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PERCHLORATE IN GROUNDWATER & SURFACE WATER

OCCURRENCE, REGULATION & REMEDIATION

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Introduction

The frequency of detection of perchlorate in groundwater and surface water has been steadily increasing since its initial identification as a chemical of regulatory concern in 1997. To date, United States (US) federal and state regulatory agencies have reported detecting perchlorate in soil, groundwater, surface water, and/or drinking water at almost 400 sites in 35 states, the District of Columbia, and two US commonwealths.[1] The source of perchlorate in water supplies has typically been attributed to US Department of Defense (DOD), National Aeronautics & Space Administration (NASA) and/or defense contractor facilities that have used **a**mmonium **p**erchlorate (AP) in rocket and missile propellants. However, in recent years, the reporting of sites impacted by perchlorate from non-military activities, including agriculture, mining and construction, fireworks displays, and production and use of **e**lectro**c**hemically-**p**roduced (ECP) chlorine chemicals, has dramatically increased, changing the paradigm that perchlorate is solely a DOD cleanup responsibility. While federal and state parties continue to disagree on a suitable federal cleanup standard for perchlorate in the nation's water supplies, there is comfort in the fact that effective treatment technologies have been developed that can remove or destroy perchlorate to meet the levels that will in all likelihood be required when a federal cleanup standard is finally set.

Perchlorate Uses & Properties

Perchlorate is an inorganic anion that consists of chlorine bonded to four oxygen atoms (ClO4). It is a primary ingredient in solid rocket propellant and has been used for decades by DOD, NASA, and the defense industry in the manufacturing, testing, and firing of rockets and missiles. On the basis of 1998 manufacturer data, it is estimated that 90 percent of the several million pounds of perchlorate produced in the US each year is used by the military and NASA. Private industry has used perchlorate to manufacture products such as fireworks, safety flares, automobile airbags, and commercial explosives. In addition, perchlorate salts and perchloric acid have been used in smaller quantities in a large number of applications, as summarized in Table 1 (next page).

Perchlorate exhibits high solubility and mobility in water and is very stable, being degraded only under anaerobic conditions. Consequently, when perchlorate is released into a typical groundwater or surface water environment, it tends to persist and can migrate great distances (many miles) in groundwater, as has been observed at many sites. Perchlorate released to the subsurface many decades ago can also be retained in the pore spaces of low permeability materials such as silts and clays, representing a long term threat to groundwater and surface water. This can be particularly problematic in areas where artificial recharge has resulted in rising groundwater elevations, solubilizing perchlorate previously held within the unsaturated soils.

Perchlorate

Table 1: Examples of Perchlorate-Containing Products & Processes

Propellant/Oxidizer	Additives and Processes	
Rocket Propellants	Leather Tanning	PVC Plastic Dopants
Blasting Agents	Metal Etching	Drying Agents
Fireworks	Electropolishing	Oxygen Generators
Ejection Seats	Analytical Laboratory Testing	Esterification of Cellulose
Flash Powder	Acid Digestion of Organics	Bleaching Agent
Matches	Electropolymerization	Paints & Enamels
Road Flares	Voltaic Cells and Batteries	Extraction of Rare Earth Metals

Perchlorate Occurrence

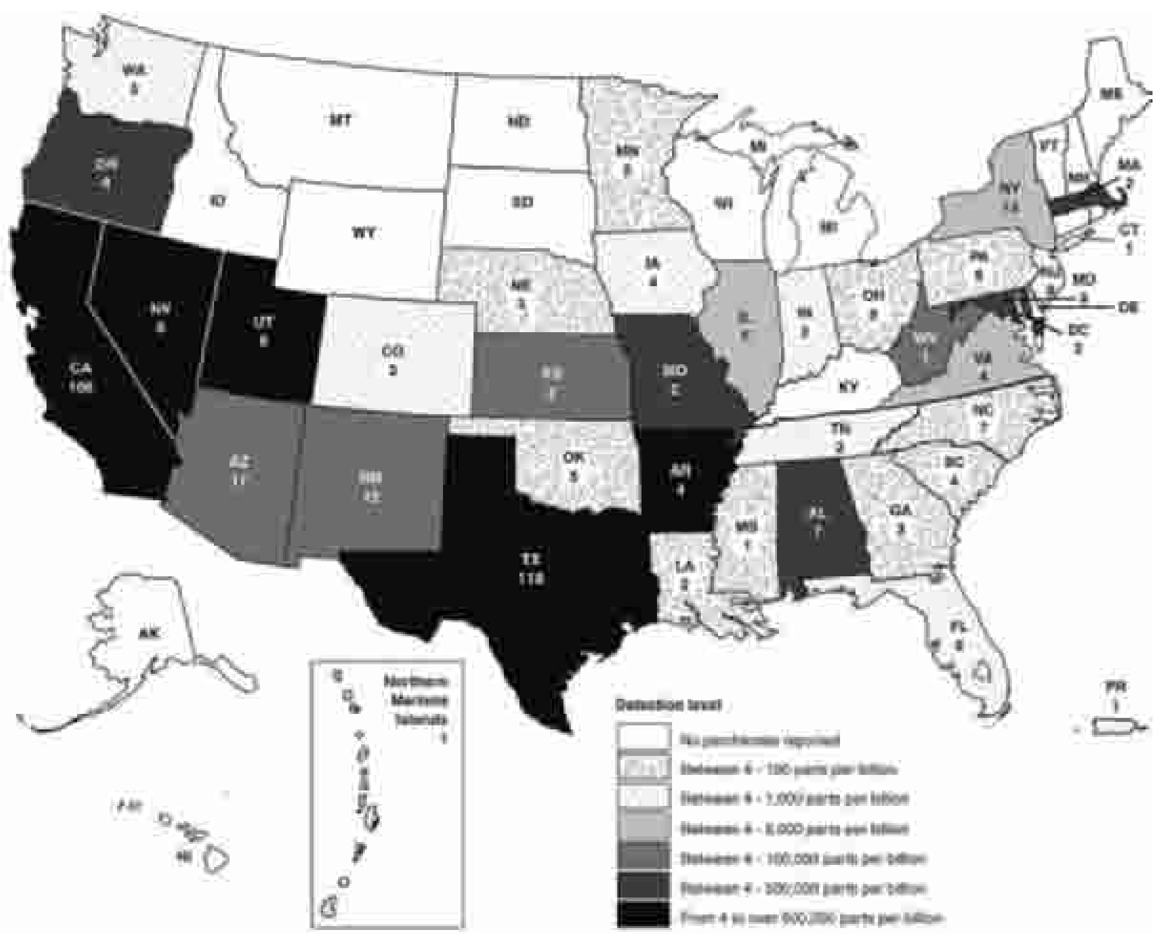
Sites Vary

Based on a recent report from the US Government Accountability Office,[1] perchlorate has been detected in drinking water, surface water, groundwater and/or soil by various federal and state regulatory agencies at 395 sites in 35 states, the District of Columbia, and two US territories. Detections were reported for military installations, commercial manufacturers, public water systems, private wells and residential areas.

Highest Levels

While concentrations exceeded **p**arts **p**er **m**illion (ppm) levels at some military and manufacturing sites, approximately two-thirds of the sites (249 of 395) reported perchlorate levels at or below 18 **p**arts **p**er **b**illion (ppb — also expressed as micrograms per liter (µg/L)), the upper limit of the US Environmental Protection Agency's (EPA's) provisional cleanup guidance for perchlorate. More than half of the sites (224 of 395) were located in Texas and California[1], where regulatory agencies have conducted broad investigations to determine the extent of perchlorate in the environment. The highest concentrations of perchlorate (more than 500,000 ppb for 11 different sites) were reported for sites in Arkansas, California, Nevada, Texas, and Utah, primarily related to rocket manufacturing or to the manufacture of perchlorate itself. Figure 1 summarizes the number of reported perchlorate detections and maximum perchlorate concentrations by state.

Figure 1
Perchlorate Detections & Concentrations



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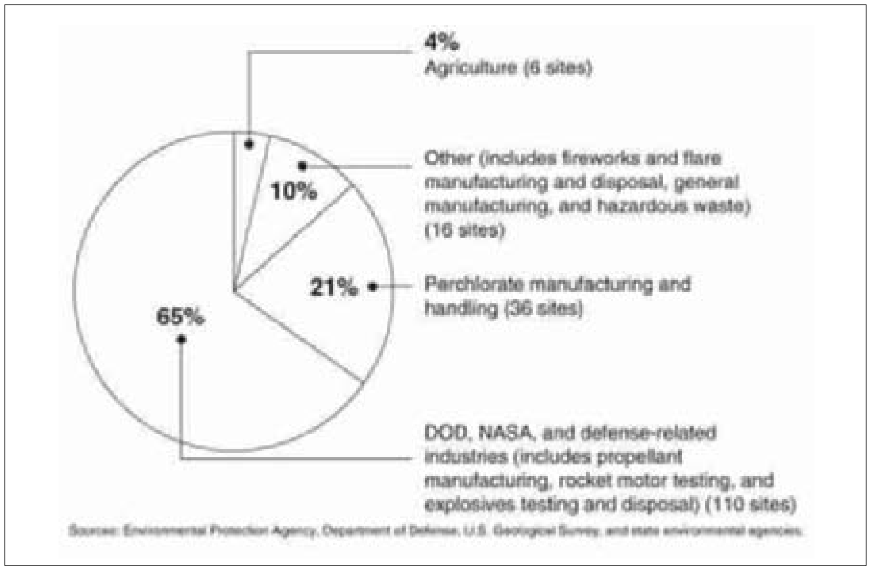
Perchlorate

Sources

Perchlorate impacts at 110 of the sites was reportedly due to activities related to defense and aerospace, such as propellant manufacturing, rocket motor research and test firing, or explosives disposal.[1] At 58 sites, perchlorate impacts were reportedly from manufacturing and handling, agriculture, and a variety of commercial activities such as fireworks and flare manufacturing, as shown in Figure 2. Interestingly, the source of the perchlorate was either undetermined or naturally occurring at more than 227 sites, of which 105 sites are located in the Texas high plains region, where perchlorate concentrations range from 4 ppb to 59 ppb.

Suspected Causes

Figure 2: Suspected Causes of Perchlorate Impacts at Reported Sites (GAO, 2005)



Perchlorate Health Effects & Regulation

Health Impacts

Potential health impacts related to perchlorate exposure include inhibition of iodine uptake by the thyroid gland, resulting in a decrease in thyroid hormone production and disruption of metabolism and other functions.[2] There is currently no national primary drinking water regulation for perchlorate. However, EPA has previously established a provisional reference dose range for perchlorate of 0.0001 to 0.0005 milligrams per kilogram of body weight per day, translating to drinking water concentrations and provisional cleanup levels between 4 ppb and 18 ppb. In February 2005, EPA established a new reference dose for perchlorate based on recommendations by the National Academy of Sciences (NAS).

Reference Dose

The new reference dose is equivalent to 24.5 ppb in drinking water, assuming that an adult weighing 70 kilograms (or 154 pounds) consumes two liters of drinking water per day and that all perchlorate ingested comes from drinking water.[1] However, a federal drinking water standard for perchlorate may be less than 24.5 ppb, since humans likely consume perchlorate from other sources, such as produce[3] and milk.[4] Currently, clean-up levels for impacted sites have been set on a site-specific basis, and several states have set advisory and/or notification levels, as summarized in Table 2. As a comparison, Health Canada[5] has recommended a drinking water guidance value of 6 ppb, although a soon to be published nation-wide survey conducted by Environment Canada has determined that perchlorate impacts above that level are limited to less than a dozen sites nationwide.[6]

Advisory Levels

Table 2. Advisory Levels for Perchlorate

State	Advisory Level (µg/L)	Comment
Arizona	14	Health-Based Guidance Level based on Child Exposure
California	6	Public Health Goal (PHG) for Perchlorate in Drinking Water
Massachusetts	2	State Maximum Contaminant Level (MCL)
Maryland	1	Advisory Level
New Mexico	1	Drinking Water Screening Level
New York	5 & 18	5 µg/L - Drinking Water Planning level 18 µg/L - Public Notification Level
Nevada	18	Public Notice Standard
Texas	17 & 51	17 µg/L - Residential Protective Cleanup Level (PCL) 51 µg/L - Industrial/Commercial PCL

Perchlorate

Public Supplies

Emerging Perchlorate Sources

As a result of its high profile and its addition to the Unregulated Contaminant Monitoring Rule (UCMR List 1), which requires perchlorate analysis by large public water suppliers and selected small water utilities, most public water supplies are now being routinely analyzed for perchlorate. Through monitoring activities, perchlorate has been detected at low levels (typically less than 50 µg/L) in a significant number of areas without apparent military sources. While natural sources or formation mechanisms for perchlorate may explain its presence in some cases,[7,8] widespread, low concentration perchlorate impacts in groundwater and surface water at an increasing number of sites relates to non-military activities such as agriculture, production and use of ECP chemicals, production and use of safety flares, and use of fireworks and explosives.

Chilean Nitrate Fertilizers

Fertilizer Impacts

Research by the EPA has confirmed that perchlorate is present in nitrate-based fertilizers manufactured from naturally-occurring caliche deposits mined from the Atacama Desert region of Chile.[9,10] Historical agronomic literature indicates that Chilean nitrate fertilizers were widely used in specific agricultural practices in the early-to-mid 1900s.[11,12,13] Past import statistics for Chilean nitrate and historical agronomic guidelines for sodium nitrate application for various crops (discussed below) indicate that significant quantities of perchlorate may have been unknowingly applied to agricultural soils over many decades from the early-to-mid 1900s. While the use of Chilean nitrate fertilizers steadily declined since about the 1930s, there is evidence of continued use through to the present day. For example, imports of fertilizer grade sodium nitrate supplied 27% and 6% of the total nitrogen used as fertilizer in 1939 and 1954, respectively. Since 2002, it is estimated that some 75,000 tons of Chilean nitrate fertilizer have been used annually in the US.

Import Estimates

Between 1909-to-1918 and 1925-to-1929, the US imported approximately 7,500,000 and 5,300,000 tons of Chilean nitrate,[11,12] respectively, for a total of approximately 13,000,000 tons of Chilean nitrate. If it can be assumed based on these estimates that approximately 1 million tons of Chilean nitrate were imported annually during 1919 through 1924, then approximately 19 millions tons of Chilean nitrate fertilizer were likely imported into the US between 1909 and 1929. During this period, it is estimated that between 49% and 70% of the imported Chilean nitrate was used as fertilizer, with an average of approximately 65%.[13] The percentage of Chilean nitrate used for fertilizer reportedly fluctuated based on its demand for use in explosives manufacturing. Assuming an average perchlorate concentration of about 0.2% in the Chilean nitrate[9] and that 65% of the imported Chilean nitrate (about 13 million tons) was used as fertilizer, then approximately 49 million pounds of perchlorate is likely to have been applied to agricultural soils during this time period.

Explosives

Current Use

Chilean nitrate fertilizer is still produced by SQM Corporation and makes up 0.14% of the total annual US fertilizer application.[9] It is sold commercially as Bulldog Soda and is primarily used in a few niche markets and specialty products. Currently, world production is 900,000 tons/year of which 75,000 tons are sold to US farmers for use on cotton, tobacco, and fruit crops.[4,9] SQM reports that the perchlorate concentration in Chilean nitrate fertilizer has been reduced through changes in the refinement processes since 2002. The current perchlorate concentration is reported as 0.01%,[10] which is more than an order of magnitude improvement compared to historic perchlorate contents. However, this amount still represents the potential introduction of more than 15,000 pounds of perchlorate annually to agricultural soils, the fate of which is not well understood.

Groundwater Retention

While the use of Chilean nitrate fertilizers containing perchlorate was most intense prior to 1950, the potential exists that impacts from these practices are only now being discovered in public water supplies. For example, researchers have determined that water produced from 59 of 176 public water supply wells in the Los Angeles Basin was in excess of 50 years old.[14] Similarly, data for four representative surficial aquifers in the eastern US measured groundwater mean ages of 27-50 years,[15] with some fraction of the groundwater being older. The persistence of agricultural pollutants (such as nitrate) in deep alluvial aquifers, resulting from agricultural practices more than 50 years ago has been well documented.[16,17] Given that perchlorate was a component of Chilean nitrate-based fertilizers, the hypothesis may be true for perchlorate.

Fireworks & Pyrotechnics

Fireworks Component

Perchlorate is a major component of fireworks used by both pyrotechnic professionals and individuals, and as such, the manufacturing, storage, handling, use and disposal of these products have the potential to introduce perchlorate into the environment. Many pyrotechnic displays are launched near or over surface waters, presumably for visual impact and safety reasons, increasing the potential for

Perchlorate

Chinese Source

perchlorate impacts to water sources. In 2003, 221 million pounds of fireworks were consumed in the US and the demand for fireworks is expected to increase. Most of the fireworks consumed in the US are imported from China, with only approximately 3% of the total mass of fireworks produced in the US.[18] In 2003, 87.5 million kilograms (192 million lbs) of the 89.2 million kilograms (196 million lbs) of imported consumer fireworks or 98% and 7.5 million kilograms (16.5 million lbs) of the 8.1 million kilograms (17.8 million lbs) or 93% of imported display fireworks were from China.[19]

Contamination from Detonation

Raw perchlorate from fireworks manufacturing facilities and perchlorate residue from detonated fireworks both have the potential to contaminate surface water and groundwater. Although fireworks contain high percentages of perchlorate, it is not currently known how much of the perchlorate finds its way into the environment. The number of case studies in the literature discussing extent of soil and water contamination at firework discharge sites is limited. In one study, perchlorate contamination linked to fireworks displays was examined by the Massachusetts Department of Environmental Protection at the University of Massachusetts at Dartmouth. Results of soil sampling immediately after the display indicted a maximum perchlorate concentration of 560 µg/kg; however, groundwater concentrations were not substantially different than they were before the display.[20] In a recent study in Ontario, perchlorate concentrations increased from less than 1 ppb to nearly 20 ppb in surface water during the 24 hours following a display adjacent to a man-made lake, confirming impacts from airborne deposition related to the display. More research is being conducted at this and other sites to quantify the potential impact of fireworks displays on water quality.

Safety Flares

Safety flares are often used in emergency situations for road-side accidents and rail and marine emergencies. Based on Material Safety Data Sheets (MSDS), these flares can contain up to 10% (by weight) potassium perchlorate. In 1997, approximately $101.5 million dollars worth of pyrotechnics (NAICS product code of 325998H107) were produced in the US. This classification includes road flares, jet fuel igniters, railroad torpedoes, and toy pistol caps, but not fireworks. While numbers are not available for total domestic flare production, assuming an average cost per flare of $0.50 to $1.00 per flare and annual sales of $20 million by the largest US manufacturer, then at least 20-to-40 million flares may be sold annually.

Leaching Potential

Preliminary research by Silva[21,22] of the Santa Clara Valley Water District (SCVWD) indicates that 3.6 grams of perchlorate can potentially leach from an unburned, damaged (i.e., run over by a motor vehicle) 20-minute road flare. According to Silva,[22] this amount of perchlorate can potentially contaminate 2.2 acre-feet of drinking water above 4 µg/L (the standard EPA Method 314.0 quantitation limit). Interestingly, even fully burned flares leached 1.9 mg perchlorate per flare.[22] More than 40 metric tons of flares were reported to be used/burned in 2002 in Santa Clara County, California alone.[22] Given this estimate, the potential for perchlorate leaching from road flares and subsequent surface runoff from highways and roads represents a potentially significant and largely uninvestigated impact to surface water and groundwater quality.

Manufacturing Plume

Road flare manufacturing has also been implicated in perchlorate contamination at a site in Morgan Hill, California.[23] From 1956-to-1996, highway flares were manufactured at this location.[23] Perchlorate was detected at one on-site monitoring well in 2001 and was detected in a municipal well in March 2002. The perchlorate plume is estimated to be 9 miles long.[24] It is important to note that this site is located in an area that was historically used for fruit and nut production, and perchlorate impacts to soil and groundwater in some areas may also be the result of past fertilizer practices.

Blasting Agents

Mining & Rock Blasting

Some blasting agents used in mining and rock blasting applications have been shown to contain perchlorate, and impacts to groundwater and surface water from blasting operations have been reported in both the US and Canada. While the main oxidizer employed in blasting agents is usually **a**mmonium **n**itrate (AN), ammonium perchlorate and other perchlorates (sodium or potassium perchlorate) are compatible with the AN mixtures and can be employed for special applications and to take advantage of perchlorate available from DOD demilitarization activities. Furthermore, sodium nitrate (Chilean origin) historically used in commercial explosives may contain perchlorate as an impurity. As shown in Table 3, some water gels, emulsions, and non-electric detonators can contain substantial amounts of perchlorate (e.g., up to 30%). In 2003, the US production of explosives, reported by 23 commercial explosive manufacturers, was 2,520,000 tons.[25] This amount of explosives is typical of the annual US production in the last decade. Of the total US commercial production, 2,475,000 tons were classed as blasting agents. Sales of blasting agents were reported in all states with West Virginia, Kentucky, Wyoming and Indiana

Perchlorate

Coal Mining

consuming the highest quantities.[25] Sixty seven percent of the blasting agents were used in coal mining. Quarrying and nonmetal mining, the second-largest consuming industry, accounted for 14% of total explosives sales, while construction accounted for 8% of explosives sales.

To our knowledge, no detailed studies are publicly available that quantify the amount of perchlorate originating from blasting agents and explosives. There have been several newspaper and internet reports linking blasting operations to perchlorate in groundwater and surface water, particularly in Massachusetts.[26,27,28] Perchlorate concentrations as high as several hundred parts per billion have been measured in close proximity to blasting sites.

Electrochemically-Produced Chlorine Products

Chlorine Manufacture

During the electrochemical manufacture of chlorine products, such as chlorate, from chloride brine feedstocks, small amounts of perchlorate may be formed as an impurity.[29,30] Because perchlorate was not known to be a chemical of regulatory concern until quite recently (1997), and because the impurity level was considered small relative to the primary chemical being produced (e.g., chlorate), little attention has been paid to its presence. Therefore, little publicly-available information regarding perchlorate contamination in **e**lectrochemically produced **c**hlorine **p**roducts (ECPs) exists. Recent analysis of several sodium chlorate feedstocks being used for large-scale commercial perchlorate manufacturing suggest that perchlorate is present in the chlorate products at concentrations ranging from 50-to-230 mg/kg chlorate, and therefore, potential exists for release of perchlorate to the environment through chlorate manufacture, storage, handling, and use.

Limited Information

Sodium Chlorate

Significant amounts of ECP chlorine chemicals such as sodium chlorate are produced in the US on an annual basis. The majority of sodium chlorate produced in the US is used domestically, with only 3% of the annual domestic production exported. To satisfy demand for use, it is estimated that an additional 40% is imported for domestic consumption. The total annual consumption of sodium chlorate is approximately 1.2 million tons.[31]

Pulp & Paper Bleaching

Historic and current uses for chlorate include pulp and paper bleaching, non-selective contact herbicide application, and plant defoliation.[32] Sodium chlorate is also used in limited capacities for water treatment, mining, and in the production of other chemicals such as sodium perchlorate and other metallic perchlorates. The pulp and paper industry uses approximately 94% of all sodium chlorate consumed in the US.[32] In this industry, it is primarily used for the on-site production of chlorine dioxide to bleach cellulose fibers. In 1998, EPA ruled that, by April 2001, pulp and paper mills in the US would have to use **e**lemental **c**hlorine **f**ree (ECF) bleaching instead of the traditional chlorine bleaching, which has the potential to produce organic halides. Chlorine dioxide produced from sodium chlorate meets this requirement.

Defoliant Use

Cotton

In addition to pulp and paper bleaching, sodium chlorate is used as a non-selective contact herbicide and a defoliant for cotton, sunflowers, sundangrass, safflower, rice, and chili peppers.[32] As a defoliant, approximately 99% of sodium chlorate application is used on cotton plants.[33] By removing the foliage, a better yield is obtained during harvest and the cotton does not become stained. The application of chlorate defoliants is generally unique to Arizona and California because of their warm climates. Elsewhere, early frost causes foliage to drop from cotton plants naturally. In California and Arizona, the frost typically occurs too late, if at all, and the leaves remain on the plants during harvesting, requiring the use of defoliants. Depending on the yearly weather conditions, other states including Mississippi, Texas, Alabama, Arkansas, Georgia, Louisiana, Tennessee and North Carolina may use sodium chlorate as a defoliant for cotton. In terms of quantity of use, California used more than 24 million pounds of sodium chlorate on cotton between 1991 and 2003, with an average application rate of 4.6 lbs/acre. By comparison, Arizona, Mississippi, and Texas had total application rates of 6.3, 4.5, and 1.7 million pounds, respectively, between 1991 and 2003.[34]

Potential Contamination

Based on the documented occurrence of perchlorate in sodium chlorate and available use statistics, it appears that chlorate use by the pulp and paper industry and as a defoliant has the potential to introduce perchlorate to the environment. For example, assuming 1.2 million tons of sodium chlorate are consumed annually in the US,[31] and that sodium chlorate may contain perchlorate at concentrations ranging from 50-to-500 mg/kg, this represents the potential handling of 120,000 to 1,200,000 lbs of perchlorate annually, the fate of which is generally unknown. Chlorine dioxide production for pulp and paper bleaching involves the addition of a sodium chlorate solution and a reducing agent to produce chlorine dioxide.[35] Chlorine dioxide is produced as a gas and later absorbed into water prior to being used as a bleaching agent. As such, perchlorate originating in the sodium chlorate would not be expected to be present in the gas stream because of its non-volatility. However, perchlorate is likely to end up in the by-product salt-cake from the chlorine dioxide generator, which is generally added back to the kraft liquor cycle, where it

Perchlorate

Study Needed

Defoliant Impacts

No MCL

Treatment Options

may undergo reduction. On occasion, excess salt-cake is sewered. The fate of perchlorate in this process is unknown, but low ppb levels of perchlorate in mill effluents are possible if the perchlorate is not significantly treated by the plant's effluent treatment system. Further study of the fate of perchlorate in pulp and paper mills is warranted.

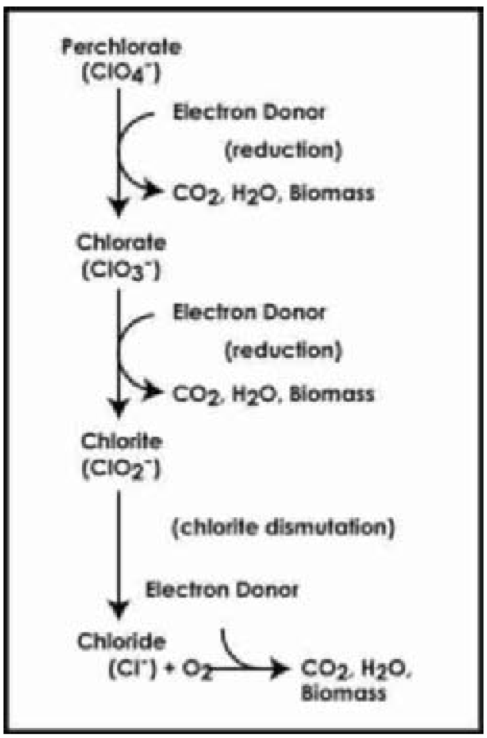
With respect to sodium chlorate use as a defoliant, the average yearly application of sodium chlorate in California is nearly 2 million pounds, applied directly to agricultural lands. Assuming a perchlorate impurity level of between 0.05 to 0.5% sodium perchlorate, the use of sodium chlorate as a defoliant may result in the application of 1,000-to-10,000 pounds of sodium perchlorate to agricultural lands in California per year. While this annual application appears to be relatively small, repeated application over many years to decades may result in an accumulation of perchlorate in soils because of its recalcitrance in most soil environments. Over time, perchlorate in soils could impact surface waters due to overland flow during rainfall events or groundwater through longer term infiltration.

Water Remediation Options

Despite the absence of a federal **m**aximum **c**ontaminant **l**evel (MCL) for perchlorate, remediation of soil and groundwater has proceeded at dozens of sites nationwide, using either state advisory or notification levels or site-specific cleanup levels as remedial goals. The water treatment technologies can be grouped into biological and non-biological processes. Biological options include: ex situ bioremediation using fluidized bed or fixed-film bioreactors; in situ bioremediation; and phytoremediation. The non-biological processes include: ion exchange; sorption to granular modified activated carbon; and membrane separation. Of these, ion exchange and bioremediation are by far the most commonly employed technologies. Detailed descriptions and project performance summaries for these technologies are provided in a recent EPA Treatment Technology Update.[2]

Figure 3

Perchlorate Biodegradation Pathway



Bioremediation

Nitrate Destroyed

Throughput

In Situ

Bioremediation

Bioremediation involves the engineered stimulation of bacteria to degrade contaminants of interest. In the case of perchlorate, a wide variety of bacteria that are naturally present in soil and water can metabolize perchlorate, breaking it down into chloride and oxygen, as shown in Figure 3. To promote the process, a carbon substrate (termed electron donor) such as acetate, lactate, vegetable oil or ethanol needs to be provided to the bacteria that will undertake the degradation reaction.

Ex situ bioremediation applications typically involve pumping groundwater or surface water containing perchlorate to large tanks, within which perchlorate-reducing bacteria are attached to media such as sand, plastic beads, or granular carbon. As the water containing perchlorate passes through the tanks, the bacteria metabolize the perchlorate to acceptable end products, and treated water exists the tanks for discharge or potentially beneficial use. As an added benefit, the process also destroys nitrate, a common contaminant in groundwater. To date, bioreactors have been installed at a half dozen sites to treat perchlorate-impacted groundwater, with throughputs ranging as high as 5,400 **g**allons **p**er **m**inute (gpm).[2]

For in situ bioremediation, the electron donors are added to the subsurface to induce the naturally occurring bacteria to biodegrade the perchlorate. Electron donor addition can be accomplished in a variety of ways, either through direct injection or recirculation. As with the ex situ bioreactors, in situ bioremediation destroys nitrate. To date, in situ bioremediation has been used at more than two dozen sites to treat perchlorate-impacted groundwater.

Ion Exchange

Ion exchange applications typically involve pumping groundwater or surface water containing perchlorate through large tanks containing resins made from materials that contain ionic functional groups to which perchlorate can attach, displacing other anions such as chlorides or hydroxides in the

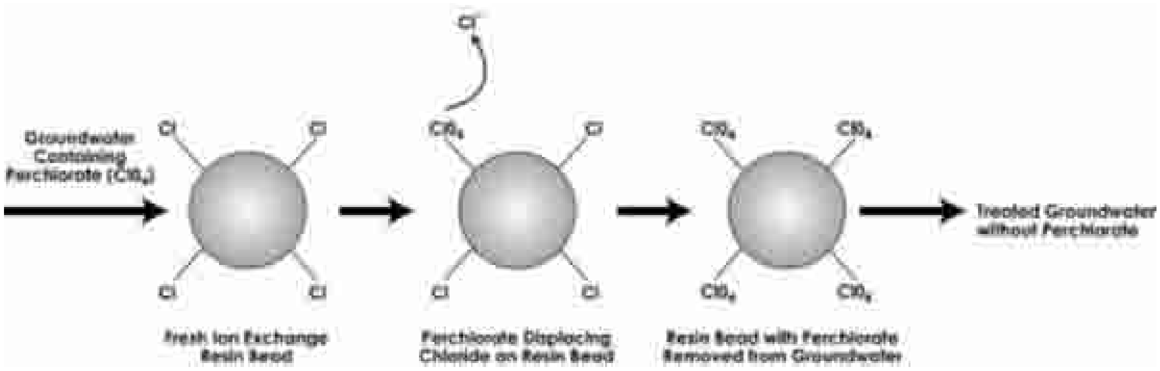
Perchlorate

Ion Exchange Available

High Throughput

process (Figure 4). Several types of resins are currently in use at various sites, including regenerable resins, which must be periodically regenerated to remove the adsorbed contaminants to replenish the exchange capacity, and disposable resins, which are destroyed once the available resin capacity has been exhausted. Ion exchange of perchlorate in environmental media and drinking water is a commercially available technology provided by several large vendors, and information is available in a recent EPA Treatment Technology Update[2] for 15 full-scale applications, with throughputs ranging as high as 10,000 gpm. Of note, groundwater treated using ion exchange can often be directly used for drinking water purposes.

Figure 4
Perchlorate Removal via Ion Exchange



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Dr. Carol Aziz is a Senior Engineer at GeoSyntec Consultants, with 11 years of professional experience in the biodegradation of chlorinated solvents and recalcitrant chemicals such as perchlorate. Dr. Aziz manages the research projects that have generated much of the data summarized in this review.

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Mining Cleanup

Past Mining

Surface Water Remediation

Impacted Watershed

Mines, Mills & Smelters

Tailings Disposal

Metro Storm Drain

MINING MEGASITE CLEANUP

CERCLA REMEDIES ADAPT TO CIRCUMSTANCES IN BUTTE, MONTANA

by Angela Frandsen, Camp, Dresser, and McKee (CDM) (Helena, MT)

Introduction

Historic mining-related discharges into Silver Bow Creek from the Butte, Montana mining district resulted in surface water quality that has not been suitable for aquatic life since mining began more than 120 years ago. Silver Bow Creek has gained notoriety over the years for its extremely poor water quality. It was declared a national priority cleanup site under the federal Comprehensive Environmental Response Compensation, and Liability Act (CERCLA or "Superfund") in the early 1980s. When remedial investigations were initiated in the 1980s, it was found that contamination was so ubiquitous and water quality exceedances so large that it was widely believed that water quality standards could never be met in Silver Bow Creek. However, in the uppermost reach of the creek that flows through the city of Butte, remedial actions over the last 15 years targeting the protection of surface water have been highly successful. Copper and zinc concentrations in recently collected water quality data are meeting Montana chronic aquatic water quality standards. Based on these data, it is likely that consistently achieving water quality standards in this reach of Silver Bow Creek during normal flow conditions is an achievable goal.

The progress that has been made in improving Silver Bow Creek water quality has not happened overnight. Remedial actions have been conducted over the last 15 years with involvement from the Atlantic Richfield Company (ARCO), the local Butte-Silver Bow government, academia, consultants, and regulatory experts from the US Environmental Protection Agency (EPA) and the State of Montana. The intent of this article is to spread awareness among technical and legal professionals in the environmental field of the success that Superfund remedial actions have had on what was a severely-impacted reach of Silver Bow Creek. In addition to the engineered actions that have lead to improved water quality, EPA has invoked a technical impracticability waiver as part of the Record of Decision for this site.

BACKGROUND

Brief History of Butte

Butte, Montana is located in southwestern Montana, just west of the continental divide. Silver Bow Creek, which flows through Butte, is one of the primary streams at the headwaters of the Clark Fork River, which drains most of western Montana and eventually flows into the Columbia River.

Historically, Butte has served as a globally important mining, milling, and smelting district. Gold was first discovered near Butte in 1864. Metal-sulfide deposits rich in copper and zinc were discovered later and became the primary ores in Butte. These low-grade ores proved difficult to recover, and Butte remained a small mining camp compared to others in the region.

By the 1870s, dozens of silver and copper claims had been located and successful treatment processes developed, prompting the construction of mills and smelters capable of refining arsenic-laden copper ores. In 1881, the purchase of mining claims by future copper baron, Marcus Daly, marked a significant turning point for Butte. Daly and his financial partners organized the Anaconda Copper Mining Company (ACMC) and rapidly accumulated surrounding mining properties on Butte Hill. By 1884, there were some 300 operating copper mines, at least 10 silver mines, 8 smelters, and over 4,000 posted claims in Butte.

By 1910, the Butte district had produced over 284 million pounds of copper, making it the largest producer of copper in North America. All of the mines produced waste piles of various compositions, and the mills and smelters produced large quantities of tailings which were disposed of in ponds or dumped in Silver Bow Creek. Between 1910 and 1927, ACMC completed consolidation, with few exceptions, of all of the major mines, smelters, and mills in Butte. Milling and smelting continued in Butte until the 1920s but, as the copper smelting capacity at Anaconda, Montana grew, Butte became primarily a mining center.

The Weed Concentrator (now known as the Montana Resources Concentrator) was an ore concentrating facility in Butte that produced large quantities of waste in the active mine area and discharged large volumes of contaminated process water to surface water via the Metro Storm Drain (the former Silver Bow Creek channel on the east side of Butte).

In 1977, ACMC merged with ARCO. Open pit mining operations, which began in 1955, continued in the Berkeley Pit until 1982 and in the adjacent Continental Pit until 1983, when ARCO suspended all mining operations. Montana Resources, which bought the Butte mining operations, began mining in the adjacent Continental Pit in 1985 and continues today.

Mining Cleanup

Superfund-1983

Floodplain Wastes

EPA & Superfund

EPA designated the original Silver Bow Creek Site as a Superfund site in September 1983 largely due to Silver Bow Creek water quality issues. Data collected in the 1980s and early 1990s demonstrated elevated metals concentrations in Silver Bow Creek during normal flow and storm flow conditions. The water quality usually exceeded state water quality standards, sometimes by several orders of magnitude. Much of the contamination was clearly attributable to fluvially deposited mine wastes and tailings in the flood plain along the entire length of Silver Bow Creek from Butte downstream to the Warm Springs Ponds, and beyond along the Clark Fork River to Missoula, 120 miles from Butte. As a result, impacted lands in the Clark Fork River basin between Butte and Missoula, Montana represent the longest contiguous set of Superfund sites in the United States (see Figure 1).

Figure 1

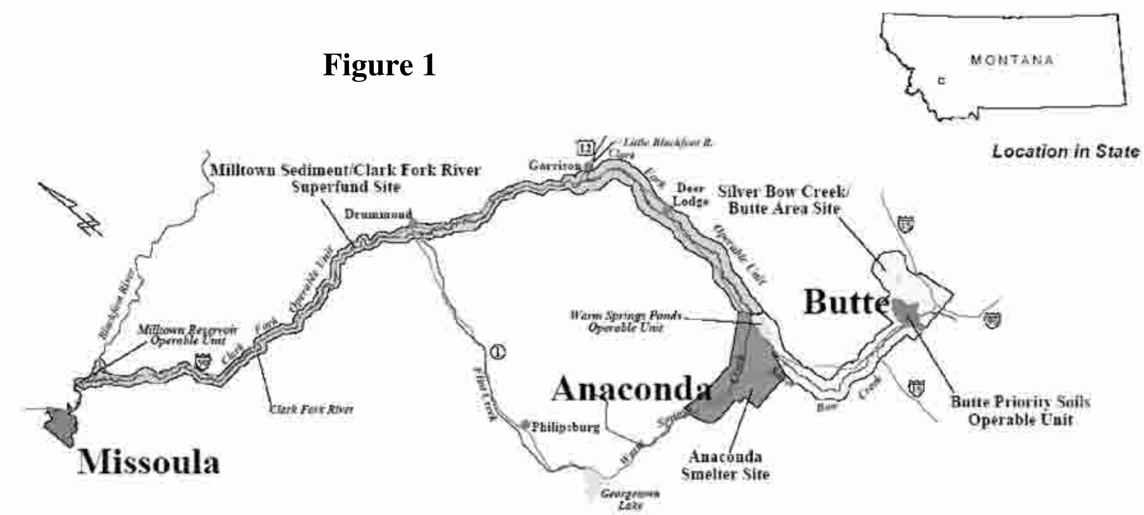
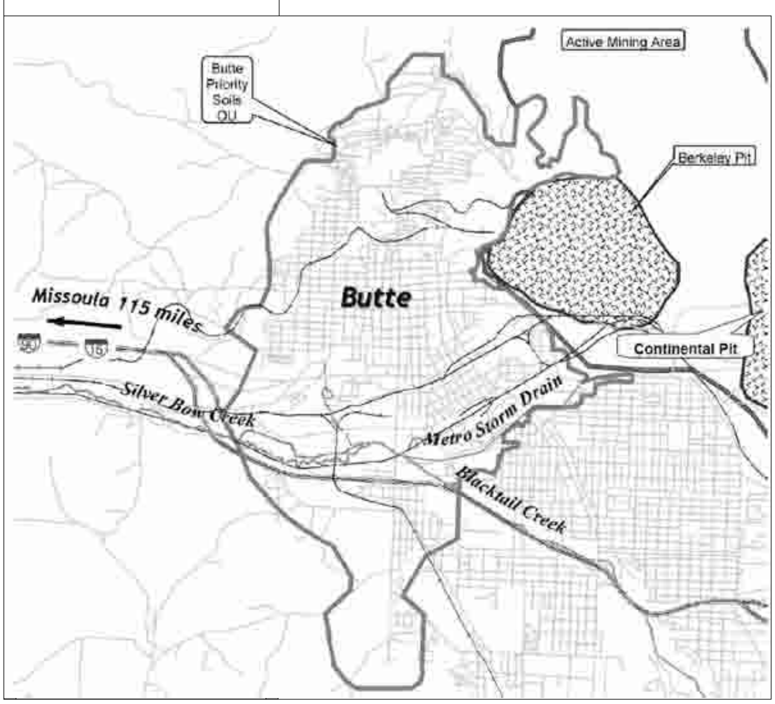


Figure 1. Contiguous Silver Bow Creek/Butte Area Site, Anaconda Smelter Site, and Milltown Sediment/Clark Fork River Site shown. This article focuses on the uppermost reach of Silver Bow Creek that flows through the urban portion of Butte.

Figure 2
Butte Priority Soils Operable Unit (BPSOU) Site Boundary and Site Features



During the course of the initial investigations, which began in 1984, the importance of Butte Hill itself as a source of contamination to Silver Bow Creek was formally recognized. Preliminary results indicated that upstream sources were partly responsible for the contamination observed in the creek. After a thorough analysis of the relationship between the two sites (Butte and Silver Bow Creek), EPA concluded that the two sites should be joined under CERCLA. In 1987, the Butte Area was added and the name of the site was formally changed to the Silver Bow Creek/ Butte Area Superfund Site.

The Butte Priority Soils Operable Unit (BPSOU, Figure 2) is one of several operable units within the Butte Area portion of the Silver Bow Creek/Butte Area site (Figure 1). The remedial focus at the BPSOU is to address human health and environmental risks associated with mining related wastes and contaminated soils within the Butte urban area and contaminated surface water and alluvial groundwater within and beneath the Silver Bow Creek floodplain. Contaminated groundwater in the Berkeley Pit and the network of interconnected underground mines beneath Butte is addressed separately under the Butte Mine Flooding Operable Unit.

Silver Bow Creek has not been the sole focus of Superfund activities at the BPSOU. Much of the work done to date has been on Butte Hill, where mine wastes and mining-impacted land with elevated arsenic and lead concentrations have been removed and reclaimed to protect human health. These human health related removals and land reclamation performed in the BPSOU have been

Mining Cleanup

Record of Decision

extensive, and have had an indirect beneficial impact on Silver Bow Creek water quality. However, these actions will only be discussed briefly as this article will instead focus on the remedial actions performed within the flood plain to specifically address water quality in Silver Bow Creek.

It should be noted that as of the date this article was written, the Record of Decision for the BPSOU has not been finalized. Therefore, when "the remedy" is described, this is describing the most likely scenario, based on the Proposed Plan (EPA 2004a) and the administrative record. It is possible that some of the details of the remedy components may change upon finalization of the Record of Decision.

SILVER BOW CREEK CHARACTERIZATION AND HISTORY

Deposition of Wastes in the Floodplain

Riparian Area

Prior to the onset of mining in Butte, the Silver Bow Creek floodplain was a riparian area with wetlands. Because it was the closest water source to Butte Hill, numerous milling and smelting plants were constructed along Silver Bow Creek in the late 1800s. An estimated total of 10 million tons of waste was generated from 1878-1925 (CH2MHill and Chen Northern 1990). Although a significant portion of wastes released to surface water were transported downstream out of the immediate Butte area, a sizeable volume remained within and adjacent to the historic stream channel and in large impoundments constructed within the floodplains and low-lying wetlands. Figure 3 is an aerial photograph from 1954 showing the Silver Bow Creek floodplain in Butte. The major tailings deposits and streamside wastes are clearly visible as bright white areas.

Deposits

Silver Bow Creek originally extended from its mountain headwaters on the continental divide north of Butte through what is now the open pit mining areas. With the advent of mining, the creek was rerouted and the original channel and floodplain was completely obliterated by the Berkeley Pit, the Continental Pit, and the Yankee Doodle Tailings Pond. This is illustrated in Figure 4.

Silver Bow Creek now begins at the confluence of the Metro Storm Drain and Blacktail Creek (refer to Figure 2 or 3). The Metro Storm Drain is a man-made surface water conveyance constructed during the 1930s to provide a means of transporting mine water, tailings, sewage, and stormwater out of Butte. The Metro Storm Drain was constructed by realigning and filling the original Silver Bow Creek channel around and through the mine waste impoundments. The Metro Storm Drain was later used to discharge waste and wastewater from the Berkeley Pit operation. Because of its industrial use, the Metro Storm Drain has no water use classification in the Administrative Rules of Montana (ARM 17.30.607) and is not recognized as a "state water."

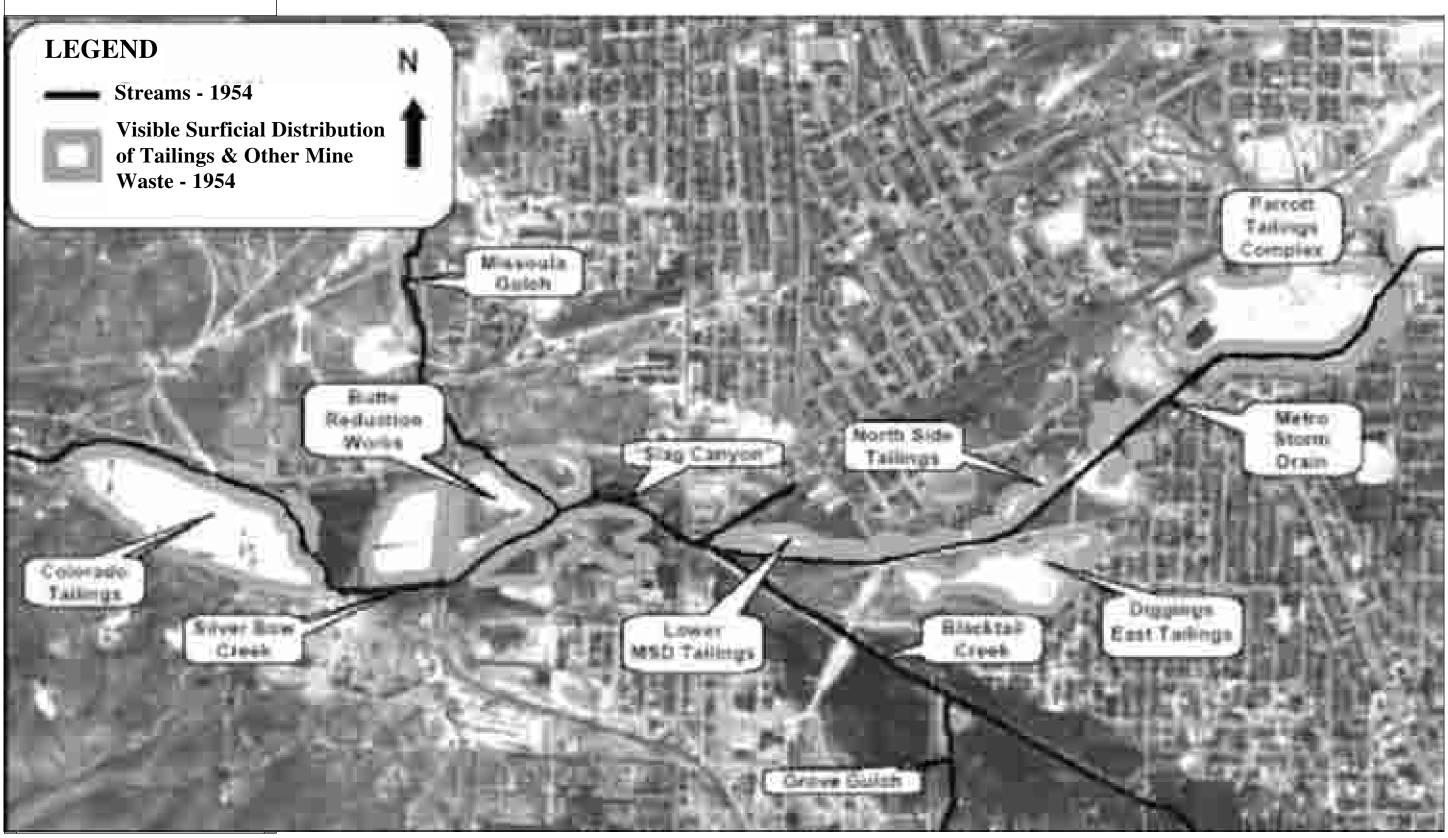


Figure 3
1954 Surficial Distribution of Tailings and Mine Waste in the Metro Storm Drain/Silver Bow Creek Corridor (modified from EPA 2006)

Mining Cleanup

Figure 4. View of the upper portion of the Silver Bow Creek floodplain showing the Yankee Doodle Tailings Pond and Berkeley Pit. The floodplain has been obliterated by the open pit mining activities.

Obliterated Floodplain

Wastes present in the Metro Storm Drain area today are largely buried below the ground surface. Portions of these wastes are in direct contact with groundwater and serve as a source of contamination to alluvial groundwater.

Groundwater Contamination

West and downstream of the Metro Storm Drain, the Silver Bow Creek floodplain (known as "Lower Area One" or LAO) has been host to at least four very large milling and smelting facilities, all of which contributed to the deposition of ore processing wastes and tailings to the area. These wastes are clearly visible in Figure 3. Prior to remedial actions in the mid-1990s, Silver Bow Creek flowed directly through these tailings deposits.

Hydrology

The surface water and groundwater hydrology in the Butte area is complex and has been greatly influenced by historic mining practices. Dewatering for underground and open pit mining lowered the groundwater table and created a "cone of depression" centered on the Berkeley Pit. Dewatering practices ceased in 1982 and groundwater levels are slowly rebounding, although the Berkeley Pit will remain a groundwater sink indefinitely as required by EPA's Record of Decision for the Mine Flooding Operable Unit. Maintaining the Berkeley Pit as a groundwater sink is necessary to prevent highly contaminated pit water from migrating to the south (i.e., groundwater will always flow toward the pit, not from the pit). The depressed groundwater surface surrounding the Berkeley Pit has resulted in a groundwater divide within the alluvial aquifer in the upper Metro Storm Drain. West and south of the divide, groundwater flows towards Metro Storm Drain and Silver Bow Creek. East and north of the divide, groundwater flows toward the Berkeley Pit. Surface water and groundwater recharge to the upper Silver Bow Creek watershed up-gradient of the groundwater divide is now captured in the Berkeley Pit. Groundwater flow in the alluvial aquifer within the Metro Storm Drain is now sustained from infiltration of precipitation and runoff from Butte Hill.

Dewatering for Mining

Groundwater Sink

Because of the obliteration of the northern portion of the Silver Bow Creek channel (see Figure 4), the primary source of flow in Silver Bow Creek is inflow from Blacktail Creek, which normally contributes 11-to-15 **c**ubic **f**eet per **s**econd (cfs). The upper portion of Metro Storm Drain is dry except during storm runoff or snowmelt episodes. The confluence of lower Metro Storm Drain and Blacktail Creek is now considered the official beginning of Silver Bow Creek. The lower Metro Storm Drain area receives flow via groundwater discharge during normal flow conditions and maintains a flow between 0.3 and 0.5 cfs.

Mining Cleanup

Flow Sources

The Metro Storm Drain and the current Silver Bow Creek floodplain also receive urban runoff from drainages on Butte Hill. Except for the lower Missoula Gulch sub-basin (see Figure 3), discharge from Butte Hill occurs only during storm runoff and snowmelt events. The Lower Missoula Gulch sub-basin intercepts shallow groundwater and maintains a flow of 0.1 to 0.3 cfs.

In addition to the perennial flow and stormwater runoff, Silver Bow Creek receives treated discharge from the Montana Pole site (a former wood treatment facility contaminated with pentachlorophenol) and from the municipal wastewater treatment plant outfall located west of the former Colorado Tailings at the western edge of the site. Discharge from the wastewater treatment plant is normally between 5 and 9 cfs, constituting roughly 30 percent of the total base flow in Silver Bow Creek as it leaves Butte.

WATER QUALITY

Base Flow ("normal" flow)

Base Flow Quality

Two surface water sampling locations are key to the discussion of base flow water quality. One is a sampling station located on Blacktail Creek upstream of the confluence with the Metro Storm Drain. The downstream station, SS-07, is located on Silver Bow Creek at the western border of the BPSOU (see Figure 5).

Base flow water quality in Blacktail Creek is considered relatively good. In comparison, water quality in Silver Bow Creek was very poor until 1998. Total recoverable concentrations for all metal contaminants of concern were above their respective standards, frequently by orders of magnitude for cadmium, copper, and zinc.

Figure 5. Key surface water features and monitoring stations for Silver Bow Creek. Compare surface water features with 1954 aerial photograph in Figure 3.

Metals Sources

The major contributors of metals to Silver Bow Creek, during periods of normal flow, were:

- Surficial tailings in Lower Area One through which Silver Bow Creek flowed prior to 1997.
- Lower Area One groundwater contaminated by the Colorado Tailings expressed directly as surface water to Silver Bow Creek.
- Metals laden sediment deposits distributed along the Silver Bow Creek stream channel.
- Groundwater contaminated by buried tailings expressed as surface water in Metro Storm Drain.
- Surficial tailings along Metro Storm Drain (through which surface water flowed prior to 2004).
- Contaminated groundwater in the Missoula Gulch drainage expressed as surface flow prior to entering Silver Bow Creek.

Mining Cleanup

Runoff Exceedances

Wet Weather Conditions

Wet weather runoff from Butte Hill is a contributor of both dissolved phase contaminants and metals laden sediments to Silver Bow Creek. Significant water quality exceedances (at times orders of magnitude above the standard) have occurred in the past for both copper and zinc during wet weather runoff events. As a result of the serious nature of these past exceedances on the aquatic environment, actions were taken in the mid to late 1990s and in the early part of this decade to reduce the impact of stormwater discharge to Silver Bow Creek (see next section). Although the magnitude and frequency of exceedances has been reduced through recent response actions, episodic exceedances still occur in Silver Bow Creek during wet weather runoff events.

SUPERFUND RESPONSE ACTIONS

EPA Goal

It is EPA's goal to meet surface water quality standards in Silver Bow Creek throughout the reach of the creek within the BPSOU during base flow and wet weather flow conditions. Based on the remedial investigation findings, the remedy for protection of Silver Bow Creek consists of three needs:

Remedy Needs

1) Control, capture, and treat contaminated alluvial groundwater to prevent it from flowing into Silver Bow Creek
3) Remove solid media contaminants from the stream corridor to prevent direct erosion and sediment contamination
3) Improve the quality of stormwater runoff from Butte Hill to prevent acute water quality exceedances in Silver Bow Creek

The actions described below were aimed at one or more of these components of the remedy.

Response Action for Lower Area One

Mitigation Actions

Mitigation efforts began in the mid-1990s to address the extremely poor water quality in Silver Bow Creek. In Lower Area One, the following critical elements for the cleanup were:

- Removal of tailings and backfilling
- Elevation, realignment, and stabilization of the Silver Bow Creek channel
- Establishment of a stabilizing, productive and diverse plant community
- Construction of a groundwater collection, extraction, and treatment system

Limited Tailings Removal

In 1997, approximately 1.2 **m**illion **c**ubic **y**ards (mcy) of tailings were removed from this area. Due to the presence of immovable structures and limitations in removal depth, it was not feasible to remove all tailings and contaminated soils. Tailings remain beneath a predetermined depth-of-excavation, beneath an operational railroad grade, beneath the municipal wastewater treatment plant, and beneath historic slag walls. Following the removal, the area was partially backfilled and the Silver Bow Creek channel and floodplain were reconstructed. Importantly, the channel was reconstructed at an elevation above the groundwater table to prevent the underlying contaminated groundwater from flowing into Silver Bow Creek surface water. Figure 6 shows a portion of the Colorado Tailings area before and after removal and channel reconstruction.

Stream Reconstruction

Figure 6
Aerial photographs of the Silver Bow Creek floodplain at the east end of the Colorado Tailings before (1969) and after (2002) waste removal and stream channel reconstruction. Note the municipal wastewater treatment plant in both photographs.

Mining Cleanup

Groundwater Capture

Cumulative Effect

Stormwater Mitigation

Coversoil Caps

Railroad Bed Materials

BMPs

Subsurface Capture & Treatment

Groundwater Control

Flow Routing

Post removal groundwater monitoring indicates that groundwater capture is highly effective due to some fortuitous underlying geology. Bedrock shallows and outcrops at the downgradient (west) edge of the site, which forces groundwater to the surface (see Figure 10). However, **c**ontaminants **o**f **c**oncern (COCs) in the alluvial aquifer remain at concentrations far exceeding groundwater quality standards.

The next remediation phase, (part of the Record of Decision this year), includes the design and construction of both the final surface reclamation plan and construction of a permanent groundwater collection, extraction, and treatment system.

Stormwater Response Actions

Impacts to Silver Bow Creek during stormwater runoff events have been greatly reduced as a result of the cumulative effects from the improvements to the stormwater conveyance system, waste removals, and land reclamation on Butte Hill.

In 1996, action was initiated to minimize the impacts of stormwater runoff on Silver Bow Creek. To control stormwater flow and minimize soil erosion and transport of contaminated sediment to Silver Bow Creek, stormwater conveyance structures were built and large areas of barren land and contaminated soil were reclaimed with coversoil and vegetation. Stormwater channels and detention ponds were placed in critical areas to minimize erosion and reduce the release and transport of contaminants from historic mining areas. This was accomplished, in part, by routing stormwater runoff from the upper east portion of Butte Hill to the Berkeley Pit. Runoff from Missoula Gulch (west-central portion of Butte Hill) was captured and routed to a series of three sediment catch basins (detention basins) prior to discharge to Silver Bow Creek.

Waste removal and land reclamation response actions on Butte Hill, implemented to address human health risks, have also greatly reduced the entrainment and transport of metal laden sediments to Silver Bow Creek during storm events. Constructed vegetative coversoil caps act as barriers, preventing the contact of waste materials with stormwater, minimizing contaminant transport.

Response actions were also implemented to address human health risks associated with potential exposures to contaminated railroad bed materials. Throughout the BPSOU, metals-contaminated railroad beds were removed or capped in-place. These caps also aided in meeting the goal of controlling stormwater runoff by providing a protective barrier that reduced off-site migration of contaminated sediment and transport to Silver Bow Creek.

The remedy calls for continued reduction of contaminants entering Silver Bow Creek during stormwater runoff events through implementation of a Stormwater Management and Best Management Practices (BMPs) program over the next 10-15 years.

Metro Storm Drain Channel Reconstruction

Consistent with remedial goals noted above, EPA granted ARCO approval to reconstruct the Metro Storm Drain channel in a manner that is intended to improve water quality in Silver Bow Creek during base flow and storm flow conditions in 2003. The reconstructed channel is designed to minimize the discharge of contaminated groundwater to the channel (using a subsurface groundwater capture system) and to prevent stormwater from contacting tailings and other waste material as it is conveyed through the Metro Storm Drain. The reconstruction of the Metro Storm Drain channel was completed in 2005. Today, captured groundwater is conveyed via pipeline for combined treatment with groundwater captured at Lower Area One. This has greatly reduced contaminant loading to Silver Bow Creek.

Groundwater Control, Capture, and Treatment System

As previously discussed, the key to achieving surface water quality standards during base flow is to prevent contaminated groundwater from discharging to Silver Bow Creek – separation of surface water and groundwater. There are two groundwater capture and control systems, one along Silver Bow Creek and one in the Metro Storm Drain.

The routing of flows is shown in the schematic in Figure 7. Here, the Metro Storm Drain collection system and the Silver Bow Creek hydraulic control systems are shown along with their separation from surface water. Groundwater collected in the Metro Storm Drain is pumped to the hydraulic control channel to manage and treat contaminated water in one location.

To protect Silver Bow Creek, the invert (bottom) of the reconstructed channel was elevated to ensure the creek remained a "losing reach" (i.e., surface water infiltrates to groundwater, rather than groundwater discharging to surface water). A hydraulic control channel was constructed to capture and route contaminated groundwater. Four large open areas were left un-backfilled to facilitate hydraulic control and capture of groundwater (Figure 7).

Mining Cleanup

Capture & Control

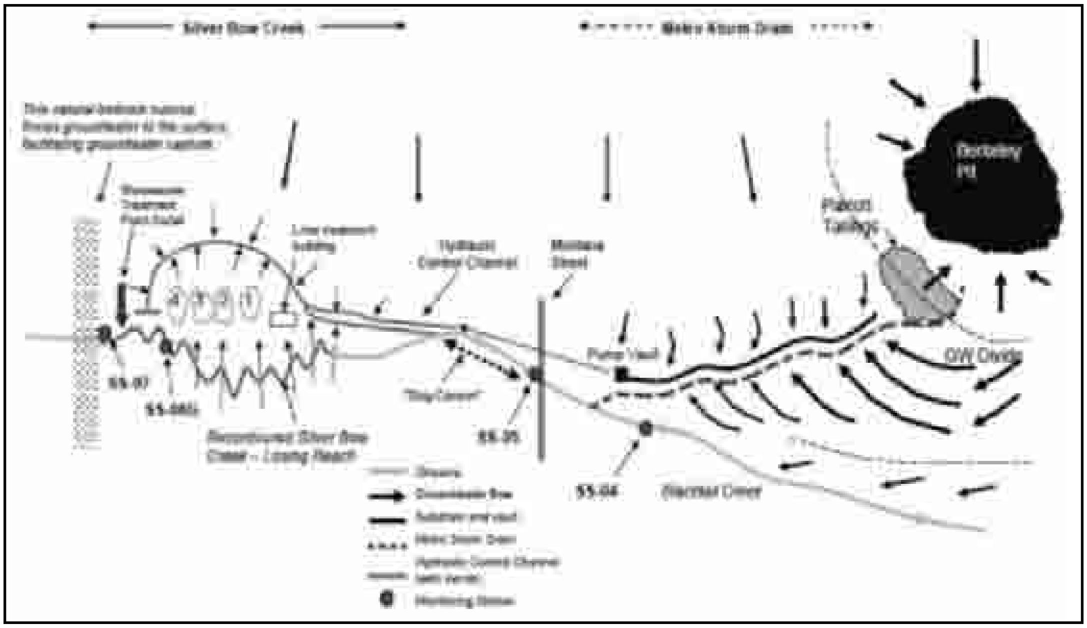


Figure 7. Schematic showing the hydraulic control, capture, and treatment system for alluvial groundwater along the Silver Bow Creek floodplain (not to scale). Key surface water monitoring stations are also shown.

Hydraulic Gradient

Water surface elevations in the open areas and hydraulic control channel are maintained at a lower elevation than Silver Bow Creek to maintain the hydraulic gradient away from the creek. A typical cross section of the former Colorado Tailings area is shown in Figure 8. One of the four open areas was re-contoured and subdivided into separate lagoons to conduct a treatability study to test the "Treatment Lagoons in a Wetland Setting" technology (described below).

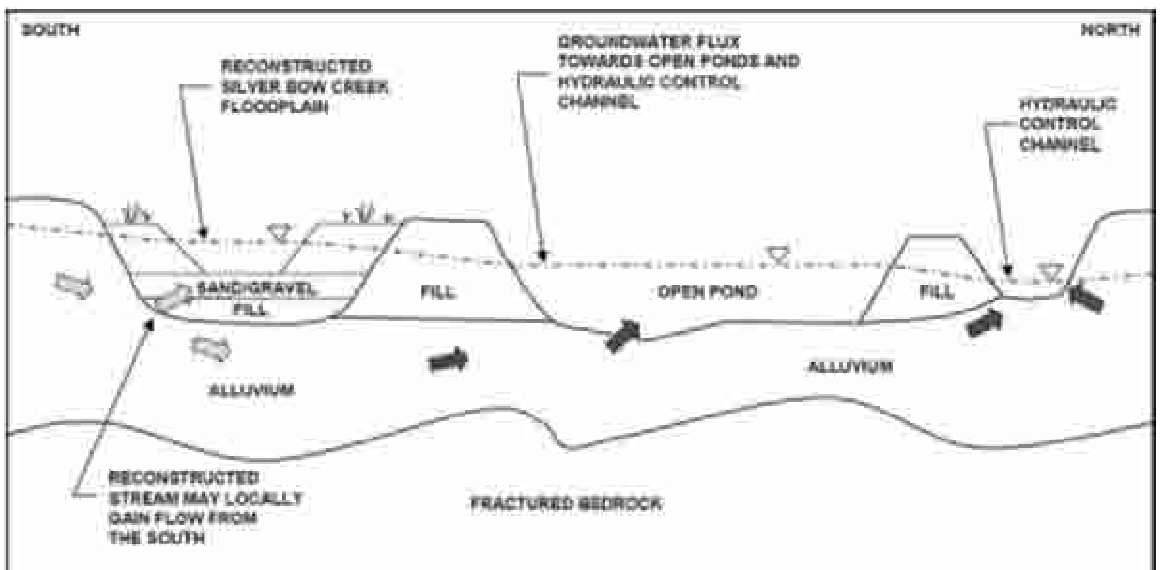


Figure 8. Cross section of the reconstructed Silver Bow Creek channel in relation to the open ponds and hydraulic control channel showing relative water surface elevations to be maintained (modified from PRP Group 2002, not to scale).

Infrastructure Constraints

In the Metro Storm Drain, separation of surface water and groundwater was also a challenge due to infrastructure constraints – the surface water and groundwater conveyances needed to follow the existing channel. A subdrain (i.e., perforated pipeline) was constructed in the invert of the Metro Storm Drain channel to collect groundwater that formerly discharged as surface water to the channel. The subdrain was covered with geotextile and the channel was cleaned out and reclaimed to convey stormwater flows (see Figure 9, next page).

Mining Cleanup

Metro Storm Drain

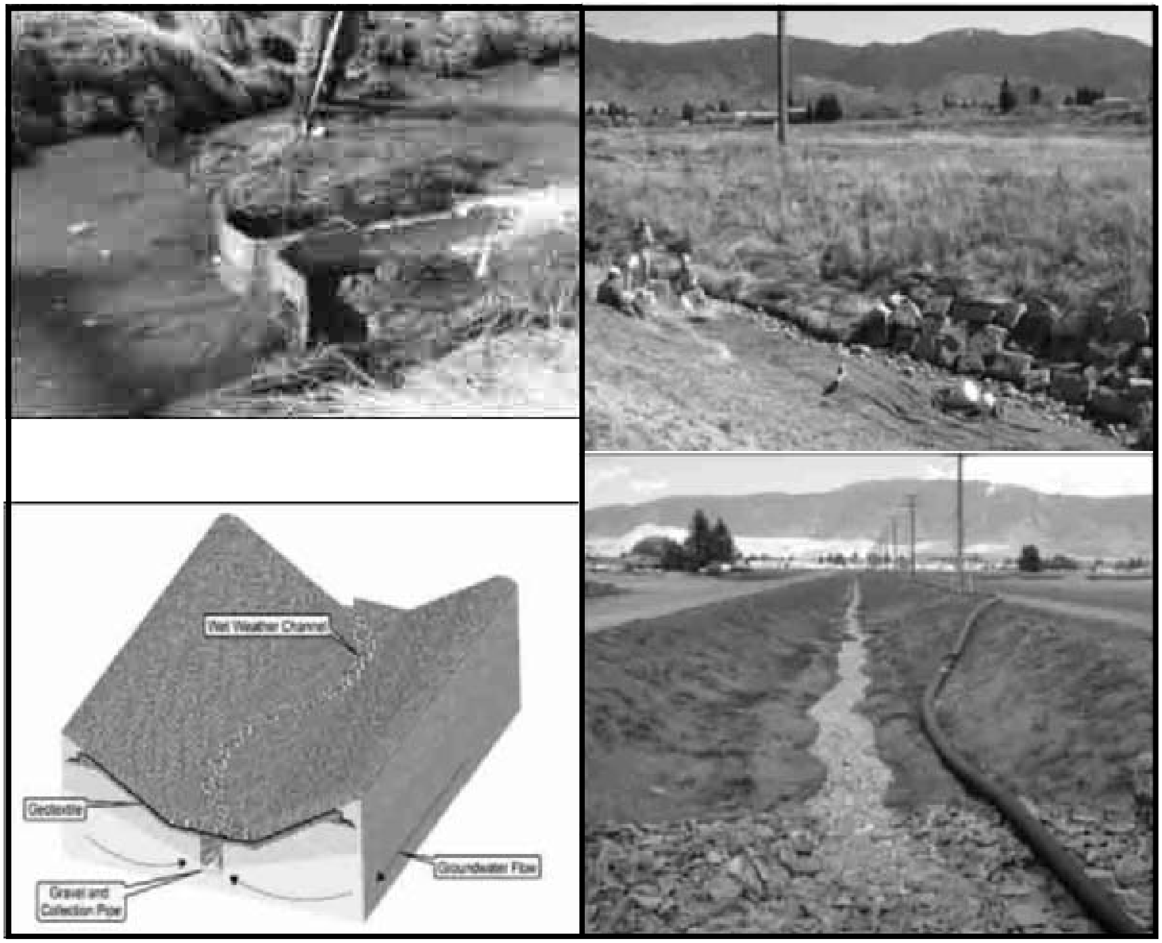


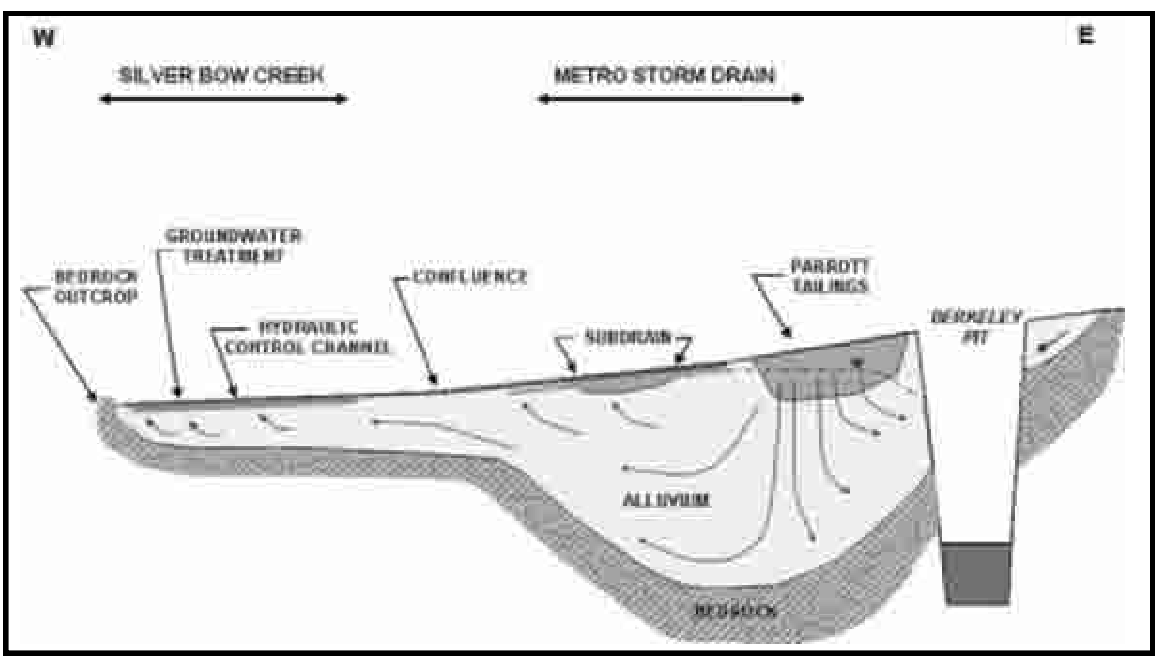
Figure 9. Metro Storm Drain prior to reconstruction (upper left). The remaining three pictures show the reconstructed channel and subdrain. Infrastructure constraints are evident in the lower right photograph.

Groundwater Movement

Both of these systems are made more effective by the shallowing of the bedrock from east to west, which forces alluvial groundwater to the surface. Also, the flux of contaminated groundwater is lessened in the upper Metro Storm Drain due to the groundwater divide created by the Berkeley Pit cone of depression (see Figure 10).

Figure 10
Groundwater Divide

Cross section showing general groundwater flow paths as they are directed to the groundwater capture systems (vertically exaggerated, not to scale). Shallowing and outcropping of bedrock at the west end of the site forces groundwater to the surface, facilitating groundwater capture.



Mining Cleanup

Groundwater Treatment

To be protective of surface water, alluvial groundwater from the Metro Storm Drain and Silver Bow Creek will need to be captured and treated indefinitely. Since completing the initial phase of the waste removal and reconstruction of Silver Bow Creek floodplain in 1998, ARCO has performed a treatability study to assist in the selection of groundwater treatment methods.

The treatability study was conducted in a series of three unlined lagoons designed to remove metals from the contaminated groundwater captured by the hydraulic control channel and open water areas. The treatment system utilizes a lime (calcium hydroxide) addition to modify the pH and chemistry of influent water to reduce metal solubility. Treatment within the lagoon system is accomplished primarily by lime precipitation (formation of metal hydroxide solids). An additional parallel set of three lagoons was constructed in 2001 to increase capacity, supplement treatment in the original lagoons, and for independent use when maintenance is required on the original lagoons (see Figure 11).

Groundwater Routing

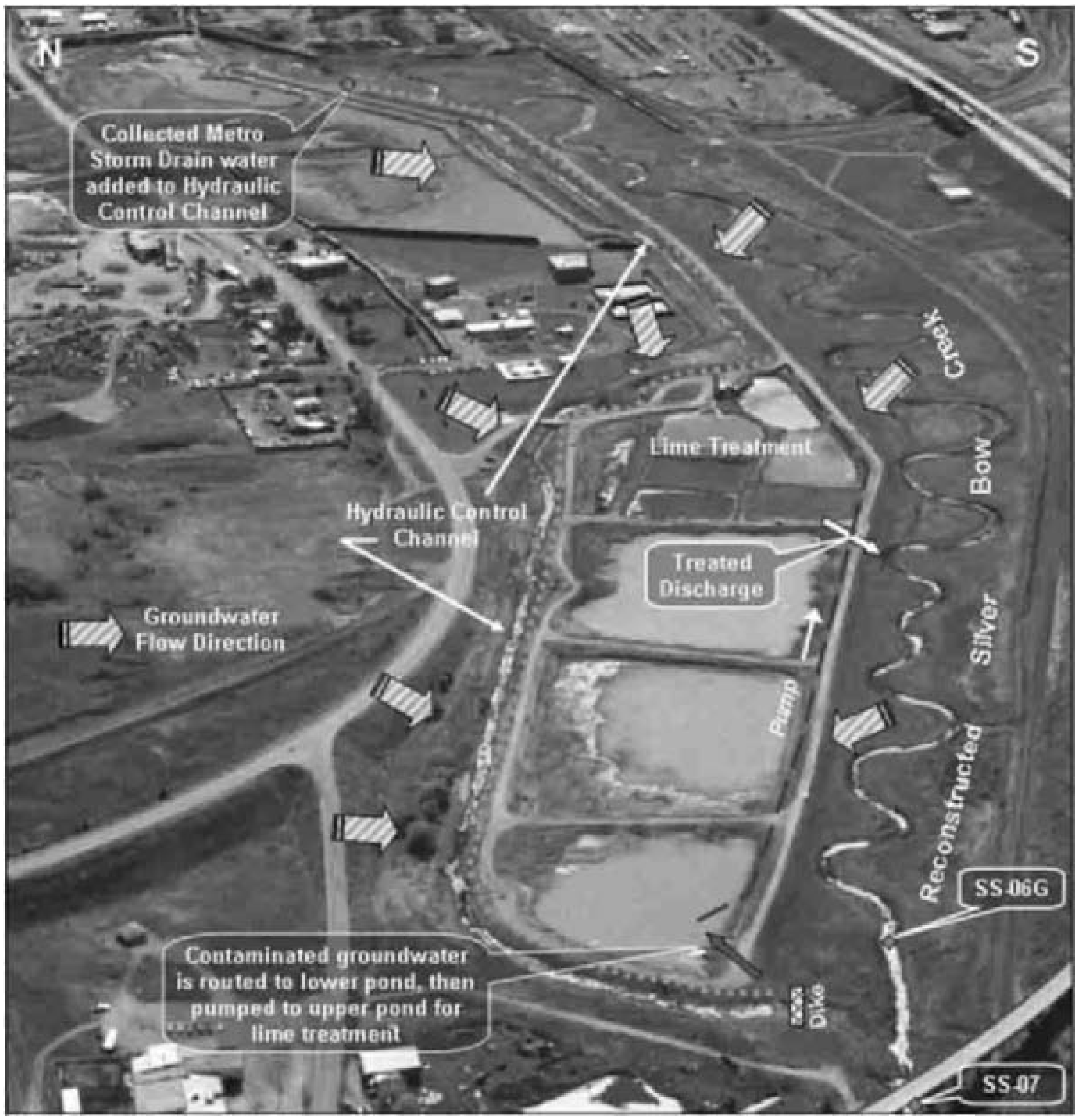


Figure 11. Routing of captured groundwater, treatment, and discharge to Silver Bow Creek.

Study Results

The study showed that the lagoon system was generally capable of effectively treating influent waters to achieve discharge standards during periods of normal operation, but it is uncertain whether effective treatment can be maintained through periods of lagoon maintenance (e.g., when sludge/ sediments are removed). Therefore, the final remedy requires construction of a conventional lime treatment plant, unless further demonstrations show effective treatment through periods of maintenance.

Mining Cleanup

Surface Water Quality Data

Figures 12 and 13 show water quality data in Silver Bow Creek downstream of Butte since 1993, prior to major remedial actions. Copper and zinc data are shown because they are the primary stressors to aquatic life in Silver Bow Creek (particularly copper). Remedial action milestones are also shown on the graphs. Montana water quality standards for copper and zinc are based on total recoverable concentrations. An obvious improvement in water quality is apparent. Monitoring station SS-07 is shown as the "downstream station" in Figure 5 and is shown on Figure 7. Station SS-06G is shown in Figure 7 and Figure 11 above.

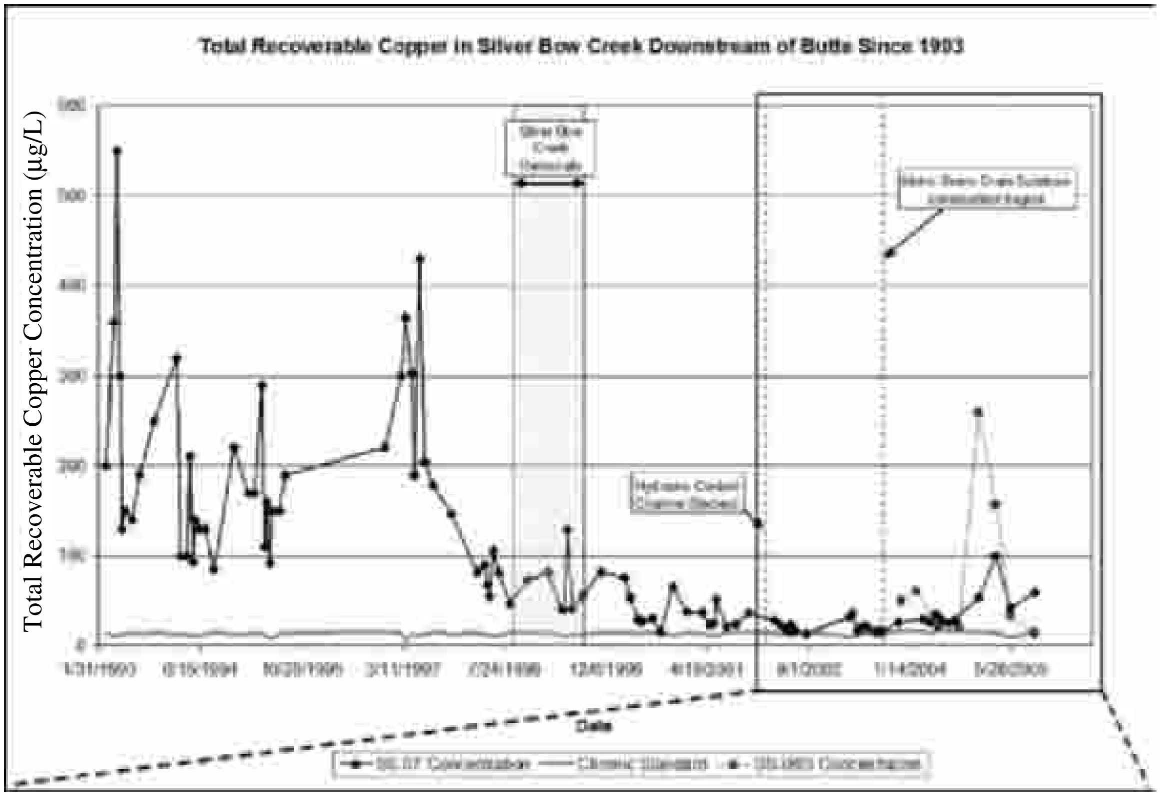


Figure 12
Total recoverable copper concentrations in Silver Bow Creek downstream of Butte along with remedial action milestones. Station SS-07 has been monitored since the 1980s and includes impacts from the wastewater treatment plant. After reconstruction of Silver Bow Creek, station SS-06G was established just upstream of SS-07 and the wastewater treatment plant effluent. (Data from USGS and ARCO 2005a,b,c)

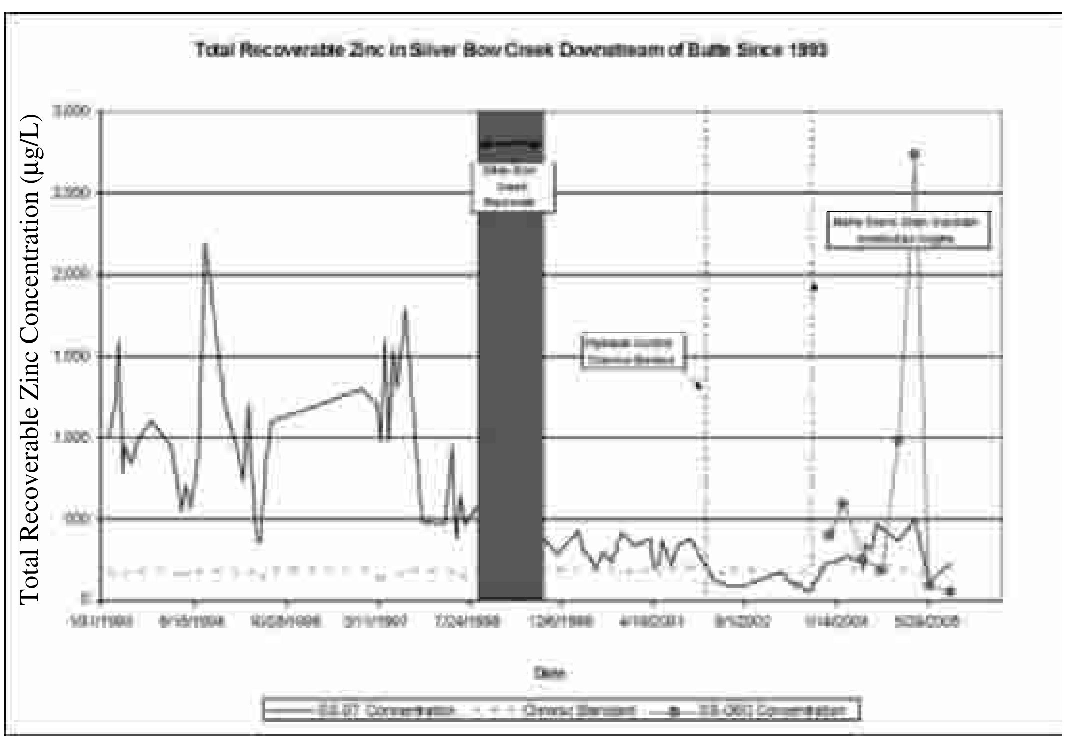


Figure 13
Total recoverable zinc concentrations in Silver Bow Creek downstream of Butte along with remedial action milestones. Station SS-07 has been monitored since the 1980s and includes impacts from the wastewater treatment plant. After reconstruction of Silver Bow Creek, station SS-06G was established just upstream of SS-07 and the wastewater treatment plant effluent. (Data from USGS and ARCO 2005a,b,c)

Mining Cleanup

Tailings Impact

The first improvement in water quality can be seen immediately after the removals in the Colorado Tailings and Butte Reduction Works (1997), largely because the creek was no longer flowing directly through the Colorado Tailings. After the removal, groundwater was directed away from Silver Bow Creek for collection in the hydraulic control channel. However, the captured groundwater was discharged back to Silver Bow Creek just upstream of station SS-07. Only a portion of the contaminated water was diverted for use in treatability studies. Therefore, surface water quality was still impacted by contaminated groundwater.

Treatment Lagoon

In 2002, ARCO expanded the treatment lagoon system to handle all of the flow being collected by the hydraulic control channel at Lower Area One. This is noted on the graphs as the blocking of the hydraulic control channel, and its effect can be seen in Figures 12 and 13 as another drop in concentrations. This step alone was nearly enough to achieve water quality standards as measured at SS-07. However, contaminated groundwater from the Metro Storm Drain was still not controlled.

Wastewater Impact

Prior to remedial actions, contaminant contributions from tailings deposits and alluvial groundwater were clearly much greater than those contributed by the wastewater treatment plant. However, after 2002, the relative importance of the contribution from the wastewater treatment plant was becoming more significant to water quality as measured at SS-07. The wastewater treatment plant increases the flows in Silver Bow Creek by roughly 50 percent. Prior to 2002, the wastewater treatment plant discharge was most likely having a dilution effect on concentrations as measured at station SS-07. After 2002, discharge from the wastewater treatment plant complicates interpretation of the data at SS-07. The data do not clearly show the impacts of remedial actions. Thus, stream concentrations at station SS-06G, just upstream of the wastewater treatment plant discharge, were added to the evaluation because they are a more accurate measurement of the impact that remedial actions have had on Silver Bow Creek. On Figures 12 and 13, water quality data as measured at station SS-06G are included for comparison against SS-07. These data show that concentrations in Silver Bow Creek were still above water quality standards at SS-06G, even though concentrations at SS-07 were at or below standards.

Subdrain Impact

The Metro Storm Drain subdrain construction began in 2003. Concentrations of copper and zinc in Silver Bow Creek show a marked increase during fall 2004 and winter 2005 due to increased sedimentation from construction activity in the Metro Storm Drain. In spring 2005, collected groundwater from Metro Storm Drain was routed to the treatment lagoon system for treatment. This is shown as an obvious decrease in concentrations as measured at station SS-06G. At station SS-07, the impact from the removal of Metro Storm Drain groundwater is not clear.

Copper Concentrations

The reduction in Silver Bow Creek dissolved and total recoverable copper concentrations are also shown in Figure 14. These graphs show concentrations from quarterly sampling conducted in May and September 2005, before and after rerouting of Metro Storm Drain groundwater (ARCO 2005c). The stations shown on the graphs are established monitoring stations from upstream to downstream and show how water quality is changing as it flows downstream through Butte. Key inputs and location information are shown on the graphs.

Concentrations measured at SS-06G show a clear decrease to near or below water quality standards. Dissolved copper concentrations decreased to be below water quality standards for the entire stream reach. Total recoverable copper was still slightly above the standard in the middle reach of the creek, but was below the standard at SS-06G.

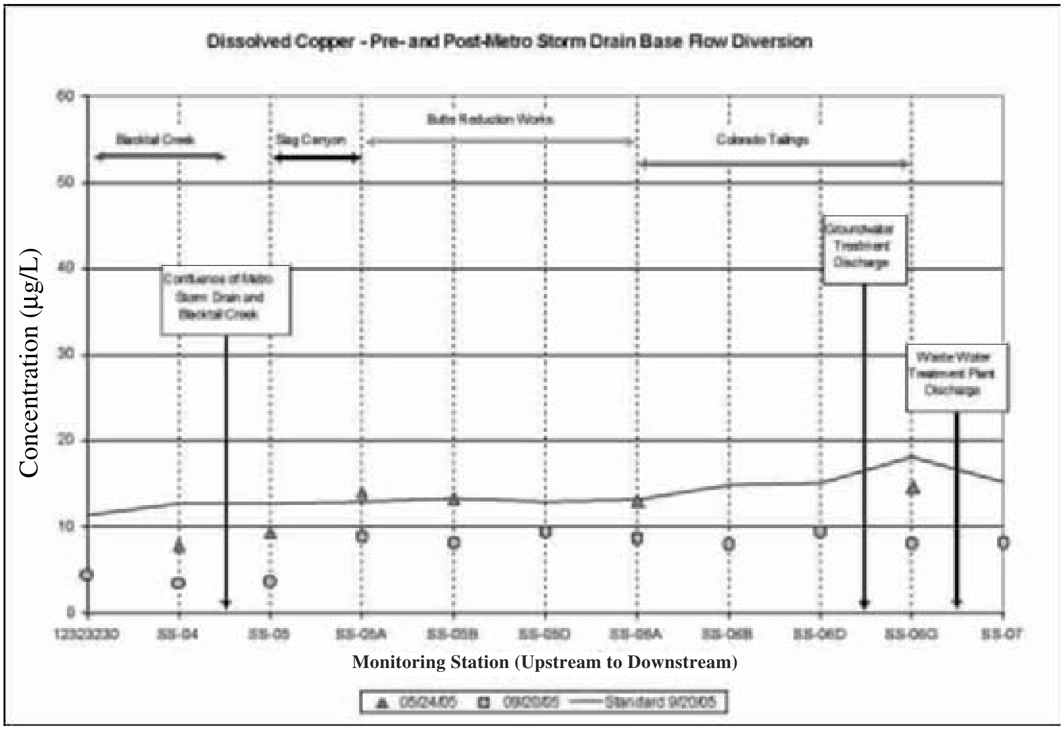
Slag Canyon

After diversion of the Metro Storm Drain groundwater, dissolved concentrations show very little change from upstream to downstream. This is the result anticipated — dissolved concentrations should roughly equal upstream concentrations in Blacktail Creek if all of the groundwater were being captured and treated. Notice that some increases in total recoverable concentrations were measured through the middle reaches of the creek. These increases are likely due to streambank and stream sediment wastes along the "slag canyon" between Metro Storm Drain and the reconstructed Silver Bow Creek channel that have not yet been addressed, but will be removed as part of the final CERCLA remedy.

(continued)

Mining Cleanup

Wastewater Treatment Contribution



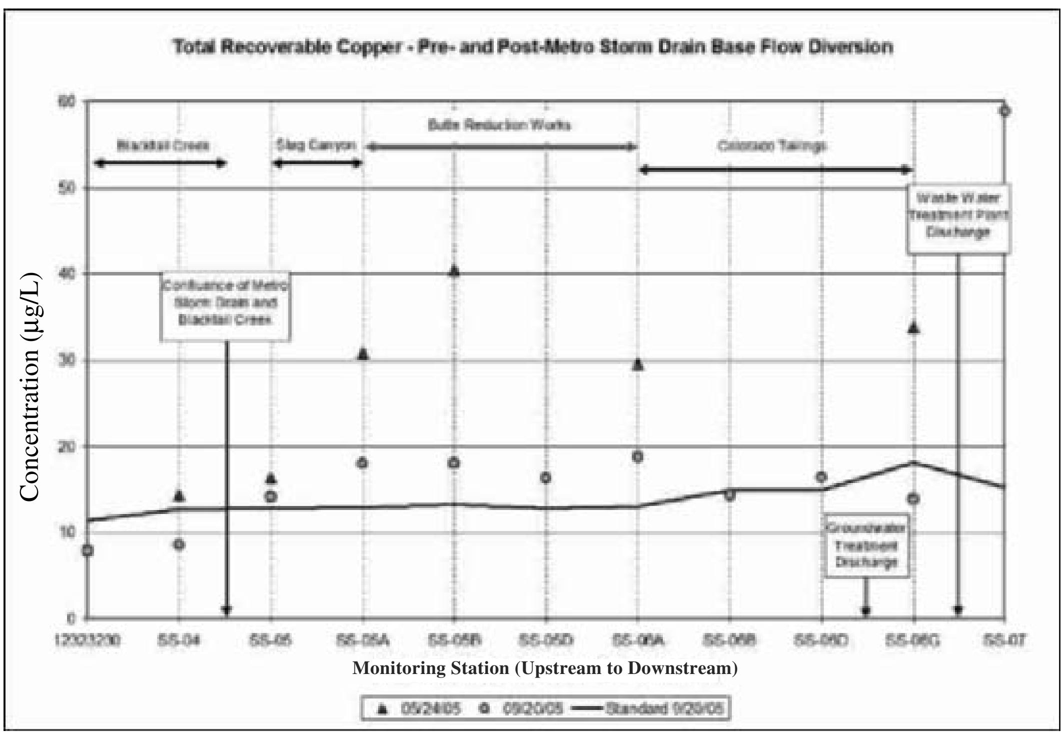


Figure 14. Dissolved and total recoverable copper concentrations from May and September 2005 from upstream to downstream through Butte (Data from ARCO 2005c)

These figures also show the relative contribution of the wastewater treatment plant. During the September 2005 sampling event, total recoverable concentrations exceeded water quality standards as measured at SS-07. Because concentrations were below standards just upstream at SS-06G, this increase would be due to the contribution from the wastewater treatment plant.

Mining Cleanup

Groundwater Remediation

Remedial Options

Alluvial Aquifer

Aquifer Matrix

Adsorbed Contaminants

Cost Effectiveness

Waste Volume Dependent

Decision Factors

TECHNICAL IMPRACTICABILITY WAIVER

As the surface water data presented have shown, capture and treatment of contaminated groundwater prior to its discharge to surface water has been highly effective and is necessary for the long-term protection of surface water quality. However, this strategy does not directly address remediation of the groundwater itself. EPA's preferred remedy does not include any further large-scale waste removal actions with the objective to improve groundwater quality. Given all of these factors, EPA is proposing a technical impracticability waiver for groundwater Applicable and Relevant or Appropriate Requirements (ARARs). Treatment in perpetuity alone without active measures to remediate the aquifer itself has been highly controversial. EPA's guidance regarding Technical Impracticability Waivers can be reviewed at their website: www.epa.gov/superfund/resources/gwdocs/techimp.htm

Remedial alternatives evaluated for the aquifer in the feasibility study process were no removals, several possible partial removals, and total removal of all source materials. EPA reached the conclusion that the alluvial aquifer could not be remediated to the degree that groundwater would meet ARARs within a reasonable time frame, *even if buried waste materials were totally removed from the area*. The total removal of all sources of groundwater contamination is not feasible (due to enormous volumes and infrastructure constraints) and, more significantly, the remediation of the alluvial aquifer itself is not technically practicable. The remedy for groundwater was the outcome of much study over more than a decade, as well as experience gained from active "pump and treat" type remedies at Superfund sites around the country. Despite these conclusions, EPA was able to craft a remedy that protects human health and the environment from contaminated groundwater and protects other downstream CERCLA operable units in the Silver Bow Creek and Clark Fork River watersheds.

The conclusion that the aquifer itself was technically impracticable to remediate was based on site-specific hydrogeology and contaminant transport investigations. These investigations have been extensive and details can be found in the EPA administrative record for the BPSOU. In short, the aquifer matrix is heterogeneous (made up of discontinuous layers of sand, silts, and clays), and heavy metal contaminants adsorb (bind) strongly to the aquifer matrix, making them difficult to flush from the aquifer. The existing groundwater contamination has had over 100 years to work its way into and through low permeability layers. This type of contamination cannot be removed by pump and treat in a reasonable period of time. The native material is so contaminated with adsorbed metals that it is also a source of contamination to groundwater. These adsorbed contaminants will continue to bleed off into the groundwater for the foreseeable future. (Note: When referring to groundwater remediation, the term "adsorb" refers to a specific chemical process by which the contaminant of concern adheres to the surface of silts, or clays. By contrast, absorb means to take something up or in, such as a sponge soaking up water. Certain heavy metal contaminants will strongly adsorb to silts and clays in an aquifer, which makes them difficult to remove from the aquifer.)

Conservative estimates (best case scenarios) for aquifer cleanup ranged from many centuries to thousands of years. It was concluded that, even under a total removal scenario, heavy metal contaminants could not be flushed from the aquifer to the point where the aquifer would be suitable for domestic use.

The cost-effectiveness of a total removal remedy is further reduced by a common acknowledgement that capture and treatment of alluvial groundwater would still be required over the long-term, even if source areas are removed. Long-term cost estimates for groundwater treatment were evaluated based on a best case scenario potential reduction of contamination in the water. It was found that the cost to treat the groundwater varied very little whether it remained contaminated (i.e., no removal action) or if contamination was reduced (i.e., groundwater concentrations decrease somewhat after a removal). Long-term treatment costs are much more dependent on the volumes of water that must be managed and treated. Thus, from the treatment perspective, little or no savings in treatment cost was gained if the groundwater concentrations decreased after a removal action.

By statute, EPA also had to consider additional modifying and balancing criteria beyond those discussed above. Contaminated groundwater in the BPSOU must be viewed with respect to the other overwhelming practicality, socioeconomic, and implementability issues. The floodplain has become a significant corridor for infrastructure (pipelines, roads, utilities, etc.), which would all have to be avoided (or destroyed and replaced) in a removal action. Significant volumes of waste would need to be left in place to avoid this infrastructure. It is also likely that additional unknown waste materials would be found and a conscious decision would need to be made to either increase the scope of the removal or leave them in place. A business district overlies major deposits of waste in the Metro Storm Drain – these businesses would incur economic hardship if commerce were disrupted by an extensive removal action. The fact that a removal would be highly disruptive to Butte citizens, and that very little benefit would be realized with a large scale removal action, led to the decision to leave waste in place.

Mining Cleanup

Threshold Criteria

Practicability of Removal

External Costs

Effectiveness Uncertain

Remedy Selection

ARARs

"Waivers"

Groundwater Treatment Effective

THE ARARS QUANDARY AT "MINING MEGASITES"

The National Research Council (NRC) performed an in-depth review of the Superfund process as it has been applied to the Bunker Hill/Coeur d'Alene River Basin in Idaho, a so-called "Mining Megasite" (NRC 2005). Similar to the Clark Fork River Basin, the Coeur d'Alene River Basin has been impacted by mining and mineral processing wastes. In particular, the NRC report indicates that at these "mining megasites," the threshold criterion of strict compliance with ARARs (numerical standards) is generally not a realistic objective.

Concerning the practicality of complete removal, the NRC report (page 313) concludes:

> The most obvious problem with "cleaning up" megasites such as the Coeur d'Alene River Basin is the massive quantities of contaminated waste materials (including waste rock, tailings, and tailings-contaminated sediments) that cover a large geographic area in a variety of upland, wetland, and aquatic environments. This complexity and volume of contaminated material practically eliminate the potential to completely remove, cap, and treat the contaminated materials, and make practical and effective remedies very difficult to design and implement. Indeed, the volume of mining wastes present in the Coeur d'Alene River Basin is so large that it is doubtful that complete removal can ever be attained. As indicated in Chapter 3 [summary of the Coeur d'Alene system], there are more than 100 million cubic yards of contaminated materials in the basin, much of which underlies buildings, roads, and railroads. Even if there were sufficient money and consensus to remove all these materials, it would be very difficult to find a place to put them where they would not create a threat of recontamination.
>
> Even the limited removals proposed for OU-3 will be costly, difficult, and disruptive. In some cases (particularly the removals proposed to protect fish and wildlife), they may not even be feasible. The extent to which proposed remedial measures would reduce dissolved metals concentrations in the river is unclear. And, the proposed removals can generate significant external costs in the form of large numbers of truck trips and associated road maintenance, noise, traffic, and accidents and will affect local populations and infrastructure over many decades. (end quote)

Certainly there are differences between the situation at the BPSOU and the Coeur d'Alene River Basin, but the similarities are significant. The volume of waste and mixed waste that is widespread and inaccessible under roads, railroads, buildings and other infrastructure is similar to the BPSOU. Also, any large removal activities would similarly incur significant disruption and external costs, with a similar uncertainty regarding thoroughness and effectiveness. The NRC also points out that even if there were sufficient money and consensus to remove the contaminated materials, the effectiveness in reducing dissolved metal concentrations in the Coeur d'Alene River is unclear. This is very applicable to the BPSOU situation: the effectiveness of source removal is highly uncertain.

Concerning the threshold criteria of compliance with ARARs, the NRC report (page 316) suggests:

> Although not unique to megasites, some of the criteria for remedy selection under Superfund make the process more difficult, at least as they are usually interpreted. The threshold criteria, according to the NCP are to: "protect public health and the environment"; and "satisfy ARARs." Any proposed remedy must meet these threshold criteria. In the case of the Coeur d'Alene River Basin, EPA's modeling studies indicate that hundreds of years will be required to meet these goals, regardless of how much remediation is performed. Unless one envisions a remediation program lasting for several centuries, one must question whether these types of ARARs are appropriate for remedy selection. Villa (2003) refers to this as "Perhaps the most intractable problem for ecological protection":
>
>> Now, here's the rub: if CERCLA requires remedies to attain ARARs, and ARARs for the Coeur d'Alene River Basin remedy include water-quality criteria, yet such criteria could not be met for less than 200 years at best, how can CERCLA be satisfied? The answer lies in the inherent flexibility of the Superfund statute and its implementing regulations. The statute itself authorizes ARARs "waivers" in specified circumstances. However, these waivers only apply to satisfaction of ARARs. There is no statutory waiver for the other threshold criterion of protecting human health and the environment. In the Coeur d'Alene River Basin, not only are water-quality criteria exceeded, but the aquatic life intended for protection by such criteria are also at risk. Therefore, waiving the ARARs in this case would offer no relief from the independent statutory obligation to protect the environment. (end quote)

The ARARs analysis described in these paragraphs applies directly to the situation faced in Butte concerning the alluvial aquifer along Silver Bow Creek. In the case of the BPSOU, however, capture and treatment of groundwater can be protective of the environment.

While it is highly uncertain that any degree of removal action in the alluvial aquifer will achieve ARARs in groundwater, the situation in Butte is fortunate because controlling, capturing, and treating groundwater can greatly improve water quality and thereby restore ecological function in Silver Bow

Mining Cleanup

Creek in the BPSOU during normal flow conditions. This, along with other BPSOU remedy components and the reconstruction of the stream channel, is restoring ecological function to the creek. This is a fantastic success given the magnitude and complexity of the Butte site.

FUTURE OF SILVER BOW CREEK IN BUTTE

Remaining Challenges

Although reduced from historic highs, significant exceedances of water quality standards still occur during periods of runoff from Butte Hill. The in-stream contaminant concentrations for wet weather flow have not been reduced by the same magnitude as those for base flow. However, the total volume of contaminants reaching Silver Bow Creek from wet weather has been reduced by diverting much of the runoff to the Berkeley Pit and by removing metals laden sediments in catch basins. Stormwater will be further addressed through a rigorous diagnostic monitoring program to identify and remedy remaining areas contributing contaminants to stormwater.

Berkeley Pit Discharge

Beneficial Dilution

In the near future, treated water from the Berkeley Pit will be discharged to Silver Bow Creek. At full capacity, the discharge will effectively double the flow in Silver Bow Creek through Butte. In effect the Berkeley Pit treatment plant will treat all of the water that Silver Bow Creek once carried before mining activities and dewatering obliterated the upper portion of the watershed. It is anticipated that this extra volume will be beneficial to Silver Bow Creek. The discharge will provide some dilution capacity to Silver Bow Creek because the discharge must meet water quality standards, which will allow Silver Bow Creek to better assimilate wet weather flows.

SUMMARY

Alluvial Groundwater

Actions taken to date have dramatically improved base flow water quality in Silver Bow Creek (in Butte, Montana) to the point where metal concentrations are starting to meet Montana water quality standards. This is a significant achievement that was not believed possible when remedial investigations were initiated in the 1980s. Apart from massive waste removals and stream reconstruction, success is primarily due to effective control, capture, and treatment of alluvial groundwater. Metal concentrations should be further improved as removals of contaminated streambank and stream sediments through the "slag canyon" between the Metro Storm Drain and reconstructed Silver Bow Creek channel are completed.

Aquifer Remediation Impracticable

A tradeoff in the success of the surface water component of the remedy is the conclusion that the aquifer is technically impracticable to remediate, regardless of the extent of waste removals performed. This has resulted in a controversial decision to leave wastes buried in the floodplain. Fortunately, the designated remedy protects human health and the environment from contaminated groundwater within the BPSOU and protects other downstream CERCLA operable units in the Silver Bow Creek and Clark Fork River watersheds.

For Additional Information: Angela Frandsen, CDM, 406/ 441-1400 or email: frandsenak@cdm.com
Angela Frandsen is an Environmental Engineer in the Helena, Montana office of the environmental consulting firm Camp, Dresser, and McKee (CDM). Her focus is on water quality, aquatic geochemistry/ contaminant fate and transport, remediation, and water treatment processes. With CDM, she provides technical support on the Butte Priority Soils Operable Unit site for the EPA Region 8 Montana Office, and has supported EPA in various capacities on many of the other Federal Superfund sites in Montana.

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WATER BRIEFS

INSTREAM SETTLEMENT WA

MUCKLESHOOT TRIBE

On March 28, the City of Seattle and the Muckleshoot Indian Tribe (Tribe) announced that they have reached agreement on a plan that insures long-term benefits for fish and wildlife in the Cedar River while providing water supply certainty for Seattle. The historic pact—which must still be approved by the City Council, the Muckleshoot Tribal Council and the federal district court—settles both a 2003 federal lawsuit over Seattle's withdrawal of water from the Cedar River, and a longstanding tribal claim over declining fish runs in the Cedar River / Lake Washington Basin.

In 2000, the US National Marine Fisheries Service and the US Fish & Wildlife Service issued permits allowing the City to operate its water supply and hydroelectric facilities on the Cedar River without incurring liability under the federal Endangered Species Act. The permits were based on the Seattle's Cedar River Habitat Conservation Plan (HCP), in which the City agreed to maintain specific water levels (instream flows) for the benefit of fish, plus a variety of other conservation measures.

In 2003, the Muckleshoot Indian Tribe filed a lawsuit against the National Marine Fisheries Service challenging the HCP and federal permit issued to the City of Seattle for operation of its Cedar River water project. The Tribe took that action due to its strong concern that water diversions from the Cedar River for municipal purposes would have serious adverse impacts on salmon and other natural resources that rely on the river. The City, the tribe, and the federal agencies agreed to mediate the dispute. In the course of that mediation they succeeded in resolving additional ongoing treaty disputes—including the effect of the City's operations on fish runs and tribal hunting access to the Cedar River Watershed for ceremonial and subsistence purposes. According to the Muckleshoot Indian Tribe, "Perhaps the most important aspect of the Agreement is that it expands and solidifies a much deeper government to government relationship between the City and the Tribe with respect to the use and management of the Cedar River Watershed."

The Settlement Agreement plan consists of three basic parts: instream flows; funding for fish and wildlife; and access for the tribe to the watershed to exercise its treaty rights of hunting and gathering.

Highlights of the agreement include:

- Guaranteed in-stream flows for fish in perpetuity
- Certainty for Cedar River water supply and system operations
- Protocols supporting the exercise of rights the Tribe reserved under treaties
- Cooperative plan for wildlife management; ten-year wildlife research program
- Protection of water quality for the region; continuing water conservation efforts; and creation of a City-Tribe framework to resolve future issues.

[See the Settlement Agreement (website below) for additional details]

Among other items in the detailed settlement agreement, the parties agreed on maximum amounts Seattle may divert. Beginning in 2031, the "Annual Average Diversion" of water from the Cedar River shall not exceed 124 **m**illion **g**allons per **d**ay (mgd) in any single calendar year. An additional 10-year average limit of 114 mgd Annual Average Diversion begins in 2051 and becomes a "rolling average" upon calculations in 2061. Interim diversion limits have also been agreed upon, starting at 105 mgd Annual Average Diversion. Seattle agreed to transfer the portion of its perfected water right claim that exceeds 124 mgd (Annual Average) to the State Water Trust for the purpose of providing instream flows. If Seattle fails or is unable to complete that transfer, the City must transfer that portion of its water right to the Tribe for instream flows upon the Tribe's request for such a transfer.

The final amount of the instream flow right to be transferred will be decided by a determination of the actual historic use of water by the City of Seattle (portion above 124 mgd to be transferred). It has been estimated that this amount should be at least 20-30 mgd, since Seattle has been using well over 148 mgd, while the final figure may be as high as 100 mgd (approximately 150 cubic feet per second).

Seattle also agreed to make a significant contribution for "Fishery Funding," with $5,000,000 to be paid to the Tribe no later than September 1, 2006 and $9,000,000 to be paid no later than December 31, 2015. Those funds "shall be in 2005 dollars and shall be adjusted annually for inflation or deflation, plus four percent (4%) annual interest, until paid." Agreement, page 18.

The Settlement Agreement includes transfer of over 1300 acres of land in fee simple to the Tribe or perpetual conservation easements for some parcels if a fee simple transfer is not possible (see Agreement, pages 19-20). The Agreement also provides that Tribal members will have access to the Cedar River Watershed (approximately 90,546 acres) for a number of purposes, including gathering traditional materials, carrying out traditional ceremonies, and hunting game animals.

For info: Rollin Fatland, Muckleshoot Indian Tribe, 206/ 442-1123; Andy Ryan, City of Seattle, 206/ 684-7688; Settlement Agreement is available at www.seattle.gov/mayor/PDF/060328PRmuckleshootAgreement.pdf

WATER BRIEFS

PURPOSE OF USE CHANGE CO

IRRIGATION TO DOMESTIC USE

The US Bureau of Reclamation's (Reclamation's) Western Colorado Area Office announced on March 23 that it has released a draft Environmental Assessment (EA) on a contract between the US and the Pine River Irrigation District (District) for the conversion of Pine River Project Water from irrigation to miscellaneous purposes. The EA evaluates a proposal to provide domestic water supplies to a rapidly growing population in the general area of southeast La Plata and southeast Archuleta Counties in Colorado. Under the proposal, a limited amount of the irrigation water stored in Vallecito Reservoir, the primary feature of the Pine River Project, would be converted for domestic and other uses. The draft EA was prepared by Reclamation in cooperation with the District to comply with the National Environmental Policy Act.

Written comments on the draft EA should be sent to the Bureau of Reclamation, Western Colorado Area Office, 835 E. 2nd Avenue, Suite 300, Durango, CO 81301. Comments may also be submitted by e-mail to ppage@uc.usbr.gov. Comments are due by Friday, April 28. Following the review period of this draft, a final EA will be prepared.

For info: Pat Page, Reclamation, 970/ 385-6560; Draft EA is available at www.usbr.gov/uc/wcao/ under Current Focus

PECOS RIVER LAWSUIT NM

ESA VIOLATIONS ALLEGED

A lawsuit has been filed recently in federal district court against the US Bureau of Reclamation (Reclamation or "BuRec") and the US Army Corps of Engineers (Corps) by Forest Guardians. The lawsuit alleges that the agencies have each violated the federal Endangered Species Act (ESA) by failing to utilize their full discretion to provide adequate flows for the endangered Pecos bluntnose shiner. Reclamation and the Corps collectively manage three reservoirs and four dams on the Pecos River.

The bluntnose shiner was first listed under the ESA in 1987. Forest Guardians maintain that the primary reason for the species' recent decline is that water managers have repeatedly allowed river drying and extremely low flows, in violation of the terms of a water plan issued in 2003. The complaint alleges that the agencies' actions adversely modify and destroy the shiner's designated critical habitat. "Specifically, the BuRec operates the Pecos River dams and reservoirs in such a way that the flow of the Pecos River is characterized by an extremely irregular and unnatural hydrograph with short periods of very high flows that occur during 'block releases'—made for the benefit of downstream irrigators—that alternate with long periods of critically low flows and river drying (or 'intermittency'). The USFWS has determined that both the block releases and the critically low flows and intermittency that are hallmarks of the BuRec's operations of the Pecos River dams and reservoirs 'are actions that adversely affect the bluntnose shiner and its critical habitat.'" Complaint, page 2.

The environmental group believes that there are solutions that can create more water needed for the species, including: 1) creating a large enough "fish conservation pool" in upstream reservoirs; 2) further modifying large volume block water releases to the Carlsbad Irrigation District to decrease the loss of juvenile fish and eggs and increase the longevity of flows in the river; 3) increasing water leasing agreements with farmers in the Fort Sumner Irrigation District to decrease farmers' diversion demands; and 4) acquisition of various ground and surface water rights by the State of New Mexico and Reclamation for instream flows in the Pecos River.

A copy of the complaint is available at Forest Guardians website: www.fguardians.org/legal/complaint-pecos-2006.pdf

For info: Steve Sugarman, 505/ 983-1700, Attorney for Forest Guardians, or website: www.fguardians.org

PESTICIDE BUFFERS OR

PARTIAL REMOVAL

Judge John Cougenhour of the US District Court in Seattle ordered the removal of the Oregon Coast Coho Salmon Evolutionary Significant Unit (ESU) from the list of waterways subject to pesticide buffer zones. The order was in response to a stipulation submitted on March 10, 2006, which was filed following the decision by NOAA Fisheries (announced February 17) that Oregon Coast coho would not be listed under the Endangered Species Act. That action effectively withdrew NOAA Fisheries' proposed June 2004 decision to list the species as threatened (TWR Water Briefs #24). All other ESUs, including the Southern Oregon/Northern California Coho ESU were unaffected by the order on pesticide buffers.

The buffer zones were initially established in 2004 through federal court action in the *Washington Toxics Coalition vs. Environmental Protection Agency* case (Beale, TWR #4 and Water Briefs, TWR #17). The Oregon Department of Agriculture currently maintains a website with information on the pesticide buffer requirements as a resource for pesticide applicators.

For info: ODA website: http://oregon.gov/ODA/PEST

GILA ADJUDICATION AZ

PRECLUSION OF CLAIMS

On February 9, the Arizona Supreme Court issued an order on an interlocutory appeal from the Gila River general stream adjudication, holding that a consent decree entered in 1935 in a federal court case precludes claims by the San Carlos Apache Tribe (Tribe) to additional water from the Gila River mainstem. The court decided, however, that the Tribe's claims for additional water from *tributaries* of the Gila River were not included in the 1935 decree and, therefore, can be pursued in the present adjudication proceeding. The consent decree from the earlier case came to be known as the Globe Equity Decree (1935 Decree).

The Gila River originates in western New Mexico and flows in a

WATER BRIEFS

general westerly direction across Arizona to its confluence with the Colorado River. The San Carlos Apache Reservation, established in 1872, borders the Gila River. The Gila general stream adjudication, under Arizona law, began in 1981 when the Arizona Supreme Court ordered a series of petitions consolidated into a single proceeding. See *In the Matter of the Rights to the Use of the Gila River* ("Gila I "), 171 Ariz. 230, 232-33, 830 P.2d 442, 444-45 (1992).

Arizona's legislature in 1995 directed the adjudication to focus on Indian and non-Indian federal water claims in the general stream adjudication for the Gila River. Accordingly, the superior court directed interested parties to file summary judgment motions as to whether claims raised by or on behalf of the Tribe in the general stream adjudication were precluded by the 1935 Decree. All the issues in the case "turn on the preclusive effect of the 1935 Decree" (Opinion, page 8). As noted by the court in its Opinion at page 11, "claim preclusion" is a legal doctrine that was "formerly referred to as res judicata."

Among other arguments, the Tribe maintained that the 1935 Decree adjudicated only its appropriative rights and not aboriginal or *Winters* Doctrine rights, while other parties claimed that the Decree adjudicated all claims of the Tribe to the mainstem. The court concluded: "Based on the language of the Complaint, the Amended Complaint, and the Decree, we conclude that all of the Tribe's water rights, under all theories, to the Gila River mainstem were placed at issue and resolved in the Globe Equity litigation. The Decree precludes all further claims to the mainstem of the Gila River by the parties to the Decree." Opinion, page 33.

The Tribe also raised the issue that it should not be bound by the 1935 Decree because it was not a party to the case. The United States had appeared on behalf of the Tribe in that case. Thus, the court had to determine whether the United States and the Tribe were in "privity" in the Globe Equity litigation such that the Tribe would be bound by the 1935 Decree. The court eventually decided that "while the Government may not have had authority to 'extinguish' the Tribe's right to water in the Globe Equity litigation, it possessed the power to 'represent [the Tribe's] interests in [the] litigation' in order to 'quantify [the Tribe's] reserved water rights.' *Truckee-Carson*, 649 F.2d at 1300."

The court also refused to consider arguments by the Tribe that the representation by the US government in the earlier case was "so inadequate as to prevent the presence of privity between the Tribe and the Government." (Opinion, pages 38-39). The Tribe asserted that the Government ignored the Tribe's substantial rights to Gila River water under the *Winters* doctrine, that there was a conflict of interest and that the Government attorneys were biased against the Tribe. Ultimately, the court based its decision primarily on the principle of "comity" and refused to consider the Tribe's arguments regarding the adequacy of counsel in the earlier case. Citing the Second Restatement § 78 cmt. a, the court found, "The principle [of comity] is that a court should not assume to disturb another court's disposition of a controversy unless there are good reasons for doing so." Opinion, page 44.

The San Carlos Apache Tribe has filed a Motion for Reconsideration.

For info: Complete Opinion, Interlocutory Appeal WC-02-0003-IR (Contested Case No. W1-206) available at the Arizona Supreme Court's website: www.supreme.state.az.us/opin/pdf2006/WC-02-0003-IR.pdf.

WETLANDS RESTORATION US

PROPOSED RULE

The US Environmental Protection Agency (EPA) and US Army Corps of Engineers (Corps) are proposing a new rule to ensure more effective wetlands restoration and preservation nationwide. The agencies' rule, which was published for public comment in the Federal Register on March 28, 2006, proposes improved science and results-oriented standards to increase the quality and effectiveness of wetlands conservation practices under the Clean Water Act (CWA) according to the EPA and the Corps' press release.

Increased reliance on innovative, market-based approaches is expected to promote the expansion of wetland banking, which is one of the most reliable and environmentally effective methods of wetland replacement. A wetland bank is a wetland, stream, or other aquatic resource area that has been restored and protected to offset permitted impacts to wetlands or other aquatic resources.

The agencies' press release also noted that the proposed rule is focusing on a watershed approach for improving wetlands conservation and that it combines accountability and flexibility. The proposed rule is designed to set clear science-based and results-oriented standards nationwide while allowing for regional variations, increase and expand public participation, and affirm the "wetlands mitigation sequence" requiring that proposed projects fully avoid and minimize potential wetland impacts.

The agencies noted that by focusing on results and accountability, the proposal would improve the quality and effectiveness of wetland replacement projects. The proposal establishes a "level playing field" ensuring that all forms of wetlands conservation satisfy the same high environmental standards, according to the March 27 press release.

For info: Dale Kemery, EPA, 202/ 564-4355, email: kemery.dale@epa.gov, or website: www.epa.gov/wetlandsmitigation; David Hewitt, Corps, 202/ 761-1807, or email: david.w.Hewitt@hq02.usace.army.mil

SILVERY MINNOW NM

SANCTUARY CONSTRUCTION UNDERWAY

On February 20, the first phase of construction began on a protected off-channel sanctuary for the endangered Rio Grande silvery minnow. The US Bureau of Reclamation, US Fish and Wildlife Service, City of Albuquerque and Middle Rio Grande Conservancy District are working together on the project in southwest Albuquerque. Senator Pete Domenici brought the

WATER BRIEFS

idea for the sanctuary to the group as all parties looked for ways to sustain the habitat for the silvery minnow.

The sanctuary was designed to mimic ideal river conditions. The channel near the river will provide breeding and rearing habitat for the minnow and protection from predator fish. Gates and fish screens will allow fish and eggs to be held in the channel and eventually released directly back into the river, with releases timed according to river conditions. Construction of the sanctuary is considered essential for successful protection of the Rio Grande silvery minnow. Albuquerque-based AJAC Enterprises Inc. has been contracted to construct the first phase, which includes part of the pump station and concrete work.

For info: Mary Perea, Reclamation, 505/ 462-3576, or website: www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=10321

COALBED METHANE MT/WY

INTERSTATE CONFLICT

An interstate conflict is brewing between Montana and Wyoming over water quality problems resulting from coalbed methane production. Montana's Board of Environmental Review (Board) on March 23 voted to protect Montana's existing water quality, by instituting a non-degradation policy. The new rule potentially impacts **c**oal**b**ed **m**ethane (CBM) producers upstream in Wyoming, who presumably will be forced to initiate additional control measures in regard to water discharged as a byproduct from their production methods. Montana's new non-degradation standard for its rivers, essentially extends upstream into Wyoming, where CBM producers were already being pressured to deal with water quality issues. (See Darin, TWR #3). Water quality rule changes approved in Montana, however, still must be submitted to the EPA for final approval. During that process, Wyoming officials are expected to assert that it is their environmental agency that maintains control over CBM discharges occurring in Wyoming.

The proposal did not pass in its entirety. The Board rejected the portion of the proposal that called for CBM produced water to be reinjected into shallow aquifers, stating that they did not have the legal authority to require reinjection. The Board postponed another aspect of the petition that would call for CBM producers to remove salts before discharging water into surface ponds or irrigating with it.

CBM development is a process to develop natural gas that requires the removal of methane gas from aquifers that are in the coal seams. The Powder River Basin in Montana, which includes the Tongue and Powder River drainages, is projected to host between 10,000 and 26,000 wells within the next two decades. The Tongue River alone drains 30,000 irrigated farm and ranch acres in southeast Montana. It provides the economic base for over 9,000 agriculture-related jobs in the Miles City area.

The CBM industry is also feeling pressure within Wyoming. Producers in Wyoming have been carving hundreds of new holding reservoirs and washing the water through upland ephemeral drainages. Ranchers in Wyoming are also concerned with impacts to surface water and groundwater from the large number of reservoirs and discharges from CBM wells. The Powder River Basin Resource Council (PRBRC) and nineteen northeastern Wyoming landowners petitioned the Wyoming Environmental Quality Council (WEQC) to amend Wyoming Department of Environmental Quality (WDEQ) rules to require "true" beneficial use of coalbed methane water that is discharged as a byproduct of the development process. They also asked that WDEQ begin addressing the critical issue of water quantity as a part of its mandate to regulate water quality. WEQC agreed to institute a rulemaking process to address the issues raised in the petition.

The petition states that "the [W]DEQ must manage CBM discharge water by recognizing that it is not generally being used; it is being disposed of. The exclusion [no water use permit required where there is no beneficial use] has become a loophole stretched so far that in application it has lost all relation to logic." Disposing of that water, PRBRC and the landowners argue, too often means flushing it down creek bottoms and draws that are normally dry during most of the year. The result is severe degradation of valuable grazing and forage grounds, loss of cattle crossings, and serious damage to groundwater and soils.

For info: Ray Muggli, Coal Bed Methane Task Force, 406/ 232-2058; Dan Feinberg, Northern Plains Resource Council, 406/ 248-1154

Montana Board of Environmental Review website: www.deq.state.mt.us/ber/index.asp

Powder River Basin Resource Council's website: http://www.powderriverbasin.org/cbm/index.htm

HYDRO RELICENSING OR/CA

KLAMATH FISH PASSAGE

On March 29, NOAA Fisheries (NOAA) and the Department of the Interior (DOI) jointly submitted preliminary fishway prescriptions for the relicensing of the Klamath Hydroelectric Project on the Klamath River. These preliminary prescriptions were developed after several years of careful analysis and interagency cooperation and include fish passage, both upstream and downstream, at PacifiCorp's Iron Gate, Copco I and II, J.C. Boyle and Keno dams.

PacifiCorp's FERC license expired on March 1, 2006, and until a new 30-50 year license is issued it will be operating on annual extensions of the existing license. The existing license contains no provision for fish passage.

The fishway prescriptions in this project area would restore 58 miles of habitat for chinook, steelhead, and lamprey, including 46 miles of habitat for the threatened coho salmon, and would improve connectivity for resident trout. Fish passage would also create the opportunity for the development and implementation of a reintroduction plan to return salmon, steelhead and lamprey to more than 300 miles of historic habitat above the project. The exclusion of these fish

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from the upper basin began with the completion of the first dam in 1918.

The Upper Klamath River, above Iron Gate Dam, historically supported the spawning and rearing of large populations of both anadromous and resident fish. Due to many factors in the watershed and in the Pacific Ocean, Klamath River anadromous fish populations are substantially diminished and, in some cases, struggling to survive. Safe, timely, and effective fishways at all hydropower and water diversion developments on the river are essential precursors to the eventual re-establishment of more robust and resilient fish populations.

NOAA Fisheries recommends that a number of specific measures be included in the license to improve habitat function and ecosystem integrity. These measures include: improvements to hatchery management and full marking of hatchery fish; improved flow and water quality conditions; parasite management and control; monitoring and other habitat improvements necessary to enhance the benefits of fish passage and mitigate for the impacts of the hydroelectric facility.

Meanwhile, the Pacific Fishery Management Council is on the verge of imposing severe restrictions, if not a complete ban, on salmon fishing off the coasts of California and Oregon to protect the declining run of chinook salmon from the Klamath River Basin. The Council is expected to make its decision on April 7.

For info: Steve Edmondson, NOAA Fisheries, email: Steve.Edmondson@noaa.gov

CALENDAR

Please Note: An extended Calendar containing ongoing updates now appears on The Water Report's website: www.thewaterreport.com. Subscribers are encouraged to submit calendar entries, email: thewaterreport@hotmail.com

April 17-19 WA
Lake Roosevelt Forum Annual Conference 2006, Spokane. For info: Lake Roosevelt Forum email: info@lrf.org

April 20 OR
Construction Defects: Water Intrusion & Other Calamities Seminar, Portland, World Trade Center. RE: Latest developments and Evolving Solutions to Construction Defects: Building Science, Insurance and Legal. For info: The Seminar Group, 800/ 574-4852, email: registrar@theseminargroup.net, or website: www.TheSeminarGroup.net

April 20-21 DC
International Environmental Law, Washington, DC, Hilton Embassy Row. RE: Multilateral Environmental Agreements, Kyoto Protocol, Chemicals Management, Living Modified Organisms, Genetic Resources, Emissions Trading, Liability Regimes, Land Conservation & Legal Developments in Emerging Markets. For info: Alexander Hart, American Law Institute-American Bar Association, 800/ 253-6397 or website: www.ali-aba.org/free

April 20-21 OR
Western Instream Flows Conference: "Restoring the Rivers of Lewis & Clark," Portland, Oregon Convention Center. RE: Instream Flows & Success? Speakers include Charles Wilkinson & Other Water Law, Science, and Policy Experts. For info: Oregon Law Institute, 800-222-8213 or website: www.lclark.edu/org/oli/objects/2006_Water_Savedate.pdf

April 20-21 WA
Land Use in Washington 2006, Seattle, Crowne Plaza Hotel. RE: Property Rights Initiative, GMA Updates, Governor's Land Use Agenda, Guidance on Critical Areas and BAS, Redesignation of Resource Lands, Urban Density, Shoreline Management Updates, ESA's Section 7 Consultation Requirements, Tribal Roles, Wetlands Case Law, Public Facilities Requirements, LUPA Procedural Pitfalls & Practice Tips from Regional Growth Hearings Board Members. For info: Law Seminars International, 800/ 854-8009, or website: www.lawseminars.com/

April 23-26 NM
Inspiring Global Environmental Standards and Ethics (NAEP 31st Annual Conference), Albuquerque. RE: Balancing Needs of the Natural & Human Environments, Finding Solutions. For info: Donna Carter, 863/ 679-3852, or website: www.naep.org/CONFERENCE05/Alexandria.html

April 24-27 OR
9th National Mitigation & Conservation Banking Conference, Portland. RE: Trends & Issues Surrounding Mitigation and Conservation Banking, Land Trusts & More. For info: www.mitigationbankingconference.com

April 25 OR
Selling Environmental Services to the Federal Government: Government Contract Assistance Program (GCAP), Northwest Environmental Business Council Breakfast & Seminar, Portland, Governor Hotel, 614 SW 11th Ave, 7am - 9am. For info: NEBC, 503/ 227-6361 or email: linda@nebc.org

April 26-28 AZ
Workshop on Molecular Modeling Fundamentals in Water Treatment Applications, Portal, Southwest Research Station. RE: Technical & Scientific Issues in Water Treatment, Wastewater Reclamation & Ultrapure Water Production. For info: Southwest Research Station website: www.desertwildlands.com/workshop/modelingworkshop.htm

April 27-28 NE
Nebraska Water Law, Lincoln, The Cornhusker Marriott. For info: CLE Int'l, 800/873-7130, or website: www.cle.com

April 27-28 WY
Wyoming Water Law, Cheyenne, Hitching Post Inn Resort & Conference Center. For info: CLE Int'l, 800/873-7130, or website: www.cle.com

April 27-29 AZ
Riparian Issues: Arizona Riparian Council 20th Annual Meeting, Flagstaff. For info: Cindy D. Zisner, ARC, email: Cindyu.Zisner@asu.edu, or website: http://azriparian.asu.edu/

April 28 MT
Tax Benefits of Conservation Easements, Missoula. For info: Bitter Root Land Trust, 406/ 375-0956

April 28 OR
Oregon Stormwater Conference, Portland. For info: Holly Duncan, Environmental Law Education Center, 503/ 282-5220, email: hduncan@elecenter.com, or website: www.elecenter.com

May 1-2 CAN
The Canadian Environmental Conference and Tradeshow, Toronto, Metro Toronto Convention Centre. RE: Environmental Engineering, Regulations and Compliance Issues. For info: Steve Davey, 905/ 727-4666, or website: www.canect.net

May 2 WY
Wyoming Water Forum Meeting, Cheyenne, State Engineer's Conference Rm, Herschler Bldg. 4E, 10am. RE: TBA. For info: Wyoming State Engineer's Office website: http://seo.state.wy.us/forum.aspx

May 2-4 CA
Environmental Impact Assessment & CEQA, Oakland, The Washington Inn. For info: Northwest Environmental Education Council, 206/ 762-1976 or website: www.nwetc.org/

May 3-4 WA
Restoring Greenspace: Ecological Reuse of Contaminated Properties in EPA Region 10, Conference, Seattle. The Wildlife Habitat Council is Partnering with EPA, NEBC, and others. For info, Website: www.wildlifehc.org/events/restoringgreenspace.cfm

May 3 OR
Selling Social Change: Creative Solutions to Reducing Pollution, Redmond, Eagle Crest Resort. For info: Oregon Environmental Council, 503/ 222-1963 x100, email: cherylb@oeconline.org, or website: www.oeconline.org

May 4 OR
Selling Social Change: Creative Solutions to Reducing Pollution, Portland, Multnomah Athletic Club. For info: Oregon Environmental Council, 503/ 222-1963 x100, email: cherylb@oeconline.org, or website: www.oeconline.org

May 4-5 OR
Oregon Water Resources Commission Meeting, Hermiston. For info: Cindy Smith (OWRD), 503/ 986-0876, website: www.wrd.state.or.us/commission/index/shtml

May 5 NM
New Mexico Water Markets, Albuquerque, Hotel Albuquerque at Old Town. RE: Buying, Selling & Leasing Water Rights, Basin Markets & Issues. For info: Ann Brown, H2O Economics, 505/ 897-5910, or website www.shoemaker.com/watermarkets.html

May 5 OR
Conservation Markets Roundtable, Willamette Partnership Event, Salem, Willamette University, Putnam University Center, 8:30am-4pm. For info: website: www.willamette.edu/go/cmr

CALENDAR

May 5-9 NH
National River Rally 2006, Bretton Woods, The Mount Washington Resort. RE: Workshops on Community, Historic & Engineering Perspectives of Dam Removal, Meeting Vital Water Needs, Alternative Storage Proposals & Hydropower Reform. For info: River Network website: www.rivernetwork.org/rally

May 7-11 CA
5th National Monitoring Conference: Connecting for Clean Water, San Jose. For info: Conference Coordinator at NWQMC2006@tetratech-ffx.com, or website: www.tetratech-ffx.com/ nwqmc06/ or http://water.usgs.gov/ wicp/acwi/monitoring

May 8-11 GA
National Environmental Partnership Summit, Atlanta, Sheraton Atlanta Hotel. RE: Stewardship Activities in Pollution Prevention, Compliance Assistance & Environmental Leadership. For info: NEPS website: www.environmentalsummit.org or Joanne Berman, EPA, 202/ 564-7064 or email: berman.joanne@epa.gov

May 9 OR
Putting Sustainability Into Action: Oregon Natural Step Network and the Zero Waste Alliance Workshop, Portland, OMSI Auditorium, 1945 SE Water Avenue, 8am-Noon. RE: System-Wide Assessments; Organizational Practices; Overview of the Natural Step; Greenhouse Gas Audits; Energy Audits; Chemical Inventories & Management Systems; More. For info: Oregon Natural Step Network, 503/ 241-1140 or email: events@ortns.org or website: www.ortns.org

May 9-11 TX
Environmental Trade Fair and Conference, Austin, Austin Convention Center. Sponsored by the Texas Commission on Environmental Quality. For info: TCEQ, Event Coordination and Education, 512/ 239-3150, email: etfc@tceq.state.tx.us, or website: www.tceq.state.tx.us/ assistance/events/etfc/etf.html

May 9-12 CA
"Get Real On Water!" ACWA Spring Conference & Exhibition, Monterrey, Monterrey Conference Center. RE: Floods, Infrastructure, The Delta & Endangered Species Act. For info: ACWA website: www.acwa.com// events/SC06/ SC06_conference_home.asp

May 11 WA
Permitting Strategies, Seattle. For info: The Seminar Group, 800/ 574-4852, email: registrar@theseminargroup.net, or website: www.TheSeminarGroup.net

May 11-12 NV
Eminent Domain, Las Vegas. For info: CLE Int'l, 800/ 873-7130, email: registrar@cle.com, or website: www.cle.com

May 11-12 AZ
Law of the Colorado River (8th Annual), Tucson, Hilton El Conquistador Golf & Tennis Resort. For info: CLE Int'l, 800/873-7130, or website: www.cle.com

May 12 CA
Desalinization, Los Angeles. For info: The Seminar Group, 800/ 574-4852, email: registrar@theseminargroup.net, or website: www.TheSeminarGroup.net

May 15-16 AZ
Water Reuse Research 10th Annual Conference: "Advancing the Science of Water Through Research," Phoenix, Hyatt Regency. RE: Water Reuse & Desalination Research Needs & Trends, Waterborne Pathogens, Pharmaceutical Agents, Endocrine Disrupting Compounds, Membrane Applications, Salinity Management & Indirect Potable Reuse. For info: WateReuse Foundation, 703/ 548-0880, or website: http://watereuse.org/ Foundation/2006conf/index.html

May 16-17 CO
Colorado Water Conservation Board Meeting, La Junta. For info: Dena Crist, CWCB, 303/ 866-2599, or website: http://cwcb.state.co.us/

May 17-19 WA
Pacific Northwest Section/AWWA Annual Conference, Spokane. For info: NW Section website: www.pnws-awwa.org/conf.cfm

May 18-19 CA
Energy Strategies for Public Agencies, San Francisco, Pan Pacific Hotel. RE: Legal Developments, New Regulations, Update on FERC/OMOI Regulatory Enforcement, Power Purchases, Energy Efficiency and Greater Use of Renewables, Financing Opportunities & More. For info: Law Seminars International, 800/ 854-8009, or website: www.lawseminars.com/

May 18-19 AZ
Eminent Domain, Phoenix. For info: CLE Int'l, 800/ 873-7130, email: registrar@cle.com, or website: www.cle.com

May 18-19 OR
Eminent Domain, Portland, The Governor Hotel, 614 SW Eleventh. RE: Current Developments in Condemnation, Valuation & Challenges. For info: The Seminar Group, 800/ 574-4852, email: info@TheSeminarGroup.net, or website: www.TheSeminarGroup.net

May 18-19 DC
Criminal Enforcement of Environment Laws, Washington, DC. For info: Alexander Hart, American Law Institute-American Bar Association, 800/ 253-6397 or website: www.ali-aba.org/free

May 18-19 TX
Texas Coastal Law, Galveston. For info: CLE Int'l, 800/873-7130, or website: www.cle.com

May 19-21 CO
Polishing Your Groundwater Modeling Skills, Colorado School of the Mines IGWMC Short Course, Golden. RE: Other Short Courses on Modeling & Surface/Groundwater Flow Systems Available. For info: Mines website: www.mines.edu/igwmc/short-course/

May 21-25 NE
World Environmental & Water Resources Congress, Omaha, Qwest Center and Hilton Omaha. Sponsored by the Environmental Water & Resources Institute of the American Society of Civil Engineers. For info: E. James Dailey III, ASCE, 703/ 295-6303, or email: jdailey@asce.org, or website: www.asce.org/conferences/ ewri2006/

May 22-25 CA
Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey. Sponsored by Battelle. For info: The Conference Group, Inc., 800-783-6338, email: info@confgroupinc.com, or website: www.battelle.org/environment/er/ conferences/chlorcon/default.stm

May 24 WA
Model Toxics Control Act, Seattle. For info: Law Seminars International, 800/ 854-8009, or website: www.lawseminars.com/

May 24-26 CO
Modeling Water Flow and Contaminant Transport in Soils and Groundwater, Colorado School of the Mines IGWMC Short Course, Golden. For info: Mines website: www.mines.edu/igwmc/short-course/

May 25 OR
Southern Willamette Valley Groundwater Management Comm. Meeting, Harrisburg, City Council Chambers, 354 Smith Street, 8am-10am. For info: Audrey Eldridge, DEQ Regional Environmental Solutions, 541/ 776-6010 x223

May 31 OR
Hydropower Relicensing Seminar, Portland, World Trade Center. RE: Energy Policy Act, Licensing Processes, Settlement Outcomes, Supreme Court Decisions, ESA & More. For info: The Seminar Group, 800/ 574-4852 or website: www.theseminargroup.net/ seminar.lasso?seminar=06.HYDOR

May 31-June 2 CA
Environmental Impact Assessment: NEPA and Related Requirements, San Francisco. For info: ALI-ABA, 800/ 253-6397, or website: www.ali-aba.org

June 1-2 ID
Hanford Advisory Board Meeting, Lewiston. 6/1: 9am-5pm; 6/2: 8:30am-3:30pm. For info: Erik Olds, 509/ 372-8656

June 2 OR
Law of Easements: Legal Issues and Practical Considerations, Portland, Fifth Avenue Suites Hotel. For info: Lorman Education Services, 866/ 352-9539 or website: www.lorman.com

June 4-8 MT
Billings Land Reclamation Symposium, Billings. RE: Change and Innovations in Public Policy, Mining, Reclamation, and Land Management. For info: www.billingslandreclamationsymposium.org

June 7-9 CO
Climate Change and the Future of the American West: Exploring the Law and Policy Dimensions, Natural Resources Law Center's Summer Conference (University of Colorado), Boulder. RE: Climate Science, Impact of Climate Change on Water Resources & Ecological Systems, Legal & Policy Dimensions. For info: NRLC, email: nrlc@Colorado.edu, or website: www.Colorado.edu/law/centers/nrlc/ summerconference/

June 8-9 WA
Global Warming, Seattle. For info: The Seminar Group, 800/ 574-4852, email: registrar@theseminargroup.net, or website: www.TheSeminarGroup.net

June 8-9 CA
Eminent Domain, Los Angeles. For info: CLE Int'l, 800/ 873-7130, email: registrar@cle.com, or website: www.cle.com

June 8-9 UT
Eminent Domain, Salt Lake City. For info: CLE Int'l, 800/ 873-7130, email: registrar@cle.com, or website: www.cle.com

June 8-9 WA
Washington Water Law, Seattle. For info: Law Seminars International, 800/ 854-8009, or website: www.lawseminars.com/

(continued from previous page)

June 8-9 **DC**
Wetlands Law and Regulation, Washington D.C. For info: ALI-ABA, 800/ CLE-NEWS, or website: www.ali-aba.org

June 9 **UT**
NEPA, Salt Lake City. For info: CLE Int'l, 800/873-7130, or website: www.cle.com

June 11-15 **TX**
ACE 06 - Annual Conference and Exposition, San Antonio, Henry B. Gonzalez Convention Center. For info: American Water Works Association, 800/ 926-7337, or website: www.awwa.org/ace06/

June 14 – 16 **FL**
Florida Stormwater Association Conference, Ft. Meyers, Sanibel Harbour Resort and Spa. RE: TMDLs & Related Regulatory Topics, Innovations in Best Management Practices, Floodplain Mapping, Hurricane Mitigation & Recovery, MS4 Permitting Requirements. For info: FSA website: www.florida-stormwater.org/conferences/conference2006.htm

June 15-16 **WA**
Land Use and Environmental Diligence, Seattle. For info: The Seminar Group, 800/ 574-4852, email: registrar@theseminargroup.net, or website: www.TheSeminarGroup.net

June 15-16 **CA**
Environmental Insurance, San Francisco. For info: ALI-ABA, 800/ CLE-NEWS, or website: www.ali-aba.org

June 19-20 **ID**
IWUA Summer Water Law Seminar & Workshop, Sun Valley. Sponsored by Idaho Water Users Association. For info: IWUA, 208/ 344-6690, website: www.iwua.org

June 20-21 **AZ**
"Providing Water to Arizona's Growing Population"-Arizona Water Resources Research Center Spring Conference, Phoenix, Hyatt Regency. For info: Cas Sprout, WRRC, 602/ 792-9591 x55, or email: csprout@ag.arizona.edu, or website: http://cals.arizona.edu/AZWATER/

June 21-23 **WA**
Salish Sea Conference, Location TBA. For info: Debra Lekanof, Swinomish Indian Tribal Community, 360/ 466-7280, email: dlekanof@swinomish.nsn.us www.salishseaconference.com/index.html

June 21-23 **Malta**
Waste Management 2006, Malta. Sponsored by Wessex Institute of Technology.For info: WIT website: www.wessex.ac.uk/conferences/2006/waste06/

June 21-24 **CO**
Environmental Litigation, Boulder. For info: ALI-ABA, 800/ CLE-NEWS, or website: www.ali-aba.org

June 22 **WA**
Dredging and Sediment Technologies Conference, Seattle. For info: Holly Duncan, Environmental Law Education Center, 503/ 282-5220, email: hduncan@elecenter.com, or website: www.elecenter.com

Corrections

The Water Report is indebted to Don Essig, Water Quality Standards Manager at the Idaho Department of Environmental Quality for corrections to our coverage of a portion of a presentation by Melanie Rowland's which appeared in our last issue ("*Sublethal Effects*"—pages 7-9). Please note that any mistakes arose from your editors' interpretation—not from Ms. Rowland.

Mr. Essig Writes:

"First of all only the national temperature criteria recommendations from EPA date back to 1977 and these were replaced in the PNW [Pacific Northwest] by the April 2003 regional temperature criteria recommendations mentioned in the article. Most toxics criteria are of more recent vintage, dating back to the 1985-87 timeframe, but several are even newer, e.g. cadmium criteria recommendations (304(a) guidance) were updated in 2001."

Mr. Essig was also concerned that we may have given the impression that CWA criteria are "based only on lethality [which] is patently wrong. While this is true of acute toxics criteria, there are chronic criteria as well. Chronic criteria are based on the non-lethal effects to growth and reproduction. Generally the chronic criteria are set at a level that is the mean between and no-effect (NOEC) and lowest-observable-effect (LOEC) concentrations determined in laboratory toxicity tests. One issue (among many) that NOAA and FWS have with EPA criteria development lie in more subtle behavioral effects such as predator avoidance or natal stream homing."

The Water Report
Water Rights, Water Quality & Water Solutions in the West
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