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APPROVAL OF THE SITE-WIDE CHARACTERIZATION REPORT RESPONSE TO COMMENTS

01/20/93

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LETTER

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
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CHICAGO, IL 60604-3590

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REPLY TO THE ATTENTION OF:

JAN 20 1993

Mr. Jack R. Craig
United States Department of Energy
Feed Materials Production Center
P.O. Box 398705
Cincinnati, Ohio 45239-8705

HRE-8J

RE: Approval of the Site-Wide Characterization Report Response to Comments

Dear Mr. Craig:

The United States Environmental Protection Agency (U.S. EPA) has completed its review of the Response to Comments (RTC) on the Site-Wide Characterization Report (SWCR). The RTC's on the SWCR adequately address the majority of U.S. EPA's comments. However, there still remain a few unresolved isssues concerning the risk assessment.

Therefore, U.S. EPA hereby approves the SWCR pending incorporation of modifications which address the enclosed comments. The United States Department of Energy must revise the document, and submit a final report to U.S. EPA within thirty (30) days of receipt of this letter.

Please contact me at (312) 886-0992 if you have any questions, or wish to schedule a meeting regarding this matter.

Sincerely,

James A. Saric
Remedial Project Manager

Enclosure

cc: Graham Mitchell, OEPA-SWDO
Pat Whitfield, U.S. DOE-HDQ
Nick Kauffman, FERMCO
Jim Theising, FERMCO
Paul Clay, FERMCO

(Janke/RC)
Partial Action Response to DOE-0484-93
(5509)

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01

bcc w/o attachments:
William Muno->Norm Niedergang->Kevin Pierard, WMD
Cheryl Allen, OPA

bcc w/attachments:
Gene Jablonowski, ARD
Jean Michaels, PRC
Brian Barwick, ORC
Pat Van Leeuwen,HSRL-5J
Eileen Helmer, HSRL-5J

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE: January 14, 1993

SUBJECT: Review of Responses to Technical Comments on the Draft Site-wide Characterization Report, Fernald Environmental Management Project (FEMP), Fernald, OH, November 1992

FROM: Pat Van Leeuwen, Toxicologist PVL
Technical Support Unit

TO: Jim Saric
Project Manager

I have reviewed the responses to my comments on Part II, the Preliminary Baseline Risk Assessment, Sections 1 through 5, of the Draft Site-wide Characterization Report for the Fernald Environmental Management Project (FEMP). My comments on the responses/suggested actions are provided below.

If you have any questions on these comments or any section of the risk assessment, please contact me at 886-4904.

Comment 253 (1) The suggested action to this comment is acceptable.

Comment 254 (2) Section 2.1.3, p 2-17, lines 31-34 Regarding the response to "What is the Risk-Based Quantitation Limit (RBQL) referred to here?", response is not clear. No explanation is given for the term RBQL. If the RBQL is the same as the SQL, use the known acronym. The use of non-standard acronyms only serves to confuse the reader. Usually detection limits (DLs) do not affect the calculations; does the first sentence of the response refer to quantitation limits? Part II, Appendix N was not completed in the August 1992 draft provided, so this response cannot be evaluated. Further clarification required on this comment.

Comment 255 (3) Section 2.2.1, p 2-18; Appendix T The use of the Upper Tolerance Limit (UTL) test, as described here to choose Chemicals of Concern, has been a point of discussion since the preparation of the site Workplan. We continue to request the use of traditional statistical methods which provide predictable outputs in this step of the risk assessment. This is

consistent with the preparation of all risk assessments reviewed in this Region. Comments and direction from Headquarters statistician, Paul White, have indicated that this approach is inconsistent with Agency guidance (RAGS, ref. EPA 1989b) and is unacceptable to EPA as it provided a means for biasing the selection.

The response/action for the second item in this comment is acceptable.

Regarding the response to the third item (background Upper Limit Concentration values which are given as < 3 or < 1), how are these values applicable in a statistical method?

Comment 256 (4) The approach used here was not objectionable; we have only objected to the arbitrary selection of the ratio of 0.01. To reinterate, the ratio used for elimination of chemicals should be reviewed with the site project manager and toxicologist and may be different in each operable unit-specific risk assessment.

Comment 257 (5) The suggested action to this comment is acceptable.

Comment 258 (6) The suggested action to this comment is acceptable.

Comment 259 (7) The suggested action to this comment is acceptable.

Comment 260 (8) The suggested action to this comment is acceptable.

Comment 261 (9) The response that benzo(a)pyrene (BAP), as well as other carcinogenic PAHs, would be lost to volatilization and thus not be available in a future land use scenario, is not supported by the data. The ATSDR Toxicological Profile on BAP, Environmental Fate, page 76, indicates that "because of its low vapor pressure B[a]P that reaches the surface will likely remain and be partitioned to soil/sediments". The text indicates that volatilization is not considered to be a degration mechanism for PAHs. The is borne out by their persistence in the environment. In addition, an alternate land use (e.g., resident farmer) may occur in the very near future.

Comment 262 (10) The suggested action to this comment is acceptable.

Comment 263 (11 a) Introduction to a set of comments; does not require a response.

Comment 264 (11 b) Regarding the comments on the SA, the response is acceptable. However, please note that in the comment "The range of values for the child/teen and the adult for soil contact pathways should be 3800-4200 cm2 and 1750-2000 cm2, respectively", the values were inadvertently reversed.

Comment 265 (11 c) Regarding the comments on the FI, the response is acceptable. However, it should be noted that changing the FI value from 0.1 to 0.25 increases the intake by 2 1/2. The actual affect on the risk calculation will depend on the media concentration and toxicity of the chemical.

Comment 266 (11 d) Regarding the use of 52 days a year, 4 hours a day, to define the trespass scenario, these values were discussed at the July 17, 1991 Workplan meeting in conjunction with the identification of the trespass populations. Some comments on this issue were provided in the review of other OU risk assessment reports. Please review comments provided in November 1990 for the risk assessment of OU #4, and other earlier comments. Region V does not have a written policy on this matter, nor is it likely to prepare one to satisfy DOE requests. The policy is consistent with the practice of using the specified parameter values in other Region V risk assessments, and this consistency in application may be deemed as justification and a method for eliminating capricious and arbitrary decisions in this matter.

The SWCR should include a discussion of how this change, as well as other changes described in this response report, affect the risk estimates presented in the SWCR report.

Comment 267 (11 e) Regarding the use of the national median residency time of 9 years as the ED value for the on-property resident, the statement in the action is not completely satisfactory. The explanation should also include a statement that this calculated risk can be expected to be exceeded by the 50% of the on-site resident population who are likely to exceed this residency time. If the average time spent at one residence by homeowners in this area is greater than the national median residency time of nine years, the percent of residents exceeding this risk level will be proportionally greater than 50%.

Comment 268 (11f) Regarding the use of an IR of 0.01 g/d for the typical on-property resident using the Exposure Factors Handbook as a reference, it should be noted that the latter guidance manual was published in May 1989. It it USEPA's policy to use current guidance, when available. The studies in the Exposure Factors Handbook have been reexamined, and EPA has released the Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors", OSWER Directive 9285.6-03, March 25, 1991, which is the basis for this commentor's recommendations. It should be further noted that it is the recommendation of the Exposure Assessment Group in Headquarters that the soil ingestion rate of 100 mg/day should also be used for the CT exposure scenario, pending further data. When the receptor is a farmer, the higher ingestion rate of 480 mg/day is the recommended value.

The suggested action can be construed as a decision to ignore provided guidance, and is not acceptable to EPA.

Comment 269 (12) The suggested action does not indicate which method the contractors intend to use in this and

future reports.

Comment 270 (13) We sympathize with the response. The suggested action is acceptable.

Comment 271 (14) The suggested actions are acceptable. It is acceptable to this risk assessor to also include an alternate approach for the calculation of risk due to exposure to carcinogenic PAHs, the second method being a Toxicity Equivalency Factor approach.

Comment 272 (15) The suggested action is acceptable.

Comment 273 (16) The suggested action is acceptable.

Comment 274 (17) The explanation provided in the response significantly clarifies the method of evaluation used in the report. Include it in the text.

Comment 275 (18) Inclusion of additional suggested tables is acceptable. Review again the suggestions in comment 267. This explanation should also be added to the results and uncertainties sections.

Comment 276 (19) The suggested action is acceptable.

Comment 277 (20) The suggested action is acceptable. The table of permeability constants will be reviewed.

Comment 278 (21) Regarding the toxicity values, all but three are based on the applied dose; this information is included as part of the chemical report on IRIS. Regarding the use of chemical specific oral absorption values, information on a large number of contaminants is available from ECAO in Cincinnati.

Comment 279 (22) EPA will review this methodology in more depth as soon as details and a sample calculation are made available.

RESPONSES TO COMMENTS
SITE-WIDE CHARACTERIZATION REPORT

GENERAL TECHNICAL COMMENT

1) The U.S. Department of Energy (DOE) response to Original General Comment No. 34 repeats the text of the DOE response to Original General Comment No. 33. The response to Comment No. 33 is adequate. However, the response does not adequately address Comment No. 34. DOE should provide an adequate response to Comment No. 34.

4075

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 23 1992

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Human Health Evaluation Manual, Supplemental Guidance: "Interim Dermal Risk Assessment Guidance" DRAFT

FROM: James J. Konz (5204G)
Toxics Integration Branch

TO: Regional Toxics Integration Coordinators

Enclosed is a WORD PERFECT file containing the "Interim Dermal Risk Assessment Guidance". This guidance is not being officially distributed to the Regions until after the SAB has completed its review of the ORD Dermal Report. In the interim it was felt that the guidance might be useful to the Regions so it is being distributed to RTICS as a draft report pending review of the ORD dermal report by the SAB. This SAB review is not expected to be complete until December 1992 at the earliest. The guidance will be revised if necessary following the release of the SAB comments.

Included on the disk are the following files:

DERMAL.DFT--Draft dermal guidance
READ.ME--Introduction to the LOTUS Spreadsheets
ORGSCR.WK1--LOTUS Spreadsheet for organics
INORGSCR.WK1--LOTUS Spreadsheet for inorganics

In reviewing/using this guidance, please contact me if you have any suggested changes that would make the guidance more useful. One reviewer has suggested that the guidance be issued as a fact sheet rather than a separate document. Since much of the current guidance is based on the ORD report, it was felt that we could simply say that we adopt the information presented in the ORD report and not repeat it in a Superfund dermal guidance document. Please let me know what you think about this idea. Do you have any other ideas on how the information could be presented to make it most useful to the Regions?

Thanks!

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DRAFT

August 18, 1992

RISK ASSESSMENT GUIDANCE FOR SUPERFUND

VOLUME I: HUMAN HEALTH EVALUATION MANUAL

SUPPLEMENTAL GUIDANCE

DERMAL RISK ASSESSMENT

INTERIM GUIDANCE

Office of Emergency and Remedial Response
Toxics Integration Branch
U.S. Environmental Protection Agency
Washington, D.C. 20460
(703) 603-8861

DRAFT

**** NOTICE ****

The policies set out in this document are not final Agency action, but are intended solely as interim guidance. They are not intended, nor can they be relied upon, to create any rights enforceable by any party in litigation with the United States. EPA officials may decide to follow the guidance provided in this document, or to act at variance with the guidance, based on an analysis of site-specific circumstances. The Agency also reserves the right to modify this guidance at any time without public notice.

****

DRAFT

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1.0 Introduction

In January 1992, the Office of Health and Environmental Assessment (OHEA), in the Office of Research and Development (ORD), issued an interim report, Dermal Exposure Assessment: Principles and Applications (EPA 1992), which provided guidance for conducting dermal exposure assessments. The conclusions of the ORD report were summarized at the National Superfund Risk Assessors Conference in January 1992 where Regional risk assessors requested that a workgroup be formed to prepare an interim dermal risk assessment guidance for the Superfund program based on the ORD Interim guidance document. The intent of the Superfund program guidance is to promote consistency in the procedures used by the Regions to assess dermal exposure pathways.

This Superfund Interim Guidance for Dermal Risk Assessment is the result of a series of workgroup meetings on the issues associated with the characterization of risk resulting from the dermal pathway of exposure. This interim dermal guidance for Superfund draws solely on the recommendations from the ORD report (EPA 1992) and users of the guidance are strongly encouraged to review and understand the material presented in the ORD Interim document. This document is considered interim pending review of the ORD report by the Science Advisory Board and additional data expected to be available from OHEA in 1993. As more data become available, the Superfund interim guidance may be updated.

2.0 General Background

General guidance for evaluating dermal exposure at Superfund sites is provided in Risk Assessment Guidance for Superfund (RAGS), Human Health Evaluation Manual (Part A). The recent ORD interim report, Dermal Exposure Assessment: Principles and Applications (EPA 1992), recommends the following equations to evaluate the dermal absorbed dose for chemicals in water:

$$DAD = \frac{DA_{event}\ EV\ ED\ EF\ A}{BW\ AT} \qquad (1)$$

where:

DAD	=	Dermally Absorbed Dose (mg/kg-day)
DA_{event}	=	Absorbed dose per event (mg/cm^2-event)
A	=	Skin surface area available for contact (cm^2)
EV	=	Event frequency (events/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days), for noncarcinogenic effects AT = ED, and for carcinogenic effects AT = 70 year or 25,550 days

DA_{event} (mg/cm^2-event) can be calculated as follows:

$$If\ t_{event} < t^*,\ then:\ DA_{event} = 2\ K_p\ C_v \sqrt{\frac{6\ \tau\ t_{event}}{\pi}} \qquad (2)$$

$$If\ t_{event} > t^*,\ then:\ DA_{event} = K_p\ C_v \left[\frac{t_{event}}{1 + B} + 2\ \tau \left(\frac{1 + 3\ B}{1 + B}\right)\right] \qquad (3)$$

Please refer to the ORD document (EPA 1992): Dermal Exposure Assessment: Principles and Applications, Chapter 5, Equations (5.9) to (5.21) for the complete procedure. Values to use for most variables are provided in RAGS Part A and supplemented in this current interim guidance (Section 5). Values for the chemical-specific dermal permeability constants (PC) were not

provided in RAGS Part A. This has lead to use of various permeability constants and inconsistency has been a concern. This current guidance provides recommended permeability constants for 200 common organic compounds (Appendix A) and 13 inorganic compounds (Section 3.1.2), and provides a default permeability constant for all other inorganic compounds (Section 3.1.2).

The standard equation for dermal contact with chemicals in soil is:

$$DAD = \frac{DA_{event}\ EF\ ED\ A}{BW\ AT} \qquad (4)$$

where:

- DAD = Dermally Absorbed Dose (mg/kg-day)
- DA_{event} = Absorbed dose per event (mg/cm^2-event)
- A = Skin surface area available for contact (cm^2)
- EF = Exposure frequency (events/year)
- ED = Exposure duration (years)
- BW = Body weight (kg)
- AT = Averaging time (days), for noncarcinogenic effects AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days

DA_{event} (mg/cm^2-event) for soil can be calculated as follows:

$$DA_{event} = C_{soil}\ AF\ ABS \qquad (5)$$

where:

- C_{soil} = Contaminant concentration in soil (mg/kg)(10^{-6} kg/mg)
- AF = Adherence factor of soil to skin (mg/cm^2-event) (also referred to as Contact Rate in RAGS Part A)
- ABS = Absorption fraction

Please refer to Equation (6.18) of the EPA document: Dermal Exposure Assessment: Principles and Applications for complete procedure and explanations. Values to use for most variables are provided in RAGS Part A and supplemented in this current interim guidance (Section 5). Values for the absorption factor were not provided in RAGS Part A. The availability of data for dermal absorption from soil is extremely limited. This guidance has adopted the ORD report recommendations and provides absorption

values for only three compounds/classes (Section 4.2).

A screening procedure is also provided for those assessors who choose to screen out chemicals that do not contribute significantly to the risk at a site for the dermal route. This screening procedure compares the exposure from the dermal route to the oral route. For the purposes of this guidance it was decided that the dermal route would be considered significant if it contributed at least 10% of the exposure derived from the oral pathway. This screening procedure is presented in section 3.4. The list of chemicals for which this dermal-to-oral comparison has been made is presented in Appendix A.

A discussion of toxicity values and the need to convert an administered dose to an absorbed dose are provided in section 6. Section 7 contains a discussion of uncertainty.

3.0 Dermal Absorption of Compounds from Water

3.1 Aqueous Dermal Permeability Coefficients (K_p)

The procedure recommended for use by the Superfund Program to estimate the permeability coefficient (K_p) of a compound was obtained from the review of this subject as presented in Dermal Exposure Assessment: Principles and Applications (EPA 1992). For the assessment of exposure resulting from dermal contact with an aqueous medium, it is recommended that one of the following methods be employed to identify a value for K_p depending on the nature of the compound.

3.1.1 Estimation of K_p for Organic Compounds

Drawing upon anatomically based physico-chemical models of transport through the skin as put forth by Scheuplein, Flynn, and others (see EPA 1992 for further discussion), the thin outermost layer of skin, the stratum corneum, is identified as the main barrier to percutaneous absorption of most chemicals. The stratum corneum can be described as sheets of dead, flattened cells containing the protein keratin, that are held together by a lipoidal substance. Based upon numerous studies, the correlation between a compound's polarity and permeation was observed and it is believed that it is the interstitial lipoidal milieu of the stratum corneum which acts as the rate-limiting transport pathway for most compounds crossing the skin. For some of the highly non-polar compounds which readily pass through the stratum corneum, the watery domain of the viable epidermis that underlies the stratum corneum, may serve as the rate-limiting step to absorption.

Another important predictor of skin permeability had also been identified by Flynn and others working in the field. They were able to identify algorithms that related skin permeability K_p, to the molecular weight of a compound. Drawing upon the importance of both polarity and molecular weight as predictors of permeability, and the analyses of data for organics in aqueous solution, the algorithm of Potts and Guy (see EPA 1992) is being recommended for use by the Superfund Program to assign a value to K_p for organic compounds. This algorithm is as follows:

$$\log K_p = -2.72 + 0.71 \log K_{o/w} - 0.061\, MW \qquad (r^2 = 0.67) \tag{6}$$

where:

K_p = permeability coefficient
log K_{ow} = log of the octanol/water partition coefficient
and MW = the molecular weight of the compound.

As can be seen from this equation, the molecular weight and polarity as described by the octanol/water partition coefficient are the sole predictors of K_p. The above equation containing predicted values of K_p was evaluated against actual experimentally determined values for K_p and was found to correlate reasonably well with just a few exceptions that may be attributed to experimental or analytical error. Consequently, it is recommended that for organics, the predicted values for K_p obtained from the Potts and Guy algorithm be used instead of actual measured values.

For compounds with log $K_{o/w}$ > 4, K_p's predicted by this correlation yield a dermal dose from 10 minutes showering/day equivalent to that of drinking 2L of water per day. The uncertainty of using this correlation for dermal exposure assessment of these high log $K_{o/w}$ compounds is currently under further analysis.

Appendix A presents predicted values of K_p obtained by using the Potts and Guy algorithm for some common pollutants.

3.1.2 Estimation of K_p for Inorganic Compounds

The above algorithm cannot be used to describe the transport of inorganic compounds across the skin as they do not have measurable octanol/water partition coefficients. As a consequence and in keeping with the recommendations put forth in Chapter 5 of Dermal Exposure Assessment: Principles and Applications (EPA 1992), it is recommended that actual measured values of K_p be used if available for the inorganics. If no value is available, then the permeability coefficient of 1×10^{-3} cm/hr is recommended as a default value.

The following is a list of permeability coefficients for the inorganic compounds as compiled in Table 5-3 of Dermal Exposure Assessment: Principles and Applications (EPA 1992):

Compound*	K_p (cm/hr)
cadmium chloride	1×10^{-3}
sodium chromate	2×10^{-3}
sodium dichromate	1×10^{-3}
chromium chloride	1×10^{-3}
cobalt chloride	4×10^{-4}
lead acetate	4×10^{-6}
mercuric chloride	1×10^{-3}
methyl mercury-dicyandiamide	1×10^{-3}
potassium mercuric-chloride	3×10^{-3}
nickel chloride	1×10^{-4}
nickel sulfate	9×10^{-6}
silver nitrate	6×10^{-4}
zinc chloride	6×10^{-4}

* = Listed K_p values are for use with the specific compound listed, only. For all compounds not listed, use the default value of 1×10^{-3}.

3.2 Calculation of Dermal Dose

Spreadsheets have been set up on LOTUS 1-2-3 to support the calculations for the dermally absorbed dose described in Chapters 5 and 10 of the document, Dermal Exposure Assessment: Principles and Applications (EPA 1992). The spreadsheets were sent to the Regions with the document.

The spreadsheets provide data for over 200 organics and about 20 inorganics, with all equations included. Calculations are also given for these chemicals, using either default or assumed values for purpose of illustration.

For each new site, the following procedures need to be followed:

Step 1: Input parameter values common to all chemicals at the top of the spreadsheet, i.e. A, t_event, EV, EF, ED, BW, AT

Step 2: Compile the list of chemicals on the site and their concentrations.

Step 3: Find the chemicals on the spreadsheet provided.

If not there, find their Molecular Weight and Log $K_{o/w}$ and enter data for the new chemicals at the bottom of the spreadsheet. **Copy** the respective formulas for all the calculations to these new chemicals. Numerical values corresponding to the conditions on the site will be calculated automatically.
Delete the ones not found on the site to obtain your own spreadsheet for the site.

Step 4: Enter the concentration of each chemical found on site in the column marked "Conc".

Step 5: Check in the Column "Chemicals to be assessed" to find out whether or not you need to include that chemical in your Risk Assessment.

Step 6: Check on all **Print** setup for your particular printer. You can rearrange the columns to print only the values of interest by **moving** the intermediate calculations to a different part of the spreadsheet. All calculations will be intact, as long as you **do not delete** any column before printing.

3.3 Screening procedure for organic chemicals in water

For purposes of scoping and planning an exposure and risk assessment, it is useful to know when it is important to consider dermal exposure pathways. Assessors must decide what level (from cursory to detailed) of analysis is needed to make this decision. The following screening procedure addresses this issue primarily by analyzing when the dermal exposure route is likely to be significant when compared to the other routes of exposure. This discussion is based on Chapter 9 of Dermal Exposure Assessment: Principles and Applications (EPA 1992) and readers are encouraged to consult this document for more details.

3.3.1 Summary of screening procedure

The first step is to identify the chemicals of concern. The next step is to make a preliminary analysis of the chemical's environmental fate and the population behavior to judge whether dermal contact may occur. The third step is to review the dermal toxicity of the compound and determine if it can cause acute effects. The scope of this effort has been limited to dermal exposure assessments in support of risk assessments for systemic chronic health effects. However, consideration of other types of health effects can be a critical factor in determining the overall importance of the dermal exposure route. Even if the

amount of a compound contacting the skin is small compared to the amount ingested or inhaled, the dermal route can still be very important to consider for compounds that are acutely toxic to the skin.

The remainder of this procedure evaluates the importance of dermal contact by comparing it to other exposure routes that are likely to occur concurrently. For example, the importance of dermal contact with water is evaluated by assuming that the same water is used for drinking purposes as for swimming or bathing and comparing these two pathways. However, the underlying assumption that concurrent exposure routes will occur is not valid in all situations. For example, the water in a contaminated quarry may not be used as a domestic water supply but may be used for occasional recreational swimming. Even where concurrent exposure routes occur, the contaminant concentrations may differ. For example, in a situation involving a contaminated river used as a domestic water supply, swimmers may be exposed to a higher concentration in the river than occurs during ingestion of tap water due to treatment. Thus, the assessor should confirm the assumptions that concurrent exposures occur and that the same contaminant levels apply. Where these assumptions are not valid, dermal exposure should be evaluated independently.

The final step is to review the dermal absorption properties of the compound to determine whether an absorbed dose of concern may occur. As shown below dermal exposure to compounds in water (from 10 minutes showering/day) with a permeability coefficient greater than 10^{-1} cm/hour may pose risks similar to or greater than direct ingestion of 2 L water/day. To ensure that this screening procedure does not eliminate compounds of potential concern, the Dermal Work Group decided to screen out only those compounds which pose dermal exposures less than 10% of the ingestion exposure. This introduces a safety factor of 10 and suggests that a full dermal exposure assessment should be conducted for any compound with a permeability coefficient greater than 10^{-2} cm/hour.

Table A-1 in Appendix A lists 200 common pollutants, their permeability coefficients and the ratio of dermal to ingestion exposures (expressed as a percentage). The compounds are listed in alphabetical order. Assessors can check this list to see if the compound of interest is on the list and whether the permeability coefficient is greater than 10^{-2} cm/hour. Chemicals which are considered appropriate to evaluate for the dermal pathway are indicated in Table A-1 with a "Y" in the "Chemicals To Be Assessed" column. The same information is present in Table A-2 for 13 inorganic contaminants.

3.3.2 Water contact scenario

Where the same water supply is used for drinking and bathing, the importance of dermal contact with water can be evaluated by comparing the possible absorbed dose occurring during bathing relative to that occurring as a result of ingestion:

$$\frac{\textit{Dermal Dose}}{\textit{Ingestion Dose}} = \frac{2\ C_w\ K_p^w\ [6\ \tau\ t_{event}\ /\ \pi]^{0.5}\ A\ x\ EV}{C_w\ IR\ ABS_{GI}} \qquad (7)$$

where:

- C_w = Contaminant concentration in water (mg/cm^3)
- K_p^w = Permeability coefficient in water (cm/hour)
- τ = Lag time (hr)
- t_{event} = Exposure time (hr/event)
- A = Exposed skin area (cm^2)
- EV = Event/day (default assumption= 1 event/day)
- IR = Water ingestion rate (L/day) x (1,000 cm^3/L)
- ABS_{GI} = Fraction of contaminant absorbed in G.I. tract

Assuming an average adult ingestion rate (IR) of 2 L/day, GI tract absorption fraction (ABS_{GI}) of 1, shower time of 10 minutes, and skin area of 20,000 cm^2, this ratio becomes:

$$\frac{\textit{Dermal Dose}}{\textit{Ingested Dose}} = 10\ K_p^w \sqrt{\tau} \qquad (8)$$

So the dermal dose exceeds the ingested dose when:

$$K_p^w\ \sqrt{\tau} > 0.1 \qquad (9)$$

In EPA (1992), the ratio of dermal dose to ingested dose for the above assumptions was computed for 200 common pollutants and plotted as a function of K_p. This plot suggests that the dermal dose exceeds the ingested dose when the K_p is greater than about 0.1 cm/hour. This can also be confirmed by inspection of Table A-1 in Appendix A.

4.0 Dermal absorption of compounds from soil

4.1 Screening procedure

For purposes of developing an interim screening level indicator of when dermal absorption should be considered, the following approach is recommended. Ignoring nonsteady-state issues and assuming that soil ingestion and dermal contact occur concurrently, that the best estimate default values for adults apply, and that 100% of the ingested dose is absorbed, the two routes can be compared as follows:

$$dermal\ dose = ingestion\ dose$$

$$C_{soil}\ ABS\ AF\ A\ EV = C_{soil}\ IR$$

$$ABS = \frac{(100\ mg/day)}{[(0.2\ mg/cm^2\text{-}event)\ (1\ event/day)\ (5000\ cm^2)]} \qquad (10)$$

$$ABS = 0.1$$

Where:

C_{soil} = Contaminant concentration in soil (mg/mg)
ABS = Absorption fraction
AF = Soil to skin adherence rate (mg/cm^2-event)
A = Exposed skin surface area (cm^2)
EV = Event frequency (event/day) = 1 event/day (default assumption)
IR = Soil ingestion rate (mg/day)

On this basis, the general guideline can be offered that compounds with a dermal percent absorbed exceeding 10% are likely to be of greater potential concern than direct soil ingestion.

4.2 Dermal absorption values

Methodologies for evaluating the applicability of experimental results to the exposure scenario of concern are presented in Chapter 6 of Dermal Exposure Assessment: Principles and Applications (EPA 1992). In this document, ORD reviewed the available experimental data for dermal absorption from contaminated soil and presented recommendations for three compounds/classes. The recommendations were presented as ranges to account for uncertainty which may arise from different soil types, loading rates, chemical concentrations, and other conditions. In this interim dermal guidance for Superfund, a

single value is selected based on the recommended ORD ranges.

For TCDD it was felt that there were sufficient data to make recommendations specific to organic carbon content of the soil; for the other two compounds/classes, the upper end of the range recommended by ORD was selected. As an interim guidance, the dermal absorption values for three compounds/classes are adopted as follows:

TCDD	
Low Organic Soil (<1%)	3.0% absorbed
High Organic Soil (≥1%)	0.1% absorbed
Other Dioxins	3.0% absorbed
PCBs	6.0% absorbed
Cadmium	1.0 % absorbed

These values have been evaluated and determined applicable using the Superfund default human exposure assumptions. Other values will be added to this list as more research becomes available. However, as an interim method, dermal exposure to other compounds should be treated either qualitatively in the uncertainty section or quantitatively after presenting the relevant studies to the Regional risk assessors so that absorption factors can be agreed upon on a site-specific basis. Particular attention should be given to compounds which are dermally active, such as benzo(a)pyrene, and should be addressed fully as to their elevated risk by this route of exposure. The Dermal Workgroup should be contacted to review any other values developed for the soil pathway.

5.0 Other dermal exposure parameters

In Dermal Exposure Assessment: Principles and Applications (EPA 1992), ORD reviewed the available data on parameters needed to characterize dermal contact scenarios involving water and soil. For each parameter, a range of default values was derived corresponding to central- and upper-end values. These values are presented in the Summary Table below (Table 5-1). Background data and rationales for the recommended default values are presented in Chapter 8 of EPA (1992).

Table 5-1. Range of Recommended Defaults for Dermal Exposure Factors

	Water Contact				Soil Contact	
	Bathing		Swimming			
	Central	Upper	Central	Upper	Central	Upper
Event time and frequency	10 min/event 1 event/day 350 days/yr	15 min /event 1 event/day 350 days/yr	0.5 hr/event 1 event/day 5 days/yr	1.0 hr /event 1 event/day 150 days/yr	40 events/yr	350 events/yr
Exposure duration	9 yr	30 years	9 yr	30 years	9 yr	30 years
Adult skin surface area (See Table 8-3 for children)	20,000 cm^2	23,000 cm^2	20,000 cm^2	23,000 cm^2	5000 cm^2	5,800 cm^2
Soil-to-skin adherence rate					0.2 mg/cm^2-event	1.0 mg/cm^2-event

6.0 Toxicity Values and Risk

The methodologies for evaluating percutaneous absorption, as described in Dermal Exposure Assessment: Principles and Applications (EPA 1992), give rise to an estimation of absorbed dose (i.e., bioavailability). IRIS validated indices of toxicity (oral slope factors and RfDs) are typically based on administered dose; consequently, adjustment of oral toxicity values should be considered when characterizing risk associated with the dermal exposure pathway.

Adjustment of an oral slope factor/RfD should be performed when the following conditions are met:

1) The critical study upon which the toxicity value is based employed an administered dose (e.g., delivery in diet or by gavage) in its study design.

2) A scientifically defensible data base exists and demonstrates that the gastrointestinal absorption of the chemical in question, from a media (e.g., water, feed) similar to the one employed in the critical study, is significantly less than 100%.

In the event that the aforementioned criteria are not met, it is recommended that a default value of complete (i.e., 100%) oral absorption be assumed, thereby eliminating the need for oral toxicity-value adjustment. It should be noted in the uncertainty analysis that employing the oral absorption default value may result in an underestimation of risk; the magnitude of the underestimation being inversely proportional to the true oral absorption of the chemical in question.

Discussion on absorption and risks

Two issues commonly arise in regard to the analysis presented in section 3.3.2. The first is how would the analysis change if the route comparisons were made on the basis of risk rather than dose. The second issue is how would the route comparison change if the GI tract absorption fraction were much less than the assumed 100%. These issues can be addressed by modifying Equation 7 (Section 3.2.2) to a risk basis:

$$\frac{Dermal\ Risk}{Ingestion\ Risk} = \frac{DOSE_{dermal}\ (\ q^* \ /\ ABS_{GI})}{DOSE_{ingestion}\ q^*} \qquad (11)$$

Where: q* = cancer slope factor (kg-day/mg)

As discussed in Chapter 10 of EPA (1992), cancer slope factors are intended to be used with administered dose. Since dermal doses are absorbed, it is necessary to convert the q* to an absorbed basis which can be done in an approximate way by dividing it by the GI tract absorption fraction. After canceling the q*'s and substituting the ratio of dermal to ingestion doses derived earlier in Equation 11, the following expression results:

$$\frac{Dermal\ Risk}{Ingested\ Risk} = \frac{10\ K_p^w \sqrt{\tau}}{ABS_{GI}} \qquad (12)$$

Comparing Equations 8 and 12 suggests that when ABS_{GI} is high it is not important to consider and the earlier conclusions for when the dermal dose exceeds the ingested dose do not change. However, when ABS_{GI} is low it can substantially increase the importance of dermal route relative to ingestion and is important to consider.

7.0 Uncertainty

Important uncertainty issues in assessing risks for dermal exposure to soil and water media are identified in Chapter 10 of Dermal Exposure Assessment; Principles and Applications (EPA 1992). Issues relevant to quantitative assessment for dermal pathways in Superfund risk assessments are discussed below.

- *Oral reference doses and slope factors are used to evaluate potential toxicity from the dermal route of exposure.*

Quantitative toxicity estimates for dermal exposures have not been developed by EPA. Therefore, oral reference doses and oral cancer potency factors were used to assess toxicity for dermal exposures. Compared to oral exposures to chemicals, dermal routes of exposure could result in different patterns of distribution, metabolism, and excretion. When oral toxicity values for systemic effects are applied to dermal exposures, uncertainty in the risk assessment is introduced because these differences are not taken into account. Because the differences between oral and dermal pathways would depend on the specific chemical, use of oral toxicity factors might result in over- or underestimation of risk, depending on the chemical. It is not possible to make a general statement about the direction or magnitude of this uncertainty.

- *Information is usually not available to adjust oral reference dose or potency factor to absorbed dose; 100% GI absorption is assumed.*

Most oral reference doses and slope factors are presented in terms of administered dose. The result of a quantitative dermal exposure assessment is a predicted systemic absorbed dose. This exposure assessment should therefore be combined in the risk characterization step with an RfD or slope factor that has been corrected for gastrointestinal absorption to also represent absorbed dose. (See Dermal Exposure Assessment; Principles and Applications EPA 1992, p. 10-10 or RAGS Part A, Appendix A, for more information on adjustment of absorbed dose.) However, in the absence of information on gastrointestinal absorption, risk characterization for dermal pathways has used unadjusted reference doses and slope factors. This results in underestimation of risk.

- *No information is available to quantitatively evaluate potential toxicity at the skin surface.*

Use of estimated dermal absorbed doses and oral toxicity factors estimates potential for systemic effects based on dermal

absorption. The resulting risk estimate does not take into account potential for toxicity at the skin surface. No quantitative toxicity values for these effects have been developed by EPA. For chemicals which have potential toxic effects at the skin surface, lack of information to describe this risk quantitatively results in underestimation of risk.

- *Permeability coefficients for water are estimated based on model prediction.*

Permeability estimates have been identified as the major parameter contributing uncertainty to the assessment of dermal exposure to contaminants in aqueous media (EPA 1992, p. 10.5)

- *For most chemicals, no quantitative description of absorption from soil is available, so risks are not quantified.*

The ability to quantify percent absorption of contaminants that would occur from exposure to soil is limited. Chemical-specific information is available for only a few chemicals. For most chemicals, no data are available, so dermal exposures have not been quantified. This lack of data results in potential underestimation of total exposure and risk.

- *For dermal exposure to soil, exposure factors such as skin surface area exposed, soil adherence, and frequency of exposure are not well defined.*

8.0 Conclusions/recommendations

Based on the information presented in the ORD report (EPA 1992), some general guidelines are proposed to evaluate when the dose received from dermal contact is important to consider:

- For most contaminants, dermal contact with water during bathing or swimming will generally pose less threat than direct consumption of the water. The fastest penetrating contaminants may pose hazards similar to or greater than direct consumption. Although these chemicals may not increase the total risk substantially, they may significantly impact the cost of remedial action. This would occur in a situation where the water was considered unsafe to drink and the remedial action plan called for replacement of drinking water only, which could be accomplished via use of bottled water. Since it now appears that these chemicals would pose an equal risk via contact during bathing, it would be equally important to replace the water used for bathing and showering. For practical purposes, this suggests that replacing the entire household water supply would be necessary. It has not been well established how many of the environmental contaminants may have K_p values in this upper range, but it appears to be a minority.

- It appears that more soil is dermally contacted than is ingested during normal exposure scenarios. Dermal absorption from soils appears to be more significant than direct ingestion for those chemicals which have a percent absorbed exceeding about 10%.

- Current studies suggest that dermal exposure may be expected to contribute no more than 10% to the total body burden of those compounds present in the vapor phase. An exception may occur for workers wearing respiratory protection but not chemical protective clothing.

- Any compounds that are acutely toxic to the skin are important to consider even if less exposure occurs by skin contact than other routes.

The exposure values recommended by the workgroup for use with dermal exposure scenarios are summarized in Table 5-1. Permeability values recommended for aqueous contact are presented in Appendix A.

Recommendations

It is strongly recommended that the Dermal Workgroup review any absorption values derived for dermal contact with soil-bound contaminants, other than the three listed in the document, before the Regions use the values in quantitative risk assessments.

Research requirements were listed in the EPA (1992) report. In addition to these research recommendations, other areas where additional research would provide much needed information for addressing the dermal exposure pathway include 1) quantification of dermal absorption from soil (percent absorbed) for high priority compounds using both in vivo and in vitro techniques; and 2) determination of the effect of soil type/size on bioavailability of soil-bound compounds. Users are encouraged to contact Superfund Regional risk assessors with additional information that can be used for addressing this pathway and with additional research needs.

APPENDIX A
SCREENING VALUES/PERMEABILITY CONSTANTS

CHEMICAL	CAS No.	MWT	logKow	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Acetaldehyde	75070	44.1	-0.22	5.9E-04	1.0E-03	2.9E-07	1.0E-05	0%	N
Acetamide	60355	59.0	-1.26	8.2E-05	1.0E-03	4.5E-08	1.6E-06	0%	N
Acetylaminofluorene, 2-	53963	223.0	3.24	1.8E-02	1.0E-03	3.1E-05	1.1E-03	31%	Y
Acrolein	107028	56.1	-0.10	6.2E-04	1.0E-03	3.3E-07	1.2E-05	0%	N
Acrylamide	79061	71.0	-0.67	1.9E-04	1.0E-03	1.1E-07	4.0E-06	0%	N
Acrylonitrile	107131	53.1	0.25	1.2E-03	1.0E-03	6.2E-07	2.2E-05	1%	N
Aldrin	309002	365.0	3.01	1.7E-03	1.0E-03	7.9E-06	2.8E-04	8%	N
Allyl chloride	107051	76.5	1.45	6.5E-03	1.0E-03	4.0E-06	1.4E-04	4%	N
Aminoanthraquinone, 2-	117793	223.0	2.15	2.8E-03	1.0E-03	4.8E-06	1.7E-04	5%	N
Aminoazobenzene, p-	60093	197.0	2.62	9.1E-03	1.0E-03	1.3E-05	4.6E-04	13%	Y
Aminoazotoluene, o-	97563	225.3	3.92	5.6E-02	1.0E-03	9.8E-05	3.4E-03	98%	Y
Aminobiphenyl, 4-	92671	169.2	2.80	1.8E-02	1.0E-03	2.1E-05	7.5E-04	21%	Y
Amino-2-methylanthraquinone, 1-	82280	237.3	2.80	7.1E-03	1.0E-03	1.3E-05	4.7E-04	13%	Y
Aniline	62533	93.1	0.90	2.0E-03	1.0E-03	1.4E-06	5.0E-05	1%	N
Anisidine, o-	90040	145.0	1.18	1.6E-03	1.0E-03	1.6E-06	5.6E-05	2%	N
Auramine	492808	267.4	3.54	1.6E-02	1.0E-03	3.8E-05	1.3E-03	38%	Y
Benzene	71432	78.1	2.13	2.0E-02	1.0E-03	1.3E-05	4.5E-04	13%	Y
Benzidine	92875	184.2	1.34	1.2E-03	1.0E-03	1.6E-06	5.6E-05	2%	N
Benzoic acid	65850	122.0	1.87	7.1E-03	1.0E-03	6.0E-06	2.1E-04	6%	N
Benzotrichloride	98077	195.0	2.92	1.6E-02	1.0E-03	2.2E-05	7.7E-04	22%	Y
Benzo-a-anthracene	56553	228.3	5.66	1.1E+00	1.0E-03	1.9E-03	6.6E-02	1861%	Y
Benzo-a-pyrene	50328	250.0	6.10	1.6E+00	1.0E-03	3.4E-03	1.2E-01	3368%	Y
Benzo-b-fluoranthene	205992	252.3	6.12	1.7E+00	1.0E-03	3.5E-03	1.2E-01	3453%	Y
Benzyl chloride	100447	127.0	2.30	1.4E-02	1.0E-03	1.2E-05	4.3E-04	12%	Y
Bis(2-chloroethyl)ether	111444	143.0	1.29	2.0E-03	1.0E-03	1.9E-06	6.9E-05	2%	N
Bromodichloromethane	75274	163.8	2.09	5.8E-03	1.0E-03	6.6E-06	2.3E-04	7%	N
Bromoform	75252	252.8	2.37	2.7E-03	1.0E-03	5.7E-06	2.0E-04	6%	N
Bromomethane	74839	95.0	1.19	3.2E-03	1.0E-03	2.3E-06	8.1E-05	2%	N
Bromophenol, p-	106412	173.0	2.65	1.3E-02	1.0E-03	1.6E-05	5.7E-04	16%	Y
Butadiene, 1,3-	106990	54.0	1.99	2.2E-02	1.0E-03	1.2E-05	4.2E-04	12%	Y
Butanediol, 2,3-	513859	90.1	-0.92	9.5E-05	1.0E-03	6.5E-08	2.3E-06	0%	N
Butanol, n-	71363	74.1	0.65	1.7E-03	1.0E-03	1.1E-06	3.7E-05	1%	N

CHEMICAL	CAS No.	MWT	logKow	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Butoxyethanol, 2-	111762	118.0	0.83	1.3E-03	1.0E-03	1.1E-06	3.7E-05	1%	N
Captan	133062	300.0	2.35	1.4E-03	1.0E-03	4.0E-06	1.4E-04	4%	N
Carbon disulfide	75150	80.0	2.24	2.4E-02	1.0E-03	1.5E-05	5.3E-04	15%	Y
Carbon tetrachloride	56235	153.8	2.83	2.4E-02	1.0E-03	2.5E-05	8.8E-04	25%	Y
Chlordane	57749	409.8	5.54	6.9E-02	1.0E-03	4.3E-04	1.5E-02	430%	Y
Chlordane (cis)	5103719	410.0	5.47	6.1E-02	1.0E-03	3.8E-04	1.3E-02	381%	Y
Chlordane (trans)	5103742	410.0	5.47	6.1E-02	1.0E-03	3.8E-04	1.3E-02	381%	Y
Chlorobenzene	108907	112.6	2.84	4.2E-02	1.0E-03	3.4E-05	1.2E-03	34%	Y
Chlorocresol	59507	142.6	3.10	4.3E-02	1.0E-03	4.3E-05	1.5E-03	43%	Y
Chlorodibromomethane	124481	208.3	2.23	4.0E-03	1.0E-03	6.1E-06	2.2E-04	6%	N
Chloroethane	75003	64.5	1.43	7.4E-03	1.0E-03	4.2E-06	1.5E-04	4%	N
Chloroform	67663	119.4	1.97	8.7E-03	1.0E-03	7.3E-06	2.6E-04	7%	N
Chloromethane	74873	50.5	0.91	3.7E-03	1.0E-03	1.9E-06	6.8E-05	2%	N
Chlorophenol, o-	95578	128.6	2.16	1.1E-02	1.0E-03	9.5E-06	3.3E-04	9%	N
Chlorophenol, p-	106489	128.6	2.39	1.6E-02	1.0E-03	1.4E-05	4.9E-04	14%	Y
Chlorothalonil	1897456	265.9	3.86	2.9E-02	1.0E-03	6.6E-05	2.3E-03	66%	Y
Chloroxylenol		132.5		2.5E-04	1.0E-03	2.3E-07	8.2E-06	0%	N
Chrysene	218019	228.3	5.66	1.1E+00	1.0E-03	1.9E-03	6.6E-02	1861%	Y
Cresidine, p-	120718	137.2	1.67	4.1E-03	1.0E-03	3.9E-06	1.4E-04	4%	N
Cresol, m-	108394	108.1	1.96	1.0E-02	1.0E-03	7.8E-06	2.7E-04	8%	N
Cresol, o-	95487	108.1	1.95	9.9E-03	1.0E-03	7.6E-06	2.7E-04	8%	N
Cresol, p-	106445	108.1	1.94	9.7E-03	1.0E-03	7.5E-06	2.6E-04	7%	N
DDD	72548	320.0	5.80	3.7E-01	1.0E-03	1.2E-03	4.4E-02	1246%	Y
DDE	72559	318.0	5.69	3.2E-01	1.0E-03	1.0E-03	3.7E-02	1047%	Y
DDT	50293	355.0	6.36	6.0E-01	1.0E-03	2.5E-03	8.9E-02	2540%	Y
Decanol	112301	158.3	4.11	2.0E-01	1.0E-03	2.1E-04	7.5E-03	214%	Y
Diaminoanisole, 2,4-	615054	138.2	-0.12	1.9E-04	1.0E-03	1.8E-07	6.4E-06	0%	N
Diaminotoluene	95807	122.0	0.34	5.2E-04	1.0E-03	4.5E-07	1.6E-05	0%	N
Diaminotoluene, 2,4-	101804	200.0	2.06	3.3E-03	1.0E-03	4.9E-06	1.7E-04	5%	N
Dibenzo(a,h)anthracene	53703	278.4	6.84	3.9E+00	1.0E-03	9.8E-03	3.4E-01	9767%	Y
Dibutyl phthalate	84742	278.0	4.13	3.9E-02	1.0E-03	9.7E-05	3.4E-03	97%	Y
Dichlorobenzene, 1,2-	95501	147.0	3.38	6.6E-02	1.0E-03	6.7E-05	2.3E-03	67%	Y

CHEMICAL	CAS No.	MWT	logKow	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Dichlorobenzene, 1,3-	541731	147.0	3.60	9.6E-02	1.0E-03	9.7E-05	3.4E-03	97%	Y
Dichlorobenzene, 1,4-	106467	147.0	3.39	6.7E-02	1.0E-03	6.8E-05	2.4E-03	68%	Y
Dichlorobenzidine, 3,3'	91941	253.1	3.51	1.9E-02	1.0E-03	4.0E-05	1.4E-03	40%	Y
Dichlorodifluoromethane	75718	120.9	2.16	1.2E-02	1.0E-03	1.0E-05	3.5E-04	10%	Y
Dichloroethane, 1,1-	75343	99.0	1.79	8.5E-03	1.0E-03	6.2E-06	2.2E-04	6%	N
Dichloroethane, 1,2-	107062	99.0	1.48	5.0E-03	1.0E-03	3.6E-06	1.3E-04	4%	N
Dichloroethylene, 1,1-	75354	96.9	2.13	1.6E-02	1.0E-03	1.1E-05	3.9E-04	11%	Y
Dichloroethylene, 1,2- (trans)	540590	96.9	1.86	9.9E-03	1.0E-03	7.1E-06	2.5E-04	7%	N
Dichlorophenol, 2,4-	120832	163.0	2.92	2.4E-02	1.0E-03	2.7E-05	9.6E-04	27%	Y
Dichloropropane, 1,2-	78875	113.0	2.00	1.0E-02	1.0E-03	8.0E-06	2.8E-04	8%	N
Dichloropropene, 1,3-	542756	111.0	1.60	5.2E-03	1.0E-03	4.1E-06	1.4E-04	4%	N
Dichlorvos	62737	221.0	1.47	9.2E-04	1.0E-03	1.5E-06	5.4E-05	2%	N
Dieldrin	60571	381.0	4.56	1.9E-02	1.0E-03	9.9E-05	3.5E-03	99%	Y
Diepoxybutane	1464535	86.1	-1.84	2.1E-05	1.0E-03	1.4E-08	4.9E-07	0%	N
Diethyl phthalate	84662	222.0	2.47	5.0E-03	1.0E-03	8.4E-06	3.0E-04	8%	N
Diethyl sulfate	64675	154.0	1.14	1.3E-03	1.0E-03	1.4E-06	4.9E-05	1%	N
Dimethoxybenzidine, 3,3'-	119904	254.4	1.81	1.0E-03	1.0E-03	2.2E-06	7.7E-05	2%	N
Dimethyl phthalate	131113	194.0	1.56	1.6E-03	1.0E-03	2.2E-06	7.6E-05	2%	N
Dimethyl sulfate	77781	126.0	1.16	2.0E-03	1.0E-03	1.8E-06	6.2E-05	2%	N
Dimethylamine, n-nitroso-	62759	74.1	-0.57	2.2E-04	1.0E-03	1.3E-07	4.6E-06	0%	N
Dimethylaminoazobenzene, 4-	60117	225.0	4.58	1.7E-01	1.0E-03	3.0E-04	1.1E-02	300%	Y
Dimethylbenzidine, 3,3'-	119937	212.3	2.34	4.5E-03	1.0E-03	7.2E-06	2.5E-04	7%	N
Dimethylcarbamyl chloride	79447	107.5	0.00	3.6E-04	1.0E-03	2.8E-07	9.7E-06	0%	N
Dimethylhydrazine, 1,1-	57147	60.0	-1.50	5.4E-05	1.0E-03	3.0E-08	1.0E-06	0%	N
Dimethylphenol, 2,4-	105679	122.2	2.30	1.5E-02	1.0E-03	1.3E-05	4.4E-04	13%	Y
Dimethylphenol, 3,4-	95658	122.0	2.23	1.3E-02	1.0E-03	1.1E-05	3.9E-04	11%	Y
Dinitrophenol, 2,4-	51285	184.1	1.54	1.7E-03	1.0E-03	2.2E-06	7.9E-05	2%	N
Dinitrotoluene, 2,4-	121142	182.1	1.98	3.7E-03	1.0E-03	4.8E-06	1.7E-04	5%	N
Dinitrotoluene, 2,6-	606202	182.1	1.72	2.4E-03	1.0E-03	3.1E-06	1.1E-04	3%	N
Dioxane, 1,4-	123911	88.1	-0.27	3.0E-04	1.0E-03	2.0E-07	7.0E-06	0%	N
Diphenylamine, n-nitroso-	86306	198.2	3.13	2.1E-02	1.0E-03	3.1E-05	1.1E-03	31%	Y
Diphenylhydrazine, 1,2-	122667	184.2	2.94	1.9E-02	1.0E-03	2.4E-05	8.6E-04	24%	Y

CHEMICAL	CAS No.	MWT	logKow	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Dipropylamine, n-nitroso-	621647	130.2	1.36	2.7E-03	1.0E-03	2.4E-06	8.4E-05	2%	N
Di-2-ethylhexyl phthalate	117817	391.0	5.11	4.3E-02	1.0E-03	2.4E-04	8.3E-03	235%	Y
Endrin	72208	381.0	4.56	1.9E-02	1.0E-03	9.9E-05	3.5E-03	99%	Y
Epichlorohydrin	106898	92.0	-0.21	3.1E-04	1.0E-03	2.1E-07	7.6E-06	0%	N
Ethanol	64175	46.0	-0.31	4.9E-04	1.0E-03	2.5E-07	8.8E-06	0%	N
Ethanol, 2-(2-butoxyethoxy)-	112345	162.0	-0.92	3.5E-05	1.0E-03	3.9E-08	1.4E-06	0%	N
Ethanol, 2-(2-ethoxyethoxy)-	111900	134.0	-0.08	2.2E-04	1.0E-03	2.0E-07	7.1E-06	0%	N
Ethanol, 2-(2-methoxyethoxy)-	111773	120.0	-0.42	1.5E-04	1.0E-03	1.2E-07	4.4E-06	0%	N
Ethoxyethanol, 2-	110805	90.0	-0.10	3.9E-04	1.0E-03	2.6E-07	9.3E-06	0%	N
Ethoxyethyl acetate, 2-	111159	132.0	0.65	7.7E-04	1.0E-03	7.1E-07	2.5E-05	1%	N
Ethyl acrylate	140885	100.0	1.32	3.8E-03	1.0E-03	2.8E-06	9.7E-05	3%	N
Ethyl carbamate	51796	89.0	-0.15	3.6E-04	1.0E-03	2.4E-07	8.6E-06	0%	N
Ethyl ether	60297	74.1	0.89	2.6E-03	1.0E-03	1.6E-06	5.6E-05	2%	N
Ethylbenzene	100414	106.2	3.15	7.8E-02	1.0E-03	6.0E-05	2.1E-03	60%	Y
Ethylene oxide	75218	44.1	-0.30	5.2E-04	1.0E-03	2.6E-07	9.0E-06	0%	N
Ethylenedibromide	106934	188.0	1.96	3.3E-03	1.0E-03	4.5E-06	1.6E-04	4%	N
Ethyleneimine	151564	43.0	-1.12	1.3E-04	1.0E-03	6.4E-08	2.3E-06	0%	N
Ethylenethiourea	96457	96.0	-0.66	1.4E-04	1.0E-03	9.7E-08	3.4E-06	0%	N
Ethylphenol, p-	123079	120.0	2.26	1.4E-02	1.0E-03	1.2E-05	4.2E-04	12%	Y
Fluoranthene	206440	202.3	4.95	4.5E-01	1.0E-03	6.6E-04	2.3E-02	660%	Y
Formaldehyde	50000	30.0	0.35	1.9E-03	1.0E-03	8.6E-07	3.0E-05	1%	N
Glycerol	56815	92.1	-1.76	2.2E-05	1.0E-03	1.5E-08	5.4E-07	0%	N
Heptachlor	76448	373.5	4.27	1.3E-02	1.0E-03	6.3E-05	2.2E-03	63%	Y
Heptanol	111706	116.0	2.41	1.9E-02	1.0E-03	1.6E-05	5.6E-04	16%	Y
Hexachlorobenzene	118741	284.8	5.31	2.6E-01	1.0E-03	6.9E-04	2.4E-02	689%	Y
Hexachlorobutadiene	87683	260.8	4.78	1.5E-01	1.0E-03	3.3E-04	1.2E-02	330%	Y
Hexachloroethane	67721	236.7	3.93	4.9E-02	1.0E-03	9.2E-05	3.2E-03	92%	Y
Hexamethylphosphoramide	680319	179.0	0.03	1.4E-04	1.0E-03	1.8E-07	6.2E-06	0%	N
Hexanol	111273	102.0	2.03	1.2E-02	1.0E-03	9.1E-06	3.2E-04	9%	N
Hydrazine/Hydrazine sulfate	302012	32.0	-2.07	3.0E-05	1.0E-03	1.4E-08	4.8E-07	0%	N
Indeno(1,2,3-CD)pyrene	193395	276.3	6.58	2.6E+00	1.0E-03	6.4E-03	2.3E-01	6407%	Y
Isophorone	78591	138.2	1.67	4.0E-03	1.0E-03	3.8E-06	1.4E-04	4%	N

CHEMICAL	CAS No.	MWT	logKow	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Lindane	58899	291.0	3.72	1.6E-02	1.0E-03	4.4E-05	1.5E-03	44%	Y
Mechlorethamine	51752	156.0	1.07	1.1E-03	1.0E-03	1.2E-06	4.3E-05	1%	N
Methanol	67561	32.0	-0.77	2.7E-04	1.0E-03	1.3E-07	4.4E-06	0%	N
Methoxyethanol, 2-	109864	76.0	-0.77	1.5E-04	1.0E-03	9.2E-08	3.3E-06	0%	N
Methoxypropan-2-ol, 1-	107982	90.0	-0.18	3.4E-04	1.0E-03	2.3E-07	8.1E-06	0%	N
Methyl ethyl ketone	78933	72.0	0.29	9.6E-04	1.0E-03	5.8E-07	2.0E-05	1%	N
Methyl hydroxybenzoate	99763	152.1	1.92	5.1E-03	1.0E-03	5.3E-06	1.9E-04	5%	N
Methyl iodide	74884	142.0	1.51	2.9E-03	1.0E-03	2.9E-06	1.0E-04	3%	N
Methylaziridine, 2-	75558	57.0	-0.60	2.6E-04	1.0E-03	1.4E-07	4.9E-06	0%	N
Methylene bis(2-chloroaniline), 4,4'-	101144	267.2	3.94	3.3E-02	1.0E-03	7.5E-05	2.7E-03	75%	Y
Methylene bis(N,N'-dimethyl)aniline, 4,4'-	101611	254.0	4.75	1.6E-01	1.0E-03	3.3E-04	1.2E-02	328%	Y
Methylene chloride	75092	84.9	1.25	4.1E-03	1.0E-03	2.7E-06	9.6E-05	3%	N
Methylenedianiline, 4,4'-	101779	198.0	1.59	1.5E-03	1.0E-03	2.2E-06	7.8E-05	2%	N
Michler's ketone	90948	268.4	4.07	4.0E-02	1.0E-03	9.3E-05	3.3E-03	93%	Y
Mustard Gas	505602	159.1	2.03	5.6E-03	1.0E-03	6.1E-06	2.2E-04	6%	N
Naphthalene	91203	128.2	3.30	7.5E-02	1.0E-03	6.6E-05	2.3E-03	66%	Y
Naphthol, b-	135193	144.2	2.84	2.7E-02	1.0E-03	2.7E-05	9.5E-04	27%	Y
Naphthylamine, 1-	134327	143.2	2.25	1.0E-02	1.0E-03	1.0E-05	3.5E-04	10%	Y
Naphthylamine, 2-	91598	143.2	2.28	1.1E-02	1.0E-03	1.0E-05	3.7E-04	10%	Y
Nitrilotriacetic acid	139139	191.0	-0.18	8.4E-05	1.0E-03	1.1E-07	4.0E-06	0%	N
Nitrobiphenyl, 4-	92933	199.2	3.77	6.3E-02	1.0E-03	9.1E-05	3.2E-03	91%	Y
Nitrofen	1836755	284.1	5.53	3.9E-01	1.0E-03	1.0E-03	3.5E-02	1008%	Y
Nitrophenol, 2-	88755	139.1	1.79	4.9E-03	1.0E-03	4.7E-06	1.7E-04	5%	N
Nitrophenol, 2-amino-4-	99570	154.1	1.36	1.9E-03	1.0E-03	2.0E-06	7.2E-05	2%	N
Nitrophenol, 3-	554847	139.1	2.00	7.0E-03	1.0E-03	6.7E-06	2.4E-04	7%	N
Nitrophenol, 4-	100027	139.1	1.91	6.0E-03	1.0E-03	5.7E-06	2.0E-04	6%	N
Nitrophenol, 4-amino-2-	119346	154.1	0.96	9.7E-04	1.0E-03	1.0E-06	3.6E-05	1%	N
Nitropropane, 2-	79469	110.0	0.55	8.9E-04	1.0E-03	7.0E-07	2.5E-05	1%	N
Nitrosodiethanolamine, n-	1116547	134.0	-1.58	1.7E-05	1.0E-03	1.6E-08	5.5E-07	0%	N
Nitrosodiethylamine, n-	55185	88.0	0.48	1.1E-03	1.0E-03	7.2E-07	2.5E-05	1%	N
Nitrosodiphenylamine, p-	156105	198.2	3.50	4.0E-02	1.0E-03	5.7E-05	2.0E-03	57%	Y
Nitrosomethylvinylamine, n-	4549400	86.1	-0.00	4.8E-04	1.0E-03	3.2E-07	1.1E-05	0%	N

CHEMICAL	CAS No.	MWT	logKow	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Nitrosomorpholine, n-	59892	116.1	-0.44	1.5E-04	1.0E-03	1.2E-07	4.3E-06	0%	N
Nitrosonornicotine, n-	16543558	177.2	0.03	1.4E-04	1.0E-03	1.8E-07	6.3E-06	0%	N
Nitrosopiperidine, n-	100754	350.3	0.36	2.3E-05	1.0E-03	9.5E-08	3.4E-06	0%	N
Nitroso-di-n-butylamine, n-	924163	158.2	1.92	4.7E-03	1.0E-03	5.1E-06	1.8E-04	5%	N
Nitroso-N-ethylurea, n-	759739	117.1	0.23	4.7E-04	1.0E-03	3.8E-07	1.3E-05	0%	N
Nitroso-N-methylurea, n-	684935	103.1	-0.03	3.6E-04	1.0E-03	2.7E-07	9.5E-06	0%	N
Nitro-o-anisidine, 5-	99592	152.7	1.47	2.3E-03	1.0E-03	2.5E-06	8.7E-05	2%	N
Nonanol	143088	144.0	3.47	8.0E-02	1.0E-03	7.9E-05	2.8E-03	79%	Y
Octanol	111875	130.0	2.97	4.1E-02	1.0E-03	3.7E-05	1.3E-03	37%	Y
Parathion	56382	291.0	3.83	1.9E-02	1.0E-03	5.3E-05	1.9E-03	53%	Y
PCB-chlorobiphenyl, 4-	2051629	292.0	6.50	1.8E+00	1.0E-03	5.0E-03	1.8E-01	4982%	Y
PCB-hexachlorobiphenyl	26601649	361.0	6.72	1.0E+00	1.0E-03	4.5E-03	1.6E-01	4500%	Y
Pentachloronitrobenzene	82688	295.3	4.64	7.3E-02	1.0E-03	2.0E-04	7.2E-03	205%	Y
Pentachlorophenol	87865	266.4	5.86	8.7E-01	1.0E-03	2.0E-03	7.0E-02	1998%	Y
Pentanol	71410	88.0	1.56	6.7E-03	1.0E-03	4.5E-06	1.6E-04	5%	N
Pentanone, 4-methyl-2-	108101	100.0	1.19	3.0E-03	1.0E-03	2.2E-06	7.8E-05	2%	N
Phenanthrene	85018	178.2	4.46	2.7E-01	1.0E-03	3.4E-04	1.2E-02	338%	Y
Phenol	108952	94.0	1.46	5.2E-03	1.0E-03	3.6E-06	1.3E-04	4%	N
Phenol, 4,6-dinitro-2-methyl-	534521	198.1	2.12	3.8E-03	1.0E-03	5.5E-06	1.9E-04	5%	N
Propanol	71238	60.0	0.30	1.2E-03	1.0E-03	6.4E-07	2.3E-05	1%	N
Propiolactone, beta-	57578	72.0	-0.46	2.7E-04	1.0E-03	1.6E-07	5.7E-06	0%	N
Propylene oxide	75569	58.1	0.03	7.5E-04	1.0E-03	4.1E-07	1.4E-05	0%	N
Resorcinol	108463	110.1	0.80	1.4E-03	1.0E-03	1.1E-06	3.7E-05	1%	N
Safrole	94597	162.2	2.66	1.6E-02	1.0E-03	1.8E-05	6.2E-04	18%	Y
Styrene	100425	104.1	2.95	5.7E-02	1.0E-03	4.3E-05	1.5E-03	43%	Y
Styrene oxide	96093	120.0	1.61	4.7E-03	1.0E-03	3.9E-06	1.4E-04	4%	N
TCDD	1746016	322.0	6.80	2.0E+00	1.0E-03	6.8E-03	2.4E-01	6751%	Y
Tetrachlorethylene	127184	165.8	3.40	5.3E-02	1.0E-03	6.1E-05	2.1E-03	61%	Y
Tetrachloroethane, 1,1,2,2-	79345	167.9	2.39	9.1E-03	1.0E-03	1.1E-05	3.8E-04	11%	Y
Thioacetamide	62555	75.0	0.71	1.9E-03	1.0E-03	1.2E-06	4.1E-05	1%	N
Thiodianiline, 4,4'-	139651	216.0	2.03	2.5E-03	1.0E-03	4.1E-06	1.5E-04	4%	N
Thiourea	62566	76.0	-0.95	1.1E-04	1.0E-03	6.8E-08	2.4E-06	0%	N

FOR INORGANIC CHEMICALS IN WATER

CHEMICAL	MWT	Kp (cm/hr)	Conc (mg/cm3)	DA_event (mg/cm2-event)	DAD (mg/kg-day)	Screening	Chemicals to be assessed
Cadmium chloride	183.3	1.0E-03	1.0E-03	1.7E-07	5.9E-06	0.17%	N
Chromium chloride	158.3	1.0E-03	1.0E-03	1.7E-07	5.9E-06	0.17%	N
Cobalt chloride	129.8	4.0E-04	1.0E-03	6.7E-08	2.3E-06	0.07%	N
Lead acetate	443.4	4.0E-06	1.0E-03	6.7E-10	2.3E-08	0.00%	N
Mercuric chloride	271.5	1.0E-03	1.0E-03	1.7E-07	5.9E-06	0.17%	N
Methyl mercury-dicyandiamide	298.6	1.0E-03	1.0E-03	1.7E-07	5.9E-06	0.17%	N
Nickel chloride	129.6	1.0E-04	1.0E-03	1.7E-08	5.9E-07	0.02%	N
Nickel sulfate	154.8	9.0E-06	1.0E-03	1.5E-09	5.3E-08	0.00%	N
Potassium mecuric chloride		3.0E-03	1.0E-03	5.0E-07	1.8E-05	0.50%	N
Silver nitrate	169.9	6.0E-04	1.0E-03	1.0E-07	3.5E-06	0.10%	N
Sodium chromate	162.0	2.0E-03	1.0E-03	3.3E-07	1.2E-05	0.33%	N
Sodium dichromate	266.0	1.0E-03	1.0E-03	1.7E-07	5.9E-06	0.17%	N
Zinc chloride	136.3	6.0E-04	1.0E-03	1.0E-07	3.5E-06	0.10%	N