March 23, 2012

MEMORANDUM

SUBJECT: Soil Action Level for Arsenic (McDermitt, Nevada)

FROM: Stanford J. Smucker, PhD
       Toxicologist
       USEPA, Region 9

TO: Tom Dunkelman
    On-Scene Coordinator
    USEPA, Region 9

This memo is in response to your request for a site-specific soil action level for arsenic (As).

A site-specific action level for arsenic was determined to be 60 mg/kg for residential areas and other areas where children are present in McDermitt, NV.

Appearing below is a summary of the action level calculations and the assumptions used in the derivation.

Please feel free to contact me at 415.972.3056 or smucker.stan@epa.gov if I can be of further assistance.
ACTION LEVEL FOR ARSENIC IN SOILS

EPA manages environmental risks at Superfund sites per a federal regulation known as the National Contingency Plan (NCP, 55 Federal Register 8665-8865, March 8, 1990). The NCP defines "acceptable" risk for both carcinogenic and non-carcinogenic (systemic) effects as follows:

(1) For systemic toxicants, acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety;

(2) For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between $10^{-4}$ and $10^{-6}$ using information on the relationship between dose and response.

EPA uses the $10^{-4}$ (1 in 10,000 risk) to $10^{-6}$ (1 in a million risk) range as a "target range" within which the Agency strives to manage risks as part of a Superfund cleanup. Exceeding the target risk range for carcinogenic and / or non-carcinogenic effects, will typically result in a removal or remedial action at Superfund sites.

This memo derives an action level for arsenic that identifies an unacceptable level of arsenic in residential soils as per the NCP’s guidance. A site-specific action level for arsenic is derived by taking into account three potential exposure pathways: 1) incidental soil ingestion, 2) dermal contact with soil, and 3) inhalation of dust containing arsenic.

The derivation is based on the following assumptions:

- Action level for arsenic in soil is to protect a child and adult resident that live in the same home for up to 30 years;
- Outdoor soil and indoor dust intake combined is 200 mg per day for young children (age 1 – 6 years) and 100 mg per day for older children and adults (age 7 – 30 years);
- Arsenic bioavailability in soil is assumed to be 60%, relative to the oral bioavailability of dissolved arsenic in water;
- Exposures occur for 350 days out of the year (allowing for a two week vacation);
- A complete discussion of all exposure assumptions and calculations used to derive an action level for arsenic is documented in the “User’s Guide to USEPA’s Regional Screening Levels (RSL, 2012)” available at: http://www.epa.gov/region9/superfund/prg/;
ARSENIC ACTION LEVEL CALCULATION

Based on personal communication with EPA Region 10’s toxicologist (Mark Stifleman), a default of 60% oral bioavailability of arsenic in soils is recommended for mine sites with limited site-specific information. Further, it is expected that in the near future, a national guidance paper issued by EPA’s Technical Review Workgroup (TRW) will recommend a similar default for arsenic in soils. An oral bioavailability assumption < 100% is also supported by bioaccessibility testing performed by EPA Region 9’s Richmond Lab and X-Ray Absorption of Fine Structures (EXAFS) speciation performed by EPA Office of Research’s Ada Lab.

Because the generic screening level or RSL assumes 100% oral bioavailability of arsenic in soils, it is necessary to adjust these values to a 60% oral bioavailability assumption. Table 1 identifies pathway-specific soil concentrations that correspond to EPA’s “acceptable” cancer risk range ($10^{-6}$ – $10^{-4}$), assuming 60 and 100% oral bioavailability. Table 2 identifies pathway-specific soil concentrations that correspond to the non-cancer reference dose range for arsenic that is presented in EPA’s Integrated Risk Information System (IRIS) database. These arsenic concentrations are set at levels at which non-carcinogenic effects associated with exposures to arsenic (hyperpigmentation, keratosis, and possible vascular complications) would not be expected, assuming 60 and 100% oral bioavailability.

### Table 1. Pathway-specific arsenic concentrations in soil (ppm) corresponding to EPA’s acceptable cancer risk range ($10^{-6}$ to $10^{-4}$)

<table>
<thead>
<tr>
<th>Pathway</th>
<th>60% Oral Bioavailability</th>
<th>100% Oral Bioavailability$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Ingestion</td>
<td>0.72 – 72</td>
<td>0.43 – 43</td>
</tr>
<tr>
<td>Dermal Contact with Soil</td>
<td>4.5 – 450</td>
<td>4.5 – 450</td>
</tr>
<tr>
<td>Inhalation of Dust</td>
<td>770 – 77,000</td>
<td>770 – 77,000</td>
</tr>
</tbody>
</table>

Footnote:
$^a$Soil concentrations are from USEPA’s Regional Screening Level (RSL) Soil Table (2012) and assume a cancer oral slope factor of 1.5 (mg/kg-day)$^{-1}$ and a cancer inhalation unit risk of $4.3 \times 10^{-3}$ (ug/m$^3$)$^{-1}$.

### Table 2. Pathway-specific arsenic concentrations in soil (ppm) corresponding to a range of exposure levels to which the human population, including sensitive subgroups, may be exposed without non-cancer health effects during a lifetime

<table>
<thead>
<tr>
<th>Pathway</th>
<th>60% Oral Bioavailability</th>
<th>100% Oral Bioavailability$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Ingestion</td>
<td>13 – 105</td>
<td>7.8 – 63</td>
</tr>
<tr>
<td>Dermal Contact with Soil</td>
<td>93 – 750</td>
<td>93 – 750</td>
</tr>
<tr>
<td>Inhalation of Dust</td>
<td>21,000</td>
<td>21,000</td>
</tr>
</tbody>
</table>

Footnote:
$^a$Estimated with USEPA’s Regional Screening Level Calculator (2012) in site-specific mode, assuming a reference dose range of 0.1 to 0.8 ug/mg-day (USEPA IRIS, 2012)
The McDermitt site action level for arsenic in calcine soils is estimated by adding the reciprocals of the pathway-specific concentrations (soil ingest + dermal contact + dust inhalation) and inverting back to a total soil number as follows:

1\textsuperscript{st} Step \((1/\text{Conc\_ingest} + 1/\text{Conc\_dermal} + 1/\text{Conc\_inhale})\)

2\textsuperscript{nd} Step \((1/(1/\text{Conc\_ingest} + 1/\text{Conc\_dermal} + 1/\text{Conc\_inhale})) = \text{Action Level}\)

These steps were performed for the upper end values of the soil ranges presented in Tables 1 and 2, assuming 60\% oral bioavailability.

For cancer:

1\textsuperscript{st} Step \((1/72 + 1/450 + 1/77,000)\)

2\textsuperscript{nd} Step \((1/(1/72 + 1/450 + 1/77,000)) = 60 \text{ ppm Arsenic}\)

For non-cancer:

1\textsuperscript{st} Step \((1/105 + 1/750 + 1/21,000)\)

2\textsuperscript{nd} Step \((1/(1/105 + 1/750 + 1/21,000)) = 90 \text{ ppm Arsenic}\)

Based on the above calculations, an arsenic action level of 60 ppm is selected for McDermitt calcine soils.
UNCERTAINTIES

There are uncertainties associated with the recommended action level for arsenic. Sources of uncertainty include assumptions regarding exposure scenarios / pathways, arsenic bioavailability in soils, and arsenic toxicity.

Human behavior patterns can strongly affect exposure results. The action level for arsenic is intended to address a reasonable maximum exposure. The soil ingestion scenario assumes that a child swallows 200 mg dirt per day every day except for 2 weeks out of the year. This is likely to be a health-protective assumption, considering that rain and snow events would likely reduce the exposure to outdoor calcine soils for more than 2 weeks out of the year. On the other hand, contact with soil-derived indoor dust can occur during rain and snow events, so a site-specific adjustment to account for bad weather days was not incorporated in this derivation of an action level.

The action level for arsenic does not account for children with pica behavior (i.e. children that deliberately ingest dirt). Exposure estimates that reflect this type of behavior could be considerably higher. However, these types of exposures are expected to be episodic and not continual over 6 years.

It was assumed that arsenic in soils has an oral bioavailability of 60% relative to dissolved arsenic in water. Based on preliminary bioaccessibility testing and EXAFS speciation studies, this is likely to be a health-protective assumption. Additional studies would be needed to more precisely estimate the site-specific bioavailability of arsenic in McDermitt calcine soils.

The supporting human toxicity database is extensive but somewhat flawed. Problems exist with all of the epidemiological studies that evaluate the toxicity of arsenic in drinking water. For example, exposure from food sources are not accounted for, which would tend to exaggerate the toxicity potential of arsenic. On the other hand, the existing cancer risk estimates for arsenic are based on incidence of skin cancer in exposed human populations but do not take into account internal cancers. This could understate potential cancer risk associated with exposure to arsenic. The USEPA is currently updating its health assessment of arsenic, which could lead to changes in the toxicity values that were applied in this tech memo.

The site action level for arsenic in soils does not address potential exposures to arsenic in the diet or in drinking water. To the extent that exposures to arsenic occur through consumption of food stuffs or ingestion of drinking water, there are potential exposures that are not accounted for in this calculation of a site-specific soil level.