Rapid Sediment Characterization (RSC) Tools for Ecological Risk Assessments

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Abstract

The primary goals of a Sampling and Analysis Plan for an Ecological Risk Assessment (ERA) are to identify potential contaminant sources and to delineate areas of contamination. However, traditional sampling and analysis approaches do not always provide all the information necessary to support the risk assessment process in a cost- and time-effective manner. Risk assessments performed in the marine environment are often hindered due to the complexity and heterogeneity of marine ecosystems. Therefore, the implementation of additional measures to facilitate the assessment process has been dictated by Navy policy.

One measure that can be implemented at various stages of the ERA process at sediment sites is the use of rapid sediment characterization (RSC) technologies. These are field transportable screening tools that provide measurements of chemical, biological or physical parameters on a real-time or near real-time basis. When used appropriately, these tools can streamline many aspects of the ERA process. The tools can be used to delineate areas of concern, to fill in information gaps and to assure that expensive, certified analyses have the greatest possible impact.

This guide provides information about several of the rapid sediment characterization technologies that can be used at marine sediment sites, including X-ray Fluorescence (XRF) for metals, UV Fluorescence (UVF) for polycyclic aromatic hydrocarbons, QwikSed bioassay for assessing toxicity as well as other techniques. Examples are provided to illustrate the efficacy of applying rapid sediment characterization tools to different stages of the ERA process. Finally, recommendations are given for the evaluation, selection and application of RSC tools for the ERA process.

Introduction

Traditional sampling and analytical approaches do not always provide the information necessary to support the Ecological Risk Assessment (ERA) decision-making process in a cost- and time-effective manner. Because of the complex nature of marine ecosystems, Navy policy (1) specifically requires that sampling programs focus primarily on the identification of potential contaminant sources and on delineation of areas of contaminated media. It further dictates that sampling programs should make use of advanced chemical and biological screening technologies, data quality objectives and statistical procedures to minimize overall sampling requirements. Implementation of advanced chemical, physical and/or biological screening technologies (i.e., rapid sediment characterization tools) at different stages of the ERA process can aid in

focusing sampling requirements and ultimately facilitate reaching final decisions in a cost- and time-effective manner.

Ecological Risk Assessment evaluates the likelihood that exposure to one or more stressors (i.e., contaminants) will result in adverse ecological effects (2). The purpose of the assessment is to provide information relevant to the remedial or no further action decision-making process. Navy policy (1) states, "Ecological Risk Assessments conducted for the Navy (should) be scientifically based, defensible, and done in a manner that is cost effective and protective of human health and the environment". Collection of data necessary to support decisions at Navy marine sites in a cost-effective manner is often hindered by the complexity and heterogeneity of marine ecosystems. Detailed site investigations require extensive sampling and subsequent laboratory analyses for both metal and organic contaminants. Samples are often collected without any *a priori* knowledge of the nature and extent of contamination. Due to the high cost of laboratory analyses, the number of samples taken is often cost-limited. Thus, zones of contamination can be missed, or, if located, over- or under-estimated. For more detailed spatial information on the extent of contamination, sites of interest must often be sampled and analyzed in an iterative manner. Chemical assays are often combined with additional laboratory analyses; including one or several bioassays to determine whether there are adverse biological effects of these contaminants in various media (e.g., sediment, elutriate, water column). This approach can be prohibitively costly, slow and labor-intensive. When used appropriately, RSC tools can streamline many aspects of the ERA process, delineating areas of concern, filling information gaps and assuring that expensive, certified analyses have the highest possible impact.

Rapid Sediment Characterization

Rapid sediment characterization (RSC) can be defined as utilization of near real-time screening techniques to rapidly delineate extent of contamination, physical characteristics and/or biological effects. Rapid sediment characterization tools are field transportable analytical tools that provide measurements of chemical, physical or biological parameters on a real-time or near real-time basis. A wide variety of tools exist which are capable of making these types of measurements. Many technologies have been tested and/or successfully used to characterize different types of environmental media (e.g., soil, sediment, water and air). A compendium of these technologies is listed in "Field Analytical and Site Characterization Technologies, Summary of Applications" (3) and in "Field Analytical Measurement Technologies, Applications, and Selection" (4). The EPA has also compiled an online Field Analytical Technologies Encyclopedia (FATE) that is intended to provide information about technologies that can be used in the field to characterize contaminated soil and ground water, monitor the progress of remedial efforts, and in some cases, for confirmation sampling and analysis for site close out (see additional references/sources for details). Although not all of the technologies currently available are applicable to marine sites, several of them have been tested and demonstrated at Navy marine sediment sites (Table 1). Examples can also be found in standard environmental textbooks such as Gilbert's 1987 "Statistical Methods for Environmental Pollution Monitoring" which provides specific examples of using

screening and laboratory data together to optimize for reduction in cost or data variability (Chapter 9) (5).

Table 1. Examples of rapid sediment characterization tools tested in marine sediments.

Measurement Type	Analytical Technique	Analyte(s)
Chemical	X-ray Fluorescence Spectrometry (XRF)	Metals
	UV Fluorescence Spectroscopy (UVF)	Polycyclic Aromatic Hydrocarbons (PAHs)
	Immunoassay	PCBs Pesticides PAHs
Physical	Laser Particle Scattering	Grain size (% fines)
	IR Moisture Analyzer	Moisture content (%)
Biological	QwikLite/QwikSed Bioassay	Organic (e.g., PAHs), inorganic (e.g., Metals)

In order to determine if RSC tools are appropriate to assess contamination at a given site, several questions should be asked. For example: What are the goals of the investigation? What are the contaminants of concern? Are the contaminants known? What are the action limits? What are the strengths and weaknesses of the analytical methods being considered? Do instrument detection limits meet action limit requirements?

By asking these questions before sampling is started and considering the advantages and disadvantages of different techniques, appropriate decisions can be made on how best to implement a technology or suite of technologies to facilitate the ERA process.

The relative advantages and limitations of rapid sediment characterization methods and standard methods are provided in Table 2. A brief description for each technology listed in Table 1 is provided below. All of the technologies described below are commercially available. Additional references and sources of information regarding RSC technologies are provided at the end of the document.

Rapid Sediment Characterization Technologies: General Principles

X-ray Fluorescence Spectrometry (XRF): Metals

This technique measures the fluorescence spectrum of x-rays emitted when metal atoms are excited by an x-ray source. The energy of emitted x-rays reveal the identity of the metals in the sample and the intensity of emitted x-rays is related to their concentrations (6, 7). Rapid, multi-element analysis can be performed by XRF. An XRF

Table 2. Advantages and limitations of screening and standard laboratory methods.

Rapid Sediment Characterization Analysis	Standard Laboratory Analysis
Benefits □ rapid results can guide sampling locations □ potential for high data density for mapping □ reduced cost per sample	Benefits □ standard methods that are very quantitative □ can often remove interferences
Limitations □ often non-specific □ semi-quantitative □ matrix sensitive	Limitations □ often blind sampling □ long delays to results □ expensive ($K/sample)

spectrometer can analyze a wide range of elements (i.e., sulfur through uranium), with a wide dynamic range, from parts per million to percent levels, encompassing typical element levels found in soils and sediments. Detection limits are different for each element. For metals such as Pb, Zn and Cu the detection limits typically range from 50 ppm to 150 ppm (7). Field portable XRF (FPXRF) instruments can be calibrated using several different methods: 1) internally, using fundamental parameters determined by the manufacturer, 2) empirically, based on site-specific calibration standards, or 3) using the Compton Normalization Method which is based on the analysis of a single, certified standard and normalization for the Compton peak (7). Field portable XRF units provide near real-time measurements with minimal sample handling, allowing for extensive, semi-quantitative analysis on site. Several examples can be found in the literature in which FPXRF has been used for the analysis of soils and sediments. Sediments in a Norwegian fjord (8), San Diego Bay (9) and a large number of sites (10) have been screened for heavy metal content by XRF. FPXRF has been certified by the USEPA as a field screening method for metals in soils (7).

UV Fluorescence Spectroscopy (UVF): PAHs

This screening method is based on the measurement of fluorescence observed following UV excitation of organic solvent extracts of sediments. In general, this method is used to measure fluorescent organics (especially PAHs), though some care must be taken to reduce signals from natural organic compounds (e.g., humics) that fluoresce. Because fluorescence measurements are matrix sensitive, it is currently necessary to make measurements on solvent extracts rather than directly on the wet, solid sediment sample in order to achieve detection limits appropriate for marine sediment PAH benchmark criteria and typical levels in many marine sediments. Solvent extraction requires additional time for sample extract analysis, so although fluorescence is a near real-time measurement, the total time for analysis may be up to half an hour. Solvent extraction makes it possible to improve detection limits by several orders of magnitude. Detection limits range from one ppm to five ppm total solid-phase PAH. Many studies have used UVF to assess total PAH levels in various types of sediment (11-13).

Immunoassays: PCBs, PAHs, Pesticides

An immunoassay is a technique for detecting and measuring a target compound through use of an antibody that binds only to that substance. Quantitation is generally performed by monitoring solution color changes with a spectrophotometer. The technology can be used to measure concentrations of a variety of organic contaminants including PCBs, PAHs and organic pesticides. Detection limits range from hundreds of ppb to low ppm levels (3,4).

Laser Particle Scattering: Grain Size

Laser Particle Scattering operates on the principle of small-angle (Rayleigh) laser scattering to obtain the size distribution of particles suspended in water. The small-angle intensity distribution of light scattered by particles suspended in water is recorded. This distribution, which is the sum of particle scattering, is inverted to obtain the particle concentration and size spectrum. Theoretically, the particle size range is 0.1 µ to 500 µ. Commercial instruments, such as the LISST (Laser In Situ Scattering Transmissometry) instruments are available for making both in situ measurements (submersible) as well as measurements of samples in the laboratory, on the manufacturing line, or in a small boat (14). The operating range (particle size range) of these instruments is typically 1.25 µ -250 µ. Grain size measurements are made because contaminants generally are associated with the fine-grained particles (15). This information can be useful in helping to delineate contaminated areas. Furthermore, grain size can be used to normalize other measurements and, at times, to predict when bioassays may encounter confounding factors.

IR Moisture Analyzer: Moisture Content

Moisture content measurements can be made quickly in the field or laboratory using commercial infrared drying instruments. Measurements are typically made by spreading a five gram sample of wet sediment on an aluminum sample dish, placing it in the analyzer, weighing it, initializing the drying procedure and then re-weighing it. Percent moisture is determined by the difference between wet weight and dry weight. Drying time is typically 5 – 15 minutes, depending upon moisture content. These results are used for conversion of data from wet weight to dry weight, for comparison with benchmarks and reference values, which are generally resolved in dry weight units. In some cases, percent moisture can be used as a proxy for grain size.

QwikSed Bioassay

The QwikLite and QwikSed Bioassays measure the inhibition of light emitted by marine bioluminescent dinoflagellates (e.g., *Gonyaulax polyedra)* exposed to a test solution (effluents, elutriates, or sediment pore waters). Any decrease in light output relative to controls suggests bioavailable contaminants or other stressors. The bioassays are capable of measuring a response within 24 hours of test setup and can be conducted for a standard four-day acute test or seven-day chronic test. QwikSed can be used to evaluate sediment toxicity. If the contaminated sediment is found to be toxic and requires cleanup, QwikSed can be used to assess the toxicity reduction. A "Standard Guide for Conducting Toxicity Tests with Bioluminescent Dinoflagellates" can be found in the1999 Annual Book of ASTM Standards (16).

Summary

Implementation of rapid characterization tools in ecological risk assessments will improve sampling and reduce uncertainty at several steps of the RI/FS process without the enormous cost of traditional re-sampling efforts. Use of these tools moves the ERA process forward in the most time- and cost-effective manner with minimum uncertainty. Several examples are provided in the following section in order to illustrate the efficacy of using rapid characterization tools in ecological risk assessments.

Rapid Characterization Tools in the Ecological Risk Assessment Process

Tier 1: Screening Risk Assessment

The goal of the Screening Risk Assessment (SRA) is to determine whether a complete exposure pathway is present between each chemical of interest and selected ecological receptors (Step 1) and to estimate risks for those chemicals for which Step 1 identifies complete pathways. Risks are estimated by comparing maximum chemical concentrations directly to media-based threshold values, or by modeling chemical doses to ecological receptors and then comparing the dose estimates to threshold dose values (Step 2). Potentially unacceptable risks are indicated for those chemicals that have environmental concentrations or doses that exceed threshold values. These chemicals are termed contaminants of potential ecological concern (COPECs). The Tier 1 assessment should employ existing data, and *should not* require additional data collection. Because the SRA is conducted using existing data, overall costs should be low. Costs are related primarily to collection of existing data, a site visit, identification of threshold values, dose modeling and report preparation. Completion of the SRA should be relatively quick (e.g., no more than 2-3 months) (1).

Existing site data, however, do not always exist. If data are lacking, rapid characterization can map the extent of contamination in order to guide sampling for full COPEC analysis. The following example illustrates how the FPXRF was used to identify metals-contaminated hotspots at a Navy shipyard. Near real-time measurements were made on wet sediment samples on board a research vessel as the samples were being collected. Over the course of one day, 25 samples along 5 transects were collected and analyzed. The resulting data were plotted using a 3-D graphing program to delineate hotspot regions. The rapid characterization by FPXRF delineated the extent of contamination and suggested that the concentrations of both Cu and Zn increased towards the inboard regions of the pier area (Figure 1). By using FPXRF to quickly map the area under investigation, subsequent sampling for full COPEC analysis was more focused.
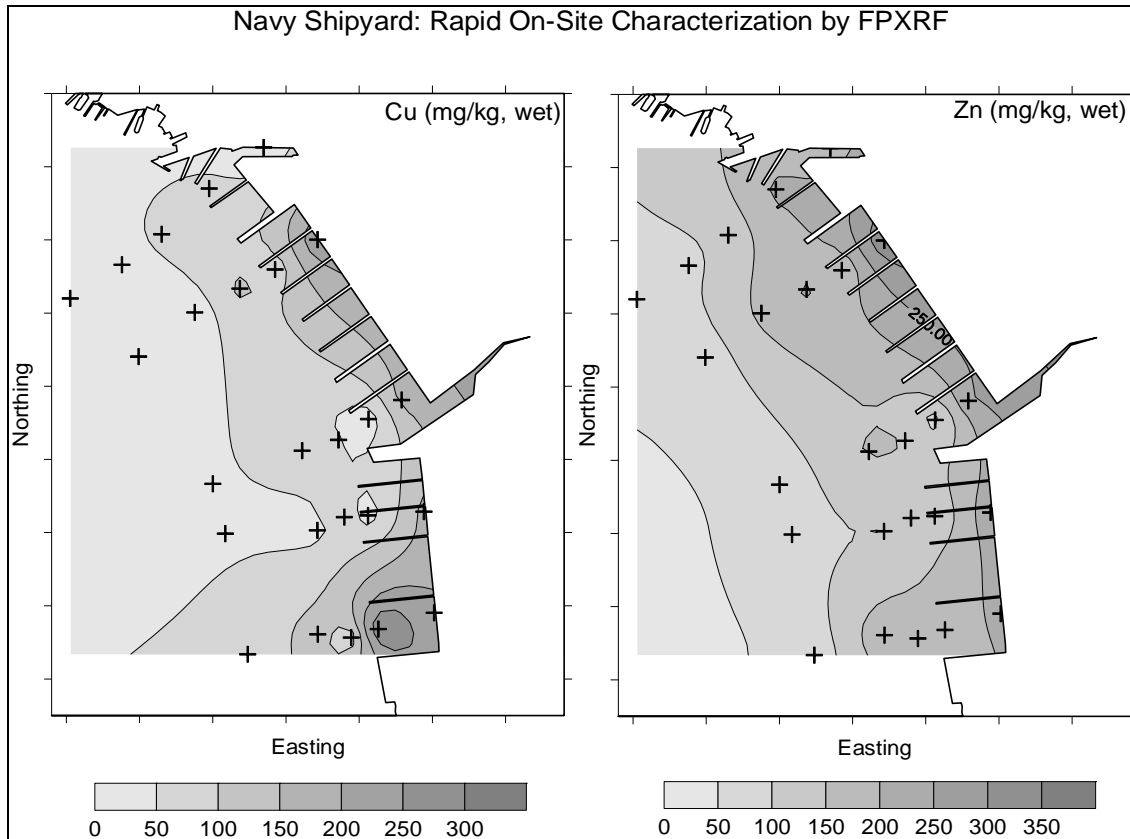
Figure 1. Tier 1 (Step 2): rapid sediment characterization of copper and zinc in sediments by FPXRF, in mg/kg (wet).

Tier 2: Baseline Ecological Risk Assessment

Tier 2 is referred to as the Baseline Ecological Risk Assessment (BERA), which is typically the most extensive activity within the ERA process, both in terms of data collection and analysis, cost, and effort. Tier 2 has two sets of objectives, the first dealing with risk management and decision-making, and the second with focusing efforts and identifying assessment objectives to avoid multiple iterations of the BERA. The Tier 2 BERA is much more site-specific and technically rigorous and much less conservative than is the Tier 1 SRA, and follows a five-step process to evaluate ecological risks and to determine whether site remediation is warranted from an ecological perspective (1). There are several steps within Tier II in which rapid characterization tools can play a critical role. Examples for Step 3a, Step 4 and Step 5 are provided.

Step 3a: Refinement of Exposure Assumptions

The Tier 2 BERA begins with a refinement of the conservative exposure assumptions employed in the Tier 1 SRA and a recalculation of the Tier 1 risk estimates (Step 3a). In addition to the refinement of conservative assumptions, this re-evaluation may include considerations of background chemical concentrations, sample detection frequency, contaminant bioavailability and realistic exposure scenarios (1). Rapid

characterization tools can aid in this step by generating high-density contours of contaminants or toxicity. In doing so, random hits are de-emphasized, unique sources are flagged and background levels or trends are characterized.

In the following example, concern at the site was raised due to evidence of high levels of polycyclic aromatic hydrocarbons (PAHs). The results obtained from a few historical samples (e.g., location denoted by star in Figure 2), drove discussions about the necessity for further delineate the extent of PAH contamination at the site. A RSC approach was chosen to further delineating the extent of contamination. Based on anecdotal information about the site (e.g., presence of creosote-pier pilings along quaywall) and the results from the historical samples, sampling transects extending from the quaywall to beyond the ends of the piers were established around inactive ships docked at site. One day of higher density rapid screening analysis using UVF suggested that PAHs in the sediments were associated with pier pilings along the quaywall (Figure 2). Based on the field screening results, a selection (30%) of samples underwent laboratory analysis that confirmed creosote impact. The resulting information suggested that the area could be divided into two discrete strata, each having a different exposure based on bulk PAH concentrations. Average PAH concentration for each stratum could be determined by combining screening and laboratory values (5). This provides a cost-effective method for refining exposure assumptions based on a more complete sampling of the area.
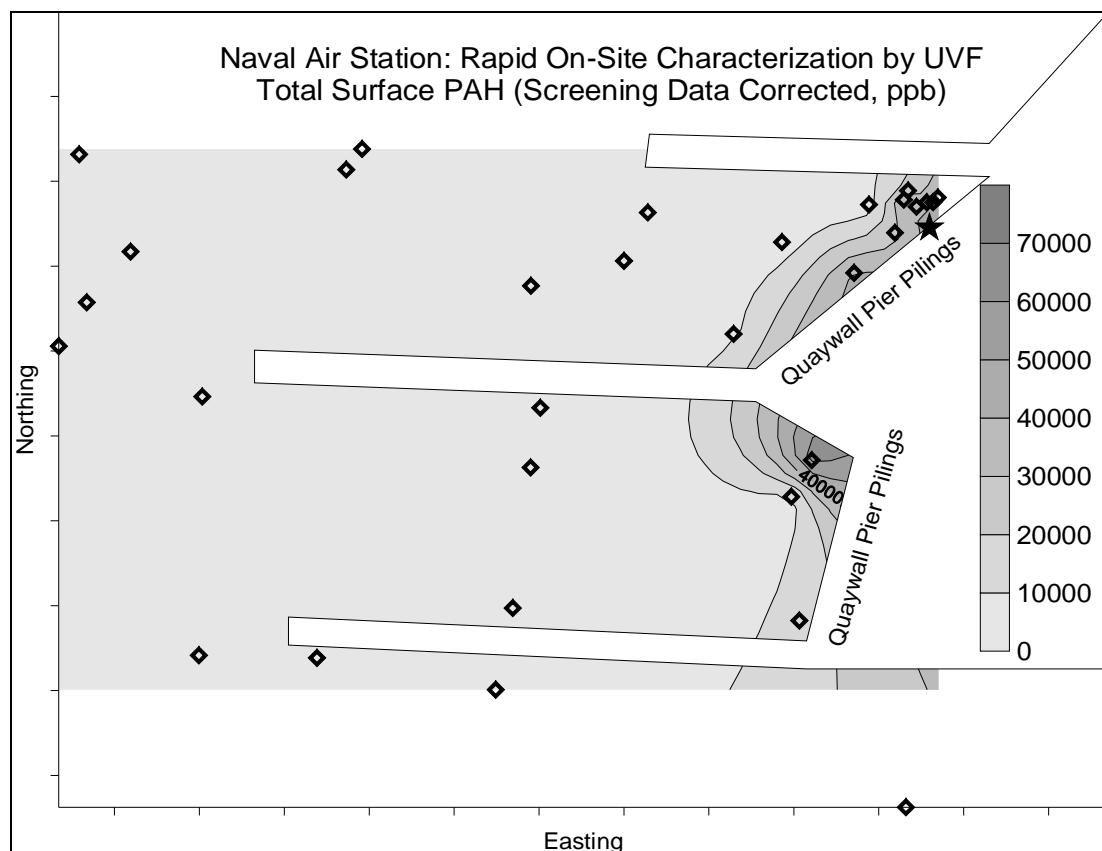
Figure 2 Tier 2 (Step 3a): rapid sediment characterization of total PAHs by UVF, in mg/kg (dry).

Step 4: Study Design and DQO Process

The primary goal of any sampling plan is to obtain data that have a high probability of reducing uncertainty. Rapid characterization, when used to guide sampling for regulatory analysis, allows for low-density sampling of homogeneous sites and focuses higher density sampling to regions of heterogeneity, gradients or interfaces.

In the following two examples, multiple sensors were deployed in two regions (Region I and Region II) of a Naval Complex over the course of two weeks. During the first week, sediment samples were collected and analyzed on site from Region 1. Measurements were made for metals, PAHs, toxicity, grain size (% fines) and % moisture. As results were generated, the data were compiled into contour plots to help guide the subsequent sampling. A final review of all data indicated that the area surveyed in Region I was fairly homogeneous in terms of sediment geochemistry. The sediment was predominantly fine-grained ($< 63\ \mu$), the level of contaminants ranged from low (e.g., Zn) to non-detect (e.g., PAHs, Pb) and no toxicity was observed (Figure 3). Such information produced from a rapid survey at this site or other sites could focus the regulatory sampling and analysis plan. In this case, the site is homogeneous, therefore fewer, well-positioned samples could be taken, reducing assessment time and cost.
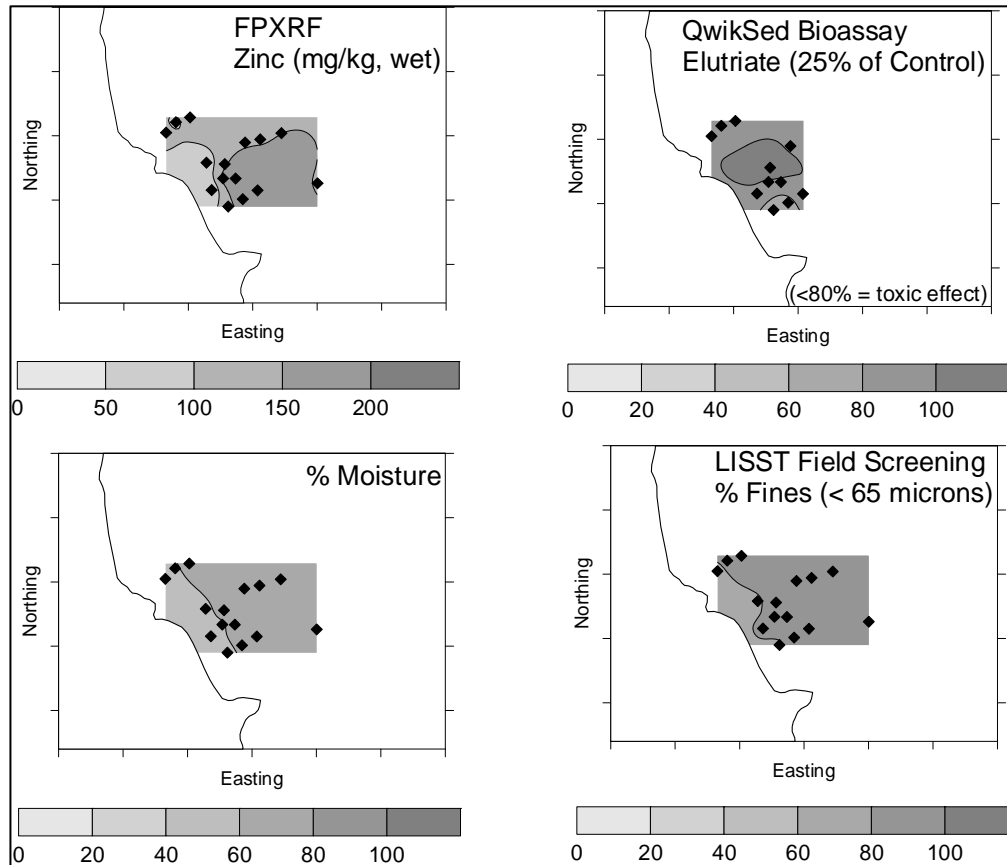
Figure 3. Tier 2 (Step 4): rapid sediment characterization results using a suite of tools illustrate homogeneity at the site (Region I).

During the second week of deployment, Region II was surveyed using the same rapid characterization tools with the exception of the LISST. Percent moisture measurements were made as a proxy for grain size. This region was quite different from Region I in terms of use and sediment geochemistry. As can be seen from the resulting contour plots (Figure 4), contaminant levels were quite elevated when compared to those in Region I. The distributions were fairly heterogeneous and different sources were indicated. PAHs appeared to be associated with the inboard region, along the piers and quay wall, which were creosote-coated. Many metals did not co-associate with each other or with PAHs. Toxic effects were also observed at this site. From these results, it appears that the sediment is predominantly fine-grained, an observation which was confirmed by subsequent analyses. Information obtained from rapid characterization of Region II illustrates the heterogeneity of contaminant distribution at the site and suggests that higher density sampling should be carried out to insure adequate coverage and to reduce uncertainty.
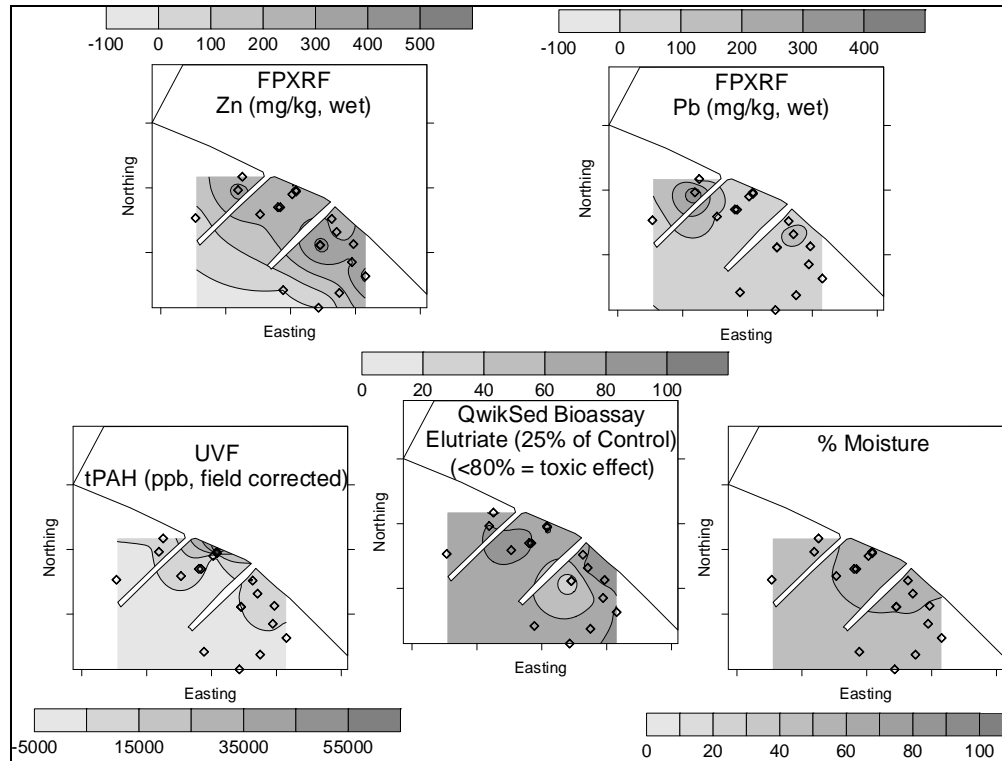
Figure 4. Tier 2 (Step 4): rapid sediment characterization results using a suite of tools illustrate heterogeneity at the site (Region II)

Step 5: Verification of Field Sampling Design

Steps 3b – 5 represent the most important aspects of the Tier 2 BERA process, namely project planning and study design and verification (Step 5). These are the steps that serve to focus the scope and magnitude of the BERA. Specifically, these steps identify (and provide the rationale for) the endpoints to be evaluated, the laboratory and field methods to be employed, the statistical analyses to be used for evaluating data, and the methods to be used for estimating and characterizing the ecological risks. By doing so, the intent of these steps is to 1) ensure that the assessment focuses on the important ecological concerns for the site; 2) ensure that the data truly necessary to make a risk management decision are collected; and 3) avoid the collection of data that are not necessary for making a risk management decision for the site in question (1).

The following example illustrates the effectiveness of using RSC to verify the sampling plan designed during Step 4. At this site, concern was voiced by both the RPMs and regulators that the extent of contamination of the COPEC (copper slag) had not been adequately delineated, and that the sampling plan developed using the historic data would not accurately delineate the extent of contamination. Therefore, the XRF was used to provide low cost, high-density data to verify the sampling design prior to proceeding with Step 6 (Site Investigation and Analysis). Figure 5a shows the historic sampling positions and Figure 5b shows the locations of the additional samples that were taken for XRF analysis (Step 5). In this case, the need for near real-time measurements
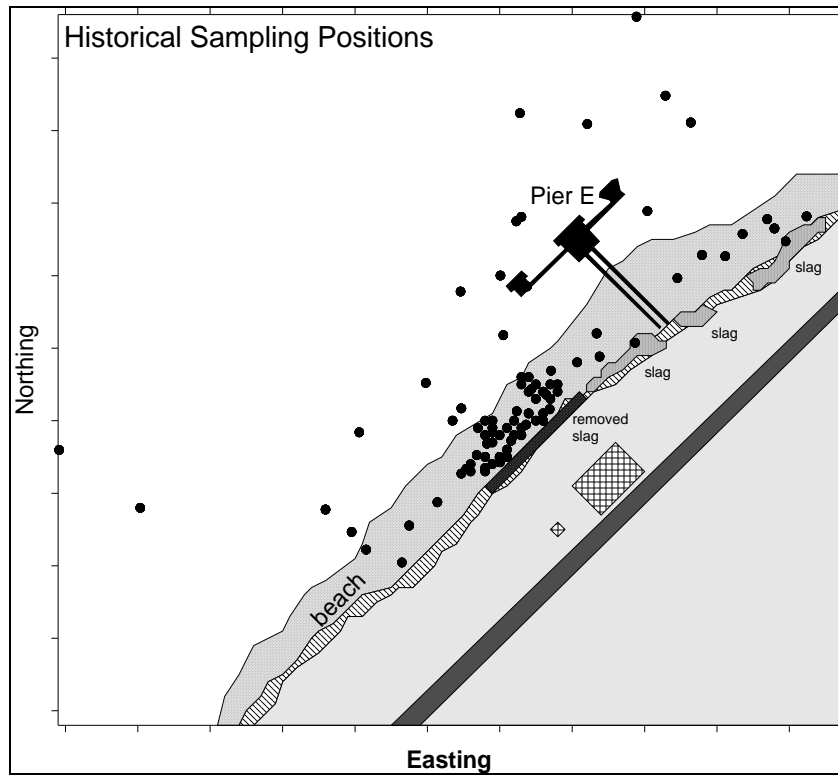
Historical Sampling Positions

Northing

Pier E

slag

slag

slag

removed
slag

beach

Easting

Figure 5a. Tier II (Step 5): sample locations from historic sampling.

XRF Sample Locations (Step 5)

(Pier)

(Beach)

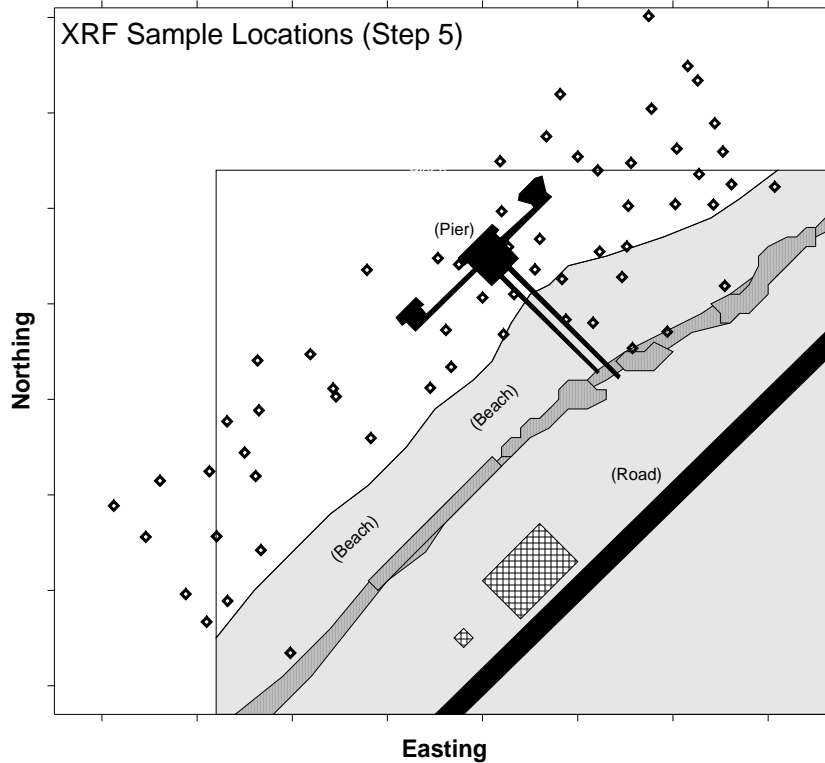(Beach)

(Road)

Northing

Easting

Figure 5b. Tier II (Step 5): sample locations for rapid characterization by XRF.

was not as important as the need for precise and accurate measurements of Cu in the sediment samples. Therefore, samples were not analyzed on-site. They were returned to the laboratory after collection for processing and analysis. Because of concern that XRF analysis of these samples would be adversely affected by the extremely heterogeneous nature of the sediment (chunks of copper slag in the sediment) the samples were dried overnight in an oven at 60 °C and ground by mortar and pestle prior to analysis. The entire process, including sample preparation, sample analysis and report writing, was completed within one week. Figure 6a shows the historic copper data contoured. Elevated levels of copper were identified primarily along the beach. The XRF results for copper were contoured to delineate any potential areas of concern that had not been previously identified (Figure 6b). The contour plot of XRF data identified only one region of elevated copper levels that exceeded the benchmarks (biological effects criteria). The XRF results were similar to results obtained from historic samples. Finally, the historic data were pooled together with the XRF data to provide a complete picture of the site (Figure 6c). The areas of concern were concentrated on the beach, as suspected. The addition of XRF data indicated that the copper slag had not migrated from on shore into the near shore environment. The results were presented to the project manager and regulators for review. The XRF results eliminated any uncertainty regarding the sampling plan and allowed the assessment to move forward without delay.
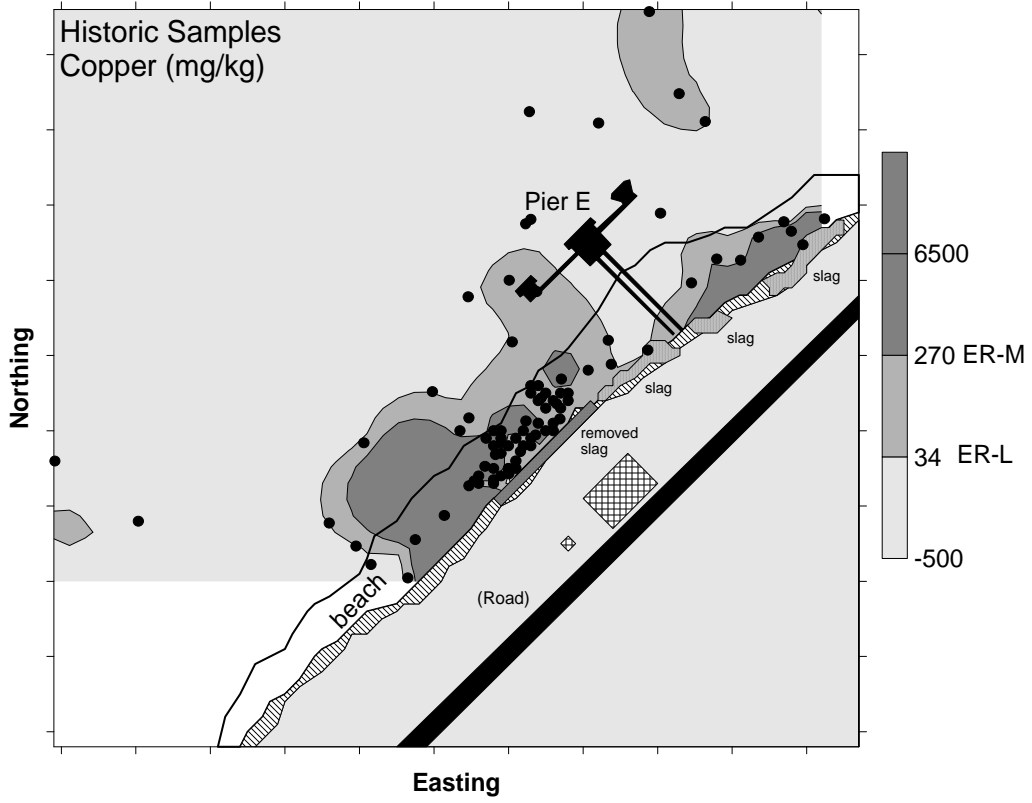
Figure 6a. Tier II (Step 5): copper results (mg/kg) from historic samples reveal contamination is primarily confined to beach area.

XRF Results (Step 5)
Copper (mg/kg)

3000

270 ER-M
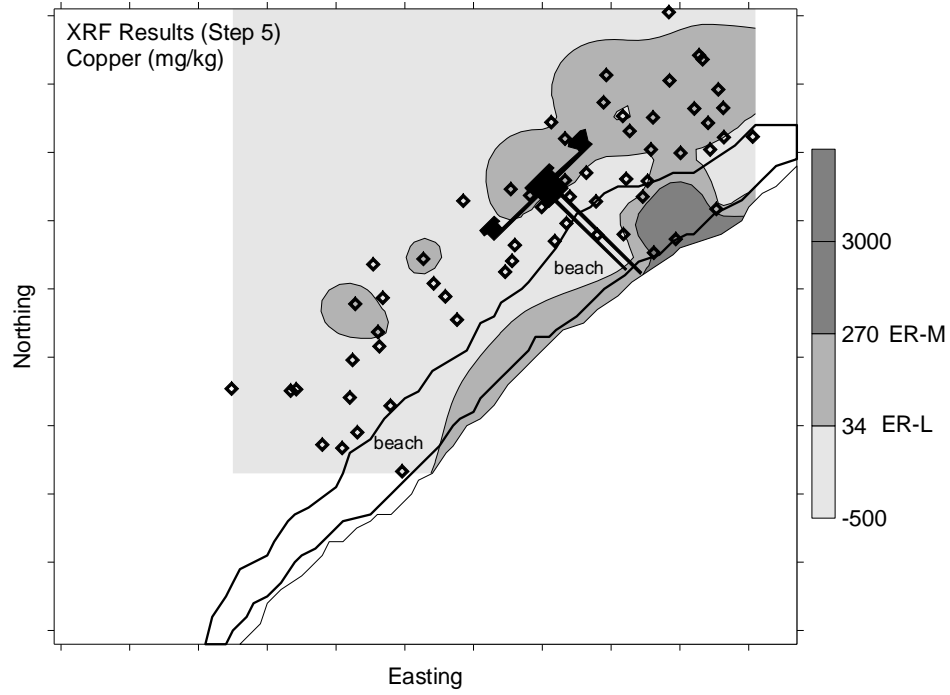
34 ER-L

-500

Northing

Easting

Figure 6b. Tier II (Step 5): copper results (mg/kg) from samples collected for rapid characterization by XRF to verify sampling design. Beach area sampled shows elevated copper levels while near-shore area appears to be less contaminated.
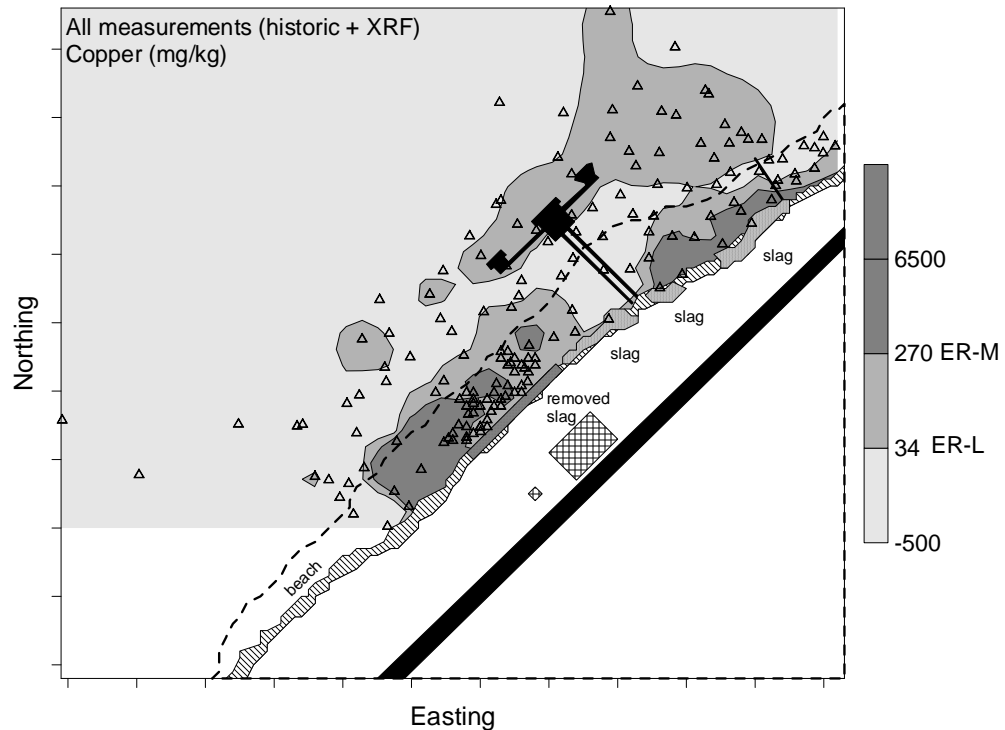
Figure 6c. Tier II (Step 5): results from all copper measurements plotted together. Additional XRF measurements confirm extent of contamination; copper slag had not migrated from beach area into near-shore area.

Tier 3: Evaluation of Remedial Alternatives

The purpose of Tier 3 is to ensure that remedial alternatives are adequately evaluated from an ecological perspective, so that the outcome of the remediation is not more detrimental to the environmental than if the site had not been remediated (1). Rapid characterization tools can play a role in this tier as well. If a remedial option is selected, costs are critically dependant on volumes or areas to be managed. Rapid characterization can be used to map out areas or volumes at higher density than were used for the assessment. Rapid characterization can also be used to verify the efficacy or completeness of a remedial option such as containment, capping or removal of impacted sediments and to monitor the long-term efficacy and impact of management strategies.

Cost Benefit Comparison: Example

An example of integrating rapid sediment characterization tools into the assessment process is provided in Table 3. In this example, in order to adequately delineate the area of concern for metals and PAHs, 400 sampling positions were identified. By measuring samples from each station using two RSC tools (XRF and UVF), and selecting 25% of those samples for confirmatory laboratory analysis, the overall analytical cost could be reduced by approximately 50% as compared to the cost of analyzing all of the samples using standard analytical methods. The cost could also be reduced by taking fewer

samples for standard laboratory analyses, however adequate coverage/delineation of the site would be compromised. By using RSC tools with lab validation better delineation of a site could be accomplished in a cost- and time-effective manner.

Table 3. Cost benefit comparison for 400 samples.

Analysis Method	RSC Tool[1] (# of samples)	Standard Method[2] (# of samples)	Total Cost
XRF[1] (metals) ($90/sample) (40 samples per day)	n = 400	n = 100	$71K
ICP/MS[2] (metals) ($350/sample) (30 – 90 days turnaround)	n = 0	n = 400	$140K
UVF[1] (PAHs) ($100/sample) (20 – 30 samples per day)	n = 400	n = 100	$80K
GCMS[2] (PAHs) ($400 – 550/sample) (30 – 90 days turnaround)	n = 0	n = 400	$160K
Total Cost (RSC + Lab validation)			$151K
Total Cost (Laboratory Only)			$300K

Recommendations

A few recommendations are provided below for consideration in the selection and application of RSC tools to the ERA process.

Determine Which Tools are Appropriate

In order to determine if RSC tools are appropriate to define the nature and extent of contamination at a given site, site-specific project goals and parameters as defined by the Data Quality Objective (DQO) Process must be considered. It is critical to assure that the contaminants or criteria that are deemed to be decision drivers are detectable with the RSC tools that are available. In most cases, even if screening tools are not available for all the contaminants of concern, the tendency for classes of contaminants to co-associate allows for use of those parameters which are more easily measured to act as proxies for a suite of contaminants, to guide sampling and to interpolate between samples where a full suite of analyses is undertaken. In all cases, RSC technologies should be supplemented with a subset of samples for which thorough, traditional, standard laboratory analyses are carried out.

Data Quality

As with any method or technology, certain limitations exist. The primary limitations to RSC technologies are that they are often 1) non-specific, 2) semi-quantitative and 3) matrix sensitive. Because of these limitations, the data produced by RSC tools/methods are not necessarily equivalent to those generated by standard methods. Data are typically classified as either "screening data with definitive confirmation" or "definitive data" (17). Screening data are those data generated by rapid, less precise methods of analysis with less rigorous sample preparation such as those produced using RSC methods, whereas, definitive data are generated using rigorous analytical methods, such as the approved EPA reference methods. Definitive data are analyte-specific, with confirmation of analyte identity and concentration (17). Depending on the data quality requirements established during the DQO Process, a well-designed RSC protocol, paired with laboratory validation, will be able to provide data which can be of sufficient quality and great value to the risk assessment.

Documentation and Reporting of Data

Documentation and reporting is a very controversial subject in environmental analytical chemistry, because it affects how data are received and perceived by the user and often the public (18). The advent of database and GIS tools for the presentation and processing of environmental data allows for an unprecedented level of data manipulation and interpretation not just by data generators but also other users, regulators and stakeholders. While this ability has many benefits, there are potential dangers as well, particularly when data from many sources are combined. Results can be misleading if non-equivalent data are combined together without careful intercalibration.

A few different approaches to the documentation and reporting of data can be used to avoid such problems when reporting results, particularly those from RSC methods. The first is to always flag numbers generated by a non-standard method in spreadsheets and data reports, and to include text, references or qualifiers that address any potential offsets from standard analyses. This has the advantage that all data are available to regulators and stakeholders, but information necessary for proper interpretation is also provided. A second approach is to carry out site-specific calibration of RSC analyses and to report only corrected, calibrated data. This has the advantage of providing results that are more easily interpolated between or contoured with standard data. However, site-specific calibration requires a higher level of effort at a site (possibly more samples sent for laboratory analyses) and may reduce the cost-effectiveness and utility of using RSC tools in the ERA process. A third option, particularly for RSC analyses that generate only qualitative data (i.e., data which identify the presence or absence of target analytes, but may have no relationship to true concentrations of the analytes) is to not report values. In such an approach, samples are either ranked (e.g., from highest to lowest levels) or ranges are reported (e.g., below detection limit, detected but not quantifiable, below action limit, above reference levels, etc.).

Obtain Regulatory Acceptance Prior to Use

A concern voiced by many potential users of RSC tools is that, since they are not subject to the same QA/QC protocols and rigors as are standard procedures, they will make the user vulnerable by not standing up to regulatory or legal scrutiny. While these concerns are not trivial, it is clear that there are a growing number of case studies in which RPMs, regulators and the user community have accepted RSC data as a critical, though not stand-alone, part of the analytical and decision making process. A number of case studies can be found in the recent literature (3, 4).

In any case, the intent to use RSC tools, and how the resulting data will be interpreted and managed, should be addressed up front with regulators and other stakeholders. Furthermore, it should be pointed out that RSC tools are only one part of the ERA process, which should always be balanced with and supplemented by standard, certified analyses. When used appropriately, RSC tools can streamline many aspects of the ERA process, delineating areas of concern, filling in information gaps and assuring that expensive, certified analyses have the highest possible impact.

Points of Contact

For more information on these and related issues, please contact:

> The Marine and Environmental Support Office
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> San Diego, CA 92152-6326

Acronyms and Abbreviations

BERA: Baseline Ecological Risk Assessment
COPEC: Contaminant of Potential Ecological Concern
Cu: Copper
DQO: Data Quality Objective
ERA: Ecological Risk Assessment
ERTAT: Ecological Risk Technical Assistance Team
FPXRF: Field Portable X-ray Fluorescence Spectrometry
FS: Feasibility Study
LISST: Laser In Situ Scattering and Transmissometry
PAH: Polycyclic Aromatic Hydrocarbon
PCB: Polychlorinated Biphenyl
Pb: Lead
PPB: Parts per Billion
PPM: Parts Per Million

QA/QC:　　　Quality Assurance/Quality Control
RI/FS:　　　　Remedial Investigation/Feasibility Study
RPM:　　　　Remedial Project Manager
RSC:　　　　Rapid sediment characterization
SRA:　　　　Screening Risk Assessment
μ:　　　　　　Micron
UVF:　　　　Ultra Violet Fluorescence Spectroscopy
XRF:　　　　X-ray Fluorescence Spectrometry

Additional Resources

XRF

❑ EPA Method 6200: http://www.epa.gov:80/epaoswer/hazwaste/test/6200.pdf

QwikSed

❑ ASTM Standard: http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/PAGES/E1924.htm?L+mystore+rbmv5448

Federal Regulatory Guidance Documents

❑ Field Analytical Measurement Technologies, Applications and Selection: http://www.epa.gov/region09/qa/r9-qadocs.html

❑ Field Analytical and Site Characterization Technologies, Summary of Applications: http://www.epa.gov/swertio1/techdrct/td0198.htm

Field Analytical Technologies

❑ http://fate.clu-in.org/

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