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FINAL
EVALUATION OF POTENTIAL RISKS ASSOCIATED WITH DERMAL EXPOSURE TO BERYLLIUM FROM SOILS AT OU2 ISSUE PAPER

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Table of Contents

1.0 Introduction 1-1
- 1.1 Background 1-1
- 1.2 Objective 1-1

2.0 Methods 2-1
- 2.1 Exposure Assessment Calculations 2-1
- 2.2 Toxicity Assessment 2-4
- 2.3 Risk Characterization Calculations 2-5
- 2.4 Example Calculations 2-5

3.0 Discussion 3-1
- 3.1 Uncertainties Associated with the Exposure Assessment 3-1
- 3.2 Uncertainties Associated with the Toxicity Assessment 3-2
- 3.3 Risk Characterization 3-6

4.0 References 4-1

1.0 Introduction

1.1 Background

In May 1993, IT Corporation published the Remedial Investigation Report for Operable Unit 2 (OU2) of Naval Air Station Moffett Field in Mountain View, California (IT, 1993). There are currently two outstanding issues under discussion with U.S. EPA Region IX.

The first issue involves the origin and distribution of beryllium at Moffett Field. It has been determined that there are no known anthropogenic sources of beryllium at Moffett Field (IT, 1993). Furthermore, there are no apparent trends in the beryllium data relative to known sources. Therefore, it was concluded that the beryllium in the OU2 soils was naturally-occurring and could not be attributed to the site.

The second issue deals with the treatment of beryllium in the risk assessment. The baseline risk assessment for OU2 (IT, 1993) has implied that dermal exposures to soils at OU2 are associated with cancer risk beyond the target range of 10^{-6} to 10^{-4}. The primary contributor to this risk is beryllium. Table 1.1 summarizes the individual ILCR values for beryllium as well as the total ILCR values which were calculated for the OU2 baseline risk assessment at each of the OU2 sites. However, major assumptions associated with the estimation of dermal exposure risks include the estimation of dermal and oral absorption factors and the derivation of a dermal slope factor for beryllium.

1.2 Objective

As a result of a meeting between EPA Region IX and the Navy and its contractors on May 28, 1993, it was agreed that these topics would be discussed in more detail via issue papers. The issue of origin and distribution of beryllium concentrations in OU2 soils will be addressed in a separate issue paper.

The purpose of this issue paper is to clarify the methods which were used to estimate the beryllium ILCRs associated with the dermal absorption pathway and discuss the uncertainties inherent to this procedure. It will be demonstrated that the magnitude of uncertainty associated with the estimation of toxicity factors results in an overestimation of the cancer risk at OU2 and that the more reasonable estimates of carcinogenic risk associated with OU2 are within or below the target range.

Table 1.1
Total and Beryllium Cancer Risk Estimates for Dermal Exposures[a]
NAS Moffett Field OU2

Exposure Scenario	Beryllium ILCR[b]	Total ILCR[b]
Site 3		
Average Current Occupational	3.21 E-06	3.21 E-06
RME Current Occupational	3.91 E-06	3.92 E-06
Average Current Recreational	4.96 E-06	4.96 E-06
RME Current Recreational	1.21 E-05	1.21 E-05
Average Future Residential Adult	1.33 E-03	1.33 E-03
RME Future Residential Adult	5.38 E-03	5.39 E-03
Site 4		
Average Current Occupational	3.85 E-04	3.85 E-04
RME Current Occupational	6.17 E-04	6.17 E-04
Average Future Residential Adult	6.76 E-04	6.76 E-04
RME Future Residential Adult	2.72 E-03	2.72 E-03
Site 5		
Average Current Occupational	2.65 E-06	2.69 E-06
RME Current Occupational	2.99 E-06	2.99 E-06
Site 7		
Average Current Occupational	1.86 E-06	1.86 E-06
RME Current Occupational	2.53 E-06	2.53 E-06
Average Future Residential Adult	7.67 E-04	7.67 E-04
RME Future Residential Adult	3.47 E-03	3.47 E-03
Site 10		
Average Current Occupational	3.96 E-04	3.96 E-04
RME Current Occupational	6.89 E-04	6.89 E-04
Average Future Residential Adult	6.95 E-04	6.95 E-04
RME Future Residential Adult	3.03 E-03	3.03 E-03
Site 19		
Average Current Occupational	2.80 E-06	2.80 E-06
RME Current Occupational	3.49 E-06	3.49 E-06

[a] The shaded areas represent values which exceed the upper bound of the target risk range of 10^{-6} to 10^{-4}.

[b] ILCR = incremental lifetime cancer risk.

2.0 Methods

The purpose of this section is to present the calculations and the underlying assumptions used in the OU2 baseline risk assessment. These calculations are performed during the following steps in the baseline risk assessment process:

- Exposure assessment
- Toxicity assessment
- Risk characterization

2.1 Exposure Assessment Calculations

An exposure model is used to estimate the intake of beryllium on a daily basis. In the case of dermal absorption, intake is expressed as an absorbed dose. The following equation was obtained from the **Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual** (RAGS) (EPA, 1989a):

$$AD = \frac{(C_i)(AdF)(Abs)(CF)(SA)(EF)(ED)}{(BW)\ (AT)}$$

where :

AD	=	Absorbed dose (mg/kg-day)
C_i	=	Chemical-specific soil concentration (mg/kg)
AdF	=	Soil to skin adherence factor (mg/cm^2)
Abs	=	Chemical specific skin absorption factor (unitless)
CF	=	Conversion factor (kg/mg)
SA	=	Skin surface area available for contact (cm^2/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time, period over which exposure is averaged (days)

There are three types of parameters that are used to estimate intake (EPA, 1989a):

- Chemical-related parameters (i.e., exposure concentrations, absorption coefficients).

- Parameters that describe the exposed population (e.g., contact rate, exposure frequency and duration, and body weight).

- Toxicity-related parameters (i.e., averaging time).

The exposure parameters for the dermal absorption exposure scenarios are summarized in the OU2 baseline risk assessment (IT, 1993). The rationale for the selection of these parameters is briefly discussed in the following paragraphs.

Exposure concentrations are chemical-related parameters for the constituents of potential concern. The concentrations for the chemicals detected in OU2 soils are presented in the OU2 baseline risk assessment (IT, 1993). A reasonable maximum exposure (RME) concentration was estimated as the upper 95th percent confidence limit of the arithmetic mean of the sampling data for each chemical of potential concern unless the 95th percent confidence limit was greater than the maximum detected value. In this case, the maximum detected value was used for the RME. The average concentration was used as the average exposure case. For samples with no detectable concentration of the chemical, a value of one-half the detection limit was used to estimate the mean and upper 95th percent confidence limit.

Currently, there is no single recommended source for chemical-specific absorption coefficients. However, a study of the dermal absorption of cadmium (Wester et al, 1991) is cited in the U.S. EPA document on dermal exposure assessment (EPA, 1992a). The data from this study are used to estimate the coefficients for other inorganics. A range of coefficients from 0.1 to 1 percent absorption of cadmium was identified in the Wester study. The lower limit of the experimental range (0.1 percent or 0.001) was assumed to be the absorption coefficient for cadmium. Since values were not available for the other inorganics, a coefficient was estimated by dividing the coefficient for cadmium (0.001) by a safety factor of ten. Therefore, the absorption coefficient for beryllium was estimated to be 0.01. Absorption coefficients for inorganics at OU2 are summarized in Table 2.1.

The population-specific parameters for the dermal exposure scenario were based on EPA guidance (EPA, 1989a, 1989b, and 1991). For occupational exposures, the exposure frequency and exposure duration were site-dependent due to the different scenarios at each site. For current exposures at Sites 3, 5, 6, 7, and 19, an exposure frequency of 5 days per

Table 2.1
Chemical-Specific Dermal Absorption Factors for Soil
NAS Moffett Field OU2

Chemical	Dermal Absorption Coefficient[a] (unitless)
Antimony	0.01
Beryllium	0.01
Cadmium	0.001
Copper	0.01
Lead	0.01
Manganese	0.01
Nickel	0.01
Silver	0.01
Thallium	0.01
Zinc	0.01

[a] The value for cadmium is a measured value from a study by Wester et al, 1991. The values for all other inorganics are estimated from cadmium using a safety factor of ten.

week was combined with an exposure duration of 4 weeks. The only exposures anticipated at these sites are a result of excavation activities which are expected to be short-term. An exposure frequency of 250 days/year and a duration of 25 years was assumed for Sites 4, 10, 11, and 13. Occupational exposures at these sites could occur as a result of routine, long-term occupational activities; therefore, these standard worker exposure parameters were used.

The exposure frequency for all residential exposure scenarios is 350 days per year (EPA, 1991). This value represents the number of days during the year that the resident spends at home. It is assumed that the resident leaves home for approximately 2 weeks of vacation or other travel per year. The exposure duration expresses the number of years that the resident lives in the same home. The 90th percentile value of 30 years was used for the exposure duration parameter (EPA, 1991).

For dermal contact, an occupational exposure area of 3,120 cm^2 representing the average adult's hands and arms was used. The surface area for the residential adult was 8,170 cm^2 based upon potential exposure to hands, arms, and legs. The soil-to-skin adherence factor of 1.05 mg/cm^2 (Driver et al, 1989) was used for both occupational and residential scenarios. The estimated average body weight for an adult (70 kg; EPA, 1991) was used for all sites.

The toxicity-related parameters are averaging times, which depend on the toxic effect of the chemical of concern. Beryllium is associated with both noncarcinogenic and carcinogenic effects. For noncarcinogenic effects, absorbed doses were averaged over the duration of exposure. For carcinogenic effects, absorbed doses were averaged over the estimated lifetime for the human population (70 years; EPA, 1991).

2.2 Toxicity Assessment

The toxicity assessment consists of evaluating the toxic effects of the chemicals of concern and obtaining the corresponding toxicity values. For the purposes of this issue paper, toxicity values for carcinogenic effects (i.e., cancer slope factors) will be addressed.

Cancer slope factors are available for beryllium for both the oral and inhalation routes. Since there are no slope factors based upon the dermal route of exposure, dermal values were derived from oral values as recommended in Appendix A of RAGS (EPA, 1989a).

Since the exposure models result in an absorbed dose, the toxicity value (e.g., the cancer slope factor) is adjusted to account for potential differences in absorption between pathways. The adjustment is made by dividing the oral slope factor for a chemical by an absorption coefficient which represents absorption across the gastrointestinal tract.

Since there is no recommended source of chemical-specific absorption coefficients for this purpose, oral absorption factors from Jones and Owen (1989) were used. Table 2.2 presents the absorption coefficients which were used for inorganics in the OU2 baseline risk assessment; the specific value for beryllium was 0.001. Therefore, by dividing the oral slope factor (4.3 $[mg/kg\text{-}day]^{-1}$) by the absorption coefficient (0.001), the resulting absorbed dose slope factor for beryllium is 4.3×10^3 $(mg/kg\text{-}day)^{-1}$.

2.3 Risk Characterization Calculations

The purpose of the risk characterization step is to combine estimates from the exposure and toxicity assessments. The ILCR is calculated by multiplying the absorbed dose (mg/kg-day) by the absorbed dose slope factor ($[mg/kg\text{-}day]^{-1}$).

2.4 Example Calculations

The three calculations discussed in the previous sections are applied to the following example. The data presented in this example are from the OU2 site and scenario for which the highest ILCR was estimated for beryllium exposures via the dermal exposure pathway.

Example: Estimated RME Incremental Lifetime Cancer Risk (ILCR) for Future Residential Adult Exposures: Site 3, NAS Moffett Field OU2

<u>Calculation of Absorbed Dose for Beryllium at Site 3</u>

$$AD = \frac{(Ci)(AdF)(Abs)(CF)(SA)(EF)(ED)}{(BW)(AT)}$$

where :

AD	=	Absorbed dose (mg/kg-day)
C_i	=	RME concentration of beryllium = 2.48 mg/kg
AdF	=	Soil to skin adherence factor = 1.05 mg/cm^2
Abs	=	Soil absorption coefficient for beryllium = 0.01 (unitless)
CF	=	Conversion factor for mass = 1 $kg/10^6$ mg
SA	=	Skin surface area = 8,170 cm^2/day
EF	=	Exposure frequency = 350 days/year
ED	=	Exposure duration = 30 years
BW	=	Body weight = 70 kg
AT	=	Averaging time for carcinogenic effect = 25,550 days

Table 2.2
Absorption Coefficients for Inorganic Chemicals Via Oral Route of Exposure[a]
NAS Moffett Field OU2

Chemical	Oral Absorption Coefficient (unitless)
Arsenic	0.98 (0.70 - 0.98)
Barium	0.10 (0.05 - 0.85)
Beryllium	0.001 (0.00006 - 0.01)
Cadmium	0.06 (0.023 - 0.10)
Chromium III	0.01 (0.005 - 0.18)
Chromium VI	0.05 (0.02 - 1.00)
Copper	0.50 (0.32 - 0.90)
Lead	0.10 (0.01 - 0.65)
Mercury - elemental	0.0001 (0.0001 - 0.45)
Mercury - inorganic	0.15 (0.02 - 0.15)
Mercury - organic	0.95 (0.40 - 1.00)
Nickel	0.05 (0.01 - 0.10)
Nickel refinery dust	0.05 (0.01 - 0.10)
Nickel subsulfide	0.05 (0.01 - 0.10)
Selenium	0.60 (0.44 - 0.90)
Zinc	0.50

[a] Values were obtained from Jones and Owen (1989).

therefore:

$$AD = \frac{(2.48\ mg/kg)\ (1.05\ mg/cm^2)\ (0.01)\ (1\ kg/10^6\ mg)\ (8{,}170\ cm^2/day)\ (350\ days/year)\ (30\ years)}{(70\ kg)\ (25{,}550\ days)}$$

$AD = 1.25 \times 10^{-6}$ mg/kg-day

Calculation of Absorbed Dose Slope Factor for Beryllium

ADSF = Oral SF/Oral Abs

where:

ADSF = Absorbed Dose Slope Factor (i.e., adjusted for dermal absorption) $(mg/kg\text{-}day)^{-1}$
Oral SF = Oral Slope Factor for beryllium = 4.3 $(mg/kg\text{-}day)^{-1}$
Oral Abs = Absorption coefficient for beryllium through gastrointestinal tract = 0.001

ADSF = 4.3 $(mg/kg\text{-}day)^{-1}/0.001$
ADSF = 4.3×10^3 $(mg/kg\text{-}day)^{-1}$

Calculation of ILCR for Beryllium at Site 3

ILCR = AD x ADSF

where:

ILCR = Incremental lifetime cancer risk (unitless)
AD = Absorbed dose = 1.25×10^{-6} mg/kg-day
ADSF = Absorbed dose slope factor = 4.3×10^3 $(mg/kg\text{-}day)^{-1}$

ILCR = $(1.25 \times 10^{-6}$ mg/kg-day$)$ $(4.3 \times 10^3$ $[mg/kg\text{-}day]^{-1})$
ILCR = 5.38×10^{-3}

3.0 Discussion

The risk assessment process includes the acknowledgement of uncertainties which may ultimately influence the estimation of ILCRs. These uncertainties affect the results of calculations at each step of the risk assessment process. The intent of this discussion is to reiterate the general uncertainties already identified in the OU2 baseline risk assessment and evaluate the specific uncertainties of the dermal exposure assessment.

3.1 Uncertainties Associated with the Exposure Assessment

Three primary types of uncertainties should be considered when reviewing the results of the exposure assessment: uncertainties associated with predicting future land use, uncertainties associated with estimating chemical concentrations at receptor locations, and uncertainties associated with assumptions used in the exposure models. Physiological (e.g., body weight, soil-to-skin adherence factor, dermal absorption coefficients, etc.) and behavioral (e.g., average time spent in one place, amount of soil ingested) values used to model the RME are a combination of average and upper-bound levels obtained from reliable sources. The use of upper-bound estimates will tend to overestimate exposure. This provides a conservative, but not necessarily realistic health-protective approach for the risk assessment.

In September, 1992, supplemental guidance for dermal risk assessment was made available to the EPA regions (EPA, 1992b). The purpose of this guidance is to supplement the interim report **Dermal Exposure Assessment: Principles and Applications** (EPA, 1992a) and to promote consistency in the procedures used by the regions to assess dermal pathways. This guidance was not available when the baseline risk assessment was conducted for NAS Moffett Field OU2. For purposes of this discussion, however, it is useful to present the default parameters from the supplemental guidance and compare the risks which are calculated on the basis of these factors versus the values which were estimated before the guidance was issued.

The following range of default parameters was recommended for evaluating dermal exposure via soil contact (EPA, 1992b):

Default Parameters	Average	RME
Event time/frequency	40 events/year	350 events/year
Exposure duration	9 years	30 years
Adult skin surface area	5,000 cm^2	5,800 cm^2
Soil-to-skin adherence rate	0.2 mg/cm^2 - event	1.0 mg/cm^2 - event

Given a combination of more current default parameters which are discussed in this section, RME and average ILCRs for dermal exposure to beryllium were calculated for comparison and presented in Tables 3.1.1 and 3.1.2, respectively.

The uncertainties involved in estimating the absorption coefficient are of particular interest to this paper. As stated in Section 2.1, there are no chemical-specific absorption coefficients for the dermal exposure pathway. On a qualitative basis, it is unlikely that beryllium is absorbed through intact skin (Agency for Toxic Substances Disease Registry [ATSDR], 1991). In the absence of chemical-specific information, the absorption coefficient for beryllium (0.01) was estimated on the basis of generic values for purposes of the quantitative risk assessment. Further support for the use of this value is provided in EPA's recent supplemental guidance for dermal risk assessment (EPA, 1992b) which indicates that the dermal absorption value of 0.01 (or 1 percent) has been adopted as interim guidance for cadmium. It is stated that this value applies to compounds as well as classes. In this discussion, the term "class" is assumed to include other metals. Since the literature suggests that beryllium is poorly absorbed, the absorption coefficient is likely to represent a very conservative value and may greatly overstate the absorption of beryllium through the skin.

3.2 Uncertainties Associated with the Toxicity Assessment

The uncertainties associated with the cancer slope factors are primarily due to the use of laboratory animal data in the derivation of these values. There are three areas of uncertainty which apply to the use of laboratory animal studies in toxicity assessment for beryllium. The first issue of uncertainty is that toxic effects are observed at the high doses necessary to conduct animal studies. The cancer slope factor is extrapolated from these data to predict effects that might occur at much lower, environmentally relevant values. The oral cancer slope factor for beryllium (4.3 $[mg/kg\text{-}day]^{-1}$) was derived on the basis of a study by

Table 3.1.1
Comparisons of RME Parameters Used in Calculation of ILCRs

Example: Future Adult Dermal Exposures: Site 3

Source	Ci (mg/kg)	AdF (unitless)	Dermal Abs (unitless)	SA (cm^2)	EF (days/year)	ED (years)	Oral Abs (unitless)	ILCR $(mg/kg\text{-}day)^{-1}$
RI Report[a]	2.48	1.05	0.01	8,170	350	30	0.001	5.38×10^{-3}
EPA Default Factors[b]	2.48	1.0	0.01	5,800	350	30	0.05	7.26×10^{-6}
EPA Region VI Default Factors[c]	2.48	1.0	0.01	5,800	350	30	0.30	1.21×10^{-6}

Ci = 95 percent upper confidence limit about the arithmetic mean for the concentration of beryllium in soil
AdF = soil adherence factor
Dermal Abs = dermal absorption factor
SA = skin surface area
EF = exposure frequency
ED = exposure duration
Oral Abs = oral absorption factor
ILCR = incremental lifetime cancer risk

[a] Parameters reflect those values which were used in the baseline risk assessment (IT, 1993).
[b] Default parameters obtained from U.S. EPA guidance. Values for the adherence factor, dermal absorption, skin surface area, exposure frequency, and exposure duration were obtained from supplemental dermal guidance (EPA, 1992b). The oral absorption factor was obtained from RAGS (EPA, 1989a).
[c] The parameters are the same as those listed in footnote b with the exception of the oral absorption factor. The oral absorption factor was obtained from Region VI guidance (EPA, 1992c).

Table 3.1.2
Comparisons of Average Parameters Used in Calculation of ILCRs

Example: Future Adult Dermal Exposures: Site 3

Source	Ci (mg/kg)	AdF (unitless)	Dermal Abs (unitless)	SA (cm^2)	EF (days/year)	ED (years)	Oral Abs (unitless)	ILCR $(mg/kg\text{-}day)^{-1}$
RI Report[a]	2.04	1.05	0.01	8,170	350	9	0.001	1.33×10^{-3}
EPA Default Factors[b]	2.04	0.2	0.01	5,000	40	9	0.05	3.53×10^{-7}
EPA Region VI Default Factors[c]	2.04	0.2	0.01	5,000	40	9	0.30	5.89×10^{-8}

Ci = arithmetic mean of the concentration of beryllium in soil
AdF = soil adherence factor
Dermal Abs = dermal absorption factor
SA = skin surface area
EF = exposure frequency
ED = exposure duration
Oral Abs = oral absorption factor
ILCR = incremental lifetime cancer risk

[a] Parameters reflect those values which were used in the baseline risk assessment (IT, 1993).
[b] Default parameters obtained from U.S. EPA guidance. Values for the adherence factor, dermal absorption, skin surface area, exposure frequency, and exposure duration were obtained from supplemental dermal guidance (EPA, 1992b). The oral absorption factor was obtained from RAGS (EPA, 1989a).
[c] The parameters are the same as those listed in footnote b with the exception of the oral absorption factor. The oral absorption factor was obtained from Region VI guidance (EPA, 1992c).

Schroeder and Mitchener (EPA, 1993), in which Long-Evans rats were administered 5 ppm of beryllium sulfate for a lifetime. Although the investigators noted a slight increase in cancer incidence, the increase was not statistically significant with respect to the control group. The study was further limited by the occurrence of high mortality.

The second area of uncertainty concerns the extrapolation of toxic effects in animals to toxic effects in humans. Human carcinogenicity data was judged to be inadequate for purposes of deriving an oral slope factor (EPA, 1993). The ATSDR states in the toxicological profile for beryllium that no studies were located regarding cancer in humans after oral or dermal exposure to beryllium or its compounds (ATSDR, 1991). Therefore, the oral cancer slope factor of 4.3 $(mg/kg\text{-}day)^{-1}$ was used in risk calculations for beryllium as a conservative measure in accordance with RAGS (EPA, 1989a).

The final source of uncertainty is the gastrointestinal absorption coefficient which is used to adjust the oral cancer slope factor for use in the dermal exposure scenario. As stated in Section 2.2, there has been no formal recommendation on chemical-specific gastrointestinal absorption coefficients. However, one source of such values is a compilation of absorption coefficients derived from the literature by Jones and Owens (1989). The oral absorption coefficients for beryllium ranged from 0.00006 (or 0.006 percent) to 0.01 (or 1 percent). The average value of 0.001 was used to adjust the oral cancer slope factor in an effort to select a reasonably conservative value.

The uncertainty associated with the gastrointestinal absorption coefficient was further evaluated by comparing the ILCRs which would have resulted if EPA default parameters had been used in absence of literature values. The first example is a default parameter of 0.05 (or 5 percent) which was used as an example of a relatively conservative default value for metals in Appendix A of RAGS (EPA, 1989a). The second example is the default value of 0.3 (or 30 percent), which is prescribed by EPA Region VI (EPA, 1992c). These default parameters were also included in the combination of parameters which were compared and presented in Tables 3.1.1 and 3.1.2.

The use of the gastrointestinal absorption coefficient is also evaluated in the context of the RAGS recommendations for adjusting oral slope factors to absorbed dose slope factors. The purpose of this adjustment is to compensate for the uncertainty as to whether absorption

through the gastrointestinal tract is equivalent to absorption through the skin. The oral slope factor is increased to account for the possibility that dermal absorption occurs. Since the degree to which absorption occurs is often unknown, the adjustment reflects an increase which is inversely proportional to the gastrointestinal absorption coefficient. Given the observations in the literature that beryllium is poorly absorbed by the dermal route (ATSDR, 1991), it appears that this assumption is unnecessarily conservative.

3.3 Risk Characterization

A risk assessment of a site is ultimately an integrated evaluation of historical, chemical, analytical, environmental, demographic, and toxicological data that are as site-specific as possible. To minimize the effect of uncertainties in the evaluation, each step is biased toward health-protective estimates. Because each step builds on the previous one, this biased approach should more than compensate for risk assessment uncertainties.

Combinations of values from three different sources were used to represent both the RME and the average dermal exposure scenario. The parameters and the calculated ILCRs for the RME and average cases are summarized in Tables 3.1.1 and 3.1.2, respectively. The ILCR for the RME case in the baseline risk assessment is 5.38×10^{-3} versus ILCRs of 7.26×10^{-5} and 1.21×10^{-5} which were calculated under the default assumptions from the EPA guidance (EPA 1992b, 1992c). Similar results were obtained from calculations for the average case; the ILCR is 1.33×10^{-3} versus ILCRs of 3.53×10^{-7} and 5.89×10^{-8} using the default values (EPA 1992b, 1992c). These comparisons demonstrate that there is a wide range of values by which the dermal exposure pathway can be evaluated. Had the default parameters been available for the baseline risk assessment at NAS Moffett Field OU2, the ILCRs for beryllium would have been within the target risk range of 10^{-6} to 10^{-4}.

As documented in this paper, the ILCRs for the dermal exposure scenario vary considerably depending upon the combination of parameters that have been used in the risk calculations. While conservative values and assumptions were used to satisfy the requirements for a quantitative risk assessment under RAGS (EPA, 1989a), the existing literature also indicates that beryllium is poorly absorbed by the dermal route. It is, therefore, recommended that the extremely conservative nature by which beryllium risks were evaluated for the dermal exposure pathway be considered in the risk management process for NAS Moffett Field OU2.

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