LETTER HEALTH CONSULTATION

Paris Mill Heritage Site

Public Health Implications of Indoor Exposures to Contaminated Soils and Dust

Alma, Park County, Colorado

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Colorado Department of Public Health and Environment

Prepared by

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SUBJECT: PUBLIC HEALTH IMPLICATIONS OF INDOOR EXPOSURES TO CONTAMINATED SOILS AND DUST AT THE PARIS MILL HERITAGE SITE

DATE: 2/28/11

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The Hazardous Materials and Waste Management Division (HM&WMD) of the Colorado Department of Health and Environment (CDPHE) requested assistance from the Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) to evaluate the potential health hazards with respect to future exposures to workers at the Paris Mill Heritage Site. The purpose of this evaluation is to determine if there are any future potential health impacts to workers resulting from ingestion of indoor soils and dust contaminated with metals, and recommend actions to reduce exposure, if necessary.

The Paris Mill is located in Park County Colorado, approximately three miles west of the town of Alma (Figure 1). Today, the Paris Mill, built in 1894, is a Park County Historic Landmark. Most of the original ore processing equipment still resides in the Mill; in particular, many of the old drive shafts, giant belt wheels, electric motors and motor mounts are still in place. The floor inside the Mill building is exposed dirt with wood planking suspended over wood floor joists. Additional dust will be generated from this dirt floor during the planned remediation activities for the interior surface of the Mill building.

The site is currently owned by the Chihuahua Mining Co. of Spokane, Wash., and is currently for sale along with 900 surrounding acres. The site has a locked gate, posted “no trespassing” signs, and the Mill building is boarded to prevent access by trespassers; however, people do occasionally break in to the Mill building. Park County intends to acquire the property, complete planning work for the parcel, and then transfer the parcel to a private owner who has agreed to develop the site in accordance with the County’s plans. The public-private

partners are interested in adapting the site for recreational mining and a living history museum, along with constructing a new guest lodge. Once restored, the mill and associated 8-acre parcel will be owned by a private party who will maintain and preserve this historic property. This project ensures that controlled public access will be afforded in perpetuity.

The processing of gold, silver, and lead ores is known to have left heavy metal remnants in tailings and as dust inside the historic mill structure. This current evaluation addresses potential risks to the workers who will be present inside the historic Mill building after rehabilitation and redevelopment of the Paris Mill site. Workers are not present inside the Mill at this time.

It should be noted that the purpose of this health consultation does not include evaluation of groundwater and surface water. Furthermore, the town of Alma does not provide any municipal drinking water through ground water wells. The Town of Alma has a surface water intake approx 1 mile downstream of the Paris Mill Site on Buckskin Gulch. However, the surface water samples collected from Buckskin Gulch and showed no site impacts from the site to the stream.

Discussion

The data used for this health consultation were collected by CDPHE as part of a Targeted Brownfields Assessment (TBA) in 2007. The purpose of the TBA was to evaluate potential site source areas, characterize surficial soils on site, and characterize surface water and shallow ground water through the collection of surface soil, sub-surface soil, and ground water samples. The outdoor contamination from mining sources has been remediated. However, the current evaluation addresses potential risks to the workers who will be present inside the historic Mill building after rehabilitation and redevelopment of the Paris Mill site.

This TBA called for the collection of a total of 32 samples, collected on August 7, 2007. Two indoor soil and fines throughout the interior of the structure were collected by decontaminated stainless steel spoon. These indoor samples were 5-point composite samples from proximal areas of the building, collected at the surface at a depth interval of 0-2 inches. These areas were selected based on the high- use and/or visual signs of high contamination. All soil samples were analyzed for aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, magnesium, nickel, mercury, selenium, silver, and zinc using the standard EPA analytical method for metal analysis. The data collected from the historic mill building is summarized in Table 3.

The overall conceptual site model at the Paris Mill Heritage Site is presented below. The indoor soil ingestion, inhalation, and dermal contact pathways are considered complete exposure pathways in this evaluation based on the future

use of the property. Incidental ingestion of soil occurs in a variety of ways including hand-to-mouth activity. Dermal exposure to soil also occurs during a variety of activities; however, dermal exposure is only important for certain contaminants that have the ability to cross the skin barrier. The dermal contact pathway for metals has been determined to be insignificant at this site based on the future use. Inhalation of chromium VI and elemental mercury is generally considered a significant exposure pathway but no indoor air data are available to evaluate this pathway at this site. As such, this evaluation will focus solely on the ingestion pathway.

Table 1. Conceptual Site Model for Future Potential Exposure Pathways

Pathway Name	Exposure Pathway Elements						
	Source	Contaminated Envt'l. Medium	Point of Exposure	Potentially Exposed Population	Route of Exposure	Time Frame	Pathway Complete?
Indoor Soil and Dust	Site related Metals Contamination	Metals in soil and dust	Indoor Soils and dust	Workers	Ingestion, Dermal absorption, Inhalation	Future	Potential

Note: Dermal and inhalation exposure pathways are not evaluated quantitatively.

The maximum detected concentration of 14 contaminants was compared with conservative health based environmental guidelines or Comparison Values (CVs) to select contaminants of potential concern (COPCs) for further evaluation of potential health effects. The (CVs) used in this evaluation are derived for industrial exposure scenarios. Exposures to contaminants below the environmental guidelines are not expected to result in adverse or harmful health effects. Yet, exceeding the comparison value (CV) does not necessarily mean that the contaminant poses a public health hazard. The amount of contaminant, duration and route of exposure, exposure probability, and the health status and lifestyle of the exposed individual are important factors in determining the potential for adverse health effects.

When more than one CV is available for comparison for the same chemical, the lower of these values is used as a conservative measure. In accordance with the CDPHE and EPA Region 8 protocol for the selection of COPCs, if multiple contaminants exist on-site, the CV values are multiplied by 0.1 (EPA, 1994). For non-carcinogenic contaminants, multiplying the CV by 0.1 is thought to account for any additive adverse effects from multiple chemicals. As shown in Table 4, arsenic, cadmium, chromium, iron, lead, and mercury were retained for analysis of cancer risks and non-cancer hazards at the Paris Mill Heritage Site.

To estimate exposure doses, one must make assumptions such as how much soil will be accidentally ingested over a period of time. These assumptions, or exposure factors, can be based on scientific literature, site-specific information, or professional judgment. The exposure factors used in this evaluation are the standard default values recommended by the federal agencies such as EPA and ATSDR for the industrial exposures. To estimate dose at the Paris Mill site, the soil ingestion rate is assumed to be 50 mg/day. Furthermore, the exposure duration for all workers is assumed to be 250 days/year for 25 years (Table 6).

Theoretical Cancer Risks: For incidental ingestion, the theoretical cancer risks for arsenic (2.36E-07) and chromium (2.01E-06) individually or combined (2.25E-06) are below or just above the low-end of the acceptable cancer risk range of 1 E-06 to 1E-04, or 1 excess cancer case per one million exposed individuals to 100 excess cancer cases per one million exposed individuals (Table 5). Overall, exposure to these contaminants in soil in the Paris Mill Heritage Site is associated with a very low risk of developing cancer.

Noncancer hazards: The non-cancer doses for incidental ingestion are well below the corresponding health-based guideline for arsenic, chromium, cadmium, iron, and mercury (Table 5). This indicates that exposure to these contaminants in soil in the Paris Mill Heritage Site is associated with a very low risk of developing noncancer health effects.

Lead: To assess the health risks associated with lead exposure, modeling is typically used to predict the blood lead concentration of those exposed because individuals are exposed to lead from a variety of environmental sources and lead exposures, and the subsequent health effects, have traditionally been described in terms of blood lead concentrations.

Unborn children can also be exposed to lead if their mothers have lead in their bodies. Lead exposure can cause problems such as premature births, low birth weight, decreased mental ability, learning difficulties, and reduced growth as young children. Young children (0-7 years) and developing fetuses are the most sensitive to the toxic effects of lead. Lead levels protective of these susceptible subpopulations are also considered protective of the general population.

Here, EPA's Adult Lead Model was applied to estimate risks to the developing fetus of a pregnant worker (USEPA, 2009).[1] For activities involving the default soil exposure (50 mg/day soil ingestion rate) and soil concentrations ranging from 4700 to 12000 ppm, the probability that fetal blood lead will exceed target blood lead level of 10 ug/dL ranges from 27.1% to 80.2% based on the exposure frequency of 219 days/year (Table 2). This result indicates that exposure to lead

[1] USEPA (2009). Available at: http://www.epa.gov/superfund/lead/products.htm#alm

could harm the developing fetuses of pregnant workers. More information regarding the application of the ALM model can be found in Appendix A.

Table 2. The ALM Model Results for Adult Workers: Probability of Fetal Blood Lead (PbB) >10 ug /dL and the 95th Percentile PbB among Fetuses of Adult Workers

Soil Concentration [mg/kg (parts per million)]	Exposure Frequency	Averaging Time	95th percentile fetal PbB (ug/dL)	Probability of fetal PbB > 10 ug/dL
4700	219 days/year	365 days/year	18.4 – 25.2*	27.2% - 34.5%*
1200	219 days/year	365 days/year	43.3 – 57.3*	76.0% - 80.2%*

***These results are based on a geometric standard deviation of PbB (GSDi) from 1.8-2.1**

Limitations

Quantitative evaluation of the risks to humans from environmental contamination is frequently limited by uncertainty (lack of knowledge) regarding a number of important exposure and toxicity factors. Some of the major uncertainties are briefly noted below.

- Exposure assumptions used in this evaluation can over or underestimate the actual exposure.
- Sampling data is limited because: (1) only two soil/dust samples; and (2) no indoor air samples were collected. Inhalation of chromium VI and elemental mercury is generally considered a significant exposure pathway.
- The site-specific risks for the ingestion pathway are overestimated because of the assumptions of: (1) 100% chromium VI in soil; and (2) 100% bioavailability of metals, based on what is known of the reduced bioavailability of metals in soils.
- The cancer and noncancer risks for arsenic are highly uncertain because of the use of an uncertain “u” value (i.e., non-detected at the reported value).
- The overall risks for arsenic, chromium, cadmium, iron, and mercury are likely to be underestimated because inhalation and dermal contact pathways are not quantitatively evaluated.

Conclusions

Based on the review of the available soil data, CCPEHA has reached the following two conclusions;

Exposure to lead in the indoor soils and dust inside the Paris Mill Heritage Site could harm the health of developing fetuses of pregnant workers.

Exposure to arsenic, chromium, cadmium, iron, and mercury *in the indoor soils and dust inside the Paris Mill Heritage Site is not expected to harm the health of adult workers.* The reason for this decision is that the estimated cancer risks and noncancer hazards for all contaminants of potential concern are associated with a very low increased risk of developing noncancer health effects and cancer.

Recommendations

To ensure a healthy environment inside the Paris Mill Heritage Site, the following recommendations should be implemented:

- Reduce exposure to lead either by remediating of contaminated indoor soil and dust or create a barrier (for example, encapsulate the dirt floor with a polymer substance) to prevent fugitive dust emissions and to prevent exposure to contaminated dust and soils inside the Mill building.
- Collect indoor soil samples after remediation is complete to test for completion of remediation or identify the end-point of cleanup.
- If reduction of exposure is completed as described in the above two recommendations, collection of indoor air samples is not recommended.

Public health action plan

- CCPEHA will evaluate any new soil data upon request.
- CCPEHA will provide health education materials upon request.

Table 3. Summary of Indoor Soil Samples Collected in 2007

Contaminant	Sample 1 [mg/kg (parts per million)]	Sample 2 [mg/kg (parts per million)]	Maximum [mg/kg (parts per million)]
Aluminum	5,100	18,000	18,000
Arsenic	1.5 U	1.8 U	1.8 U
Cadmium	32.0	37.0	37.0
Chromium	6.7	23.0	23.0
Copper	1,200	620	1,200
Iron	110,000	76,000	110,000
Lead	12,000	4,700	12,000
Manganese	11,000	2,300	11,000
Magnesium	3,300	6,700	6,700
Mercury	16.0	11.0	16.0
Nickel	4.0	17.0	17.0
Selenium	20	16	20.0
Silver	60	38	60.0
Zinc	6,600	5,500	6,600

Note:
- mg/kg = Milligrams per kilogram or parts per million
- Max = Maximum Concentration
- U = not detected at the reported value

Table 4. Selection of Chemicals of Potential Concern (COPCs) Based on Indoor Soil Samples Collected in 2007

Contaminant	Max Value [mg/kg (parts per million)]	ATSDR Comparison Value Chronic CREG/EMEG [mg/kg (parts per million)]	EPA Regional Screening Level (Industrial Soil) [mg/kg (parts per million)]	Selected COPCs
Aluminum	18,000	700,000	990,000	N
Arsenic	0.9 U	0.5	1.6	Y
Cadmium	37.0	70	800	Y
Chromium	23.0	700	5.6	Y
Copper	1,200	NA	41,000	N
Iron	110,000	NA	720,000	Y
Lead	12,000	NA	800	Y
Manganese	11,000	NA	NA	NA
Magnesium	6,700	NA	NA	NA
Mercury	16.0	NA	34	Y
Nickel	17.0	NA	44,000	N
Selenium	20.0	4,000	5,100	N
Silver	60.0	NA	5,100	N
Zinc	6,600	200,000	310,000	N

Note:

- mg/kg = Milligrams per kilogram or parts per million
- Max = Maximum Concentration
- U = not detected; the value listed in this table is one-half of the detection limit
- CREG = Cancer Risk Evaluation Guide
- EMEG = Environmental Media Evaluation Guide
- COPC = Contaminant of Potential Concern
- The Regional Screening Level is based on EPA methodology. Available at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2010.pdf

Table 5. Theoretical Cancer Risks and Non-cancer Hazards in Indoor Soil

Compound	Max Value (ug/m^3)	Dose	Cancer Risk	Non Cancer Hazards
Arsenic	0.9	1.57E-07	2.36E-07	
Chromium	23	4.02E-06	2.01E-06	
Arsenic	0.9	4.40E-07		0.001
Chromium	23	1.13E-05		0.004
Cadmium	37	1.81E-05		0.02
Iron	110,000	5.38E-02		0.08
Mercury	16	7.83E-06		0.05
Cumulative risk			2.25E-06	0.15

Note:

- mg/kg = Milligrams per kilogram or parts per million
- Max = Maximum Concentration
- U = not detected; the value listed in this table is one-half of the detection limit

Table 6. Exposure Parameters for the Calculation of Dose (Soil Ingestion in mg/kg/day) by Indoor Commercial Workers

Exposure Paramenter	Value	Source
CS = Chemical concentration in soil	Varies by chemical (mg/kg)	Maximum value from samples collected on site
IR = Soil Ingestion rate	50 mg/day	USEPA (2002)
CF = Conversion factor	10E-06 kg/mg	
EF = Exposure frequency	250 days/year	USEPA (2002)
ED = Exposure duration	25 years	USEPA (2002)
BW = Body weight	70 kg	USEPA (2002)
AT = Averaging time	Noncancer = 365 days * 25 years	USEPA (2002)
	Cancer = 365 days * 70 years	

Note:

- kg = kilogram
- mg = milligram
- mg/kg = Milligrams per kilogram or parts per million
- USEPA (2002) Supplemental Guidance for Developing Soil Screening levels at Superfund Sites. OSWER 9355.4-24. Available at: http://epa-prgs.ornl.gov/chemicals/help/documents/SSG_nonrad_supplemental.pdf

Table 7. Equation for Cancer Dose Calculation for Soil Ingestion by Indoor Commercial Workers

Dose Equation		Intake (mg.kg/day) = CS * IR * CF * EF * ED / (BW * AT)
Example Calculation Chromium, Cancer		(23 mg/kg * 50 mg/day * 0.000001 kg/mg * 250 days/year * 25 years) / (70 kg * 365 days * 70years) = 4.02E-06

Note:

- CS = Chemical concentration in soil – Chromium – 23 mg/kg
- IR = Soil Ingestion rate - 50 mg/day
- CF = Conversion factor - 10E-06 kg/mg
- EF = Exposure frequency - 250 days/year
- ED = Exposure duration - 25 years
- BW = Body weight - 70 kg
- AT = Averaging time - Cancer = 365 days * 70 years
- kg = kilogram
- mg = milligram
- mg/kg = Milligrams per kilogram or parts per million

Table 8. Health Based Guidelines for Contaminants of Potential Concern (Soil Ingestion)

COPC	Health Based Guideline	Oral Slope Factor - SFO (mg/kg-day)-1	Reference Dose - RfDo (mg/kg-day)
Arsenic	3 x10E-04 mg/kg-day (EPA IRIS)	1.5 (EPA IRIS)	3.00E-04 (EPA IRIS)
Chromium	3 x10E-03 mg/kg-day (EPA IRIS)	5.00E-01 (EPA Regional Value)	3.00E-03 (EPA IRIS)
Cadmium	1 x10E-03 mg/kg-day (EPA IRIS)		1.00E-03 (EPA IRIS)
Iron			7.00E-01 (EPA Regional Value / EPA Provisional Peer-Reviewed Toxicity Value (PPRTV)
Lead			
Mercury (elemental)			1.60E-04 (California EPA)

Note:

- kg = kilogram
- mg = milligram
- mg/kg = Milligrams per kilogram or parts per million
- EPA IRIS health guidelines can be found at: http://www.epa.gov/iris/
- EPA Regional Values can be found at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2010.pdf

Appendix A- Adult Lead Model

The ALM model is designed to express the probability that the fetal blood lead concentration will be greater than the target blood lead value of 10 ug/dL. Table 2 shows the results of the ALM using the default input parameters and site-specific indoor soil lead concentration of 4700 to 12000 ppm. For activities involving the default soil exposure (50 mg/day soil ingestion rate) and soil concentrations ranging from 4700 to 12000 ppm, the probability that fetal blood lead will exceed target blood lead level of 10 ug/dL ranges from 27.1% to 80.2% based on the exposure frequency of 219 days/year. All input parameters for the ALM model are further described in table A1.

It is important to note that the adult lead model relies on many input parameters to estimate blood lead levels. EPA developed default values for all parameters to allow the model to be used without performing costly and time-consuming site-specific studies. Several of these parameters can be measured more accurately on a site-specific basis. In the absence of site-specific data, this evaluation uses default values. These default values could lead the model to over predict or under predict actual blood lead levels. In addition, it is important to keep in mind that evidence is growing that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 ug/dL (EPA, 2003). This suggests that the target blood lead level of 10 ug/dL in fetuses and young children for the ALM model may result in underestimation of lead hazards

Table A1. Input Parameters for the ALM Model Results for Adult Workers. Default Soil Ingestion Rate (50 mg/day): Probability of Fetal Blood Lead (PbB) >10 ug /dL and the 95th Percentile PbB among Fetuses of Adult Workers

Variable	Description of Variable	Units	Value
PbS	Soil lead concentration	ug/g or ppm	4,700 or 12,000
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8 or 2.1
PbB_0	Baseline PbB	ug/dL	1.0 or 1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365

Reference

Environmental Protection Agency (EPA, 2003). *America's Children and the Environment: Measures of Contaminants, Body Burden and Illnesses, Second Edition*.

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