APPENDIX A

ADJUSTMENTS FOR ABSORPTION EFFICIENCY

This appendix contains example calculations for absorption efficiency adjustments that might be needed for Superfund site risk assessments. Absorption adjustments might be necessary in the risk characterization step to ensure that the site exposure estimate and the toxicity value for comparison are both expressed as absorbed doses or both expressed as intakes.

Information concerning absorption efficiencies might be found in the sections describing absorption toxicokinetics in HEAs, HEEDs, HEEPs, HADs, EPA drinking water quality criteria or ambient water quality criteria documents, or in ATSDR toxicological profiles. If there is no information on absorption efficiency by the oral/inhalation routes, one can attempt to find absorption efficiencies for chemically related substances. If no information is available, conservative default assumptions might be used. Contact ECAO for further guidance.

Adjustments may be necessary to match the exposure estimate with the toxicity value if one is based on an absorbed dose and the other is based on an intake (i.e., administered dose). Adjustments may also be necessary for different vehicles of exposure (e.g., water, food, or soil).

For the dermal route of exposure, the procedures outlined in Chapter 6 result in an estimate of the absorbed dose. Toxicity values that are expressed as administered doses will need to be adjusted to absorbed doses for comparison. This adjustment is discussed in Section A.1.

For the other routes of exposure (i.e., oral and inhalation), the procedures outlined in Chapter 6 result in an estimate of daily intakes. If the toxicity value for comparison is expressed as an administered dose, no adjustment may be necessary (except, perhaps, for vehicle of exposure). If the toxicity value is expressed as an absorbed dose, however, adjustment of the exposure estimate (i.e., intake) to an absorbed dose is needed for comparison with the toxicity value. This adjustment is discussed in Section A.2.

Adjustments also may be necessary for different absorption efficiencies depending on the medium of exposure (e.g., contaminants ingested with food or soil might be less completely absorbed than contaminants ingested with water). This adjustment is discussed in Section A.3.

A.1 ADJUSTMENTS OF TOXICITY VALUE FROM ADMINISTERED TO ABSORBED DOSE

Because there are few, if any, toxicity reference

ACRONYMS FOR APPENDIX A

ATSDR = Agency for Toxic Substances and Disease Registry
ECAO = Environmental Criteria and Assessment Office
HAD = Health Assessment Document
HEA = Health Effects Assessment
HEED = Health and Environmental Effects Document
HEEP = Health and Environmental Effects Profile
RfD = Reference Dose

DEFINITIONS FOR APPENDIX A

Absorbed Dose. The amount of a substance penetrating the exchange boundaries of an organism after contact. Absorbed dose is calculated from the intake and the absorption efficiency, and it usually is expressed as mass of a substance absorbed into the body per unit body weight per unit time (e.g., mg/kg-day).

Administered Dose. The mass of substance administered to an organism and in contact with an exchange boundary (e.g., gastrointestinal tract) per unit body weight per unit time (e.g., mg/kg-day).

Exposure Route. The way a chemical or physical agent comes in contact with an organism (i.e., by ingestion, inhalation, or dermal contact).

Intake. A measure of exposure expressed as the mass of substance in contact with the exchange boundary per unit body weight per unit time (e.g., mg/kg-day). Also termed the normalized exposure rate, equivalent to administered dose.

Reference Dose (RfD). The Agency's preferred toxicity value for evaluating noncarcinogenic effects resulting from exposures at Superfund sites. See specific entries for chronic RfD, subchronic RfD, and developmental RfD. The acronym RfD, when used without other modifiers, either refers generically to all types of RfDs or specifically to chronic RfDs; it never refers specifically to subchronic or developmental RfDs.

Slope Factor. A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of

values for dermal exposure, oral values are frequently used to assess risks from dermal exposure. Most RfDs and some slope factors are expressed as the amount of substance administered per unit time and unit body weight, whereas exposure estimates for the dermal route of exposure are eventually expressed as absorbed doses. Thus, for dermal exposure to contaminants in water or in soil, it may be necessary to adjust an oral toxicity value from an administered to an absorbed dose. In the boxes to the right and on the next page are samples of adjustments for an oral RfD and an oral slope factor, respectively. If the oral toxicity value is already expressed as an absorbed dose (e.g., trichloroethylene), it is not necessary to adjust the toxicity value.

In the absence of any information on absorption for the substance or chemically related substances, one must assume an oral absorption efficiency. Assuming 100 percent absorption in an oral administration study that serves as the basis for an RfD or slope factor would be a non-conservative approach for estimating the dermal RfD or slope factor (i.e., depending on the type of chemical, the true absorbed dose might have been much lower than 100 percent, and hence an

EXAMPLE: ADJUSTMENT OF AN ADMINISTERED TO AN ABSORBED DOSE RfD

An oral RfD, unadjusted for absorption, equals 10 mg/kg-day.

Other information (or an assumption) indicates a 20% oral absorption efficiency in the species on which the RfD is based.

The adjusted RfD that would correspond to the absorbed dose would be:

10 mg/kg-day x 0.20 = 2 mg/kg-day.

The adjusted RfD of 2 mg/kg-day would be compared with the amount estimated to be absorbed dermally each day.

absorbed-dose RfD should similarly be much lower or the slope factor should be much higher). For example, some metals tend to be poorly absorbed (less than 5 percent) by the gastrointestinal tract. A relatively conservative assumption for oral absorption in the absence of appropriate information would be 5 percent.

EXAMPLE: ADJUSTMENT OF AN ADMINISTERED TO AN ABSORBED DOSE SLOPE FACTOR

An oral slope factor, unadjusted for absorption equals 1.6 $(mg/kg\text{-}day)^{-1}$.

Other information (or an assumption) indicates a 20% absorption efficiency in the species on which the slope factor is based.

The adjusted slope factor that would correspond to the absorbed dose would be:

$$1.6 (mg/kg\text{-}day)^{-1}/0.20 = 8\ (mg/kg\text{-}day)^{-1}.$$

The adjusted slope factor of 8 $(mg/kg\text{-}day)^{-1}$ would be used to estimate the cancer risk associated with the estimated absorbed

A.2 ADJUSTMENT OF EXPOSURE ESTIMATE TO AN ABSORBED DOSE

If the toxicity value is expressed as an absorbed rather than an administered dose, it may be necessary to convert the exposure estimate from an intake into an absorbed dose for comparison. An example of estimating an absorbed dose from an intake using an absorption efficiency factor is provided in the box in the top right corner. Do not adjust exposure estimates for absorption efficiency if the toxicity values are based on administered doses.

A.3 ADJUSTMENT FOR MEDIUM OF EXPOSURE

EXAMPLE: ADJUSTMENT OF EXPOSURE ESTIMATE TO AN ABSORBED DOSE

The exposure assessment indicates that an individual ingests 40 mg/kg-day of the chemical from locally grown vegetables.

The oral RfD (or slope factor) for the chemical is based on an absorbed, not administered, dose.

The human oral absorption efficiency for the contaminant from food is known or assumed to be 10 percent.

The adjusted exposure, expressed as an absorbed dose for comparison with the RfD (or slope factor), would be:

$$40\ mg/kg\text{-}day \times 0.10 = 4\ mg/kg\text{-}day.$$

If the medium of exposure in the site exposure assessment differs from the medium of exposure assumed 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, 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 desorb from soil in the gastrointestinal tract). Similarly, a substance might be more completely absorbed following inhalation of vapors than following inhalation of particulates. The selection of adjustment method will depend upon the absorption efficiency inherent in the RfD or slope factor used for comparison. 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 absorption of the substance from food or soil and from water is needed. A sample calculation is provided in the box on the next page.

In the absence of a strong argument for making this adjustment or reliable information on

EXAMPLE: ADJUSTMENT FOR MEDIUM OF EXPOSURE

The expected human daily intake of the substance in food or soil is estimated to be 10 mg/kg-day.

Absorption of the substance from drinking water is known or assumed to be 90%, and absorption of the substance from food or soil is known or assumed to be 30%.

The relative absorption of the substance in food or soil/drinking water is 0.33 (i.e., 30/90).

The oral intake of the substance, adjusted to be comparable with the oral RfD (based on an administered dose in drinking water), would be:

relative absorption efficiencies, assume that the relative absorption efficiency between food or soil and water is 1.0.

If the RfD or slope factor is expressed as an absorbed dose rather than an administered dose, it is only necessary to identify an absorption efficiency associated with the medium of concern in the site exposure estimate. In the example above, this situation would translate into a relative absorption of 0.3 (i.e., 30/100).