Health Consultation

Evaluation of Arsenic and Mercury in Soil along BIA 120

ELEM INDIAN COLONY

SULPHUR BANK MERCURY MINE

CLEARLAKE OAKS, CALIFORNIA

JUNE 9, 2009

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:

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Background

The U.S. Department of Interior, Bureau of Indian Affairs (BIA) asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review and evaluate environmental sampling data collected from the vicinity of road BIA 120 leading to the Elem Indian Colony (Sulphur Bank Rancheria) from the Sulphur Bank Mercury Mine Site in Clearlake Oaks, CA.

Prior to the early 1970s, access to the Sulfur Bank Rancheria was via an unpaved road. Road construction was completed in the early 1970s. In the interim, the existing unpaved road was maintained by the BIA. In the course of maintaining the old Rancheria roadway, the BIA used mine waste from the nearby Sulphur Mercury Mine to gravel the road. Additionally, mine waste rock was used in the construction of the paved road bed [1]. The U.S. Environmental Protection Agency (EPA) conducted a remedial investigation and identified the presence of arsenic and mercury in the abandoned gravel roadway, in the base rock materials and along the shoulders of the existing paved road.

During the period 2006-2008, the EPA removed contaminated soil from around homes and in roadways along Sulphur Bank and Ward road [2, 3]. Mine wastes remained in the shoulder of BIA route 120 that leads from Sulphur Bank road to the Elem Indian Colony. The purpose of this health consultation is to determine if residual levels of arsenic and mercury in the soil next to route 120 are a health hazard for people walking along the road.

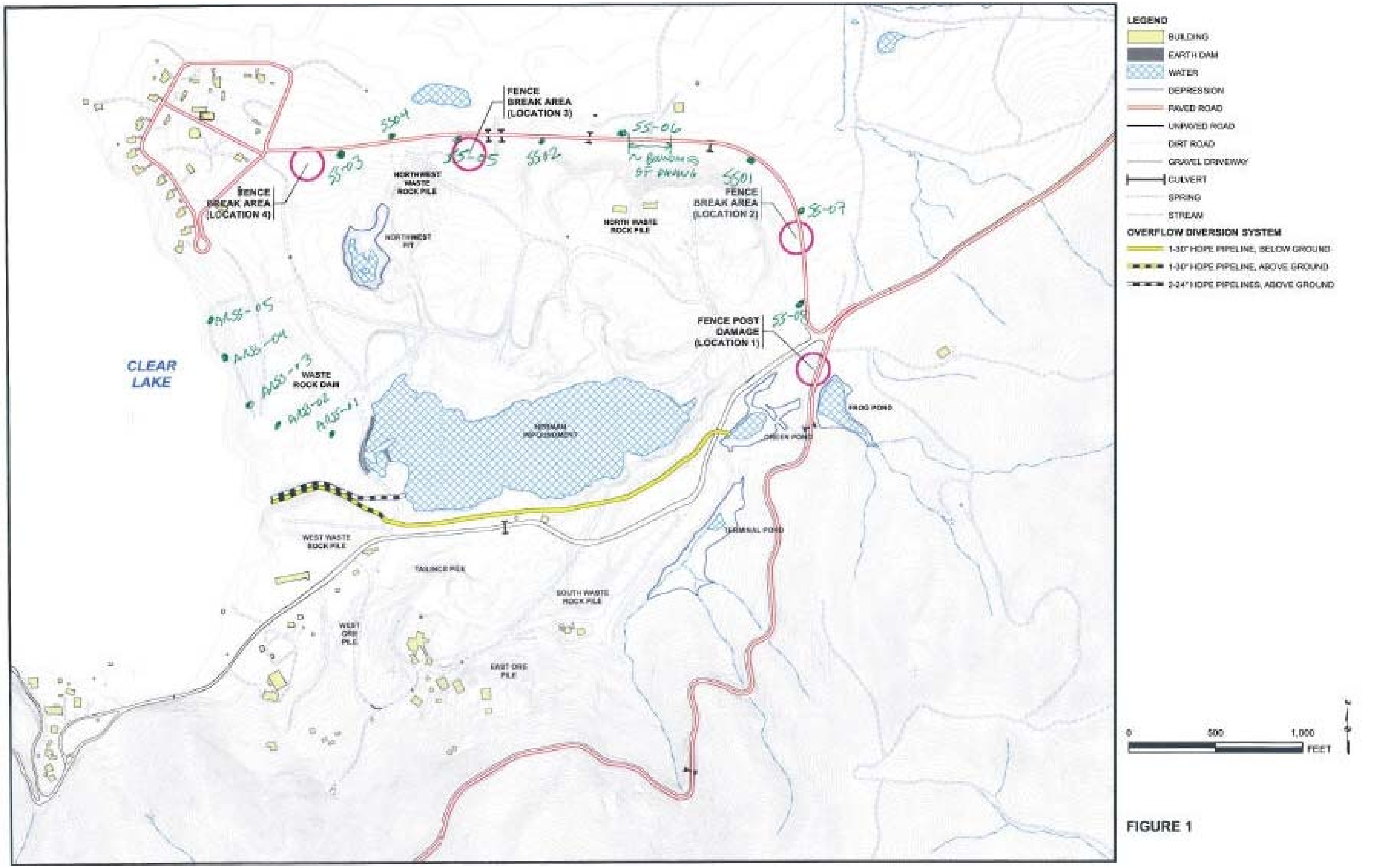
Discussion

Soil sampling data

Analytical sampling data from the roadway were provided by the EPA Region 9 office in San Francisco, CA (Rick Sugarek, EPA R9, personal communication). Nine surface soil samples were taken from the road shoulder along BIA 120 from the intersection of Sulphur Bank Drive to the Elem Indian Colony. Six additional soil samples were taken from an unpaved road leading south from the Elem Indian Colony to the waste rock dam area. Sample locations are presented in Figure 1.

Soil samples were analyzed for metals using an approved inductively coupled plasma-automic emission spectrometry (ICP-AES) analysis method. With the exception of arsenic and mercury, the concentrations of metals in the soil were below their applicable detection limits (were not detected or were too low to be reported with confidence). Sampling data are provided in Tables 1 and 2.

The analytical results of the samples collected along BIA 120 indicate low variability and imply little chance of there being localized areas of higher contamination (i.e. “hot spots”). The



CLEAR LAKE
FENCE BREAK AREA (LOCATION 4)
FENCE BREAK AREA (LOCATION 3)
FENCE BREAK AREA (LOCATION 2)
FENCE POST DAMAGE (LOCATION 1)
NORTHWEST WASTE ROCK PILE
NORTHWEST PIT
NORTH WASTE ROCK PILE
WASTE ROCK DAM
GREEN POND
FROG POND
TERMINAL POND
WEST WASTE ROCK PILE
TAILINGS PILE
SOUTH WASTE ROCK PILE
WEST ORE PILE
EAST ORE PILE
SS-03
SS04
SS-05
SS02
SS-06
SS01
SS-07
ARSS-05
ARSS-04
ARSS-03
ARSS-02
ARSS-01
LEGEND
BUILDING
EARTH DAM
WATER
DEPRESSION
PAVED ROAD
UNPAVED ROAD
DIRT ROAD
GRAVEL DRIVEWAY
CULVERT
SPRING
STREAM
OVERFLOW DIVERSION SYSTEM
1-30" HDPE PIPELINE, BELOW GROUND
1-30" HDPE PIPELINE, ABOVE GROUND
2-24" HDPE PIPELINES, ABOVE GROUND
0
500
1,000
FEET

FIGURE 1

samples collected along Waste Rock Dam road show mercury to be more variable and arsenic to be quantified with less certainty. While no result was over 100 times higher than the rest, the variability in the Waste Rock Dam Road samples suggests a higher chance of an isolated area of higher concentration.

BIA 120 soil sampling data

Analytical results of surface soil samples taken from the road shoulder of BIA 120 are presented in Table 1. The maximum and average concentration of arsenic along the roadway was 46.4 milligram per kilogram (mg/kg) and 31.0 mg/kg respectively. The maximum and average concentrations of mercury were 100 mg/kg and 77.3 mg/kg respectively.

Table 1. BIA 120 soil sampling data

Sample ID	**Collection date**	**Sample media**	**Unit**	**Arsenic**	**Mercury**
BIA120SS01	8/10/2007	Soil	mg/kg	20.2	53.5
BIA120SS02	8/10/2007	Soil	mg/kg	46.4	97.6
BIA120SS102	8/10/2007	Soil	mg/kg	41.2	92.6
BIA120SS03	8/10/2007	Soil	mg/kg	26.9 J	100.0
BIA120SS04	8/10/2007	Soil	mg/kg	41.6 J	71.6
BIA120SS05	8/10/2007	Soil	mg/kg	29.5 J	98.9
BIA120SS06	8/10/2007	Soil	mg/kg	23.9 J	35.0
BIA120SS07	8/10/2007	Soil	mg/kg	23.0 J	73.5
BIA120SS08	8/10/2007	Soil	mg/kg	26.2 J	72.6

Notes:
mg/kg: milligram chemical per kilogram soil (dry weight). Also called ppm or parts per million.
J: Indicates an estimated value. This data qualifier is used when the data indicate the presence of an analyte, but the result is less than the required quantitation limit but greater than zero.

Waste Rock Dam road soil sampling data

Analytical results from nine surface soil samples taken from the road leading from the Elem Indian Colony south to the waste rock dam area are shown in Table 2. The maximum and average concentration of arsenic along the roadway was 149.0 milligram per kilogram (mg/kg) and 61.7 mg/kg respectively. The maximum and average concentrations of mercury were 100 mg/kg and 40.9 mg/kg respectively.

Table 2. Waste Rock Dam road soil sampling data

Sample ID	**Collection date**	**Sample media**	**Unit**	**Arsenic**	**Mercury**
ARSS01	8/28/2007	Soil	mg/kg	61.7 J	100
ARSS02	8/28/2007	Soil	mg/kg	130 J	68.3
ARSS102	8/28/2007	Soil	mg/kg	149 J	69.6
ARSS03	8/28/2007	Soil	mg/kg	7.8 J	0.71
ARSS04	8/28/2007	Soil	mg/kg	11.1 J	2.7
ARSS05	8/28/2007	Soil	mg/kg	10.6 J	4.2

Notes:
mg/kg: milligram chemical per kilogram soil (dry weight). Also called ppm or parts per million.
J: Indicates an estimated value. This data qualifier is used when the data indicate the presence of an analyte, but the result is less than the required quantitation limit but greater than zero.

Exposure and health effects

How could someone contact the contaminated soil on the roads?

People can only be exposed to a contaminant if they come in contact with it. Exposure to arsenic and mercury in road bed materials would most likely occur by accidental ingestion of dust and soil. This could happen if someone touches the soil and then later touches their mouth or an object that goes into the mouth. Adults might accidentally ingest soil or dust particles that adhere to food, cigarettes, or their hands.

The potential for exposure to contaminants in soil via incidental ingestion is greater for children because they are more likely to ingest more soil than adults as a result of behavioral patterns present during childhood. Inadvertent soil ingestion among children may occur through the mouthing of objects or hands. Mouthing behavior is considered to be a normal phase of childhood development.

However, there are some children who intentionally eat soil. This is called soil-pica. Soil pica behavior is most likely to occur in preschool children as part of their normal exploratory behavior. General pica behavior is greatest in 1 and 2 year old children and decreases as children age. Several studies have reported that this behavior occurs in as few as 4% of children or in as many as 21% of children [4-8]. Children with soil-pica behavior are a special concern for acute (short-term) exposures because ingesting high amounts of soil could lead to higher exposure to arsenic and mercury in soil. It is not known with certainty whether children in the Elem community have pica behavior, so ATSDR assumed that some children may eat higher amounts of soil.

What are the levels of exposure to arsenic and mercury from walking on the roads?

ATSDR estimated potential exposure levels for adult and child residents who may come into contact with the exposed surface soil while walking along BIA 120 or Waste Rock Dam road. ATSDR made assumptions about the potential frequency and duration of contact with soil that would result in a higher estimate of exposure than most people walking on the road would usually experience.

ATSDR assumed that someone walked along the road every day of the week for 4 hours (2 hours down and 2 hours back). ATSDR used recommended body weights and soil ingestion rates for adults and children, and also included a soil ingestion rate for children with soil-pica behavior [9, 10]. ATSDR used average chemical concentrations to estimate exposure levels. This approach is reasonable because it is not realistic to assume that on a regular basis a child or an adult would ingest surface soil with the maximum concentration each time they contacted road bed soil over a specified period of time. However, it's possible that a pica child may come into contact with the area of maximum concentration, or someone may drop and then eat some food on a more highly contaminated area of the road edge. For those situations, ATSDR used the maximum detected concentration. Results of the exposure estimate calculations are presented in Tables 3-6. Details of the exposure assumptions and calculations are in Appendix A.

Table 3. Estimated <u>arsenic</u> doses from contaminated soil along <u>BIA 120</u>

Population	Exposure concentration (mg/kg)	Soil screening level (mg/kg)	Estimated exposure (mg/kg-day)	Short-term exposure MRL (mg/kg-day)	Longer-term exposure MRL (mg/kg-day)
Adult	36.9	20	0.0000018	n/a	0.0003
Child	36.9	20	0.000013	n/a	0.0003
Pica-child	46.4	10	0.002	0.005	n/a

Note: n/a, not applicable to exposure situation. MRL, ATSDR Minimal Risk Level

Table 4. Estimated <u>mercury</u> doses from contaminated soil along <u>BIA 120</u>

Population	Exposure concentration (mg/kg)	Soil screening level (mg/kg)	Estimated exposure (mg/kg-day)	Short-term exposure MRL (mg/kg-day)	Longer-term exposure MRL (mg/kg-day)
Adult	91.2	20	0.0000030	n/a	0.002
Child	91.2	20	0.000023	n/a	0.002
Pica-child	100	10	0.002	0.007	n/a

Note: n/a, not applicable to exposure situation. MRL, ATSDR Minimal Risk Level

Table 5. Estimated arsenic doses from contaminated soil along Waste Rock Dam road

Population	Exposure concentration (mg/kg)	Soil screening level (mg/kg)	Estimated exposure (mg/kg-day)	Short-term exposure MRL (mg/kg-day)	Longer-term exposure MRL (mg/kg/day
Adult	114.2	20	0.0000054	n/a	0.0003
Child	114.2	20	0.000041	n/a	0.0003
Pica-child	149	10	0.005	0.005	n/a

Note: n/a, not applicable to exposure situation. MRL, ATSDR Minimal Risk Level

Table 6. Estimated mercury doses from contaminated soil along Waste Rock Dam road

Population	Exposure concentration (mg/kg)	Soil screening level (mg/kg)	Estimated exposure (mg/kg-day)	Short-term exposure MRL (mg/kg-day)	Longer-term exposure MRL (mg/kg/day
Adult	76.8	20	0.0000026	n/a	0.002
Child	76.8	20	0.000019	n/a	0.002
Pica-child	100	10	0.002	0.007	n/a

Note: n/a, not applicable to exposure situation. MRL, ATSDR Minimal Risk Level

Are these levels of exposure a health hazard?

Adults and children who walk along BIA 120 and the Waste Rock Dam road near the Elem Indian Colony should not experience harmful effects from arsenic or mercury in soil along the roads.

All estimated exposures were below ATSDR minimal risk levels (MRLs). MRLs are comparison values that establish exposure levels many times lower than levels where no effects were observed in animals or human studies. The MRL is designed to protect the most sensitive, vulnerable individuals in a population. Although concentrations at or below the relevant comparison value may reasonably be considered safe, exceeding a comparison value does not imply that adverse health effects would be expected. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (for example, duration and frequency), the toxicology of the contaminant, other epidemiology studies, and the weight of evidence for health effects. See Appendix A for additional details.

Arsenic

ATSDR has developed an acute (short term) and chronic (longer term exposure) oral minimal risk level (MRL) for arsenic of 0.005 mg/kg-day and 0.0003 mg/kg-day, respectively. The MRL is an exposure level below which non-cancerous harmful effects are unlikely, even after daily exposure over a lifetime. The acute MRL is based on several transient (i.e., temporary) effects including nausea, vomiting, and diarrhea. When an estimated acute dose of arsenic is below 0.005 mg/kg/day, non-cancerous harmful effects are unlikely. It should be noted that: 1) the acute MRL is 10 times below the levels that are known to cause harmful effects in humans; 2) the acute MRL is based on people being exposed to arsenic dissolved in water instead of arsenic in soil (a fact that might influence how much arsenic can be absorbed since arsenic in water gets into the body more easily when swallowed); and 3) the chronic MRL of 0.0003 mg/kg/day is about 46 times below the Lowest Observed Adverse Effect Level (LOAEL) of 0.014 mg/kg/day where skin changes were seen in people drinking contaminated water [11].
Adult and child exposures to arsenic were all below the chronic MRL. Pica-child or accidental one-time maximum exposures (e.g. dropping and eating food) did not exceed the acute MRL. This indicates that non-cancer health effects would not be expected.

Arsenic is considered a human carcinogen (cancer-causing agent). Average daily exposure levels resulted in a theoretical lifetime excess cancer rate of 3 additional cases of cancer over background in a population of one million. This is considered by ATSDR and EPA to be an insignificant risk in regards to determining whether a health hazard exists and the need to take corrective action. The highest average lifetime daily dose of arsenic in adults was estimated at 0.0000035 mg/kg-day. This exposure level was 285 times below the lowest exposure level where cancer was observed in a human study (0.001 mg/kg-day) [11]. This implies that cancer effects are very unlikely from exposure to arsenic in soil near the roadways.

Mercury

ATSDR has developed acute and intermediate oral minimal risk levels (MRL) for mercury of 0.007 mg/kg-day and 0.002 mg/kg-day, respectively. The acute MRL is based on kidney effects. When an estimated acute dose of arsenic is below 0.007 mg/kg-day, non-cancerous harmful effects are unlikely. It should be noted that the MRL of 0.002 mg/kg-day is based on kidney effects and is about 80 times below the No Observed Adverse Effect Level (NOAEL) of 0.16 mg/kg-day [12].

Adult and child exposures to mercury were all below the MRL. Pica-child or accidental one-time maximum exposures (e.g. dropping and eating food) did not exceed the acute MRL. This indicates that non-cancer health effects would not be expected.

Mercury is not classified as a human carcinogen; therefore no evaluation of human cancer risk was performed.

Child Health Considerations

ATSDR recognizes the unique vulnerabilities of children that put them at a greater risk for harm than adults from exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increases their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight than adults. If exposure to a toxin is high enough during critical growth stages (for example, mercury exposure during nervous system and brain development), developing body systems in children can sustain permanent damage. ATSDR considers these factors in making conclusions and recommendations about the potential public health hazards from exposure to Sulphur Bank mine waste along BIA route 120 and Waste Rock Dam roads

As discussed previously, children and children with soil-pica behavior are a special concern for acute exposures at this area. ATSDR used average and maximum surface soil arsenic and mercury concentrations to calculate the estimated doses in children with typical and high-end soil ingestion. The exposure estimates indicated that children who walk along BIA120 or Waste Rock Dam road are unlikely to experience adverse harmful effects. No significant increase in cancer risk would be expected for exposure in these areas.

Conclusions

No health hazard exists from exposure to soil contamination from walking along BIA 120 or Waste Rock Dam roads near the Elem Indian Colony. Estimated levels of exposure for adults, children, children with soil-pica (intentional ingestion of soil), were well below ATSDR comparison values for harmful health effects.

Recommendations

No health hazard was identified, therefore no recommendations are warranted. However, for those individuals who are concerned about exposure to soil contamination, the following information outlines common-sense methods to reduce contact with soil contaminants:

- Wash hands before cooking, eating, and after outdoor recreational activities.
- Encourage young children to frequently wash their hands, especially before eating.
- Discourage young children from ingesting soil or eating food that has fallen on the ground.
- Remove dusty shoes and clothing before entering homes and bathe pets frequently.
- Damp mop rather than sweep dust from the inside of homes and vehicles.

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Appendix A: Exposure Dose Calculations and Assumptions

The following equation was used to estimate exposure levels:

$$Dose = \frac{CxIRxABSxEFxED}{BWxEDx365d / y}$$

Where:

Dose is the average daily dose in milligrams of chemical per kilogram bodyweight per day (mg/kg-day) For soil pica and accidental one-time events (e.g., dropping food on the road and eating it) the maximum concentrations was used. Note that for these acute events, exposure frequency and duration are not used in the calculation.

C is the soil concentration in milligrams contaminant per kilogram soil (mg/kg) The 95% upper confidence level on the mean was used as the exposure point concentration. The maximum concentration was used for the pica-child exposure scenario.

IR is the assumed soil intake rate in kilograms per day (adult 0.00005 kg/day, child 0.0001 kg/day, pica child 0.001 kg/day) [9, 10].

ABS is the oral absorption factor (mercury 0.28, arsenic 0.40). Arsenic oral bioavailability is based on a study by Casteel et. all [13]. Oral bioavailability of mercury at the site is based on EPA analysis of the forms of mercury in the soils present at the Sulphur Bank Mercury Mine [14]. This soil testing demonstrated approximately 10% soluble forms (e.g. mercuric chloride) and 90% less soluble species (e.g. mercuric sulfide).

EF is the assumed exposure frequency (in days/year = 7 days/week, 52 weeks/year, 4 hours walking per day/24 hours).

ED is the assumed exposure duration (child 6 years: ages 1-5, adult 24 years) [9, 10].

BW is the assumed body weight in kilograms (pica child 11.4 kg, child 18.6 kg, adult 70 kg) [9,10].

Notes:

Quality Assurance

In preparing this report, ATSDR relied on the information provided in the referenced documents. ATSDR reviewed the available quality assurance and control data and determined that it was adequate for the purpose of this document.

Human Exposure Pathway Evaluation and the Use of ATSDR Comparison Values

ATSDR assesses a site by evaluating the level of exposure in a potential or completed exposure pathway. An exposure pathway is the way chemicals may enter a person's body. A completed exposure pathway must include all the steps between the release of a chemical and the exposed person: (1) a chemical release source, (2) chemical movement in the environment, (3) a place at which people can come into contact with the chemical, (4) a route of human exposure, and (5) a person that could be exposed. *If any of these elements is missing, exposure and the potential for health harm can not occur.*

Comparison values are used as screening tools to evaluate environmental data relevant to exposure pathways. Comparison values are concentrations of contaminants that are considered to be not likely to cause health effects. Comparison values used in this document include ATSDR's environmental media evaluation guide (EMEG), used as a soil screening guide. Comparison values are derived from available health guidelines, such as ATSDR's Minimal Risk Levels (MRLs) and EPA's Reference Doses (RfDs).

The derivation of a comparison value uses conservative exposure assumptions, resulting in values that are much lower than exposure concentrations that have been observed to cause adverse health effects. These comparison values are therefore protective of public health in essentially all exposure situations. That is, if the concentrations in the exposure medium are less than the comparison values, the exposures are not of health concern and no further analysis of the pathway is required.

While concentrations below the comparison value are not expected to lead to any observable health effect, it should not be inferred that a concentration greater than the comparison value will necessarily lead to adverse effects. Depending on site-specific environmental exposure factors (for example, duration of exposure) and human activities that result in exposure (time spent in area of contamination), exposure to levels above the comparison value may or may not lead to a health effect. ATSDR's comparison values, therefore, are not used to predict the occurrence of adverse health effects.

After identifying contaminants in site media above comparison values, ATSDR further evaluates exposures to these contaminants considering information about exposures combined with scientific information from the toxicological and epidemiological literature. If necessary, ATSDR estimates exposure doses, which are estimates of how much contaminant a person is exposed to on a daily basis.