Appendix A: Overview of Sediment Monitoring Tools

Content: *This appendix discusses general monitoring tool for physical, chemical and biological measurements, while Section 4 describes specific tools pertinent to individual remedies. USEPA (2000a, 2001b, 2003b) guidance also offers detailed information on monitoring techniques. The choice of monitoring tools depends on the requirements of the ROD, the monitoring objectives, the monitoring plan hypotheses, and the decision rules established under the monitoring DQO process. The focus of this appendix is on the field monitoring tool used to collect or directly measure a parameter of interest. Monitoring tools must be coupled with appropriate analytical methods to obtain the specific data of interest.*

A.1 Physical Measurements

Physical testing may include measurements of sediment erosion or deposition, ground water advection, surface water flow, and physical characteristics of the sediment (e.g., particle size distribution (PSD), porosity, organic carbon content), and sediment heterogeneity. Most physical endpoints are relatively straightforward to measure and interpret. USEPA (2005b) identifies the following types of physical data and their uses for sediment:

- **Sediment Geochemical Properties**. Used to model fate and transport, evaluate bioavailability, and characterize habitat.
- **Water Column Physical Measurements** (e.g., turbidity, total suspended solids). Used to monitor resuspension of sediment during dredging and cap placement.
- **Bathymetry Data**. Used to evaluate sediment stability over time, navigable depths, bottom surfaces for remedy design, and post-remediation bottom elevations.
- **Side Scan Sonar Data**. Used to monitor the distribution of sediment types and bedforms, commonly used to evaluate presence of debris or bottom formations.
- **Sediment Settlement Plate Data**. Used to monitor cap consolidation and changes in cap thickness over time.
- **Sediment Profile Camera Data**. Used to monitor changes in thin layering within sediment profiles, sediment grain size, bioturbation and oxidation depth, and presence of gas bubbles.
- **Subbottom Profiler Data**. Used to measure density changes in surface and subsurface sediment bedding layers, surface mixing depths, and presence of gas bubbles.
- **Physical Habitat Data**. Used to identify physical structures or measure conditions (depth, salinity, sediment grain size, etc.) related to benthic habitat quality.

A.2 Chemical Measurements

Chemical measurements involve collecting sediment, pore water, surface water, and biota samples and analyzing those samples for chemical concentrations. Chemical measurements also include water quality variables such as organic carbon content, pH, dissolved oxygen, or hardness. USEPA (2005b) identifies the following sampling tools used in support of chemical measurements:

- **Sediment Grab Samples**. Used to collect samples for measurement of surface sediment chemistry. This generally includes COCs, but can also include ancillary analytes related to chemical conditions (organic carbon content, pH, redox conditions, etc.).
- **Sediment Coring** (e.g., vibracore, gravity piston, or drop tube samplers). Used to obtain a vertical sediment profile of sediment chemistry or to detect chemical movement through a cap.
- **Direct Water Column Measurements**. Used to measure water quality parameters such as temperature, pH, dissolved oxygen, salinity, suspended solids, and turbidity in the water column.
- **Surface Water Samplers**. Used to collect and measure dissolved or total chemical concentrations in surface water.
- **Passive Sampling Devices**. Used to measure dissolved chemicals in water; generally used for low-solubility chemicals where accumulation on passive samplers greatly lowers detection levels.
- **Seepage Meters**. Used to measure ground water advection and aqueous chemical flux through sediment and into the water column.

A.3 Biological Measurements

Biological measurements, such as those summarized by USEPA (2005b) and listed below, may be used to evaluate ecological risks, evaluate restoration effectiveness, and determine bioaccumulation:

- **Benthic Community Analysis**. Used to evaluate benthic community structure (e.g., population size, diversity, presence/absence of taxa).
- **Toxicity Testing**. Used to measure acute or chronic effects (e.g., survival, growth, reproduction) of chemicals on biota.
- **Tissue Sampling**. Used to measure bioaccumulation and assess trophic transfer.
- **Caged Fish/Invertebrate Studies**. Used to monitor changes in uptake of chemicals by biota from the sediment or water column.
- **Sediment Profile Camera Studies**. Used to indirectly measure macroinvertebrate recolonization (e.g., population density of polychaetes may be estimated by counting the number of burrow tubes per linear centimeter along the

sediment-water interface).

- **Sediment Surface Camera Studies**. Used to directly and indirectly measure macroinvertebrate recolonization. For example, epifauna can be counted and identified, while infauna can be estimated based on burrow openings and fecal mounds found at the sediment water interface.

Biological measurements integrate the cumulative effects of all stressors to which biota are exposed. This characteristic can complicate data collection and interpretation, but also can provide direct information on remedial effectiveness. To investigate the biological effects of chemicals in sediment or water, biological measurements should control for confounding factors related to nonchemical stressors, such as habitat quality. For example, the results of toxicity tests and benthic community structure surveys often are compared to concentrations of chemicals in sediment and water, but they also should be interpreted in light of physical characteristics of the media (e.g., grain size, organic carbon content, salinity, ammonia, redox conditions, etc.) and presence of other possible stressors (e.g., hydrologic changes due to urbanization of a watershed, siltation due to agriculture).

Toxicity tests must be tailored to the monitoring need. For example, acute toxicity tests may be appropriate for monitoring short-term impacts of remedial construction practices (e.g., placement of cap, dewatering of dredge sediment); whereas long-term (chronic) sublethal toxicity tests are best employed to assess longer-term impacts and changes affected by a remedy. Measurement of chemical concentrations in biota can provide the best integration of site-specific conditions affecting chemical bioavailability and exposure; however, interpretation is complicated by a number of factors, including inter-individual and inter-species variability in home range, lipid content, sex and age, feeding regime, contaminant excretion rates, and other life history parameters. Particularly at low chemical concentrations, these variables can confound the interpretation of relationships between chemical concentrations in sediment and biota, and can complicate the interpretation of data used to evaluate remedy success and the attainment of remedial goals (USEPA, 2005).

Note: A comprehensive list of examples of monitoring tools and needs can be found at ***"www.ISRAP.org"****. The example tools and needs address a wide spectrum of stakeholder concerns and remedial goals that are not all likely to be relevant for all sites. For example, monitoring programs at most sites would not include addressing risks to near shore avian communities, but examples are included to illustrate the ranges of monitoring tools and needs provided in the Monitoring Tool Matrices. Many of the examples are ecologically-focused or risk-focused. In some cases, little or no ecological monitoring is required, and site-specific monitoring needs and tools strictly focus on chemical concentrations in sediment and water.*