9. INCORPORATION OF BIOAVAILABILITY INTO RISK ASSESSMENT AND RISK MANAGEMENT

Bioavailability information can augment traditional site characterization and human/ecological risk assessments to help refine the CSM for a contaminated sediment site and to better understand a receptor's likely exposure to site contaminants. The following sections summarize the use of bioavailability in assessing the risk associated with contaminated sediment sites and provide an overview of the use of the bioavailability assessment data in risk management. Risk management integrates the results of the risk assessment with other technical, political, legal, social, and economic objectives to develop and implement risk reduction and exposure prevention strategies (SERDP and ESTCP 2008). This section provides insight on how bioavailability information can be used to understand, mitigate, and/or manage risk at a contaminated sediment site within the areas of risk assessment and risk management.

The ITRC Contaminated Sediments Team is developing follow-up guidance on strategic selection of remedial alternatives and best management practices for mitigating exposure and risk from contaminated sediment sites. Assessing bioavailability as a monitoring parameter will be important in this next guidance as well.

9.1 Risk Assessment

To truly understand sources of risk[1] at a site, an investigator or regulator should strive to gain the best possible understanding of the physical, chemical, and biological processes that "drive" the risk (i.e., the means of COPC transfer, uptake, and concentrations at which adverse effects to receptors occur). Tools selected to determine toxicity depend on site specific habitat and receptor groups (Figure 9-1). The tools and measures identified in Chapters 4–8 aid in the assessment of site-specific contaminant bioavailability. Bioavailability assessments provide a more accurate measure of site specific risk than comparing analytical results to generic screening values. For example, it has been shown through extensive laboratory and field research that the presence of carbon (naturally occurring or anthropogenic) in sediments has a large influence on pore-water concentrations of HOCs (see Section 4.1.1.2). Since impacts to benthic organisms depend to a large extent on the dissolved pore-water concentrations of these compounds, applying methods to determine pore-water concentrations enhances the ability to predict current and potential effects.

The decision-making process to determine the cause of toxicity within a risk assessment (Figure 9-1) likely involves using a weight-of-evidence approach. This approach is necessary because there is generally no definitive measurement tool that adequately demonstrates all bioavailability processes at the site. Decisions based on bioavailability measurements are influenced by the fact that bioavailability is often highly site specific and depends on soil/sediment type, aging/weathering of contaminants, fate and transport of the contaminant or the media in which the contaminant is present, exposure pathways, and potential receptors. Therefore, a single measurement, such as the indirect or direct analysis of pore-water concentrations, often requires

[1] As discussed in Chapter 2, a detailed discussion of risk assessment is beyond the scope of this document; however, Table 2-2 provides references for conducting ecological/human health risk assessments.

supporting information to determine whether the bioavailability measurement is truly representative of site conditions (NRC 2003).

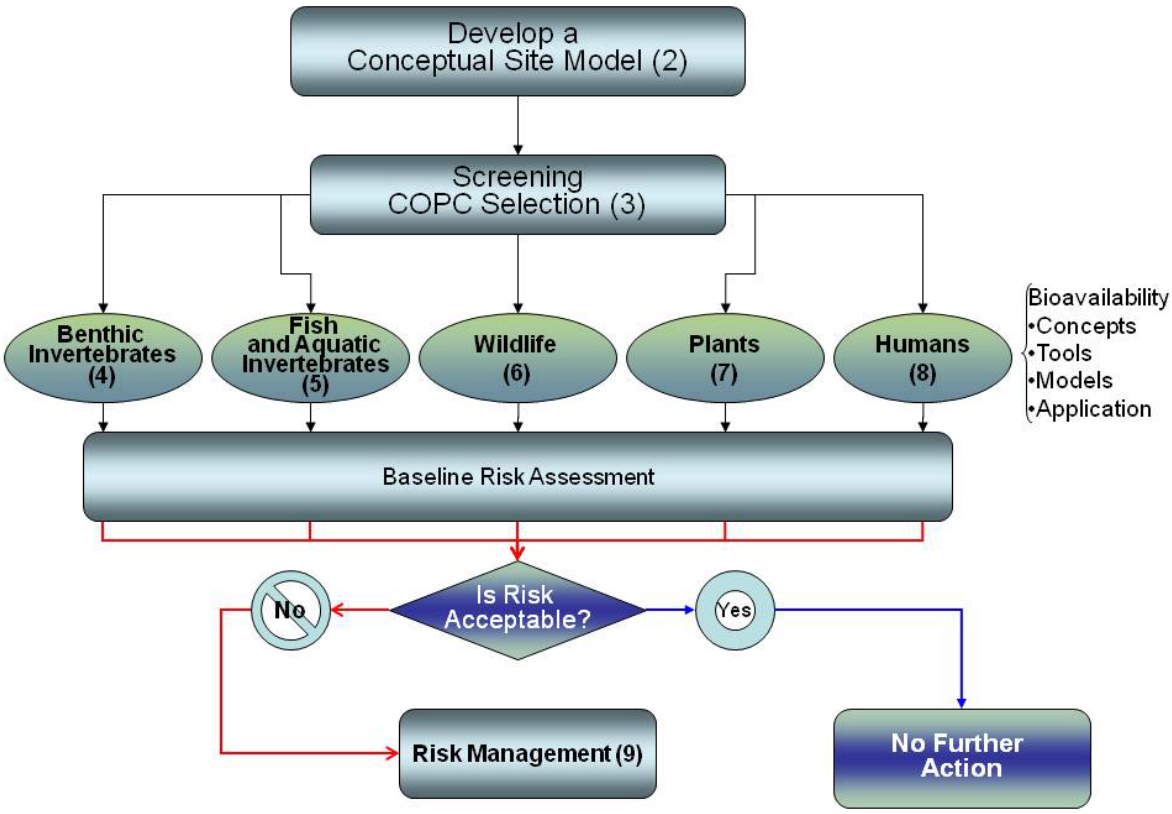

Figure 9-1. Sediment assessment process followed in this guidance.

An example of a weight-of-evidence approach for contaminated sediments is the three-tiered evaluation called the Sediment Quality Triad, which is often used to evaluate the benthic pathway (see Section 1.1). The SQT approach consists of three distinct measurements: sediment chemistry, toxicity testing, and macroinvertebrate surveys. Impact is evaluated based on consistent indications from at least two of the measurements. The complexity of a site and the number of exposure pathways evaluated determine the nature and number of lines of evidence needed to understand risk, including the selection of the appropriate bioavailability measurements.

The assessment of bioavailability can be a valuable tool in the site characterization and exposure assessment process. Advantages and challenges of using bioavailability information within the risk assessment process while contemplating risk management decisions are listed below:

Advantages

- Contaminants that are not bioavailable are not included in the calculation of risk.
- Protective cleanup plans can be optimized, and remedial costs may be reduced.
- Limited resources are more efficiently used.
- Risk of cleanup can be balanced with the risk posed by the contaminants in sediments.

- More technically defensible cleanup goals can be achieved and more accurate cleanup priorities established while still ensuring protection of human health and the environment.

Challenges

- Acceptance by the regulatory agency, stakeholders, and public is uncertain.
- Site-specific bioavailability results may be difficult to compare across sites.
- Higher initial cost during site characterization phase may be required.
- Time may be added to the schedule, which may be inconsistent with short timelines for remediation.

In general, bioavailability considerations should be incorporated into the risk assessment process to obtain a clearer understanding of contaminant toxicity and exposure pathways, such that remedy selection decisions can be optimized. The ITRC Contaminated Sediments Team has summarized the pathways, contaminants, and bioavailability tools that were used at various sediment sites in Table 9-1. Information in Table 9-1 was submitted to the ITRC during the course of this project. More information about each site is provided in Appendix D and may be useful in determining whether bioavailability considerations contributed to remedy decision making at a particular site and how the bioavailability data were used in the process.

Table 9-1. Summary table of exposure pathways, contaminants, and bioavailability tools at sediment sites

Site name	Exposure pathway	Contaminants	Bioavailability tools
1. Bremerton Naval Complex, OU B Marine, WA	Human health	Mercury	• Bioaccumulation (fish tissue)
2. Bradford Island Disposal Site, OR	• Human health • Benthic • Pelagic	• PCBs • Metals	• Tissue chemistry • Surface water chemistry • Trophic modeling
3. Buffalo River, NY	• Benthic • Pelagic	Parent and alkylated PAHs	• Pore-water EqP normalized to TOC
4. Camp Lejeune IR Site 89, NC	• Benthic • Pelagic	PAHs	• Trophic modeling • Macro invertebrate chemistry
5. Cass Lake, MN	• Human health • Benthic • Plants	• Dioxins • PCP	• Bioaccumulation
6. Centre County Kepone, PA	• Human health • Benthic • Pelagic	• Mirex • Kepone • Photomirex	• BAF
7. Diamond Alkali–Passaic River Study Area, NJ	• Human health • Benthic • Pelagic	• PCBs • Dioxin • Dieldrin • Chlordane • DDT • Tetrachlorodibenzo-p-dioxin (TCDD) • Mercury • Copper • Lead	• Tissue chemistry • Toxicity testing • BSAFs

Site name	Exposure pathway	Contaminants	Bioavailability tools
8. Fifteenmile Creek, OR	• Benthic • Wildlife	Oxyflourfen	• Tissue chemistry • Toxicity testing (in situ and caged fish)
9. Fox River, WI	• Human health • Pelagic	• PCBs • Mercury	• Benthic community survey • Bioassay of bulk sediment • Toxicity tests
10. Glenbrook Nickel–Coos Bay, OR	Benthic	Nickel	• Metal concentration relative to fine-grained material
11. Hackensack River, NJ	• Human health • Benthic • Pelagic	Chromium	• Pore-water chemistry • SEM/AVS • Benthic tissue analysis • Laboratory toxicity and bioaccumulation testing • Benthic community survey
12. HoltraChem, ME	• Benthic • Water-column vertebrates and invertebrates • Human health	Mercury	• Toxicity tests • Benthic community surveys • Bioaccumulation/bioassay
13. Horseshoe Road and Atlantic Highlands Superfund Site, NJ	• Benthic • Pelagic • Wildlife	Arsenic	• Tissue chemistry • Toxicity testing • Benthic community survey • Bioaccumulation
14 Imperial Refinery, OK	Benthic	PAHs	• Tissue chemistry • BSAFs • Toxicity testing
15. Industri-plex, MA	Human health	Arsenic	• In vivo relative bioavailability
16. Indian River Power Plant, DE	Benthic	PAHs	• Pore-water estimates using (EqP)
17. Johnson Lake, OR	• Human health • Benthic • Wildlife	• PCBs • Metals • PAHs • Petroleum hydrocarbons (PHCs)	• Tissue chemistry • Toxicity testing
18. Lake Hartwell PCB Superfund Site, SC	• Human health fish consumption • Benthic	• PCBs	• Sediment deposition and bioaccumulation modeling • Fish tissue analysis • Benthic tissue analysis
19. McCormick & Baxter Superfund Site, OR	• Human health • Benthic • Pelagic	• PAHs • Hydrocarbons • PCP • Metals	• Surface-water chemistry • Fish tissue analysis • Toxicity tests
20. Mocks Pond, IN	• Benthic • Human health	• PCE, TCE, DCE, VC	• Diffusion samplers in pore water
21. Myrtle Street Embayment, WA	• Benthic • Human health	• PCE, TCE, DCE, VC	• Diffusion-bed samplers in pore water
22. Moffett Field, CA	Benthic	• PCBs • Arochlor 1268 • Asbestos • Lead	• Tissue chemistry • Bioaccumulation (BAF) • Food-chain modeling

Site name	Exposure pathway	Contaminants	Bioavailability tools
23. Onondaga Lake, NY	• Human health • Benthic	• Metals • PAHs • PCBs	• Pore-water chemistry • Toxicity testing • Benthic community surveys • Tissue chemistry • Bioaccumulation/bioassay
24. OU 1, Marine Corps Air Station, NC	Benthic	• Organics • Metals	• Toxicity testing
25. Pearl Harbor Sediment, HI	• Benthic • Human health • Fish and water-column invertebrates • Birds	• Metals • PCBs • Dioxin • PAHs • Pesticides • Herbicides • Ordnance	• Tissue chemistry • Pore water • Toxicity tests • Benthic community surveys • Bioaccumulation/bioassay
26. Philadelphia Reserve Basin, PA	• Human health • Benthic • Pelagic • Wildlife	• PCBs • Metals	• Pore-water chemistry • Fish tissue chemistry • SEM/AVS • Benthic community survey • Bioaccumulation tests • Toxicity test
27. Portland Harbor, OR	• Human health • Benthic • Pelagic • Wildlife	• PCBs • Metals • PAHs • Pesticides • Tributyltin • Total petroleum hydrocarbons • SVOCs	• Surface water chemistry • Pore water • Benthic/pelagic tissue chemistry • Toxicity testing
28. Private Residence, PA	Benthic	• VOCs • PAHs	• Benthic community survey
29. Soda Lake, WY	• Benthic • Pelagic • Wildlife	Selenium	• Bioassays • Pore water (EqP) • Tissue chemistry • Trophic modeling
30. Former Springfield Gas Works, MA	Benthic	PAHs	• Pore-water chemistry (SPME) • Toxicity testing
31. Former Tarrytown General Motors Assembly Plant, NY	Benthic	• Chromium • Copper • Lead • Mercury • Zinc	• AVS/SEM • Pore-water chemistry • Benthic community survey • Tissue chemistry • Toxicity testing • Bioaccumulation
32. Tectronix Wetlands, Beaverton, OR	Benthic	• Cadmium • Copper • Chromium • Lead • Mercury • Nickel • Silver • Zinc	• Bulk sediment chemistry • SEM/AVS • Bulk sediment toxicity bioassay

Site name	Exposure pathway	Contaminants	Bioavailability tools
33. Tri-State Mining District, KS	Benthic	• Cadmium • Lead • Zinc	• Pore-water chemistry • Toxicity testing
34. Vandenberg AFB Site 5 Cluster	Benthic	Metals	• Bulk sediment chemistry • Toxicity testing
35. Washington Navy Yard, DC	Benthic	PAHs	• Pore-water chemistry (SPME) • Toxicity testing

9.2 Risk Management

USEPA recognizes the need to improve the scientific foundation for contaminated sediment remedy selection by improving site and risk characterization, understanding how different remedial options can effectively reduce risks to humans and the environment, and optimizing the cost-effectiveness of remedial actions. Furthermore, USEPA recognizes the important role that bioavailability plays in this scientific foundation (USEPA 2005a). Assessing bioavailability by using the tools described in this document can increase the understanding of the cause and sources of toxicity and lay the foundation for the most appropriate remedy and monitoring requirements at a site. As a result, RAOs can be established that more specifically address the risk pathways and sources.

Bioavailability can also be important in determining the appropriate methods for managing identified risk. Assessing bioavailability will not only help to focus action on chemicals that are available for uptake by receptors (with the potential to cause adverse effects), but also provide information pertinent to effective remedy design and implementation. By incorporating bioavailability considerations into the early stages of site characterization through the risk assessment process and up through the point of remedy selection, a more effective remediation may be accomplished, which will optimize overall cost. This approach can be particularly important at sediment sites where contamination has been spread across large areas and, in some cases, through multiple watersheds.

Sediment remedies typically involve capping, dredging, and/or natural recovery. Table 9-2 presents bioavailability considerations that may influence the remedial design, implementation, and monitoring associated with each of these cleanup options. These considerations apply as well to managing contaminant release and transport during implementation of capping and dredging, as well as monitoring residual contamination from both undisturbed sediments and sediments redeposited from suspended sediments resulting from cap placement or dredging operations.

Table 9-2. Reasons to consider bioavailability in the remedy selection, design, implementation, and monitoring phases

Remedy	Remedy selection	Remedy design	Remedy implementation	Remedy monitoring
No further action (NFA)	Provides a more accurate site exposure evaluation, which leads to a decision that there is no adverse impact to the environment as opposed to using standard (i.e., conservative, non-site-specific) risk assessment inputs (i.e., SQGs).	NA	NA	Can verify the lack of COC bioavailability over time.
Monitored natural recovery (MNR)/ enhanced monitored natural recovery (EMNR)	Provides a more accurate site exposure evaluation, which indicates that COC bioavailability will either remain constant or decrease with time.	Can provide a more accurate prediction of changes in COC concentrations and associated bioavailability with time based on site-specific data. EMNR cap design can be based on modeled reduction in bioavailability.	Thin layer caps may require similar bioavailability considerations as those included in Capping (see below).	Provides a measure of biota recovery (i.e., sediment toxicity, benthic community size and/or diversity). Can quantify either a decrease in bioavailability through sequestration/burial or an increases in bioavailability due to resuspension, groundwater flow, bioturbation, scouring, etc.
Capping	Provides a more accurate site exposure evaluation as opposed to using standard (i.e., conservative, non-site-specific) risk assessment inputs (i.e., SQGs) to establish RAOs. This evaluation may lead to a determination that capping can effectively isolate contaminants and adequately reduce bioavailability.	Can help provide a more accurate determination of cap thickness requirement based on estimated breakthrough (i.e., from pore-water measurement), or to isolate biota from direct contact with COCs (bioactive depth). Can help to determine cap materials that will limit contaminant mobility (e.g., OC content).	Provides verification of adequate cap thickness to isolate contaminated sediments from overlying water and biota. Can identify an increase in contaminant bioavailability during implementation: contaminant release and transport downstream. Provides a measurement of residual bioavailable contamination in sediments redeposited from particulates resuspended during cap placement.	Offers a measurement of cap effectiveness (i.e., cap integrity or pore-water COC concentrations migrating into and through the cap).

Remedy	Remedy selection	Remedy design	Remedy implementation	Remedy monitoring
Removal	Provides a more accurate site exposure evaluation as opposed to using standard (i.e., conservative, non-site-specific) risk assessment inputs (i.e., SQGs) to establish RAOs, enabling dredging to be focused on areas which are true source of bioavailability concern. Consideration of bioavailability should also be included in an assessment of impacts from dredging alternatives (e.g., resuspension impacts, residual sediment following removal, etc.).	Can assist in the development of site-specific cleanup goals and more accurately identify the associated limits of sediment in need of removal. Aids in the design of resuspension controls, should they be necessary.	Can identify an increase in contaminant bioavailability during implementation: contaminant release and transport downstream. Provides a measurement of residual bioavailable contamination in both undisturbed sediments and sediments redeposited from suspended sediments resulting from dredging operations.	Monitoring residual contamination focuses on concentrations that are actually bioavailable and pertinent media of concern (e.g., water column fish, benthic diversity, etc.).

The selected remedy should be designed to take into account where bioavailability measurements indicate adverse impact to receptors and the relationship to a particular media, concentration, or exposure pathway. For example, the thickness of and material used in a capping system could be adjusted to account for contaminant concentrations in sediment pore water rather than in bulk sediment. Likewise, the quality and quantity of components in active capping systems could be designed to take into account the fate and transport of contaminants in the exposure media of concern (i.e., advection/diffusion of pore water vs. static bulk sediment chemistry).

Since the objective of a remedial approach is to mitigate potentially unacceptable risks, bioavailability measurement tools can be useful in monitoring the effectiveness of a remedy as they can focus efforts on the particular pathway/media of concern. For example, pore-water monitoring within a cap might indicate whether groundwater discharge or upwelling is mobilizing contaminants into a clean cap or whether bioturbation is mixing clean sediment with the underlying contaminated sediment to a degree that receptors are being exposed again at harmful levels.

The future ITRC contaminated sediments guidance document will discuss the selection and implementation of a remedy at a contaminated sediment site; however, the following provides a brief overview on how bioavailability considerations have been incorporated into remedial decisions at a contaminated sediment sites.

The team has identified the following remedies and used case studies to highlight how bioavailability information influenced the decision at the site:

- no further action (NFA)
- monitored natural recovery (MNR) or enhanced MNR (EMNR)
- in situ capping
- removal

9.2.1 NO FURTHER ACTION

This decision is typically based on the evaluation that there is no adverse impact to human health or the environment from bioavailable levels of COPCs in the sediment. USEPA (2005a) states "No-action or no-further-action alternatives normally do not include any treatment, engineering controls, or institutional controls but may include monitoring. For example, at a site where risk is acceptable (e.g., because contaminant levels in surface sediment and biota are low and the site is stable), but the site contains higher levels of contamination at depth, it may be advisable to periodically evaluate the continued stability of buried contaminants." An NFA decision could be affected by considering site-specific bioavailability measurements which indicate contaminant concentrations that are actually available for receptor uptake and result in a risk-based evaluation of no adverse effect upon ecological or human receptors. As an example, at IR Site 89, Marine Corps Base (MCB) Camp Lejeune, sediment and surface water data indicated exceedances of benchmarks; however, an evaluation of bioavailability parameters indicated that conditions associated with the site were not different than reference conditions. Accordingly, it was concluded that there was no risk associated with the site, and no cleanup was performed. As an example, at Tektronix in Oregon, metals concentrations exceeded conservative screening levels, but evaluation of AVS/SEM indicated metals were not bioavailable at concentrations of concern. As a result, no remedial action for Beaverton Creek was determined to be necessary.

9.2.2 MONITORED NATURAL RECOVERY

MNR is a remedy that typically uses known, ongoing, naturally occurring processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of contaminants in sediment (ESTCP 2009). The decision to use MNR at a site is generally derived from a risk-based process that indicates that bioavailability of COPCs will either remain constant or decrease over time. MNR was the selected remedy at Lake Hartwell Site in South Carolina. At this site, even though there was a significant volume of sediment containing PCBs above the 1 ppm cleanup level established in the ROD, the higher PCB levels were buried at depth below sediments with lower PCB levels. Predictive modeling was used to estimate PCB levels in surface sediment and bioaccumulation in fish tissue over time. The results of this modeling showed that PCB concentrations were expected to decrease over time in both surface sediment and fish, and combined with the impracticability of dredging the large volume of impacted sediments (and anticipated limited effectiveness of dredging to reduce PCBs), MNR was selected. In addition, the ROD specified that sediment transport be enhanced in Twelvemile Creek by flushing sediments through dammed impoundments to accelerate MNR. EMNR is MNR combined with some other intrusive remedy (e.g., thin-layer placement of clean sediment at sites where the natural rate of sedimentation is insufficient to bury contaminants in a reasonable timeframe) to accelerate reductions in surface sediment concentrations (USEPA 2005a).

9.2.3 CAPPING

In situ capping refers to the placement of a subaqueous covering or cap of clean material over contaminated sediment that remains in place (USEPA 2005a). The design of appropriate capping systems depends on many physical, chemical, and biological variables. For instance, cap thickness depends on the rate of transfer of COPCs from underlying sediment pore water to the surface water above the cap, and therefore a more accurate determination of pore-water COPC concentrations and their effects on biota is essential. Additionally the cap thickness is often determined by considering the site-specific thickness needed to isolate biota from contaminated sediment (i.e., providing a clean bioavailable layer). A modification to this is an active cap. In the case of active caps, the physical, chemical, and biological processes that affect bioavailability, as outlined in this document, would be used to design a cover system to reduce bioavailability of COPCs (e.g., the use of activated carbon to sequester hydrophobic organics within the active cap). Capping of contaminated sediment has been employed at numerous sites throughout the United States. One example of where bioavailability played a role in delineating the areas to be capped is Onondaga Lake in New York. At this site there are numerous contaminants for which cleanup levels were established using multiple lines of bioavailability evidence. The remedy includes dredging in near-shore littoral areas to make room for an engineered cap, thin-layer capping in the main body of the lake, and MNR for the remainder of the site.

9.2.4 REMOVAL

Dredging and excavation are means of removing contaminated sediment either while it is submerged (dredging) or after water has been diverted or drained (excavation) (USEPA 2005a). Dredging volumes are generally based on remedial goals that have been established during the site characterization process. Incorporating bioavailability measurements into a risk-based decision process can aid in the development of a site-specific remedial goal, thus targeting sediment removal only to areas that are known to cause toxicity. For instance, cleanup levels based on the EqP-TU approach were calculated for intertidal sediments contaminated with

NAPL and dissolved-phase, diesel-range organics at the Indian River Power Plant site in Delaware. An underground pipeline leaked diesel fuel into sediments in the Indian River.

Bulk sediment chemical measures of PAH parent compounds and alkylated homologs were normalized to the TOC concentrations. Pore-water concentrations of these compounds were predicted using EqP and were subsequently divided by the analyte-specific acute and chronic values calculated from narcosis theory. For each sample, the individual quotients were summed to yield acute and chronic TUs. TUs >1 indicated that pore-water exposure concentrations were potentially high enough to cause toxicity to benthic organisms. The state required excavation of all sediments with chronic TUs >1, which corresponded to a total PAH cleanup criterion of 2 mg/kg. The PAH cleanup criterion determined the volume of sediments removed from Indian River. In total, approximately 480 cubic yards of sediment was ultimately removed from the Indian River shoreline, and confirmatory samples indicated that the calculated cleanup criteria were met.

9.3 Summary

This Web-based technical and regulatory guidance describes the mechanisms affecting contaminant bioavailability, the tools used to assess bioavailability, proper application of those tools relative to a specific endpoint (ecological or human), and how bioavailability information can be incorporated into risk management decisions at contaminated sediment sites. The tools described in this document aid in conducting a successful assessment with increased acceptance by regulators, practitioners, and public interests in your state or region. The ITRC Contaminated Sediments Team has developed this document to assist state regulators and practitioners in understanding and incorporating fundamental concepts of bioavailability into contaminated sediment management.

The bioavailability concepts, tools, and measures identified in this document are grouped based on receptor group, such as ecological (i.e., benthic, fish and aquatic organisms, wildlife, and plants) and human. The tools and measures identified in Chapters 4–8 aid in the assessment of site-specific contaminant bioavailability. Case studies are used to provide examples of how the identified tools and measures were used in decision making within each receptor group. The team has seen that these tools and models have been used to set scientifically and technically defensible cleanup goals at contaminated sediment sites and also have helped to select appropriate remedial strategies to mitigate exposure. The application of the tools described in this document may depend upon a variety of project constraints, such as schedule, number of COPCs, investigation resources, and acceptance by the regulatory agency and regulated community. The team has found that bioavailability processes are often not addressed when setting risk-based cleanup levels due to lack of scientific or technical understanding. Thus, the use of bioavailability in the sediment management process varies by state, although many use consistent risk assessment processes, i.e., USEPA's ERA guidance for Superfund (USEPA 1998c, 1997b, 1992b) and for human health (USEPA 1989a, 1989d).

Assessing bioavailability increases the understanding of the sources and causes of toxicity, and lays the foundation for the most appropriate remedy or monitoring requirements at a site. As NRC (2003) stated, "Explicit consideration of bioavailability processes and modeling in risk assessment would help to adjust cleanup goals by more accurately identifying that fraction of

contaminant total mass that has the potential to enter receptor." In general, an investigator or regulator should strive to gain the best possible understanding of the physical, chemical, and biological processes that "drive" the risk (i.e., bioavailability by the means of COPC transfer, uptake, and concentrations at which adverse effects to receptors occur). Ultimately, if contaminants are present but not bioavailable, they should not be included in the calculation of risk. The decision-making process will most likely involve using a weight-of-evidence approach. Decisions based on bioavailability measurements are often highly site specific and influenced by soil/sediment type, contaminant aging/weathering, contaminant fate and transport, the media in which is the contaminant is present, exposure pathways, and potential receptors. Bioavailability should be incorporated in the risk assessment process to obtain a clearer understanding of contaminant toxicity and exposure pathways, such that remedy selection decisions can be optimized and resources efficiently focused. By incorporating bioavailability considerations into the early stages of site characterization through the risk assessment process and up through the point of remedy selection, a more effective remediation may be accomplished, which will optimize overall cost. Numerous case studies are provided throughout the document to illustrate the application of bioavailability adjustments or considerations in the establishment of remedial goals/decisions.