Health Consultation

STANDARD MINE NPL SITE

EVALUATION OF POTENTIAL PUBLIC HEALTH IMPACT OF
SURFACE WATER CONTAMINATION

GUNNISON NATIONAL FOREST, GUNNISON COUNTY, COLORADO

EPA FACILITY ID: CO0002378230

NOVEMBER 13, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation

Statement of Issues

The Standard Mine is an abandoned mine located in a remote mountainous area about 10 miles west of Crested Butte, Colorado, in an area known as the southern Ruby Mining District. Historic mining activities contaminated soil, sediment, and surface water at and downstream of the mine, and acid mine drainage from former mine workings continues to add metals contamination to surface waters draining from the site. In this health consultation, the Agency for Toxic Substances and Disease Registry (ATSDR) evaluates current and potential public health impacts of surface water contamination resulting from the site as it might impact Crested Butte municipal water intakes downstream. ATSDR reviewed available environmental data, community concerns, and potential exposure scenarios to reach conclusions about the site and recommend actions to protect the public from harmful exposures.

The U.S. Environmental Protection Agency (EPA) proposed the Standard Mine site for the National Priorities List (NPL) on April 27, 2005 and listed it on September 14, 2005. ATSDR is required by Congress to conduct public health activities at all sites proposed for the NPL. This document was previously released for public comment in June 2006; the current version includes public comments received and ATSDR responses in an appendix beginning on page 24.

Background

Background information for the site comes from site documents [1–3]. Silver mining began in the southern Ruby Mining District in 1874 and continued into the early 1970s. Standard Mine, one of the largest former silver-producing mines in the area, comprises 10 acres of land containing waste piles, abandoned and dilapidated mill structures, and a surface water impoundment. Open adits and shafts throughout the site give access to 6 levels of mine workings. Waste piles contain over 50,000 cubic yards of waste rock and almost 30,000 cubic yards of mill tailings, and the unlined surface water impoundment (300 feet in diameter and 15 feet deep) is constructed entirely of waste rock.

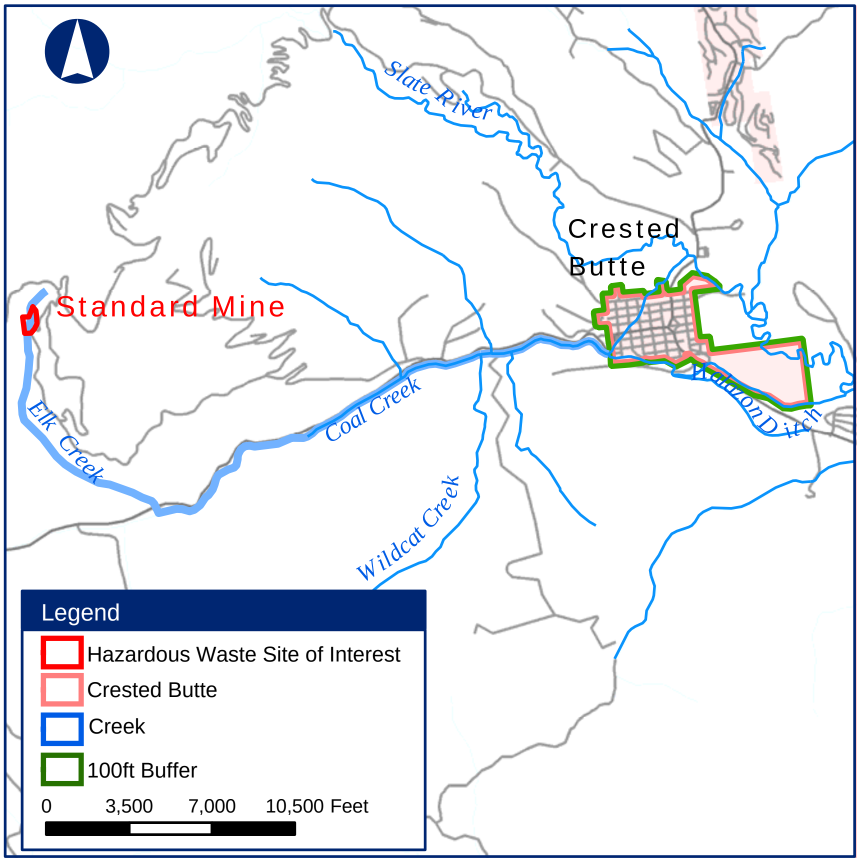
The mine site is located at 10,700 feet elevation on the south flank of the Scarp Ridge of Mount Emmons. It is only accessible in the summer by 4-wheel drive, on foot, or by mountain bike. Most of the area surrounding the mine is U.S. Forest Service land and some private claims. No residences are located in the vicinity of the mine. The human activities in the immediate area are mainly recreational, including hiking, mountain biking, ATV and dirt bike use.

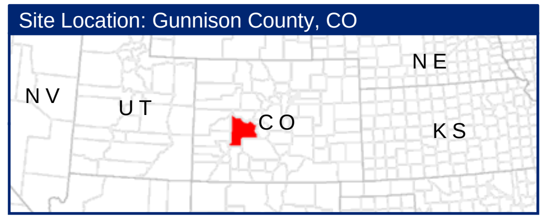
Elk Creek flows through the mine site and along the edge of the surface water impoundment. Acid mine drainage (water which, because of its acidity, dissolves metals from surfaces as it drains through) flows from the mine workings and seeps from waste piles into Elk Creek and the surface water impoundment (which periodically overflows into Elk Creek). Elk Creek flows downstream to Coal Creek, which runs through the town of Crested Butte before joining the Slate River.

Figure 1 shows demographic information for persons living in potentially impacted areas along Elk Creek, along Coal Creek, and in Crested Butte. The vast majority live in Crested Butte, a town of just over 1,500 residents [4]. The Crested Butte municipal water system serves about

Figure 1. Site Location and Demographic Information

Standard Mine
Gunnison National Forest, CO
EPA Facility ID: CO0002378230

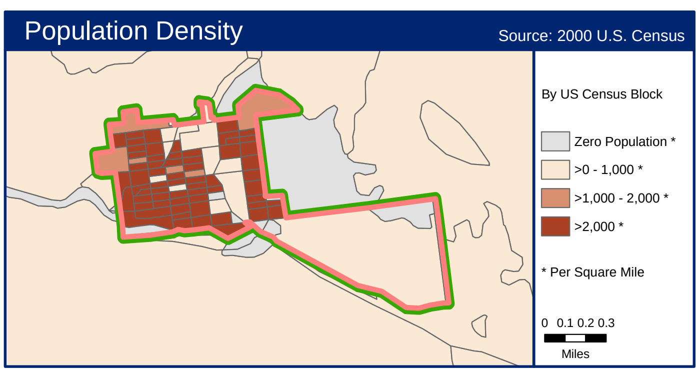


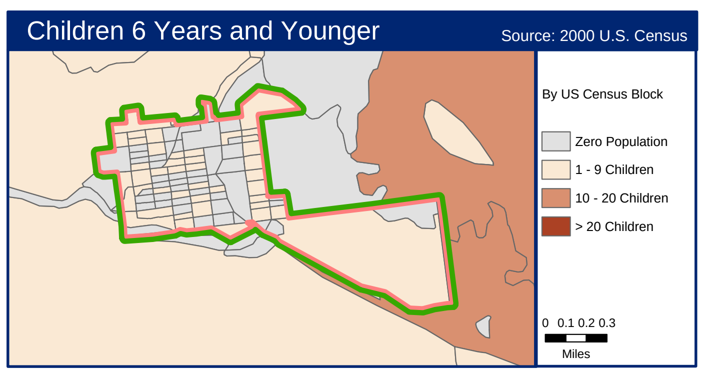


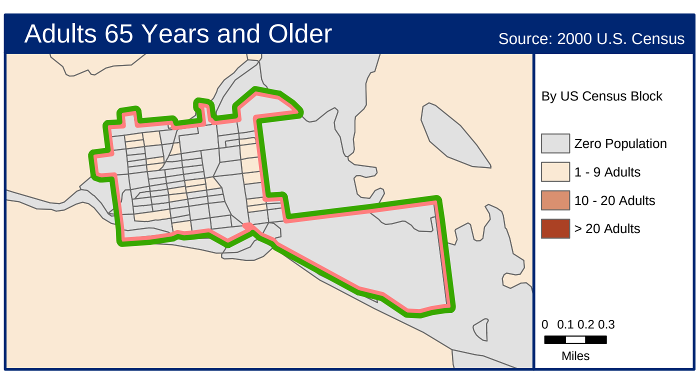
Demographic Statistics Within Specified Distance of Site*	Within Town Boundary
Total Population	1,538
White Alone	1,495
Black Alone	4
Am. Indian & Alaska Native Alone	14
Asian Alone	11
Native Hawaiian & Other Pacific Islander Alone	0
Some Other Race Alone	7
Two or More Races	7
Hispanic or Latino**	42
Children Aged 6 and Younger	74
Adults Aged 65 and Older	29
Females Aged 15 to 44	464
Total Housing Units	936

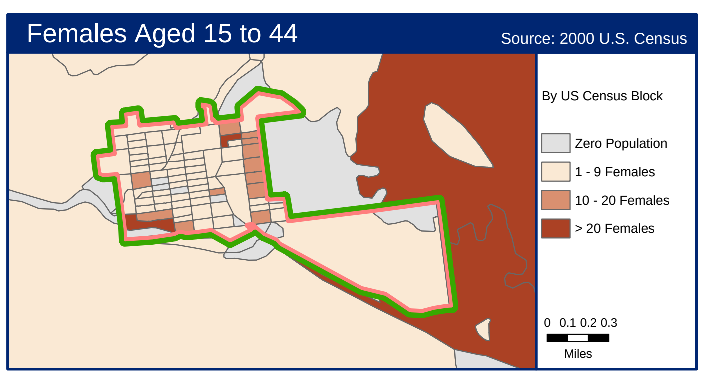
Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Public Health GIS Program, May 2005.
Coordinate System (All Panels): NAD1983 StatePlane Colorado Central FIPS 08051 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.









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820 residences and 120 commercial businesses (personal communication, L.C. Adams, Town of Crested Butte, November 3, 2005). Crested Butte's primary municipal drinking water intake is located on Coal Creek, about 4 miles downstream of the mine site. The intake normally draws about 2.8 cubic feet per second (cfs), but intake has been as low as 1.8 cfs during drought conditions (personal communication, L.C. Adams, Town of Crested Butte, November 3, 2005). To protect the water supply, the Town has established a watershed protection district requiring a permit for activities that could degrade water quality (residential construction, sewage treatment systems, road construction, logging, mining, or any other disturbance of soil or water).

Crested Butte and Gunnison County are working with the Coal Creek Watershed Coalition (CCWC), a local citizen's group, to develop a comprehensive watershed protection plan for Coal Creek. The goal of the CCWC is to restore the health of aquatic life and habitat, and protect other water uses in the Coal Creek watershed, which have been impaired due to metals and other pollutant loading from point and non-point sources [5]. Stakeholders include local, state, and federal governmental and non-governmental agencies as well as the public. The CCWC has developed a comprehensive watershed protection plan for all segments of Coal Creek, including tributaries such as Elk Creek and Wildcat Creek [6]. The plan examines pollution sources in the Coal Creek watershed as well as management strategies and monitoring needs. A watershed sampling and analysis plan was also developed to document planned monitoring for physical parameters, heavy metals and other pollutants to help identify all pollutant sources in the watershed that have the potential to degrade the water supply and harm aquatic life [7].

Analysis and Discussion

Data Used

- Two sets of <u>environmental sampling data</u> were reviewed for this health consultation. EPA's contractor collected streamflow data and surface water and sediment samples in June 2005 and in September 2005 [8]. These sampling events were intended to capture typical seasonal high and low flow conditions, respectively. Surface water samples were analyzed for metals as well as water quality parameters.
- The Town of Crested Butte published results of <u>drinking water quality testing</u> in the 2005 annual report [9].
- ATSDR visited the site in August 2005 and observed the physical layout and <u>site conditions</u>.
- ATSDR attended an EPA public meeting held in Crested Butte in February 2006 and gathered the <u>community's health concerns</u> related to the site. (Concerns will be tabulated and addressed later in the document.)

The conclusions reached in this document are based on the data available at this time and might be modified on the basis of results of additional information collected in the future. For example, the Coal Creek Watershed Coalition is planning an ongoing program to evaluate water quality in Coal Creek and its tributaries [7]. ATSDR will, upon request, review this data to determine any impact it might have on the conclusions of this report.

Evaluation Focus

The two main potentially impacted groups are recreational users of the site and residents of Crested Butte drinking water potentially impacted by the site. Because of the limited direct access to the site and the larger number of people potentially affected in Crested Butte, ATSDR chose to focus the current evaluation on potential impacts of site contaminants to surface waters downstream. ATSDR will evaluate potential exposures to recreational users of the site in a future health consultation.

ATSDR will focus this evaluation on two separate issues related to surface water impacts from the site. These issues were identified on the basis of community concerns, current removal/remedial decisions EPA is making, and level of potential public health impact. The two areas that will be addressed in this health consultation are:

1. What is the current impact of the site on surface water downstream of the site and on the Crested Butte municipal water supply? What health effects could result from current levels of exposure?
2. What impact could occur if a failure of the surface water impoundment at the site released a large volume of contaminated water? What health effects could result from such a potential exposure?

Although the consult focuses on these two areas, specific health concerns and questions raised at the February 2006 public meeting will also be addressed in the "Community Health Concerns" section of this document.

Summary of Environmental Sampling Results Evaluated

EPA Remedial Investigation Sampling

EPA collected flow data from various locations in Elk Creek and Coal Creek in spring and fall of 2004. Table 1 summarizes the data obtained from each of these locations (locations not potentially impacted by the mine site were not included in the summary). The table indicates the large seasonal variability in streamflows in both creeks.

Table 1. Streamflows, Downstream from Standard Mine NPL Site [8]

	Streamflow, Cubic Feet per Second (cfs)			
	Spring Maximum	Spring Average	Fall Maximum	Fall Average
Elk Creek	11	8	0.6	0.5
Coal Creek	84	73	28	8

Surface water samples were analyzed for both dissolved metals and total recoverable metals. ATSDR evaluated total recoverable metals results, which would include both dissolved and suspended metals particles, for samples collected from the area of the mine itself (including adit discharges and the tailings impoundment), Elk Creek downstream from the mine, and Coal Creek downstream from the entry of Elk Creek. Samples collected from areas outside the impacted area (for example, locations in Elk Creek above the mine), were excluded from the analysis.

Tables 2–4 show, for the three areas, contaminants that were detected at least once above the corresponding health-based screening comparison values (CVs)[1]. Data are presented separately for spring and fall, as differing streamflows could affect contaminant level. As indicated in the tables, contaminant concentrations are highest in the mine site surface waters and tend to be diluted with further distance downstream.

Table 2. Contaminants of Potential Concern in Standard Mine Site Surface Water [8]

Contaminant	Total Recoverable Metals Concentration in micrograms per liter (µg/L)				Comparison Value in µg/L	CV Source (Defined in Appendix B)
	Spring Maximum	Spring Average	Fall Maximum	Fall Average		
Arsenic	4.5	2.6	8.2	3.5	3	EMEG
Cadmium	139	56	150	70	2	EMEG
Copper	821	329	249	148	100	iEMEG
Lead	1,630	637.8	924	431	15	AL
Manganese	6,000	2,348	10,400	4,584	500	RMEG
Zinc	20,900	8,472	21,800	10,512	3,000	EMEG

Table 3. Contaminants of Potential Concern in Elk Creek Surface Water [8]

Contaminant	Total Recoverable Metals Concentration in micrograms per liter (µg/L)				Comparison Value in µg/L	CV Source (Defined in Appendix B)
	Spring Maximum	Spring Average	Fall Maximum	Fall Average		
Arsenic	1.0	1.0	4.9	1.4	3	EMEG
Cadmium	17	10	37	17	2	EMEG
Lead	113	57	73	28	15	AL
Manganese	667	349	1200	485	500	RMEG
Zinc	2390	1435	5400	2630	3000	EMEG

Table 4. Contaminants of Potential Concern in Coal Creek Surface Water [8]

Contaminant	Total Recoverable Metals Concentration in micrograms per liter (µg/L)				Comparison Value in µg/L	CV Source (Defined in Appendix B)
	Spring Maximum	Spring Average	Fall Maximum	Fall Average		
Arsenic	0.5	0.5	6	3	3	EMEG
Thallium	NA	NA	0.6	0.2	0.5	LTHA

Town of Crested Butte Municipal Water Sampling

Crested Butte performs annual sampling of water quality at the intake on Coal Creek. Some

[1] CVs are screening values below which no adverse health effects would be expected. Exceeding a CV does not mean that exposure to the contaminant would result in health effects, but just indicates that more evaluation is needed. CVs used in this document are defined in Appendix B.

contaminants are analyzed annually, and some are analyzed less frequently. Table 5 shows data taken from the annual drinking water quality report from 2005 [9]. Only metals detections are included in the table since those are contaminants likely to be associated with the Standard Mine site. The reported results are for samples collected in the spring. Among the contaminants listed in Table 5, none are higher than the corresponding ATSDR CV.

**Table 5. Table of Detected Contaminants (Metals Data Taken from Town of Crested Butte 2005 Annual Drinking Water Quality Report [9]*

Contaminant	Date	Exceedance	Level	Unit†	Maximum Contaminant Level Goal	Maximum Contaminant Level
Antimony	3/24/2003	N	0.3	μg/L	6	6
Arsenic	3/24/2003	N	0.7	μg/L	0	10
Barium	3/1/2004	N	29	μg/L	200	200
Cadmium	3/1/2004	N	0.99	μg/L	5	5
Chromium	3/18/2002	N	1.1	μg/L	100	100
Nickel	3/24/2003	N	1.9	μg/L	100	100
* All results were converted to micrograms per liter (μg/L), which is equivalent to parts per billion (ppb).						
† In addition to the annual sampling, 90th percentile values for copper and lead were presented [9]. For the period 1/1/2002-12/31/2004, 90% of the samples were lower than 150 part per billion copper (action level = 1300 ppb) and 90% of the samples were lower than 7 parts per billion lead (action level = 15 ppb).						

Discussion

Current impact on municipal water supply

On the basis of the drinking water quality report, municipal water meets all drinking water requirements. Some metals contaminants, which could come from the Standard Mine site or other manmade or natural sources, were detected in annual testing, but all values were well below EPA maximum contaminant levels (MCLs) and ATSDR CVs. The levels detected are not associated with any expected risk of adverse health effects.

The drinking water quality samples were collected in the spring. Contaminant levels are expected to change throughout the year. Indeed, the RI sampling showed that 2 contaminants (arsenic and thallium) were detected in Coal Creek in the fall at levels that exceeded CVs (none of the other contaminants detected in the fall sampling exceeded CVs). Arsenic and thallium will be evaluated further to see if possible seasonal exposure to those levels would be associated with any measurable adverse health effects.

Arsenic was detected at a concentration as high as 6 μg/L in the fall RI sampling. This is well below the MCL of 10 μg/L. In addition, the average fall concentration is equivalent to the CV. No short- or long-term adverse health effects would be expected from drinking water containing this level of arsenic. Similarly, while the maximum concentration of thallium detected in the fall was slightly above the CV, the average was lower and no adverse health effects would be expected from that exposure.

In summary, *the site's impact on the municipal supply at the current time poses no apparent* *public health hazard to the community.*

Potential impact on municipal water supply in the event of structural failure of tailings impoundment dam

ATSDR was asked to evaluate whether a structural failure of the tailings impoundment dam could adversely affect the Crested Butte water supply. ATSDR's purpose in performing an evaluation of this hypothetical situation is to provide additional information so that EPA can prioritize removal and remedial decisions and actions for the site.

In Fall 2005, an inspection of the tailings dam reported no critical conditions affecting the safety or stability of the tailings impoundment [10]. However, more detailed investigations were recommended. ATSDR does not have the expertise to evaluate the structural stability of the dam, but performed an evaluation of potential exposures, and potential adverse health effects resulting from such exposures, if the dam did fail. Due to the large number of assumptions inherent in this evaluation, the conclusions must be considered highly uncertain. Nevertheless, even an uncertain evaluation will at least give a basis for prioritizing necessary removal/remedial actions and thus meet the stated purpose.

The assumptions made, equations used, and calculation results are detailed fully in Appendix A. ATSDR evaluated 2 hypothetical scenarios, dam failure in spring high flow conditions, and dam failure in fall low flow conditions. To summarize the conclusions documented in detail in the appendix:

- If the dam were to fail in spring high flow conditions, the contaminants would be diluted by the high streamflows in Elk Creek and Coal Creek. A potential exists for water not meeting drinking water quality guidelines to reach the public, but a short-term (several days) exposure of the general public to this water would not be expected to result in any short- or long-term adverse health effects.

- If the dam were to fail in fall low flow conditions, water with more concentrated contaminants (well above drinking water quality guidelines) could potentially reach the municipal intakes. It would likely be easier to observe a failure since streamflow would show a large change, allowing intake shut-off protocols to be implemented. However, if the intake was not shut off, highly contaminated water could enter the storage reservoir for a short period (about a day) and reach the consumer. Some contaminants (copper and lead) could be present at levels high enough to potentially cause gastrointestinal problems and changes in blood chemistry if small children were exposed. These effects would be reversible and would not be expected to result in long-term problems.

In summary, *although very unlikely, a failure of the tailings impoundment dam along with a failure to prevent entry of the impoundment water into the water system could result in a potential public health hazard, since it could lead to adverse health effects in exposed children.*

Community Health Concerns

On February 28, 2006, ATSDR participated in an EPA-sponsored public meeting in Crested

Butte. The meeting was attended by approximately 20 residents, as well as several officials from city, state, and federal organizations. During this meeting, community members conveyed their health concerns regarding the site. The health concerns are summarized and addressed below.

Concern: *If cadmium builds up in tissues why is any level safe? That is, won't I eventually build up enough to have a toxic effect?*

Response: Most of the cadmium that enters the body goes to the liver and kidneys and builds up there. These organs produce a protein called metallothionein, which binds to cadmium and renders it less toxic. Too much cadmium can overload the ability of liver or kidney to detoxify the cadmium. The first effect seen would be damage to the renal tubules in the kidney [11].

Cadmium can be detected in the tissues of virtually all adults from industrialized countries. The main source of cadmium is through diet. The average American dietary intake of cadmium is 0.0004 mg/kg/day, with cigarette smokers taking in an additional 0.0004 mg/kg/day [11]. By comparison, the EPA maximum contaminant level for cadmium in drinking water, 5 μg/L, corresponds to a daily intake of 0.00014 mg/kg/day. The amount of cadmium potentially contributed by drinking water that meets drinking water standards is only a fraction of the normal amount taken in by diet, so it would not be expected to overload the body's normal detoxifying mechanisms.

Concern: *Why is cadmium a problem for fish and not for humans?*

Response: Cadmium can be toxic to both fish and humans, depending on the dose, bioavailability of cadmium, and exposure and metabolic factors. Ecological screening levels for fish are designed to protect sensitive life stages of target species which spend their entire lives in the water. It is difficult to compare ecological and human screening levels because of the many differences in the ways they are calculated.

Concern: *I have heard of dogs getting sick after drinking creek water. Is it safe for my dog to drink from Elk Creek or Coal Creek?*

Response: There are many things in untreated creek water which could cause illness in dogs drinking the water. The possibility for microbial or parasitic illness is much greater than the chance of disease resulting from metals contamination from Standard Mine. ATSDR calculated potential exposure doses to the contaminants of potential concern in Standard Mine, Elk Creek, and Coal Creek surface water based on the highest level of contaminants measured and assuming a dog weighed 18 kg (about 40 lb) and drank 1 liter of water 3 days a week, for 4 months out of the year. The doses for Elk Creek and Coal Creek were much lower than human health guidelines for chronic exposure. Dogs do not appear to be more susceptible than humans to the toxic effects of these contaminants, so the human guidelines are considered protective of dogs. ATSDR also checked potential doses for dogs drinking surface water at the Standard Mine. Some of the exposures were slightly higher than human health guidelines. Although the chances of a dog actually getting sick from drinking this water are very slim, the risk of long-term health effects would be greater if a dog regularly drank from the tailings impoundment or mine adit discharges at the mine. To summarize, while the metals contaminants in creek water would not be expected to lead to any health effects in dogs, to avoid the risk of other infectious agents it would be best not to let your dog drink untreated creek water.

Concern: *I am concerned that building a road to haul tailings for the cleanup would stir up more contaminants and cause more problems than doing nothing.*

Response: EPA and the community must make risk management decisions to determine whether the potential risk posed by the site justifies potential risks involved with the cleanup. It is true that construction and cleanup activities will result in disruption of tailings and the possibility of transfer of contamination. It is essential for EPA and its contractors to follow standard operating procedures, including dust suppression and runoff control measures, to minimize such disruption.

Concern: *Should there be a fishing advisory on Coal Creek?*

Response: The current evaluation does not include an assessment of fish tissue data, which is not available at this time. ATSDR will evaluate fish tissue data, if available, and report findings in its next health consultation on recreational exposures associated with the Standard Mine site.

Concern: *Would contaminants from the mine contribute to an elevated risk of multiple sclerosis or other autoimmune diseases in this community?*

Response: The current evaluation of potential exposures to contaminants in surface water showed no indication that exposures are high enough to contribute to any increased risk of adverse health effects. The exact mechanisms causing multiple sclerosis and other autoimmune disorders are not completely understood; but bacteria, viruses, toxins, and some drugs may play a role in triggering an autoimmune process in someone who already has a genetic predisposition to develop such a disorder [12]. ATSDR will continue to research this question as further information is gained about the site and in the preparation of its consult on recreational exposures at the site.

Concern: *I am concerned that breast cancer and skin cancer rates may be elevated in the community.*

Response: The current evaluation of potential exposures to contaminants in surface water showed no indication that exposures are high enough to contribute to any increased risk of adverse health effects, including cancers. None of the contaminants of potential concern are known to be associated with breast cancer. One contaminant of potential concern, arsenic, can, among other effects, cause a specific type of skin cancer [13]. The levels of arsenic present in surface water are not high enough to significantly increase the risk of cancer and are not thought to be a result of mining activities at the site.

Public Comments

This health consultation was available for public review and comment at the Crested Butte Library in Crested Butte, Colorado from July 5, 2006, through August 7, 2006. The document also was available for viewing or downloading from the ATSDR Web site.

The public comment period was announced to local media outlets. The health consultation also was sent to federal, state, and local officials.

Comments were received from a community group, the town of Crested Butte, and from a private citizen. They can be found in Appendix C, along with ATSDR's responses to them.

Conclusions

- The site's impact on the municipal supply at the current time poses no apparent public health hazard to the community.
- Although very unlikely, a failure of the tailings impoundment dam along with a failure to prevent entry of the impoundment water into the water system could result in a potential public health hazard, since it could lead to transient adverse health effects in exposed children.

Recommendations

- Local, state, and federal agencies should work together to develop contingency plans or other options to minimize risk to the public associated with a failure of the tailings impoundment dam.
- ATSDR should evaluate the impact of potential site exposures on recreational users of the site, including fish consumption from potentially impacted creeks.

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Appendix A. Potential Impact on Municipal Water Supply in the Event of Structural Failure of Tailings Impoundment Dam

ATSDR was asked to evaluate whether a structural failure of the tailings impoundment dam could adversely affect the Crested Butte water supply. ATSDR agreed to do this theoretical evaluation, but would like to emphasize that the purpose of the evaluation is merely to provide additional information so that EPA can prioritize removal and remedial decisions and actions for the site. In Fall 2005, EPA's contractor performed an inspection of the tailings dam and found no critical conditions affecting the safety or stability of the tailings impoundment, but recommended further investigations [10]. ATSDR does not have the expertise to evaluate the structural stability of the dam, but will postulate what exposures to the public might be possible, and the resulting potential for adverse health effects, if the dam did fail. Many assumptions and conjectures are inherent in attempting an evaluation of such a theoretical scenario, so the conclusions must be considered highly uncertain. Nevertheless, even an uncertain evaluation will at least give a basis for prioritizing necessary removal/remedial actions and thus meet the stated purpose.

Hypothetical Scenario

If the tailings dam failed, a large release of contaminated water could potentially reach the Crested Butte water intakes. Town protocols call for turning off the main municipal intakes and switching to a secondary, unimpacted intake in the event of a release (personal communication, L.C. Adams, Town of Crested Butte, November 3, 2005). However, if the release were not noticed right away, some contaminants could make their way into the municipal system/stores. Current treatment of water does not remove metals, so metals could reach the consumer. ATSDR estimated levels of contaminants that could potentially reach consumers in the unlikely event that such a failure occurred and was not detected immediately.

Information and Assumptions Used

Volume of contaminated water in tailings impoundment

Sampling activity reports from the Expanded Site Inspection for Ruby Mining District - South describe the larger tailings pond as 300 feet in diameter and 15 feet deep [3]. A smaller tailings pond (120 feet in diameter , 8 feet deep) was also seen in one inspection but it was not present at a later visit. (In the ATSDR site visit in August 2006 only the larger tailings pond was present). Assuming a cylinder of water, diameter 300 feet and depth 15 feet, the volume of contaminated water is:

$$Volume = 15\,ft \times \frac{1}{4} \times \prod \times (300\ \ ft)^2 = 1.06 \times 10^6\ \ ft^3 \times \frac{7.4805\ gallons}{ft^3} = 7.9 \times 10^6\ \ gallons$$

Potential Release through Elk Creek

Measured flows for Elk Creek ranged from less than 1 cubic feet per second (cfs) to 11 cfs in the fall and spring of 2005, respectively. If the tailings impoundment failed, the creek would carry as much water as its banks could hold until the pond water was depleted. To estimate the maximum volume of water that Elk Creek could carry, ATSDR scaled the Elk Creek flow measured in spring 2005 using data collected in June 1999 and denoted as “near peak flow” conditions [3]. Elk Creek was not gauged in the 1999 sampling, but Coal Creek at the municipal intakes was measured as 86.42 cfs. This area in the 2005 spring sampling was 80 cfs. Therefore, the scaled estimate of the highest flowrate of water Elk Creek can contribute to Coal Creek is given by:

$$Max\ Flow = 11\ cfs \times \frac{86.42\ cfs}{80\ cfs} = 11.9\ cfs$$

For this evaluation, the capacity of Elk Creek was assumed to be 12 cfs.

Calculating Contaminant Concentration in Coal Creek

As the contaminants flow downstream, they will be diluted by normal streamflow in Elk Creek and by Coal Creek. For each contaminant, the concentration in Elk Creek during the dam failure would be given by:

$$\frac{C_T \times F_T + C_{E,B} \times F_E}{F_T + F_E} = C_E\ ,$$

where
C_T = concentration of contaminant in the tailings impoundment, in μg/L
F_T = flow of water from the tailings impoundment due to the dam failure, in L/sec
$C_{E,B}$ = background concentration of contaminant in Elk Creek, in μg/L
F_E = flow of water in Elk Creek (normally), in L/sec
C_E = resulting contaminant concentration in Elk Creek, in μg/L

Similarly, the concentration in Coal Creek during the dam failure would be given by:

$$\frac{C_E \times (F_T + F_E) + C_{C,B} \times F_C}{F_T + F_E + F_C} = C_C\ ,$$

where, additionally,
$C_{C,B}$ = background concentration of contaminant in Coal Creek, in μg/L
F_C = flow of water in Coal Creek (normally), in L/sec
C_C = resulting contaminant concentration in Coal Creek, in μg/L

ATSDR assumed that, upon dam failure, water from the impoundment would immediately fill Elk Creek up to its capacity and travel down Elk and Coal Creeks until the impoundment is drained, at which time conditions would immediately return to normal. This is, of course, an extreme simplification of events that would occur if the dam were actually to fail. This analysis does not consider additional contaminated sediments that would wash down the creek along with the contaminated water from the tailings impoundment.

Spring Flow Conditions

If the dam failed, it would, presumably, more likely occur in the spring when runoff conditions add flow and therefore pressure to the dam. Elk Creek might likely be flowing at near peak conditions as well. For the purposes of this hypothetical scenario, ATSDR assumed normal flow of Elk Creek to be 9 cfs, so the capacity of Elk Creek (12 cfs) allows an additional flow of contaminated impoundment water of 3 cfs. At this flow rate, the time needed to completely drain the impoundment would be:

$$Time = \frac{1.06 \times 10^6 \;\; ft^3}{3\,cfs = \; ft^3/\sec} \times \frac{1\,day}{3600 \times 24\sec} = 4\;days$$

Although it is possible that downstream observers would note signs that a dam failure had occurred (e.g., debris, unusually turbid or discolored water), the relatively small increase in total flow would probably not be noticeable in spring-type flow conditions on Coal Creek. (In the fall, a failure would be much more noticeable since all streamflows are lower). Therefore, the spring evaluation is performed assuming that the municipal water intakes downstream continue normal operation during the failure event.

ATSDR evaluated all the contaminants of potential concern from the mine site listed in Table 2 in the main body of the document, since they are all present above CVs and would be released downstream. Table A1 presents the assumptions used in performing the calculation for spring flow conditions, and Table A2 presents the results.

Table A1. Assumed Values for Calculating Potential Contaminant Levels from Dam Failure, Spring Flow Conditions

Variable	Assumed Value	Rationale
C_T	"Spring Maximum" value from Table 2	Conservatively high spring estimate
$C_{E,B}$	Spring result from Elk-15 sample	Sample collected from Elk Creek upstream from Standard Mine
$C_{C,B}$	Average of spring results from Coal-20 and Coal-25 samples	Samples collected from Coal Creek before confluence with Elk Creek
F_T	3 cfs = 85 L/sec	Likely high flow without overflowing creek banks
F_E	9 cfs = 255 L/sec	Near high flow, expected during spring
F_C	84 cfs = 2,379 L/sec	Highest spring flow measured in Coal Creek

Table A2. Results from Tailings Impoundment Failure Calculation, Spring Flow Conditions

Contaminant	Concentration in Surface Water in μg/L			Drinking Water Comparison Value (CV)	CV Source (Defined in Appendix B)
	Mine Site (Measured)	Elk Creek (Calculated)	Coal Creek (Calculated)		
Arsenic	5	2	1	3	EMEG
Cadmium	139	36	5	2	EMEG
Copper	821	208	27	100	iEMEG
Lead	1,630	416	52	15	AL
Manganese	6,000	1,504	193	500	RMEG
Zinc	20,900	5,374	677	3,000	EMEG

The results indicate that if the tailings impoundment failed during spring flow conditions, levels in Coal Creek of cadmium and lead have the potential to reach municipal water intakes at concentrations above the CVs during the period of time the tailings pond drains (about 4 days). These contaminants will be evaluated further to determine the potential impact on municipal water consumers.

Further Evaluation – Spring Flow Conditions

The main municipal intake normally operates at 2.8 cfs (79 L/sec). In four days, the volume of intake in liters (L) is:

$$79\ \frac{L}{\sec} \times \frac{3600\ \sec}{hr} \times \frac{24\ hr}{day} \times 4\ days = 2.7 \times 10^{7}\ L$$

The town reservoir has a capacity of 3.8×10^7 L (10 million gallons), so 4 days of water intake would correspond to a large percentage of the reservoir. To evaluate potential health effects, ATSDR assumed that a person drank water containing the calculated Coal Creek level of contamination from Table A2 for 4 days. In reality, due to mixing effects as the contaminant builds up in the reservoir (and is later "washed out" by clean water), it is likely the exposure would be to a lower, changing amount spread out over a longer period. However, assuming the exposure is to the highest concentration possible will be protective of lower concentration exposures.

For cadmium, no adverse health effects would be expected. The calculated concentration in Coal Creek, 5 μg/L, is equivalent to the MCL and therefore would meet water quality guidelines for cadmium. Although the value is higher than ATSDR's screening level, the screening level is based on chronic exposure (a year or more) and exceeding it does not mean any health effects are likely [11]. Further discussion of cadmium and its potential health effects is in the document in the Community Health Concerns section.

For lead, exposure to a concentration of 52 μg/L for 4 days would not be expected to lead to measurable health effects. The lead level in blood is a good measure of recent exposure to lead and also correlates well with health effects. Children are especially sensitive to lead, and many of its effects are observed at lower concentrations in children than in adults. Levels of 10 micrograms per deciliter (μg/dL), and perhaps even lower, in children's blood have been associated with small decreases in IQ and slightly impaired hearing and growth. A slope factor for the increase in blood lead concentration per increase in water lead concentration for infants has been determined from epidemiological studies as 0.04 μg/dL blood per microgram per liter (μg/L) lead for water lead levels above 15 μg/L [14]. The corresponding slope factor for school children was found to be 0.03 μg/dL per μg/L. At the calculated concentration of 52 μg/L lead measured, the predicted increases in blood lead concentrations for infants and school children are 2 μg/dL and 1.6 μg/dL, respectively. Any actual increase would be much lower than this, if measurable at all, since the slope factor was developed based on chronic exposure to elevated lead levels in drinking water. In conclusion, although the level of lead that could potentially reach the consumer is higher than drinking water standards and clearly not an acceptable long-term level, it is unlikely that a 4-day exposure to this level of lead in drinking water would contributed significantly to children's overall body burden of lead.

Summary – Spring Flow Conditions

A dam failure during spring flow conditions could possibly result in a temporary elevation in the lead level of drinking water above water quality guidelines, but consumer exposure to this level would not be expected to result in measurable adverse health effects.

Fall Flow Conditions

If the dam failed during the fall, the tailings impoundment water would drain much more quickly (reduced flow in Elk Creek would leave more room for impoundment water). For the purposes of this hypothetical scenario, ATSDR assumed the fall normal flow of Elk Creek to be 0.5 cfs and an additional flow of contaminated impoundment water of 11.5 cfs (since the maximum capacity of the creek is about 12 cfs). At this flow rate, the time needed to completely drain the impoundment would be:

$$Time = \frac{1.06 \times 10^6 \ \ ft^3}{11.5\ cfs = \ ft^3/\sec} \times \frac{1\ day}{3600 \times 24\sec} = 1\ day$$

Because normal fall flows in both Elk and Coal Creek are well below the assumed flow from the tailings impoundment, it is very likely that downstream observers would notice the large change in flow (as well as debris, turbid water, etc.) and take appropriate measures (i.e., shutting off the main drinking water intake and switching to the secondary intake). However, in order to present a “worst case” scenario for planning purposes, ATSDR performed the evaluation assuming that the municipal water intakes continue to operate normally throughout the dam failure event.

Similarly to the spring flow condition calculation, ATSDR evaluated all the contaminants listed in Table 2. Table A3 presents the assumptions used in performing the calculation for fall flow conditions, and Table A4 presents the results.

Table A3. Assumed Values for Calculating Potential Contaminant Levels from Dam Failure, Fall Flow Conditions

Variable	Assumed Value	Rationale
C_T	“Fall Maximum” value from Table 2	Conservatively high fall estimate
$C_{E,B}$	Average of fall results from COP-00, Elk-29 and Elk-30 samples	Samples collected from Copley Lake Outfall into Elk Creek and Elk Creek upstream from Standard Mine
$C_{C,B}$	Average of fall results from Coal-20 and Coal-25 samples	Samples collected from Coal Creek before confluence with Elk Creek
F_T	11.5 cfs = 326 L/sec	Assumed Elk Creek capacity (12 cfs) minus assumed Elk Creek fall flow
F_E	0.5 cfs = 14 L/sec	Average measured fall flow in Elk Creek
F_C	8 cfs = 227 L/sec	Average measured fall flow in Coal Creek

Table A4. Results from Tailings Impoundment Failure Calculation, Fall Flow Conditions

Contaminant	Concentration in Surface Water in μg/L			Drinking Water Comparison Value (CV)	CV Source (Defined in Appendix B)
	Mine Site (Measured)	Elk Creek (Calculated)	Coal Creek (Calculated)		
Arsenic	8.2	7.9	7.4	3	EMEG
Cadmium	150	144	86	2	EMEG
Copper	249	239	144	100	iEMEG
Lead	924	886	532	15	AL
Manganese	10,400	9,968	5,984	500	RMEG
Zinc	21,800	20,900	12,542	3,000	EMEG

The results indicate that if the tailings impoundment failed during fall flow conditions, levels in Coal Creek of all contaminants of potential concern have the potential to reach municipal water intakes at concentrations well above the CVs during the period of time the tailings pond drains (about a day). Further evaluation was performed to determine what potential impact this might have on municipal water provided to consumers in Crested Butte.

Further Evaluation – Fall Flow Conditions

The main municipal intake normally operates at 2.8 cfs (79 L/sec). In one day, the volume of intake in liters (L) is:

$$79\ \frac{L}{\sec} \times \frac{3600\ \sec}{hr} \times \frac{24\ hr}{day} \times 1\ day = 6.8 \times 10^{6}\ L$$

The town reservoir has a capacity of 3.8×10^{7} L (10 million gallons), so 1 day of water intake would correspond to about 20% of the reservoir. To evaluate potential health effects, ATSDR assumed that a person drank water containing the calculated Coal Creek level of contamination. Depending on possible mixing effects as the contaminant builds up in the reservoir (and is later "washed out" by clean water), it is likely the exposure would be to a lower, changing amount spread out over a longer period. However, assuming the exposure is to the highest concentration possible will be protective of lower concentration exposures. For each of the contaminants listed in Table A4 (all of which exceeded the CV), acute exposure doses were calculated for adults and children and compared to acute health guidelines. In calculating doses, ATSDR assumed adults drank 2 L, and children drank 1 L, of contaminated water. These are the default values for daily drinking water consumption given in EPA's Exposure Factors Handbook [15]. Adults were assumed to weigh 70 kg (154 lb), and children 10 kg (22 lb). These are default values for body weight [15]. Exposure was assumed to occur on a single day only. Each contaminant will be discussed further below.

Arsenic

The calculated potential concentration of arsenic in Coal Creek following failure of the tailings impoundment dam during fall low flow conditions (7.4 μg/L) is below the MCL for arsenic of 10 μg/L. (In fact, the calculated value is only slightly higher than the "background" fall concentration measured in Coal Creek before the addition with Elk Creek, suggesting that arsenic is not specifically a mine site-related contaminant.) No short- or long-term adverse health effects would be expected from drinking water containing this level of arsenic.

Cadmium

The potential acute cadmium exposure doses calculated for adults and children are 0.003 milligrams per kilogram (mg/kg) and 0.009 mg/kg, respectively. Initial symptoms of acute cadmium poisoning include severe nausea, vomiting, and diarrhea, with a threshold emetic dose in humans of about 3 mg [16]. The National Academy of Sciences has used this threshold to calculated a 24-hour suggested no-adverse-response level of 0.15 mg/L [16]. This concentration corresponds to adult and child doses of 0.004 mg/kg and 0.0.015 mg/kg, respectively. Because the potential acute exposure is lower than these values, no adverse health effects would be expected from drinking water containing this levels of cadmium for one day.

Copper

The potential acute copper exposure doses calculated for adults and children are 0.004 milligrams per kilogram (mg/kg) and 0.014 mg/kg, respectively. ATSDR developed an acute oral minimal risk level for copper based on study which found a no observed adverse effect level of 0.0272 mg/kg/day for gastrointestinal effects in women ingesting copper sulfate in drinking water for 2 weeks, with an uncertainty factor of 3 for human variability [17]. The adult acute dose is lower than acute oral minimal risk level, but the child dose is higher. There is a possibility that children who drank water containing the calculated potential level of copper could experience abdominal pain, nausea, and/or vomiting. These effects would be transient; the acute exposure would not be expected to result in long-lasting health effects.

Lead

The potential exposure concentration for lead in this scenario is 532 μg/L. A one-day exposure to water containing lead at this level would result in estimated lead doses of 0.015 mg/kg and 0.05 mg/kg for adults and children, respectively. Studies showed that children exposed to doses of lead of 0.02-0.03 mg/kg/day for 3-14 days had minor changes in levels of certain blood enzymes [14]. It is possible that children exposed for one day to elevated lead in drinking water due to a dam failure could exhibit such changes; however, the changes would be transient and would not be expected to result in long-term adverse health effects.

Manganese

No health guidelines for acute oral manganese exposure exist. According to the National Academy of Sciences, “Acute manganese poisoning is extremely rare. Chronic exposure is seldom fatal but may result in permanent crippling. Diagnosis is difficult unless a history of exposure of at least three months is present [18].” Symptoms of manganese poisoning are similar to those of Parkinson’s disease and include muscular twitching, a characteristic spastic gait, emotional disturbances, and a fixed mask-like expression.

EPA’s secondary maximum contaminant level for manganese, 50 μg/L, is set for aesthetic reasons. Water containing higher levels of manganese (over 22,000 μg/L) would have a bitter metallic taste, would be black to brown color, and would cause black staining on household goods [19,20]. For the fall dam failure scenario, the potential acute manganese concentration would potentially make the water distasteful, but a one-day or several day exposure to that level of manganese would not be expected to result in short- or long-term adverse health effects.

Zinc

No health guidelines for acute oral exposure to zinc exist. A case of zinc poisoning was reported from prolonged consumption of water from galvanized pipes, which contained a concentration of 40 mg/L (40,000 μg/L). This exposure caused irritability, muscular stiffness and pain, loss of appetite, and nausea in two adults [21]. Since the calculated potential concentration for zinc in the dam failure scenario is only a fraction of this concentration, and because exposure is assumed to only occur for a very short time, no adverse health effects would be expected from this exposure.

Summary – Fall Flow Conditions

A dam failure during fall flow conditions could result in a temporary significant elevation in contaminant levels in drinking water above water quality guidelines. A short (one-day) consumer exposure to the highest potential levels of contaminants would not be expected to result in long-term adverse health effects, but some contaminants (copper and lead) could potentially cause transient gastrointestinal problems and changes in blood chemistry if small children were exposed. These effects would be reversible and would not be expected to result in long-term problems.

Appendix B. Comparison Values Used for Screening

A. Screening Process

In evaluating these data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are health-based contaminant concentrations found in a specific media (air, soil, or water) and are used to screen contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that someone might inhale or ingest each day. ATSDR used CVs developed for drinking water in evaluating the surface water data available for the Standard Mine, since this surface water could affect a municipal drinking water supply.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and noncancer health effects. Noncancer levels are based on valid toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are based on a one-in-a-million excess cancer risk for an adult exposed to contaminated soil or drinking contaminated water every day for 70 years. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

CVs used in this document are listed below:

Environmental Media Evaluation Guides (EMEGs) are estimated contaminant concentrations in a media where noncarcinogenic health effects are unlikely. EMEGs are derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL).

Reference Media Evaluation Guides (RMEGs) are estimated contaminant concentrations in a media where noncarcinogenic health effects are unlikely. RMEGs are derived from EPA's reference dose (RfD).

Lifetime Health Advisories (LTHAs) are derived by EPA from a drinking water equivalent level below which no adverse noncancer health effects are expected to occur over a 70-year lifetime.

EPA Action Levels (ALs) are estimated contaminant concentrations in drinking water at which additional evaluation is needed to determine if action is required to eliminate or reduce exposure.

Some CVs may be based on different durations of exposure. Acute duration is defined as exposure lasting 14 days or less. Intermediate duration exposure lasts between 15 and 364 days, and chronic exposures last 1 year or more. To be protective, CVs based on chronic exposure studies are used whenever available. If an intermediate or acute comparison value is used, it is denoted with a small *i* or *a* before the CV (e.g., iEMEG refers to the intermediate duration EMEG).

Appendix C. Public Comments and Responses

This health consultation was available for public review and comment at the Crested Butte Library in Crested Butte, Colorado from July 5, 2006, through August 7, 2006. The document also was available for viewing or downloading from the ATSDR Web site.

The public comment period was announced to local media outlets. The health consultation also was sent to federal, state, and local officials. Comments were received from a community group, the Town of Crested Butte, and from a private citizen.

A. Comments from the High Country Citizens' Alliance and the Steering Committee of the Coal Creek Watershed Coalition:

Comment A1: *…The preliminary conclusion that the public water supply poses no apparent public health hazard to the community is reassuring. We still have underlying concerns, though, because of our lack of expertise to evaluate your findings and the scientific basis for these findings produced both by EPA and your agency. You have identified several metals (arsenic, thallium, lead and cadmium) with elevated concentrations that cause us some concern even though they are below EPA's Maximum Contaminant Level Goals. We are hoping to secure a Technical Assistance Grant from EPA that will allow us to avail ourselves of the expertise needed to review your findings in the near future.*

Response: Our conclusions are based on information available at this time and are subject to change. ATSDR is committed to continuing to work with your community to better understand and interpret the public health implications of potential contaminant exposures from this site. Please feel free to contact us in the future if you would like us to respond to comments by technical advisors regarding the findings of this final health consultation, or to provide us with additional information you feel may impact the conclusions reached herein.

Comment A2: *We also understand that you have not yet received enough information to evaluate potential health risks from other pathways. Until we have seen your evaluation of the risks associated from all potential pathways and have had independent confirmation of your findings, we reserve judgment of your conclusions.*

Response: When the data become available, ATSDR will be working with the Colorado Department of Public Health and Environment (working through ATSDR's Cooperative Agreement Program) to evaluate risks to recreational users near the Standard Mine NPL Site, including fish consumption and other direct exposure pathways at the site. We will publish the findings in a second health consultation. The public will have an opportunity to comment on the findings of that document during a public comment period at that time.

B. Comments from the Town of Crested Butte:

Comment B1: *[comments similar to those from above citizens' groups]…The town would also like to know the opinions of the experts hired by SMAG* [Standard Mine Advisory Group] *prior to commenting on the ATSDR.*

Response: Please see our response to Comment A1 above. Our conclusions are based on information available at this time and are subject to change. ATSDR is committed to continuing to work with your community to better understand and interpret the public health implications of potential contaminant exposures from this site.

Comment B2: *We also understand that you have not yet received enough information to evaluate potential health risks from other pathways. Until we have seen your evaluation of the risks associated from all potential pathways and have had independent confirmation of your findings, we reserve judgment of your conclusions.*

Response: When the data become available, ATSDR will be working with the Colorado Department of Public Health and Environment (working through ATSDR's Cooperative Agreement Program) to evaluate risks to recreational users near the Standard Mine NPL Site, including fish consumption and other direct exposure pathways at the site. We will publish the findings in a second health consultation. The public will have an opportunity to comment on the findings of that document during a public comment period at that time.

C. Comments from a private citizen:

Comment C1: *How might pregnant women, infants and people with impaired immune systems be impacted by the level of cadmium in our water supply? In other words, what happens to people who aren't producing sufficient metallothionein?*

Response: Both ATSDR's minimal risk level and EPA's maximum contaminant level are derived including uncertainty factors of 10. The uncertainty factor accounts for human variability, to be protective of sensitive groups such as those described. Exposure to cadmium in the municipal drinking water from Crested Butte is not expected to result in any adverse health effects.

In scientific literature and Internet searches, ATSDR staff could find no human-specific medical information about fluctuations in metallothionein levels that might be expected during pregnancy, high growth periods, or immune-deficient situations. On the basis of animal studies, it appears metallothionein levels in various organs are a complex and transient function of metal intake, nutritional status, and metabolism [22]. Metallothionein changes could result in changing the distribution of stored cadmium [23]. In addition, nutritional changes such as pregnancy-related iron deficiency could affect uptake of cadmium [24]. However, it is difficult to predict resulting toxicity, since the body appears to have additional or backup mechanisms for sequestering cadmium [25,26].

Comment C2: *What happens when the renal tubules are damaged by cadmium?*

Response: Renal tubules are part of the kidney's filtration system in which bodily wastes are filtered out of the blood and excreted in urine. The basic functional unit is the nephron, composed of an initial filtering component (the renal corpuscle) and a tubule specialized for reabsorption and secretion (the renal tubule). The renal corpuscle filters cells and large proteins from the blood, leaving a plasma-like filtrate to be further modified in the renal tubule. The renal tubules (consisting of proximal convoluted and straight tubules, the "loop of Henle", and distal convoluted tubule) function to reabsorb small proteins, salts, and water from the filtrate back into the blood in the proper ratios before sending the waste to collecting ducts and the bladder for elimination [27].

Cadmium can accumulate in the kidney for decades, with no apparent toxic effects observed until a "critical concentration" is reached. Toxicity associated with this "critical concentration" in the kidney is thought to occur as metallothionein-binding capacity in the tubular cell is exceeded – since free or unbound cadmium is believed to be responsible [28]. The initial toxic effect is damage to the proximal convoluted tubules so that small proteins cannot be reabsorbed properly back into the bloodstream. Thus, the first sign of kidney damage is an increased level of low molecular weight proteins in the urine, called proteinuria. (Later damage can occur to the initial filtering membrane of the renal corpuscle, resulting in excretion of larger proteins such as albumin.) Proteinuria itself may not result in any subjective symptoms of ill health, or it may eventually lead to other complications such as skeletal effects [29].