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Technical Memorandum

To: Brian A. Rakvica, P.E.
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From: Teri Copeland, M.S., DABT and Joanne Otani Fehling, R.N., M.S.N., P.H.N.,

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Re: Justification for Using an Adjustment Factor for Arsenic Bioavailability in Soil

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This memorandum documents the technical basis for the application of an adjustment factor for arsenic oral bioavailability when assessing human health risk associated with exposure to arsenic via soil ingestion.

I. USEPA Guidance for Adjustment for Absorption Efficiency

As discussed in Appendix A of USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989), when conducting health risk assessments based on USEPA toxicity values, adjustments for absorption efficiency may need to be made in order for the exposure assessment to be consistent with the toxicity value. USEPA identifies two types of adjustments: (1) adjustments associated with administered versus absorbed dose and (2) adjustments for medium of exposure. The latter adjustment is relevant as the basis for arsenic oral bioavailability. The remainder of this section outlines the rationale for employing an oral bioavailability factor when assessing risk associated with ingestion of soil and using the USEPA oral slope factor (SF) and/or the reference dose (RfD) for arsenic.

The oral SF and RfD for arsenic are based on administered doses estimated in a human drinking water exposure study (Tseng et al., 1968 and Tseng, 1977, as cited in USEPA, 2008). As discussed by USEPA (1989):

> *If the medium of exposure in the site exposure assessment differs from the medium of exposure by the toxicity value (e.g. RfD values usually are based on or have been adjusted to reflect exposure via drinking water, while the site medium of concern may be soil), an absorption adjustment may, on occasion[1], be appropriate. For example, a substance might be more completely absorbed following exposure to contaminated drinking water than following exposure to contaminated food or soil (e.g. if the substance does not [fully] desorb from soil in the gastrointestinal tract)… To adjust a food or soil ingestion exposure estimate to match an RfD or slope factor based on the assumption of drinking water ingestion, an estimate of the relative*

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[1] i.e., where appropriate soil matrix absorption data are available.

absorption of the substance from food or soil and from water is needed (USEPA, 1989, Appendix A, p. A-3).

USEPA (1989, Appendix A, p. A-4) provides the following example calculation for adjustment of an exposure estimate to an absorbed dose:

Adjusted Dose = (unadjusted dose) x (relative absorption efficiency)

Where:

relative absorption efficiency = (absorption of chemical in soil/absorption of chemical in water).

II. Use of an Oral Bioavailability Factor of 25% for Arsenic in Soil

In August of 2001, the USEPA Health Effects Division's Hazard Identification Assessment Review Committee (HIARC) evaluated the toxicology database for inorganic arsenic and established toxicological endpoints for incidental residential and commercial/industrial exposure risk assessments (USEPA, 2001). As a key component of that assessment, HIARC established the appropriate relative bioavailability of arsenic in soil versus arsenic in water. The basis for this value is summarized below.

For purposes of health risk assessment, USEPA evaluated a number of studies of relative bioavailability of arsenic (USEPA, 2001). After careful consideration of data reported in the various bioavailability studies, USEPA determined that the monkey was considered an appropriate study model for humans due to its similarity in excretion and gastrointestinal absorption characteristics (USEPA, 2001). The USEPA identified the comprehensive monkey study conducted by Roberts et al. (2002) as the study of choice. This study was conducted on the behalf of the Florida Department of Environmental Protection (DEP) in order to specifically establish a gastrointestinal absorption efficiency factor for arsenic in soil that could be applied to soil risk assessments. The Roberts et al. study identified the maximum of the arithmetic mean value (for five animals) for relative bioavailability for each of five soil types, 24.7%, as a "conservative, upper bound case for any particular soil type". While the maximum individual value reported in the study was 32.4%, the authors did not recommend this value for use as a reasonable maximum exposure (RME) value for risk assessment on the basis that "Only under highly specific, rare circumstances is the maximum value for a particular parameter used in environmental characterization, exposure assessment and risk assessment." USEPA agreed with Florida DEP and selected 25% as a RME value for relative bioavailability for health risk assessments of arsenic in soil (USEPA, 2001) and both agencies currently endorse the value of 25%. While the Roberts et al. study utilized five soil types typical of Florida soils, another monkey study (using a difference species) was conducted by Freeman et al. (1995) using soil near a smelter in Anaconda Montana. The mean absolute percentage bioavailabilities, based on urinary excretion data, were 68, 19, and 14 percent for the gavage (soluble sodium arsenate in oral solution), house dust, and soil treatments, respectively. The values for house dust and soil are consistent with those reported by Roberts et al. (2002) for soil.

III. References Cited

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