



Ecological Risk Assessment

AN OVERVIEW

Margaret G Forbes, PhD
Lewisville, Texas



Presentation Overview

What-Why-When Ecological Risk Assessment?

Common Concepts

Conducting an ERA

- Tier 1
- Tier 2
- Case Study – Petroleum Release
- Tier 3

Conclusions

What is an ERA?

...a process that evaluates the **likelihood** that **adverse ecological effects** are occurring or may occur as a result of exposure to one or more **stressors** (EPA, 1992).

...the ERA provides a **recommendation** to support a **risk management decision**.

WHY CAN'T ANYONE SEE HOW DEAD THESE ARE??





Credit Adrees Latif/Reuters

Cars sit in a pool of leaked fuel and floodwaters after Harvey smacked Port Arthur, Texas. Thomson Reuters

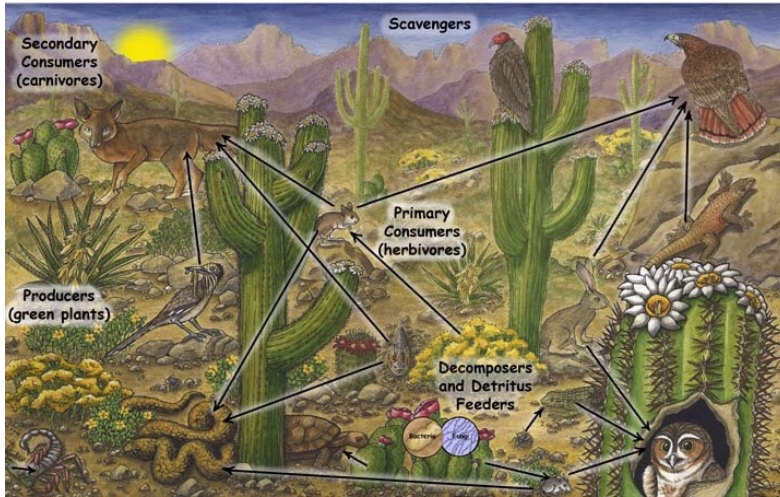
Under the Texas Risk Reduction Program (TRRP) rule, some form of an ERA is required to be conducted at all remediation sites.

Purpose of an ERA

- Determine if a remediation site has potential or actual ecological risk.
- Screen chemicals of concern (COCs) to determine which are causing the risk.
- Focus additional assessment (a single wildlife group or species, or a certain location “hotspot”); and
- If unacceptable risk cannot be eliminated, develop protective concentration levels (PCLs).

Ecological vs Human Health Risk Assessment

Desert Food Web



- Multiple Ecosystems
- Many Species
- Complex Environment



Eco- PCL

Human Food Web



- Single Ecosystem
- One Species
- Simple Environment



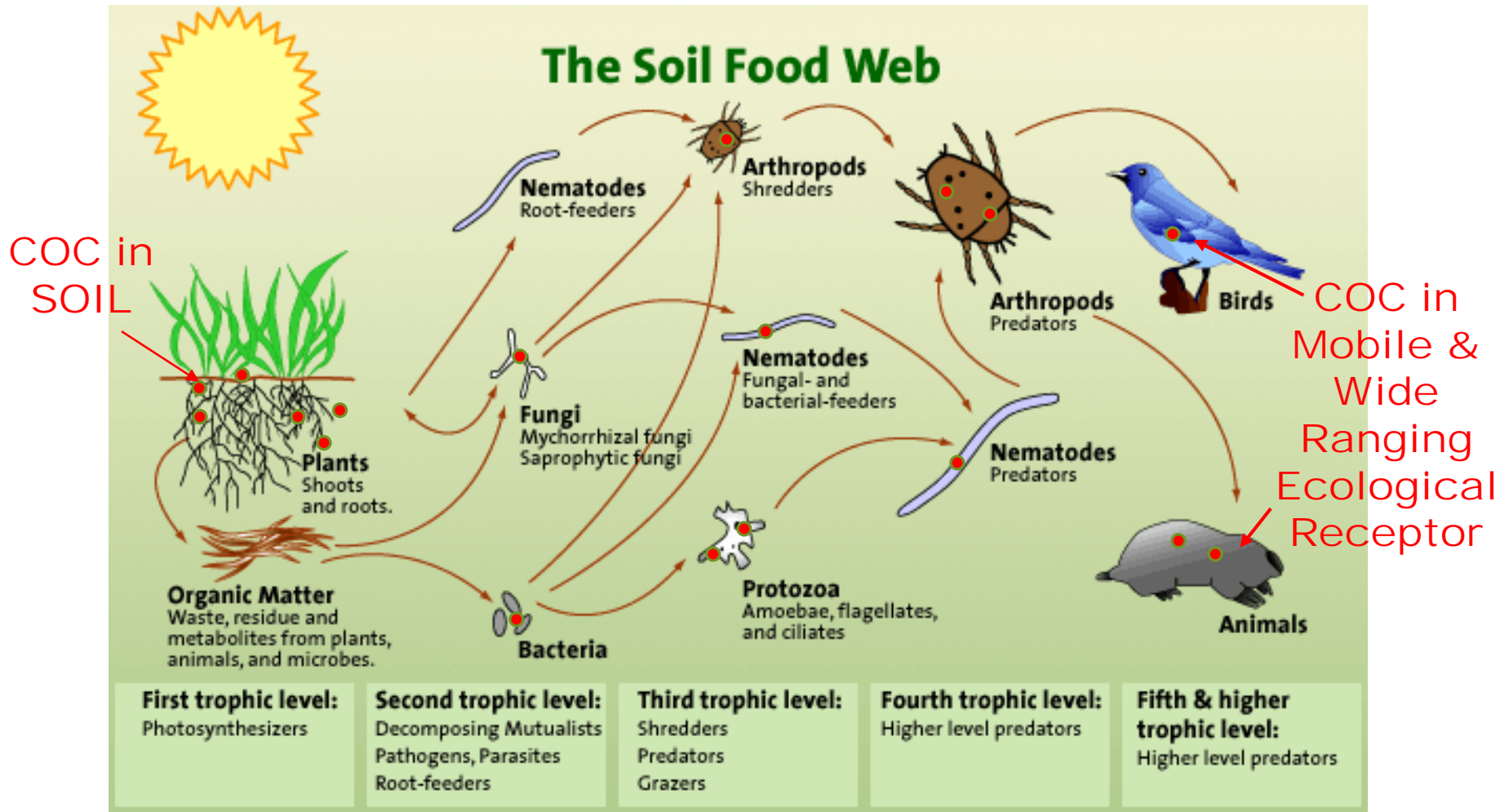
Human Health PCL

CRITICAL PCL

What are Potential Affected Media?

- Surface Water
- Sediment
- Surface Soil
(0 to 0.5 ft bgs)
- Subsurface Soil
(0.5 to 5 ft bgs)

Complete Exposure Pathway



Tier 1 – Purpose

- A TRRP Form (check-the-box) that requires detailed site description and release history;
- Lists conditions that allow a property or media to be excluded from further ecological assessment;
- Documents the presence or absence of complete & significant ecological exposure pathways.



Property Boundary

“Disturbed Ground”

Surface Water/Sediment

Exposure Pathway Example – BTEX & PAHs in Soil & Groundwater

Tier 1 – Exclusion Criteria Checklist



- No complete pathway to nearest waterbody (eliminates surface water);
- No COCs within top 5 feet of ground surface (eliminates soil); or
- Affected area is “disturbed ground”; or
- De Minimis* Land Area
 - ✓ Affected area is now and will remain \leq 1 acre; and
 - ✓ No impact on Protected Species; and
 - ✓ Similar habitat within 0.5 mile; and
 - ✓ Not within 0.25 mile of sensitive area.



“Disturbed Ground”

Property Boundary

Surface Water/Sediment

Complete pathway for soil on **part** of property
Complete pathway via groundwater is present off property
“Affected Property” includes soil, surface water, sediment

Two Texas Wildcards – More Exit Strategies

- Reasoned Justification
- Expedited Stream Evaluation



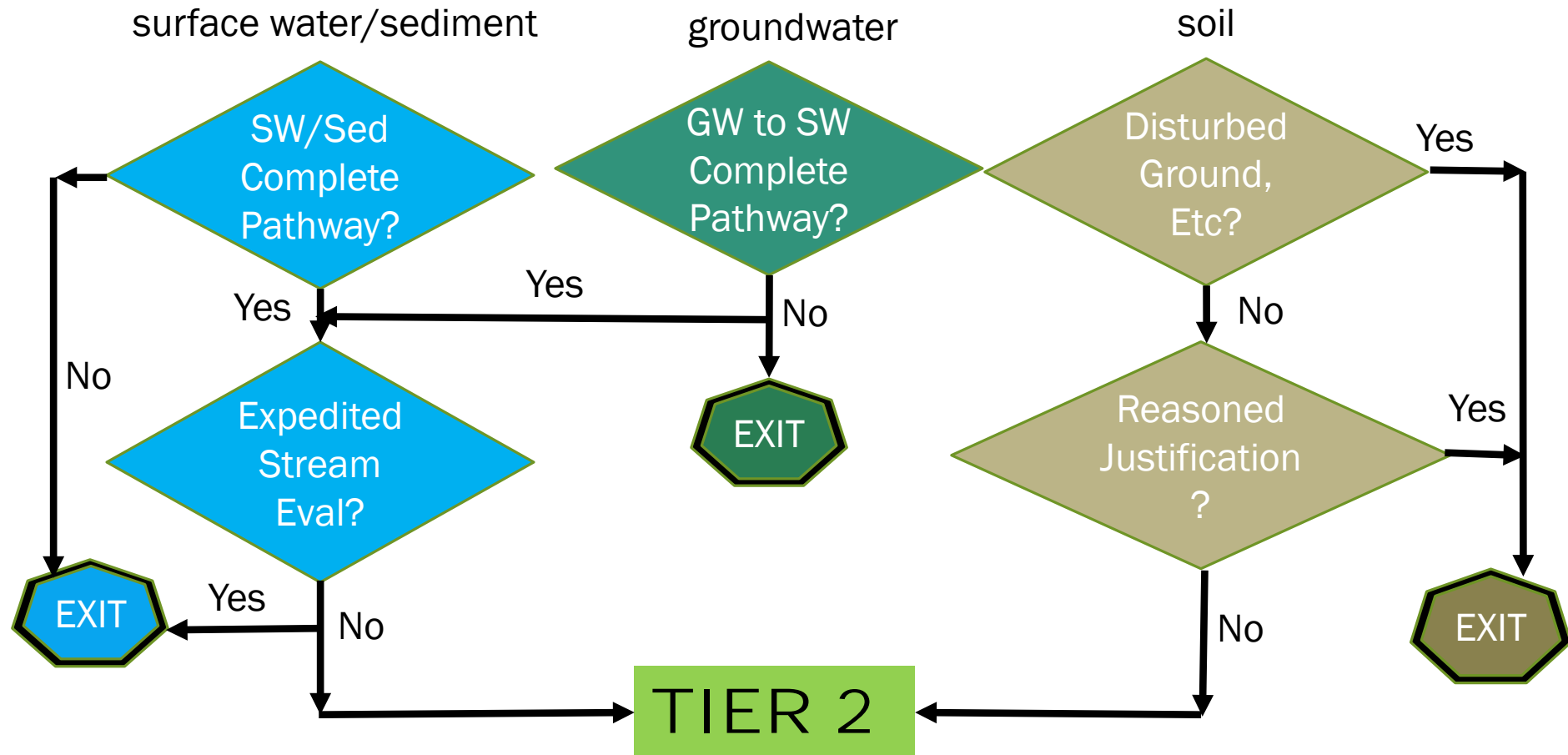


Expedited Stream Evaluation






Summary

TIER 1



Tier 2 – Screening Level ERA

1. Screen COCs against ecological benchmarks.
 - retain COCs/media that exceed benchmarks.
 - retain COCs that are bioaccumulative.
2. Develop food webs & select receptor species (guilds).
3. Dose the eco-receptors and measure the risk.
4. Calculate concentration that would produce acceptable risk (i.e. the Eco-PCL).

Case Study – Gasoline Release

RECALL FROM TIER 1

1. Data indicate BTEX & PAHs in top 5 ft of soil.
2. Part of affected area is not “disturbed ground”.
3. There is a complete pathway to surface waters.

Tier 1 Conclusions

Surface water, sediment, and soil COCs are carried into Tier 2.

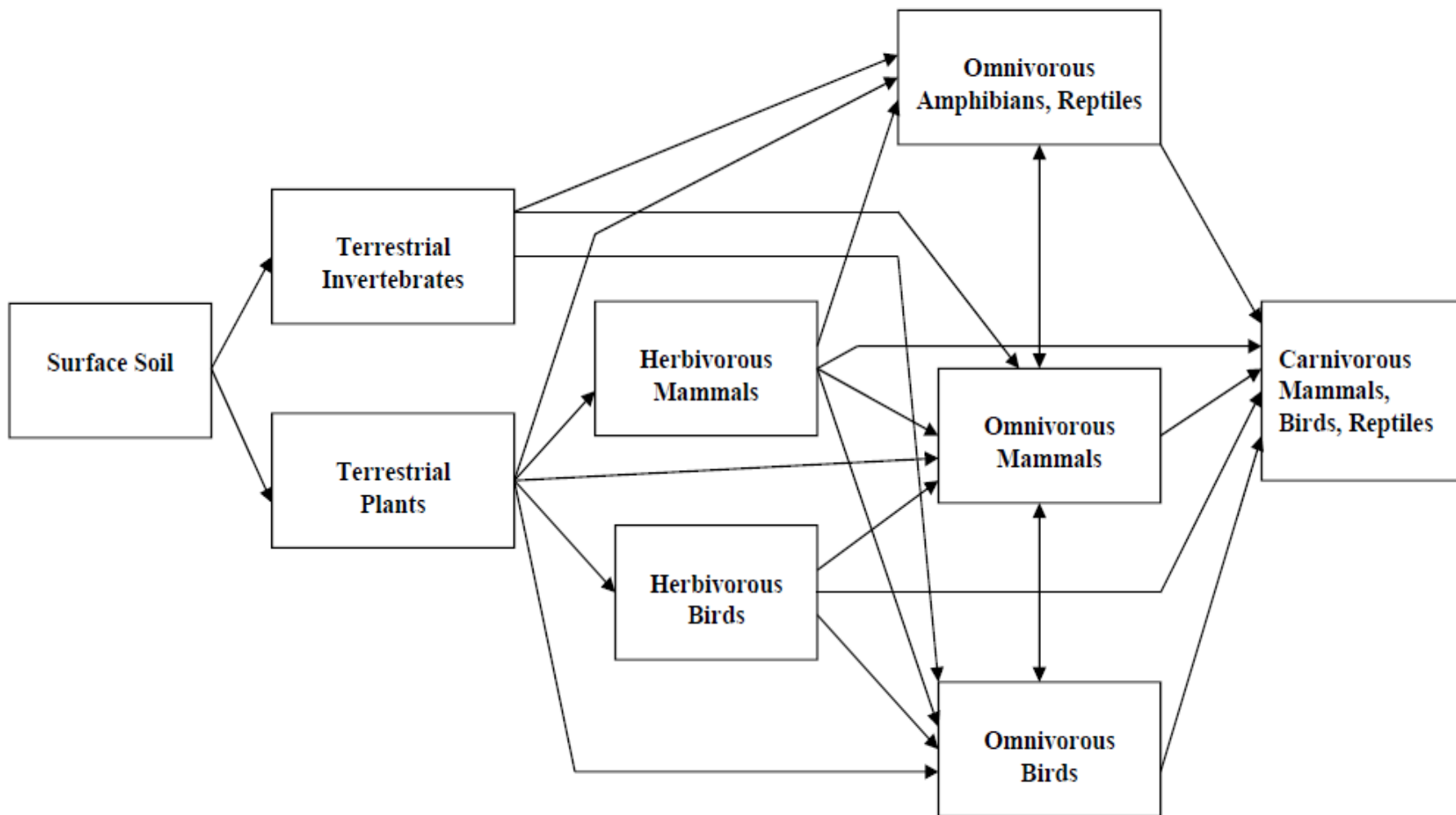


First Step in Tier 2 -Screen COCs against Ecological Benchmarks.

Surface Soil Chemical of Concern	Maximum Site Concentration mg/kg:	Soil Ecological Benchmark mg/kg:
BTEX		
Toluene	19	200 ^b
Xylenes	0.012	0.05 ^a
PAHs		
1-Methylnaphthalene	0.08	0.9 ^c
2-Methylnaphthalene	0.04	0.9 ^c
Acenaphthene	8.2	20 ^b
Acenaphthylene	0.89	0.9 ^c
Anthracene	0.08	0.1 ^a
Fluorene	15.2	30 ^b
Naphthalene	200	0.1 ^a
Phenanthrene	0.08	0.1 ^a

Only naphthalene is carried forward.

Tier 2 Step 2 – Ecological Receptors & Pathways



Tier 2 Step 3 – Exposure Assessment

- Calculate the 95%UCL of the COC concentrations in each retained media (e.g. 190 mg/kg Naphthalene)
- Develop an “exposure model” for representative species.
- Calculate the initial (worst case) exposure as a daily dose via oral ingestion.
- Compare that daily dose to a threshold “no effects” dose

Initial Exposure Example – Cottontail & Naphthalene

Cottontail food
ingestion rate
(kg/d)

Cottontail water
ingestion rate
(L/d)

Naphthalene concentration
in water (mg/L) = $95\%UCL_{wtr}$

Cottontail incidental
soil ingestion
rate (kg/d)

Naphthalene concentration
in food/soil (mg/L)
= $95\%UCL_{soil}$



Cottontail
body weight (kg)

$$Naph\ Dose = \frac{[food+soil+water]}{BW} = mg/kg-d$$

Calculate the Worst Case Daily Dose –

Initial Assessment Exposure Dosage Calculations for Naphthalene in Surface Soil.



Soil Representative Species	Body Weight (kg) ^a	Food Ingestion Rate (kg/day)	Soi Conc. (mg/kg)	Media Conc. (mg/kg)	Food Conc. (mg/kg)	Soil Ingestion ^c (% of Food Ingestion)	Water Ingestion Rate (L/day)	Surface Water Conc. (mg/L)	Dosage Oral (mg/kg /day)
Cottontail	1.2197	0.8428	190	190	190	2.4	0.1184	0.02	134

Calculate the Hazard Quotient

$$HQ_{\text{NOAEL}} = \frac{\text{Dose}}{\text{TRV based on NOAEL}}$$

NOAEL is the highest dose of a substance at which no adverse effect is found in exposed test organisms.

EPA defines **LOAEL** as the lowest level of a chemical stressor that shows harmful effects on a plant or animal.

If the $HQ > 1$, the species is at unacceptable risk.

Hazard Quotient Results Cottontail – Naph - Surface Soil

Surface Soil Representative Species	Dosage _{oral} (mg/kg/day)	TRV _{NOAEL} (mg/kg/day)	TRV _{LOAEL} (mg/kg/day)	↓	Hazard Quotient
				NOAEL	
cottontail	134	53	267	2.54	0.50



Eastern Cottontail HQ is > 1

Options if HQ > 1 for Any Species

Two Commonly Used Exposure Modifying Factors

1. Area Use Factor – species specific
2. Bioconcentration Factor – species & chemical-specific

Modify the Assumption that Cottontail Feeds Exclusively within Affected Area

Naph-affected Area = 0.78 ac

Home Range = 7.73 ac



$$\text{Area Use Factor (AUF)} = \frac{\text{Affected Area}}{\text{Home Range}} = 0.101$$

Modify the Dose & HQ by Applying the Area Use Factor

Modified Naphthalene Dose = AUF x Initial Dose

$$= 0.101 \times 134 = 13.5 \frac{\text{mg}}{\text{kg} - \text{d}}$$

Representative Species	Dosage _{oral} (mg/kg/day)	TRV _{NOAEL} (mg/kg/day) ^a	TRV _{LOAEL} (mg/kg/day)	Hazard Quotient ^b _{NOAEL}	Hazard Quotient ^b _{LOAEL}
Cottontail	13.5	53	267	0.26	0.05



Could Also Modify the Dose by Applying the Bioconcentration Factor (BCF) – **[Food] ≠ [Soil]**



$$\begin{aligned} BCF \text{ Modified Food Conc} &= 95\%UCL \times BCF_{soil \text{ to plant}} \\ &= 190 \times 0.122 \\ &= 23.18 \text{ mg/kg} \end{aligned}$$

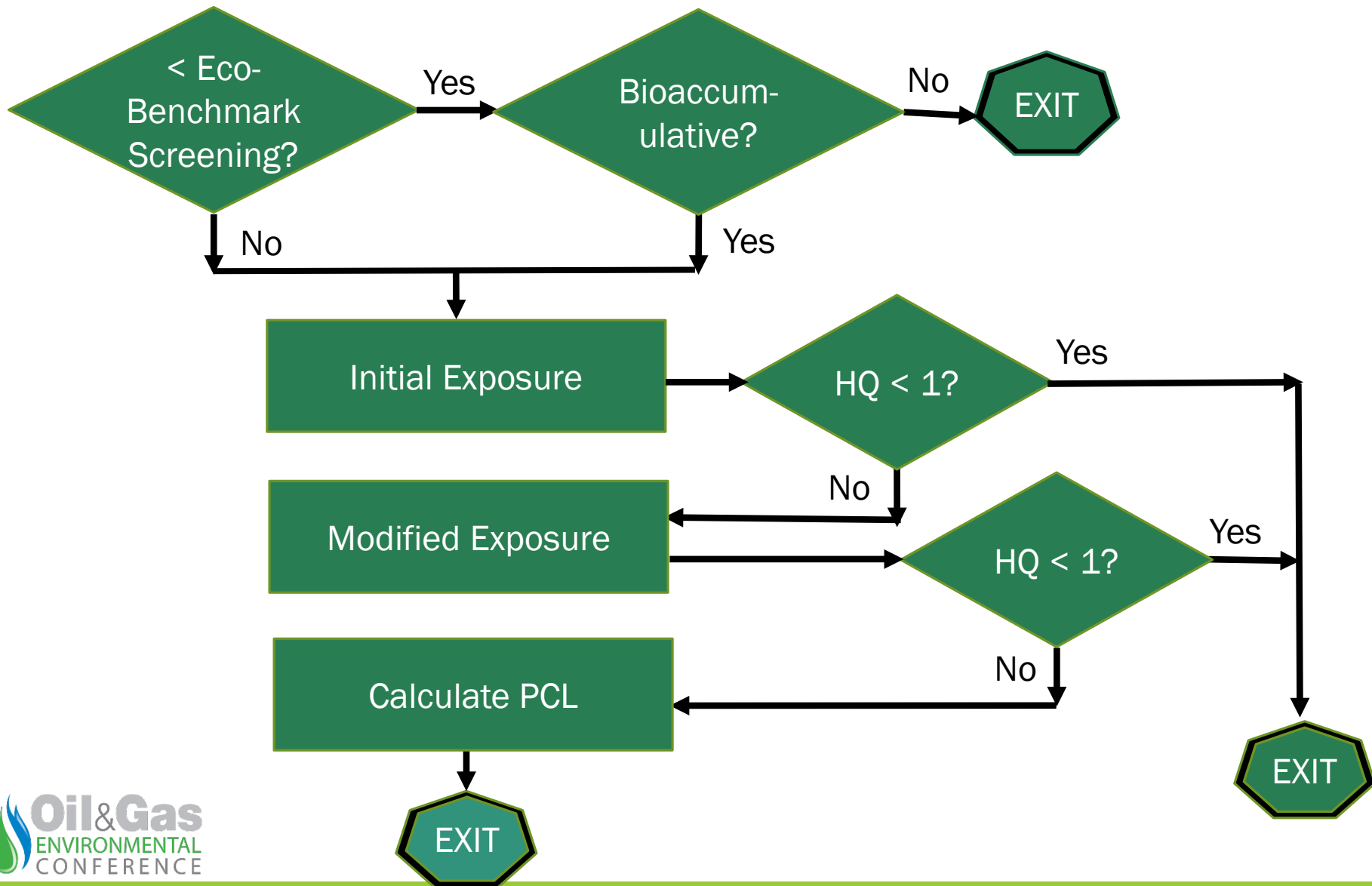
If All Species Cannot be Eliminated, Calculate the Eco-PCL*

- The PCL is the concentration of the COC in media that will produce a **HQ = 1**
- There is a PCL_{NOAEL} and a PCL_{LOAEL}
- In most cases, the Eco-PCL is the midpoint of these two numbers.
- Remember, the **critical PCL** is the lower of the Eco-PCL and the Human Health PCL.



Summary

TIER 2



Tier 3 –Site-specific ERA

- Some Tier 3 actions could include:
 - tissue residue and bioaccumulation studies
 - comparison of site data to reference area data (e.g. surveys)
 - toxicity tests with site-collected media
- Optional, time-consuming, costly

Conclusions

- Eco-risk assessment is an iterative process.
- Many ERAs exit at Tier 1 or early in Tier 2.
- PCLs are calculated only if risk to all selected species cannot be eliminated.
- ERAs support risk management decisions.

Questions?



Margaret G Forbes, PhD
Principal Environmental Scientist
Lewisville, Texas

E. mforbes@gesonline.com

T. 800-871-6417 ext.3406