Review of PFAS Baseline Human Health and Ecological Risk Assessment Work Plan

GSI ENVIRONMENTAL

Former Wurtsmith Air Force Base

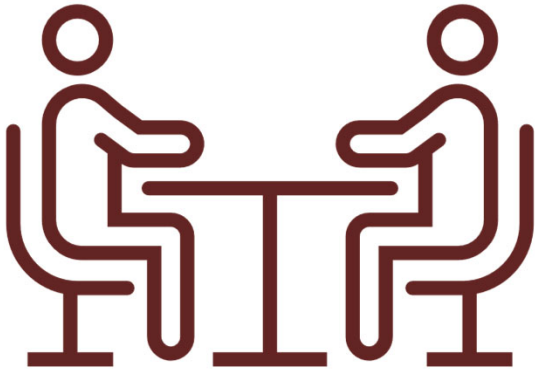
RAB Meeting

April 24, 2023

Janet K. Anderson, PhD, DABT
Philip E. Goodrum, PhD, DABT

Goals for Today

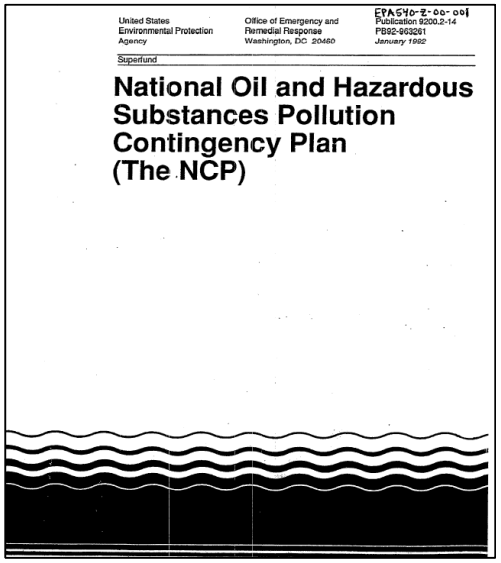
- Review key components of the proposed approach to the PFAS BERA and BHHRA
- Discuss how data, models, and federal and state science policies are incorporated in the proposed exposure and toxicity assessments
- Provide an update on schedule and milestones



BERA = baseline ecological risk assessment
BHHRA = baseline human health risk assessment

CERCLA Baseline Risk Assessment

Baseline Risk Assessment is the foundation for making decisions that protect public health and the environment



National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 1990):

"…**the lead agency shall conduct a site-specific baseline risk assessment** to characterize the current and potential threats to human health and the environment…"

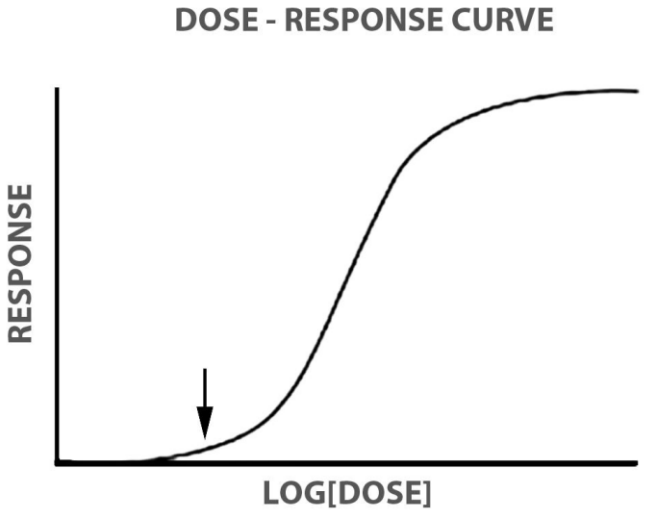
CERCLA Baseline Risk Assessments are RISK-BASED to inform future risk management decisions and guide remedial actions, if necessary

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Risk = Exposure x Toxicity

"Meaningful opportunity for risk reduction"

- SDWA – Health Risk Reduction and Cost Analysis [§300g-1 Section 1412]
- **CERCLA – Response Actions must be feasible and cost-effective [§121(a)]**



Paracelsus

SDWA = Safe Drinking Water Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Risk = Exposure x Toxicity

https://scimoms.com/hazard-risk/

Risk = Toxicity x Exposure

- What is the risk to human health / eco?
- What chemicals are driving the risk?
- How much risk is attributable to site (vs background)?

- What are the chemical's health effects?
- What is the relationship between exposure and health effects?

- How will receptors contact the chemical?
- What is the magnitude, frequency and duration of contact?
- Are exposures changing over time?

Key Outcomes of Baseline Risk Assessments

What risk assessments DO:

- Estimate potential exposures
- Characterize the probability of potential adverse effects
- Focus evaluation on key chemicals and receptor scenarios
- Guide risk management decisions

What risk assessments DON'T DO:

- Estimate risks to individuals
- Provide firm conclusions about disease, causation or health status

Regulatory Framework

Source: ITRC RISK-3 Section 3.1.3

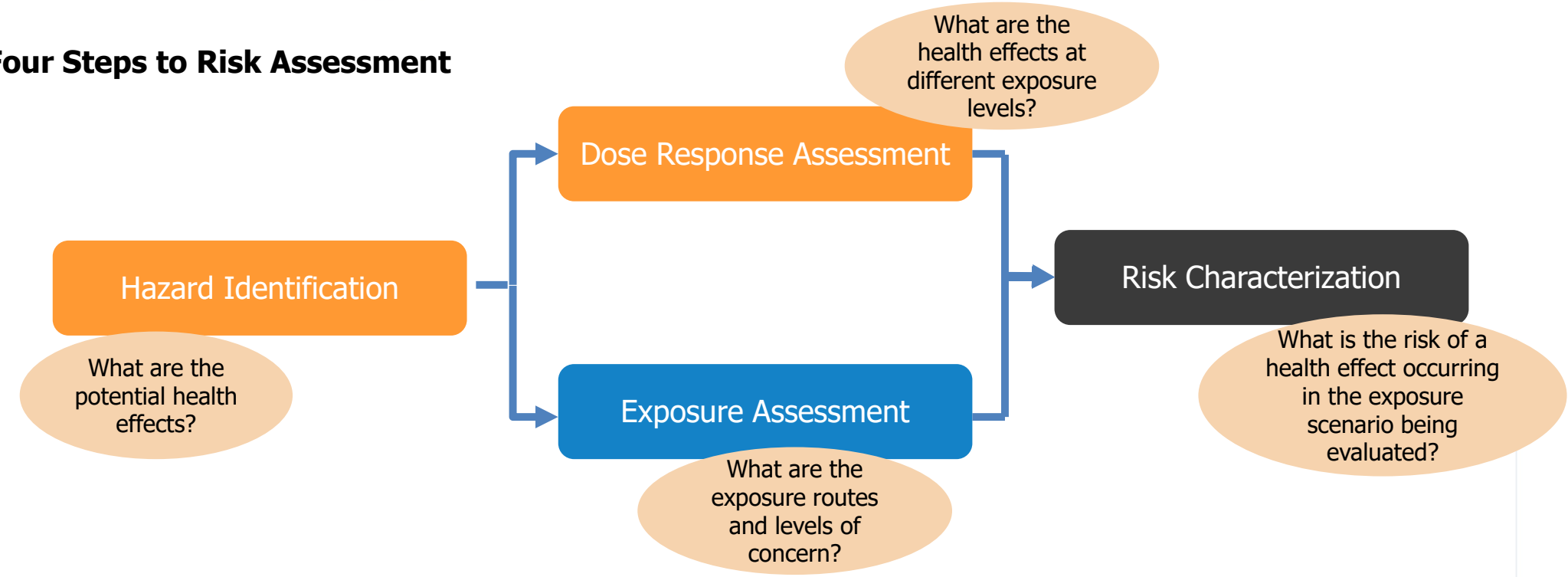
- CERCLA
- DoD policies/guidance
- EPA guidance for PFAS

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

State Information:
- MCLs
- SW quality criteria (HH)
- GW to SW Interface
- Soil guidance
- SW for eco values
- Sediment
- Tissue

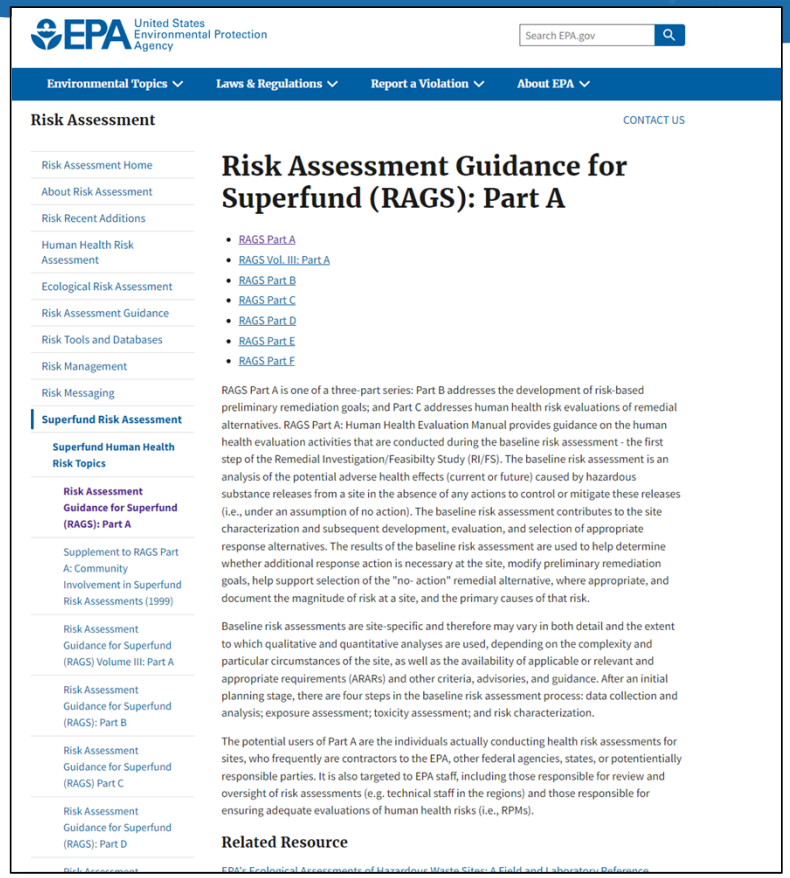
General Risk Assessment Components – Human Health and Ecological

Four Steps to Risk Assessment



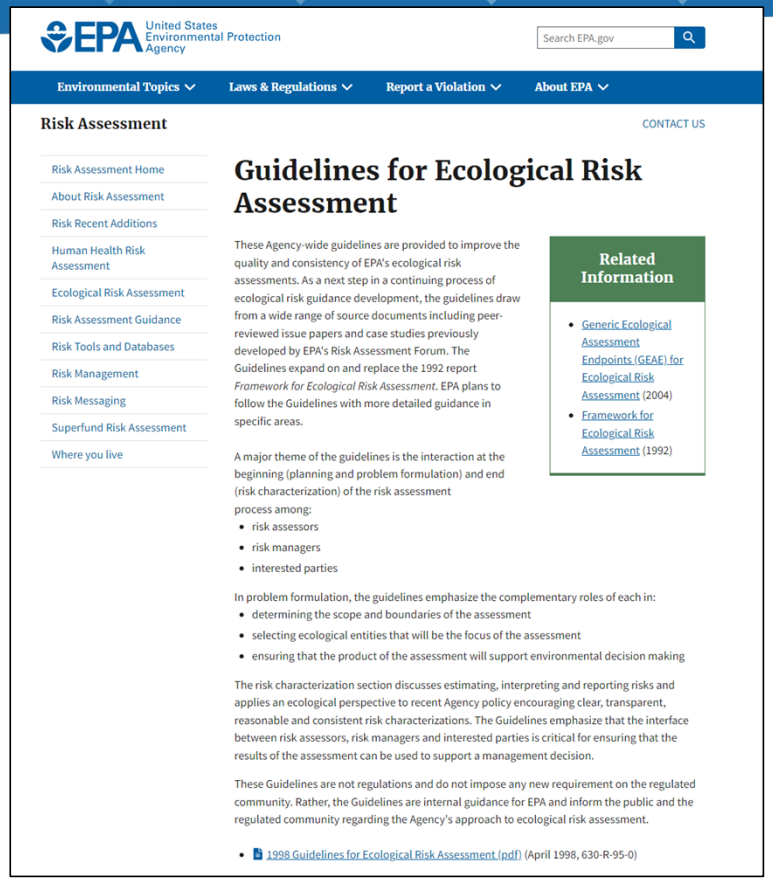
Adapted from the National Research Council (1983), Risk Assessment in the Federal Government: Managing the Process

Risk Assessment Guidance from USEPA



Spoiler Alert!

There is a very large collection of USEPA guidance developed for CERCLA risk assessments over the last 30+ years.



Extra Considerations for PFAS Risk Assessments

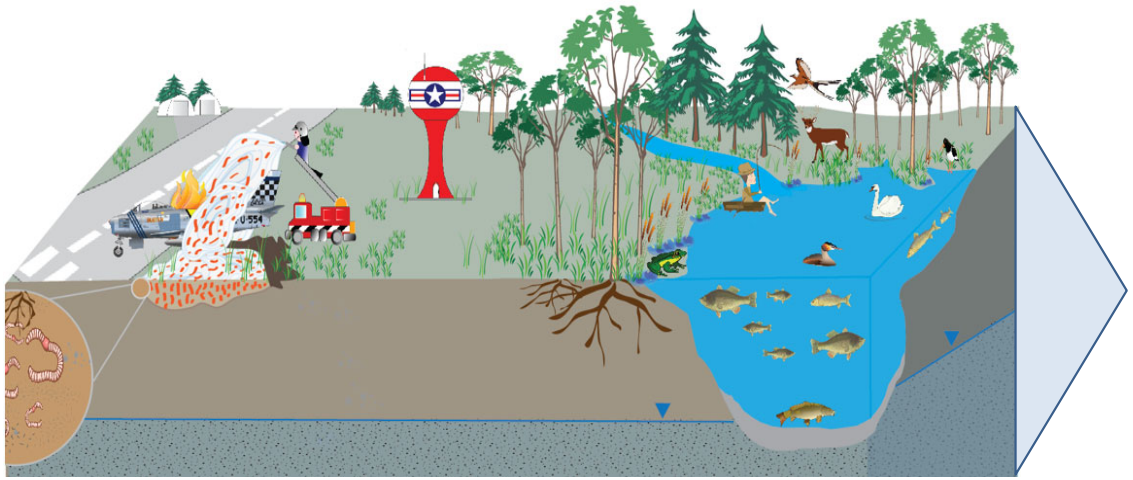


Image courtesy of H. Anderson, AFCEC

Regulation

- Dynamic policies, changing guidance
- Which regulation/screening value and why?
- Risk communication

Science

- Given low ppt detection levels, what is site-related?
- Which PFAS and why?
- What about mixture effects?

Site Considerations

- Complex conceptual site models

Relevant PFAS Investigations: 2010 - 2020

2010
USAF began investigating PFOS/PFOA

2011
EGLE conducted sampling*

2012/2013
PFAS Site Inspection

2015
USAF sampled public and private water supply wells for PFAS

2016
PFAS Preliminary Assessment identified 17 AFFF Areas

2017/2018
Expanded Site Inspection at 17 AFFF Areas

2017-2020
EGLE conducted surface water and pore water sampling**

2017-2020
MDHHS and DNR sampled deer population near Former WAFB

*groundwater, sediment, soil, seep samples at former WAFB and fish samples in Clark's Marsh
** Clark's Marsh, Van Etten Lake and Creek, and Au Sable River

Scope of BHHRA and BERA at Former WAFB

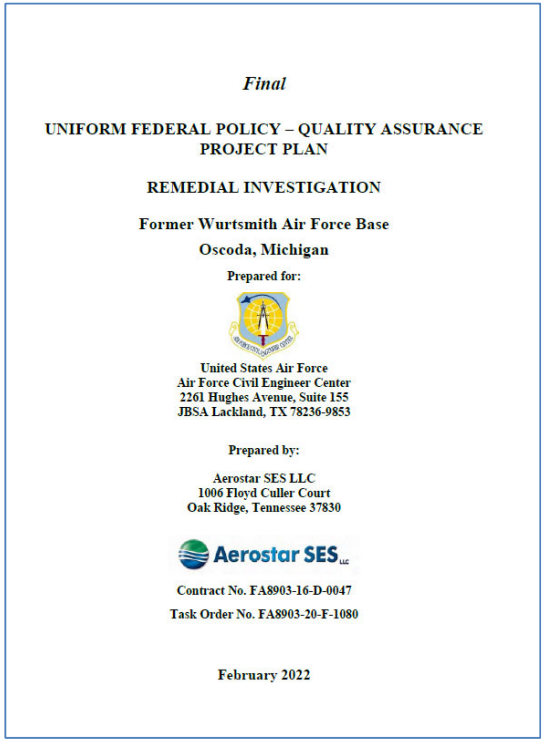
BHHRA and BERA are part of the Former WAFB Remedial Investigation (RI):

- Measure PFAS in soil, groundwater, surface water, sediment, biota
- Estimate potential human health risk
- Estimate potential ecological risk
- Characterize uncertainty

- Inform risk management decisions regarding future investigations and/or remedial actions, if necessary

Key Planning Documents

Quality Assurance Project Plan



Final

UNIFORM FEDERAL POLICY – QUALITY ASSURANCE PROJECT PLAN

REMEDIAL INVESTIGATION

Former Wurtsmith Air Force Base
Oscoda, Michigan

Prepared for:

United States Air Force
Air Force Civil Engineer Center
2261 Hughes Avenue, Suite 155
JBSA Lackland, TX 78236-9853

Prepared by:

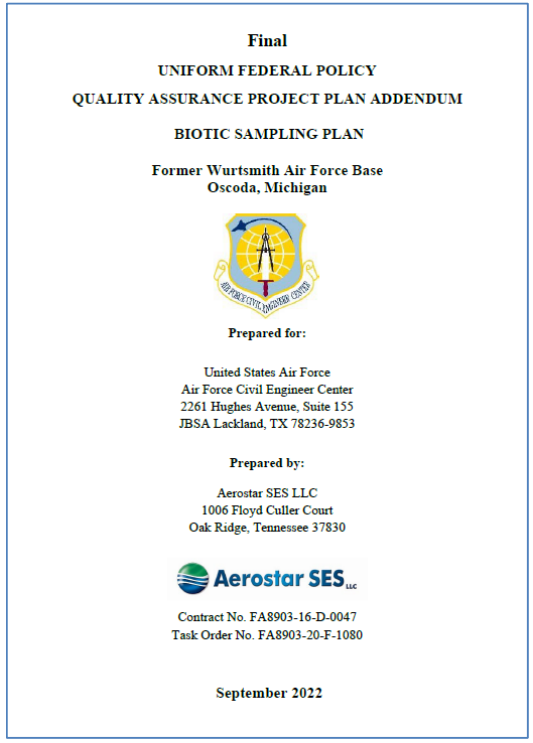
Aerostar SES LLC
1006 Floyd Culler Court
Oak Ridge, Tennessee 37830

Aerostar SES LLC

Contract No. FA8903-16-D-0047
Task Order No. FA8903-20-F-1080

February 2022

Biotic Sampling Plan



Final

UNIFORM FEDERAL POLICY

QUALITY ASSURANCE PROJECT PLAN ADDENDUM

BIOTIC SAMPLING PLAN

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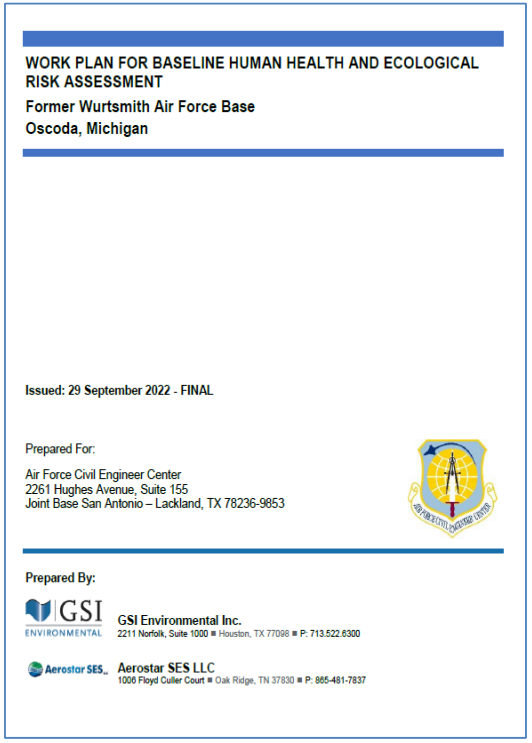
September 2022

Risk Assessment Work Plan



WORK PLAN FOR BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

Former Wurtsmith Air Force Base
Oscoda, Michigan

Issued: 29 September 2022 - FINAL

Prepared For:

Air Force Civil Engineer Center
2261 Hughes Avenue, Suite 155
Joint Base San Antonio – Lackland, TX 78236-9853

Prepared By:

GSI Environmental Inc.
2211 Norfolk, Suite 1000 ■ Houston, TX 77098 ■ P: 713.522.6300

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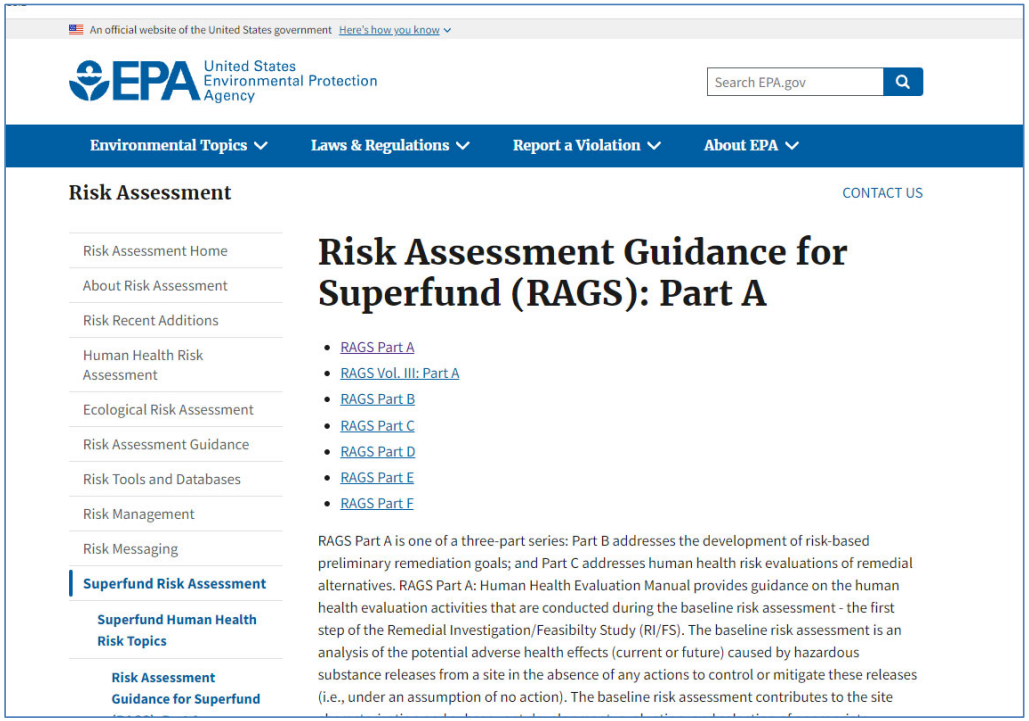
1006 Floyd Culler Court ■ Oak Ridge, TN 37830 ■ P: 865-481-7837

Guidance Used for BHHRA

Other federal and state guidance was used as described in RA Work Plan



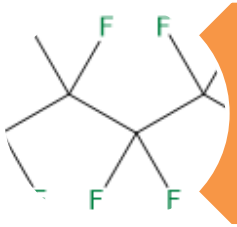
Primary Tasks for an RI

The RI will characterize the nature and extent of PFAS contamination in groundwater, soil, sediment, and surface water, evaluate fate and transport mechanisms in soil and groundwater, and provide data for use in the risk assessments.

- Biota
- Soil (Surface and Subsurface)
- Sediment and Surface Water
- Groundwater

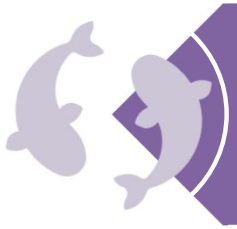
Database and Data Evaluations

BASELINE RISK ASSESSMENT DATABASE



PFAS Target analytes

Abiotic data collected as part of PFAS RI



Biological Data
(e.g., fish, invertebrates, plants)

Other Datasets to be Considered

MDCH* Fish Consumption Survey (2007)

MDNR data on fish, white-tailed deer, muskrat, and tree swallow

Meteorological data

PFAS uptake factors reported in peer-reviewed literature

Bird population studies (e.g., Custer et al., 2019)

National Health and Nutrition Examination Survey (NHANES)

Lead Health Intervention Program (LHIP)

*MDCH = Michigan Dept. of Community Health is now under MDHHS = Dept of Health and Human Services

MDNR = Michigan Dept. of Natural Resources

Review of Data for Use in Risk Assessments

- ASSESS DATA USABILITY
- GROUP BY EXPOSURE UNIT
- EVALUATE VARIABILITY AND UNCERTAINTY

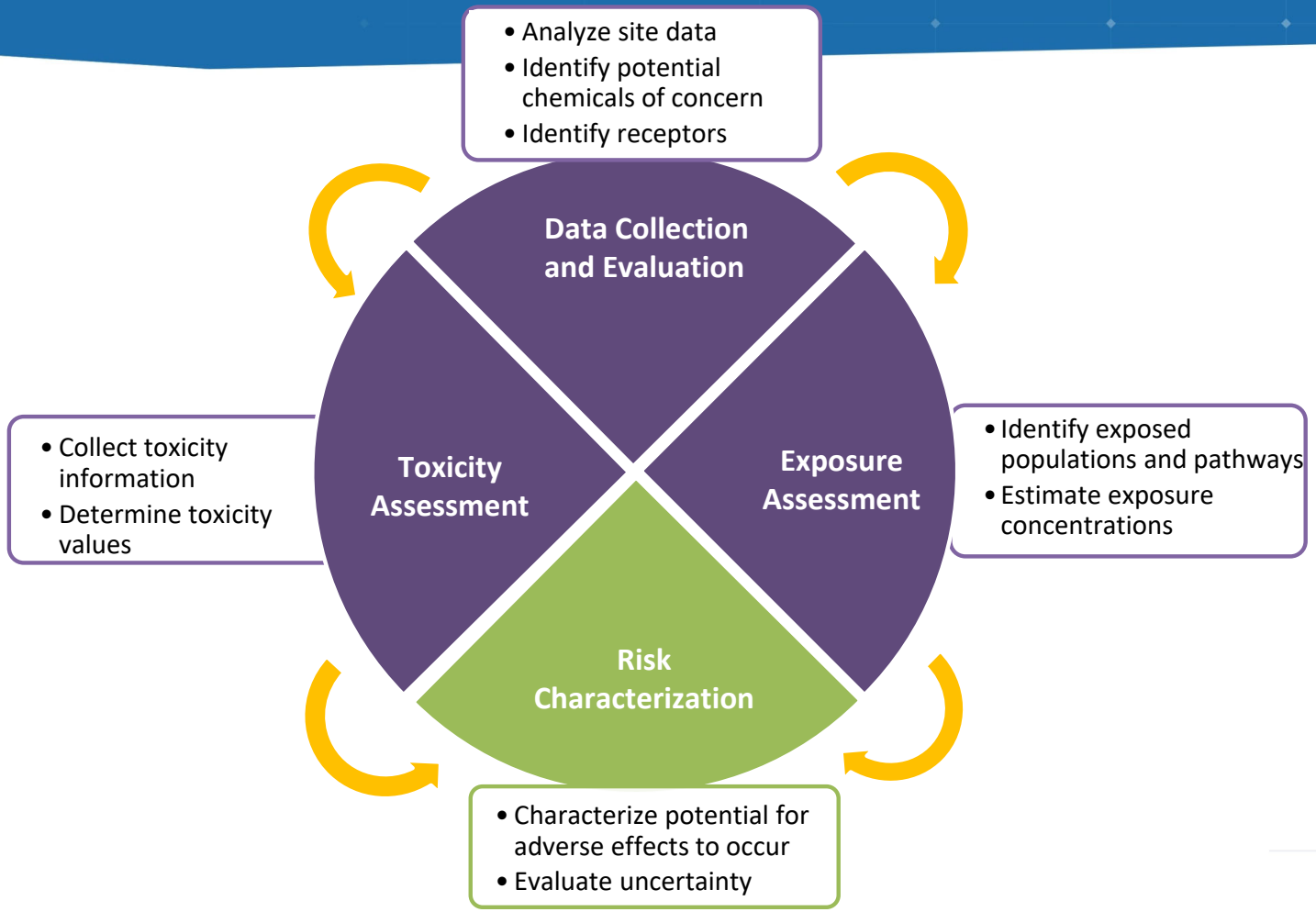
FOLLOW USEPA PROTOCOLS AND GUIDANCE

INCLUDE "J" FLAG DATA IN STATISTICS

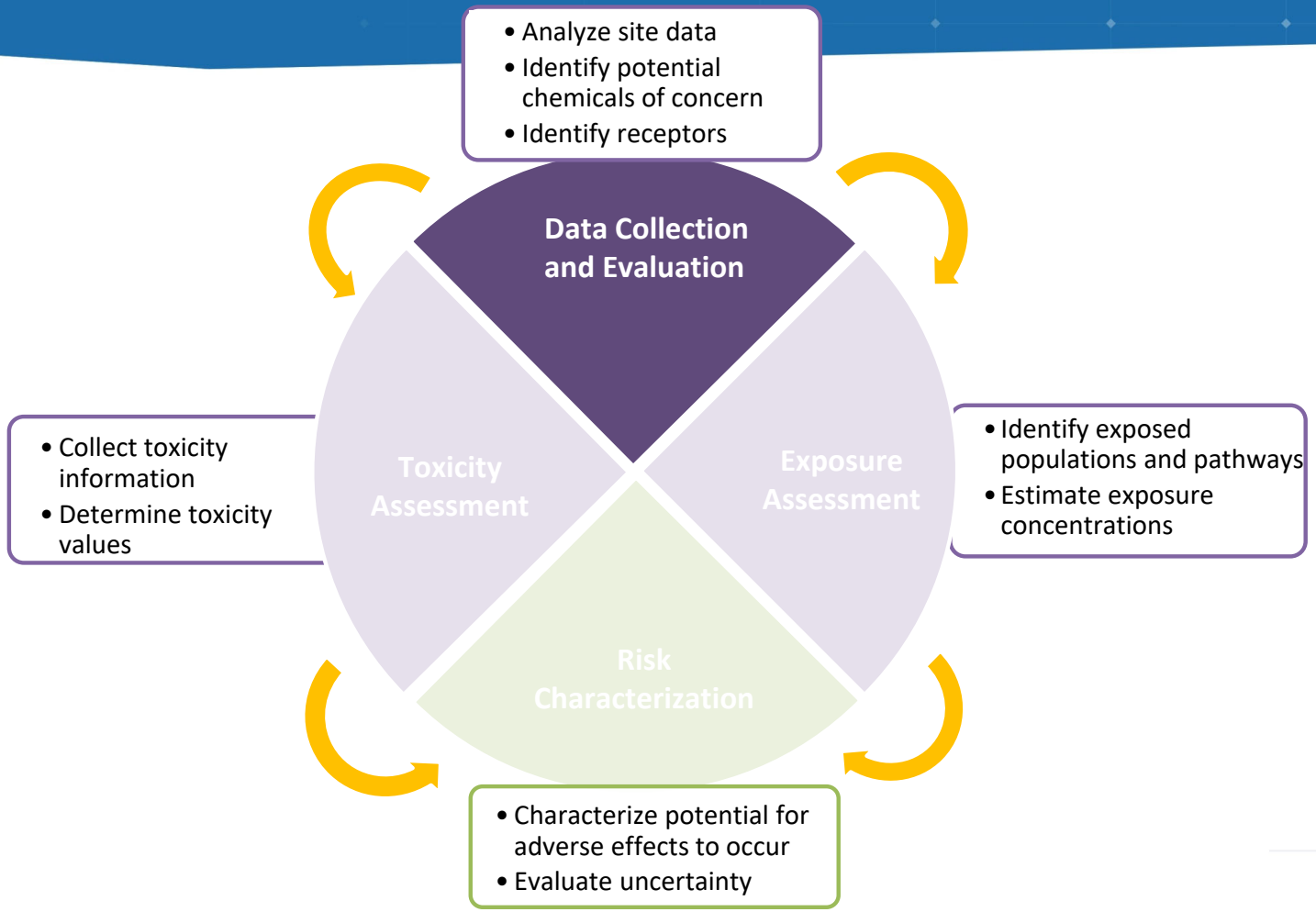
"R" flagged (rejected) data will not be used

CONDUCT EXPLORATORY DATA ANALYSIS

BHHRA Methods



BHHRA Methods



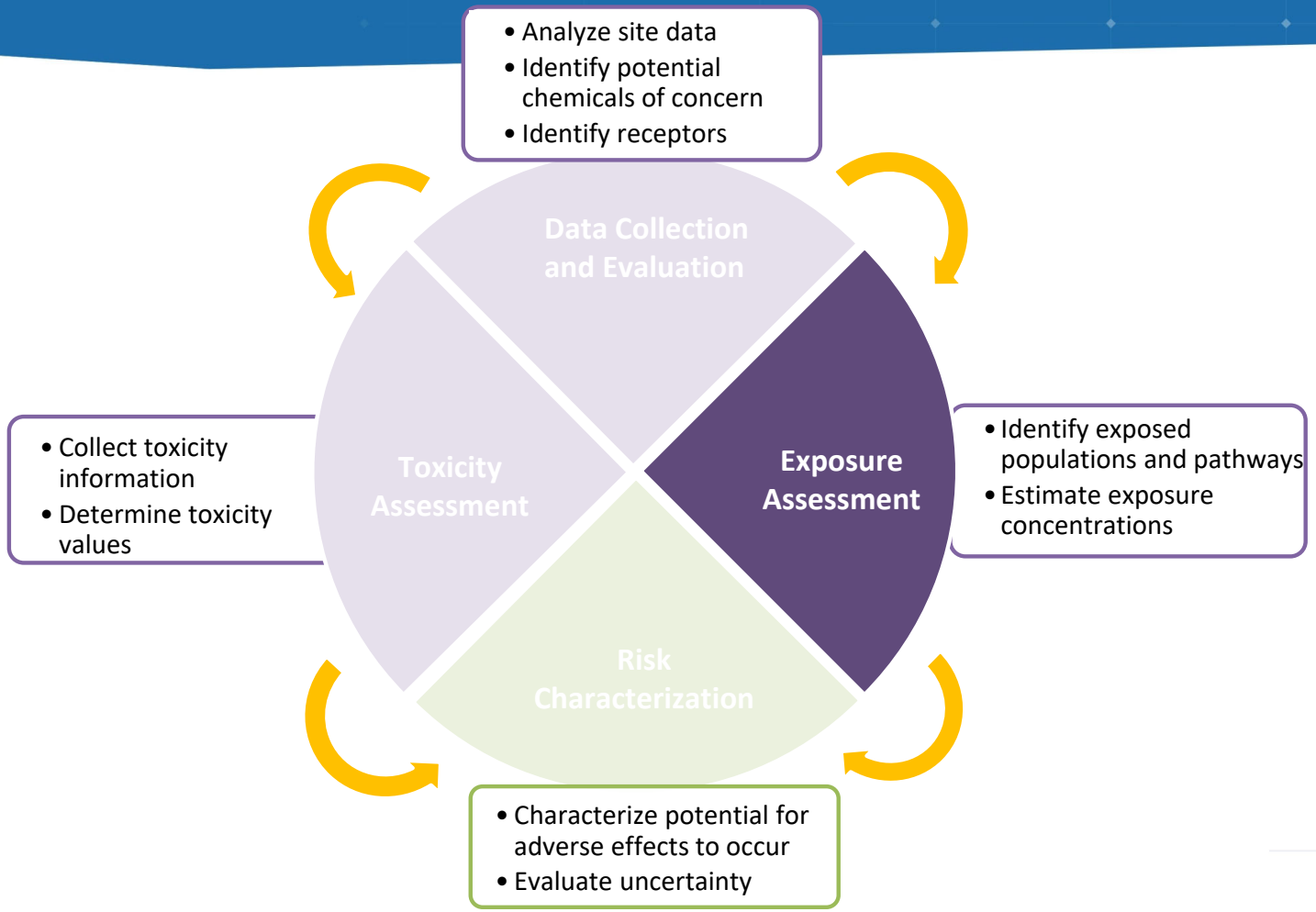
Identifying PFAS of Potential Concern

For each receptor scenario, PFAS will be retained as a COPC for that media and evaluated further in the BHHRA if any of the following conditions are true:

Detects:	Nondetects:	Data gap:
Maximum concentration exceeds a screening level	Method detection limit exceeds a screening level	Screening level is not available

COPC = contaminant of potential concern

BHHRA Methods



Risk = Exposure x Toxicity

https://scimoms.com/hazard-risk/

Risk = Toxicity x Exposure

- What is the risk to human health / eco?
- What chemicals are driving the risk?
- How much risk is attributable to site (vs background)?

- What are the chemical's health effects?
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- How will receptors contact the chemical?
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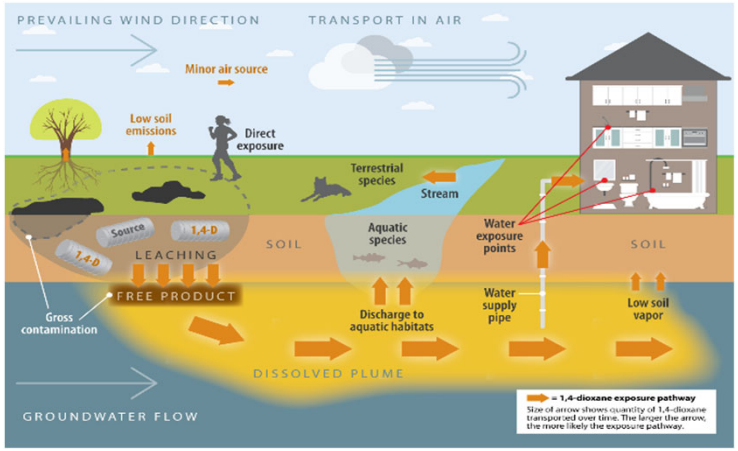
- Are exposures changing over time?

Conceptual Site Model for Risk Assessment

If a pathway is incomplete, exposure via that pathway (and subsequent risk) does not occur.



Source: ITRC 1,4-DX Technical Guidance Document

For an Exposure Pathway to be complete, there must be:

1. Source and mechanism of chemical release into the environment.
2. An environmental transport medium for the released chemical or mechanism of transport between media.
3. A point of potential receptor contact with the contaminated medium.
4. An exposure route at the point of contact (i.e., dermal absorption, inhalation, or ingestion).

Human Receptors and Exposure Routes (PFAS)

Contaminant Source	Environmental Media	Exposure Routes*
Project area PFAS releases	**Groundwater**	*Ingestion*
	Surface water	
	Soil/Sediment	
	Plants and Wildlife	

*Consistent with Michigan Rule 299, it will be assumed that untreated groundwater is used for domestic purposes

Current and Reasonable Likely Future Receptors

Based on current land use and reasonably anticipated future land use, the receptors identified for the BHHRA include:

- Commercial/industrial workers
- Construction workers
- Trespassers/visitors
- Current and hypothetical future residents
- Hunters and anglers
- Recreators
- USDA Forest Service specialists

Future (Hypothetical) Use includes Fish and Game Consumption

Dietary exposure for angler and hunter will be quantified in the BHHRA despite current consumption advisories.

Fish Advisory: "do not eat"* (In Clark's Marsh and in lower Au Sable River)

Deer Advisory: "do not eat"* (In Clark's Marsh and within 3 miles of Clark's Marsh)

*Advisories are issued by Michigan Department of Health and Human Services (MDHHS)

Fish Consumption Pathway in the BHHRA

A fish advisory is based on categories of fish consumption rates, whereas a risk assessment uses a specific estimate of fish consumption from surveys of anglers.

- Freshwater fin-fish consumption
- Midwest (national survey) and Michigan
- Population demographics:
  - Age groups (e.g., young child, adult)
- Fraction of fish consumption from site: 1.0

Age Group	Arithmetic Mean (g/day)	95th Percentile (g/day)
Youth	6.3	13.0
Adult	4.2	13.2

Aggregate Exposure Scenarios

The following receptors could potentially have overlapping scenarios:

- Commercial/ industrial worker + swimmer, angler and/or hunter scenarios
- Construction worker + recreator scenarios
- Commercial/ industrial worker + resident
- Resident + recreator scenarios
- Forest Service specialist + recreator scenarios
- Recreator scenarios combined

Exposure Units (EUs)

Exposure units are defined in WP

Exposure units reflect current and foreseeable future receptor scenarios

0.25 acre EU = current and future residential scenarios

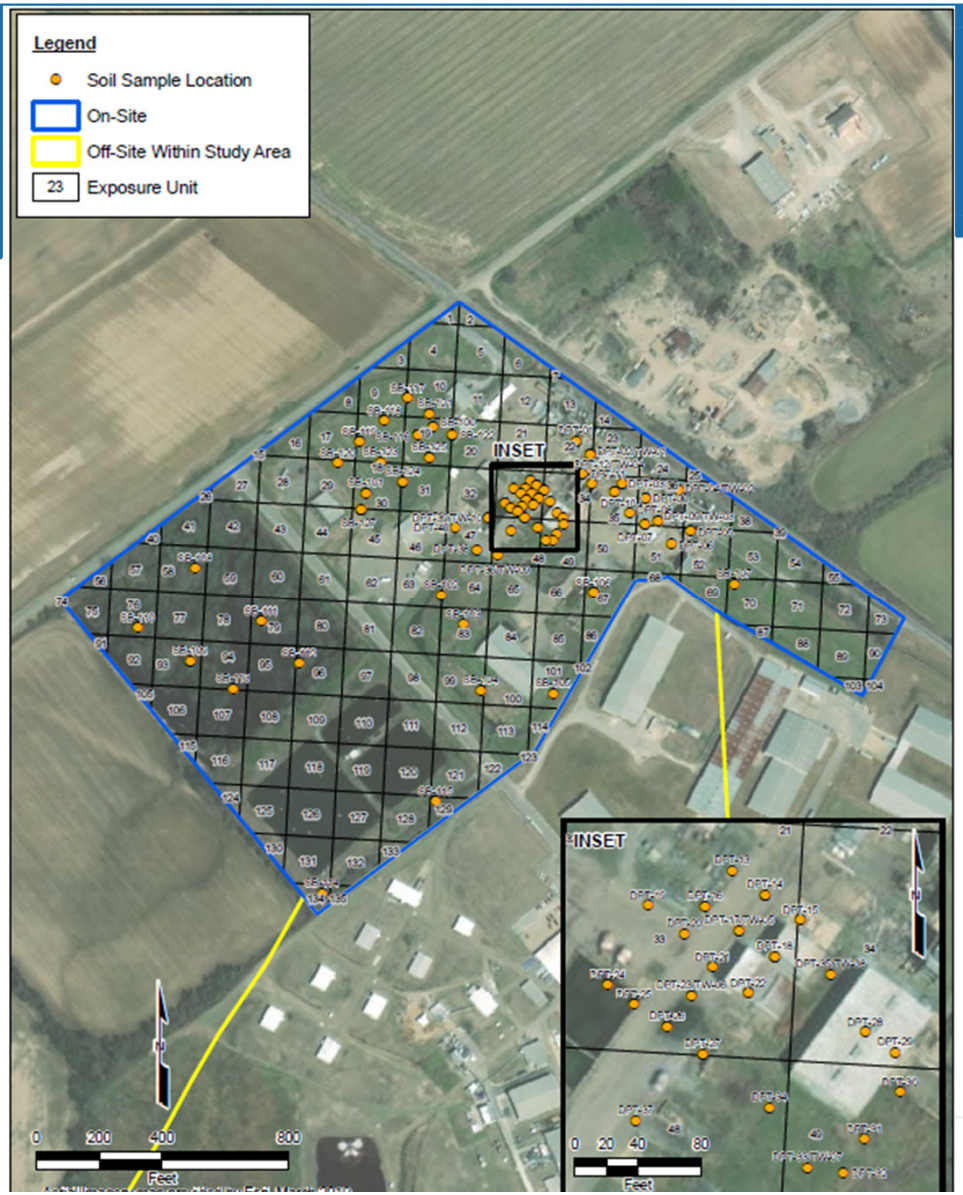
2 acre EU = commercial /industrial worker scenario

Angler EU = given waterbody

Hunter and recreator EUs = the Project Boundary

This approach may be modified based on spatial distribution of sampling and other considerations

Example EU Grid



* NOT FWAFB

Summary of Exposure Scenarios and Receptors for Former WAFB

GSI ENVIRONMENTAL

Exposure Scenarios	Exposure Media[1]							Receptor Age Group		
Receptors	Surface Soil	Subsurface Soil	Groundwater	Sediment	Surface Water	Wild Game	Fish	Younger Child (<6 yrs)	Older Child (6 - <16 yrs)	Adult (16+ yrs)
Current and Hypothetical Resident	0.25 acres	0.25 acres	Core of Plume[3]					X	X	X
Construction Worker	0.25 acres	0.25 acres								X
Commercial / Industrial Worker	2.0 acres									X
USDA Forest Service Specialist	Clark's Marsh									X
Trespasser/ Visitor	Project Boundary[2]								X	X
Recreator / Hunter	Project Boundary[2]			Water Body[4]	Water Body[4]	Project Boundary[2]		X		X
Recreator / Angler	Project Boundary[2]			Water Body[4]	Water Body[4]		Water Body[4]	X		X
Recreator / Swimmer	Project Boundary[2]			Water Body[4]	Water Body[4]			X		X

Notes:

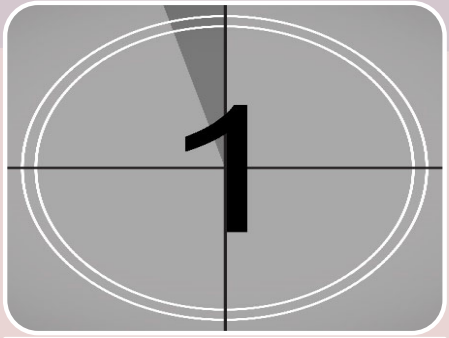
1 - Entries in this table are the size of the exposure unit (EU) or general exposure unit area. For soil, a square grid of EUs is overlaid on the Project Boundary. Blanks indicate that the exposure medium/receptor combination is not a complete exposure pathway in the conceptual site model for the BHHRA (see Figure 5-1).

2 - Project Boundary combines on-installation and off-installation areas. The final size of this EU will be determined by the extent of the RI delineation.

3 - For groundwater, data are grouped by monitoring wells within the core of the plume, which is chemical-specific and includes the two most recent sampling events.

4 - For sediment, surface water, and fish, data are grouped by water body types (e.g., Clark's Marsh ponds, Au Sable River, Van Etten Lake, Van Etten Creek) as described in Section 2.3 Habitat Characterization.

Exposure Point Concentrations (EPCs)

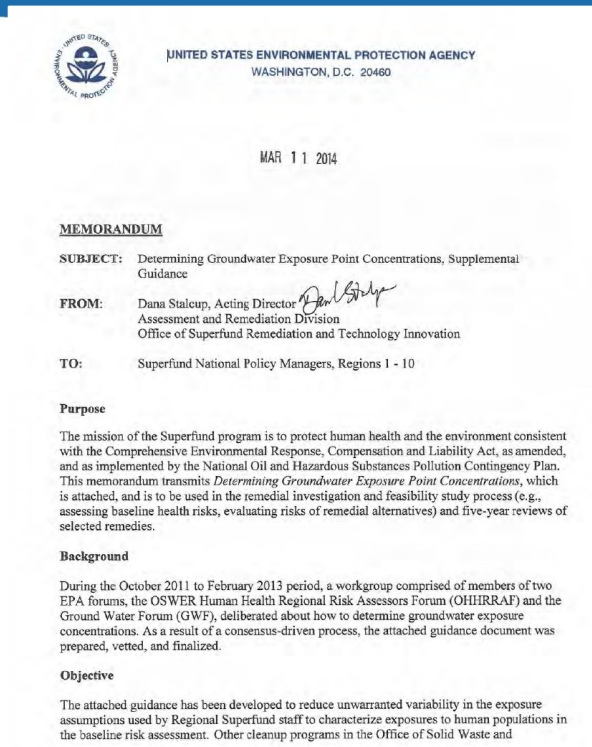


Long-term average concentration of a chemical in an environmental medium that a receptor may contact within a given EU

Protective: Typically based on an upper confidence limit for the arithmetic mean (95% UCL)

Calculated using USEPA's ProUCL software for data grouped by chemical, exposure medium, and EU

EPCs for Groundwater



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

MAR 11 2014

MEMORANDUM

SUBJECT: Determining Groundwater Exposure Point Concentrations, Supplemental Guidance

FROM: Dana Stalcup, Acting Director
Assessment and Remediation Division
Office of Superfund Remediation and Technology Innovation

TO: Superfund National Policy Managers, Regions 1 - 10

Purpose

The mission of the Superfund program is to protect human health and the environment consistent with the Comprehensive Environmental Response, Compensation and Liability Act, as amended, and as implemented by the National Oil and Hazardous Substances Pollution Contingency Plan. This memorandum transmits *Determining Groundwater Exposure Point Concentrations*, which is attached, and is to be used in the remedial investigation and feasibility study process (e.g., assessing baseline health risks, evaluating risks of remedial alternatives) and five-year reviews of selected remedies.

Background

During the October 2011 to February 2013 period, a workgroup comprised of members of two EPA forums, the OSWER Human Health Regional Risk Assessors Forum (OHHRRAF) and the Ground Water Forum (GWF), deliberated about how to determine groundwater exposure concentrations. As a result of a consensus-driven process, the attached guidance document was prepared, vetted, and finalized.

Objective

The attached guidance has been developed to reduce unwarranted variability in the exposure assumptions used by Regional Superfund staff to characterize exposures to human populations in the baseline risk assessment. Other cleanup programs in the Office of Solid Waste and

USEPA (2014) Office of Superfund Remediation and Technology Innovation

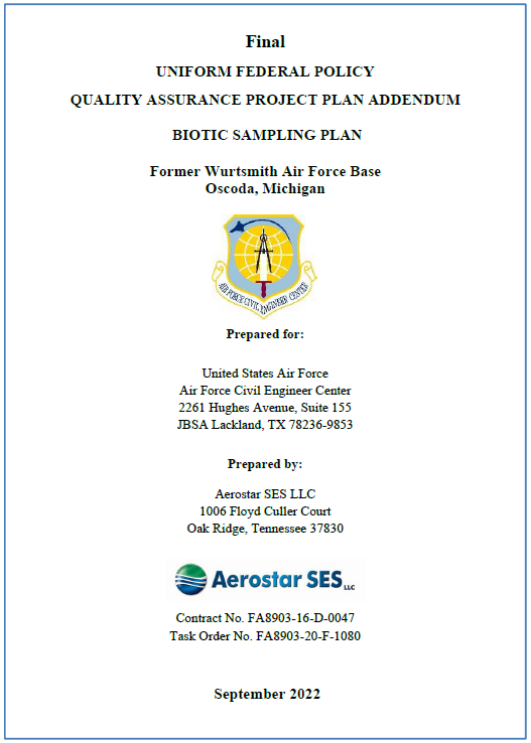
Identify wells in the core of the plume:
- **Spatial patterns (concentration isopleths)**
- **Temporal patterns (seasonal variability, trends)**

Develop the dataset:
- **Most recent sampling events from each well in the core of the plume**

Calculate the EPC:
- **Use the 95% UCL if data are from at least 3 wells and includes at least 8 observations**
- **Use the maximum detect for smaller datasets**

95% UCL = 95 percent upper confidence limit for the arithmetic mean

EPCs (cont'd)



Final

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QUALITY ASSURANCE PROJECT PLAN ADDENDUM

BIOTIC SAMPLING PLAN

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Task Order No. FA8903-20-F-1080

September 2022

EPCs for surface water, sediment, and biota will be based on the 95% UCL of samples representing the area or waterbody potentially impacted by the site-related releases.

Background conditions will be characterized using samples that are not impacted by the site-related releases (e.g., outside the Project Boundary).

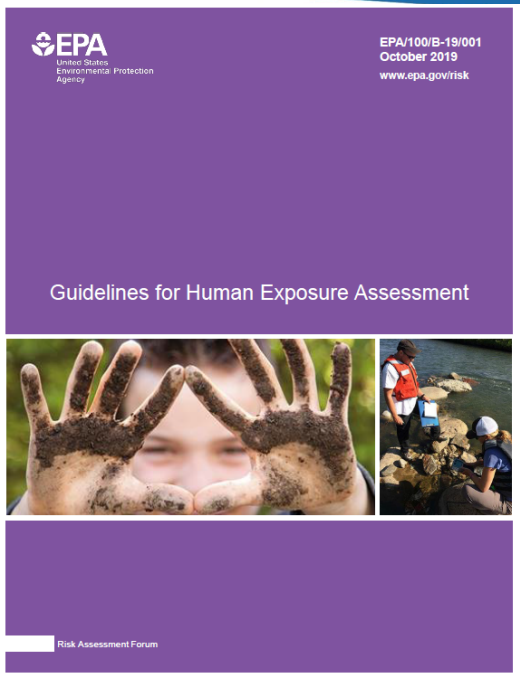
Calculating Exposure

$$\text{Average Daily Dose} = \frac{\text{EPC} \times \text{Ingestion Rate} \times \text{Bioavailable Fraction} \times \text{Exposure Frequency} \times \text{Exposure Duration}}{\text{Body Weight} \times \text{Averaging Time}}$$

Taking into account:

- Chemical concentration
- Chemical characteristics (such as bioavailability: how much reaches the target organs)
- Exposure:
  - **What pathways/routes?**
  - **How frequent? – Exposure frequency**
  - **How long? – Exposure duration**
  - **Absorption / uptake**

Use of Standard Exposure Equations



- **Exposure equations**
- **Exposure factors**

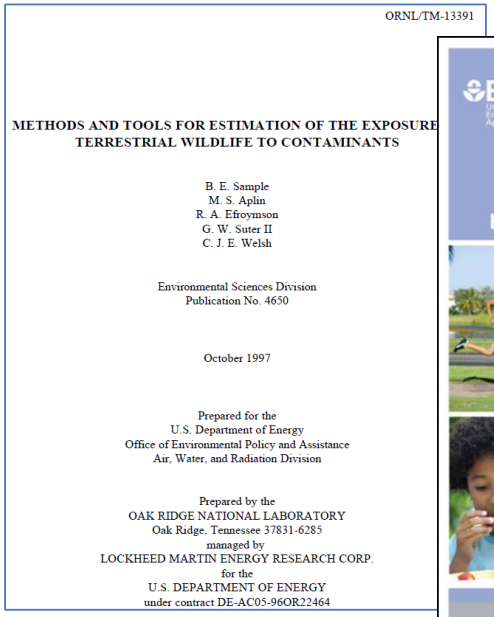
- **Incidental soil and dust ingestion**

$$ADD_s(mg/kg-day) = \frac{C_s \times CF_1 \times IR_s \times RBA_s \times EF \times ED}{AT \times BW}$$

Where:

ADD_s	-	average daily dose from incidental ingestion of soil or sediment (mg/kg-day)
C_s	-	concentration of COPC in soil or sediment (mg/kg)
CF_1	-	mass conversion factor for soil or sediment (10^{-6} kg/1 mg)
IR_s	-	average daily ingestion rate of soil or sediment (mg/day)
RBA_s	-	bioavailability from soil or sediment relative to bioavailability from water (unitless)
EF	-	exposure frequency (days/year)
ED	-	exposure duration (years)
AT	-	averaging time (days)
BW	-	body weight (kg)

Characterize Exposed Populations


ORNL/TM-13391

METHODS AND TOOLS FOR ESTIMATION OF THE EXPOSURE
TERRESTRIAL WILDLIFE TO CONTAMINANTS

B. E. Sample
M. S. Aplin
R. A. Efroymson
G. W. Suter II
C. J. E. Welsh

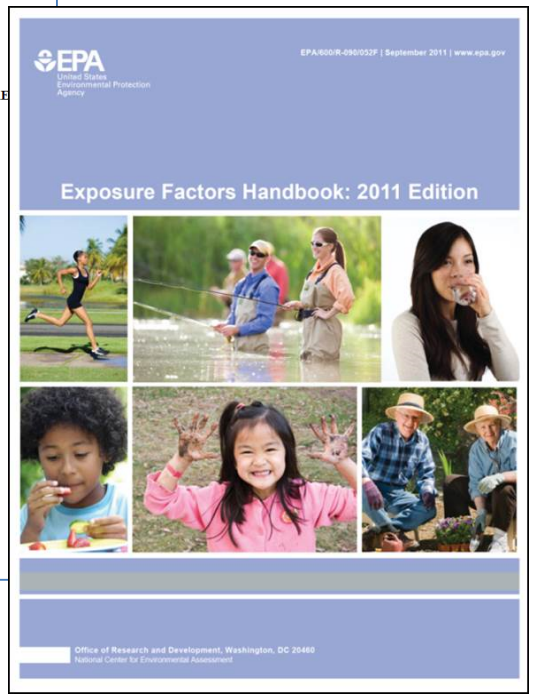
Environmental Sciences Division
Publication No. 4650

October 1997

Prepared for the
U.S. Department of Energy
Office of Environmental Policy and Assistance
Air, Water, and Radiation Division

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

Oak Ridge National Laboratory 1997



USEPA 2011 (and updates)

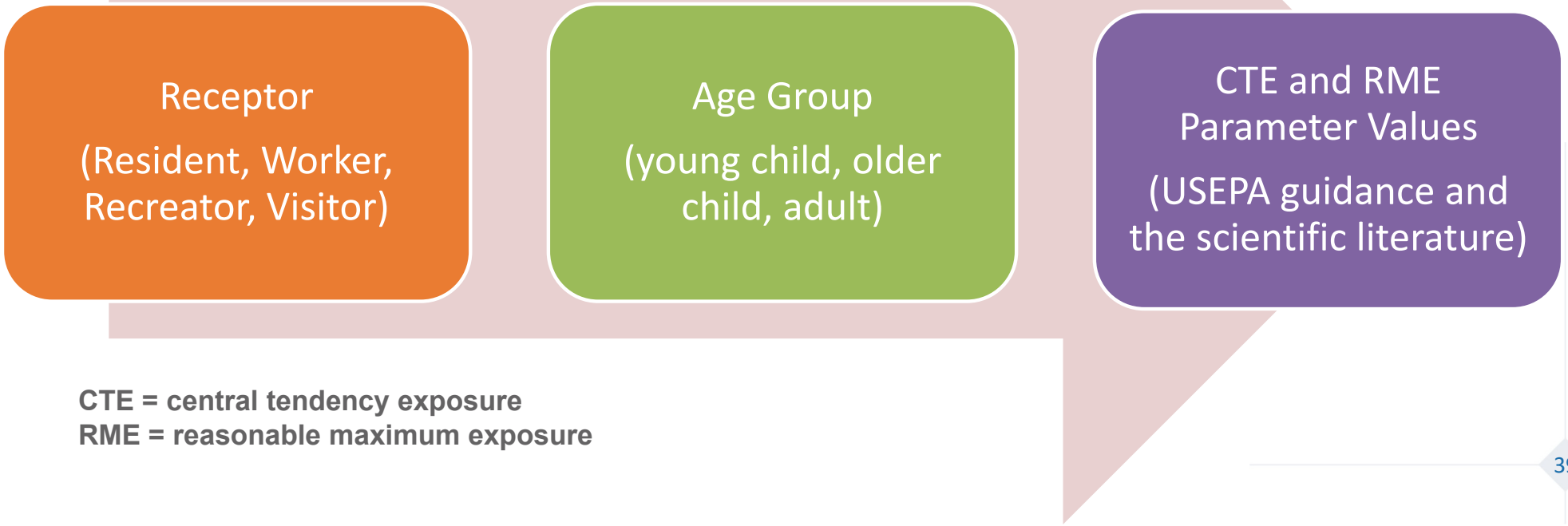
- Variability addressed by using mix of central and high-end exposure estimates
- Example for drinking water:

  2.5 L /day = 6.5 glasses of water …

  …everyday for 30 years

Exposure Parameter Values

- **Exposure assumptions are listed in tables in the Work Plan: Appendix A, Tables A-1 through A-7**

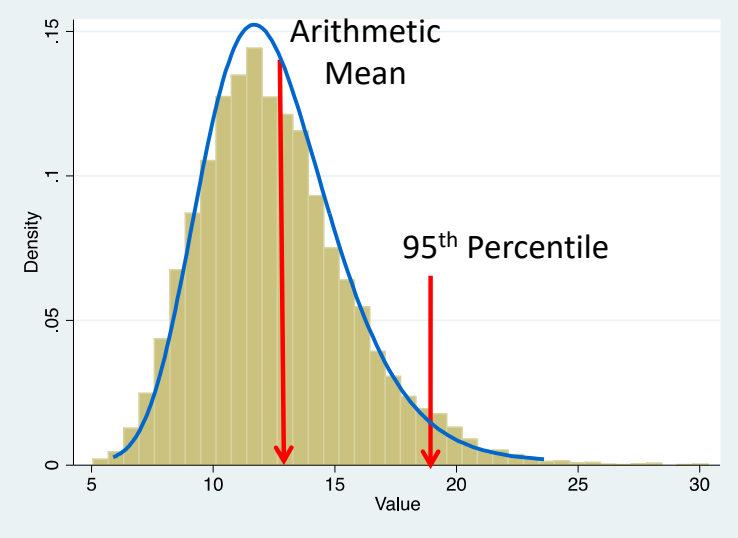


CTE = central tendency exposure
RME = reasonable maximum exposure

Conservatism in Exposure Assessment

Central Tendency Exposure (CTE)

- ***Average or median exposure***

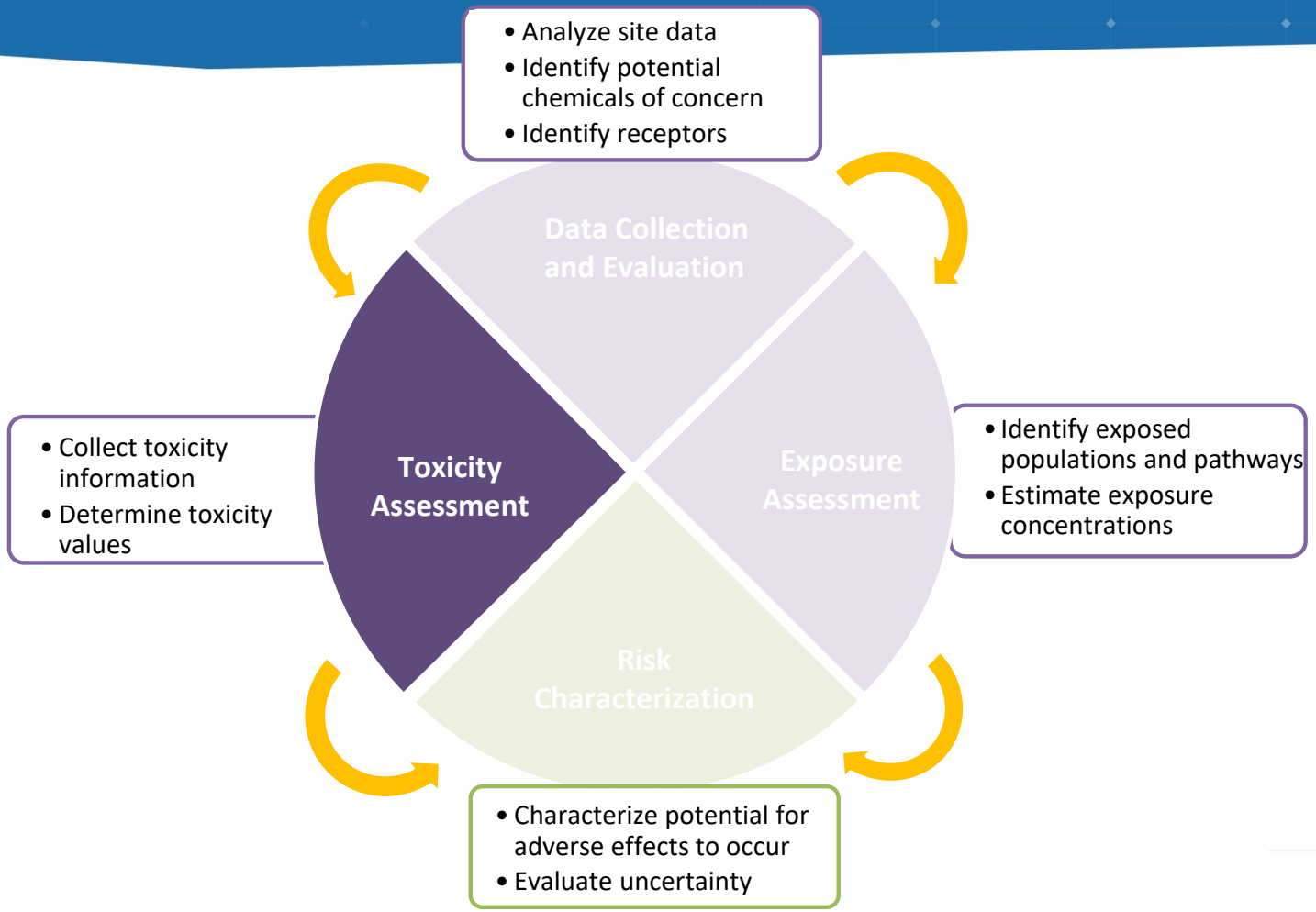


Reasonable Maximum Exposure (RME)

- ***The highest exposure that can reasonably be expected to occur***
- ***The purpose of the RME is to estimate a conservative exposure case still within the range of possible exposures***

KEY POINT:
RME and CTE together should provide a measure of confidence in the risk range.

BHHRA Methods



Risk = Exposure x Toxicity

https://scimoms.com/hazard-risk/

Risk = Toxicity x Exposure

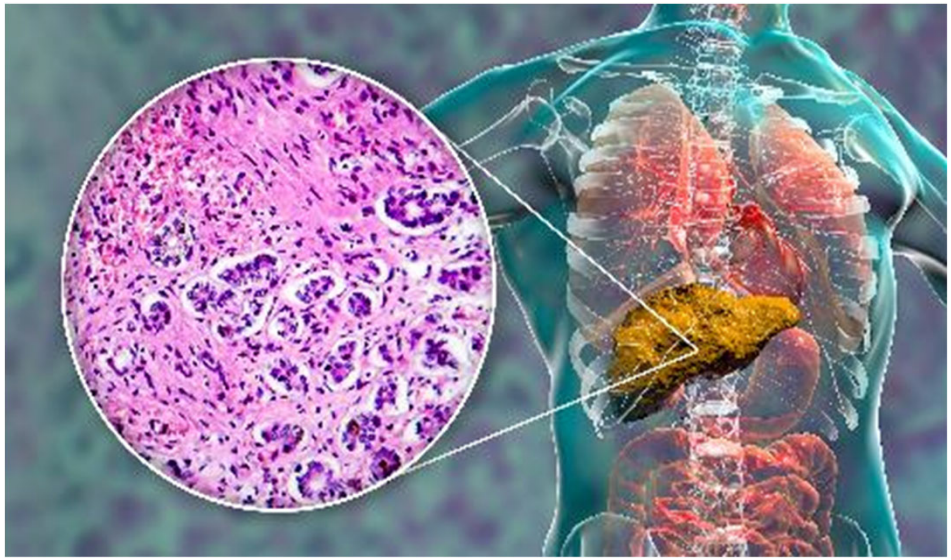
- What is the risk to human health / eco?
- What chemicals are driving the risk?
- How much risk is attributable to site (vs background)?

- What are the chemical's health effects?
- What is the relationship between exposure and health effects?

- How will receptors contact the chemical?
- What is the magnitude, frequency and duration of contact?
- Are exposures changing over time?

Toxicity Assessment – Toxicity Values

- Noncancer
  - Development
  - Reproduction
  - Systemic
  - Short-term or Chronic
- Cancer
- Susceptibility
  - Developmental stage



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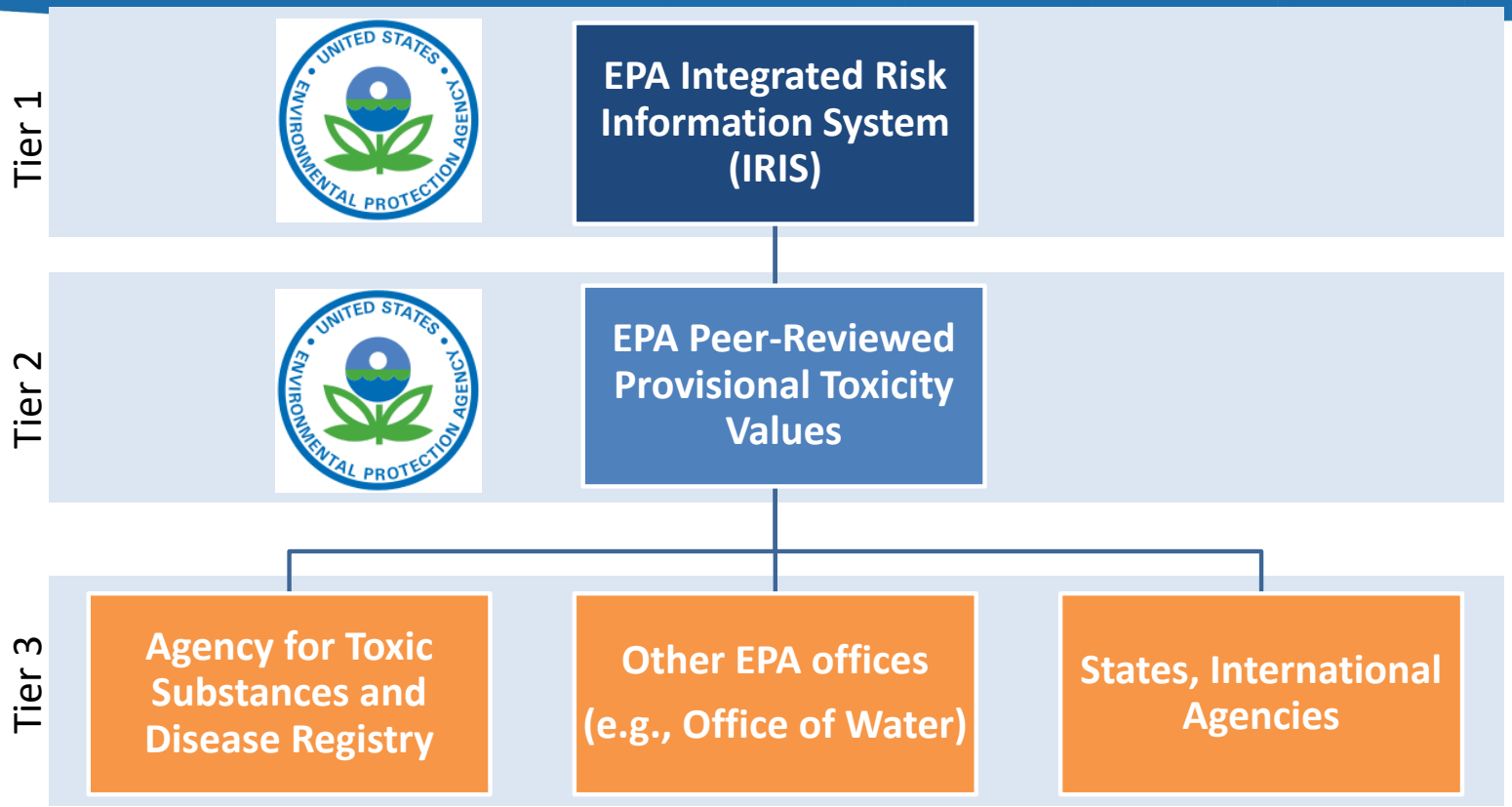
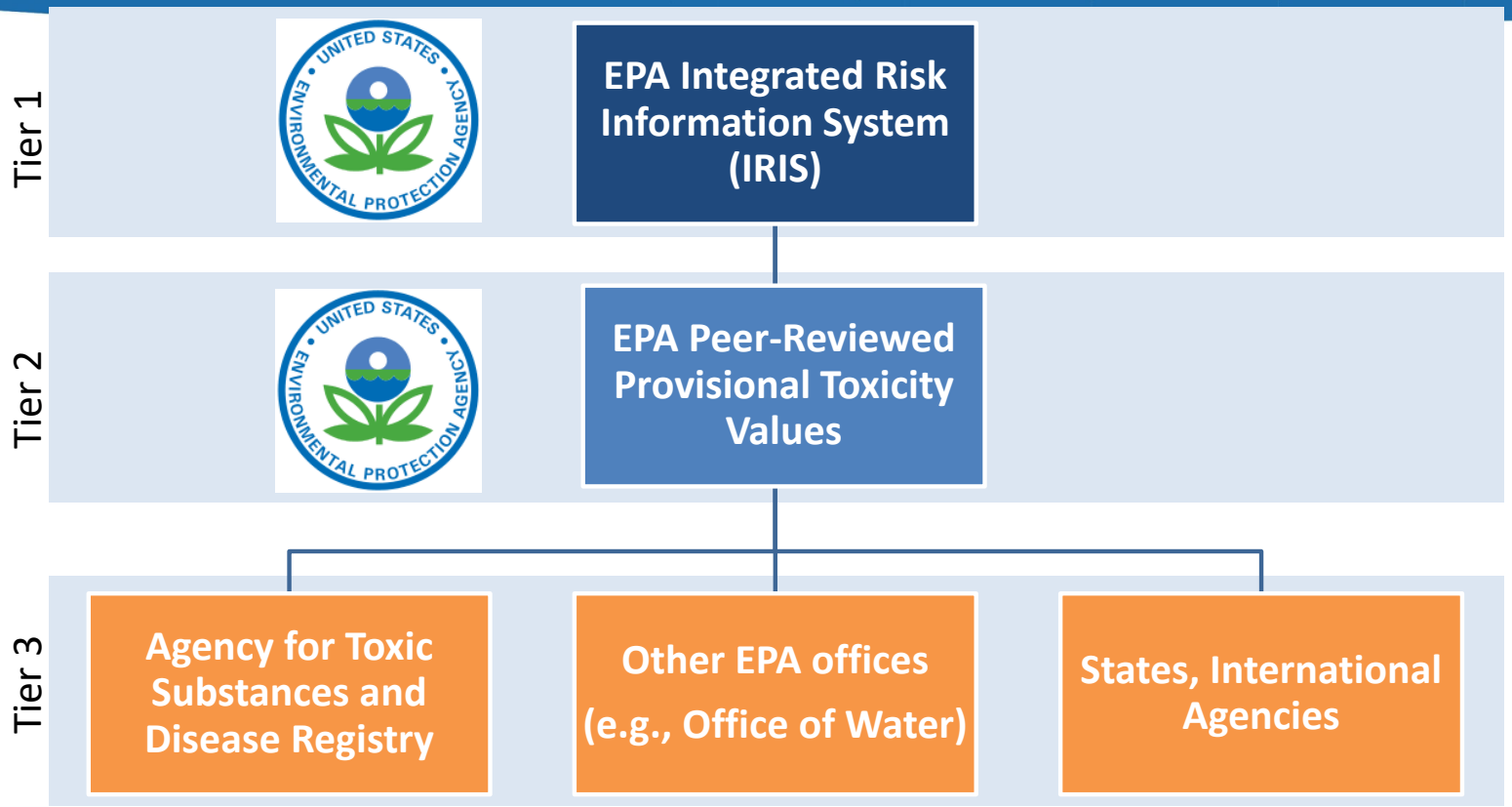
Selection of Toxicity Values Follows EPA and DoD Policy



WJVZNWJR JSYX

- ☑ USEPA methods
- ☑ Transparent
- ☑ Most current science
- ☑ Peer-reviewed
- ☑ Finalized with public input

Selection of Toxicity Values Follows EPA and DoD Policy

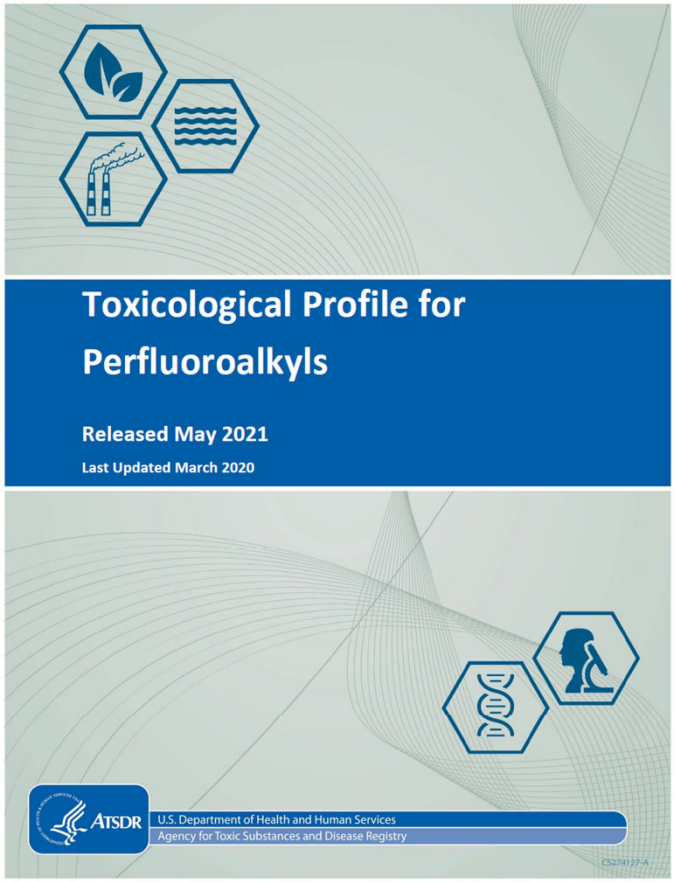


WJVZNWJR JSYX

- ☑ USEPA methods
- ☑ Transparent
- ☑ Most current science
- ☑ Peer-reviewed
- ☑ Finalized with public input

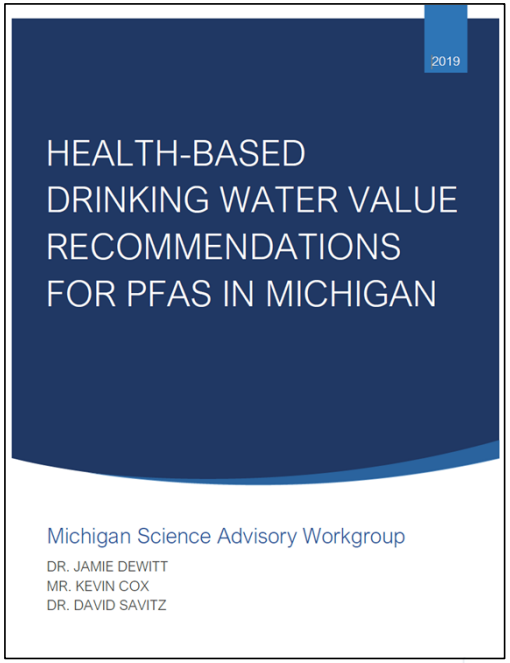
The BHHRA will use the most up-to-date toxicity values available.

Status of Toxicity Evaluation

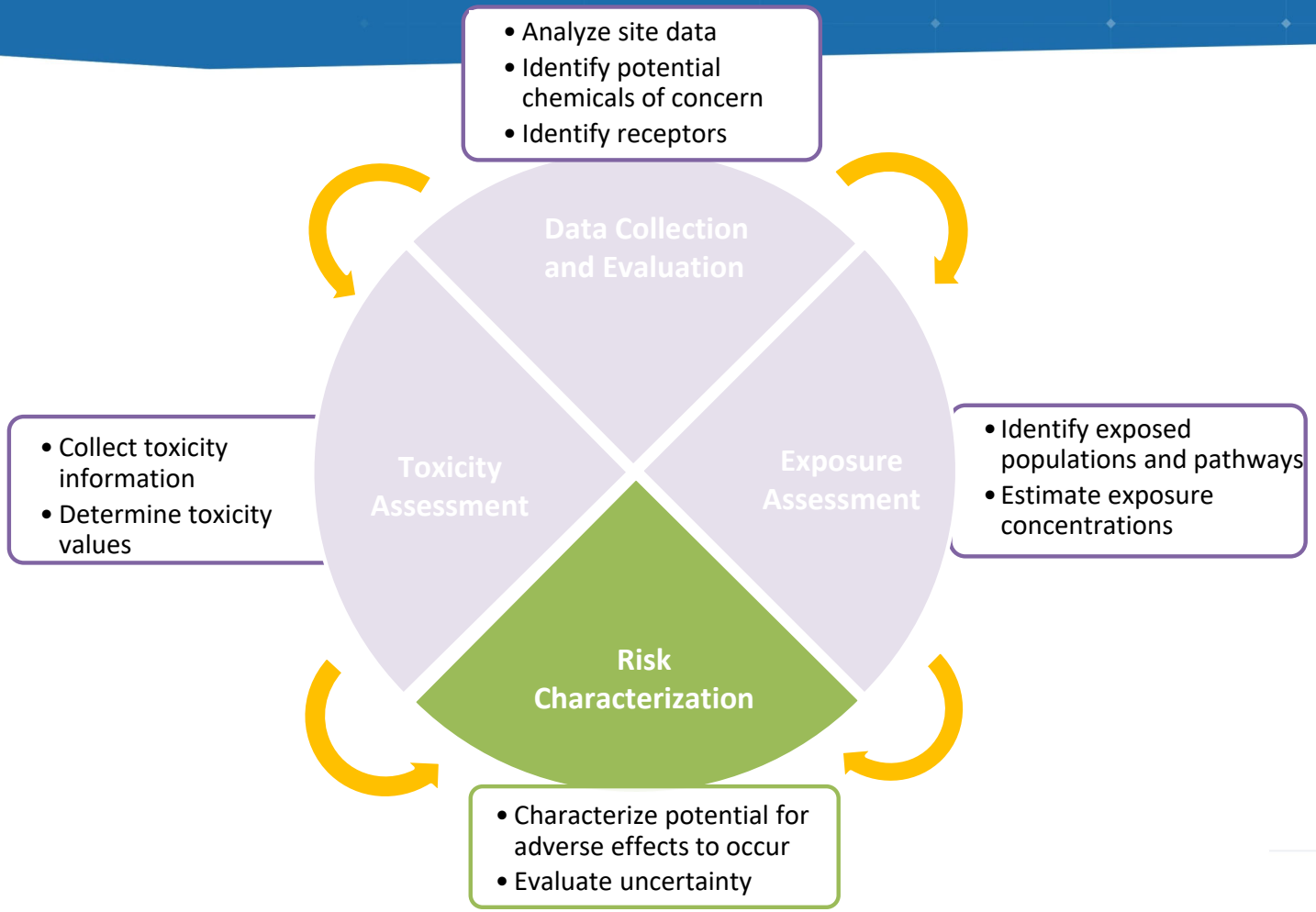


- ✓ PFOA
- ✓ PFOS
- ✓ PFNA
- ✓ PFHxS

- ✓ PFBA
- ✓ PFBS
- ✓ PFHxA
- ❑ PFDA
- ❑ PFHxS
- ❑ PFNA



BHHRA Methods



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Risk = Toxicity x Exposure

- What is the risk to human health / eco?
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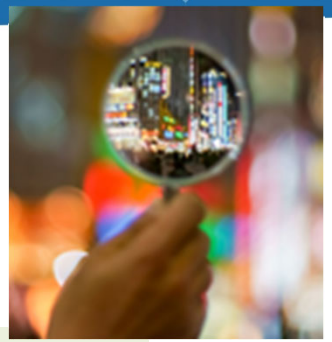
- What are the chemical's health effects?
- What is the relationship between exposure and health effects?

- How will receptors contact the chemical?
- What is the magnitude, frequency and duration of contact?
- Are exposures changing over time?

Risk Characterization



NONCANCER HAZARD INDEX

- **Hazard quotient (HQ) for one chemical:**

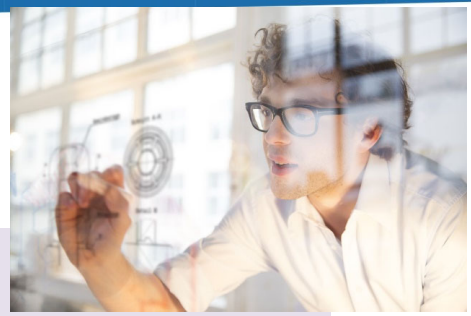
  Ingestion = Dose/RfD Inhalation = Concentration/RfC

$$HQ = \frac{Exposure}{Toxicity\ Value}$$

- **Hazard index (sum of HQs) for multiple chemicals:**

  HI = $HQ_A + HQ_B + HQ_C + HQ_D + \cdots$

Risk Characterization



CARCINOGENIC RISK

- **Risk = Lifetime avg. daily dose x Cancer Slope Factor**
- **$1x10^{-6}$ to $1x10^{-4}$**

  one in a million to one in ten thousand is regulatory goal
- **Increased risk of cancer in a population (not individual) that is exposed to same conditions**

Uncertainty Analysis

Qualitative

- Chemicals without tox values
- Sampling design
- Receptor evaluation

- Uncertainties are inherent and cannot be eliminated.
- The magnitude and impact of some uncertainties can be estimated:
  - Using upper and lower bound point estimates.
  - Using probabilistic methods.

Quantitative

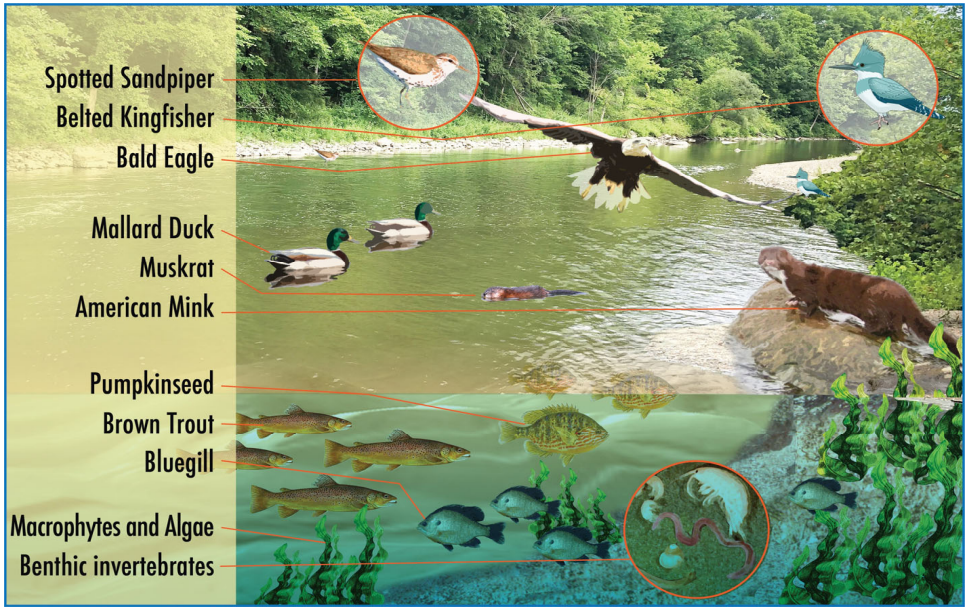
- Choice of tox value
- Exposure assumptions

Uncertainty Analysis

Methods for Quantitative Evaluation of Uncertainty

- Use of Alternative PFAS Toxicity Criteria
  - Evaluate multiple sources of alternative tox info
  - Evaluate EGLE's toxicity criteria for PFAS
- Use of Alternate Exposure Parameters
  - Including Alternative Exposure Point Concentrations
- Comparison of site-related PFAS risks to:
  - Regional Concentrations since PFAS are ubiquitous contaminants

Baseline Ecological Risk Assessment (BERA)



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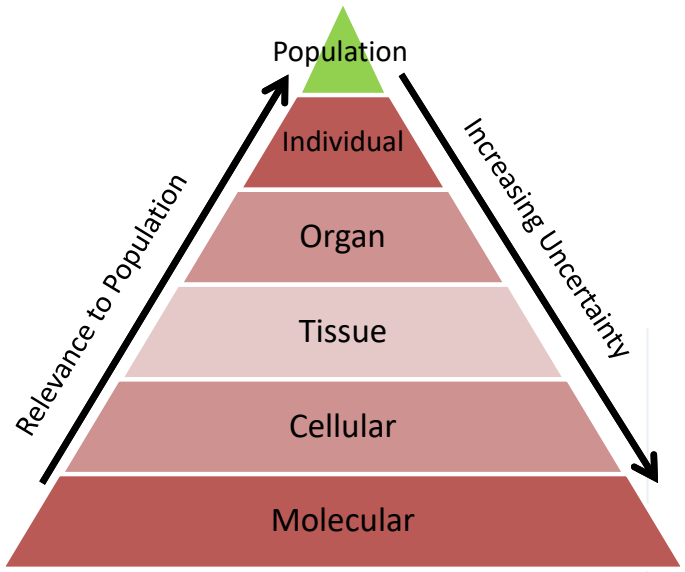
BERA – Key Concepts

Site Investigation	Conceptual Site Model	Screening
• Target analytes • Paired abiotic/biotic • Spatial scales • Sufficient to address key questions	• Chemicals • Pathways • Receptors	• Ecological screening levels • Background • **Bioaccumulation potential**



Identifying Chemicals of Potential Ecological Concern (COPECs)

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For soil and sediment, the maximum concentrations from all depths are used to identify COPECs

Work Plan Tables 6-6 through 6-8 provide the benchmarks used for identifying COPECs

COPECs identified in this step are further evaluated in BERA

Identifying PFAS COPECs

For each receptor scenario, PFAS will be retained as a COPEC for that media and evaluated further in the BERA if any of the following conditions are true:

- Maximum concentration is a detection and exceeds ecological screening level
- Maximum concentration is an ND, and the MDL proxy value exceeds an ecological screening level
- An ecological screening level is not available for the analyte for the receptor scenario

ND = nondetect
MDL = method detection limit

Fundamental Elements of BERA

Problem Formulation

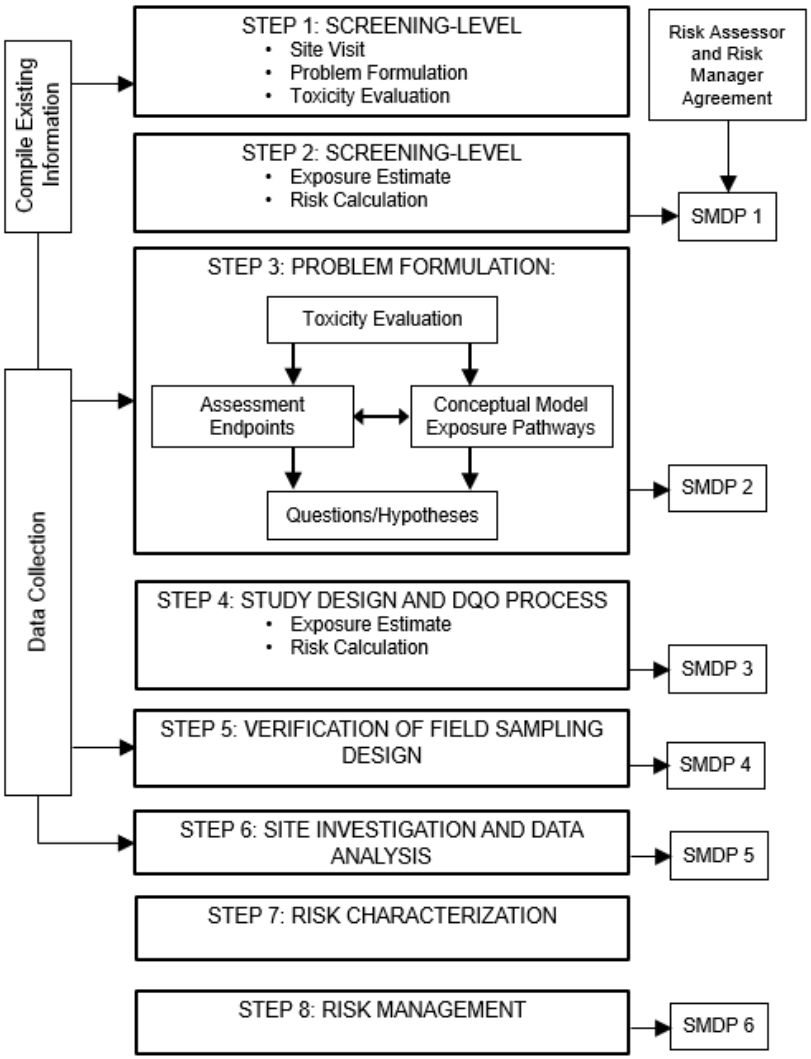
- articulates goals, breadth, and focus of the assessment

Analysis

- technical evaluation of data on exposure and ecological effects

Risk Characterization

- likelihood of adverse effects associated with exposure to a stressor



- USEPA (1997) Ecological Risk Assessment Guidance for Superfund
- BERA includes Step 1 through Step 7

SMDP = Scientific/Management Decision Point

Problem Formulation

Goal is to determine whether PFAS detected in the Project area could pose a risk to ecological receptors.

Presents Eco Conceptual site Model (CSM):

- intended to be iterative/updated.

Preliminary CSMs are based on prior PFAS Investigations.

Exposure Pathways and Exposure Routes

Potential Exposure Routes:

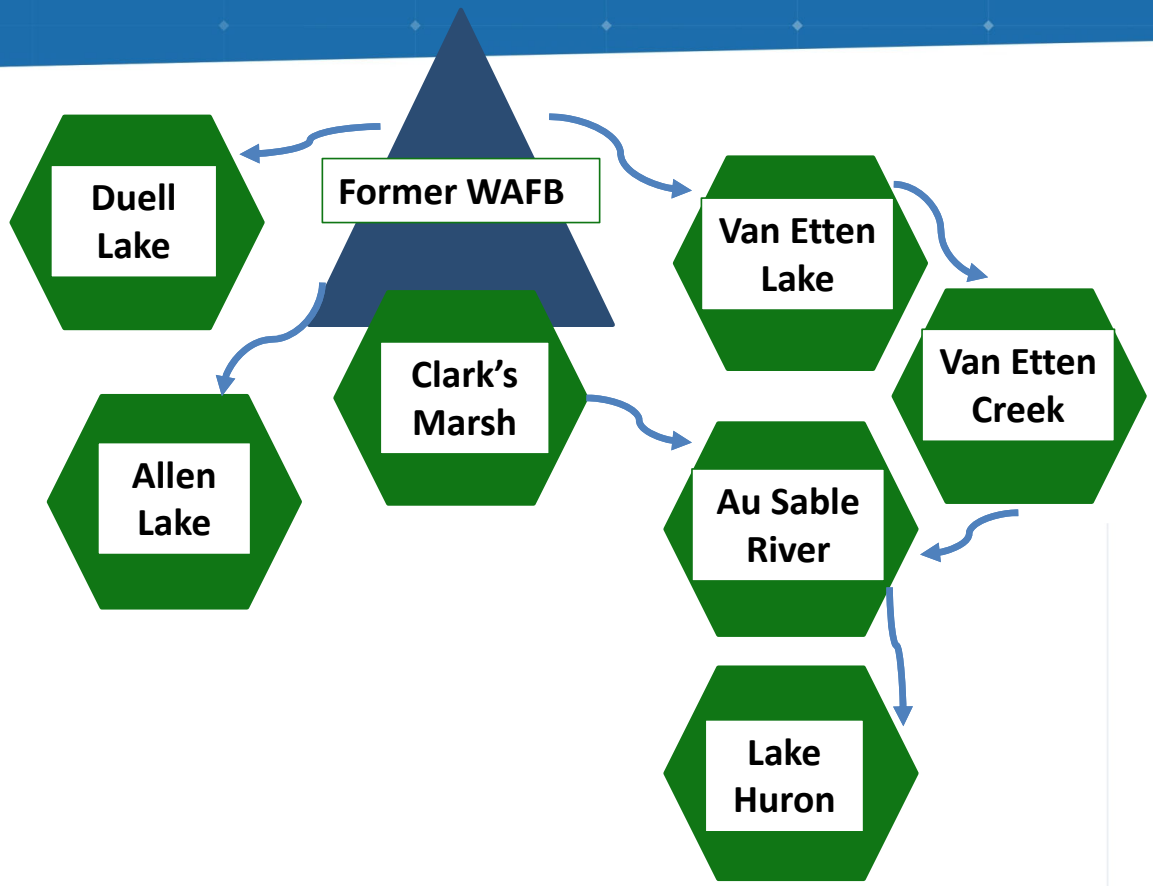
- Food web (prey consumption)
- Direct contact with environmental media (e.g., sediment, soil, or water) and uptake (e.g., dermal, roots, gills)
- Ingestion of environmental media

Preliminary Conceptual Model

Contaminant Source	Environmental Media	Exposure Routes
Project area **PFAS releases**	 **Surface water / Sediment**	 **Ingestion** **(direct and food web)**
	 **Soil**	 **Food Web**

Habitat Characterization

- Former WAFB is on slight topographic mound that gently slopes from crest (at flightline on Former WAFB) toward several surface water bodies and wetlands in the Au Sable River Valley.
- Some terrestrial habitat within the boundaries of former WAFB since it is largely developed and used for industrial purposes.



Ecological Receptors Abundant in Area

Wildlife that were selected as representative species in the BERA include:

Mallard
Spotted Sandpiper
Belted Kingfisher
Bald Eagle

Tree Swallow
American Robin
Red-tailed Hawk

Terrestrial Plants

Terrestrial Invertebrates
American Mink
Northern Short-tailed Shrew
Meadow Vole

Eastern Cottontail

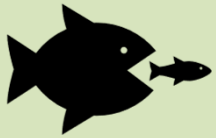
Racoon

Ecological Receptors (cont'd)

Primary Aquatic Ecological Receptors include:

Mallard
Spotted Sandpiper
Belted Kingfisher
Bald Eagle
American Mink
Muskrat

Macrophytes and Algae
Invertebrates
Pumpkinseed
Bluegill
Brown Trout



Receptors are Representative of Feeding Guilds

Feeding guilds selected are standard choices for ecological risk assessment for climates in the Great Lakes region.

Aquatic mammals

- Piscivore/omnivore
- Semi-aquatic herbivore

Aquatic birds

- Herbivore/invertivore
- Invertivore shore bird
- Piscivore/invertivore
- Omnivore

Terrestrial Mammals

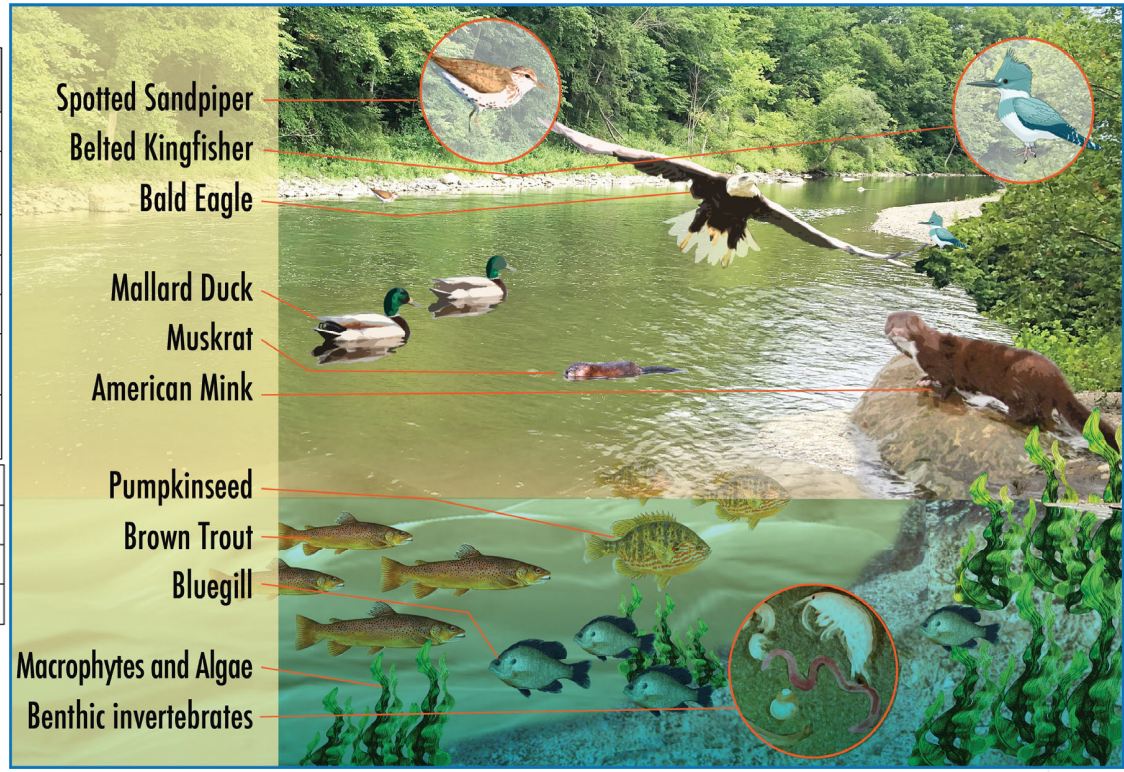
- Invertivore
- Herbivore
- Ominvore

Terrestrial Birds

- Insectivore
- Omnivore
- Carnivore

Aquatic Receptors and Indicator Species

Category	Taxonomic Group / Trophic Level	Aquatic or Semi-Aquatic Species
Macrophytes and Algae	Primary Producer	Filamentous algae, phytoplankton
Invertebrates (Planktonic, Benthic)	Primary Consumer	Aquatic macroinvertebrates
Fish	Primary Consumer	Pumpkinseed (*Lepomis gibbosus*)
		Bluegill (*Lepomis macrochirus*)
	Secondary Consumer	Brown Trout (*Salmo trutta*)
Aquatic Mammals	Primary Consumer	Muskrat (*Ondatra zibethicus*)
	Tertiary Consumer/Predator	American Mink (*Neovison vison*)
Birds	Primary Consumer	Mallard Duck (*Anas platyrhynchos*)
		Spotted Sandpiper (*Actitis macularius*)
	Tertiary Consumer	Belted Kingfisher (*Megaceryle alcyon*)
		Bald Eagle (*Haliaeetus leucocephalus*)

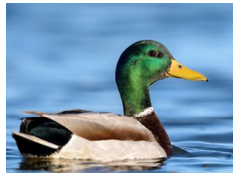


Terrestrial Receptors and Indicator Species

Category	Taxonomic Group/ Trophic Level	Terrestrial Species
Plants	Primary Producer	Terrestrial plants
Invertebrates	Primary Consumer	Soil invertebrates
Terrestrial Mammal	Primary Consumer	Eastern Cottontail (*Sylvilagus floridanus*)
	Secondary Consumer	Northern Short-tailed Shrew *(Blarina brevicauda)*
	Secondary Consumer	Meadow Vole (*Microtus pennsylvanicus)*
	Secondary Consumer	Raccoon *(Procyon lotor)*
Birds	Secondary Consumer	Tree Swallow *(Tachycineta bicolor)*
	Secondary Consumer	American Robin *(Turdus migratorius)*
	Tertiary Consumer	Red-tailed Hawk *(Buteo jamaicensis)*

Exposure Pathways and Routes per Receptor

Potentially Complete & Significant Exposure Routes: Aquatic Ecological Receptors		
Media Type	**Exposure Route**	**Receptor**
Surface soil	Ingestion of surface soil/plants	Muskrat
	Ingestion via surface prey	American mink & mallard duck
Surface water	Ingestion	American mink, muskrat, mallard duck, spotted sandpiper, belted kingfisher, bald eagle
	Direct contact/uptake	Macrophytes and algae, invertebrates, pumpkinseed, bluegill, brown trout
	Ingestion of macrophytes/algae	Invertebrates, pumpkinseed, muskrat, mallard duck
	Ingestion of aquatic prey	Invertebrates, pumpkinseed, bluegill, brown trout, American mink, mallard duck, spotted sandpiper, belted kingfisher, bald eagle
Sediment	Incidental ingestion	Invertebrates, American mink, muskrat, mallard duck, spotted sandpiper, belted kingfisher
	Direct contact/uptake	Macrophytes and algae, invertebrates



Exposure Pathways and Routes per Receptor (cont'd)

Potentially Complete & Significant Exposure Routes: Terrestrial Ecological Receptors		
Media Type	**Exposure Route**	**Receptor**
Surface soil	Dermal/direct contact	Terrestrial plants and invertebrates
	Dietary ingestion of soil/plants	Terrestrial invertebrates, northern short-tailed shrew, meadow vole, eastern cottontail, raccoon, American robin
	Dietary ingestion via prey	Northern short-tailed shrew, raccoon, tree swallow, American robin, red-tailed hawk
Surface water	Direct ingestion	Northern short-tailed shrew, meadow vole, eastern cottontail, raccoon, tree swallow, American robin, red-tailed hawk

Threatened and Endangered Species

The US Fish and Wildlife Service (USFWS) identified the following list of federally threatened, endangered, proposed, and candidate species that may occur within the Project Boundary.

Taxonomic Group	Federal List Designation	Species Scientific Name	Determination
Mammals	Threatened	Northern long-eared bat (*Myotis septentrionalis*)	No Effect
Birds	Endangered	Piping plover (*Charadrius melodus*)	NLAA
	Threatened	Rufa red knot (*Calidris canutus rufa*)	NLAA
Reptiles	Threatened	Eastern Massasauga rattlesnake (*Sistrurus catenatus*)	May Affect
Plants	Threatened	Pitcher's thistle (*Cirsium pitcheri*)	NLAA

NLAA = no likely adverse effect

USFWS Interactive Map: Example Species Range for Northern Long-eared Bat
https://www.fws.gov/species/northern-long-eared-bat-myotis-septentrionalis

Threatened and Endangered Species (cont'd)

BERA will address risks to threatened and endangered species, or similarly listed species:

Observed during site investigations	Reported to have been observed in the Project Boundary	Suitable habitat is available to support one or more species that were identified as potentially present by conservation program

Key Considerations in the BERA

Locations of listed species during biological surveys during biota sampling	Lower-bound toxicity reference values in risk calculations	Probabilistic risk assessment methods to quantify variability and uncertainty	Range of risk thresholds

Assessment and Measurement Endpoints

Assessment endpoints are an explicit expression of the environmental values to be protected.

Measurement endpoints are a measurable biological response to a stressor related to an assessment endpoint.

Measurement endpoints are frequently numerical expressions of observations compared to a control or reference EU.

Assessment Endpoints

Are concentrations of COPECs on- and off-base within the Project Boundary sufficient to cause a decreased ecological function or population abundance?

Are the COPEC exposures and risk estimates significantly greater than reference areas? If yes, is there evidence of ecological, biological impairment?

Are risk estimates dominated by COPEC concentrations in a particular exposure medium?

COPEC = chemical of potential ecological concern

Exposure Assessment

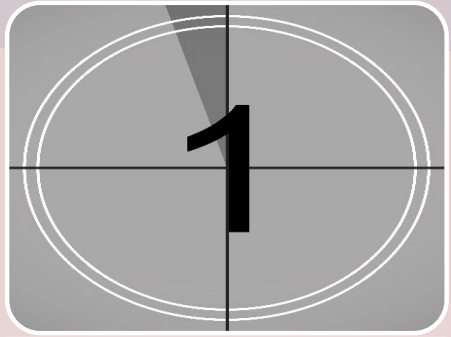
- **Technical Evaluation of Data**
- **Characterization of Ecological Effects**
- **Characterization of Exposure**

Exposure Units - Ecological

Exposure units for ecological receptor scenarios is determined by habitat preferences, home ranges and feeding territories. [Table 6-1 of Work Plan]

Linear distance of shoreline habitat for semi-aquatic mammals and birds		Acre (square grids) across the Project Boundary for terrestrial receptors			
0.5 km	3 km	0.25 acre	0.5 acre	1 acre	4 acres

Exposure Point Concentrations (EPCs)



EPC will be calculated based on the subset of sampling points within EU.

Calculated EPC using USEPA methods and tools (e.g., ProUCL)

Address data gaps by examining spatial patterns across EUs

Dose Equations and Exposure Factors

$$ADD_{Cumulative} = ADD_{diet} + ADD_{water}$$

where:

$ADD_{Cumulative}$	=	average daily dose (mg/kg BW per day)
ADD_{diet}	=	average daily dose via diet (food plus soil and/or sediment (mg/kg BW per day)
ADD_{water}	=	average daily dose via water (mg/kg BW per day)

- Section 6.2.3 of Work Plan provides Daily Dose calculation for dietary, water, and soil/sediment intake.
- Exposure parameter values are summarized by receptor in Appendix B, Tables B-1 through B-12.

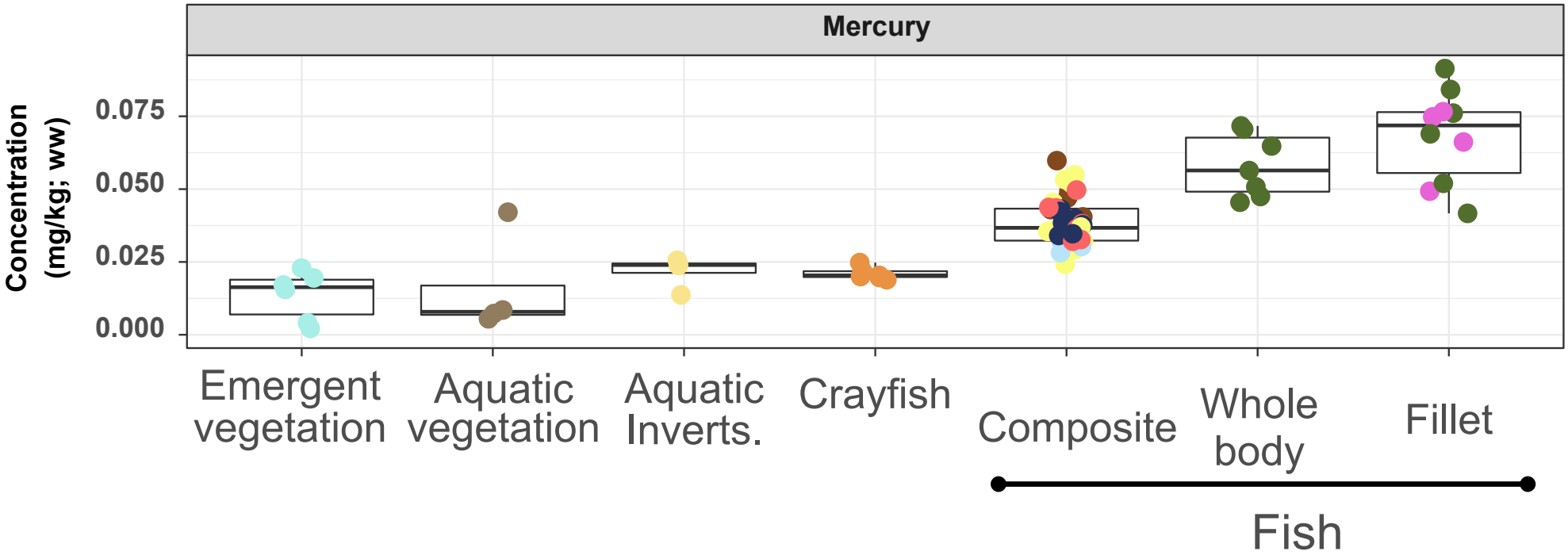
Estimating Concentrations in Biota

- Biota data will be compiled from Site investigations and open scientific literature

- Biota data will be supplemented by modeling concentrations using published media-to-tissue bioaccumulation factors (BAFs) and regression relationships.

- BAFs for selected PFAS
  - Table 6-4: invertebrates and plants
  - Table 6-5: fish

“Old School” Bioaccumulation - Mercury



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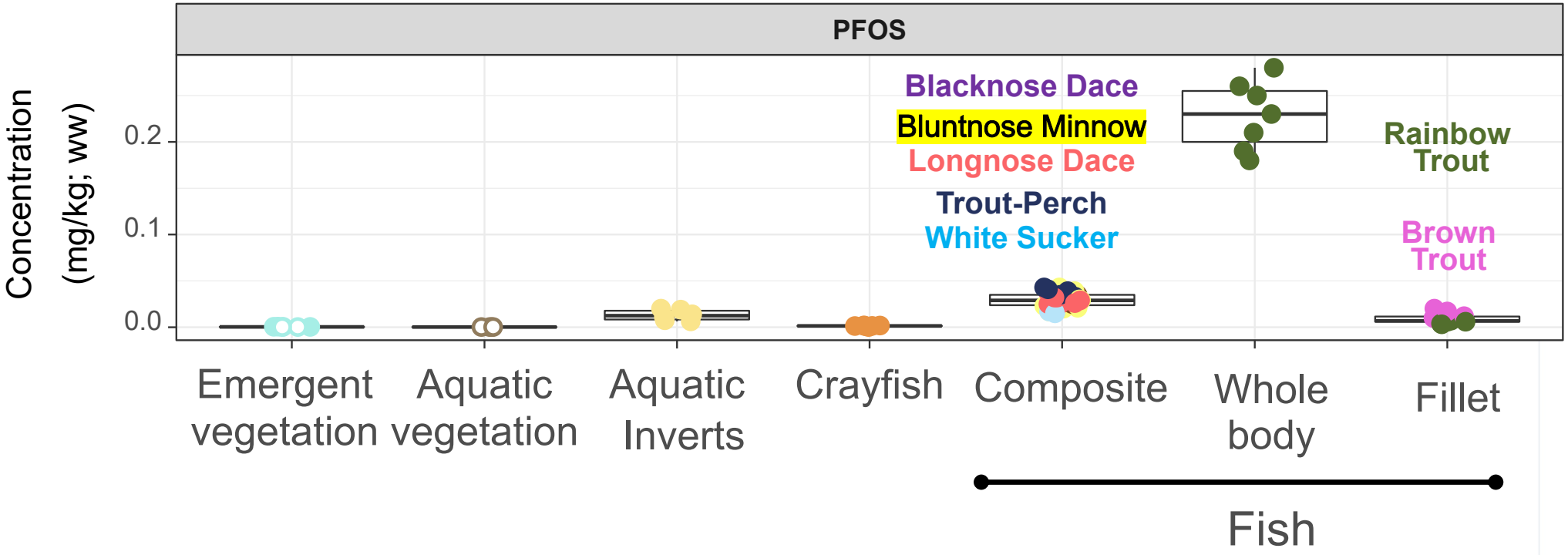
● Detect ○ Non-Detect

Distributions of PFOS Across Aquatic Biota



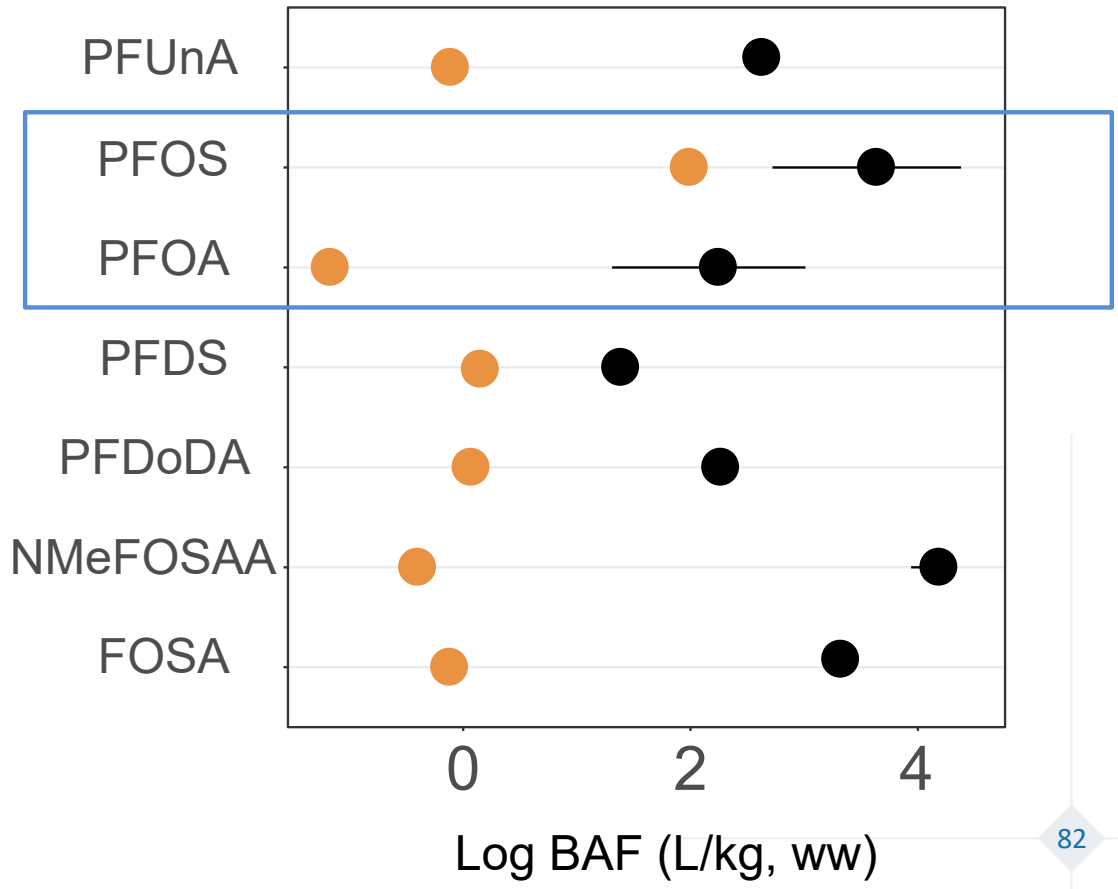
GSI ENVIRONMENTAL

● Detect ○ Non-Detect

Site-specific Data are Critical

Challenges to using BAFs:

- Diversity of PFAS characteristics
- Varying species-specific uptake
- **Environmental and geochemical modulators**



- Burkhard (2022) whole body BAFs
- Rainbow Trout: Remediation Site A (2021)

Effects Assessment

- **Screening Level Benchmarks**
- **NOAEL-based TRVs**
- **LOAEL-based TRVs**

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level

Toxicity Reference Values for PFAS (often in mg/kg-day)

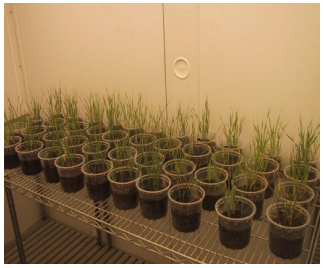
Table 6-9 in Work Plan provides Avian and Mammalian TRVs that will be used in the BERA

A toxicity reference value (TRV) is a dose of a specific chemical above which ecologically relevant effects might occur to wildlife or other species following chronic exposure and below which it is reasonably expected that such effects will not occur.

- **Species and endpoint specific (e.g., growth, reproduction, mortality)**
- **Route specific (e.g., dermal/gill uptake, ingestion, etc.**
- **NOAELs (No Observable Adverse Effects Level) or LOAELs (Lowest Observable Adverse Effect Level)**

Toxicity Studies by Media and Test Organism

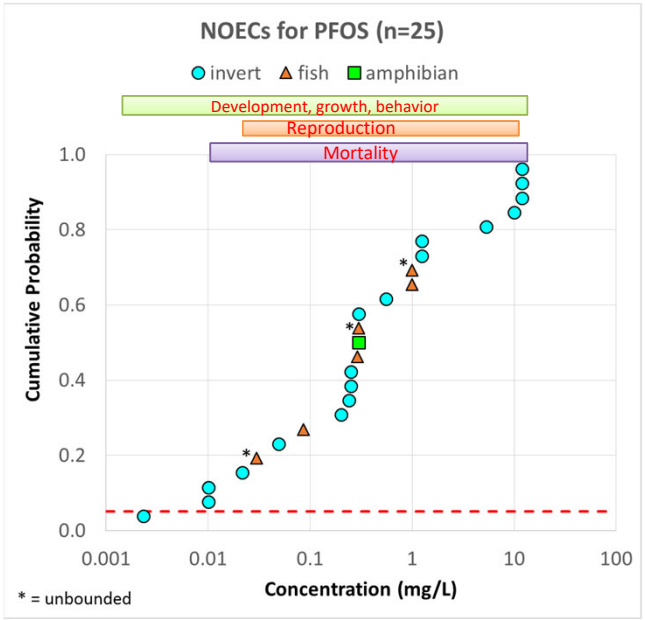
- Aquatic (surface water)
  - Acute Freshwater – copepods
  - Chronic Freshwater – fathead minnow
  - Acute Marine – bivalves
  - Chronic Marine – sheepshead minnow
- Sediment
  - Chronic Freshwater – amphipod
  - Chronic Marine - amphipod
- Terrestrial
  - Acute - earthworms
  - Chronic - plants
- Microbial
  - ATP-TOX
  - Microtox

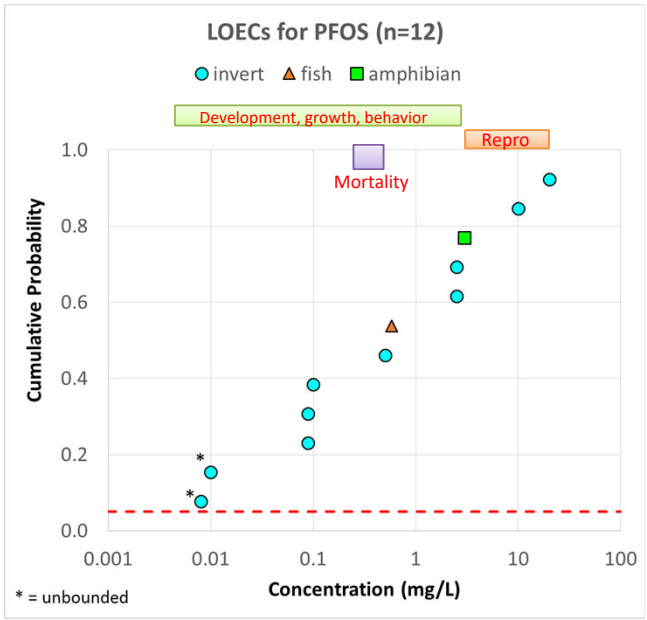


Medium	Common Name	Organism	Acute toxicity	Chronic toxicity	Bioaccum-ulation
Freshwater	Water flea	*Daphnia magna/pulex*	X	X	
	Water flea	*Ceriodaphnia dubia*	X	X	
	Fathead minnow	*Pimephales promelas*	X	X	
	Zebra fish	*Danio rerio*	X	X	X
	Green algae	*Pseudokirchneriella*		X	
	Northern Leopard Frog	*Rana pipiens* tadpoles	X	X	X
Freshwater sediment	Amphipod	*Hyalella azteca*	X	X	X
	Midge fly	*Chironomus*	X	X	
	Worm	*Tubifex tubifex*	X	X	X
	Black worm	*Lumbriculus*			X
	Asiatic clam	*Corbicula fluminea*			X
Estuarine/marine water column	Mysid shrimp	*Americamysis bahia*	X		
	Sheepshead minnow	*Cyprinodon variegatus*	X	X	
	Silverside	*Menidia beryllina*	X		
Estuarine/marine sediment	Amphipod	*Leptocheirus*	X	X	X
	Amphipod	*Ampelisca abdita*	X		
	Amphipod	*Eohaustorius estuarius*	X		X
	Polychaete worm	*Neanthes*	X	X	X
	Bent nose clam	*Macoma nasuta*			X
	Polychaete worm	*Nereis virens*			X
	Hardshell clam	*Mercenaria*			X
	Clam	*Yoldia limatula*			X
	Copepod	*Amphiascus tenuiremis*	X	X	
Soil	Earthworm	*Eisenia fetida*	X	X	X

http://www.epa.gov/oswer/riskassessment/ecoup/pdf/v2no2.pdf

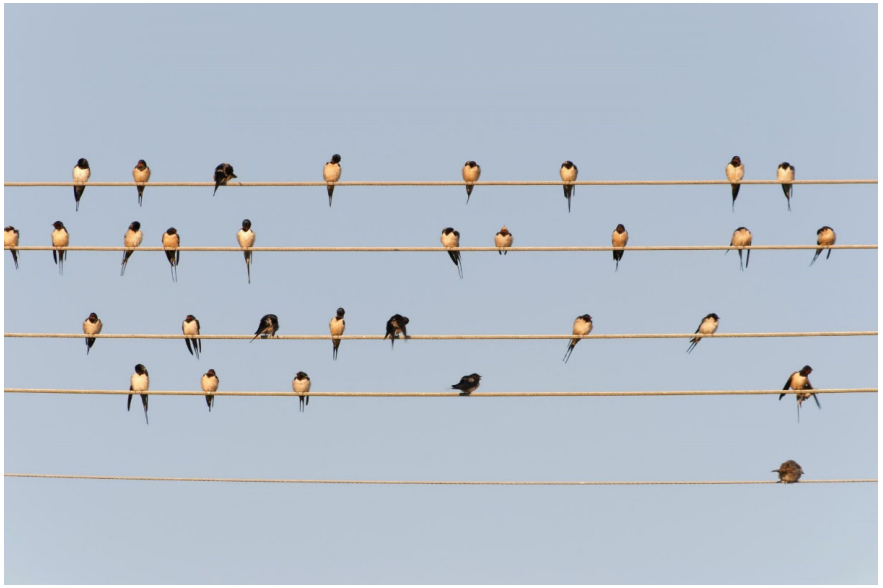
Example – Distribution of TRVs for PFAS





- Database (number of studies): invertebrates > fish > amphibians
- 5th percentile LOEC ~ 0.01 mg/L (10 µg/L); 5th percentile NOEC ~ 0.005 mg/L (5 µg/L)
- Typical background PFOS in surface water: < 0.1 µg/L (Vedagiri et al. 2018)

Risk Characterization



- Combines potential EU-related exposure with effects to estimate likelihood of ecological risks
- Conducted for each COPEC and receptor scenario
- Includes risk description that interprets risk estimates by lines of evidence

Risk Estimation

$$HQ = \frac{Exposure}{Toxicity\ Value}$$

where:

HQ	=	hazard quotient (HQ)
Exposure	=	EPC (mg/kg or mg/L) or average daily dose (mg/kg bw-day)
Toxicity Value	=	toxicity value (mg/kg or mg/L) for ecological communities or toxicity reference value (mg/kg-bw/day) for wildlife exposed to soil/sediment and prey.

Risk Estimation (cont'd)

HQ ≤ 1 indicates that there is a high likelihood of no impacts to ecological receptors

HQ > 1 indicates that a *potential* impacts to ecological receptor exists that may warrant further evaluation

Hazard Index: HQs will be summed across COPECs that share a common mode of action or effect endpoint (USEPA 1998 Ecological Guidelines)

Risk Description

For COPECs with HQs > 1, the likelihood of potential adverse effects will be evaluated using multiple lines of evidence:

Protection of Populations/Communities

- PFOS in eggs and tree swallow hatching success

Reproductive Toxicology 33 (2012) 556–562

Contents lists available at ScienceDirect

Reproductive Toxicology

journal homepage: www.elsevier.com/locate/reprotox

Exposure and effects of perfluoroalkyl compounds on tree swallows nesting at Lake Johanna in east central Minnesota, USA

Christine M.

ARTICLE

Archives of Environmental Contamination and Toxicology (2019) 77:1–13
https://doi.org/10.1007/s00244-019-00620-1

Perfluoroalkyl Contaminant Exposure and Effects in Tree Swallows Nesting at Clarks Marsh, Oscoda, Michigan, USA

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Received: 30 November 2018 / Accepted: 22 March 2019 / Published online: 6 April 2019
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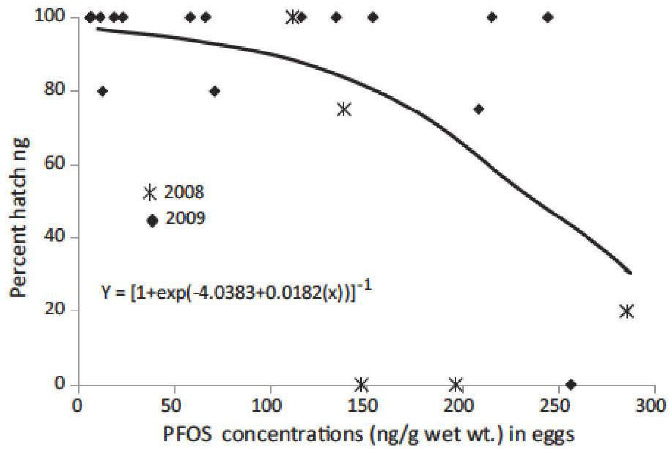
Abstract

A site in northeastern Michigan, Oscoda Township, has some of the highest recorded exposure in birds to perfluorinated substances (PFASs) in the United States. Some egg and plasma concentrations at that location exceeded the lowest reproductive effect threshold established for two avian laboratory species. The objectives of this study were to determine whether there were reproductive effects or physiological responses in a model bird species, the tree swallow (*Tachycineta bicolor*), associated with this extremely high exposure to PFASs. The lack of exposure above background to other contaminants at this site allowed for an assessment of PFAS effects without the complication that responses may be caused by other contaminants. A secondary objective was to determine the distribution of PFASs in multiple tissue types to better understand and interpret residues in different tissues. This can best be done at highly exposed locations where tissue concentrations would be expected to be above detectable levels if they are present in that tissue. There were no demonstrable effects of PFAS exposure on reproduction nor on most physiological responses.

- Minnesota study showed reproductive effects at ~ 150 ng/g ww



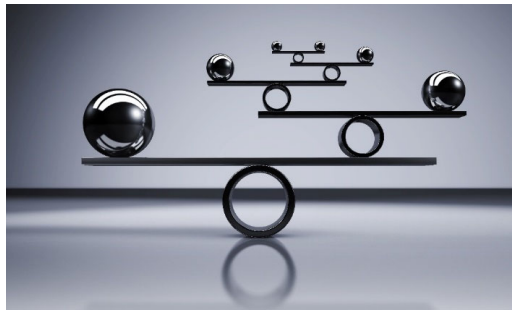
Source: Custer et al. 2012

- Michigan study showed no effects at 730 ng/g ww (median) on reproduction or associated biomarkers
  - Low exposure to non-PFAS chemicals
  - PFAS profile dominated by PFOS
  - Consistent with toxicity reference values ~ 1,000 ng/g ww

Source: Custer et al. 2019

Uncertainty Analysis

Uncertainties are inherent in the BERA process and cannot be eliminated; however, their impact can be better understood by:



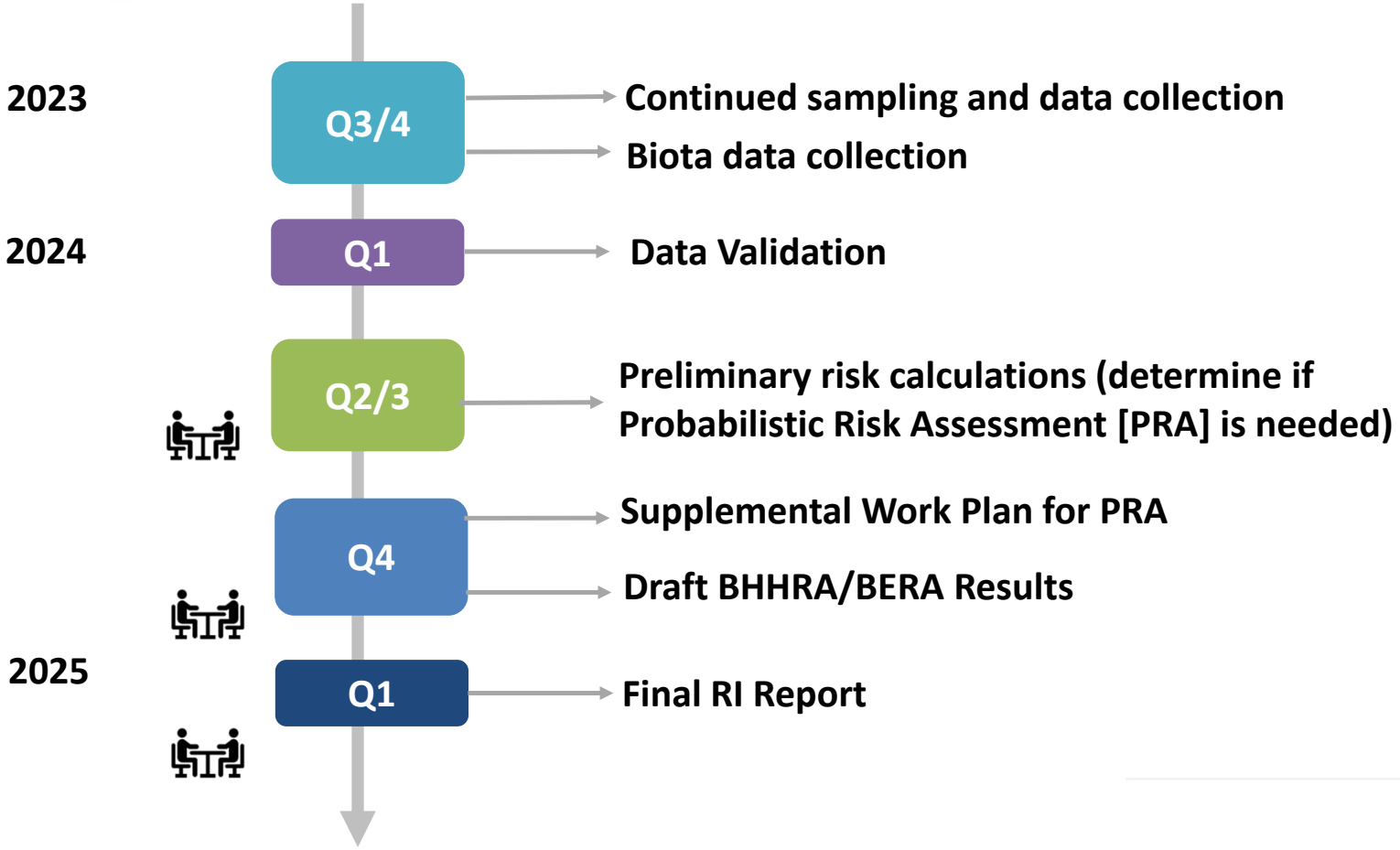
Qualitative Assessment of Uncertainty: 1) Identify sources of uncertainty and variability; 2) Conduct sensitivity analysis for important components.

Probabilistic Risk Assessment: a stochastic model may be used with probability distributions of key variables for COPECs with HQ > 1.

Additional Uncertainty Analysis Considerations: discussion related to level of confidence in exposure and effects assessment.

Questions?

Risk Assessment Schedule



Key Take Home Points

- Air Force must follow all applicable policies and guidance (EPA, DoD and CERCLA – Federal Law) – Work Plan complies with applicable guidance
-  Human exposure can potentially occur via various pathways including fish/game
-  Ecological receptors include fish, invertebrates, plants, mammals, and birds
- Science and regularity landscape continues to change rapidly: GSI scientist are knowledgeable in this area and stay abreast of evolving science related to PFAS
-  Things to Watch: DoD policies, USEPA guidance, changing PFAS toxicity information

THANK YOU

GSI ENVIRONMENTAL

Science · Strategy · Solutions

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