Human Health Ambient Water Quality Criteria

Human Health Risk Assessment Branch/HECD/OST/OW

US Environmental Protection Agency

Virtual WQS Academy

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Outline

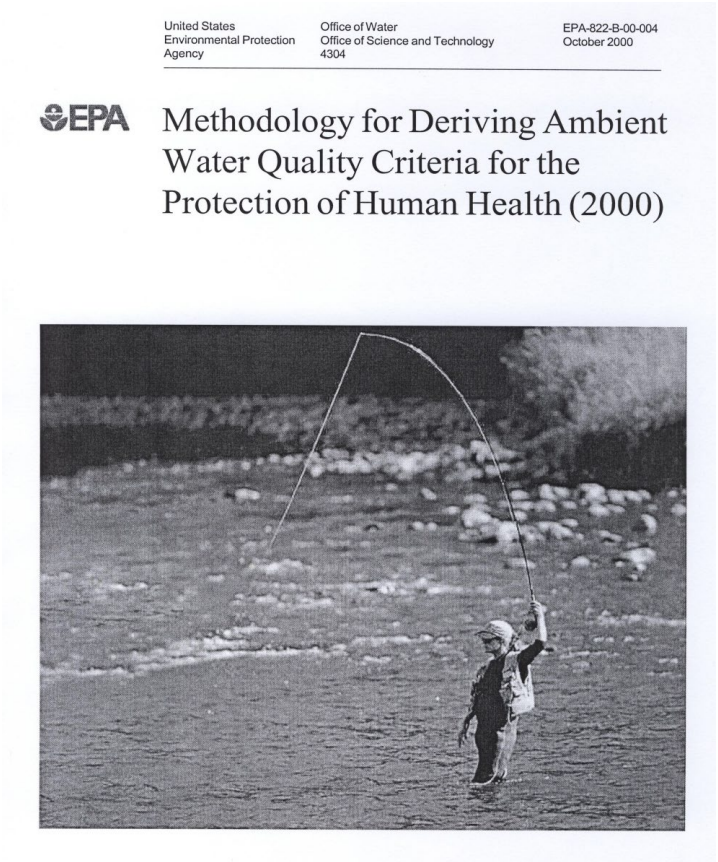
1. What are aquatic water quality criteria (AWQC)?

2. How are health assessments interpreted and used?
   - Hazard identification
   - Dose response: Linear and non-linear for cancer and noncancer health effects

3. How is an exposure analysis conducted?
   - Identification of Target population
   - Defining exposure parameters for target population
     - Drinking water intake, fish consumption, bioaccumulation factor, relative source contribution

4. How is a human health criterion calculated?
   - Equations used to calculate AWQC

EPA Method for AWQC Development



Source: USEPA (2000a). Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

- Describes EPA's recommended current methods for developing AWQC as required under Section 304(a) of the Clean Water Act (CWA).
  - States and authorized Tribes are required to adopt regulations which contain legally enforceable criteria
- Summarizes "state of the science" as of 2000
- Recommends approaches based on different chemical properties, exposure scenarios, and risk management policy decisions.

2015 Updated AWQC

- Goals
  - Incorporate the latest science on toxicity and exposure
  - Increase transparency
- Process
  - May 2014: EPA published draft updated criteria for 94 chemicals
  - August 2014: 90-day extended public comment period closed
  - June 2015: EPA published final updated criteria for 94 chemicals based on peer reviewed studies and methods
- Outcomes
  - 94 of 116 chemicals were updated
  - Publication of 94 criteria documents addressing chemical specific input values, assumptions, and calculations

Source: USEPA (2015a). Human Health Ambient Water Quality Criteria: 2015 Update Factsheet

What are AWQC?

- Water quality criteria are derived to establish ambient concentrations of pollutants which, if not exceeded, will protect the general population from adverse health impacts from those pollutants due to consumption of aquatic organisms and drinking water, including incidental water consumption related to recreational activities.
- Water quality criteria can be referred to as
  - Ambient Water Quality Criteria (AWQC)
  - Human Health Criteria (HHC)
  - 304a Criteria

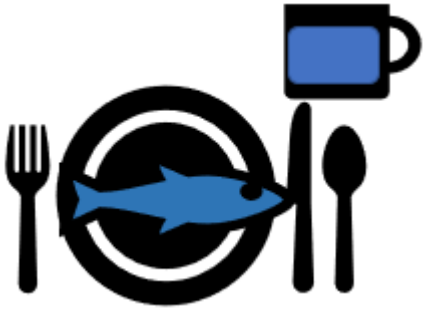
Source: USEPA (2000a). Section 1.1 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

AWQC Example: Chlorobenzene

100 µg/L

Water and Organism Criteria

Protects against histopathologic changes in the liver from exposure to chlorobenzene through **drinking water and fish/shellfish consumption**



800 µg/L

Organism Only Criteria

Protects against histopathologic changes in the liver from exposure to chlorobenzene through **fish/shellfish consumption only**

20 µg/L

Organoleptic Criteria

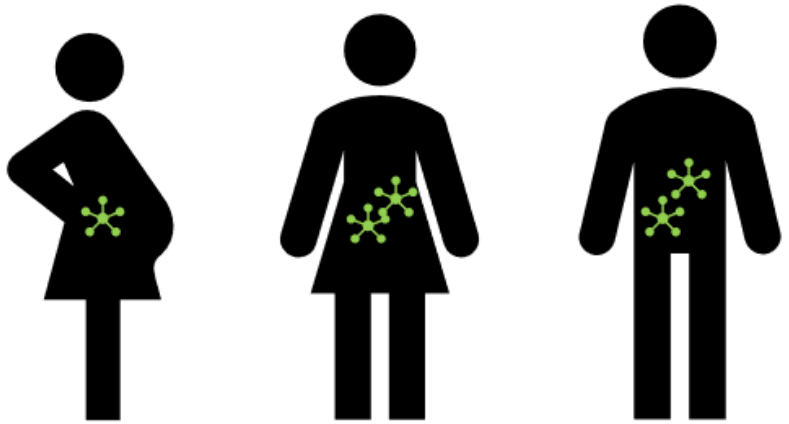
Controls undesirable taste and odor quality

*Chlorobenzene is also regulated under the Safe Drinking Water Act, and therefore has a National Primary Drinking Water Regulation.

Source: USEPA (2015b). Update of Human Health Ambient Water Quality Criteria: Chlorobenzene

Goal of AWQC

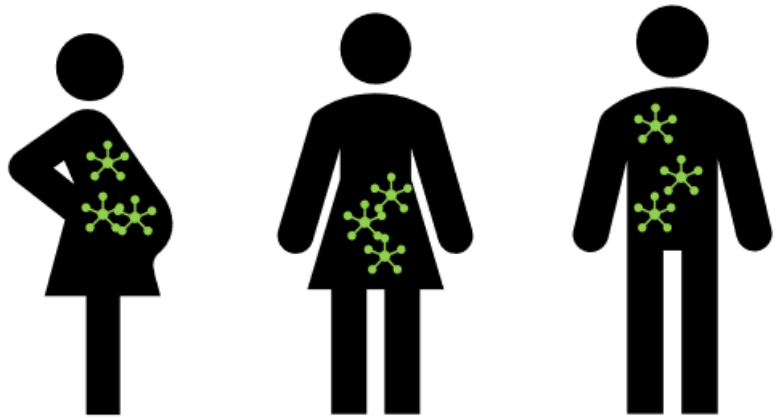
The concentration of the pollutant that the population is exposed to



Is less than or equal to

$\leq$

The concentration of the pollutant that is unlikely to cause adverse health effects *or* the concentration that achieves the target risk level for the population



Example AWQC

1,1 Dichloroethylene

Water + Organism Criteria =

300 µg/L

No adverse health effects are expected if the population is exposed to 1,1 dichloroethylene at concentrations

≤ 300 µg/L.

Source: USEPA (2015c). Update of Human Health Ambient Water Quality Criteria: 1,1 Dichloroethylene

Hexachlorobenzene*

Water + Organism Criteria =

7.9×10^{-5} µg/L

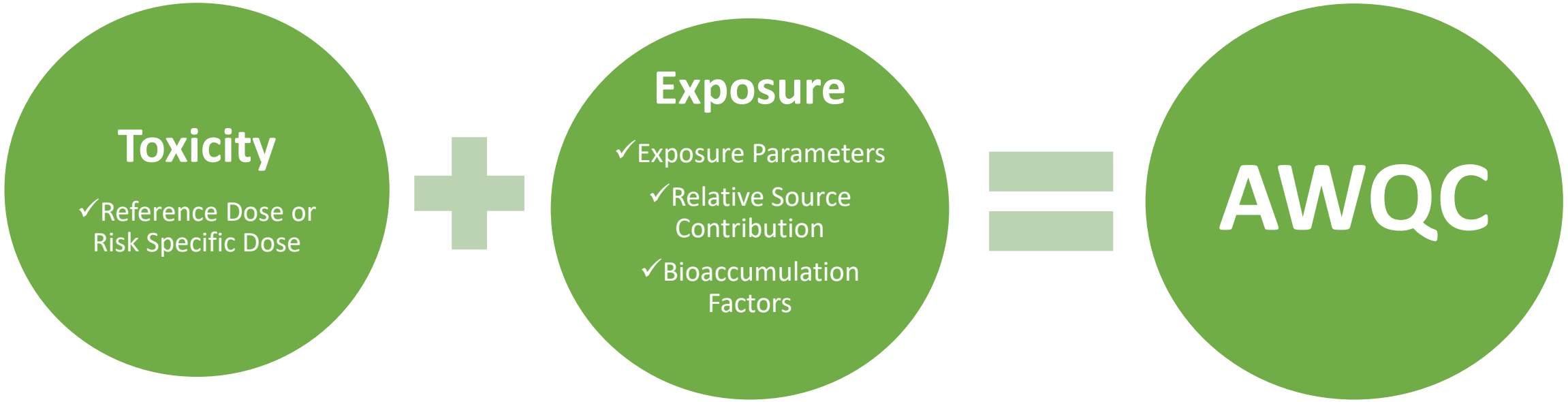
There is potential for one additional cancer case per one million people due to exposure to hexachlorobenzene at concentrations

≤ 7.9×10^{-5} µg/L.

* This criterion is based on carcinogenicity of 10^{-6} risk.

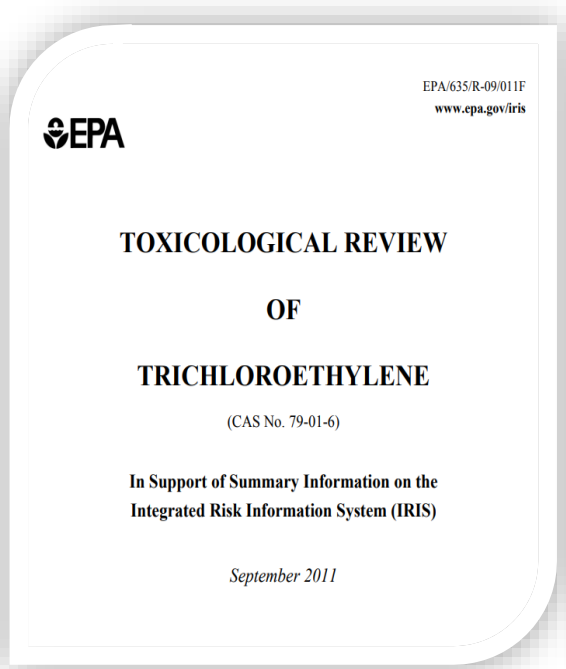
Source: USEPA (2015d). Update of Human Health Ambient Water Quality Criteria: Hexachlorobenzene

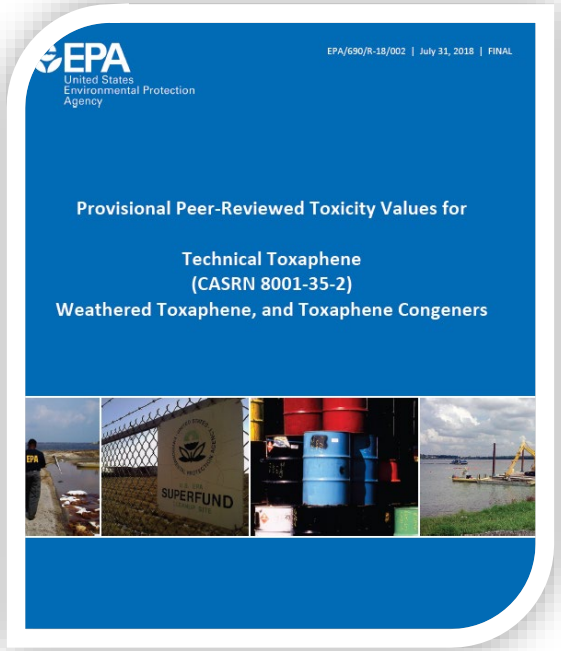
Required Information Input Values for Criteria Development

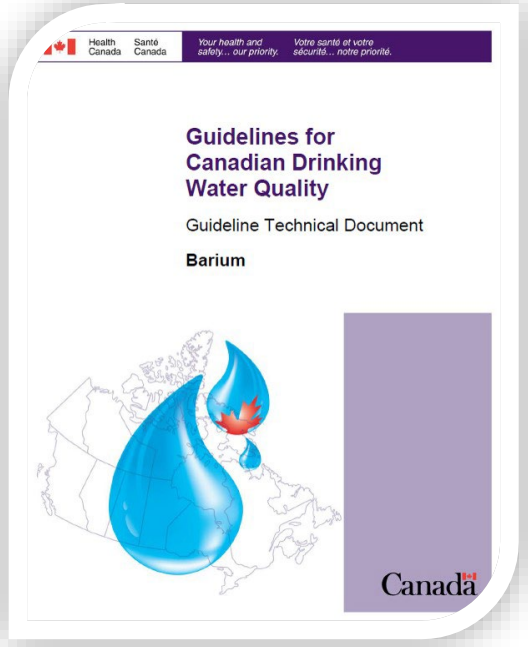


Learn About a Contaminant's Toxicity

- Does the contaminant have publicly available Health Assessments?







Peer-reviewed health assessment sources include:

EPA considers *publicly available* assessments that have undergone *peer-review.*

EPA Assessments

Office of Water:
- Health Advisories, Criteria Documents, Health Effects Support Documents

Office of Research and Development:
- Integrated Risk Information System assessments, Provisional Peer-Reviewed Toxicity Value Reports

Office of Pesticides
- Registration Eligibility Documents, Human Health Risk Assessments

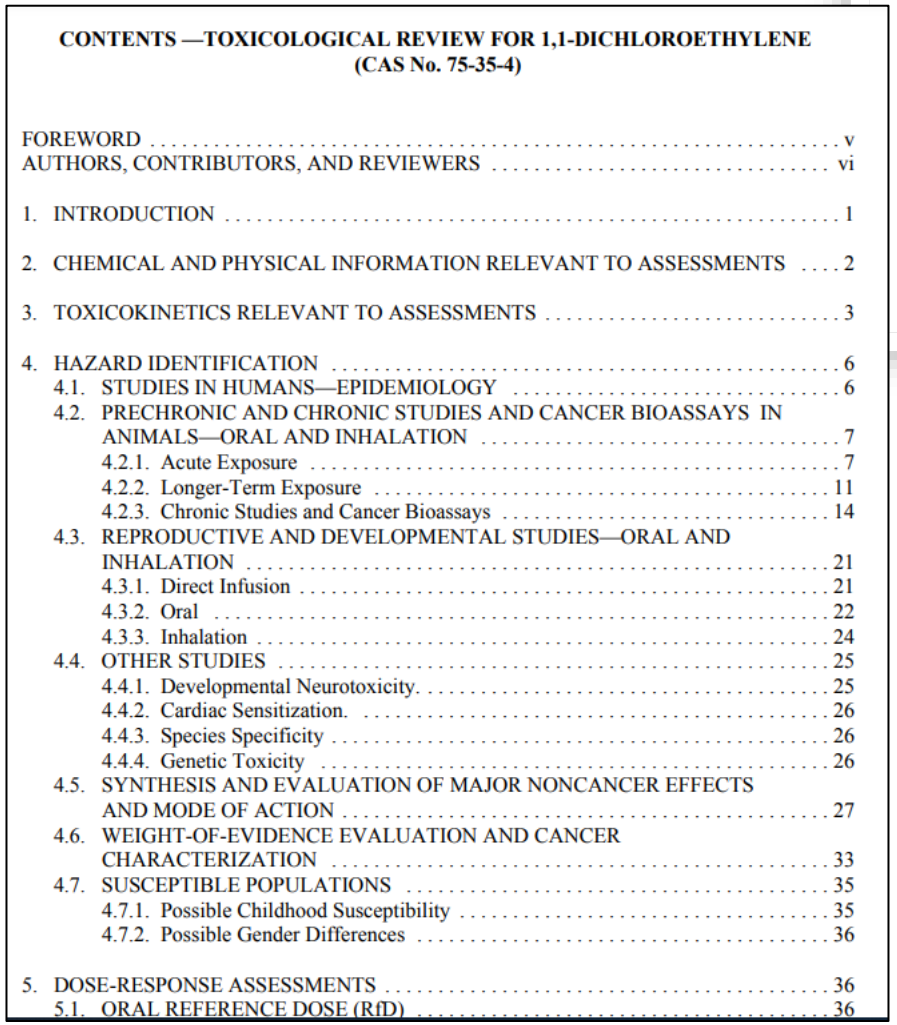
Office of Pollution Prevention and Toxics:
- Toxic Substance Control Act (TSCA) Risk Evaluations

Other Assessments

Agency for Toxic Substances and Disease Registry Toxicological Profiles	Guidelines for Drinking Water	Drinking Water Guidelines	State assessments - e.g., CalEPA Public Health Goals

Components of a Health Assessment

- Health assessments detail
  - Hazard (adverse health effects) and dose response for a given chemical.
    - dose-response information generally results in the development of toxicity values such as a Reference Dose (RfD) or Cancer Slope Factor (CSF)
  - Physical/chemical properties, fate and transport, use profiles, etc.



CONTENTS —TOXICOLOGICAL REVIEW FOR 1,1-DICHLOROETHYLENE (CAS No. 75-35-4)

FOREWORD v
AUTHORS, CONTRIBUTORS, AND REVIEWERS vi

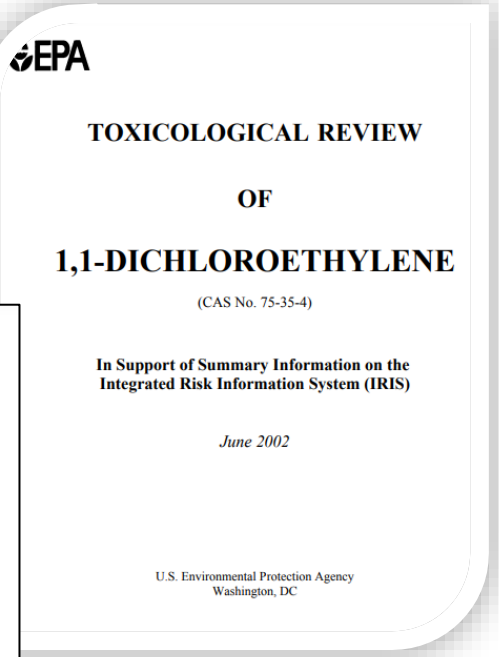
1. INTRODUCTION 1

2. CHEMICAL AND PHYSICAL INFORMATION RELEVANT TO ASSESSMENTS 2

3. TOXICOKINETICS RELEVANT TO ASSESSMENTS 3

4. HAZARD IDENTIFICATION 6
   4.1. STUDIES IN HUMANS—EPIDEMIOLOGY 6
   4.2. PRECHRONIC AND CHRONIC STUDIES AND CANCER BIOASSAYS IN ANIMALS—ORAL AND INHALATION 7
      4.2.1. Acute Exposure 7
      4.2.2. Longer-Term Exposure 11
      4.2.3. Chronic Studies and Cancer Bioassays 14
   4.3. REPRODUCTIVE AND DEVELOPMENTAL STUDIES—ORAL AND INHALATION 21
      4.3.1. Direct Infusion 21
      4.3.2. Oral 22
      4.3.3. Inhalation 24
   4.4. OTHER STUDIES 25
      4.4.1. Developmental Neurotoxicity. 25
      4.4.2. Cardiac Sensitization. 26
      4.4.3. Species Specificity 26
      4.4.4. Genetic Toxicity 26
   4.5. SYNTHESIS AND EVALUATION OF MAJOR NONCANCER EFFECTS AND MODE OF ACTION 27
   4.6. WEIGHT-OF-EVIDENCE EVALUATION AND CANCER CHARACTERIZATION 33
   4.7. SUSCEPTIBLE POPULATIONS 35
      4.7.1. Possible Childhood Susceptibility 35
      4.7.2. Possible Gender Differences 36

5. DOSE-RESPONSE ASSESSMENTS 36
   5.1. ORAL REFERENCE DOSE (RfD) 36



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TOXICOLOGICAL REVIEW

OF

1,1-DICHLOROETHYLENE

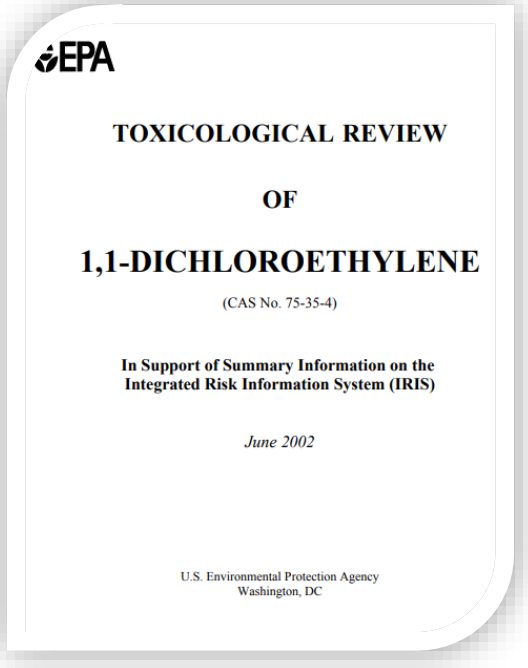
(CAS No. 75-35-4)

In Support of Summary Information on the Integrated Risk Information System (IRIS)

June 2002

U.S. Environmental Protection Agency
Washington, DC

AWQC Example: 1,1 Dichloroethylene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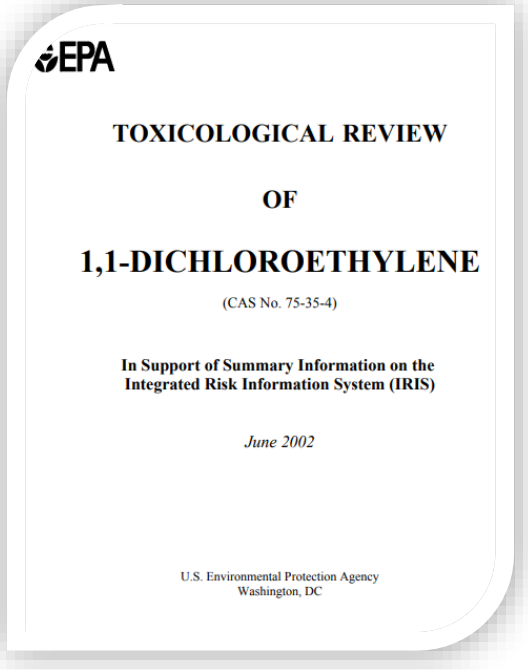
Available Data Summarized in the Health Assessment

- Epidemiological study in 138 employees
  - no significant impact on hematology or clinical chemistry parameters (Ott et al., 1976)
- Acute study in rodents
  - increase in liver enzymes in serum (Jenkins et al., 1972)
- Chronic study in rats
  - liver toxicity (Quast et al., 1983)
- Chronic study in dogs
  - No adverse health effects observed (Quast et al., 1983)
- Developmental study in rats
  - No evidence of toxicity to dams or offspring (Murray et al., 1979)
- Carcinogenicity study in mice
  - Evidence of induction of kidney adenocarcinomas, however, data presented is insufficient (Speerschneider and Dekant, 1995; Amet et al., 1997; Cummings et al., 2000)

Source: USEPA (2002). Toxicological Review of 1,1-Dichloroethylene

* Not an exhaustive list of available data

AWQC Example: 1,1 Dichloroethylene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The *weight of evidence* suggests that liver toxicity is the most sensitive effect (i.e. adverse effect seen at the lowest does)

Available Data Summarized in the Health Assessment

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Source: USEPA (2002). Toxicological Review of 1,1-Dichloroethylene

* Not an exhaustive list of available data

Hazard Identification: Qualitative Cancer Descriptors

- Assessments may assign qualitative cancer descriptors for evidence of human carcinogenic potential based on available cancer information
- 2005 EPA Cancer Guidelines replace the 1986 and 1999 guidelines.

2005 Cancer Descriptors

- Carcinogenic to humans
- Likely to be carcinogenic to humans
- Suggestive evidence of carcinogenic potential
- Inadequate information to assess carcinogenic potential
- Not likely to be a carcinogen

Helpful Guidance: USEPA (2005). Cancer Guidelines

AWQC Example: 1,1 Dichloroethylene

- Under the 1986 guidelines:
  - Group C, possible human carcinogen.
- Under the 1999 guidelines:
  - Suggestive evidence of carcinogenicity
- Under the 2005 guidelines:
  - Suggestive evidence of carcinogenic potential

Source: USEPA (2015c). Update of Human Health Ambient Water Quality Criteria: 1,1 Dichloroethylene

Understanding Health Assessment Toxicity Conclusions

A pollutant typically has one prevailing dose-response pattern

Non-Linear or Threshold Dose-Response

Indicates that there is a dose below which no adverse effects were observed

Typical of non-cancer effects

Linear Dose-Response

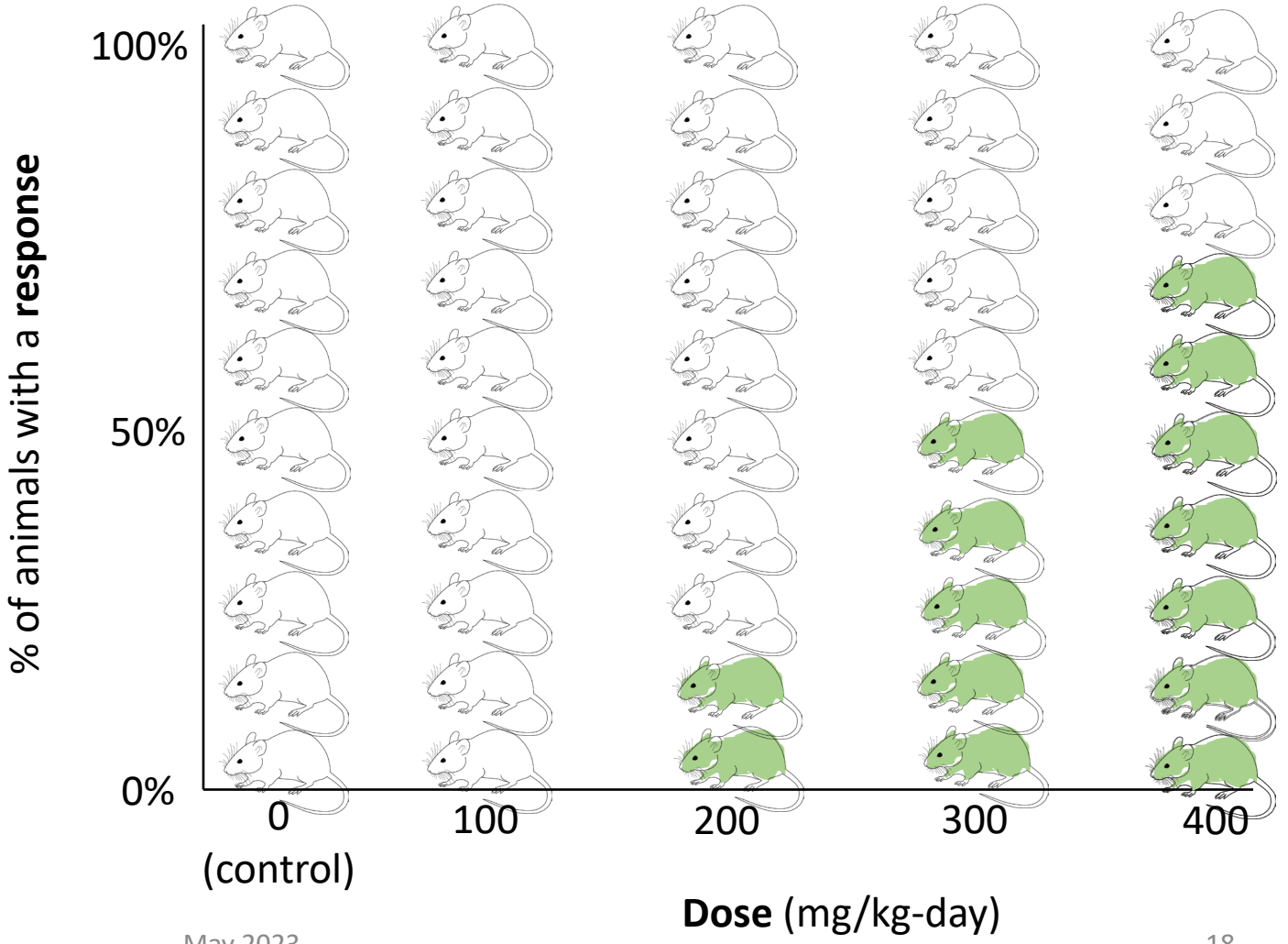
Assumes increased probability of effects at all levels of exposure

Typical of cancer effects

Source: USEPA (2022). IRIS Glossary

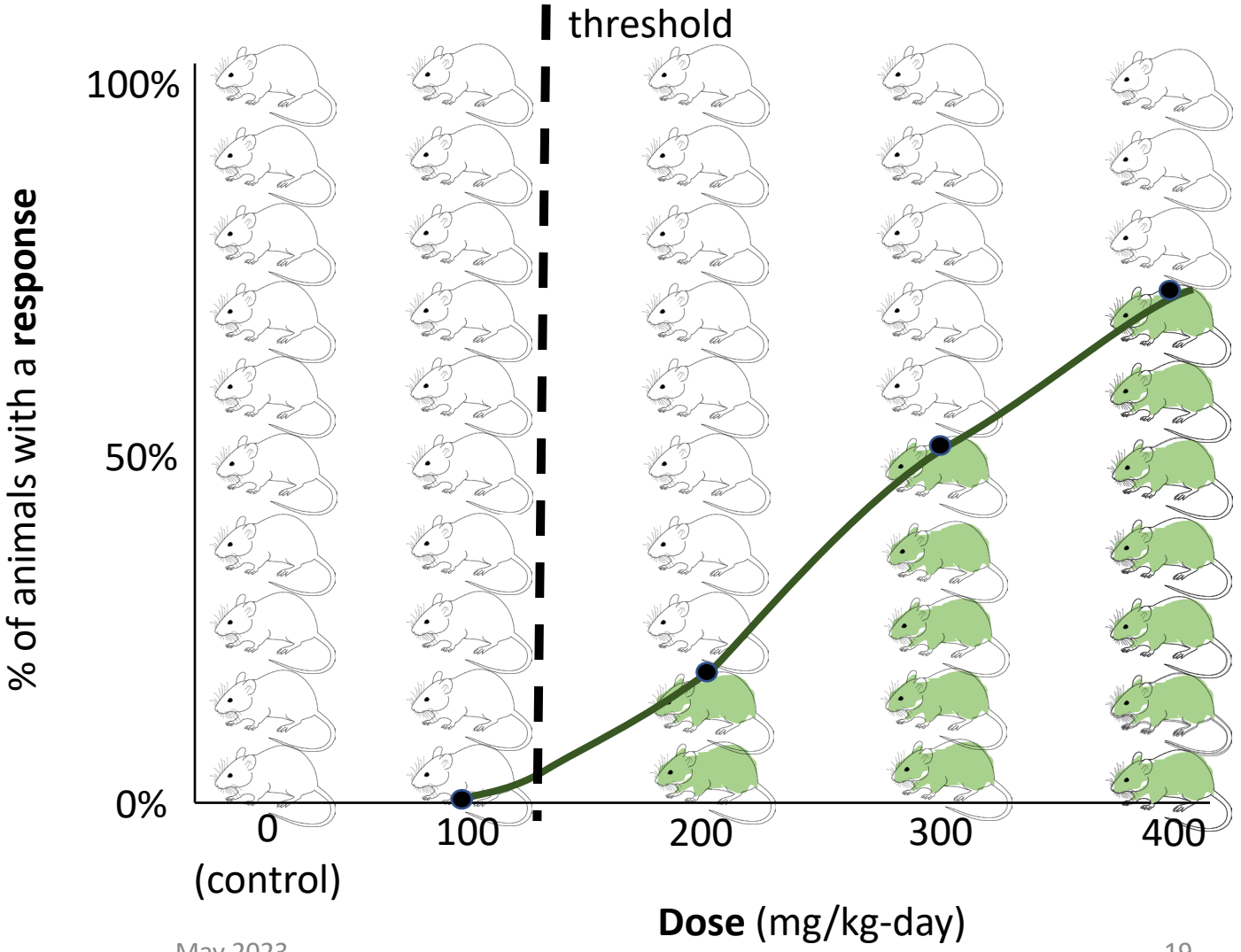
“Non-linear” or “Threshold” Dose-Response Curve

- In a hypothetical study, groups of 10 mice were exposed to Chemical A at 0, 100, 200, and 300, and 400 mg/kg/day.



“Non-linear” or “Threshold” Dose-Response Curve

- In a hypothetical study, groups of 10 mice were exposed to Chemical A at 0, 100, 200, and 300, and 400 mg/kg/day.
- We can see that exposure at some doses do not result in adverse effects.
  - Threshold
    - there is a dose below which no adverse effects were observed



“Point of Departure” for Threshold Effects

Point of Departure **(POD)** is the dose in the toxicity study used to calculate the “protective” dose in humans.

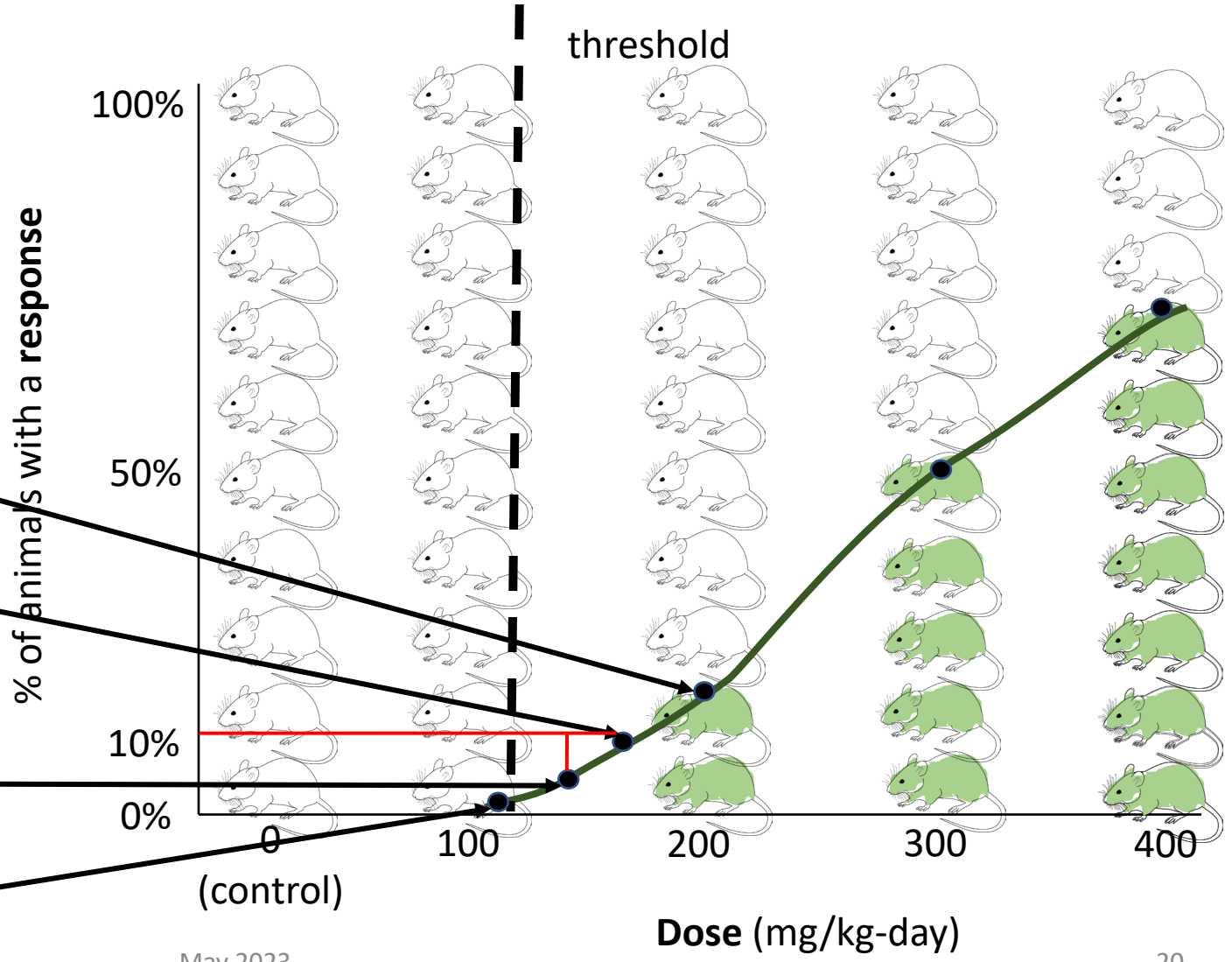
Possible PODs

LOAEL: lowest dose at which an adverse effect is observed

BMD: exposure level determined from a dose-response model

BMDL: lower bound of confidence interval for BMD; corresponds to a pre-defined level of response (such as 5% or 10%) in excess of a control response

NOAEL: highest dose at which NO adverse effect is observed



Point of Departure (POD)

A point of departure **(POD)** is the dose in the toxicity study used to calculate the "protective" dose in humans. There are several different types of PODs:

- **Lowest observed adverse effect level (LOAEL)** = lowest dose at which an adverse effect is observed

- **No observed adverse effect level (NOAEL)** = highest dose at which no adverse effect is observed

- **Benchmark dose lower bound (BMDL)** = lower bound of a confidence interval for a specific benchmark dose (BMD) which is a dose level corresponding to specific response levels, or benchmark responses, near the low end of the observable range of the data

Helpful Guidance: USEPA (2012). BMD Technical Guidance; USEPA (2023). BMD Tools

Source: USEPA (2022). IRIS Glossary

Calculating a Reference Dose (RfD) from the POD using Uncertainty Factors (UFs)

- **Reference Dose = POD / UF_{Total}**
  - *A reference dose is an estimate of the amount of a chemical a person can ingest daily over a lifetime (chronic RfD) or less (subchronic RfD) that is unlikely to lead to adverse health effects.*
  - Five areas of uncertainty
    - Intraspecies variation **(UF_H)** 
    - Interspecies variation **(UF_A)** 
    - Uncertainty due to study exposure duration **(UF_S)** 
    - Uncertainty due to use of a LOAEL **(UF_L)** 
    - Uncertainty due to inadequate database **(UF_D)** 

$UF_{Total} = UF_H \times UF_A \times UF_S \times UF_L \times UF_D$

- UF values of either 1, 3, or 10 can be selected
- EPA policy is that the maximum total UF = 3000

Helpful Guidance: EPA (2000b). Technical Support Document Volume 1: Risk Assessment

Source: USEPA (2000a). Section 3.2.2 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

Example Uncertainty Factor Selection for AWQC

Chemical	Selected Assessment	Critical Effect	POD	Uncertainty Factors	RfD
1,1 Dichloroethylene	US EPA IRIS, 2002	Liver toxicity in rats (chronic study)	$BMDL_{10}$ = 4.6 mg/kg-day	TOTAL = 100 UF_H = 10 UF_A = 10	0.05 mg/kg-day

Source: USEPA (2015c). Update of Human Health Ambient Water Quality Criteria: 1,1 Dichloroethylene

Chemical	Selected Assessment	Critical Effect	POD	Uncertainty Factors	RfD
2,4-dinitrophenol	US EPA IRIS, 1986	Development of cataracts in humans (chronic study)	LOAEL = 2 mg/kg-day	TOTAL = 1000 UF_H = 10 UF_L = 10 UF_S= 10	0.002 mg/kg-day

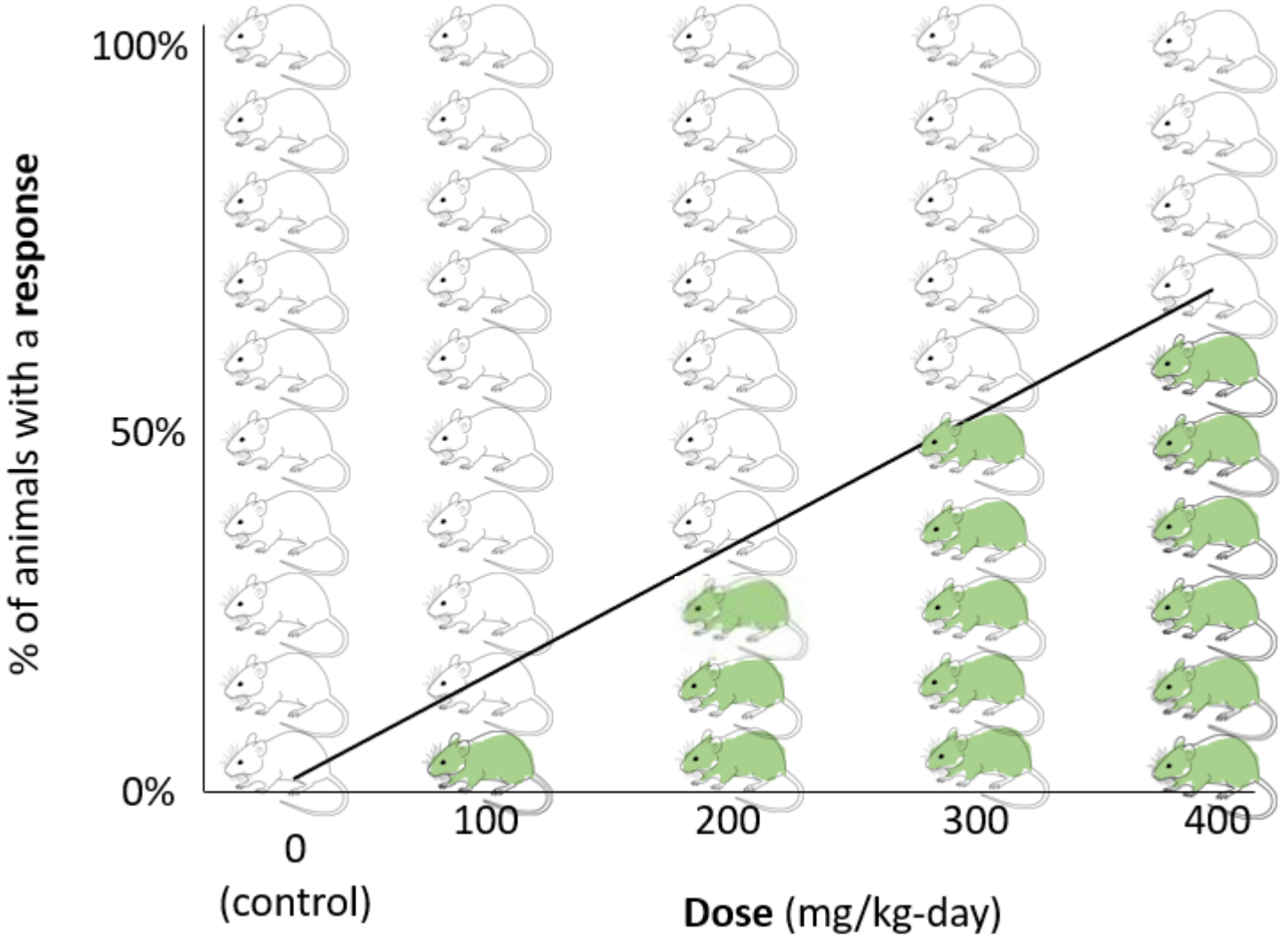
Source: USEPA (2015e). Update of Human Health Ambient Water Quality Criteria: 2,4-dinitrophenol

Chemical	Selected Assessment	Critical Effect	POD	Uncertainty Factors	RfD
1,1,1-trichloroethane	US EPA IRIS, 2007	Reduced bodyweight in mice (subchronic study)	$BMDL_{10}$ = 2,155 mg/kg-day	TOTAL = 1000 UF_H = 10 UF_A = 10 UF_S = 3 UF_D= 3	2 mg/kg-day

Source: USEPA (2015f). Update of Human Health Ambient Water Quality Criteria: 1,1,1-trichloroethane

Linear Dose-Response Curve

- Assumes increased probability of effects at all levels of exposure (typically cancer)
- EPA targets a $1x10^{-6}$ cancer risk level (CRL)
  - One additional cancer case per one million people due to exposure to pollutant
  - Other cancer risk levels could be evaluated for consideration of risk management options and/or policy decisions
    - 1 case in 10,000 people
    - 1 case in 100,000 people
    - 1 case in 10 million people



Source: USEPA (2000a). Section 2.4 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

Risk-Specific Dose (RSD)

The RSD is the dose at which the population meets the targeted cancer risk level (e.g., 1 case in 1 million or 10^{-6})

$$\textbf{Risk Specific Dose (RSD)} = \frac{\textbf{Cancer Risk Level (CRL)}}{\textbf{Cancer Slope Factor (CSF)}}$$

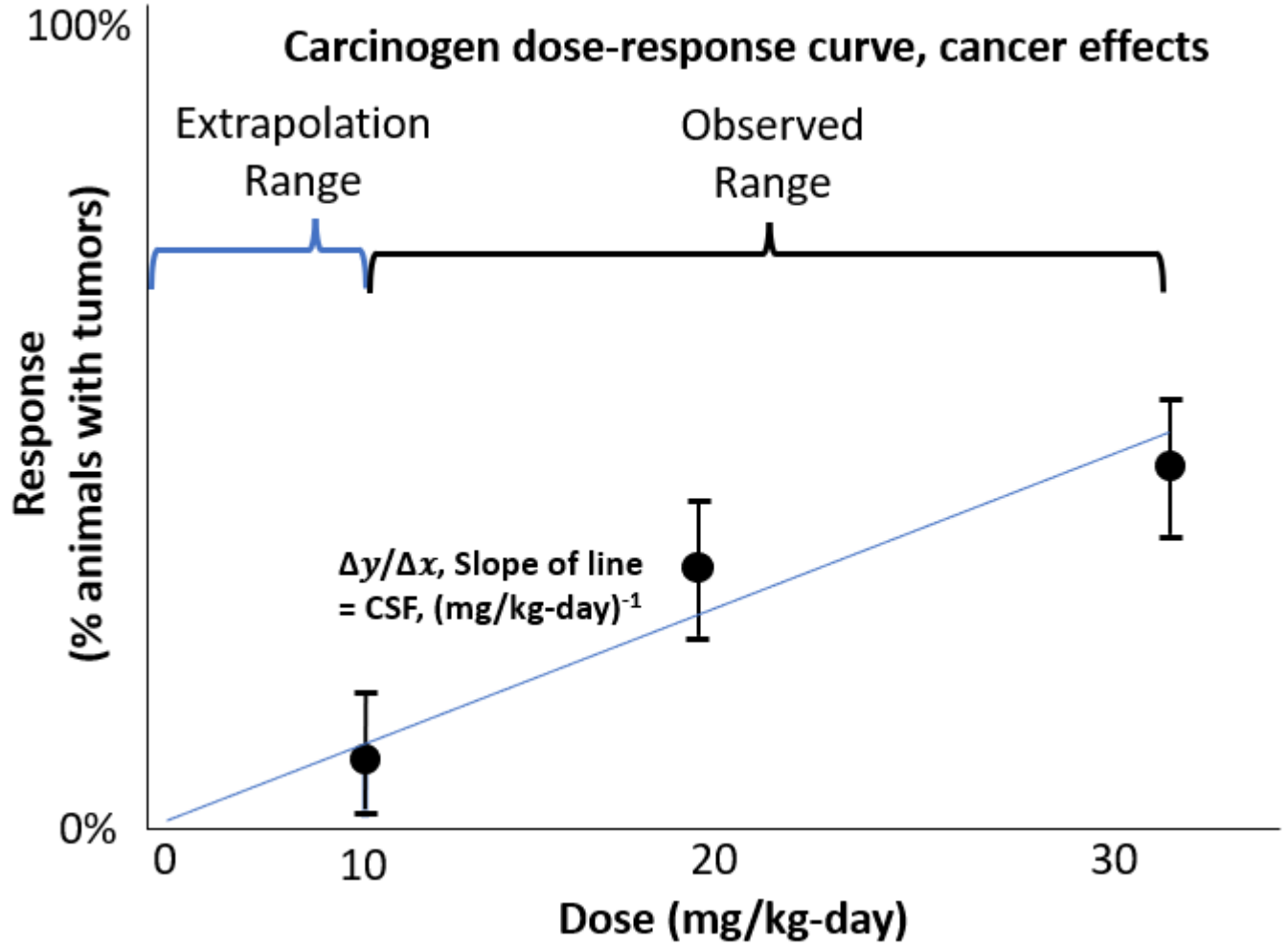
From 2000 Methodology on the Cancer Risk Level:

- "With the 2000 Methodology, EPA will publish its national 304(a) water quality criteria at the 10^{-6} risk level, which EPA considers appropriate for the general population."

Source: USEPA (2000a). Section 3.1 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

Understanding the Cancer Slope Factor (CSF)

- Cancer Slope Factor
  - Measures incidence of cancer relative to dose over a lifetime exposure to a carcinogen
  - Used to derive the risk-specific dose
  - Derived similarly to a non-cancer BMD



Source: USEPA (2000a). Section 3.1 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

Example Risk Specific Dose Calculations

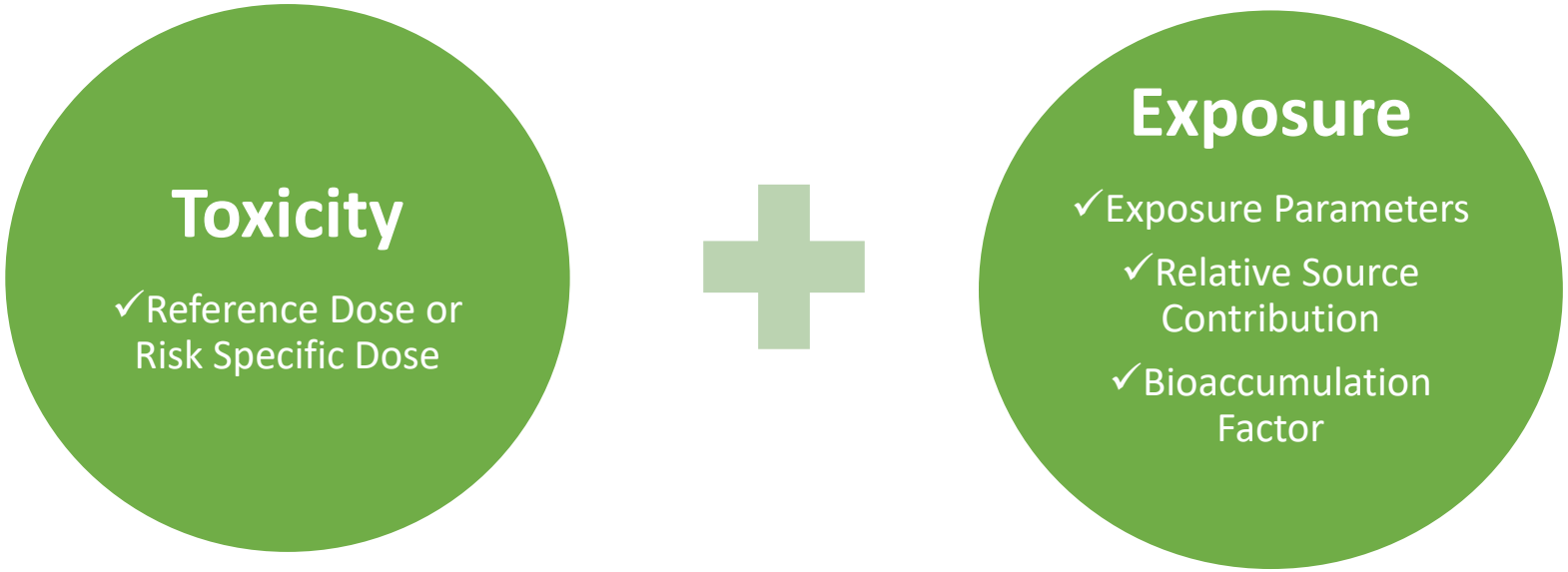
Chemical	Selected Assessment	Critical Effect	Cancer Slope Factor	Cancer Risk Level	RSD
Hexachlorobenzene	EPA OPP RED, 2008	Development of hepatocellular carcinomas in rats	1.02 per mg/kg-day	1×10^{-6}	9.8×10^{-7}

Hexachlorobenzene is classified as B2, "probably human carcinogen" based on the 1996 Proposed Guidelines for Carcinogen Risk Assessment.
Source: USEPA (2015d). Update of Human Health Ambient Water Quality Criteria: Hexachlorobenzene

Chemical	Selected Assessment	Critical Effect	Cancer Slope Factor	Cancer Risk Level	RSD
1,2-Dichloroethane	Health Canada, 2015	Development of mammary tumors in female rats	0.0033 per mg/kg-day	1×10^{-6}	3.0×10^{-4}

1,2 Dichloroethane is classified as B2, "probably human carcinogen" based on the 1986 EPA Guidelines for Carcinogen Risk Assessment.
Source: USEPA (2015g). Update of Human Health Ambient Water Quality Criteria: 1,2-Dichloroethane

Required Information for Criteria Development



Exposure Information for Criteria Development

- How much exposure to a pollutant could occur from direct ingestion of the drinking water?
- What is the drinking water intake value? **(DI)**
- How much exposure could occur from eating fish and shellfish?
- What is the Fish Intake rate? **(FI)**
- How much does this compound accumulate in fish/shellfish tissue (bioaccumulation factor)? **(BAF)**
- How much exposure could occur from other sources (e.g., air, diet, soil, dust)?
- What is the relative source contribution? **(RSC)**
- Are any life stages or populations either more highly exposed or more sensitive to exposure compared to the general population?

Exposure parameters for adults in the general population used in AWQC

- Body Weight (**BW**)
  - 80 kg; average adult body weight

- Drinking Water Intake (**DI**)
  - 2.4 L/day; 90th percentile per capita consumption rate

- Fish Intake (**FI**) for trophic level (**TL**)
  - TL 2 (first order consumers) = 7.6 g/day
  - TL 3 (intermediate predators)= 8.6 g/day
  - TL 4 (top predators) = 5.1 g/day

See USEPA (2019). Chapter 3 (2019) of EPA's Exposure Factors Handbook and USEPA (2014) report "Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)" for BW, DI, and fish consumption rate statistics

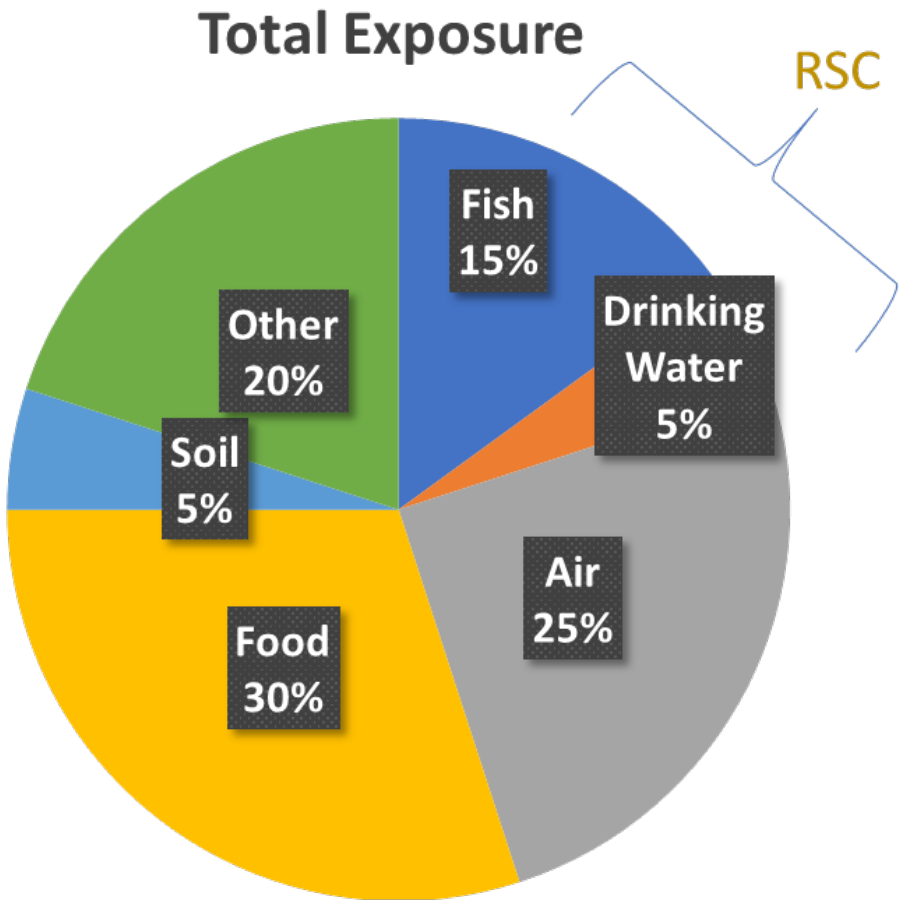
Other Exposure Parameters to Consider

Parameters for specific life stages or population(s) may sometimes be appropriate when deriving criteria.

- If a pollutant causes adverse effects in a specific population or life stage
  - **Pregnant women, lactating women, or women of childbearing age**
    - Consider as a target population if observed effects include development of the fetus, breastfed newborn baby, or female reproductive system
  - **Children**
    - Consider as a target population if observed effects include postnatal developmental effects
- If a specific population or life stage is likely to be highly exposed versus general population
  - **Subsistence fishers**
    - Consider as a target population if there are subsistence fishers in the community, or if the toxicant bioaccumulates dramatically in fish, such that the majority of exposure occurs through fish consumption
  - **Postnatal Childhood**
    - Consider as a target population due to incidental ingestion from recreational exposure in ambient waters

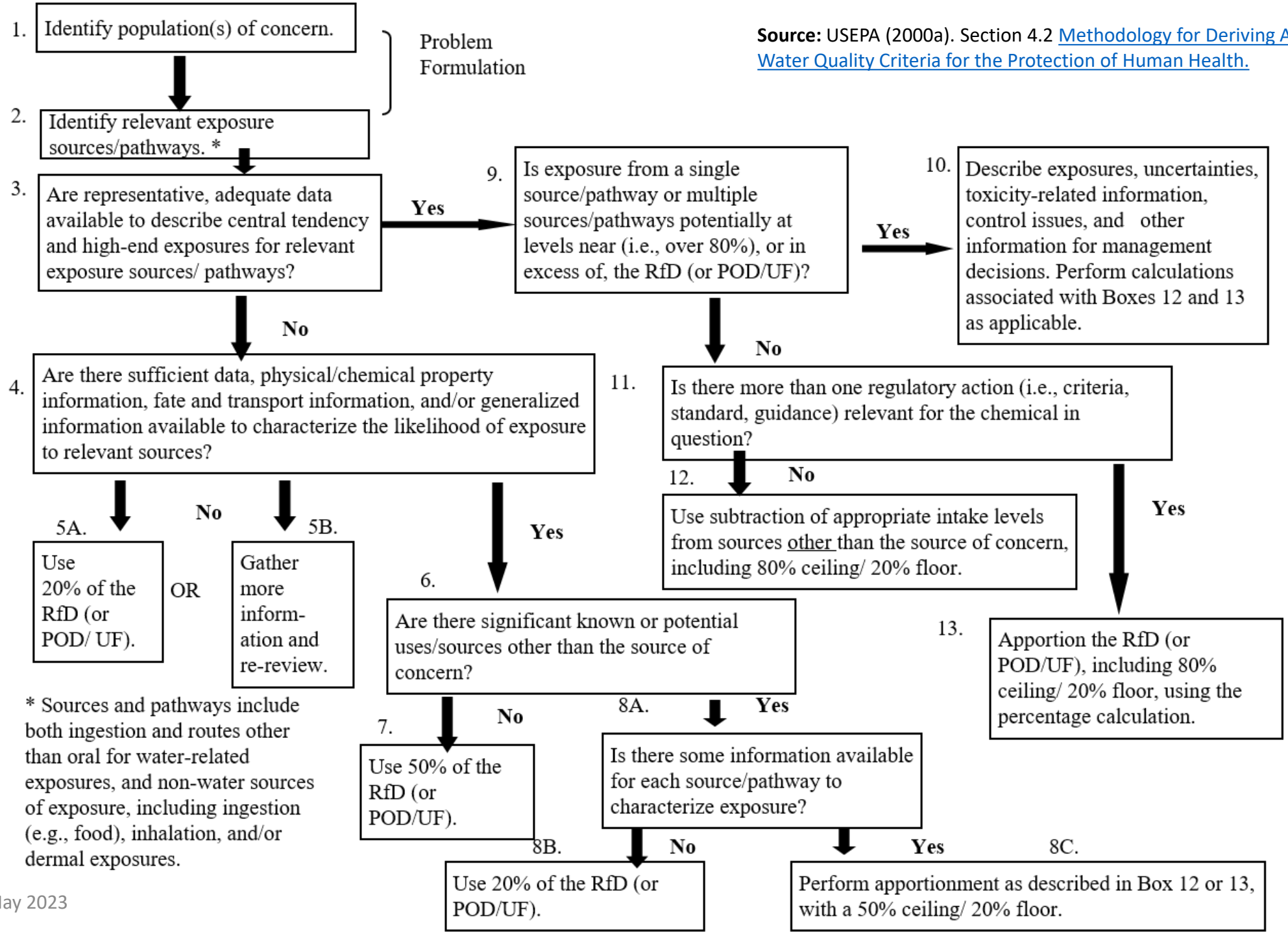
Relative Source Contribution (RSC)

- The RSC is the percentage of total exposure to a pollutant attributed to drinking water and eating fish and shellfish.
  - EPA follows the Exposure Decision Tree approach described in the 2000 methodology when making decisions about the RSC.
- Other sources of exposure could include:
  - Inhalation from ambient air
  - Consumption of food other than freshwater and estuarine fish/shellfish (especially locally-grown and prepared)
  - Consumption of soil or dust
  - Dermal exposure



Source: USEPA (2000a). Section 4.2 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health.

The RSC Decision Tree



Source: USEPA (2000a). Section 4.2 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health.

RSC Examples for AWQC

1,1 Dichloroethylene

- Air, drinking water, and non-fish food are potentially significant sources.
- Following the Exposure Decision Tree, significant potential sources other than fish and shellfish from inland and nearshore waters and water ingestion exist (**Box 8A** in the Decision Tree); however, information is not available to **quantitatively** characterize exposure from these different sources (**Box 8B** in the Decision Tree). Therefore, EPA recommends an RSC of **20%.**

Source: USEPA (2015c) Update of Human Health Ambient Water Quality Criteria: 1,1 Dichloroethylene

Hexachlorobenzene

- For substances for which the toxicity endpoint is carcinogenicity based on a linear low-dose extrapolation, only the **exposures from drinking water and fish ingestion** are reflected in human health AWQC: non-water sources are not explicitly included and **no RSC** is applied.
- AWQC are derived with respect to the incremental lifetime cancer risk posed by the presence of a substance in water, rather than an individual's total risk from all sources of exposure.

Source: USEPA (2015d) Update of Human Health Ambient Water Quality Criteria: Hexachlorobenzene

How Much Exposure Is Coming From Fish?

- Bioaccumulation Factors (**BAFs**) translate the kilograms of fish consumed into liters of contaminated water that results in the same amount of exposure.

$$\text{Total Exposure}\left(\frac{\text{L}}{\text{day}}\right) = \text{DI}\left(\frac{\text{L}}{\text{day}}\right) + \text{FI}\left(\frac{\text{kg}}{\text{day}}\right) * \text{BAF}\left(\frac{\text{L}}{\text{kg}}\right)$$

Source: USEPA (2000a). Section 5 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health.

Goals of the National BAF/BCF

- To represent the long-term, average bioaccumulation potential of a chemical in edible tissues of aquatic organisms that are commonly consumed by humans throughout the United States.
- Derive separate BAFs/BCFs for each trophic level to account for potential biomagnification of some chemicals in aquatic food webs and broad physiological differences among organisms that may influence bioaccumulation.

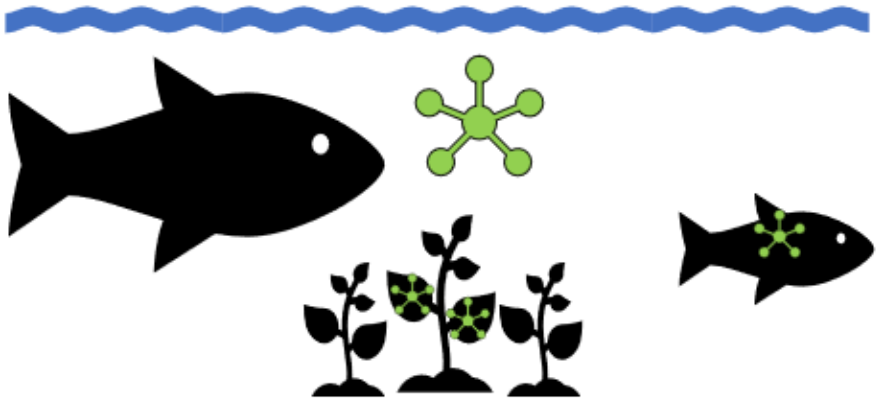
Helpful Guidance: EPA (2000c). Technical Support Document Volume 2: Development of National BAFs; EPA (2016) Development of BAFs; Supplemental Information for EPA's 2015 Human Health Criteria Update

Source: USEPA (2000a). Section 5.1 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

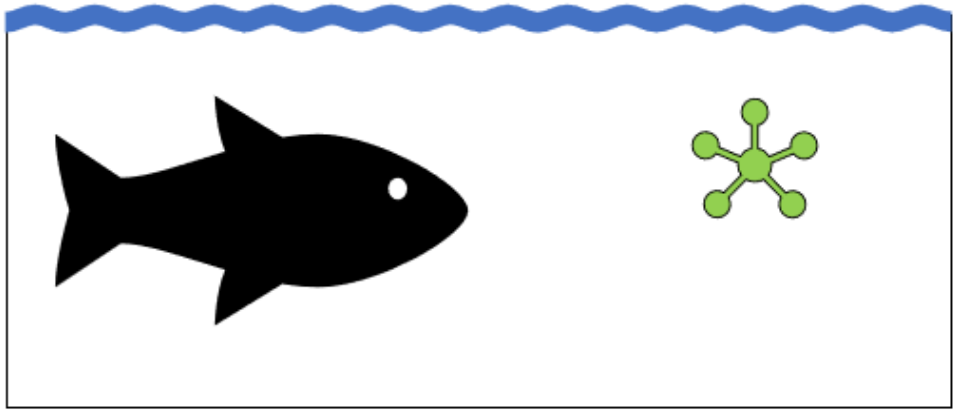
Ways to Determine the Bioaccumulation

$$\text{Bioaccumulation} = \frac{\text{Concentration in fish tissue}}{\text{Concentration in water}}$$

Bioaccumulation Factor (BAF): measurements in natural conditions



Bioconcentration Factor (BCF): measurement in lab with only direct water exposure

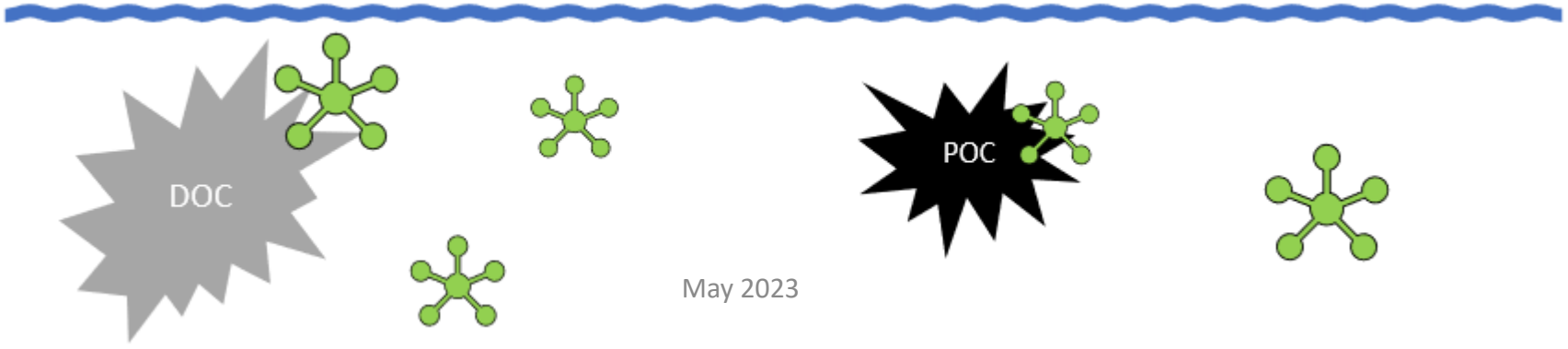


While BAFs are preferred, BCFs can be used in the absence of BAF values.

Source: USEPA (2000a). Section 5.2 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

EPA Methods for Deriving Bioaccumulation Factors (BAFs)

- The degree of bioaccumulation depends on the *bioavailable* concentration of the compound in water
  - **Dissolved organic carbon (DOC)** and **particulate organic carbon (POC)** concentrations correlate to the bioavailable fraction of the compound.
  - When compiling field BAF data from the literature for the 2015 HHC update, EPA recorded the POC and DOC concentrations at the location of the BAF sample so that BAF values could be compared across sites with differing biochemical conditions.
- States can derive **state and/or site-specific BAF values** from EPA's published baseline BAFs by using representative POC and DOC concentrations for their state.
- BCFs make no adjustments to control for natural conditions, like POC and DOC concentrations, that might lessen or heighten the bioaccumulation of the compound in the environment.

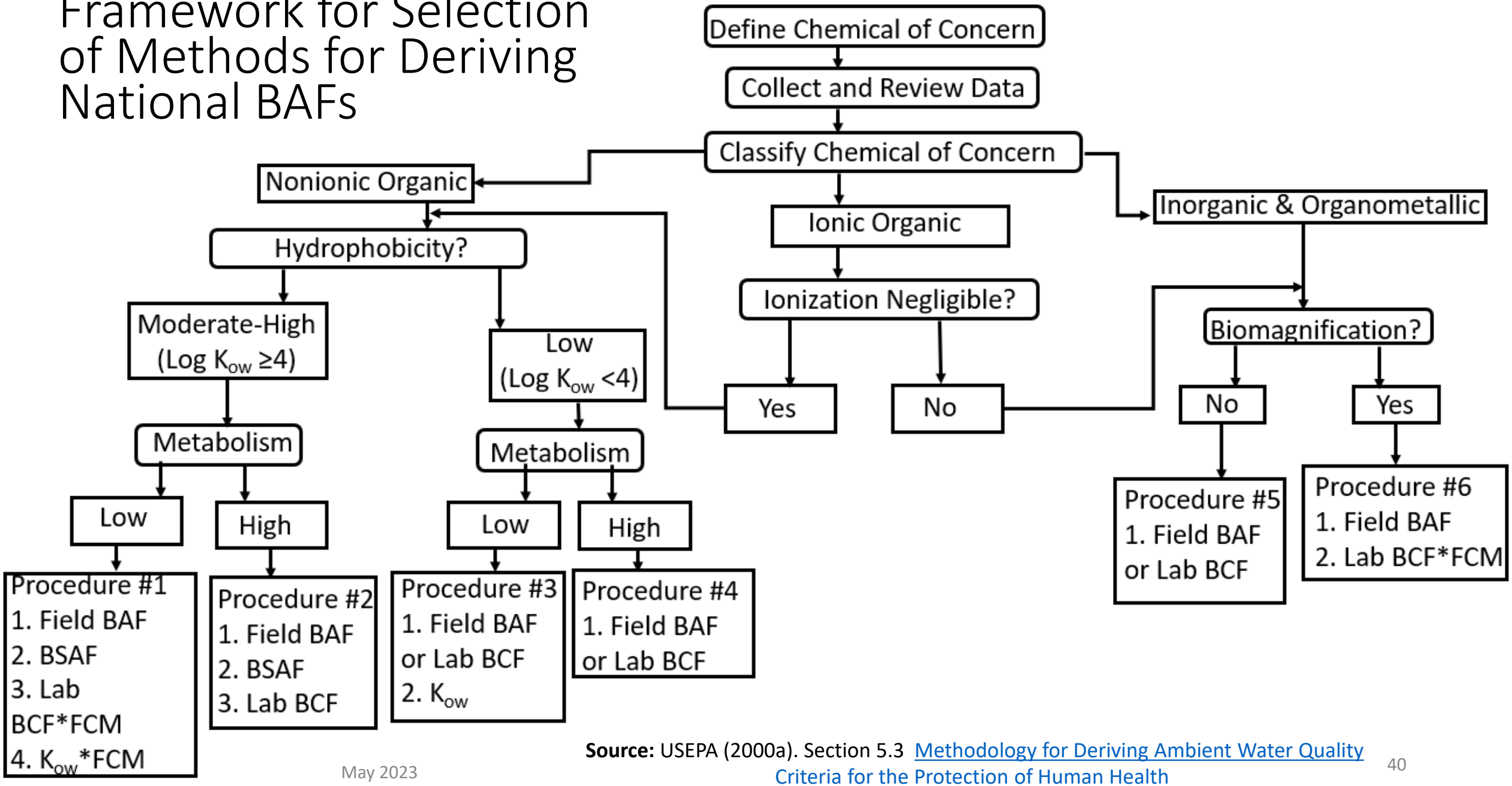


EPA Methods for Deriving BAFs

Field-measured BAF	• Applicable to all chemical types • High-quality data currently limited to a few sites and chemicals
BAF predicted from field-measured BSAF	• Limited to nonionic organic chemicals • Useful for chemicals that are difficult to analyze in water
BAF predicted from lab-measured BCF x FCM	• Applicable to all chemicals types • Chemical metabolism, when present in food web, generally not accounted for
BAF predicted from a K_{OW} x FCM	• Limited to nonionic organic chemicals • Readily applied with minimal input data

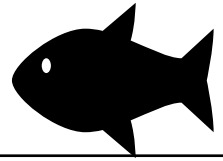
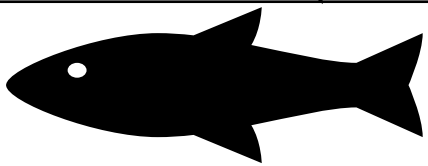
Source: USEPA (2000a). Section 5.3 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

Framework for Selection of Methods for Deriving National BAFs



Source: USEPA (2000a). Section 5.3 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

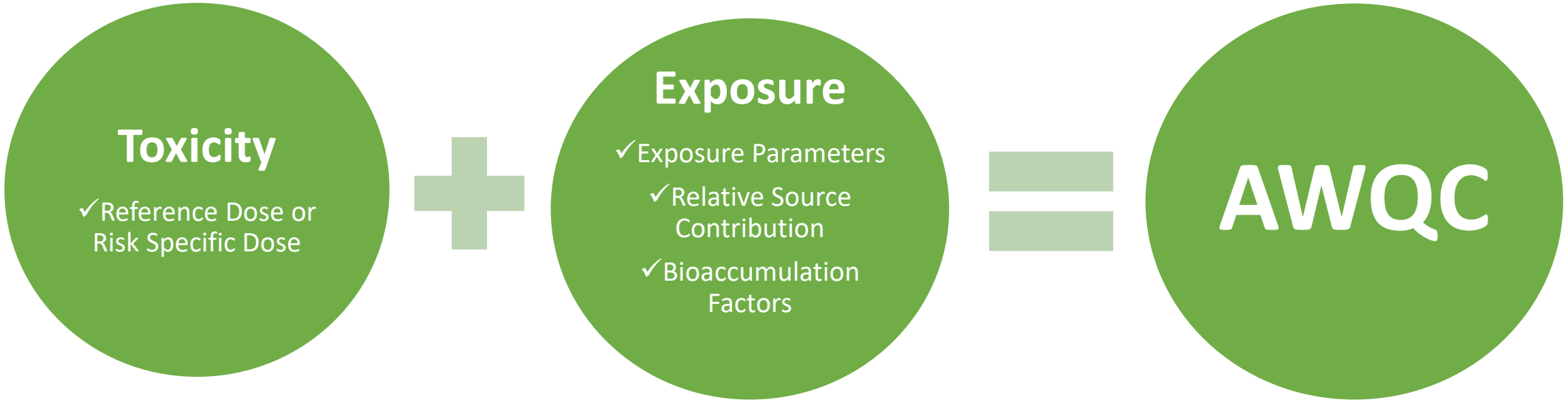
BAF Examples for AWQCs

Trophic Level (TL)	1,1 Dichloroethylene BAF (L/kg)	Hexachlorobenzene BAFs (L/kg)
Primary producer 		
TL 2 	2.0	18,000
TL 3 	2.4	46,000
TL 4 	2.6	90,000
Method	**Procedure 3: K_{ow} Method**	**Procedure 1: Field-measured BAFs**

Source: USEPA (2015c) Update of Human Health Ambient Water Quality Criteria: 1,1 Dichloroethylene

Source: USEPA (2015d) Update of Human Health Ambient Water Quality Criteria: Hexachlorobenzene

Required Input Values for Criteria Development



Calculating Criteria for a Threshold Contaminant

Ambient Water Quality Criteria (AWQC) definition: At this concentration, the majority of the population is exposed to a total dose of pollutant from water and fish consumption that is equal to or less than the dose that is unlikely to cause adverse health effects.

$$\mathrm{AWQC} = \mathrm{RfD} * \mathrm{RSC} * \left(\frac{\mathrm{BW}}{\mathrm{DI} + \sum_{i=2}^{4} \mathrm{FI_i} * \mathrm{BAF_i}} \right)$$

Source: USEPA (2000a) Section 1.6 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

AWQC Example: 1,1, Dichloroethylene

Input Values:

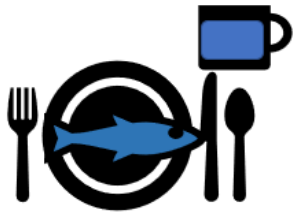
Toxicity

- RfD = 0.05 mg/kg-day

Exposure

- RSC = 0.20
- BW = 80 kg
- DI = 2.4 L/day
- FCR =
  - TL 2 = 7.6 g/day
  - TL 3 = 8.6 g/day
  - TL 4 = 5.1 g/day
- BAFs =
  - TL 2 = 2.0 (L/kg)
  - TL 3 = 2.4 (L/kg)
  - TL 4 = 2.6 (L/kg)

For consumption of water and organisms:



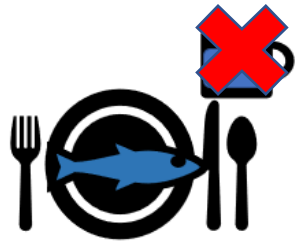
$$\text{AWQC } (\mu g/L) = \frac{\text{toxicity value (RfD [mg/kg-d]} \times \text{RSC)} \times \text{BW (kg)} \times 1{,}000\ (\mu g/mg)}{\text{DI (L/d)} + \sum_{i=2}^{4} (\text{FCR}_i\ (\text{kg/d}) \times \text{BAF}_i\ (\text{L/kg}))}$$

$$= \frac{0.05\ \text{mg/kg-d} \times 0.20 \times 80.0\ \text{kg} \times 1{,}000\ \mu g/mg}{2.4\ \text{L/d} + ((0.0076\ \text{kg/d} \times 2.0\ \text{L/kg}) + (0.0086\ \text{kg/d} \times 2.4\ \text{L/kg}) + (0.0051\ \text{kg/d} \times 2.6\ \text{L/kg}))}$$

= 327 µg/L

= 300 µg/L (rounded)

For consumption of organisms only:



$$\text{AWQC } (\mu g/L) = \frac{\text{toxicity value (RfD [mg/kg-d]} \times \text{RSC)} \times \text{BW (kg)} \times 1{,}000\ (\mu g/mg)}{\sum_{i=2}^{4} (\text{FCR}_i\ (\text{kg/d}) \times \text{BAF}_i\ (\text{L/kg}))}$$

$$= \frac{0.05\ \text{mg/kg-d} \times 0.20 \times 80.0\ \text{kg} \times 1{,}000\ \mu g/mg}{(0.0076\ \text{kg/d} \times 2.0\ \text{L/kg}) + (0.0086\ \text{kg/d} \times 2.4\ \text{L/kg}) + (0.0051\ \text{kg/d} \times 2.6\ \text{L/kg})}$$

= 16,293 µg/L

= 20,000 µg/L (rounded)

EPA recommends rounding the number of significant figures at the end of the criterion calculation to the same number of significant figures in the least precise parameter.

Source: USEPA (2015c) Update of Human Health Ambient Water Quality Criteria: 1,1 Dichloroethylene

AWQC: Calculating Criteria for a Linear Carcinogen

Ambient Water Quality Criteria (AWQC) for a linear carcinogen definition: At this concentration, the majority of the population is exposed to a dose of pollutant from water and fish consumption that results in the population achieving the target cancer risk level (e.g., 1 in a million or 10^{-6} excess cases of cancer from exposure).

$$\mathrm{AWQC} = \mathrm{RSD}^{*}\left(\frac{\mathrm{BW}}{\mathrm{DI}+\sum_{i=2}^{4}\mathrm{FI_i}*\mathrm{BAF_i}}\right)$$

Source: USEPA (2000a) Section 1.6 Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health

AWQC Example: Hexachlorobenzene

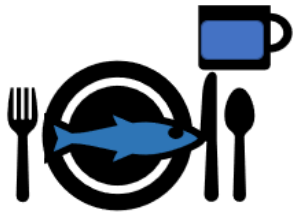
Input Values:

Toxicity

- RSD = 9.8 x 10^{-7} mg/kg-day

Exposure

- RSC = N/A
- BW = 80 kg
- DI = 2.4 L/day
- FCR =
  - TL 2 = 7.6 g/day
  - TL 3 = 8.6 g/day
  - TL 4 = 5.1 g/day
- BAFs =
  - TL 2 = 18,000 (L/kg)
  - TL 3 = 46,000 (L/kg)
  - TL 4 = 90,000 (L/kg)



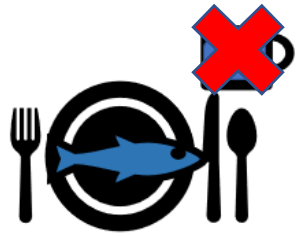
For consumption of water and organisms:

$$\text{AWQC } (\mu g/L) = \frac{\text{toxicity value } (10^{-6} / \text{CSF}) \text{ [mg/kg-d]} \times \text{BW (kg)} \times 1{,}000 \text{ } (\mu g/mg)}{\text{DI (L/d)} + \sum_{i=2}^{4} (\text{FCR}_i \text{ (kg/d)} \times \text{BAF}_i \text{ (L/kg)})}$$

$$= \frac{(10^{-6} / 1.02) \text{ mg/kg-d} \times 80.0 \text{ kg} \times 1{,}000 \text{ } \mu g/mg}{2.4 \text{ L/d} + ((0.0076 \text{ kg/d} \times 18{,}000 \text{ L/kg}) + (0.0086 \text{ kg/d} \times 46{,}000 \text{ L/kg}) + (0.0051 \text{ kg/d} \times 90{,}000 \text{ L/kg}))}$$

= 0.00007892 µg/L

= 0.000079 µg/L (rounded)



For consumption of organisms only:

$$\text{AWQC } (\mu g/L) = \frac{\text{toxicity value } (10^{-6} / \text{CSF}) \text{ [mg/kg-d]} \times \text{BW (kg)} \times 1{,}000 \text{ } (\mu g/mg)}{\sum_{i=2}^{4} (\text{FCR}_i \text{ (kg/d)} \times \text{BAF}_i \text{ (L/kg)})}$$

$$= \frac{(10^{-6} / 1.02) \text{ mg/kg-d} \times 80.0 \text{ kg} \times 1{,}000 \text{ } \mu g/mg}{(0.0076 \text{ kg/d} \times 18{,}000 \text{ L/kg}) + (0.0086 \text{ kg/d} \times 46{,}000 \text{ L/kg}) + (0.0051 \text{ kg/d} \times 90{,}000 \text{ L/kg})}$$

= 0.00007911 µg/L

= 0.000079 µg/L (rounded)

EPA recommends rounding the number of significant figures at the end of the criterion calculation to the same number of significant figures in the least precise parameter.

Source: USEPA (2015d) Update of Human Health Ambient Water Quality Criteria: Hexachlorobenzene

Helpful Resources

Methodology Resources

- Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health
- Technical Support Documents:
  - Volume 1: Risk Assessment
  - Volume 2: Development of National Bioaccumulation Factors
  - Volume 3: Development of Site-Specific Bioaccumulation Factors
- Human Health Ambient Water Quality Criteria Fish Consumption Rates FAQ
- Guidelines for Carcinogen Risk Assessment
- Benchmark Dose Tools
- Update for Chapter 3 of the Exposure Factors Handbook

2015 Update Resources

- Fact Sheet: Human Health Ambient Water Quality Criteria: 2015 Update
- Table Comparing EPA's Updated 2015 Final Updated Human Health Criteria
- Table Summarizing Updated Input Values for EPA's 2015 Final Updated Human Health Criteria
- Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)
- 2015 National Bioaccumulation Factors- Supplemental Information Document

For a full list of available resources, visit EPA's Human Health Water Quality Criteria and Methods for Toxics homepage.

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Questions?