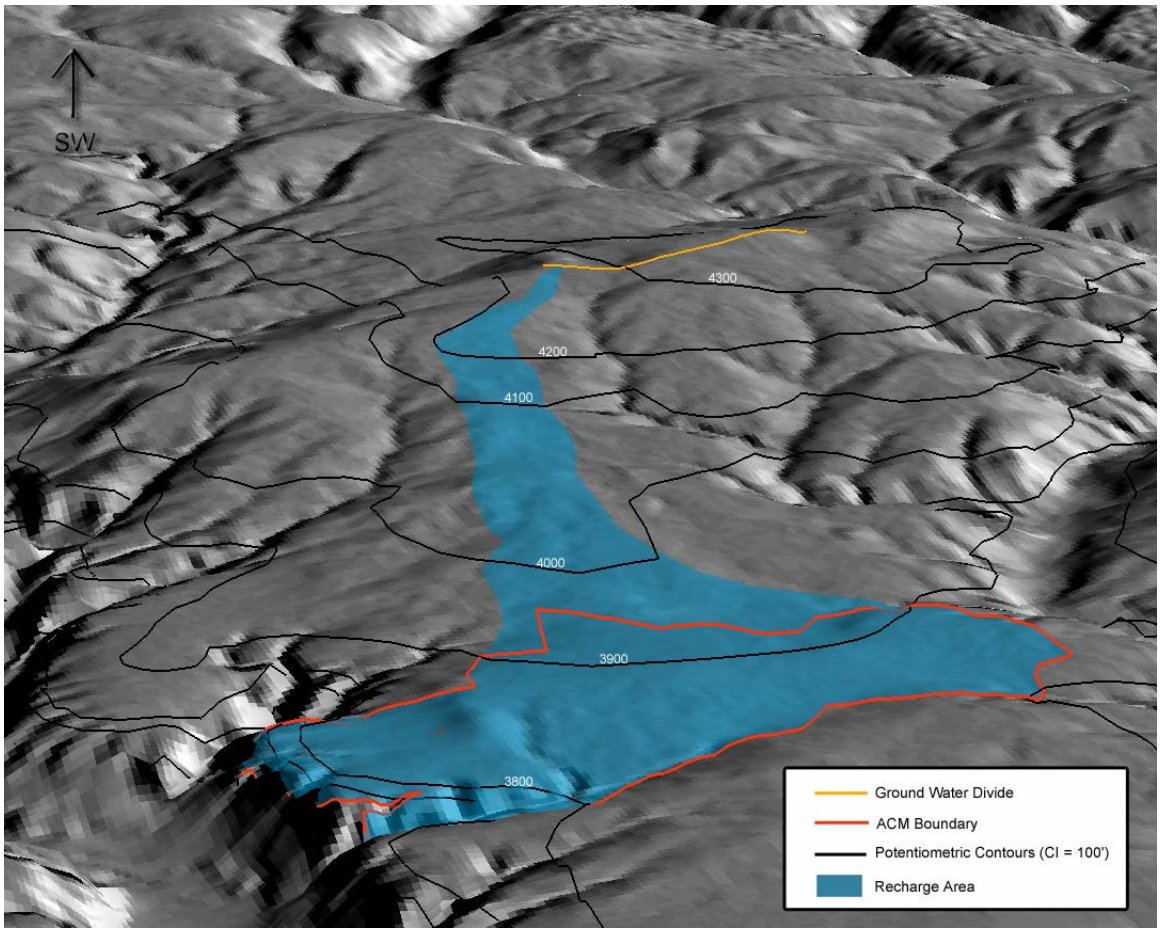
Figure 2. Recharge area for ACM near Belt shown on a 3-D image of the land surface. View is upslope towards the Southwest, with the ACM in the foreground.