Poll Question: What is Your Experience Level with Soil Contaminant Bioavailability?

• little or no experience
• some knowledge and experience
• expert
Training Course Overview:


Risk-based cleanup goals are often calculated assuming that chemicals present in soil are absorbed by humans as efficiently as the chemicals dosed during the toxicity tests used to determine regulatory toxicity values (such as the Reference Dose or Cancer Slope Factor). This assumption can result in inaccurate exposure estimates and associated risks for some contaminated sites because the amount of a chemical absorbed (the chemical's bioavailability) from contaminated soil can be a fraction of the total amount present. Properly accounting for soil-chemical interactions on the bioavailability of chemicals from soil can lead to more accurate estimates of exposures to soil contaminants and improve risk assessments by decreasing uncertainty.

The basis for this training course is the ITRC guidance: Bioavailability of Contaminants in Soil: Considerations for Human Health Risk Assessment (BCS-1). This guidance describes the general concepts of the bioavailability of contaminants in soil, reviews the state of the science, and discusses how to incorporate bioavailability into the human health risk assessment process. This guidance addresses lead, arsenic, and polycyclic aromatic hydrocarbons (PAHs) because evaluating bioavailability is better understood for these chemicals than for others, particularly for the incidental ingestion of soil.

The target audience for this guidance and training course are:
- Project managers interested in decreasing uncertainty in the risk assessment which may lead to reduced remedial action costs.
- Risk assessors new to bioavailability or those who want additional confidence and training in the current methods and common practices for using bioavailability assessment to more accurately determine human health risk at a contaminated site.

As a participant in this training you should learn to:
- Value the ITRC document as a “go-to” resource for soil bioavailability
- Apply the decision process to determine when a site-specific bioavailability assessment may be appropriate
- Use the ITRC Review Checklist to develop or review a risk assessment that includes soil bioavailability
- Consider factors that affect arsenic, lead and PAH bioavailability
- Select appropriate methods to evaluate soil bioavailability
- Use tools to develop site-specific soil bioavailability estimates and incorporate them into human health risk assessment

Learners can envision themselves implementing the ITRC guidance through case study applications. Training participants are encouraged to view the associated ITRC guidance, Bioavailability of Contaminants in Soil: Considerations for Human Health Risk Assessment (BCS-1) prior to attending the class.
Notes:
I’m sure that some of you are familiar with these rules from previous CLU-IN events, let’s run through them quickly for our new participants.

We have started the seminar with all phone lines muted to prevent background noise. Please keep your phone lines muted during the seminar to minimize disruption and background noise. During the question and answer break, press #6 to unmute your lines to ask a question (note: *6 to mute again). Also, please do NOT put this call on hold as this may bring unwanted background music over the lines and interrupt the seminar.

Use the “Q&A” box to ask questions, make comments, or report technical problems any time. For questions and comments provided out loud, please hold until the designated Q&A breaks.

Everyone – please complete the feedback form before you leave the training website. Link to feedback form is available on last slide.
The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and Puerto Rico and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we’re building the environmental community’s ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the “contacts” section at www.itrcweb.org. Also, click on “membership” to learn how you can become a member of an ITRC Technical Team.

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Bryn Thoms is a hydrogeologist with Oregon Department of Environmental Quality’s (ODEQ) Cleanup Program in Eugene, Oregon. Since 1998, Bryn has worked in ODEQ’s Cleanup Program with prior experience in environmental consulting. Bryn oversees a variety of cleanup projects including solvent groundwater plumes, legacy pesticide sites, former wood products mill sites, petroleum releases, and abandoned mine lands. His work on abandoned mine lands has led him to assisting on cleanup of mercury mines and artisanal gold mines internationally. In 2015, he became active with ITRC in the Bioavailability of Contaminants in Soil Team as a result of overseeing one of the first ODEQ projects that utilized bioavailability adjustments in human health risk assessment. Bryn helped develop the Decision Section of the Bioavailability Guidance document, where his regulatory experience provided valuable perspective on incorporating bioavailability into the regulatory cleanup process. He has led presentations on assessment and cleanup of mercury and arsenic-contaminated sites to several university geochemistry classes, NGOs, and the Peru Ministry of Environment. Bryn earned a bachelor’s degree in geology from Oregon State University in Corvallis, Oregon in 1992. He has been an Oregon registered professional geologist since 1997.

Yvette Lowney is Principal and owner of Alloy, LLC. She has been an environmental consultant since the 1980s, and represents SERDP on the ITRC project team. She has served as PI on research programs to assess the bioavailability of metals and organic chemicals from soil, and has extensive experience in applying bioavailability adjustments in human health risk assessments, addressing issues of data collection, bioavailability evaluations, incorporation in risk calculations, and negotiations for regulatory approval. She worked within the California Department of Health Services for several years before entering the consulting community. Yvette joined the ITRC Bioavailability in Contaminated Soils Team in 2015 and is one of the lead authors on the introduction, arsenic, and PAH chapters of the document. Yvette earned a Bachelor’s degree in Molecular, Cellular, and Developmental Biology from The University of Colorado, Boulder in 1992, and a Master’s degree in Public Health from UC Berkeley in 1996.

Kevin Long is a Principal Consultant in Terraphase’s Princeton, NJ office. Since 2000, he has applied risk assessment and risk management strategies to support site characterization, risk management, and redevelopment at hazardous waste and brownfield sites under Superfund, RCRA, and various state and provincial cleanup programs. Working on such projects, he has helped to control unacceptable human exposures at dozens of sites, including those that may pose an imminent and substantial danger to human health. Such projects have involved addressing contamination in all sorts of environmental media and, in many cases, have required complex exposure assessment, fate and transport modeling, statistical analysis, risk management design, and risk communication. He has been a member of the ITRC Risk Assessment team since 2012. Kevin earned a bachelor’s degree in 2000 and master’s degree in 2006, both in Civil and Environmental Engineering, from Princeton University in Princeton, NJ.

Dr Valerie Hanley is a Staff Toxicologist in the Human and Ecological Risk Office at the California Department of Toxic Substances Control (DTSC) in Sacramento, CA. Valerie has been with DTSC since 2008. She recently authored a Human Health Risk Assessment Note on how to evaluate Arsenic contaminated sites with a specific emphasis on how and when to use bioavailability in those site evaluations. Valerie has been involved in the study of arsenic bioavailability since 2009 when DTSC was awarded funding from US EPA to evaluate and develop new methods to determine arsenic bioavailability in mining soils. Through this work Valerie helped develop the California Arsenic Bioaccessibility (CAB) Method, which is now recommended for use in sites throughout California. Valerie joined the ITRC Bioavailability in Contaminated Soils Team in 2015 and is one of the lead authors on the arsenic chapter of the document. In addition to her work on arsenic, Valerie evaluates Human Health Risk Assessments for a variety of sites and is involved in DTSC’s Safer Consumer Products program. Valerie earned a Bachelor’s degree in Molecular, Cellular, and Developmental Biology from The University of California (UC) Santa Cruz in 2001 and her PhD in Comparative Pathology from UC Davis in 2007. She completed a postdoctoral fellowship at UC Davis in Respiratory Toxicology in 2008.

Barrie Selcoe is a Principal Technologist with Jacobs in Houston, Texas. Barrie has worked at Jacobs since 2018, specializing in human health risk assessment. She is responsible for planning and overseeing human health risk-based activities at hazardous waste sites across the U.S. and internationally. She utilizes numerous federal (USEPA and Department of Defense) and state guidance documents in risk assessment projects, and is involved in all stages of site planning, investigation and reporting, cleanup level identification, and remedial action planning. She has been involved in risk assessments in 40 states and about 20 countries. She has worked on risk assessments incorporating incremental sampling and site-specific bioaccessibility studies. She has provided risk assessment services for numerous Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Superfund sites, Resource Conservation and Recovery Act (RCRA) facilities, state-program sites, voluntary actions, and international projects. She has prepared risk assessments for various types of sites, including industrial and commercial facilities, industrial and municipal landfills, bulk fuel terminals, rivers, U.S. Department of Defense facilities, and residential areas. Prior to Jacobs (which purchased CH2M in 2018), she worked as a human health risk assessor for 19 years with CH2M, 7 years with Philip Environmental, and 3 years with O’Brien & Gere Engineers. Since 2013, Barrie has contributed as a team member on ITRC’s Risk Assessment team, Bioavailability in Contaminated Soil team, TPH Risk Evaluation at Petroleum-Contaminated Sites team, and PFAS team. She earned a bachelor’s degree in microbiology from San Diego State University in San Diego, California in 1986, and a Master’s of Public Health from the University of Pittsburgh Graduate School of Public Health in Pittsburgh, Pennsylvania in 1999.
Today’s Training Road Map

- Importance of Evaluating Bioavailability in Soils
  - Bioavailability Basics
  - Case Study 1 (Arsenic Site)
    - Questions and Answers
  - Case Study 2 (Lead Site)
    - Discussion: Polycyclic Aromatic Hydrocarbons (PAHs)
    - Taking Action
      - Questions and Answers

No associated notes.
Poll: If a contaminant is ingested and passes through (is not absorbed FROM) the human gastrointestinal tract (G.I. Tract), DOES IT CONTRIBUTE TO SYSTEMIC RISK?

Yes
No
I don’t know

Answer is NO because our risk assessment process for ingestion of contaminated soil focuses on risks from systemic exposure to contaminants in soil. The next sections of this training and the ITRC document address exactly this issue.
You Should Learn to…

- Value the ITRC document as a “go-to” resource for soil bioavailability
- Apply decision process to determine when a site-specific bioavailability assessment may be appropriate
- Use the ITRC Review Checklist to develop or review a risk assessment that includes soil bioavailability
- Consider factors that affect arsenic, lead and polycyclic aromatic hydrocarbons (PAH) bioavailability
- Select appropriate methods to evaluate soil bioavailability
- Be able to incorporate soil bioavailability into human health risk assessments

No associated notes.
Why You Should Consider Evaluating Bioavailability in Soils

► Reduces uncertainty, provides a more accurate understanding of chemical exposures and associated risk
► Leads to a more effective use of resources without compromising health protection
► May reduce remedial action costs and increase flexibility of remedial options
► Risk assessment allows for modifying exposure factors to better represent site conditions

Photo courtesy of Geoff Siemering, University of Wisconsin, 2017

No associated notes.
No associated notes.
Focus of ITRC Training and Guidance

- Bioavailability of contaminants in soil to humans
  - Bioavailability in sediment or in reference to ecological receptors
    (see ITRC Guidance: http://www.itrcweb.org/contseds-bioavailability/)

- Specifically covers As (arsenic), Pb (lead), and polycyclic aromatic hydrocarbons (PAHs)
  - Although guidance can be used for assessing bioavailability of other contaminants

- Focuses on the soil ingestion pathway
- Limited dermal bioavailability information as it relates to PAHs

No associated notes.
Bioavailability Tools

► Web-based Guidance Document ITRC BCS-1
  • The go-to guide for bioavailability assessments

*(Provided in the Webinar Handouts)*

► Decision Process Flow Chart - Section 4.1
  • Will be presented in both case studies

► Definition of Terms

► Review Checklist
  • Can be used as a tool to review a bioavailability assessment
  • Can be used to prepare a bioavailability study

ITRC BCS-1 [http://bcs-1.itrcweb.org/](http://bcs-1.itrcweb.org/)

No associated notes.
Poll Question: (was originally shown as participants log on slide 1) and brought back here to show results and discuss
- little or no experience
- some knowledge and experience
- expert
Today’s Training Road Map

Importance of Evaluating Bioavailability in Soils

- Bioavailability Basics
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  - Taking Action
  - Questions and Answers

No associated notes.
Bioavailability of Contaminants in Soil

Basics

- History: how we recognized the issue
- Relevance to Human Health Risk Assessment
- Concepts with applicability to all chemicals
- Key definitions
- In vivo - in vitro correlation (IVIVC)
- Soil properties that influence bioavailability
Studies relating soil lead and blood lead: Source of lead makes a difference

Smelter Average = 4.6
Urban Average = 3.2
Mining Average = 1.7

$\Delta$PbB per $\Delta$1000 PbS

PbB = lead blood (µg/dL)
PbS = lead soil (mg/kg)

Data presented in Steele et al. 1990

Range: 1% (Galena-enriched soil) to 105%
Lowest site soil was 6%, for Tailings sample from California Gulch
Highest value California Gulch Fe/Mn PbO

Target lead dose (75, 225) – expressed in units of micrograms of lead per kg of body weight per day.

Range: 1% (Galena-enriched soil) to 105%
Lowest site soil was 6%, for Tailings sample from California Gulch
Highest value California Gulch Fe/Mn PbO

Range: 1% (Galena-enriched soil) to 105%
Lowest site soil was 6%, for Tailings sample from California Gulch
Highest value California Gulch Fe/Mn PbO

Graph of concentration of lead in blood over time.

21 Regulatory Recognition of Using Bioavailability for Risk Assessment

“If the medium of exposure [at] the site… differs from the medium of exposure assumed by the toxicity value… an absorption adjustment may… be appropriate.”

 “[to] adjust a food or soil ingestion exposure estimate to match a RfD or slope factor based on… drinking water…”


Bioavailability: Relevance to Toxicity Assessment and Exposure Assessment

Site-Specific RBA
- Soil ingestion exposure
- Critical toxicity study used a different exposure medium
- Account for the difference

Toxicity Assessment

RfD or CSF

Exposure Assessment

Site-Specific Exposure Media

RBA – Relative Oral Bioavailability
RfD – Reference Dose
CSF – Cancer Slope Factor

ITRC BCS-1 Section 9

No associated notes
**Definition:**
Relative Oral Bioavailability (RBA)

- Comparison of bioavailability of a chemical in different dosing media

- \[ RBA = \frac{\text{Absolute Bioavailability from Soil}}{\text{Absolute Bioavailability from form dosed in critical toxicity study}} \]

ITRC BCS-1 Section 1.3

No associated notes
Incorporation of RBA Results into Human Health Risk Assessment (HHRA)

\[
\text{Exposure} = \frac{C_s \times RBA \times IR \times EF \times ED}{BW \times AT}
\]

- \(C_s\) (Concentration in soil) = site-specific, mg/kg
- \(RBA\) (Relative bioavailability) = site-specific, unitless
- \(IR\) (Ingestion rate) = mg soil / day
- \(EF\) (Exposure Frequency) = days / year
- \(Ed\) (Exposure Duration) = years
- \(AT\) (Averaging time) = days
- \(BW\) (Body weight) = kg

ITRC BCS-1 Section 9.1.3.2
**Bioavailability Evaluation Can Apply to All Chemicals**

- Including priority listed chemicals

  The ATSDR 2017 Substance Priority List

<table>
<thead>
<tr>
<th>Rank</th>
<th>Substance Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ARSENIC</td>
</tr>
<tr>
<td>2</td>
<td>LEAD</td>
</tr>
<tr>
<td>3</td>
<td>MERCURY</td>
</tr>
<tr>
<td>4</td>
<td>VINYL CHLORIDE</td>
</tr>
<tr>
<td>5</td>
<td>POLYCHLORINATED BIPHENYS</td>
</tr>
<tr>
<td>6</td>
<td>BENZENE</td>
</tr>
<tr>
<td>7</td>
<td>CADMIUM</td>
</tr>
<tr>
<td>8</td>
<td>BENZO(A)PYRENE</td>
</tr>
<tr>
<td>9</td>
<td>POLYCYCLIC AROMATIC HYDROCARBONS</td>
</tr>
<tr>
<td>10</td>
<td>BENZO(B)FLUORANTHENE</td>
</tr>
</tbody>
</table>

- Although current default assumes RBA of 100% for all chemicals in soil except arsenic and lead (default 60%)

**Definition: Bioaccessibility**

\[
\text{Bioaccessible Fraction (\%) = } \frac{\text{Mass of chemical soluble from soil}}{\text{Total mass of chemical present in soil}} \times 100
\]

- Fraction of total amount of chemical present that is soluble / available for uptake
- In vitro methods attempt to characterize this parameter
  - In vitro bioaccessibility (IVBA)

ITRC BCS-1 Section 5.2

No associated notes
No associated notes
The goal of IVIVC is to promote an in vitro IVBA test method to replace in vivo RBA feeding studies. Successful IVIVC has been established when the RBA of a test soil can be determined using a predictive model (for example, simple linear regression), and meet the USEPA requirement (2007b) that "the in vitro result (entered as input) will yield an estimate of the in vivo value (as output)." If a good IVIVC has been established, then the in vitro data for soils can be used as the sole basis for adjusting RBA in a human health risk assessment" (BCS-1 document, Section 5.2.3).

The IVIVCs for lead and arsenic that currently have approval from regulatory agencies were developed either by aggregating information about several (or many) soils that were investigated over several different studies, or were part of a large-scale study that included many soils.

Generally, IVIVC development requires significant research. So IVIVCs for use in risk assessment are generally either developed and published in the peer-reviewed literature, or developed with the involvement of regulatory agencies – and frequently both!

Using an IVIVC to Predict RBA

RBA: Relative Oral Bioavailability
IVBA: In Vitro Bioaccessibility
IVIVC: In Vivo - In Vitro correlation

RBA = IVBA*slope + intercept

See notes on Slide 29
See notes on Slide 29.
**Definition:**

**In Vivo - In Vitro correlation (IVIVC)**

- Refers to a correlation between in vitro bioaccessibility results and in vivo bioavailability results.
- Good correlation indicates that the in vitro method provides a good prediction of bioavailability.
- Poor correlation indicates that the in vitro method is not a good predictor of bioavailability, and likely not a valid surrogate for estimating bioavailability.

ITRC BCS-1 Section 5.2.3

No associated notes
No associated notes.
Poll Question: Does the state you work in use bioavailability when assessing risk?
- Yes
- No
- Don't Know
Today’s Training Road Map

Importance of Evaluating Bioavailability in Soils
  Bioavailability Basics
    Case Study 1 (Arsenic Site)
      Questions and Answers
    Case Study 2 (Lead Site)
      Discussion: Polycyclic Aromatic Hydrocarbons (PAHs)
  Taking Action
    Questions and Answers

No associated notes.
Considerations for Bioavailability Decision Process Flowchart

Full size flow chart available in “Related Links”

No associated notes
Considerations for Bioavailability
Decision Process Flowchart - Part 2

STOP! Bioavailability assessment is not justified.

NO

Do the benefits of bioavailability assessment justify the cost?

YES

Steps to Conduct Cost/Benefit Analysis

- Define data needs.
- Estimate bioavailability assessment costs.
- Estimate risk and cost reduction.

Further Considerations

Public Acceptance
Regulatory Constraints
Logistical Constraints
Technical Constraints

Conduct site-specific bioavailability assessment.

No associated notes
Arsenic Case Study: Former AgriculturalParcel

100 acre parcel formerly used for agricultural purposes
Suspected use of pesticides that may have contained arsenic
Homogeneous soil (silty sand)

Base map aerial source: Google Earth © 2017 Google

No associated notes.
No associated notes
Considerations for Bioavailability Decision Process Flowchart

Does the project focus on human exposure to contaminated soil?

ITRC BCS Figure 4-1

No associated notes.
No associated notes.
Arsenic Case Study: Residential Land Use

Photo courtesy of K. Long

No associated notes.
Arsenic Case Study: Residential Land Use

Photo courtesy of V. Hanley

No associated notes.
Arsenic Case Study: Recreational Land Use

No associated notes.
Considerations for Bioavailability Decision Process Flowchart

ITRC BCS Figure 4-1

No associated notes.
Incorporation of RBA Results into Human Health Risk Assessment (HHRA)

\[
\text{Exposure} = \frac{C_s \times RBA \times IR \times EF \times ED}{BW \times AT}
\]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>(C_s)</td>
<td>Concentration in soil</td>
<td>site-specific, mg/kg</td>
</tr>
<tr>
<td>RBA</td>
<td>Relative bioavailability</td>
<td>site-specific, unitless</td>
</tr>
<tr>
<td>IR</td>
<td>Ingestion rate</td>
<td>mg soil/day</td>
</tr>
<tr>
<td>EF</td>
<td>Exposure Frequency</td>
<td>days/year</td>
</tr>
<tr>
<td>ED</td>
<td>Exposure Duration</td>
<td>years</td>
</tr>
<tr>
<td>AT</td>
<td>Averaging time</td>
<td>days</td>
</tr>
<tr>
<td>BW</td>
<td>Body weight</td>
<td>kg</td>
</tr>
</tbody>
</table>

ITRC BCS-1 Section 9.1.3.2
Background Arsenic in Soils > Residential Risk-based Concentrations

US EPA Regional Screening Level: 0.68 mg/kg
CA DTSC Screening Level: 0.11 mg/kg
*Assume USEPA Default of 60% Bioavailability

Source USGS 2008:
https://mrdata.usgs.gov/geochem/doc/averages/as/usa.html

No associated notes.
No associated notes
Arsenic Case Study: Risk Characterization (60% RBA)

No associated notes
Arsenic Case Study: Areas Warranting Remediation (60% RBA)

Approximately 65% of the site could warrant risk management

Area ~ 65 acres
Depth ~ 1 ft
104,000 yd³ of soil remediation (160,000 tons)

Cost for soil removal and disposal & backfill ~ $26M

Base map aerial source: Google Earth © 2017 Google

No associated notes
Considerations for Bioavailability
Decision Process Flowchart

Is there a method available?

ITRC BCS Figure 4-1

No associated notes.
# Available Methods for Determining Arsenic Bioavailability In Vivo

<table>
<thead>
<tr>
<th>Animal model</th>
<th>Biomarkers of arsenic exposure</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Swine</td>
<td>Steady state urinary excretion</td>
<td>Rodriguez et al. 1990; Casteel et al. 2006; Weis and LaVelle, 1991; Basta et al. 2007; Denys et al. 2012; Brattin and Casteel 2013</td>
</tr>
<tr>
<td>Mice (C57BL/6)</td>
<td>Steady state urinary excretion</td>
<td>Bradham et al. 2011</td>
</tr>
</tbody>
</table>

ITRC BCS-1 Table 7-1

No associated notes.
### Available Methods for Determining Arsenic Bioavailability In Vitro

<table>
<thead>
<tr>
<th>Method</th>
<th>Key Reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USEPA Method 1340</strong></td>
<td>Diamond et al. 2016</td>
<td>Method adopted by USEPA. Guidance issued May 2017</td>
</tr>
<tr>
<td><strong>Also known as RBALP, SBRC, and USEPA 9200</strong></td>
<td></td>
<td><a href="https://semspub.epa.gov/work/HQ/196750.pdf">https://semspub.epa.gov/work/HQ/196750.pdf</a></td>
</tr>
<tr>
<td><strong>Unified BARGE Method (UBM)</strong></td>
<td>Wragg et al. 2011</td>
<td>ISO certification (17924) – widely used throughout Europe. <a href="https://www.bgs.ac.uk/barge/home.html">https://www.bgs.ac.uk/barge/home.html</a></td>
</tr>
<tr>
<td><strong>In Vitro Gastrointestinal Method (IVG)</strong></td>
<td>Basta et al. 2007</td>
<td>No regulatory guidance exists to support this method. First published method to report strong IVIVC, but did not include interlaboratory round robin study necessary for regulatory guidance and approval by USEPA.</td>
</tr>
<tr>
<td><strong>Physiological Based Extraction Test (PBET)</strong></td>
<td>Ruby et al. 1996</td>
<td>No regulatory guidance exists to support this method.</td>
</tr>
</tbody>
</table>

*ITRC BCS-1 Table 7-3*
Considerations for Bioavailability Decision Process Flowchart

STOP! Bioavailability assessment is not justified.  NO  Could bioavailability assessment affect the remedial decisions?

ITRC BCS Figure 4-1

No associated notes.
No associated notes
Considerations for Bioavailability Decision Process Flowchart

Steps to Conduct Cost/Benefit Analysis:
1. Define data needs.
2. Estimate bioavailability assessment costs.
3. Estimate risk and cost reduction.

Do the benefits of bioavailability assessment justify the cost?

YES

NO

STOP! Bioavailability assessment is not justified.

ITRC BCS Figure 4-1

No associated notes.
Poll Question: How much do you think the in vitro bioavailability study would cost for this site?

- $1,000
- $20,000
- $100,000
<table>
<thead>
<tr>
<th>Analysis</th>
<th>Approximate Unit Cost Per Sample (USD)</th>
<th>Provider</th>
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</thead>
<tbody>
<tr>
<td>Soil properties</td>
<td>$500-$1,000 (per sample)</td>
<td>Commercial labs</td>
</tr>
<tr>
<td>Soil mineralogy</td>
<td>$200-$1,000 (per sample)</td>
<td>Academic and commercial labs</td>
</tr>
<tr>
<td>IVBA for Pb or As</td>
<td>$150–$1,000 (per sample)</td>
<td>Academic and commercial labs</td>
</tr>
<tr>
<td>IVBA for PAHs</td>
<td>$350 - $1000 (per sample)</td>
<td>Academic and commercial labs</td>
</tr>
<tr>
<td>In vivo (mouse, rat)</td>
<td>$25,000-$30,000 (per study)</td>
<td>Academic or government labs</td>
</tr>
<tr>
<td>In vivo (swine)</td>
<td>$75,000 (for 3 soils, metals only)</td>
<td>Academic labs</td>
</tr>
<tr>
<td>In vivo (primate)</td>
<td>$90,000 (for three soils, metals only)</td>
<td>Academic labs</td>
</tr>
</tbody>
</table>

ITRC BCS-1 Table 4-1  
Cost data collected in 2015-16

No associated notes.
Arsenic Case Study: Conducting Bioavailability Study

Cost for in vitro bioavailability study
~ $10,000 - $20,000

No associated notes
Considerations for Bioavailability Decision Process Flowchart

Further Considerations
- Public Acceptance
- Regulatory Constraints
- Logistical Constraints
- Technical Constraints

ITRC BCS Figure 4-1

No associated notes
Arsenic Case Study: Conducting Bioavailability Study

No associated notes
In vitro analysis gives IVBA %, which can be used to determine RBA using a validated IVIVC. This is an example from the CAB method.

**Arsonic Case Study: Incorporation of Results into Human Health Risk Assessment (HHRA)**

<table>
<thead>
<tr>
<th><strong>Cancer Risk</strong></th>
<th><strong>Non-Cancer Hazard</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>$ELCR = \frac{C_s \times RBA \times IR \times EF \times ED}{(1/CSF) \times BW \times AT \times CF}$</td>
<td>$HQ = \frac{C_s \times RBA \times IR \times EF \times ED}{RfD \times BW \times AT \times CF}$</td>
</tr>
</tbody>
</table>

- **AT** (Averaging time) = days (for cancer = 70 years x 365 days/year; for noncancer = ED x 365 days/year)
- **BW** (Body weight) = kg
- **C_s** (Concentration in soil) = site-specific, mg/kg
- **CF** (Conversion factor) = 1.0E+6 mg/kg
- **CSF** (Cancer slope factor) = chemical-specific, (mg/kg-day)$^{-1}$
- **ED** (Exposure duration) = years
- **EF** (Exposure frequency) = days/year
- **ELCR** (Excess lifetime Cancer risk) = unitless
- **HQ** (Hazard quotient) = unitless
- **IR** (Ingestion rate) = mg/day
- **RBA** (Relative bioavailability) = site-specific, unitless
- **RfD** (Oral reference dose) = chemical-specific, mg/kg-day

ITRC BCS-1 Section 9.1.3.2

No associated notes
No associated notes
Arsenic Case Study: Areas Warranting Remediation (35% RBA)

- Approximately 25% of the site could warrant risk management
- 50% Reduction
- Area ~ 25 acres
- Dentition: 6,000 lbs
- 4,000 cubic yards of remediation (~62,000 tons)
- Cost for soil removal and disposal & backfill ~ $16 Million Savings

Base map aerial source: Google Earth © 2017 Google

No associated notes
No associated notes
No associated notes.
Lead Case Study

- Case study is presented as a series of meetings between regulator and consultant
- Historic lead mining area
- Contaminant source – lead tailings
- Residential area
- Future land uses are residential and commercial

Source: Pixnio.com

No associated notes
Lead Case Study: Former Lead Mining Area

3 acre parcel overlaid on larger former lead mine. Mining ceased in 1960s.

1943 air photo, scarred areas present tailings which are approx. 1 to 2 ft thick.

Urban growth (residential) expanded into contaminated area in the 1960s.

Source: Oregon DEQ Black Butte Mine File #1857

No associated notes
Lead Case Study: Site is Now a Residential Area

1980s development, with 1/3 acre or smaller lots
Includes play areas and gardens
Each parcel has front, back, and 2 side yards

Base map aerial source: Google Earth © 2017 Google
Lead Case Study: Total Lead Sampling Complete

- Available samples for nature & extent
  - 10 properties; 4 yards each (1 composite sample/yard) = 40 samples
  - 5 properties with gardens (2 discrete samples/garden) = 10 samples
  - 5 properties with play areas (1 discrete sample/play area) = 5 samples

- Total lead concentrations
  - 380 to 1,321 mg/kg, arithmetic mean = 850 mg/kg, low standard deviation

- Background - 30 mg/kg

- Soil type – Well graded gravel with fines and thin organic silt at surface

No associated notes
Lead Case Study: All Properties Exceed Default Cleanup Level

Legend
- Discrete Sample Locations
- Composite Sample Locations
- Discrete Sampling Areas
- Composite Sampling Areas
- Tax Lots
- Total Lead Concentration in mg/kg

Current state residential screening level = 400 mg/kg

Base map aerial source: Google Earth © 2017 Google

No associated notes
Lead Case Study: Estimated Costs Could Justify a Site-Specific Bioavailability Study

- Excavation volume based on nature & extent sampling
  - 3 acres
  - 1 to 2 ft depth
  - ~5,000 cy

- Estimated excavation cost = $700,000

- ~250 truck trips @ 20 yards each during remediation

- Disposal is large portion of $

- ~2 weeks for excavation and yard restoration
Lead Case Study: Need to Determine if Bioavailability Study is Worthwhile

Full size decision flow chart available in "Related Links"
No associated notes
Lead Case Study: USEPA Recent Guidance on Lead IVBA Testing

- Soil Bioavailability at Superfund Sites Web Page
  https://www.epa.gov/superfund/soil-bioavailability-superfund-sites-guidance

Apparatus used in USEPA Method

ITRC BCS-1 Section 6.3.3  Photo courtesy of Geoff Siemering, University of Wisconsin, 2017


https://www.epa.gov/superfund/soil-bioavailability-superfund-sites-guidance
Lead Case Study: Should Studies be In Vitro or In Vivo?

- Reasons we don’t need in vivo
  - Lead has been well studied with a variety of soils with good in vivo - in vitro correlation
  - Site soil is well-characterized
  - Site soil type & waste type are similar to those tested by USEPA
  - Site soil type has an established in vivo – in vitro correlation

No associated notes
Lead Case Study: Bioavailability Study Could Affect Remediation Decisions

ITRC BCS-1 Figure 6-3

No associated notes
Lead Case Study: Cost Benefit Analysis

YES

NO

Steps to Conduct Cost/Benefit Analysis

- Define data needs.
- Estimate bioavailability assessment costs.
- Conduct site-specific bioavailability assessment.
- Estimate risk and cost reduction.

Do the benefits of bioavailability assessments justify the cost?

ITRC BCS-1 Section 4.4

No associated notes
Lead Case Study: Bioavailability Study has Various Components

- Work Plan (SAP & QAPP)
- Coordination (Agency & Stakeholder)
- Sample Collection
- Interpreting Lab Data
- Calculating Site-Specific Cleanup Levels

ITRC BCS-1 Section 4.4

No associated notes
Poll Question

How many samples should be collected for bioavailability testing (not including duplicate samples) at this 3-acre site? (Note: nature & extent sampling is complete)

- 1 incremental sample across 3 acres
- 2 incremental samples across 3 acres
- 10 incremental samples across 3 acres
- 1 discrete sample per property
- 2 discrete samples per property

Source: pxabay.com

No associated notes.
Lead Case Study: Guidance on Lead Sampling for IVBA Testing

  - “2 composites made up of 30 increments”
  - “In general, for most risk assessment applications, acceptable Type I error rate can be expected if ITRC (2012) recommendations are followed (30 increments per composite”
- Equal representation (volume, depth) from all increments
- Collected in triplicate
- ITRC ISM guidance at [www.itrcweb.org/ism-1](http://www.itrcweb.org/ism-1)


https://www.epa.gov/superfund/soil-bioavailability-superfund-sites-guidance Team.
www.itrcweb.org/ism-1.
Lead Case Study: Where Should IVBA Samples be Collected?

DU could be the entire area or property boundary.

Single source of lead - agreed on 2 DUs with a similar concentration range.

Sample across entire DU because till is present in whole DU and exposures occur anywhere.

1 triplicate incremental sample in each DU.

Base map aerial source: Google Earth © 2017 Google.

ITRC BCS-1 Section 9.1.6

DU = decision unit.

https://www.epa.gov/superfund/lead-superfund-sites-guidance#sampling
Lead Case Study: Potential Cost Impacts on the Project

- Without bioavailability study (based on existing nature & extent sampling only)
  - excavation volume = 5000 cy (1-2 ft. depth, 3 acres)
  - ~$700,000

- After bioavailability study (potentially)
  - Possible RBA = 20 to 30%
  - Excavation volume = 0 cy
  - ~$30,000 (cost of study)
    - Work planning
    - Sampling & analysis
    - Reporting
  - Remedy will be protective

Photo Source: Oregon DEQ Black Butte Mine File #1857

No associated notes
Lead Case Study: Further Considerations

Further Considerations

- Not addressed in previous public meetings
- Prepare Fact Sheet with overview of bioavailability concepts and study details
- Further discussed in ITRC document

ITRC BCS-1 Section 4.5

No associated notes
Lead Case Study: Planning Meeting Resolved Path Forward

- Use USEPA Method 1340
- Divide site into 2 decision units
- Collect an incremental sample in triplicate from each decision unit
- Calculate site-specific soil cleanup levels using results

Base map aerial source: Google Earth © 2017 Google

No associated notes
Lead Case Study: Follow-up Meeting Held to Discuss Study Results

- Work Plan was submitted and approved
- Bioavailability study samples were collected
- Laboratory provided results for the samples
- Meeting between agency and consultant

Source: Pixnio.com

No associated notes
Lead Case Study: RBA Predicted from IVBA

- Laboratory measured in vitro bioaccessibility (IVBA)
- Used data to predict relative bioavailability (RBA)
- Linear regression model established by USEPA (2007):
  \[ \text{RBA} = 0.88 \times \text{IVBA} - 0.028 \]

No associated notes
Lead Case Study: Absolute Bioavailability (ABA) Results Similar Between Samples

\[ \text{ABA}_{\text{soil}} = 50\% \times \text{RBA}_{\text{soil}} \]

ABA:
The fraction of an ingested dose that is absorbed and reaches systemic circulation.

IS-2-1, IS-2-2, IS-2-3
RBA = 14 to 17%
ABA = 7 to 8.5%

IS-1-1, IS-1-2, IS-1-3
RBA = 14 to 15%
ABA = 7 to 7.5%

ITRC BCS-1 Section 9.1.9.2

Base map aerial source: Google Earth © 2017 Google
Poll Question

► What RBA % would you use in a site-specific risk-based cleanup level calculation?

- Maximum of 6 values (17%)
- Average of 6 values (15%)
- Higher 95% UCL on the mean of the 2 triplicate samples (16.5%)
Lead Case Study: Site-specific Bioavailability Data Incorporated into Lead Models

- Pharmacokinetic models are used to evaluate lead exposures
- Residential land use – Integrated Exposure Uptake Biokinetic (IEUBK) Model
- Commercial land use – Adult Lead Methodology
- Default RBA in models is 60%
- Guidance document discusses methodology to incorporate site-specific RBA
- Site-specific RBA data reduces uncertainty

ITRC BCS-1 Section 9.1.9.2

No associated notes
USEPA Recently Published Guidance on Target Blood Lead Levels


  “OLEM recognizes adverse health effects as blood lead concentrations below 10 ug/dL. Accordingly, OLEM is updating the soil lead strategy to incorporate this new information.”

  (OLEM = USEPA Office of Land and Emergency Management)

- ITRC RISK-3 (2015) – Section 5.1.5 addresses lead toxicity and blood lead levels

https://www.epa.gov/superfund/lead-superfund-sites-guidance#adultlead
Lead Case Study: Area Warranting Remediation (16.5% RBA) – Residential

- Lower site-specific RBA than default (lower site risk)
- Site-specific cleanup level = 580 mg/kg (5 μg/dL blood lead target, 16.5% RBA)
- State default cleanup level = 400 mg/kg (10 μg/dL blood lead target, 60% RBA)

Legend

- Locations
- Above Site Specific Goals
- Discrete Sampling Areas
- Composite Sampling Areas
- Tax Lots
- Total Lead Concentration in mg/kg

75% reduction in area
3,750 less cubic yards
$500,000 savings

Base map aerial source: Google Earth © 2017 Google

No associated notes.
Lead Case Study: No Area Warranting Remediation (16.5% RBA) - Commercial

- Potential for future commercial zoning
- Lower site-specific RBA than default (lower site risk)
- Site-specific cleanup level = 3,800 mg/kg (5 μg/dL blood lead target, 16.5% RBA)
- State default cleanup level = 800 mg/kg (10 μg/dL blood lead target, 60% RBA)
- No excavation needed for commercial land use (but ICs needed)
  - ITRC guidance: http://institutionalcontrols.itrcweb.org/

Legend
- Discrete Sample Locations
- Composite Sample Locations
- Discrete Sampling Areas
- Composite Sampling Areas
- Tax Lots
- Total Lead Concentration in mg/kg

Base map aerial source: Google Earth © 2017 Google

100% reduction in area
5,000 less cubic yards
$700,000 savings

No associated notes
Lead Case Study: Site-Specific Bioavailability Results Useful for Decisions

- **Reduces:**
  - Uncertainty in site risk and risk-based cleanup
  - Disruption of residents
  - Remediation-related risks (e.g., truck traffic, tree damage)
  - Remedial action costs

- **Provides:**
  - Additional site-specific data to supplement nature and extent sampling
  - Decisions protective of human health
  - Achievement of same target risk level
  - Flexibility of remedial options
  - Stakeholder outreach is important throughout

No associated notes
No associated notes.
Bioavailability of PAHs from Soil

- Polycyclic Aromatic Hydrocarbons (PAHs)
  - Over 10,000 individual chemicals
- Seven PAHs currently considered carcinogenic by USEPA
  - 4 rings: benz(a)anthracene, chrysene
  - 5 rings: benzo(a) pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene
  - 6 rings: Indeno(1,2,3-c,d)pyrene
- Lipophilic, log Kow range from 5.2 to 6.6
- Low water solubility (0.01 to 0.00076 ug/mL)
- Low vapor pressure (6.3E-7 to 9.6E-11 mm Hg)

Images from Final Report SERDP Project ER-1743 “PAH Interactions with Soil and Effects on Bioaccessibility and Bioavailability to Humans.”
# Sources of PAHs in Soil

<table>
<thead>
<tr>
<th>Type</th>
<th>PAH Source</th>
<th>Primary PAH-bearing Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>Forest fires</td>
<td>Soot, char</td>
</tr>
<tr>
<td></td>
<td>Grass fires</td>
<td>Soot, char</td>
</tr>
<tr>
<td></td>
<td>Volcanic eruptions</td>
<td>Soot, char</td>
</tr>
<tr>
<td></td>
<td>Oil seeps</td>
<td>Weathered crude oil</td>
</tr>
<tr>
<td>Industrial</td>
<td>Manufactured gas plants</td>
<td>Coal tar, pitch, coal, char, soot</td>
</tr>
<tr>
<td></td>
<td>Coking operations</td>
<td>Coal tar, coal, coke, soot</td>
</tr>
<tr>
<td></td>
<td>Aluminum production</td>
<td>Coal tar pitch (making and disposing of anodes)</td>
</tr>
<tr>
<td></td>
<td>Foundries</td>
<td>Coal tar pitch, creosote, fuel oil (used in making sand casts), soot</td>
</tr>
<tr>
<td></td>
<td>Wood treating</td>
<td>Creosote</td>
</tr>
<tr>
<td></td>
<td>Refineries</td>
<td>Soot, various NAPLs (crude oil, fuel oil, diesel)</td>
</tr>
<tr>
<td></td>
<td>Carbon black manufacture</td>
<td>Soot, oil tar</td>
</tr>
<tr>
<td></td>
<td>Fuel spills and/or disposal</td>
<td>Various NAPLs (crude oil, fuel oil, waste oil, diesel)</td>
</tr>
<tr>
<td>Non-industrial Sources</td>
<td>Skeet</td>
<td>Coal tar pitch or bitumen (used as binder in targets)</td>
</tr>
<tr>
<td></td>
<td>Asphalt sealants</td>
<td>Coal tar</td>
</tr>
<tr>
<td></td>
<td>Landfills</td>
<td>Creosote (treated wood), soot, char</td>
</tr>
<tr>
<td></td>
<td>Incinerators (municipal, hospital)</td>
<td>Soot</td>
</tr>
<tr>
<td></td>
<td>Open burning</td>
<td>Soot, char</td>
</tr>
<tr>
<td></td>
<td>Fire training</td>
<td>Soot</td>
</tr>
<tr>
<td></td>
<td>Fires</td>
<td>Soot, char</td>
</tr>
<tr>
<td></td>
<td>Auto/truck emissions</td>
<td>Soot</td>
</tr>
</tbody>
</table>

State of the Science: Bioavailability of PAHs from Soil

- Among the most common chemicals of concern at contaminated sites
- Current regulatory default is to assume that the RBA of PAHs in soil is 100%  
  - Assumes absorption of PAHs from soil equivalent to absorption from PAH-spiked food

No associated notes.
State of the Science: Bioavailability of PAHs from Soil

- Considerable interest in incorporating bioavailability estimates in HHRA
- Over 60 studies performed (including in vivo and in vitro studies)
- Studies have supported site-specific RBA values for use in HHRA
  - Elucidating factors controlling binding of PAHs to soil
  - Still no consensus on in vitro nor even in vivo methods

Source: Alloy 2017

Studying RBA of organic chemicals is harder than metals!

- Methods for estimating bioavailability
  - Lagged behind metals such as lead and arsenic
  - Assessment is complex
- Chemical Mixture
- Analytical costs

- Metabolism
  - Hepatic (in the liver)
  - Target tissue
  - Microbial
  - Multiple metabolites
- Enterohepatic recirculation
  - Most absorbed PAHs are returned to the GI tract through bile and some are reabsorbed
- IVBA requires simulated intestinal environment
Key Considerations in Study Design
ITRC Document Provides Useful Information to Assess Studies

- Appropriate soil particle size
- Relevant comparison group
- Linearity of pharmacokinetics
- Repeated versus single dose
- Measurement of parent compound, metabolites, or both
- Adequate number of subjects
- Relevant concentrations/doses, number of different doses
- Ability to demonstrate full range of RBA
- Average versus individual subject RBA measurements
- Mass balance

ITRC BCS-1 Section 5

No associated notes
Key Considerations in Study Design
ITRC Document Provides Overview Specific to PAHs

- Sources
- Toxicity
- Factors influencing RBA from soil
- In vivo and in vitro methods
- Summary of research conducted to date
- Considerations for dermal absorption
- Case study

ITRC BCS-1 Section 8

No associated notes
Bioavailability of PAHs from Soil
What We Know

► Source of PAHs to soil dominates partitioning (in vitro) and RBA (in vivo)
► Some sources have higher RBA, others significantly reduced relative to soluble forms
  • Lower RBA: Soil, Skeet, Pitch
  • Higher: Fuel oil, Non-aqueous phase liquid (NAPL)
► Soil characteristics are less important to controlling RBA (peat, clay content)
► Addition of charcoal to the soil reduces RBA
► Dermal exposure pathway important to calculated exposures
► More work to be done – and is being done!
Welcome
Bioavailability of Contaminants in Soil: Considerations for Human Health Risk Assessment (ITRC BCS-1)

This ITRC guidance describes how to integrate bioavailability information into the human health risk assessment to improve the decision-making process. Regulators, practitioners, and stakeholders will find help performing the following tasks:

- select and properly interpret site-specific bioavailability testing information
- understand the strengths and weaknesses of different in vivo and in vitro methods
- consider the factors for selecting the most appropriate approaches for a site-specific evaluation of bioavailability of contaminants in soil without compromising the level of protectiveness for human health
- use the appropriate tools to develop site-specific bioavailability values in human health risk assessment.

If you are visiting this site for the first time please review the Introduction of this guidance. All users may find Navigating this Website helpful.

No associated notes
No associated notes
Two sites are shown in Figure 4-2, each with a maximum concentration of 2,000 mg/kg of a contaminant that has a cleanup level of 100 mg/kg (at an RBA of 100%). The RBA values are overlaid, to illustrate the cleanup levels corresponding to a given RBA.

As an example, the green circles indicate the volumes impacted if an RBA of 20% were accepted, effectively raising the cleanup level to 500 mg/kg.

At Site A, only 15% of the total contaminated soil volume is above 500 mg/kg, (contaminant distribution is log normal) and therefore would require cleanup. In contrast, with a different distribution (linear distribution) of the contaminant concentrations (Site B), 75% of the total volume would still require remediation at an RBA of 20%.

Site-specific conditions will vary, but some key features of the analysis of volume and RBA in Figure 4-2 are worth pointing out:

- Risk-based criteria, such as cleanup levels, increase significantly at RBA values of approximately 25% or less. For example:
  - an RBA of 25% yields a cleanup level that is 4x higher
  - an RBA of 10% yields a cleanup level that is 10x higher

The typical default value of a 60% RBA results in a relatively modest increase in cleanup levels: 1.67x higher.

**Estimating the volume requiring treatment at a range of realistic RBAs before beginning a site-specific bioavailability study may be valuable.**

Some general observations regarding the value of incorporating site-specific RBA values include the following:

- Small sites may not justify the expense of testing and increased regulatory costs.
- At sites where discrete hot spots account for most of the risk (like Site A), or at sites with only a small volume of soil above cleanup goals, site-specific bioavailability assessment may be less valuable.

Bioavailability assessment is more valuable at sites with relatively high volumes of soil, and where most of the soil is contaminated at concentrations between the default cleanup levels and cleanup levels that incorporate an
estimated RBA value (based on prior literature or experience with the specific soils or waste materials).
Typical Risk Assessment: Relative Bioavailability 100%

Cleanup Goal $10^{-6}$ risk = 10 mg/kg

Courtesy of C. Sorrentino, CA DTSC

No associated notes
Applying US EPA Default: Relative Bioavailability 60%

Cleanup Goal $10^{-6}$ risk = 17 mg/kg

No associated notes
No associated notes
No associated notes
Site-Specific RBA Evaluation
Take Home Messages

- Decrease the uncertainty of the risk assessment
- Maintains the Target Risk Level
- Improve Remedial Decision Making
- Often lead to significant savings of the resources available for remediation
- Multidisciplinary: Involve the Whole Team Early!
  - Regulatory: Project Managers, Geologists, Risk Assessors/Toxicologists
  - Consultants
  - Stakeholders: Responsible Parties, Public

No associated notes
Links to additional resources:
http://www.clu-in.org/conf/itrc/bcs/resource.cfm

Your feedback is important – please fill out the form at:
http://www.clu-in.org/conf/itrc/bcs/feedback.cfm

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

- Helping regulators build their knowledge base and raise their confidence about new environmental technologies
- Helping regulators save time and money when evaluating environmental technologies
- Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states
- Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations
- Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

How you can get involved with ITRC:

- Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches
- Sponsor ITRC’s technical team and other activities
- Use ITRC products and attend training courses
- Submit proposals for new technical teams and projects