APPENDIX A. ATSDR MINIMAL RISK LEVEL WORKSHEETS

MRLs are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration for a given route of exposure. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified route and duration of exposure. MRLs are based on noncancer health effects only; cancer effects are not considered. These substance-specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors to identify contaminants and potential health effects that may be of concern at hazardous waste sites. It is important to note that MRLs are not intended to define clean-up or action levels.

MRLs are derived for hazardous substances using the NOAEL/uncertainty factor approach. They are below levels that might cause adverse health effects in the people most sensitive to such chemical-induced effects. MRLs are derived for acute (1–14 days), intermediate (15–364 days), and chronic (≥365 days) durations and for the oral and inhalation routes of exposure. Currently, MRLs for the dermal route of exposure are not derived because ATSDR has not yet identified a method suitable for this route of exposure. MRLs are generally based on the most sensitive substance-induced endpoint considered to be of relevance to humans. Serious health effects (such as irreparable damage to the liver or kidneys, or birth defects) are not used as a basis for establishing MRLs. Exposure to a level above the MRL does not mean that adverse health effects will occur.

MRLs are intended only to serve as a screening tool to help public health professionals decide where to look more closely. They may also be viewed as a mechanism to identify those hazardous waste sites that are not expected to cause adverse health effects. Most MRLs contain a degree of uncertainty because of the lack of precise toxicological information on the people who might be most sensitive (e.g., infants, elderly, nutritionally or immunologically compromised) to the effects of hazardous substances. ATSDR uses a conservative (i.e., protective) approach to address this uncertainty consistent with the public health principle of prevention. Although human data are preferred, MRLs often must be based on animal studies because relevant human studies are lacking. In the absence of evidence to the contrary, ATSDR assumes that humans are more sensitive to the effects of hazardous substance than animals and that certain persons may be particularly sensitive. Thus, the resulting MRL may be as much as 100-fold below levels that have been shown to be nontoxic in laboratory animals.

APPENDIX A

Proposed MRLs undergo a rigorous review process: Health Effects/MRL Workgroup reviews within the Division of Toxicology and Human Health Sciences, expert panel peer reviews, and agency-wide MRL Workgroup reviews, with participation from other federal agencies and comments from the public. They are subject to change as new information becomes available concomitant with updating the toxicological profiles. Thus, MRLs in the most recent toxicological profiles supersede previously published MRLs. For additional information regarding MRLs, please contact the Division of Toxicology and Human Health Sciences, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road NE, Mailstop F-57, Atlanta, Georgia 30329-4027.

APPENDIX A

MINIMAL RISK LEVEL (MRL) WORKSHEET

***Chemical Name*:** 1,2-Dibromo-3-chloropropane
CAS Numbers: 96-12-8
Date: September 1992
March 2017—Updated literature search
Profile Status: Final
Route: Inhalation
Duration: Acute

MRL Summary: There are insufficient data for derivation of an acute-duration inhalation MRL.

Rationale for Not Deriving an MRL: Sufficient information was not available on the health effects of 1,2-dibromo-3-chloropropane to derive an MRL for acute-duration inhalation exposure. In one study, reproductive effects were noted in rats following acute inhalation exposure to 1,2-dibromo-3-chloropropane (Saegusa et al. 1982). The male reproductive system is a particularly sensitive endpoint for 1,2-dibromo-3-chloropropane toxicity. Available human and animal data indicate that humans and rabbits are more sensitive than rats and mice to 1,2-dibromo-3-chloropropane effects on the male reproductive system. Acute-duration inhalation data for rabbits are lacking; therefore, an acute-duration inhalation MRL was not derived for 1,2-dibromo-3-chloropropane.

Agency Contact (Chemical Manager): Rae T. Benedict, Ph.D.

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MINIMAL RISK LEVEL (MRL) WORKSHEET

***Chemical Name*:**	1,2-Dibromo-3-chloropropane
CAS Numbers:	96-12-8
Date:	September 1992 March 2017—Updated literature search
Profile Status:	Final
Route:	Inhalation
Duration:	Intermediate
MRL	0.0002 ppm
Critical Effect:	Changes in spermatogenesis and testicular atrophy
Reference:	Rao et al. 1982
Point of Departure:	NOAEL of 0.1 ppm
Uncertainty Factor:	100
LSE Graph Key:	9
Species:	Rabbit

MRL Summary: An intermediate-duration inhalation MRL of 0.0002 ppm was derived for 1,2-dibromo-3-chloropropane. The MRL is based on a NOAEL of 0.1 ppm and a LOAEL of 1 ppm for changes in spermatogenesis and testicular atrophy in rabbits exposed to 1,2-dibromo-3-chloropropane for 6 hours/day, 5 days/week for up to 14 weeks (Rao et al. 1982). The NOAEL was adjusted for intermittent exposure, converted to a human equivalent concentration (assuming a value of 1 for ratio of blood/gas partition coefficients), and divided by an uncertainty factor of 100 (10 for extrapolation from animals to humans and 10 for human variability).

Selection of the Critical Effect: No human data are available. Intermediate-duration inhalation data for animals include a series of studies in rats, rabbits, guinea pigs, and monkeys (Torkelson et al. 1961); 13-week studies in rats and mice (NTP 1982); a 14-week study in rats (Rao et al. 1983); and an 8–14-week study in rabbits (Rao et al. 1983). Table A-1 summarizes available NOAEL and LOAEL values for noncancer health effects in animals following intermediate-duration inhalation exposure to 1,2-dibromo-3-chloropropane. The lowest LOAEL value of 1 ppm is associated with testicular effects in rabbits (Rao et al. 1982); respiratory, hepatic, and renal effects in rats (NTP 1982; Reznik et al. 1980a); and endocrine effects in rats (Rao et al. 1983). Among available intermediate-duration inhalation studies, reproductive toxicity was selected as the critical effect because male reproductive effects have been reported in multiple animal species and in humans.

Selection of the Principal Study: Male reproductive effects have been reported in studies of rats and rabbits following intermediate-duration inhalation exposure to 1,2-dibromo-3-chloropropane (NTP 1982; Rao et al. 1982; Torkelson et al. 1961). The study in rabbits (Rao et al. 1982) identified the lowest LOAEL and corresponding NOAEL for reproductive effects, indicating that rabbits may be more sensitive than rats to 1,2-dibromo-3-chloropropane-induced male reproductive effects. Therefore, the rabbit study (Rao et al. 1982) was selected as the principal study for deriving an intermediate-duration inhalation MRL for 1,2-dibromo-3-chloropropane.

Table A-1. Summary of Relevant NOAEL and LOAEL Values from Studies Considered for Derivation of an Intermediate-Duration Inhalation MRL for 1,2-Dibromo-3-Chloropropane

Species	Duration/ route	NOAEL (ppm)	LOAEL (ppm)	Effect	Reference
Reproductive effects					
Unspecified rat strain	≤10 weeks 5 days/week 7 hours/day		5	Testicular atrophy	Torkelson et al. 1961
New Zealand White rabbit	14 weeks 5 days/week 6 hours/day	0.1	1.0	Testicular atrophy, sperm abnormalities, decreased serum FSH	Rao et al. 1982
Respiratory effects					
F344 rat	13 weeks 5 days/week 6 hours/day		1	Respiratory tract lesions (necrotic and proliferative)	NTP 1982; Reznik et al. 1980a
B6C3F1 mouse	13 weeks 5 days/week 6 hours/day	1	5	Respiratory tract lesions (necrotic and proliferative)	NTP 1982; Reznik et al. 1980a
Body weight effects					
Unspecified rat strain	≤10 weeks 5 days/week 7 hours/day	Not determined	5	Depressed body weight gain	Torkelson et al. 1961
Hepatic effects					
F344 rat	13 weeks 5 days/week 6 hours/day	Not determined	1	Hydropic changes of hepatocytes	NTP 1982; Reznik et al. 1980a
Renal effects					
F344 rat	13 weeks 5 days/week 6 hours/day		1	Nephrosis	NTP 1982; Reznik et al. 1980a
Unspecified rat strain	≤10 weeks 5 days/week 7 hours/day		5	Unspecified epithelial changes in renal collecting tubules	Torkelson et al. 1961

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Table A-1. Summary of Relevant NOAEL and LOAEL Values from Studies Considered for Derivation of an Intermediate-Duration Inhalation MRL for 1,2-Dibromo-3-Chloropropane

Species	Duration/ route	NOAEL (ppm)	LOAEL (ppm)	Effect	Reference
Endocrine effects					
Sprague-Dawley rat	4 or 14 weeks 5 days/week 6 hours/day	0.1	1	Hyperplastic nodules in adrenal gland	Rao et al. 1983
Ocular effects					
Unspecified rat strain	≤10 weeks 5 days/week 7 hours/day		5	Ocular irritation	Torkelson et al. 1961

FSH = follicle stimulating hormone; LOAEL = lowest observed adverse effect level; NOAEL = no-observed-adverse-effect level; WBCs = white blood cells

Summary of the Principal Study:

Rao KS, Burek JD, Murray FJ, et al. 1982. Toxicologic and reproductive effects of inhaled 1,2-dibromo-3-chloropropane in male rabbits. Fundam Appl Toxicol 2:241-251.

Groups of male New Zealand White rabbits were exposed by inhalation to 0, 0.1, 1.0, or 10 ppm of 1,2-dibromo-3-chloropropane for 6 hours/day, 5 days/week for up to 14 weeks. Semen was evaluated weekly during the exposure period and periodically during a 32- or 38-week recovery period. Fertility was assessed by mating males with unexposed females at study weeks 14 and 41. At sacrifice, male reproductive organs and tissues were processed for gross and histopathologic evaluations. Exposure at 10 ppm was terminated at week 8 due to two mortalities. Exposure concentration-related increasing severity of gross and histopathologic testicular effects were noted at 1.0 and 10 ppm exposure levels. Surviving 10 ppm rabbits were infertile. Evidence of recovery was noted during the recovery period. An equivocal increase in abnormal sperm was reported among the 0.1 ppm males at week 14, which was not evident at the end of the recovery period; therefore, the 0.1 ppm exposure level was considered a NOAEL for testicular effects.

Selection of the Point of Departure for the MRL: The NOAEL of 0.1 ppm was selected as the basis for the MRL.

Intermittent Exposure: The NOAEL was adjusted from intermittent exposure (6 hours/day, 5 days/week) to account for continuous exposure:

NOAEL of 0.1 ppm x 6 hours/24 hours x 5 days/7 days = 0.0179 ppm ($NOAEL_{ADJ}$)

Human Equivalent Concentration: The duration-adjusted NOAEL was converted to a human equivalent concentration (assuming a value of 1 for ratio of blood/gas partition coefficients):

$NOAEL_{ADJ} = NOAEL_{HEC} = 0.0179$ ppm

Uncertainty Factor: The human equivalent NOAEL was divided by a total uncertainty factor of 100:

- 10 for extrapolation from animals to humans
- 10 for human variability

$MRL = NOAEL_{HEC} \div$ uncertainty factors
$0.0179 \text{ ppm} \div (10 \times 10) \approx 0.0002$ ppm

Other Additional Studies or Pertinent Information that Lend Support to this MRL: Testicular effects were also observed in rats repeatedly exposed to 1,2-dibromo-3-chloropropane vapor for 2–13 weeks (NTP 1982; Saegusa et al. 1982; Torkelson et al. 1961).

Agency Contact (Chemical Manager): Rae T. Benedict, Ph.D.

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MINIMAL RISK LEVEL (MRL) WORKSHEET

***Chemical Name*:** 1,2-Dibromo-3-chloropropane
CAS Numbers: 96-12-8
Date: September 1992
March 2017—Updated literature search
Profile Status: Final
Route: Inhalation
Duration: Chronic

MRL Summary: There are insufficient data for derivation of a chronic-duration inhalation MRL.

Rationale for Not Deriving an MRL: Information regarding effects following chronic-duration inhalation exposure to 1,2-dibromo-3-chloropropane was available for rats and mice (NTP 1982). The lowest LOAEL for nonneoplastic effects was 0.6 ppm (the lowest exposure level tested in rats and mice of NTP 1982); effects included inflammation and hyperplasia in nasal cavity and hyperplasia in lungs; hyperkeratosis and acanthosis in forestomach; and hyperplasia in the urinary bladder and inflammation in the kidney. These nonneoplastic lesions may represent precancerous lesions as a variety of nasal cavity tumors were also observed at this exposure level. In the absence of adequate data regarding nonneoplastic effects in laboratory animals exposed to 1,2-dibromo-3-chloropropane that would not be considered potential precancerous lesions, the database of information is considered inadequate to derive a chronic-duration inhalation MRL for 1,2-dibromo-3-chloropropane.

Agency Contact (Chemical Manager): Rae T. Benedict, Ph.D.

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MINIMAL RISK LEVEL (MRL) WORKSHEET

***Chemical Name*:** 1,2-Dibromo-3-chloropropane
CAS Numbers: 96-12-8
Date: September 1992
March 2017—Updated literature search
Profile Status: Final
Route: Oral
Duration: Acute

MRL Summary: There are insufficient data for derivation of an acute-duration oral MRL.

Rationale for Not Deriving an MRL: Several studies provided information on LD_{50} values and selected nonneoplastic effects following acute oral exposure to 1,2-dibromo-3-chloropropane. However, among the available acute-duration oral studies, no acute-duration oral MRL was derived for 1,2-dibromo-3-chloropropane because dominant lethality (which represents a serious LOAEL) was observed at the lowest dose tested (10 mg/kg/day) (Teramoto et al. 1980).

Agency Contact (Chemical Manager): Rae T. Benedict, Ph.D.

APPENDIX A

MINIMAL RISK LEVEL (MRL) WORKSHEET

***Chemical Name*:**	1,2-Dibromo-3-chloropropane
CAS Numbers:	96-12-8
Date:	September 1992 March 2017—Updated literature search
Profile Status:	Final
Route:	Oral
Duration:	Intermediate
MRL	0.002 mg/kg/day
Critical Effect:	Decreased spermatogenesis and increased abnormal sperm morphology
Reference:	Foote 1986a, 1986b
Point of Departure:	LOAEL of 1.88 mg/kg/day
Uncertainty Factor:	1,000
LSE Graph Key:	22
Species:	Rabbit

MRL Summary: An intermediate-duration oral MRL of 0.002 mg/kg/day was derived for 1,2-dibromo-3-chloropropane. The MRL is based on a LOAEL of 1.88 mg/kg/day for effects on spermatogenesis and sperm morphology in rabbits administered 1,2-dibromo-3-chloropropane in the drinking water for 10 weeks (Foote et al. 1986a, 1986b). The LOAEL was divided by an uncertainty factor of 1,000 (10 for use of a LOAEL, 10 for extrapolation from animals to humans, and 10 for human variability).

Selection of the Critical Effect: No human data are available. Intermediate-duration oral data for animals include a 77-day gavage study in rats (Amann and Berndtson 1986); 60- and 64-day drinking water studies in rats (Heindel et al. 1989; Johnston et al. 1986); a 90-day feeding study in rats (Torkelson et al. 1961); 6-week gavage studies in rats and mice (NCI 1978); 128- and 140-day gavage studies in mice (Reel et al. 1984); and a 10-week drinking water study in rabbits (Foote et al. 1986b). Table A-2 summarizes relevant NOAEL and LOAEL values for noncancer health effects in animals following intermediate-duration oral exposure to 1,2-dibromo-3-chloropropane from studies that serve as candidate principal studies for deriving an intermediate-duration oral MRL. Among available intermediate-duration oral studies, male reproductive toxicity was selected as the critical effect because it represents the lowest LOAEL, which is lower than the lowest NOAEL for other effects.

Selection of the Principal Study: Male reproductive effects have been reported in studies of rats and rabbits following intermediate-duration oral exposure to 1,2-dibromo-3-chloropropane (Amann and Berndtson 1986; Foote et al. 1986a, 1986b; Heindel et al. 1989; Johnston et al. 1986). The study in rabbits (Foote et al. 1986a, 1986b) identified the lowest LOAEL for male reproductive effects, indicating that rabbits may be more sensitive than rats to 1,2-dibromo-3-chloropropane-induced male reproductive effects. Therefore, the rabbit study (Foote et al. 1986a, 1986b) was selected as the principal study for deriving an intermediate-duration oral MRL for 1,2-dibromo-3-chloropropane.

Table A-2. Summary of Relevant NOAEL and LOAEL Values from Studies Considered for Derivation of an Intermediate-Duration Oral MRL for 1,2-Dibromo-3-Chloropropane

Species	Duration/route	NOAEL (ppm)	LOAEL (ppm)	Effect	Reference
Reproductive effects					
Dutch rabbit	10 weeks 5 days/week in drinking water	0.94[a]	1.88	Abnormal sperm morphology, decreased spermatogenesis	Foote et al. 1986b
Body weight effects					
Sprague-Dawley rat	64 days in drinking water	5.4	9.7	Depressed body weight gain	Heindel et al. 1989
Unspecified rat strain	90 days in food	2.5	7.5	Depressed body weight gain	Torkelson et al. 1961
Renal effects					
Sprague-Dawley rat	64 days in drinking water	3.3	5.4	Increased turnover of proximal tubular cells	Heindel et al. 1989

[a]The study authors stated the following: "The no effect level for DBCP administered to male rabbits in drinking water appears to be about 0.94 mg/kg for the most sensitive indicators of testicular function measured, if one accepts the null hypothesis at p=0.05. Because means were slightly higher for controls, on this basis the no effect level is <0.94 mg/kg of body weight." For this reason, the 0.94 mg/kg/day dose level is not used as basis for deriving an intermediate-duration oral MRL for 1,2-dibromo-3-chloropropane.

DBCP = 1,2-dibromo-3-chloropropane; GD = gestation day; LOAEL = lowest observed adverse effect level; NOAEL = no-observed-adverse-effect level; PPD = postpartum day

Summary of the Principal Study:

Foote RH, Berndtson WE, Rounsaville TR. 1986a. Use of quantitative testicular histology to assess the effect of dibromochloropropane (DBCP) on reproduction in rabbits. Fundam Appl Toxicol 6:638-647.

Foote RH, Schermerhorn EC, Simkin ME. 1986b. Measurement of semen quality, fertility, and reproductive hormones to assess dibromochloropropane (DBCP) effects in live rabbits. Fundam Appl Toxicol 6:628-637.

Groups of male Dutch belted rabbits (6/group) were administered 1,2-dibromo-3-chloropropane in the drinking water 5 days/week for 10 weeks at concentrations resulting in 1,2-dibromo-3-chloropropane intakes of 0, 0.94, 1.88, 3.75, 7.5, or 15 mg/kg/day during each 5-day period. Ejaculate was evaluated periodically during the exposure period for volume, percent motile sperm, and sperm concentration. Fertility was assessed by mating males with unexposed females during the last week of the study or collecting ejaculate and artificially inseminating unexposed females. Blood levels of FSH, LH, and testosterone were determined during the last week of the study as well. At sacrifice, epididymal sperm was collected for analysis and reproductive organs and tissues were processed for gross and histopathologic evaluations. There were no treatment-related effects on blood LH or testosterone levels. High-dose rabbits exhibited significantly elevated blood FSH (consistent with impaired spermatogenesis). Percent normal sperm was significantly decreased at the two highest dose levels; mean seminiferous tubule diameter was significantly reduced at these dose levels as well. Testicular weight was significantly decreased in high-dose rabbits (55% less than controls). Mean numbers of spermatogonia per stage I seminiferous tubular cross section were significantly decreased at doses ≥1.88 mg/kg/day (mean numbers for controls, 0.94, 1.88, 3.75, 7.5, and 15 mg/kg/day dose groups were 2.3±0.13 [SE], 2.0±0.13, 1.8±0.12, 1.6±0.12, 1.5±0.12, and 1.0±0.15, respectively). Mean numbers of preleptotene primary spermatocytes per stage I seminiferous tubular cross-section were significantly decreased at doses ≥1.88 mg/kg/day as well (mean numbers for controls, 0.94, 1.88, 3.75, 7.5, and 15 mg/kg/day dose groups were 42.5±0.2.4, 41.9±2.4, 35.0±2.2, 29.3±2.2, 26.0±2.2, and 13.6±2.6, respectively). Dose-related increases in percent abnormal sperm were noted starting with the 1.88 mg/kg/day dose level. At the highest dose, mean testes weight was 55% less than that of controls. Dose-related decreased mean seminiferous tubular diameter was noted at the two highest dose levels. There was no apparent treatment-related effect on fertility. The 1.88 mg/kg/day dose level is considered a LOAEL for effects on sperm morphology.

Selection of the Point of Departure for the MRL: The LOAEL of 1.88 mg/kg/day was selected as the basis for the MRL.

Intermittent Exposure: No adjustment was made for treatment in the drinking water for only 5 days/week.

Uncertainty Factor: The LOAEL was divided by a total uncertainty factor of 1,000:

- 10 for use of a LOAEL
- 10 for extrapolation from animals to humans
- 10 for human variability

MRL = LOAEL ÷ uncertainty factors

1.88 mg/kg/day ÷ (10 x 10 x 10) ≈ 0.002 mg/kg/day

Other Additional Studies or Pertinent Information that Lend Support to this MRL: Testicular effects were also observed in rats orally exposed to 1,2-dibromo-3-chloropropane for 60–77 days (Amann and Berndtson 1986; Heindel et al. 1989; Johnston et al. 1986).

Agency Contact (Chemical Manager): Rae T. Benedict, Ph.D.

APPENDIX A

MINIMAL RISK LEVEL (MRL) WORKSHEET

***Chemical Name*:** 1,2-Dibromo-3-chloropropane
CAS Numbers: 96-12-8
Date: September 1992
March 2017—Updated literature search
Profile Status: Final
Route: Oral
Duration: Chronic

MRL Summary: There are insufficient data for derivation of a chronic-duration oral MRL.

Rationale for Not Deriving an MRL: Available chronic-duration oral data are not suitable for MRL development. The lowest LOAEL is 1 mg/kg/day for hyperkeratosis and acanthosis in the gastrointestinal tract of rats (Hazleton 1977, 1978a, 1978b). The same study reported liver, kidney, and stomach tumors at the next higher dose level (3 mg/kg/day). The nonneoplastic stomach lesions may be representative of precancerous lesions. NOAELs and LOAELs for other endpoints are higher than the lowest LOAEL and corresponding NOAEL for intermediate-duration oral exposure. Therefore, a chronic-duration oral MRL was not derived for 1,2-dibromo-3-chloropropane.

Agency Contact (Chemical Manager): Rae T. Benedict, Ph.D.

APPENDIX B. LITERATURE SEARCH FRAMEWORK FOR 1,2-DIBROMO-3-CHLOROPROPANE

The objective of the toxicological profile is to evaluate the potential for human exposure and the potential health hazards associated with inhalation, oral, or dermal/ocular exposure to 1,2-dibromo-3-chloro-propane.

B.1 LITERATURE SEARCH AND SCREEN

A literature search and screen was conducted to identify studies examining health effects, toxicokinetics, mechanisms of action, susceptible populations, biomarkers, and chemical interactions data for 1,2-dibromo-3-chloropropane. ATSDR primarily focused on peer-reviewed articles without publication date or language restrictions. Non-peer-reviewed studies that were considered relevant to the assessment of the health effects of 1,2-dibromo-3-chloropropane have undergone peer review by at least three ATSDR-selected experts who have been screened for conflict of interest. The inclusion criteria used to identify relevant studies examining the health effects of 1,2-dibromo-3-chloropropane are presented in Table B-1.

Table B-1. Inclusion Criteria for the Literature Search and Screen

- Health Effects
  - Species
    - Human
    - Laboratory mammals
  - Route of exposure
    - Inhalation
    - Oral
    - Dermal (or ocular)
    - Parenteral (these studies will be considered supporting data)
  - Health outcome
    - Death
    - Systemic effects
    - Body weight effects
    - Respiratory effects
    - Cardiovascular effects
    - Gastrointestinal effects
    - Hematological effects
    - Musculoskeletal effects
    - Hepatic effects
    - Renal effects
    - Dermal effects
    - Ocular effects
    - Endocrine effects
    - Immunological effects
    - Neurological effects
    - Reproductive effects

Table B-1. Inclusion Criteria for the Literature Search and Screen

Developmental effects
Other noncancer effects
Cancer
Toxicokinetics
Absorption
Distribution
Metabolism
Excretion
PBPK models
Biomarkers
Biomarkers of exposure
Biomarkers of effect
Interactions with other chemicals

B.1.1 Literature Search

The current literature search was intended to update the health effects sections of the existing toxicological profile for 1,2-dibromo-3-chloropropane (ATSDR 1992), thus, the literature search was restricted to studies published between January 1990 to March 2017. The following main databases were searched in March 2017:

- PubMed
- National Library of Medicine's TOXLINE
- Scientific and Technical Information Network's TOXCENTER

The search strategy used the chemical names, Chemical Abstracts Service (CAS) numbers, synonyms, and Medical Subject Headings (MeSH) terms for 1,2-dibromo-3-chloropropane. The query strings used for the literature search are presented in Table B-2.

The search was augmented by searching the Toxic Substances Control Act Test Submissions (TSCATS), NTP website, and National Institute of Health Research Portfolio Online Reporting Tools Expenditures and Results (NIH RePORTER) databases using the queries presented in Table B-3. Additional databases were searched in the creation of various tables and figures, such as the TRI Explorer, the Substance priority list (SPL) resource page, and other items as needed. Regulations applicable to 1,2-dibromo-3-chloropropane were identified by searching international and U.S. agency websites and documents.

Review articles were identified and used for the purpose of providing background information and identifying additional references. ATSDR also identified reports from the grey literature, which included unpublished research reports, technical reports from government agencies, conference proceedings and abstracts, and theses and dissertations.

Table B-2. Database Query Strings

Database search date	Query string
PubMed	
03/2017	((96-12-8[rn] OR 67708-83-2[rn] OR 96K0FD4803[rn] OR "1,2-dibromo-3-chloropropane"[supplementary concept] OR "1,2-dibromo-3-chloropropane"[nm]) AND (1990/01/01 : 3000[dp] OR 1990/01/01 : 3000[mhda])) OR (("1,2-Dibrom-3-chlor-propan"[tw] OR "1,2-Dibromo-3-chloropropane"[tw] OR "1,2-Dibromo-3-cloro-propano"[tw] OR "1,2-Dibromochloropropane"[tw] OR "1,2-Dibroom-3-chloorpropaan"[tw] OR "1-Chloro-2,3-dibromopropane"[tw] OR "2,3-Dibromo-1-chloropropane"[tw] OR "3-Chloro-1,2-dibromopropane"[tw] OR "BBC 12"[tw] OR "Dibromchlorpropan"[tw] OR "Dibromochloropropane"[tw] OR "Durham Nematicode EM 17.1"[tw] OR "Fumagon"[tw] OR "Fumazon 86"[tw] OR "Fumazone"[tw] OR "Fumazone 86"[tw] OR "Fumazone 86E"[tw] OR "Gro-Tone Nematode Granular"[tw] OR "Nemabrom"[tw] OR "Nemafume"[tw] OR "Nemagon"[tw] OR "Nemagone"[tw] OR "Nemanax"[tw] OR "Nemanex"[tw] OR "Nemapaz"[tw] OR "Nemaset"[tw] OR "Nematocide EM 12.1"[tw] OR "Nematocide EM 15.1"[tw] OR "Nematocide Solution EM 17.1"[tw] OR "Nematox"[tw] OR "Nemazon"[tw] OR "Oxy DBCP"[tw]) NOT medline[sb]) AND (1990/01/01 : 3000[dp] OR 1990/01/01 : 3000[crdat] OR 1990/01/01 : 3000[edat]))
Toxline	
03/2017	("1 2-dibrom-3-chlor-propan" OR "1 2-dibromo-3-chloropropane" OR "1 2-dibromo-3-cloro-propano" OR "1 2-dibromochloropropane" OR "1 2-dibroom-3-chloorpropaan" OR "1-chloro-2 3-dibromopropane" OR "2 3-dibromo-1-chloropropane" OR "3-chloro-1 2-dibromopropane" OR "bbc 12" OR "dibromchlorpropan" OR "dibromochloropropane" OR "durham nematicode em 17 1" OR "fumagon" OR "fumazon 86" OR "fumazone" OR "fumazone 86" OR "fumazone 86e" OR "gro-tone nematode granular" OR "nemabrom" OR "nemafume" OR "nemagon" OR "nemagone" OR "nemanax" OR "nemanex" OR "nemapaz" OR "nemaset" OR "nematocide em 12 1" OR "nematocide em 15 1" OR "nematocide solution em 17 1" OR "nematox" OR "nemazon" OR "oxy dbcp" OR 96-12-8 [rn] OR 67708-83-2 [rn]) AND 1990:2017 [yr] AND (ANEUPL [org] OR BIOSIS [org] OR CIS [org] OR DART [org] OR EMIC [org] OR EPIDEM [org] OR HEEP [org] OR HMTC [org] OR IPA [org] OR RISKLINE [org] OR MTGABS [org] OR NIOSH [org] OR NTIS [org] OR PESTAB [org] OR PPBIB [org]) AND NOT PubMed [org] AND NOT pubdart [org]
Toxcenter	
03/2017	FILE 'TOXCENTER' ENTERED AT 09:06:42 ON 23 MAR 2017 L1 2132 SEA 96-12-8 L2 11 SEA 67708-83-2 L3 2141 SEA L1 OR L2 L4 2113 SEA L3 NOT TSCATS/FS L5 2029 SEA L4 NOT PATENT/DT L6 781 SEA L5 AND PY>=1990 ACTIVATE TOXQUERY/Q --------- L7 QUE (CHRONIC OR IMMUNOTOX? OR NEUROTOX? OR TOXICOKIN? OR BIOMARKER? OR NEUROLOG?) L8 QUE (PHARMACOKIN? OR SUBCHRONIC OR PBPK OR EPIDEMIOLOGY/ST,CT, IT) L9 QUE (ACUTE OR SUBACUTE OR LD50# OR LD(W)50 OR LC50# OR LC(W)50) L10 QUE (TOXICITY OR ADVERSE OR POISONING)/ST,CT,IT L11 QUE (INHAL? OR PULMON? OR NASAL? OR LUNG? OR RESPIR?)

Table B-2. Database Query Strings

Database search date	Query string
	L12 QUE ((OCCUPATION? OR WORKPLACE? OR WORKER?) AND EXPOS?)
	L13 QUE (ORAL OR ORALLY OR INGEST? OR GAVAGE? OR DIET OR DIETS OR DIETARY OR DRINKING(W)WATER?)
	L14 QUE (MAXIMUM AND CONCENTRATION? AND (ALLOWABLE OR PERMISSIBLE))
	L15 QUE (ABORT? OR ABNORMALIT? OR EMBRYO? OR CLEFT? OR FETUS?)
	L16 QUE (FOETUS? OR FETAL? OR FOETAL? OR FERTIL? OR MALFORM? OR OVUM?)
	L17 QUE (OVA OR OVARY OR PLACENTA? OR PREGNAN? OR PRENATAL?)
	L18 QUE (PERINATAL? OR POSTNATAL? OR REPRODUC? OR STERIL? OR TERATOGEN?)
	L19 QUE (SPERM OR SPERMAC? OR SPERMAG? OR SPERMATI? OR SPERMAS? OR SPERMATOB? OR SPERMATOC? OR SPERMATOG?)
	L20 QUE (SPERMATOI? OR SPERMATOL? OR SPERMATOR? OR SPERMATOX? OR SPERMATOZ? OR SPERMATU? OR SPERMI? OR SPERMO?)
	L21 QUE (NEONAT? OR NEWBORN? OR DEVELOPMENT OR DEVELOPMENTAL?)
	L22 QUE (ENDOCRIN? AND DISRUPT?)
	L23 QUE (ZYGOTE? OR CHILD OR CHILDREN OR ADOLESCEN? OR INFANT?)
	L24 QUE (WEAN? OR OFFSPRING OR AGE(W)FACTOR?)
	L25 QUE (DERMAL? OR DERMIS OR SKIN OR EPIDERM? OR CUTANEOUS?)
	L26 QUE (CARCINOG? OR COCARCINOG? OR CANCER? OR PRECANCER? OR NEOPLAS?)
	L27 QUE (TUMOR? OR TUMOUR? OR ONCOGEN? OR LYMPHOMA? OR CARCINOM?)
	L28 QUE (GENETOX? OR GENOTOX? OR MUTAGEN? OR GENETIC(W)TOXIC?)
	L29 QUE (NEPHROTOX? OR HEPATOTOX?)
	L30 QUE (ENDOCRIN? OR ESTROGEN? OR ANDROGEN? OR HORMON?)
	L31 QUE (OCCUPATION? OR WORKER? OR WORKPLACE? OR EPIDEM?)
	L32 QUE L7 OR L8 OR L9 OR L10 OR L11 OR L12 OR L13 OR L14 OR L15 OR L16 OR L17 OR L18 OR L19 OR L20 OR L21 OR L22 OR L23 OR L24 OR L25 OR L26 OR L27 OR L28 OR L29 OR L30 OR L31
	L33 QUE (RAT OR RATS OR MOUSE OR MICE OR GUINEA(W)PIG? OR MURIDAE OR DOG OR DOGS OR RABBIT? OR HAMSTER? OR PIG OR PIGS OR SWINE OR PORCINE OR MONKEY? OR MACAQUE?)
	L34 QUE (MARMOSET? OR FERRET? OR GERBIL? OR RODENT? OR LAGOMORPHA OR BABOON? OR CANINE OR CAT OR CATS OR FELINE OR MURINE)
	L35 QUE L32 OR L33 OR L34
	L36 QUE (NONHUMAN MAMMALS)/ORGN

Table B-2. Database Query Strings

Database search date	Query string
	L37 QUE L35 OR L36 L38 QUE (HUMAN OR HUMANS OR HOMINIDAE OR MAMMALS OR MAMMAL? OR PRIMATES OR PRIMATE?) L39 QUE L37 OR L38 --------- L40 595 SEA L6 AND L39 L41 83 SEA L40 AND MEDLINE/FS L42 97 SEA L40 AND BIOSIS/FS L43 332 SEA L40 AND CAPLUS/FS L44 83 SEA L40 NOT (MEDLINE/FS OR BIOSIS/FS OR CAPLUS/FS) L45 469 DUP REM L41 L42 L44 L43 (126 DUPLICATES REMOVED) L*** DEL 83 S L40 AND MEDLINE/FS L*** DEL 83 S L40 AND MEDLINE/FS L46 83 SEA L45 L*** DEL 97 S L40 AND BIOSIS/FS L*** DEL 97 S L40 AND BIOSIS/FS L47 53 SEA L45 L*** DEL 332 S L40 AND CAPLUS/FS L*** DEL 332 S L40 AND CAPLUS/FS L48 267 SEA L45 L*** DEL 83 S L40 NOT (MEDLINE/FS OR BIOSIS/FS OR CAPLUS/FS) L*** DEL 83 S L40 NOT (MEDLINE/FS OR BIOSIS/FS OR CAPLUS/FS) L49 66 SEA L45 L50 386 SEA (L46 OR L47 OR L48 OR L49) NOT MEDLINE/FS D SCAN L50

Table B-3. Strategies to Augment the Literature Search

Source	Query and number screened when available
TSCATS[a]	
03/2017	Compounds searched: 96-12-8, 67708-83-2
NTP	
03/2017	96-12-8 67708-83-2 1,2-Dibromo-3-chloropropane 1,2-Dibromochloropropane 1-Chloro-2,3-dibromopropane 2,3-Dibromo-1-chloropropane 3-Chloro-1,2-dibromopropane Dibromochloropropane
NIH RePORTER	
06/2017	Text Search: "1,2-Dibrom-3-chlor-propan" OR "1,2-Dibromo-3-chloropropane" OR "1,2-Dibromo-3-cloro-propano" OR "1,2-Dibromochloropropane" OR "1,2-Dibroom-3-chloorpropaan" OR "1-Chloro-2,3-dibromopropane" OR "2,3-Dibromo-1-chloropropane" OR "3-Chloro-1,2-dibromopropane" OR "BBC 12" OR "Dibromchlorpropan" OR "Dibromochloropropane" OR "Durham Nematicode EM 17.1" OR "Fumagon" OR

Table B-3. Strategies to Augment the Literature Search

Source	Query and number screened when available
	"Fumazon 86" OR "Fumazone" OR "Fumazone 86" OR "Fumazone 86E" OR "Gro-Tone Nematode Granular" OR "Nemabrom" OR "Nemafume" OR "Nemagon" OR "Nemagon 20" OR "Nemagon 206" OR "Nemagon 20G" OR "Nemagon 90" OR "Nemagon soil fumigant" OR "Nemagone" OR "Nemanax" OR "Nemanex" OR "Nemapaz" OR "Nemaset" OR "Nematocide EM 12.1" OR "Nematocide EM 15.1" OR "Nematocide Solution EM 17.1" OR "Nematox" (Advanced), Search in: Projects Admin IC: All, Fiscal Year: Active Projects
Other	Identified throughout the assessment process

[a]Several versions of the TSCATS database were searched, as needed, by CASRN including TSCATS1 via Toxline (no date limit), TSCATS2 via https://yosemite.epa.gov/oppts/epatscat8.nsf/ReportSearch?OpenForm (date restricted by EPA receipt date), and TSCATS via CDAT (date restricted by 'Mail Received Date Range'), as well as google for recent TSCA submissions.

The 2017 results were:

- Number of records identified from PubMed, TOXLINE, and TOXCENTER (after duplicate removal): 813
- Number of records identified from other strategies: 35
- Total number of records to undergo literature screening: 848

B.1.2 Literature Screening

A two-step process was used to screen the literature search to identify relevant studies on 1,2-dibromo-3-chloropropane:

- Title and abstract screen
- Full text screen

Title and Abstract Screen. Within the reference library, titles and abstracts were screened manually for relevance. Studies that were considered relevant (see Table B-1 for inclusion criteria) were moved to the second step of the literature screening process. Studies were excluded when the title and abstract clearly indicated that the study was not relevant to the toxicological profile.

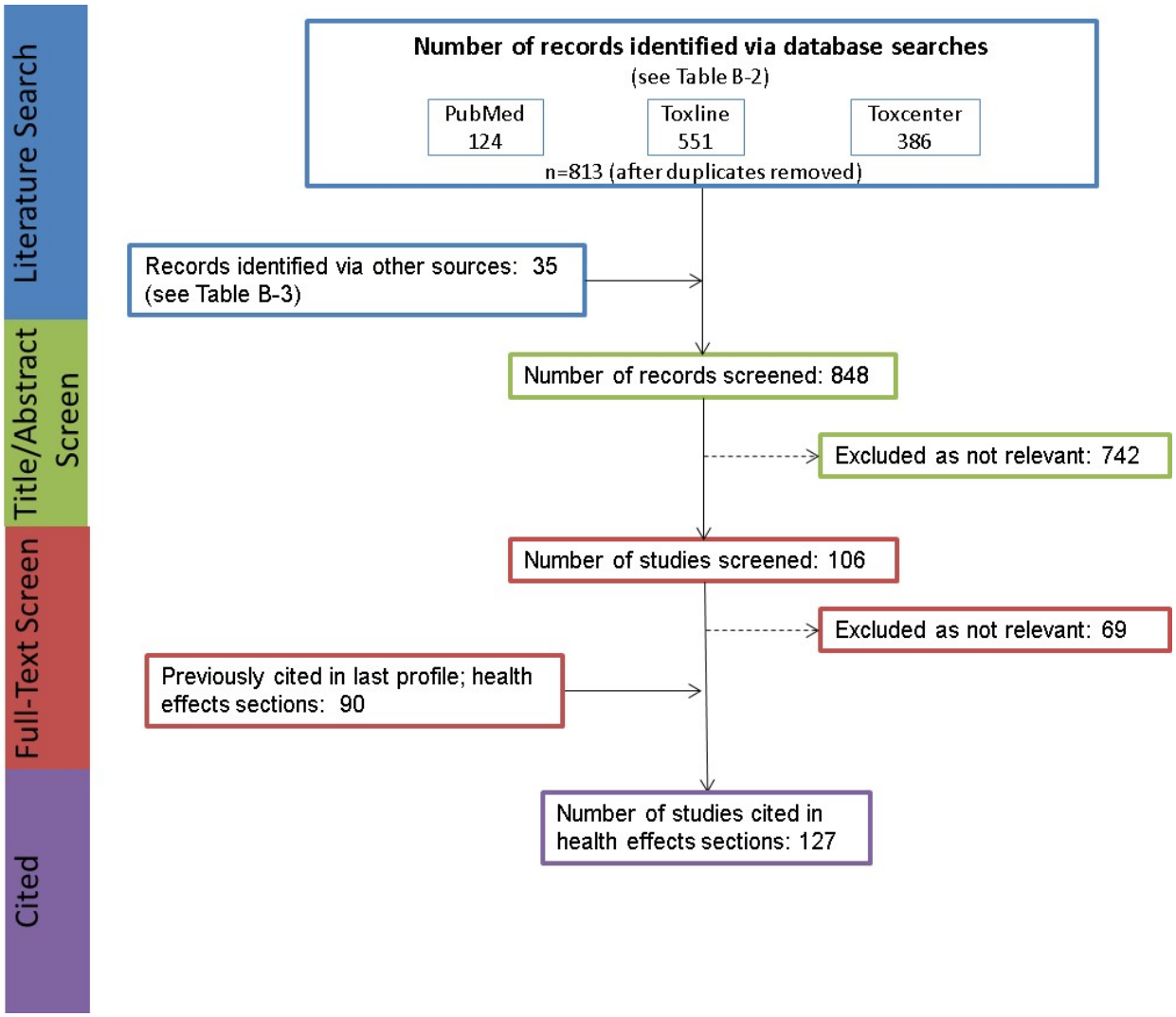
- Number of titles and abstracts screened: 848
- Number of studies considered relevant and moved to the next step: 106

Full Text Screen. The second step in the literature screening process was a full text review of individual studies considered relevant in the title and abstract screen step. Each study was reviewed to determine whether it was relevant for inclusion in the toxicological profile.

- Number of studies undergoing full text review: 106
- Number of studies cited in the health effects sections of the existing toxicological profile (September, 1992): 90
- Total number of studies cited in the health effects sections of the updated profile: 127

A summary of the results of the literature search and screening is presented in Figure B-1.

Figure B-1. March 2017 Literature Search Results and Screen for 1,2-Dibromo-3-chloropropane



APPENDIX C. USER'S GUIDE

Chapter 1. Relevance to Public Health

This chapter provides an overview of U.S. exposures, a summary of health effects based on evaluations of existing toxicologic, epidemiologic, and toxicokinetic information, and an overview of the minimal risk levels. This is designed to present interpretive, weight-of-evidence discussions for human health endpoints by addressing the following questions:

1. What effects are known to occur in humans?

2. What effects observed in animals are likely to be of concern to humans?

3. What exposure conditions are likely to be of concern to humans, especially around hazardous waste sites?

Minimal Risk Levels (MRLs)

Where sufficient toxicologic information is available, ATSDR derives MRLs for inhalation and oral routes of entry at each duration of exposure (acute, intermediate, and chronic). These MRLs are not meant to support regulatory action, but to acquaint health professionals with exposure levels at which adverse health effects are not expected to occur in humans.

MRLs should help physicians and public health officials determine the safety of a community living near a hazardous substance emission, given the concentration of a contaminant in air or the estimated daily dose in water. MRLs are based largely on toxicological studies in animals and on reports of human occupational exposure.

MRL users should be familiar with the toxicologic information on which the number is based. Section 1.2, Summary of Health Effects, contains basic information known about the substance. Other sections, such as Section 3.2 Children and Other Populations that are Unusually Susceptible and Section 3.4 Interactions with Other Substances, provide important supplemental information.

MRL users should also understand the MRL derivation methodology. MRLs are derived using a modified version of the risk assessment methodology that the Environmental Protection Agency (EPA) provides (Barnes and Dourson 1988) to determine reference doses (RfDs) for lifetime exposure.

To derive an MRL, ATSDR generally selects the most sensitive endpoint which, in its best judgement, represents the most sensitive human health effect for a given exposure route and duration. ATSDR cannot make this judgement or derive an MRL unless information (quantitative or qualitative) is available for all potential systemic, neurological, and developmental effects. If this information and reliable quantitative data on the chosen endpoint are available, ATSDR derives an MRL using the most sensitive species (when information from multiple species is available) with the highest no-observed-adverse-effect level (NOAEL) that does not exceed any adverse effect levels. When a NOAEL is not available, a lowest-observed-adverse-effect level (LOAEL) can be used to derive an MRL, and an uncertainty factor of 10 must be employed. Additional uncertainty factors of 10 must be used both for human variability to protect sensitive subpopulations (people who are most susceptible to the health effects caused by the substance) and for interspecies variability (extrapolation from animals to humans). In deriving an MRL, these individual uncertainty factors are multiplied together. The product is then divided into the inhalation concentration or oral dosage selected from the study. Uncertainty factors used in developing a

substance-specific MRL are provided in the footnotes of the levels of significant exposure (LSE) tables that are provided in Chapter 2. Detailed discussions of the MRLs are presented in Appendix A.

Chapter 2. Health Effects

Tables and Figures for Levels of Significant Exposure (LSE)

Tables and figures are used to summarize health effects and illustrate graphically levels of exposure associated with those effects. These levels cover health effects observed at increasing dose concentrations and durations, differences in response by species and MRLs to humans for noncancer endpoints. The LSE tables and figures can be used for a quick review of the health effects and to locate data for a specific exposure scenario. The LSE tables and figures should always be used in conjunction with the text. All entries in these tables and figures represent studies that provide reliable, quantitative estimates of NOAELs, LOAELs, or Cancer Effect Levels (CELs).

The legends presented below demonstrate the application of these tables and figures. Representative examples of LSE tables and figures follow. The numbers in the left column of the legends correspond to the numbers in the example table and figure.

TABLE LEGEND

See Sample LSE Table (page C-5)

(1) Route of exposure. One of the first considerations when reviewing the toxicity of a substance using these tables and figures should be the relevant and appropriate route of exposure. Typically, when sufficient data exist, three LSE tables and two LSE figures are presented in the document. The three LSE tables present data on the three principal routes of exposure (i.e., inhalation, oral, and dermal). LSE figures are limited to the inhalation and oral routes. Not all substances will have data on each route of exposure and will not, therefore, have all five of the tables and figures. Profiles with more than one chemical may have more LSE tables and figures.

(2) Exposure period. Three exposure periods—acute (<15 days), intermediate (15–364 days), and chronic (≥365 days)—are presented within each relevant route of exposure. In this example, two oral studies of chronic-duration exposure are reported. For quick reference to health effects occurring from a known length of exposure, locate the applicable exposure period within the LSE table and figure.

(3) Figure key. Each key number in the LSE table links study information to one or more data points using the same key number in the corresponding LSE figure. In this example, the study represented by key number 51 identified NOAELs and less serious LOAELs (also see the three "51R" data points in sample LSE Figure 2-X).

(4) Species (strain) No./group. The test species (and strain), whether animal or human, are identified in this column. The column also contains information on the number of subjects and sex per group. Chapter 1, Relevance to Public Health, covers the relevance of animal data to human toxicity and Section 3.1, Toxicokinetics, contains any available information on comparative toxicokinetics. Although NOAELs and LOAELs are species specific, the levels are extrapolated to equivalent human doses to derive an MRL.

(5) Exposure parameters/doses. The duration of the study and exposure regimens are provided in these columns. This permits comparison of NOAELs and LOAELs from different studies. In this case (key number 51), rats were orally exposed to “Chemical X” via feed for 2 years. For a

more complete review of the dosing regimen, refer to the appropriate sections of the text or the original reference paper (i.e., Aida et al. 1992).

(6) Parameters monitored. This column lists the parameters used to assess health effects. Parameters monitored could include serum (blood) chemistry (BC), behavioral (BH), biochemical changes (BI), body weight (BW), clinical signs (CS), developmental toxicity (DX), enzyme activity (EA), food intake (FI), fetal toxicity (FX), gross necropsy (GN), hematology (HE), histopathology (HP), lethality (LE), maternal toxicity (MX), organ function (OF), ophthalmology (OP), organ weight (OW), teratogenicity (TG), urinalysis (UR), and water intake (WI).

(7) Endpoint. This column lists the endpoint examined. The major categories of health endpoints included in LSE tables and figures are death, body weight, respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, renal, dermal, ocular, endocrine, immunological, neurological, reproductive, developmental, other noncancer, and cancer. "Other noncancer" refers to any effect (e.g., alterations in blood glucose levels) not covered in these systems. In the example of key number 51, three endpoints (body weight, hematological, and hepatic) were investigated.

(8) NOAEL. A NOAEL is the highest exposure level at which no adverse effects were seen in the organ system studied. The body weight effect reported in key number 51 is a NOAEL at 25.5 mg/kg/day. NOAELs are not reported for cancer and death; with the exception of these two endpoints, this field is left blank if no NOAEL was identified in the study.

(9) LOAEL. A LOAEL is the lowest dose used in the study that caused an adverse health effect. LOAELs have been classified into "Less Serious" and "Serious" effects. These distinctions help readers identify the levels of exposure at which adverse health effects first appear and the gradation of effects with increasing dose. A brief description of the specific endpoint used to quantify the adverse effect accompanies the LOAEL. Key number 51 reports a less serious LOAEL of 6.1 mg/kg/day for the hepatic system, which was used to derive a chronic exposure, oral MRL of 0.008 mg/kg/day (see footnote "c"). MRLs are not derived from serious LOAELs. A cancer effect level (CEL) is the lowest exposure level associated with the onset of carcinogenesis in experimental or epidemiologic studies. CELs are always considered serious effects. The LSE tables and figures do not contain NOAELs for cancer, but the text may report doses not causing measurable cancer increases. If no LOAEL/CEL values were identified in the study, this field is left blank.

(10) Reference. The complete reference citation is provided in Chapter 8 of the profile.

(11) Footnotes. Explanations of abbreviations or reference notes for data in the LSE tables are found in the footnotes. For example, footnote "c" indicates that the LOAEL of 6.1 mg/kg/day in key number 51 was used to derive an oral MRL of 0.008 mg/kg/day.

FIGURE LEGEND

See Sample LSE Figure (page C-6)

LSE figures graphically illustrate the data presented in the corresponding LSE tables. Figures help the reader quickly compare health effects according to exposure concentrations for particular exposure periods.

(13) Exposure period. The same exposure periods appear as in the LSE table. In this example, health effects observed within the chronic exposure period are illustrated.

(14) Endpoint. These are the categories of health effects for which reliable quantitative data exist. The same health effect endpoints appear in the LSE table.

(15) Levels of exposure. Concentrations or doses for each health effect in the LSE tables are graphically displayed in the LSE figures. Exposure concentration or dose is measured on the log scale "y" axis. Inhalation exposure is reported in mg/m^3 or ppm and oral exposure is reported in mg/kg/day.

(16) LOAEL. In this example, the half-shaded circle that is designated 51R identifies a LOAEL critical endpoint in the rat upon which a chronic oral exposure MRL is based. The key number 51 corresponds to the entry in the LSE table. The dashed descending arrow indicates the extrapolation from the exposure level of 6.1 mg/kg/day (see entry 51 in the sample LSE table) to the MRL of 0.008 mg/kg/day (see footnote "c" in the sample LSE table).

(17) CEL. Key number 59R is one of studies for which CELs were derived. The diamond symbol refers to a CEL for the test species (rat). The number 59 corresponds to the entry in the LSE table.

(18) Key to LSE figure. The key provides the abbreviations and symbols used in the figure.

APPENDIX C

Table 2-X. Levels of Significant Exposure to [Chemical X] – Oral (1)

Figure key[a] (3)	Species (strain) No./group (4)	Exposure parameters (5)	Doses (mg/kg/day) (5)	Parameters monitored (6)	Endpoint (7)	NOAEL (mg/kg/day) (8)	Less serious LOAEL (mg/kg/day) (9)	Serious LOAEL (mg/kg/day) (9)	Effect
CHRONIC EXPOSURE (2)									
51	Rat (Wistar) 40 M, 40 F	2 years (F)	M: 0, 6.1, 25.5, 138.0 F: 0, 8.0, 31.7, 168.4	CS, WI, BW, OW, HE, BC, HP	Bd wt	25.5	138.0		Decreased body weight gain in males (23–25%) and females (31–39%)
					Hemato	138.0			
					Hepatic		6.1[c]		Increases in absolute and relative weights at ≥6.1/8.0 mg/kg/day after 12 months of exposure; fatty generation at ≥6.1 mg/kg/day in males and at ≥31.7 mg/kg/day in females, and granulomas in females at 31.7 and 168.4 mg/kg/day after 12, 18, or 24 months of exposure and in males at ≥6.1 mg/kg/day only after 24 months of exposure
Aida et al. 1992 (10)									
52	Rat (F344) 78 M	104 weeks (W)	0, 3.9, 20.6, 36.3	CS, BW, FI, BC, OW, HP	Hepatic	36.3			
					Renal	20.6	36.3		Increased incidence of renal tubular cell hyperplasia
					Endocr	36.3			
George et al. 2002									
59	Rat (Wistar) 58M, 58F	Lifetime (W)	M: 0, 90 F: 0, 190	BW, HP	Cancer		190 F		Increased incidence of hepatic neoplastic nodules in females only; no additional description of the tumors was provided
Tumasonis et al. 1985									

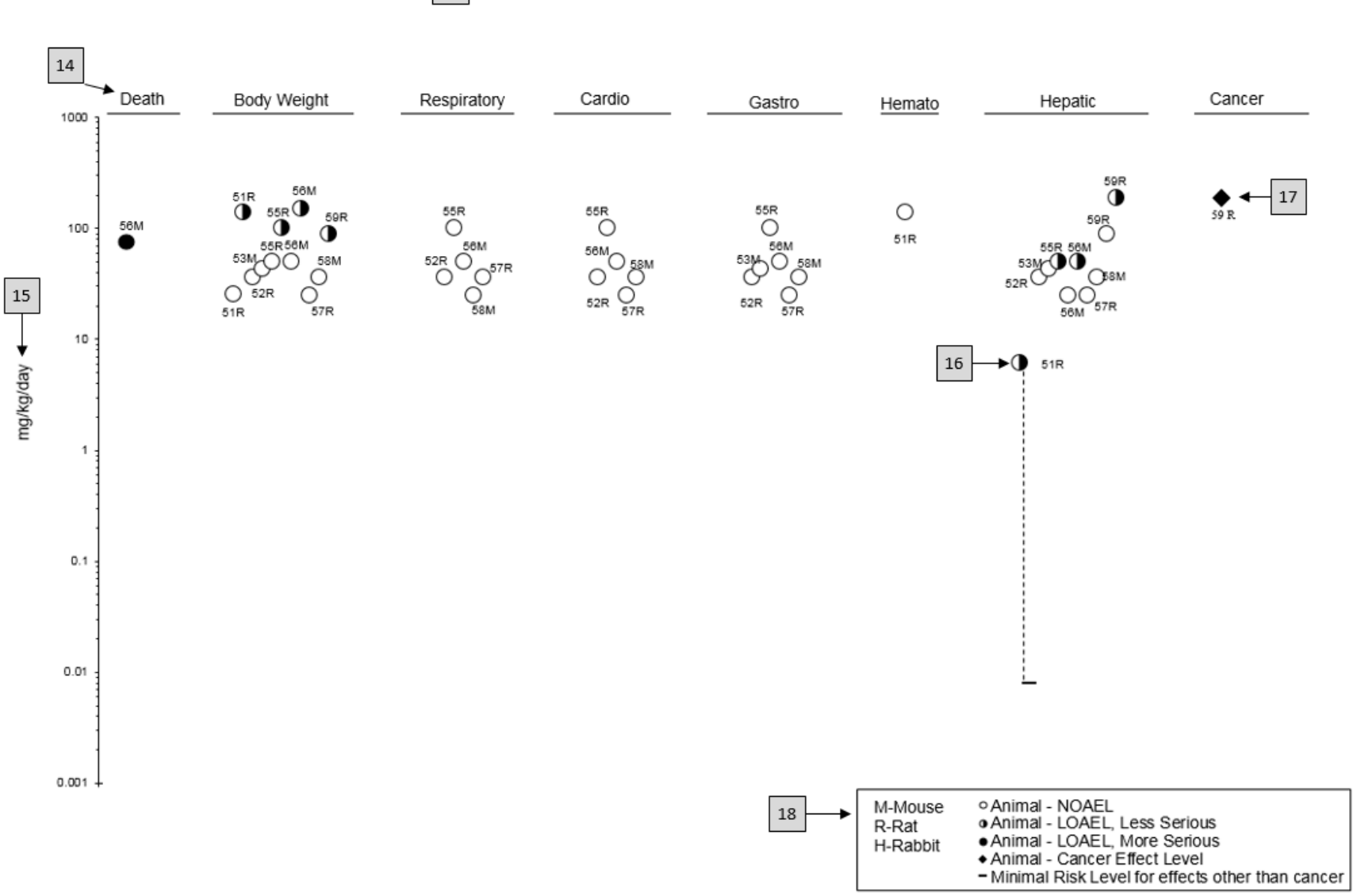
[a]The number corresponds to entries in Figure 2-x.

(11) [b]Used to derive an acute-duration oral minimal risk level (MRL) of 0.1 mg/kg/day based on the $BMDL_{05}$ of 10 mg/kg/day and an uncertainty factor of 100 (10 for extrapolation from animals to humans and 10 for human variability).

[c]Used to derive a chronic-duration oral MRL of 0.008 mg/kg/day based on the $BMDL_{10}$ of 0.78 mg/kg/day and an uncertainty factor of 100 (10 for extrapolation from animals to humans and 10 for human variability).

APPENDIX C

Figure 2-X. Levels of Significant Exposure to [Chemical X] - Oral



APPENDIX D. QUICK REFERENCE FOR HEALTH CARE PROVIDERS

Toxicological Profiles are a unique compilation of toxicological information on a given hazardous substance. Each profile reflects a comprehensive and extensive evaluation, summary, and interpretation of available toxicologic and epidemiologic information on a substance. Health care providers treating patients potentially exposed to hazardous substances may find the following information helpful for fast answers to often-asked questions.

Primary Chapters/Sections of Interest

Chapter 1: Relevance to Public Health: The Relevance to Public Health Section provides an overview of exposure and health effects and evaluates, interprets, and assesses the significance of toxicity data to human health. A table listing minimal risk levels (MRLs) is also included in this chapter.

Chapter 2: Health Effects: Specific health effects identified in both human and animal studies are reported by type of health effect (e.g., death, hepatic, renal, immune, reproductive), route of exposure (e.g., inhalation, oral, dermal), and length of exposure (e.g., acute, intermediate, and chronic).
NOTE: Not all health effects reported in this section are necessarily observed in the clinical setting.

Pediatrics:

Section 3.2 Children and Other Populations that are Unusually Susceptible
Section 3.3 Biomarkers of Exposure and Effect

ATSDR Information Center

Phone: 1-800-CDC-INFO (800-232-4636) or 1-888-232-6348 (TTY)
Internet: http://www.atsdr.cdc.gov

The following additional materials are available online:

Case Studies in Environmental Medicine are self-instructional publications designed to increase primary health care providers' knowledge of a hazardous substance in the environment and to aid in the evaluation of potentially exposed patients (see https://www.atsdr.cdc.gov/csem/csem.html).

Managing Hazardous Materials Incidents is a three-volume set of recommendations for on-scene (prehospital) and hospital medical management of patients exposed during a hazardous materials incident (see https://www.atsdr.cdc.gov/MHMI/index.asp). Volumes I and II are planning guides to assist first responders and hospital emergency department personnel in planning for incidents that involve hazardous materials. Volume III—*Medical Management Guidelines for Acute Chemical Exposures*—is a guide for health care professionals treating patients exposed to hazardous materials.

Fact Sheets (ToxFAQs™) provide answers to frequently asked questions about toxic substances (see https://www.atsdr.cdc.gov/toxfaqs/Index.asp).

Other Agencies and Organizations

The National Center for Environmental Health (NCEH) focuses on preventing or controlling disease, injury, and disability related to the interactions between people and their environment outside the workplace. Contact: NCEH, Mailstop F-29, 4770 Buford Highway, NE, Atlanta, GA 30341-3724 • Phone: 770-488-7000 • FAX: 770-488-7015 • Web Page: https://www.cdc.gov/nceh/.

The National Institute for Occupational Safety and Health (NIOSH) conducts research on occupational diseases and injuries, responds to requests for assistance by investigating problems of health and safety in the workplace, recommends standards to the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA), and trains professionals in occupational safety and health. Contact: NIOSH, 395 E Street, S.W., Suite 9200, Patriots Plaza Building, Washington, DC 20201 • Phone: 202-245-0625 or 1-800-CDC-INFO (800-232-4636) • Web Page: https://www.cdc.gov/niosh/.

The National Institute of Environmental Health Sciences (NIEHS) is the principal federal agency for biomedical research on the effects of chemical, physical, and biologic environmental agents on human health and well-being. Contact: NIEHS, PO Box 12233, 104 T.W. Alexander Drive, Research Triangle Park, NC 27709 • Phone: 919-541-3212 • Web Page: https://www.niehs.nih.gov/.

Clinical Resources (Publicly Available Information)

The Association of Occupational and Environmental Clinics (AOEC) has developed a network of clinics in the United States to provide expertise in occupational and environmental issues. Contact: AOEC, 1010 Vermont Avenue, NW, #513, Washington, DC 20005 • Phone: 202-347-4976 • FAX: 202-347-4950 • e-mail: AOEC@AOEC.ORG • Web Page: http://www.aoec.org/.

The American College of Occupational and Environmental Medicine (ACOEM) is an association of physicians and other health care providers specializing in the field of occupational and environmental medicine. Contact: ACOEM, 25 Northwest Point Boulevard, Suite 700, Elk Grove Village, IL 60007-1030 • Phone: 847-818-1800 • FAX: 847-818-9266 • Web Page: http://www.acoem.org/.

The American College of Medical Toxicology (ACMT) is a nonprofit association of physicians with recognized expertise in medical toxicology. Contact: ACMT, 10645 North Tatum Boulevard, Suite 200-111, Phoenix AZ 85028 • Phone: 844-226-8333 • FAX: 844-226-8333 • Web Page: http://www.acmt.net.

The Pediatric Environmental Health Specialty Units (PEHSUs) is an interconnected system of specialists who respond to questions from public health professionals, clinicians, policy makers, and the public about the impact of environmental factors on the health of children and reproductive-aged adults. Contact information for regional centers can be found at http://pehsu.net/findhelp.html.

The American Association of Poison Control Centers (AAPCC) provide support on the prevention and treatment of poison exposures. Contact: AAPCC, 515 King Street, Suite 510, Alexandria VA 22314 • Phone: 701-894-1858 • Poison Help Line: 1-800-222-1222 • Web Page: http://www.aapcc.org/.

APPENDIX E. GLOSSARY

Absorption—The process by which a substance crosses biological membranes and enters systemic circulation. Absorption can also refer to the taking up of liquids by solids, or of gases by solids or liquids.

Acute Exposure—Exposure to a chemical for a duration of ≤14 days, as specified in the Toxicological Profiles.

Adsorption—The adhesion in an extremely thin layer of molecules (as of gases, solutes, or liquids) to the surfaces of solid bodies or liquids with which they are in contact.

Adsorption Coefficient (K_{oc})—The ratio of the amount of a chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of the chemical in solution at equilibrium.

Adsorption Ratio (Kd)—The amount of a chemical adsorbed by sediment or soil (i.e., the solid phase) divided by the amount of chemical in the solution phase, which is in equilibrium with the solid phase, at a fixed solid/solution ratio. It is generally expressed in micrograms of chemical sorbed per gram of soil or sediment.

Benchmark Dose (BMD) or Benchmark Concentration (BMC)—is the dose/concentration corresponding to a specific response level estimate using a statistical dose-response model applied to either experimental toxicology or epidemiology data. For example, a BMD_{10} would be the dose corresponding to a 10% benchmark response (BMR). The BMD is determined by modeling the dose-response curve in the region of the dose-response relationship where biologically observable data are feasible. The BMDL or BMCL is the 95% lower confidence limit on the BMD or BMC.

Bioconcentration Factor (BCF)—The quotient of the concentration of a chemical in aquatic organisms at a specific time or during a discrete time period of exposure divided by the concentration in the surrounding water at the same time or during the same period.

Biomarkers—Indicators signaling events in biologic systems or samples, typically classified as markers of exposure, effect, and susceptibility.

Cancer Effect Level (CEL)—The lowest dose of a chemical in a study, or group of studies, that produces significant increases in the incidence of cancer (or tumors) between the exposed population and its appropriate control.

Carcinogen—A chemical capable of inducing cancer.

Case-Control Study—A type of epidemiological study that examines the relationship between a particular outcome (disease or condition) and a variety of potential causative agents (such as toxic chemicals). In a case-control study, a group of people with a specified and well-defined outcome is identified and compared to a similar group of people without the outcome.

Case Report—A report that describes a single individual with a particular disease or exposure. These reports may suggest some potential topics for scientific research, but are not actual research studies.

Case Series—Reports that describe the experience of a small number of individuals with the same disease or exposure. These reports may suggest potential topics for scientific research, but are not actual research studies.

Ceiling Value—A concentration that must not be exceeded.

Chronic Exposure—Exposure to a chemical for ≥365 days, as specified in the Toxicological Profiles.

Clastogen—A substance that causes breaks in chromosomes resulting in addition, deletion, or rearrangement of parts of the chromosome.

Cohort Study—A type of epidemiological study of a specific group or groups of people who have had a common insult (e.g., exposure to an agent suspected of causing disease or a common disease) and are followed forward from exposure to outcome, and who are disease-free at start of follow-up. Often, at least one exposed group is compared to one unexposed group, while in other cohorts, exposure is a continuous variable and analyses are directed towards analyzing an exposure-response coefficient.

Cross-sectional Study—A type of epidemiological study of a group or groups of people that examines the relationship between exposure and outcome to a chemical or to chemicals at a specific point in time.

Data Needs—Substance-specific informational needs that, if met, would reduce the uncertainties of human health risk assessment.

Developmental Toxicity—The occurrence of adverse effects on the developing organism that may result from exposure to a chemical prior to conception (either parent), during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the life span of the organism.

Dose-Response Relationship—The quantitative relationship between the amount of exposure to a toxicant and the incidence of the response or amount of the response.

Embryotoxicity and Fetotoxicity—Any toxic effect on the conceptus as a result of prenatal exposure to a chemical; the distinguishing feature between the two terms is the stage of development during which the effect occurs. Effects include malformations and variations, altered growth, and *in utero* death.

Epidemiology—The investigation of factors that determine the frequency and distribution of disease or other health-related conditions within a defined human population during a specified period.

Excretion—The process by which metabolic waste products are removed from the body.

Genotoxicity—A specific adverse effect on the genome of living cells that, upon the duplication of affected cells, can be expressed as a mutagenic, clastogenic, or carcinogenic event because of specific alteration of the molecular structure of the genome.

Half-life—A measure of rate for the time required to eliminate one-half of a quantity of a chemical from the body or environmental media.

Health Advisory—An estimate of acceptable drinking water levels for a chemical substance derived by EPA and based on health effects information. A health advisory is not a legally enforceable federal standard, but serves as technical guidance to assist federal, state, and local officials.

Immediately Dangerous to Life or Health (IDLH)—A condition that poses a threat of life or health, or conditions that pose an immediate threat of severe exposure to contaminants that are likely to have adverse cumulative or delayed effects on health.

Immunotoxicity—Adverse effect on the functioning of the immune system that may result from exposure to chemical substances.

Incidence—The ratio of new cases of individuals in a population who develop a specified condition to the total number of individuals in that population who could have developed that condition in a specified time period.

Intermediate Exposure—Exposure to a chemical for a duration of 15–364 days, as specified in the Toxicological Profiles.

***In Vitro*—**Isolated from the living organism and artificially maintained, as in a test tube.

***In Vivo*—**Occurring within the living organism.

Lethal Concentration$_{(LO)}$ (LC_{LO})—The lowest concentration of a chemical in air that has been reported to have caused death in humans or animals.

Lethal Concentration$_{(50)}$ (LC_{50})—A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.

Lethal Dose$_{(LO)}$ (LD_{Lo})—The lowest dose of a chemical introduced by a route other than inhalation that has been reported to have caused death in humans or animals.

Lethal Dose$_{(50)}$ (LD_{50})—The dose of a chemical that has been calculated to cause death in 50% of a defined experimental animal population.

Lethal Time$_{(50)}$ (LT_{50})—A calculated period of time within which a specific concentration of a chemical is expected to cause death in 50% of a defined experimental animal population.

Lowest-Observed-Adverse-Effect Level (LOAEL)—The lowest exposure level of chemical in a study, or group of studies, that produces statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control.

Lymphoreticular Effects—Represent morphological effects involving lymphatic tissues such as the lymph nodes, spleen, and thymus.

Malformations—Permanent structural changes that may adversely affect survival, development, or function.

Metabolism—Process in which chemical substances are biotransformed in the body that could result in less toxic and/or readily excreted compounds or produce a biologically active intermediate.

Minimal Risk Level (MRL)—An estimate of daily human exposure to a hazardous substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified route and duration of exposure.

Modifying Factor (MF)—A value (greater than zero) that is applied to the derivation of a Minimal Risk Level (MRL) to reflect additional concerns about the database that are not covered by the uncertainty factors. The default value for a MF is 1.

Morbidity—The state of being diseased; the morbidity rate is the incidence or prevalence of a disease in a specific population.

Mortality—Death; the mortality rate is a measure of the number of deaths in a population during a specified interval of time.

Mutagen—A substance that causes mutations, which are changes in the DNA sequence of a cell's DNA. Mutations can lead to birth defects, miscarriages, or cancer.

Necropsy—The gross examination of the organs and tissues of a dead body to determine the cause of death or pathological conditions.

Neurotoxicity—The occurrence of adverse effects on the nervous system following exposure to a hazardous substance.

No-Observed-Adverse-Effect Level (NOAEL)—The dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Although effects may be produced at this dose, they are not considered to be adverse.

Octanol-Water Partition Coefficient (K_{ow})—The equilibrium ratio of the concentrations of a chemical in *n*-octanol and water, in dilute solution.

Odds Ratio (OR)—A means of measuring the association between an exposure (such as toxic substances and a disease or condition) that represents the best estimate of relative risk (risk as a ratio of the incidence among subjects exposed to a particular risk factor divided by the incidence among subjects who were not exposed to the risk factor). An odds ratio that is greater than 1 is considered to indicate greater risk of disease in the exposed group compared to the unexposed group.

Permissible Exposure Limit (PEL)—An Occupational Safety and Health Administration (OSHA) regulatory limit on the amount or concentration of a substance not to be exceeded in workplace air averaged over any 8-hour work shift of a 40-hour workweek.

Pesticide—General classification of chemicals specifically developed and produced for use in the control of agricultural and public health pests (insects or other organisms harmful to cultivated plants or animals).

Pharmacokinetics—The dynamic behavior of a material in the body, used to predict the fate (disposition) of an exogenous substance in an organism. Utilizing computational techniques, it provides the means of studying the absorption, distribution, metabolism, and excretion of chemicals by the body.

Pharmacokinetic Model—A set of equations that can be used to describe the time course of a parent chemical or metabolite in an animal system. There are two types of pharmacokinetic models: data-based and physiologically-based. A data-based model divides the animal system into a series of compartments, which, in general, do not represent real, identifiable anatomic regions of the body, whereas the physiologically-based model compartments represent real anatomic regions of the body.

Physiologically Based Pharmacodynamic (PBPD) Model—A type of physiologically based dose-response model that quantitatively describes the relationship between target tissue dose and toxic endpoints. These models advance the importance of physiologically based models in that they clearly describe the biological effect (response) produced by the system following exposure to an exogenous substance.

Physiologically Based Pharmacokinetic (PBPK) Model—A type of physiologically based dose-response model that is comprised of a series of compartments representing organs or tissue groups with realistic weights and blood flows. These models require a variety of physiological information, including tissue volumes, blood flow rates to tissues, cardiac output, alveolar ventilation rates, and possibly membrane permeabilities. The models also utilize biochemical information, such as blood:air partition coefficients, and metabolic parameters. PBPK models are also called biologically based tissue dosimetry models.

Prevalence—The number of cases of a disease or condition in a population at one point in time.

Prospective Study—A type of cohort study in which a group is followed over time and the pertinent observations are made on events occurring after the start of the study.

Recommended Exposure Limit (REL)—A National Institute for Occupational Safety and Health (NIOSH) time-weighted average (TWA) concentration for up to a 10-hour workday during a 40-hour workweek.

Reference Concentration (RfC)—An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer health effects during a lifetime. The inhalation RfC is expressed in units of mg/m^3 or ppm.

Reference Dose (RfD)—An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily oral exposure of the human population to a potential hazard that is likely to be without risk of deleterious noncancer health effects during a lifetime. The oral RfD is expressed in units of mg/kg/day.

Reportable Quantity (RQ)—The quantity of a hazardous substance that is considered reportable under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). RQs are (1) $\geq$1 pound or (2) for selected substances, an amount established by regulation either under CERCLA or under Section 311 of the Clean Water Act. Quantities are measured over a 24-hour period.

Reproductive Toxicity—The occurrence of adverse effects on the reproductive system that may result from exposure to a hazardous substance. The toxicity may be directed to the reproductive organs and/or the related endocrine system. The manifestation of such toxicity may be noted as alterations in sexual behavior, fertility, pregnancy outcomes, or modifications in other functions that are dependent on the integrity of this system.

Retrospective Study—A type of cohort study based on a group of persons known to have been exposed at some time in the past. Data are collected from routinely recorded events, up to the time the study is undertaken. Retrospective studies are limited to causal factors that can be ascertained from existing records and/or examining survivors of the cohort.

Risk—The possibility or chance that some adverse effect will result from a given exposure to a hazardous substance.

Risk Factor—An aspect of personal behavior or lifestyle, an environmental exposure, existing health condition, or an inborn or inherited characteristic that is associated with an increased occurrence of disease or other health-related event or condition.

Risk Ratio/Relative Risk—The ratio of the risk among persons with specific risk factors compared to the risk among persons without risk factors. A risk ratio that is greater than 1 indicates greater risk of disease in the exposed group compared to the unexposed group.

Short-Term Exposure Limit (STEL)—A STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday.

Standardized Mortality Ratio (SMR)—A ratio of the observed number of deaths and the expected number of deaths in a specific standard population.

Target Organ Toxicity—This term covers a broad range of adverse effects on target organs or physiological systems (e.g., renal, cardiovascular) extending from those arising through a single limited exposure to those assumed over a lifetime of exposure to a chemical.

Teratogen—A chemical that causes structural defects that affect the development of an organism.

Threshold Limit Value (TLV)—An American Conference of Governmental Industrial Hygienists (ACGIH) concentration of a substance to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect. The TLV may be expressed as a Time-Weighted Average (TLV-TWA), as a Short-Term Exposure Limit (TLV-STEL), or as a ceiling limit (TLV-C).

Time-Weighted Average (TWA)—An average exposure within a given time period.

Toxicokinetic—The absorption, distribution, metabolism, and elimination of toxic compounds in the living organism.

Toxics Release Inventory (TRI)—The TRI is an EPA program that tracks toxic chemical releases and pollution prevention activities reported by industrial and federal facilities.

Uncertainty Factor (UF)—A factor used in operationally deriving the Minimal Risk Level (MRL), Reference Dose (RfD), or Reference Concentration (RfC) from experimental data. UFs are intended to account for (1) the variation in sensitivity among the members of the human population, (2) the uncertainty in extrapolating animal data to the case of human, (3) the uncertainty in extrapolating from data obtained in a study that is of less than lifetime exposure, and (4) the uncertainty in using lowest-observed-adverse-effect level (LOAEL) data rather than no-observed-adverse-effect level (NOAEL) data. A default for each individual UF is 10; if complete certainty in data exists, a value of 1 can be used; however, a reduced UF of 3 may be used on a case-by-case basis (3 being the approximate logarithmic average of 10 and 1).

Xenobiotic—Any substance that is foreign to the biological system.

APPENDIX F. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AAPCC	American Association of Poison Control Centers
ACGIH	American Conference of Governmental Industrial Hygienists
ACOEM	American College of Occupational and Environmental Medicine
ACMT	American College of Medical Toxicology
ADI	acceptable daily intake
ADME	absorption, distribution, metabolism, and excretion
AEGL	Acute Exposure Guideline Level
AIC	Akaike's information criterion
AIHA	American Industrial Hygiene Association
ALT	alanine aminotransferase
AOEC	Association of Occupational and Environmental Clinics
AP	alkaline phosphatase
AST	aspartate aminotransferase
atm	atmosphere
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BCF	bioconcentration factor
BMD/C	benchmark dose or benchmark concentration
BMD_X	dose that produces a X% change in response rate of an adverse effect
$BMDL_X$	95% lower confidence limit on the BMD_X
BMDS	Benchmark Dose Software
BMR	benchmark response
BUN	blood urea nitrogen
C	centigrade
CAA	Clean Air Act
CAS	Chemical Abstract Services
CDC	Centers for Disease Control and Prevention
CEL	cancer effect level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curie
CI	confidence interval
cm	centimeter
CPSC	Consumer Products Safety Commission
CWA	Clean Water Act
DHHS	Department of Health and Human Services
DNA	deoxyribonucleic acid
DOD	Department of Defense
DOE	Department of Energy
DWEL	drinking water exposure level
EAFUS	Everything Added to Food in the United States
ECG/EKG	electrocardiogram
EEG	electroencephalogram
EPA	Environmental Protection Agency
ERPG	emergency response planning guidelines
F	Fahrenheit
F1	first-filial generation
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act

FR	Federal Register
FSH	follicle stimulating hormone
g	gram
GC	gas chromatography
gd	gestational day
GGT	γ-glutamyl transferase
GRAS	generally recognized as safe
HEC	human equivalent concentration
HED	human equivalent dose
HHS	Department of Health and Human Services
HPLC	high-performance liquid chromatography
HSDB	Hazardous Substance Data Bank
IARC	International Agency for Research on Cancer
IDLH	immediately dangerous to life and health
IRIS	Integrated Risk Information System
Kd	adsorption ratio
kg	kilogram
kkg	kilokilogram; 1 kilokilogram is equivalent to 1,000 kilograms and 1 metric ton
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
L	liter
LC	liquid chromatography
LC_{50}	lethal concentration, 50% kill
LC_{Lo}	lethal concentration, low
LD_{50}	lethal dose, 50% kill
LD_{Lo}	lethal dose, low
LDH	lactic dehydrogenase
LH	luteinizing hormone
LOAEL	lowest-observed-adverse-effect level
LSE	Level of Significant Exposure
LT_{50}	lethal time, 50% kill
m	meter
mCi	millicurie
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MF	modifying factor
mg	milligram
mL	milliliter
mm	millimeter
mmHg	millimeters of mercury
mmol	millimole
MRL	Minimal Risk Level
MS	mass spectrometry
MSHA	Mine Safety and Health Administration
Mt	metric ton
NAAQS	National Ambient Air Quality Standard
NAS	National Academy of Science
NCEH	National Center for Environmental Health
ND	not detected
ng	nanogram
NHANES	National Health and Nutrition Examination Survey

NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute for Occupational Safety and Health
NLM	National Library of Medicine
nm	nanometer
nmol	nanomole
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
NR	not reported
NRC	National Research Council
NS	not specified
NTP	National Toxicology Program
OR	odds ratio
OSHA	Occupational Safety and Health Administration
PAC	Protective Action Criteria
PAH	polycyclic aromatic hydrocarbon
PBPD	physiologically based pharmacodynamic
PBPK	physiologically based pharmacokinetic
PEHSU	Pediatric Environmental Health Specialty Unit
PEL	permissible exposure limit
PEL-C	permissible exposure limit-ceiling value
pg	picogram
PND	postnatal day
POD	point of departure
ppb	parts per billion
ppbv	parts per billion by volume
ppm	parts per million
ppt	parts per trillion
REL	recommended exposure level/limit
REL-C	recommended exposure level-ceiling value
RfC	reference concentration
RfD	reference dose
RNA	ribonucleic acid
SARA	Superfund Amendments and Reauthorization Act
SCE	sister chromatid exchange
SD	standard deviation
SE	standard error
SGOT	serum glutamic oxaloacetic transaminase (same as aspartate aminotransferase or AST)
SGPT	serum glutamic pyruvic transaminase (same as alanine aminotransferase or ALT)
SIC	standard industrial classification
SMR	standardized mortality ratio
sRBC	sheep red blood cell
STEL	short term exposure limit
TLV	threshold limit value
TLV-C	threshold limit value-ceiling value
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TWA	time-weighted average
UF	uncertainty factor
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey

USNRC	U.S. Nuclear Regulatory Commission
VOC	volatile organic compound
WBC	white blood cell
WHO	World Health Organization

>	greater than
≥	greater than or equal to
=	equal to
<	less than
≤	less than or equal to
%	percent
α	alpha
β	beta
γ	gamma
δ	delta
μm	micrometer
μg	microgram
q_1^*	cancer slope factor
–	negative
+	positive
(+)	weakly positive result
(–)	weakly negative result