823R94002

PROCEEDINGS OF THE

NATIONAL SEDIMENT INVENTORY WORKSHOP

April 26-27, 1994
Dupont Plaza Hotel
Washington, DC

Sponsored by:

United States Environmental Protection Agency
Office of Science and Technology
Standards and Applied Science Division
Washington, DC

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EXECUTIVE SUMMARY

On April 26-27, 1994, in Washington, D.C., the U.S. Environmental Protection Agency (EPA) sponsored the National Sediment Inventory Workshop. The purpose of the workshop was to bring together experts in the field of sediment quality to develop a methodology for evaluating the National Sediment Inventory (NSI) data using a "weight-of-evidence" approach that will identify known and suspected sites of sediment contamination. This information will be included in a Report to Congress, which was mandated under the Water Resources Development Act of 1992 (WRDA). The purpose of the Report to Congress is to identify the geographic extent and severity of sediment contamination in the United States.

Elizabeth Southerland of EPA's Office of Science and Technology (OST) opened the meeting and provided background information on the NSI and on the purpose and goals of the workshop. Next, Catherine Fox of EPA's OST reviewed the data elements in the NSI and explained the approach used in the preliminary evaluation of the sediment chemistry data that was provided to the EPA Regions. Finally, Peter Chapman of EVS Consultants reviewed potential methodologies for use in evaluating the NSI data. The participants then broke into four workgroups to discuss methodologies that should be used to evaluate the different data types in the NSI, as well as to develop a categorization of sites to be used in the evaluation of data currently housed in the NSI.

Following the second day's workgroup breakout sessions, the workshop participants were brought together to summarize workgroup discussions and to reach consensus on the issues discussed.

Consensus was reached on the definition of categories. Five categories of sites were identified:

- High probability of adverse effects caused by sediment contamination
- Medium-high probability of adverse effects caused by sediment contamination
- Medium-low probability of adverse effects caused by sediment contamination
- Low probability of adverse effects caused by sediment contamination
- Unknown.

The participants also identified various types of data that could be used alone or in combination with other data to place a site into one of the above-mentioned categories. The following table summarizes the categories of site classifications and types of data used to determine classifications.

Following the development of the final approach for evaluating the NSI data (based on recommendations from this workshop) and the incorporation of comments from the EPA Regions on the preliminary evaluation of NSI sediment chemistry data, EPA will begin to evaluate the NSI data for inclusion in the Report to Congress.

SUMMARY TABLE OF CATEGORIES OF SITE CLASSIFICATIONS AND TYPES OF DATA USED TO DETERMINE CLASSIFICATIONS

Category of Site Classifications	Data Used to Determine Classifications				
	Sediment Chemistry (site is identified by any one of the following characteristics)		**Toxicity**		**Tissue Residue/ Biological Indicator**
High Probability of Adverse Effects	Sediment chemistry values exceed sediment quality criteria for any one of the five chemicals for which criteria have been developed by EPA (based on measured TOC)	OR	Toxicity demonstrated by two or more acute toxicity tests (one of which must be a solid-phase nonmicrobial test)	OR	Human health thresholds for dioxin or PCBs are exceeded in resident species (not a consensus agreement—participants evenly divided on this issue)
	Sediment chemistry values exceed *all* relevant AETs (high), ERMs, PELs,and EqPs for any one chemical (can use default TOC and AVS)				
	Sediment chemistry values >50 ppm for PCBs				
	Sediment chemistry TBP exceeds FDA action levels or EPA risk levels	AND	———	——	Tissue levels in resident species exceed FDA action levels or EPA risk levels
	Sediment chemistry TBP exceeds wildlife criteria	AND	———	——	Tissue levels in resident species exceed wildlife criteria
	Elevated sediment chemistry concentrations of PAHs	AND	———	——	Presence of fish tumors
Medium-High Probability of Adverse Effects	Sediment chemistry values exceed at least two of the sediment upper threshold criteria (i.e., ERM, EqP, PEL, high AET) (can use default TOC—EqPs for metals cannot be used unless with measured AVS)	OR	Toxicity demonstrated by a single species toxicity test (solid-phase, nonmicrobial)	OR	Tissue levels in resident species exceed FDA action levels or wildlife criteria
	Sediment chemistry TBP exceeds FDA action levels or wildlife criteria				
Medium-Low Probability of Adverse Effects	Sediment chemistry values exceed one of the lower threshold criteria (ERL, EqP, TEL, lower AET) (can use default TOC and AVS)	OR	Toxicity demonstrated by a single species toxicity test (elutriate-phase, nonmicrobial)	——	———
Low Probability of Adverse Effects	No exceedance of lower threshold criteria and No sediment chemistry TBP exceedances of FDA action levels or wildlife criteria	AND	No toxicity demonstrated in tests using at least two species and at least one solid-phase test using amphipods	AND	Tissue levels in resident species are lower than FDA action levels and wildlife criteria
Unknown	Not enough data to place a site in any of the other categories				

NATIONAL SEDIMENT INVENTORY WORKSHOP

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DAY ONE - METHODOLOGIES FOR EVALUATING NSI DATA

Purpose and Objectives of the NSI Workshop, Elizabeth Southerland, USEPA OST (overheads included in Appendix B)

Elizabeth Southerland welcomed the participants and explained the purpose of the workshop: to develop a methodology for evaluating the National Sediment Inventory (NSI) data using a "weight-of-evidence approach" that will identify known and suspected sites of sediment contamination.

She gave some background on the development of the NSI, noting that the NSI has been developed in response to the Water Resources Development Act of 1992 (WRDA), which calls for the compilation of all existing information on the location of pollutants in aquatic sediment, including the probable source of such pollutants and identification of those sediments which are contaminated.

Elizabeth stressed to the group that Congress wants to know the geographic extent and severity of sediment contamination in the United States. The Report to Congress, as mandated by WRDA, will include this information and will be revised every 2 years.

Some participants expressed some concern about actually performing a numerical ranking of the contaminated sites, and Elizabeth responded that the ranking does not have to be numerical but can involve general classifications.

NSI Data Overview, Catherine Fox, USEPA OST (overheads included in Appendix B)

Catherine Fox presented an overview of the NSI project and a timeline for completed and proposed activities under the project. She then reviewed the inventory itself, identifying how data sets were obtained and what minimum data elements were needed to include a data set.

Catherine presented graphically the location of NSI stations with data on sediment chemistry, tissue residue, toxicity, benthic abundance, and histopathology, as well as matched data sets.

She reviewed the limitations of NSI data, such as the limited TOC and AVS data available for sediment chemistry analysis. Some participants expressed their belief that TOC should be a "must have" data element to be included in the NSI. Catherine explained that a TOC requirement would severely limit the geographic coverage of the study and perhaps lessen the usefulness of the information given to Congress.

Catherine described the preliminary evaluation of the sediment chemistry data, which will be distributed to the EPA Regions in the near future. The purpose of this evaluation is to quickly identify highly contaminated sites for Regional review. The methodology recommended for the final evaluation of sites and the Report to Congress may differ from the preliminary evaluation approach. The Regions will also be asked to add additional sites that are suspected areas of concern.

Catherine next explained the approach used in the preliminary evaluation of the sediment chemistry data provided to the EPA Regions. The approach involves using the National Oceanic and Atmospheric Administration's (NOAA's) effects range mediums (ERMs) for metals, EPA's equilibrium partitioning (EqP) approach for nonionic organics, and Washington State's lowest apparent effects thresholds (AETs) for ionic organics. The analysis was performed at the waterbody segment level of detail. Each analyte in the inventory was screened at the 50th percentile concentration. (Nondetects and less thans were treated as zero.) If the 50th percentile concentration in a waterbody segment was greater than the reference value for that contaminant, then the waterbody segment was considered a potential area of concern. The advantages of the approach are that it targets the most highly contaminated sites (based on 50th percentile concentrations); comparisons are based on reference levels demonstrated to cause biological impacts (i.e., ERMs, EqPs, and AETs); and the results are presented at the waterbody segment level of detail, which will allow the Regions to compare the results with known sampling results in the Region. The disadvantages of the approach are that it uses only sediment chemistry data, TOC and AVS data are not provided in many data sets, and there is a lack of documented QA/QC information.

Based on the preliminary evaluation, Catherine presented the top 20 potential contaminants of concern and showed the geographical extent of sites where those contaminants were identified as a concern.

Potential Methodologies for Use in Evaluating the NSI Data, Peter Chapman, EVS Consultants (overheads included in Appendix B)

Peter Chapman presented a "discussion" paper on potential evaluation methodologies for the Report to Congress and what the selected methodology should contain. He stated that the methodology employed should include data on ecological and human health risk, should allow the use of future data (e.g., greater emphasis on biology), should direct future data-gathering activities, and should be able to answer the central question: Are contaminated sediments a national problem or only a "hot spot" problem?

He then reviewed the status of the NSI and the kinds of data sets included. He stressed that the NSI is not currently in the form of a user-friendly "database." The NSI is in a series of Statistical Analysis Software (SAS) files and requires specialized software to perform evaluations. Peter pointed out that the NSI will eventually be converted to a more user-friendly format and that the data evaluation should include toxicity as well as sediment chemistry at a minimum.

Peter explained that the evaluation of the data in the NSI should be treated as a risk assessment. Tier 1 requires an exposure assessment and a toxicity/hazard assessment, taking into account bulk chemical concentrations, background chemical concentrations, and receptors. Tier 2 includes direct measures of bioavailability and standard bioassessment studies. For example, in a Tier 1 assessment ecoregions would be compared to background levels using sediment chemistry thresholds as well as sediment tissue data (e.g., human health, fish advisory comparisons). In a Tier 2 assessment effects data would be added for the final site classification. Many participants stated that it is not possible to link chemical concentrations to biological effects without matched data. Some, however, stated that an inventory of contamination (i.e., elevated chemical concentration) can be done using only sediment chemistry data.

Peter then presented possible sediment chemistry screening tools and posed the question of how to score the sites: on a continuum or using a binary system. EPA prefers a system based on a continuum.

He then reviewed the QA/QC issue. What is an appropriate level of QA validation? How stringent can we be with QA/QC requirements and still have data left to evaluate? He stressed that minimum QA/QC expectations should be met for all types of data in the NSI. Peter stated that in the future the QA/QC requirements could become more stringent.

The participants then broke into workgroups to discuss individual data types.

DAY ONE - WORKGROUP BREAKOUT SESSIONS

Workshop participants were divided into three workgroups and were charged with answering the following four questions:

1. What methodology should be used to evaluate the NSI's toxicity data (solid phase and elutriate toxicity test data)?

2. Should we incorporate the NSI's fish tissue residue data into the evaluation? If so, what methodology should be used to evaluate these data?

3. Should we incorporate the NSI's benthic community data into the evaluation? If so, what methodology should be used to evaluate these data?

4. What methodology should be used (threshold values and ranking approach, if appropriate) to evaluate the NSI's sediment chemistry data (metals, ionic organics, nonionic organics)?

Following are the preliminary recommendations of each of the three workgroups concerning these questions.

Question #1: ***What methodology should be used to evaluate the NSI's toxicity data?***

Workgroup #1 Response:

- Elutriate toxicity with sediment chemistry data cannot be enough to place a site in the "known contamination" or "clean" category. These data can place a site higher in the "suspected contamination" category range.

- A site cannot be placed on the "known" list without more than one solid-phase sample and more than one species. If data from only one solid-phase sample using only one species are available, a site can be placed in the "suspected" category.

Workgroup #2 Response:

- The NSI should include all toxicity tests, regardless of medium (e.g., whole sediment or elutriate) and species as long as (1) the tests have appropriate QA/QC (defined as having a negative control and acceptable control responses and appropriate test conditions) and (2) there is an appropriate statistical evaluation of the response to the particular test that would allow reaching a conclusion as to whether sediments are toxic or nontoxic.

- Tests to be included in the NSI should be those approved by EPA or designated by the Office of Water as acceptable tests.

- For the future, sediment toxicity data sets must include at least one whole-sediment test with amphipods.

Workgroup #3 Response:

- Advantages of evaluating toxicity data
  - Is an effects-based approach to evaluating contaminated sediments
  - Integrates biological effects with sediment contamination
  - Field validation data for some tests are available

- Disadvantages of evaluating toxicity data
  - Is a data quality issue (uses a mixed bag of species and endpoints)
  - There is a potential for manipulation effects on observed toxicity
  - False positive results can occur
  - In many cases results cannot be compare to controls

- Use of data
  - Can be used alone to target sites of high concern if mortality is the endpoint
  - Other endpoints represent lower concerns

- Confidence in test results
  - There is a high level of confidence in solid-phase tests

- There is a low level of confidence in elutriate-phase tests (unless toxic)
- There is a low level of confidence in pore water tests
- Mortality to an insensitive organism is significant (bad)

- Species tested
  - There is a high level of confidence in tests using benthic species (have significant contact with sediment)

- Method used
  - Multiple species responses are preferred

- Controls
  - Data should be eliminated if no control information is available. Criteria for targeting sites should include a significant response relative to control/reference.

Question #2: ***Should we incorporate the NSI's fish tissue residue data into the evaluation? If so, what methodology should be used to evaluate these data?***

Workgroup #1 Response:

- Data on resident species or species with a known life history can be used. The focus should be on "key species." The decision as to which species should be used will be determined on a site-by-site basis. Fish tissue residue data can be used for human health assessments and for the development of sediment criteria for protection of human health.

- Concern was expressed regarding other compounds, such as PAHs in bile, that are not looked at. In many cases, organ-specific data are not collected. Organ-specific and compound-specific fish tissue levels protective of wildlife should also be monitored.

- Tissue residue data for known bioaccumulative compounds such as PCBs and dioxins can place a site in the "known" category without additional sediment chemistry information. To be placed in the "known" category, samples of resident species or species whose life history is known should be used. Some in the group believed that fish tissue residue data (from resident species) alone could place a site in the known category for any contaminant. Fish tissue residue data from mobile species would place a site in the "unknown" category.

- Limits for fish tissue residue concentrations are needed for both human health and wildlife protection.

Workgroup # 2 Response:

- Data on species that are migratory or wide-ranging should be excluded for the purposes of the NSI.

- Tissue data alone (finfish and shellfish) cannot flag a "hot spot" of sediment contamination; they only identify a reach as a possible problem, but the source remains to be determined.

- Tissue levels of concern include FDA action levels, wildlife criteria, state criteria for the protection of human health, and extrapolations from water quality criteria.

Workgroup #3 Response:

- Advantages of evaluating fish tissue residue data
  - Considers the human health issue through comparison with FDA action levels, fish advisory limits, or human health risks
  - Also can consider wildlife impacts/endpoints
  - Integrates broad areal exposures

- Disadvantages of evaluating fish tissue residue data
  - Fish mobility clouds the interpretation of site-specific exposure to contamination
  - Tissue levels might not be related to exposure to contaminated sediments

- Use of fish tissue residue data
  - Can be used as confirmatory only (to corroborate other data)
  - Need to differentiate between resident (high-confidence) and migratory (low-confidence) species
  - Need to differentiate between tests using whole body, fillet, and liver samples for evaluation (human health versus wildlife effects)
  - Need to know the life history of the species in question
  - Use might be more applicable when data are aggregated at higher levels, e.g., watersheds or estuaries

Question #3: ***Should we incorporate the NSI's benthic community data into the evaluation? If so, what methodology should be used to evaluate these data?***

Workgroup #1 Response:

- To place a site in the "known" category, reference site data are needed and results from the site in question must be significantly different from data from the reference site. Historical reference sites are less desirable. Benthic community data alone cannot be used to place a site in the "known" category. Benthic community changes can be a result of NH_3 and anoxia.

Workgroup #2 Response:

- Macrobenthic community structure is extremely important information because benthic species have intimate contact with the sediment.

- However, macrobenthic community structure cannot be efficiently evaluated at this time in the NSI (i.e., nationally) because of the variety of factors that influence the benthos (e.g., biotic and abiotic, as well as anthropogenic). Site-specific benthic conditions need to be assessed to determine sediment "hot spots" rather than trying to use set indices across the Nation. These assessments can then lead to a national assessment.

Workgroup #3 Response:

- Issues related to evaluating benthic community data
  - Variability in collection methods
  - Freshwater/marine comparisons (different properties of freshwater and marine systems)
  - Interpretations of community structure/function as a function of contamination
  - Lack of reference data

- Criteria to use in evaluating benthic community data
  - Presence of indicator/sensitive species
  - Total abundance and biomass
  - Species richness

- Advantages of evaluating benthic community data
  - The benthic community is the endpoint of interest

- Disadvantages of evaluating benthic community data
  - There is often no reference comparison
  - Significant differences can exist between sites (e.g., freshwater versus marine)
  - Impacts may not be the result of contamination
  - Data quality is often uncertain

- Use of benthic community data
  - Can be used as confirmatory only
  - A significant issue is how to mesh benthic community data with other data types

Question #4: ***What methodology should be used to evaluate the NSI's sediment chemistry data?***

Workgroup #1 Response:

- Sediment chemistry data that are a "blow-out" can be used to place a site in the "known" category but cannot be used to place a site in the "clean" category. Exceedances of multiple thresholds or at multiple stations can be used to place a site in the "known" category. Use of sediment quality thresholds is an appropriate method for identifying sites of known contamination. Caution should be used in evaluating blow-out data for metals; reference sites are needed. A site cannot be placed on the "known" list using data from a single sample but can be placed there based on a single chemical.

- A site can be classified as "clean" (acceptable) if chemicals do not exceed chemical criteria and are nontoxic.

Workgroup #2 Response:

- Sediment chemistry data alone can be used to categorize sites as "suspected," but not as "known" (e.g., as either polluted or the reverse, "clean").

- There is no single sediment chemistry screening approach that is universally appropriate; a burden-of-evidence approach combining different sediment screening approaches should be used for the present.

- Greater confidence exists for a smaller number of chemicals than for all chemicals. (It is anticipated that the number of chemicals in future national assessments will increase.) Sites that do not include data for the high-confidence chemicals may not be properly addressed.

Workgroup #3 Response:

- Advantages of evaluating sediment chemistry data
  - There are a lot of sediment chemistry data in the NSI
  - Sediment contamination is what you manage against (it is the essential measure against which progress will be measured)

- Disadvantages of evaluating sediment chemistry data
  - The sediment chemistry data in the NSI are of varying quality
  - The information necessary to evaluate bioavailability is not always included with data in the NSI (TOC/grain size for normalization)
  - Metals extraction methods vary (metals data are a function of the extraction scheme)
  - Natural as well as anthropogenic sources of contamination exist (need means to distinguish)

- Evaluation procedures for nonionic organic chemicals
  - High AETs are appropriate
  - Levels exceeding ERMs will probably result in effects
  - For EqPs, should use measured TOC or use 1 percent as a default
  - If all of the above (high AETs, ERMs, and EqPs) are exceeded, a site can be considered contaminated

- One individual felt that PAHs need to be dealt with separately because of detection limits

- Evaluation procedure for metals
  - EqPs for certain metals (i.e., Cd, Zn, Pb, Ni, Cu)—need to determine default AVS values
  - AETs and ERMs can be used for other metals
  - If a site exceeds all of the above values, it can be considered contaminated
  - Need to consider metals digestion scheme—measures may be conservative by 5-fold

- Bioaccumulation issues
  - Can model theoretical bioaccumulation potential (TBP) using measured TOC or a default value
  - Need to construct a sediment-to-fish model for mercury
  - FDA action level = 1 ppm for mercury

- Use of data
  - High-quality sediment chemistry data that exceed reference levels are stand-alone criteria

DAY ONE - AFTERNOON WORKGROUP PRESENTATIONS

Following the first day's workgroup breakout sessions, all of the workshop participants were brought together in an afternoon session to summarize workgroup deliberations and to reach consensus on the methodologies to be used to evaluate sediment contamination. A summary of the workgroup deliberations was presented in the previous section of this meeting summary. The following is a summary of the consensus reached by workshop participants related to methodologies to be used to evaluate sediment contamination.

Toxicity

- Toxicity data can be used alone to identify a known contaminated sediment site if the data include multiple species, multiple stations, control data, and solid-phase testing results. Mortality and other endpoints can be used.

- Elutriate or pore water toxicity testing results can be used to evaluate sediment toxicity but cannot be used alone to place a site in the "known" category. At least one solid-phase test is needed to place a site in the "known" category.

Tissue Residue

- Tissue residue data can be used only with other data to target "known" sites of contamination.
- Resident species, bottom feeders, and shellfish (mollusks) provide higher-confidence results.
- Pelagic and migratory species provide lower-confidence results.

Benthic Community

- Benthic community data should be reported, but alone these data cannot target a "known" contaminated site. Other data types should be used to determine to which category a site belongs.
- Benthic community data can, however, be used to move a site from one category to another.
- By themselves, these data can be used only for local/regional evaluations; they carry low importance in a national assessment.
- These data will not be interpreted in the first Report to Congress.

Sediment Chemistry

Consensus was not reached during the afternoon plenary session concerning the use of sediment chemistry data taken alone to target a potential site of concern. Completion of this discussion was postponed until the morning session of day two of the workshop.

Day Two Issues

The following were identified as issues to be addressed during the day two morning plenary session:

- Definition of contamination: should the evaluation be based on elevated concentrations alone, or can we predict ecological or human health risk from the data contained in the NSI?
- Can "blow-out" sediment chemistry data alone be used to target potential sites of concern?
- Aggregation of data by station, reach, or other methods; or, what is a site?
- Should we develop a categorization system for evaluating NSI data?

DAY TWO - MORNING SESSION

Discussions continued on the issues identified during the afternoon session of the first day of the workshop. The discussions began by addressing whether a site could be classified as a "known" contaminated site based solely on sediment chemistry data. In leading the discussion, Elizabeth Southerland suggested using a categorization approach for the identification of contaminated sediment sites. Under this approach, a site could be considered "known," "suspected," or in another category of contamination based on (1) sediment chemistry data only or (2) a combination of parameters (chemical and biological). After a long group discussion of these issues, no consensus was reached. The workgroups were then directed to continue to address these and other remaining issues in the breakout sessions.

Overview of Potential Ranking Approaches, Peter Chapman, EVS Consultants (overheads included in Appendix B)

Prior to the morning breakout sessions, Peter Chapman presented a discussion of ranking/ categorization schemes that could be used in the evaluation of the NSI data. He discussed programs that have implemented one of two types of assessment methods: inference and demonstration. The inference method infers biological impact by comparing measured chemistry or biological parameters to predetermined thresholds. The demonstration method demonstrates biological impact by taking site-specific measurements of synoptic (or coincident) chemistry and biological parameters. The approaches briefly reviewed by Peter were the following:

- Reyoldsan (Great Lakes) approach (demonstration)
- SEDRANK (Puget Sound) approach (inference)
- Chesapeake Bay approach (inference)
- ARCS approach (inference)
- Region 5 prioritization approach (inference)

Peter then presented several ideas concerning the evaluation of the NSI data and their limitations. He suggested that no single approach for evaluating the NSI data was appropriate; rather, a "battery" of trigger levels should be used depending on available data. He then proposed several categories of data combinations that could be used to classify sites as sites of known or suspected contamination, clean sites, and uncertain.

DAY 2 - WORKGROUP BREAKOUT SESSIONS

Issue #1: ***What parameters define "contamination?"***

Workgroup #1 Response:

- Contamination can be defined based on sediment chemistry data alone, as well as on the probability of biological and human health effects.

Workgroup #2 Response:

- Six categories of parameters could conceivably define contamination:
  - Elevated sediment chemistry
  - Sediment chemistry above effects guidelines
  - Sediment chemistry above effects guidelines and bioeffects at the site
  - Bioeffects (toxicity, biology, histopathology)
  - Human health risk
  - Wildlife risk

Workgroup #3 Response:

- Contamination can be defined based on elevated concentration alone or based on human health and ecological risk. The Report to Congress should include both approaches. It should also distinguish between freshwater and marine samples and biased (e.g., STORET) versus unbiased (e.g., NS&T and EMAP) data.

Issue #2: ***Can a site be classified as a "known" contaminated site based solely on sediment chemistry data?***

Workgroup #1 Response:

- "Blow-out" sediment chemistry concentrations can be used alone to classify a site as a "known" contaminated site.

- If sediment chemistry data alone are to be used to classify "known" sites of contamination, the level of uncertainty associated with this approach needs to be determined. This can be done by looking at those sites with complete data (both sediment chemistry and biological), comparing the results of evaluating combined sediment chemistry and biological data with the results of evaluating sediment chemistry data alone.

- The level of certainty of using sediment chemistry data alone to classify sites would increase if the number of chemicals evaluated were limited.

Workgroup #2 Response:

- Initially, some workgroup members were not comfortable using elevated sediment chemistry alone as a primary criterion for identifying sites of concern, but they did believe it would be worthwhile to provide this information as an appendix to the Report to Congress (including appropriate caveats) using a frequency distribution or other appropriate presentation method. Later discussions indicated agreement under certain circumstances on using sediment chemistry data alone to classify a site as contaminated.

Workgroup #3 Response:

- Yes, sediment chemistry data alone can be used to classify a known contaminated sediment site.

Issue #3: ***How should sites be aggregated for evaluation of potential contamination?***

Workgroup #1 Response:

- Sites should first be defined on a station-by-station basis and then aggregated by reach. The categorization of sites would be based on the number of stations in a reach that exceed the classification criteria. A reach with only one station cannot be classified.

Workgroup #2 Response:

Workgroup #2 did not have time to address this issue.

Workgroup #3 Response:

- NSI data should be analyzed by station. The number of "hits" per reach should then be calculated. Maps should then be presented representing the number of hits in each category (e.g., known, suspected, etc.).

Issue #4: ***What system should be used to categorize the results of the NSI data evaluation?***

Workgroup #1 Response:

- Four categories of sediment contamination should be used:
  - Known contamination (high probability of effects)
  - Suspected contamination (medium probability of effects)
  - Suspected acceptable (no probability of effects)
  - Uncertain

- If any of the following criteria are met, a site can be classified as a known contaminated site:

- Sediment chemistry data exceed EqPs for one of the five nonionic organics with sediment quality criteria or exceed other upper threshold values (e.g., ERMs) for other chemicals.

- Multiple toxic bioassay effects are demonstrated and no supporting sediment chemistry data are available, or a single toxic bioassay effect is demonstrated and supporting sediment chemistry data are available.

- Tissue residue data exceed human health or ecological thresholds (including high BSAF probability) and are supported by sediment chemistry data.

Benthic abundance data cannot be used to classify sites.

- If any of the following criteria are met, a site can be classified as a suspected contaminated site:

  - Sediment chemistry data exceed one or more of the lower threshold limits (e.g., ERLs).

  - A single toxic bioassay effect is demonstrated (without supporting chemistry).

  - Tissue residue data exceed human health or ecological thresholds. Supporting sediment chemistry data are not required.

  Benthic abundance data cannot be used to classify sites.

- If any of the following criteria are met, a site can be classified as a suspected acceptable site:

  - Sediment chemistry data levels are below all lower thresholds.

  - There are no demonstrated toxic bioassay effects using multiple tests.

  - Tissue residue levels are below all thresholds.

  Benthic abundance data cannot be used to classify sites.

- Sites are classified as uncertain in terms of contamination if there are inadequate data to place them in any of the other categories.

Workgroup #2 Response:

- The following possible categories for ranking sites were discussed
  - Known contaminated
  - Suspected contaminated
  - Suspected clean

- Clean
- Unknown

- A known contaminated site is one at which convincing evidence of environmental degradation due to sediment contamination exists based on *any one* of the following criteria:

  - Exceeds EPA sediment quality criteria.

  - Exceeds the highest relevant and reliable value for EqPs, ERMs, AETS, and SQTs. Only relevant and reliable values should be considered for a short list of chemicals following peer review of the highest values for each approach—some may be regional.

  - Two different toxicity tests result in significant acute toxicity (i.e., mortality). Tests must be approved by EPA or ASTM or designated by the Office of Water, as appropriate. One of the tests must be a solid-phase amphipod test (or chironomid in fresh water).

  - Tissue concentrations of an appropriate (e.g., nonmigratory) field or laboratory species exceed FDA action levels, wildlife criteria, or EPA levels, as appropriate. This applies to any chemical for which such levels are available.

  - "Major" evidence exists of contaminant-related histopathology in an appropriate (e.g., nonmigratory) field species.

  - Degradation of the benthic community exists based on regional indicators clearly related to sediment contamination. At present, this is a non-stand-alone measure because the benthos are affected by various factors (e.g., DO, habitat, biology, etc.).

- A suspected contaminated site is one at which an indication of environmental degradation at a site due to sediment contamination exists based on *any one* of the following criteria:

  - Exceeds the higher of any two values for EqPs, ERMs, AETs, or SQTs. Only relevant and reliable values should be considered for a short list of chemicals following peer review of the highest values for each approach—some may be regional.

  - One toxicity test shows significant acute or chronic toxicity. The test must be approved by EPA or ASTM or designated by the Office of Water, as appropriate. It does not have to be a solid-phase amphipod test.

  - Occurrence of contaminant-related histopathology in appropriate (e.g., nonmigratory) field species (not "major" evidence).

- Alteration of benthos based on regional indicators clearly related to sediment contamination.

- Other ideas that were presented but for which there was not consensus:
  (1) Tissue residue concentrations of appropriate (e.g., nonmigratory) field or laboratory species exceed calculated tissue concentrations based on BCFs using the water quality criteria.
  (2) Predicted tissue residue levels based on chemical concentration compared to FDA action levels, wildlife criteria, or EPA levels, as appropriate. This would apply to any chemical for which such levels are available.
  (3) Theoretical bioaccumulation potential (TBP).

- A site with low probability for adverse effects is one at which little evidence of environmental degradation due to sediment contamination exists based on *all* of the following criteria:

  - No reasonable expectation of sediment contamination based on location.

  - Two different toxicity tests do not result in significant toxicity. Tests must be approved by EPA or ASTM or designated by the Office of Water, as appropriate, and one of the tests must be a solid-phase amphipod test (or chironomid in fresh water).

  - The workgroup could not agree on a good lower bound for chemistry but suggested that perhaps both of the following criteria could be used:
    (1) All chemicals are below their respective ERLs
    and
    (2) All chemicals are an order of magnitude below the EqP. (The workgroup suggested comparing these numbers with each other and with the frequency distribution in the NSI data.)

- A "clean" subcategory could be determined based on either of the last two criteria listed under "low probability," assuming that there are no toxicity data.

Workgroup #3 Response:

- Four categories of contamination could be used to classify sites:
  - Contaminated
  - Likely contaminated
  - Unlikely contaminated
  - Uncertain

- A contaminated (impacted) site would have one or more of the following characteristics:

  - PCB concentrations are greater than 50 ppm.

- Sediment chemistry values are above the 95th percentile confidence level for the sediment quality criteria (SQC) for the five chemicals that have SQCs (must have measured TOC).

- Sediment chemistry values exceed all AETs, EqPs, ERMs, and other threshold values, times some multiplier (not determined). Predictions can be made using default TOC and AVS values.

- Toxicity is demonstrated with multiple species, at least one of which is a solid-phase test.

- Sediment chemistry values exceed all AETs, ERMs, EqPs, and other threshold values, and toxicity is demonstrated in one solid-phase test.

- Sediment chemistry values exceed PAH criterion and fish tumors are present.

- Sediment chemistry/TBP (BSAF) calculations and resident fish/shellfish tissue levels exceed FDA action levels or human health risk factor of 10^{-4}.

• Sites where contamination is likely would have one or more of the following characteristics:

- Sediment chemistry values exceed any one of the high AETs, ERMs, or EqPs, using a default TOC. EqPs cannot be used to evaluate metals if a default AVS is used.

- Demonstrated toxicity in any nonmicrobial test.

- No tissue data exist and sediment chemistry/TBP exceeds FDA action levels or a human health risk of 10^{-4}.

- Tissue residue data exist and sediment chemistry/TBP exceeds wildlife criteria.

• A site where contamination is unlikely would have all of the following characteristics:

- Sediment chemistry values below all AETs, ERLs, and EqPs; no positive demonstrated toxicity in multiple species; no tissue residue in resident species; and no TBP exceedance.

• Unknown sites are those with the following characteristics:

- Only sediment chemistry data are available and there are no ERLs, ERMs, AETs, or other reference values available for comparison.

- Sediment chemistry TBP is high and fish tissue levels are low or nondetects.

- No sediment chemistry data are available and one toxicity test was conducted with negative results.

- No sediment chemistry data are available and resident fish tissue levels are high.

- Positive toxicity is demonstrated using only microbial tests.

- Only sediment chemistry data are available and values are between ERLs and ERMs and low AETs and high AETs.

DAY TWO - CLOSING SESSION

Following the day two workgroup breakout sessions, all workshop participants were brought together to summarize workgroup discussions and to reach consensus on the issues discussed. A summary of each of the workgroup's deliberations was presented in the previous section of this meeting summary. The following is a summary of the closing session deliberations and the consensus reached concerning the issues discussed during day two of the workshop.

Biased Versus Unbiased Data

A suggestion was made that an appendix to the Report to Congress should be prepared to evaluate the frequency distribution of sediment chemistry data from the various data sets. Some of the data originated from programs that use a random sampling design (e.g., EMAP) or specifically target areas away from known sources of pollution (e.g., NOAA's NS&T). Other data sets (e.g., STORET) were gathered from programs designed specifically to target areas of known pollution sources. The purpose of this analysis would be to screen for chemicals for which there is an adequate unbiased data set.

Data Aggregation

Data should be analyzed at the station level first. Graphics could then be used to present river reach information based on the number of samples per station and number of stations per reach that met the criteria to place a reach in a given contamination category. A reach would be listed in the highest category of contamination even if only one station had a sample or samples that met the criteria to place it in that category. A map could be produced for each classification category. For sediment chemistry analyses, the highest recent measurements taken from surficial sediments should be used. In addition, the maximum concentrations at depth should also be considered in terms of potential biological effect because material can be brought to the surface through bioturbation and resuspension.

Road Test/Pilot Project

The purpose of this analysis would be to determine the accuracy of classifying sites as known contaminated sites based on sediment chemistry data alone. Sediment chemistry data should be analyzed and categorized by comparing measured chemical values to low AETs, high

AETs, ERLs, ERMs, and EqPs. The results of this analysis would be compared to measured toxicity values to determine how well they match. Workgroup participants could not reach consensus on the utility of this analysis. It was agreed, however, that any site categorized as a "known" contaminated site based on sediment chemistry data alone should be subject to additional QA/QC evaluation.

Categorization of Sites

Workshop participants agreed that five categories of sites could be classified based on an evaluation of the data currently housed in the NSI:

- High probability of adverse effects
- Medium-high probability of adverse effects
- Medium-low probability of adverse effects
- Low probability of adverse effects
- Unknown

The following types of data could be used to place a site into one of these five categories.

High Probability of Adverse Effects

- Based on sediment chemistry data only, one or more of the following characteristics should be demonstrated:
  - Sediment chemistry values exceed the sediment quality criteria for the five chemicals for which criteria have been developed (based on measured TOC).
  - Sediment chemistry values exceed all appropriate AETs (high), ERMs, PELs, and EqPs for any one chemical (can use default TOC and AVS).
  - Sediment chemistry values exceed 50 ppm for PCBs.
- Based on toxicity data only
  - Toxicity demonstrated by two or more acute toxicity tests, at least one of which must be a solid-phase nonmicrobial test.
- Based on tissue residue data only
  - Human health thresholds for dioxin or PCBs are exceeded in resident species (This was not a consensus agreement. Participants were evenly divided on whether tissue residue data alone could be used to a place a site in the "high probability of adverse effects" category.)
- Based on sediment chemistry and tissue residue data, one or more of the following characteristics should be demonstrated:

- Sediment chemistry theoretical bioaccumulation potential (TBP) and tissue levels in resident species exceed FDA action levels or EPA risk levels.

- Sediment chemistry TBP and tissue levels in resident species exceed wildlife criteria.

- Based on sediment chemistry and histopathology data

  - Fish tissue tumors present and elevated sediment chemistry concentrations for PAHs.

- Based on sediment chemistry and benthic community data

  - Significant benthic degradation associated with elevated sediment chemistry concentrations. (The workgroup agreed that this was an evaluation category for the future. It cannot be used for the first Report to Congress.)

Medium-High Probability of Adverse Effects

- Based on sediment chemistry data only, one or more of the following characteristics should be demonstrated:

  - Sediment chemistry values exceed at least two of the sediment upper threshold criteria (i.e., ERM, EqP, PEL, high AET). Can use default TOC. EqPs for metals cannot be used unless with measured AVS.

  - Sediment chemistry TBP exceeds FDA action levels or wildlife criteria.

- Based on toxicity data only

  - Toxicity demonstrated by a single species toxicity test (solid-phase, nonmicrobial).

- Based on fish tissue residue data only

  - Fish tissue residue levels exceed FDA action levels or wildlife criteria.

Medium-Low Probability of Adverse Effects

- Based on sediment chemistry data only

  - Sediment chemistry values exceed one of the lower threshold criteria (ERL, EqP, TEL, lower AET). Can use default TOC and AVS.

- Based on toxicity data only

- Toxicity demonstrated by a single species toxicity test (solid- or elutriate-phase, nonmicrobial).

Low Probability of Adverse Effects

- All of the following must be met:
  - No exceedance of lower threshold criteria for sediment chemistry.
  - No toxicity demonstrated in tests using at least two species and at least one solid-phase test using amphipods.
  - No sediment chemistry TBP exceedances of FDA action levels or wildlife criteria.
  - Tissue levels of resident species below FDA action levels and wildlife criteria.

Unknown

- Not enough data to place a site in any of the other categories.

SUMMARY TABLE OF CATEGORIES OF SITE CLASSIFICATIONS AND TYPES OF DATA USED TO DETERMINE CLASSIFICATIONS

Category of Site Classifications	Data Used to Determine Classifications				
	Sediment Chemistry (site is identified by any one of the following characteristics)		**Toxicity**		**Tissue Residue/ Biological Indicator**
High Probability of Adverse Effects	Sediment chemistry values exceed sediment quality criteria for any one of the five chemicals for which criteria have been developed (based on measured TOC)	**OR**	Toxicity demonstrated by two or more acute toxicity tests (one of which must be a solid-phase nonmicrobial test)	**OR**	Human health thresholds for dioxin or PCBs are exceeded in resident species (not a consensus agreement— participants evenly divided on this issue)
	Sediment chemistry values exceed *all* relevant AETs (high), ERMs, PELs,and EqPs for any one chemical (can use default TOC and AVS)				
	Sediment chemistry values >50 ppm for PCBs				
	Sediment chemistry TBP exceeds FDA action levels or EPA risk levels	**AND**	———	—	Tissue levels in resident species exceed FDA action levels or EPA risk levels
	Sediment chemistry TBP exceeds wildlife criteria	**AND**	———	—	Tissue levels in resident species exceed wildlife criteria
	Elevated sediment chemistry concentrations of PAHs	**AND**	———	—	Presence of fish tumors
Medium - High Probability of Adverse Effects	Sediment chemistry values exceed at least 2 of the sediment upper threshold criteria (i.e., ERM, EqP, PEL, high AET) (can use default TOC—EqPs for metals cannot be used unless with measured AVS)	**OR**	Toxicity demonstrated by a single species toxicity test (solid-phase, nonmicrobial)	**OR**	Tissue levels in resident species exceed FDA action levels or wildlife criteria
	Sediment chemistry TBP exceeds FDA action levels or wildlife criteria				
Medium - Low Probability of Adverse Effects	Sediment chemistry values exceed one of the lower threshold criteria (ERL, EqP, TEL, lower AET) (can use default TOC and AVS)	**OR**	Toxicity demonstrated by a single species toxicity test (elutriate-phase, nonmicrobial)	—	———
Low Probability of Adverse Effects	No exceedance of lower threshold criteria and No sediment chemistry TBP exceedances of FDA action levels or wildlife criteria	**AND**	No toxicity demonstrated in tests using at least two species and at least one solid-phase test using amphipods	**AND**	Tissue levels in resident species are lower than FDA action levels and wildlife criteria
Unknown	Not enough data to place a site in any of the other categories				

NEXT STEPS

The EPA Regional offices are being asked to review the preliminary evaluation of sediment chemistry data from the NSI that are relevant to their Region. The Regions will review the data set and are being asked to:

- Verify sites targeted as contaminated.
- Identify sites that were targeted as potential areas of concern but may not be.
- Identify potential areas of concern that were not targeted but should have been.
- Provide EPA Headquarters with additional sediment quality data that should be included in the NSI to make it more accurate and complete.

This information is to be provided to EPA Headquarters in time to allow the incorporation of changes to the NSI prior to the evaluation of the data for the first Report to Congress.

Following the development of the final approach for evaluating NSI data (based on recommendations from the April workshop) and incorporation of Regional comments on the preliminary evaluation, EPA will evaluate all of the NSI data. EPA will then prepare the first Report to Congress, which will classify sites (using the five categories identified at the workshop) in the country, based on an evaluation of both sediment chemistry and biological data from the NSI.

APPENDIX A

AGENDA

National Sediment Inventory Workshop:
Evaluation and Ranking of Sites
April 26-27, 1994

Dupont Plaza Hotel
1500 New Hampshire Avenue, NW
Washington, DC 20036

Day One - Methodologies for Evaluating NSI Data

8:30-9:00	**I.**	**Purpose and Objectives of the NSI Workshop** Betsy Southerland - EPA
9:00-10:00	**II.**	**NSI Data Overview** Catherine Fox - EPA
10:00-11:00	**III.**	**Potential Methodologies for Use in Evaluating NSI Data** (sediment chemistry, fish tissue, toxicity, benthic abundance, QA/QC) Peter Chapman - EVS
11:00-11:15	Break	
11:15-3:00	**IV.**	**Workgroups Meet to Discuss Methodologies**
3:00-4:00	**V.**	**Presentations of Workgroups' Recommendations**
4:00-5:00	**VI.**	**Finalize Selection of Methodologies**

Day Two - Approach for Ranking Sites

8:30-9:00	**I.**	**Summary of Previous Day's Work and Outline of Today's Charge** Betsy Southerland - EPA
9:00-10:00	**II.**	**Overview of Potential Ranking Approaches** (Puget Sound, Great Lakes, Chesapeake Bay) Peter Chapman - EVS
10:00-10:15	Break	
10:15-2:00	**III.**	**Workgroups Meet to Identify Ranking Approach**
2:00-3:00	**IV.**	**Presentations of Workgroups' Recommendations**
3:00-4:00	**V.**	**Finalize Ranking Approach**
4:00-5:00	**VI.**	**Wrap-Up and Next Steps**

APPENDIX B

LIST OF ATTENDEES

National Sediment Inventory Workshop
April 26-27, 1994

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APPENDIX C

NSI WORKGROUP BREAKOUT ASSIGNMENTS

Group One

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Paul Koska, Region 6
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NATIONAL SEDIMENT INVENTORY WORKSHOP

Environmental Protection Agency
Office of Science and Technology

April 26-27, 1994
Washington, D.C.

THE WATER RESOURCES DEVELOPMENT ACT OF 1992

Section 503(a)(1):

The EPA Administrator shall "compile all existing information on the location of pollutants in aquatic sediment, including the probable source of such pollutants and identification of those sediments which are contaminated pursuant to Section 501(b)(4)."

According to WRDA 1992, Contaminated Sediment Means:

"Aquatic sediment which -

a) contains chemical substances in excess of appropriate geochemical, toxicological or sediment quality criteria measures; or

b) is considered by the EPA Administrator to pose a threat to human health or the environment."

THE WATER RESOURCES DEVELOPMENT ACT OF 1992

Requires EPA to Submit a Report to Congress That Describes:

> "The findings, conclusions, and recommendations of such survey, including recommendations for actions necessary to prevent contamination of aquatic sediments and to control sources of contamination."

STATUS OF THE PROJECTS

- National Sediment Management Strategy
  - Tiered Testing Methodologies
- National Sediment Contaminant Source Inventory
  - Point Source Analysis
  - Non-point Source Analysis
- National Sediment Inventory

PURPOSE OF THE WORKSHOP

- To Develop a Methodology for Evaluating NSI Data Using a "Weight of Evidence Approach" That Will Identify Known and Suspected Sites of Sediment Contamination

USE OF THE INVENTORY

- Notify Congress about the Geographic Extent and Severity of Sediment Contamination in the United States

- Provide Basis for Agency's Contaminated Sediments Program
  - Target Chemicals for Pollution Prevention
  - Target Geographic Areas for Additional Monitoring, Pollution Prevention, Source Control and Remediation

CHARGE TO THE WORKSHOP

- Devise a Methodology Using NSI Data to Identify Known, Suspected and Unknown Sites of Sediment Contamination

- Report to Congress on the National Extent and Severity of the Contaminated Sediments Problem in 1995, and Continuously Refine the Message Every Two Years Thereafter

NATIONAL SEDIMENT INVENTORY: DATA OVERVIEW

Catherine Fox
U.S. Environmental Protection Agency
Office of Science and Technology
Standards and Applied Science Division

NATIONAL SEDIMENT INVENTORY: DATA OVERVIEW

Topics of Discussion

- Project Overview
- Sources of NSI Data
- Description of NSI Data
- Limitations of NSI Data
- Preliminary Evaluation of Sediment Chemistry Data

PROJECT OVERVIEW

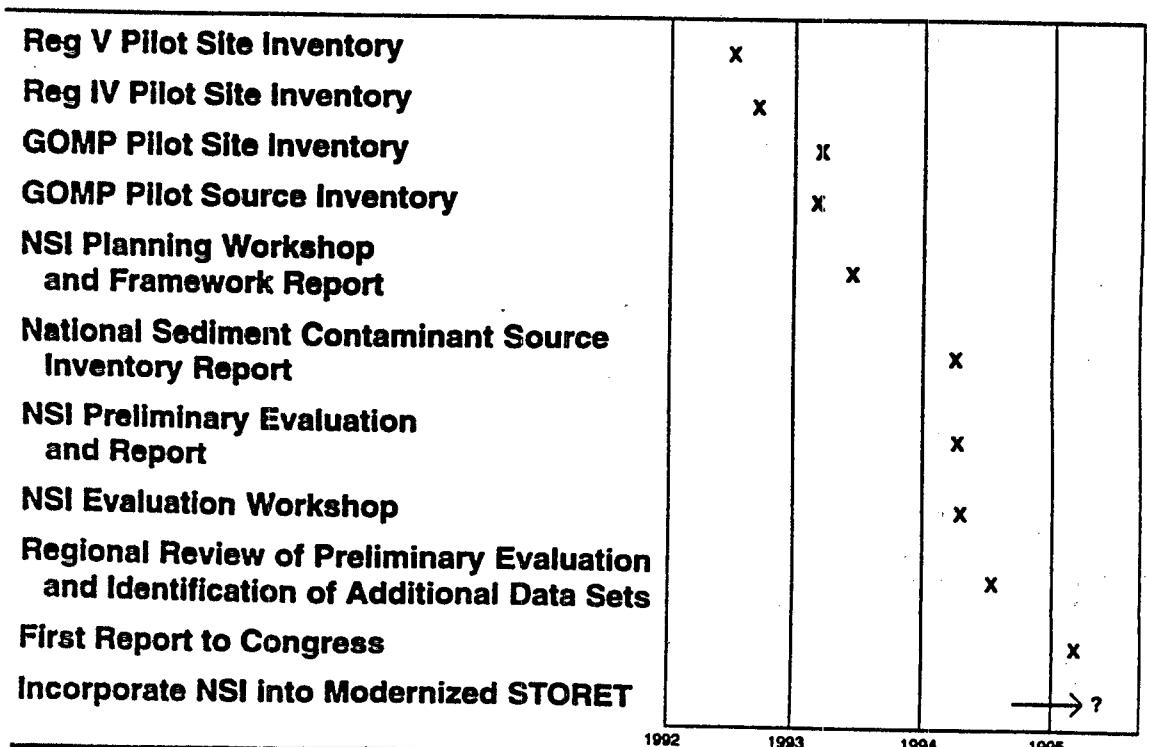
Past Activities

- 3 Pilot Site Inventories (Regions IV & V, Gulf of Mexico Program)
- 1 Pilot Source Inventory (Gulf of Mexico Program)
- NSI Planning Workshop and Framework Report
- National Sediment Contaminant Source Inventory Report
- NSI Preliminary Evaluation and Report

Current/Future Activities

- NSI Evaluation Workshop
- Regional Review of Preliminary Evaluation and Submission of Additional Data Sets
- Biennial Report to Congress

TIMELINE FOR COMPLETION OF NSI AND NSCSI



MINIMUM DATA ELEMENTS: Data Record

Minimum Data Element	Necessary	If Available	Comments
In Computerized Format	X		With data dictionary specifying field names, widths, delimiters, or file structure
Location	X		
Sampling Date	X		
Lat/Long	X		Conforming to EPA's standards
Reach Number		X	
Units	X		

MINIMUM DATA ELEMENTS: Site Characteristics

Minimum Data Element	Necessary	If Available	Comments
Land Use		X	Urban, industrial, rural, etc.
Management Status of Site		X	Remedial action, etc.
Location of Haz Waste/ Superfund Site		X	
Spill Information		X	
Frequency of Dredging		X	i.e., dredging history
Point Source Information		X	Current/historical
Presence of Endangered Species		X	

MINIMUM DATA ELEMENTS: QA/QC

Minimum Data Element	Necessary	If Available	Comments
Source of Information	X		Sponsor or client name and address, name of analytical lab or principal investigator and address
Lab Methods		X	Detection limits used in analyses to be included
Field Methods		X	

MINIMUM DATA ELEMENTS: Sampling Parameters

Minimum Data Element	Necessary	If Available	Comments
Sediment Chemistry	X		
Total Organic Carbon		X	
Grain Size		X	
Acid Volatile Sulfides		X	
Tissue Residue		X	
Toxicity		X	
Benthic Abundance		X	Benthic infauna, community, other indices
Histopathology		X	

SOURCES OF NSI DATA

Timeline: 1980 to present

Sources of data

- Select Data Sets from STORET (COE, USGS, EPA, States, BIOACC, etc.)
- EPA Region IV's Sediment Quality Inventory
- EPA Gulf of Mexico Program's Contaminated Sediment Inventory
- EPA's Ocean Data Evaluation System
- EPA's Environmental Monitoring and Assessment Program's Sediment Quality Data
- EPA Region X/COE Seattle District's Sediment Inventory
- USGS Mass. Bay data (metals only)
- NOAA's Coastal Sediment Data Base (includes NS&T)
- EPA Great Lakes Data Base
- EPA Region IX's DMATS Data Base
- EPA's National Sediment Contaminant Source Inventory (TRI & PCS)

Additional data sets to be added following Regional review of Preliminary Evaluation

DATA INCLUDED IN NSI: Type of Data

Data Set	Data Type					
	Sed Chem	Tissue	Toxicity	Abund	Histopath	Effluent
STORET	x	x				
Reg. IV	x					
GOMP	x		x			
ODES	x	x	x	x		
EMAP	x	x	x	x	x	
Reg. X/Seattle COE	x		x	x		
USGS Mass Bay	x					
COSED/NS&T	x					
Great Lakes	x	x	x	x		
Reg. IX DMATS	x	x	x			
Source Inv.						x

DESCRIPTION OF NSI DATA:
Categories of Data

- Sediment Chemistry
- QA/QC
- Tissue Residue
- Toxicity
  - elutriate
  - solid phase
- Benthic Abundance
- Histopathology
- Matched Data
  - sediment chemistry and tissue residue
  - sediment chemistry and toxicity
  - sediment chemistry and abundance
  - sediment chemistry and histopathology
  - sediment chemistry, tissue residue, and toxicity
  - sediment chemistry, toxicity, and abundance

DATA ELEMENTS INCLUDED IN NSI
(when available):
Sediment Chemistry

- Analyte concentration (all converted to ppb)
- Wet weight or dry weight (converted to dry weight only, when possible)
- Percent organic carbon
- Acid volatile sulfides
- Sediment grain size

DATA ELEMENTS INCLUDED IN NSI

(when available):

Tissue Residue

- Composite or individual sample
- Life stage
- Wet or dry weight
- Analyte concentration
- Sex
- Species
- Tissue, organ, or whole animal

DATA ELEMENTS INCLUDED IN NSI

(when available):

Benthic Species Abundance and Community Analysis

<u>Benthic Abundance</u>

- Organism order, genus, species
- Number of organisms
- Area sampled

<u>Benthic Community Analysis</u>

- Number of organisms (amphipods, arthropods, crustaceans, echinoderms, molluscs, nematodes, oligochaetes, polychaetes, miscellaneous taxa)
- Mean abundance (amphipods, bivalves, capitellids, decopods, polychaetes, tubificids)
- Total abundance
- Mean abundance/grab
- Total biomass
- Mean biomass/grab

DATA ELEMENTS INCLUDED IN NSI

Benthic Abundance (Continued)

- Mean biomass/polychaete
- Mean Shannon-Wiener Diversity Index
- Total number of species
- Mean number species/grab
- Pooled Shannon-Wiener Diversity Index
- Numeric dominance
- Evenness
- % abundance (amphipods, bivalves, gastropods, tubificids)
- Abundance of pollution-sensitive organisms (%)
- Abundance of pollution-tolerant organisms (%)

DATA ELEMENTS INCLUDED IN NSI

(when available):

Toxicity

- Type of bioassay reported
- Endpoint of bioassay test
- Organism genus, species
- Life stage
- Results
- Phase (medium) in which bioassay organisms are housed
- Type of response
- Sphere (environment) from which sample came
- Test duration
- Test used
- Test exposure periods

DATA ELEMENTS INCLUDED IN NSI

(when available):

Histopathology

- Number of fish w/body pathologies
- Number of fish w/branchial pathologies
- Number of fish w/buccal pathologies
- Number/trawl
- Number of species
- Identification of species

SUMMARY OF QA/QC INFORMATION

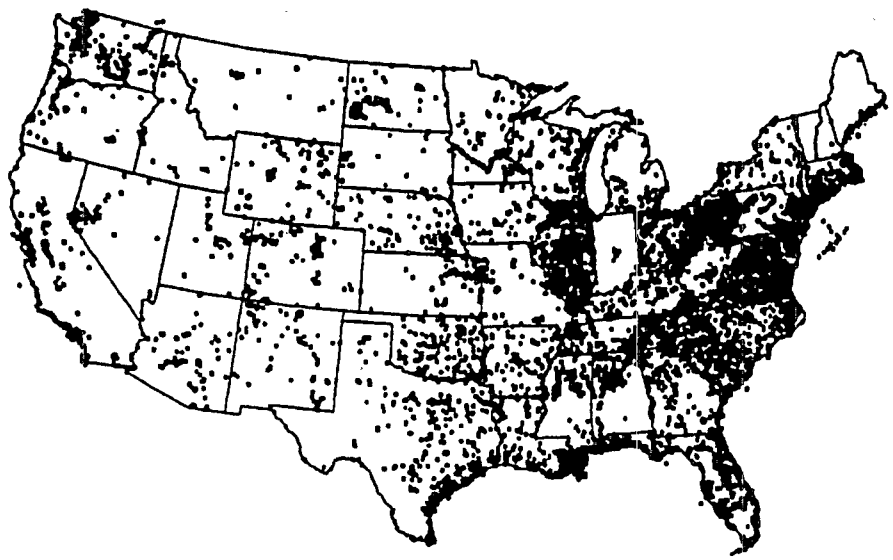
Database	Are There QA/QC Reports	Was the Data Peer Reviewed	Are the Sampling and Analytical Methods Available	Are the Detection Limits for the Analytes Available	Comments
ODES	Yes	Yes (301(h))	Yes	Yes	Data Qualifiers
EMAP	Yes	Yes	Yes	Yes	Data Qualifiers
Reg. X/ Seattle COE	Yes	Yes	Yes	Yes	Data Qualifiers
Reg. IV	Some	No	Some	Yes	Data Qualifiers
GOMP	Some	No	Some	Yes	Data Qualifiers
COSED	Yes	Yes	Yes	Some	
Great Lakes	Yes	Yes	Yes	Yes	
DMATS	Some	Yes	Yes	Yes	Data Qualifiers
STORET	Unknown	Unknown	No	Yes	Data Qualifiers
USGS	Some	Yes	Yes	Yes	

DESCRIPTION OF NSI DATA: Number of Stations

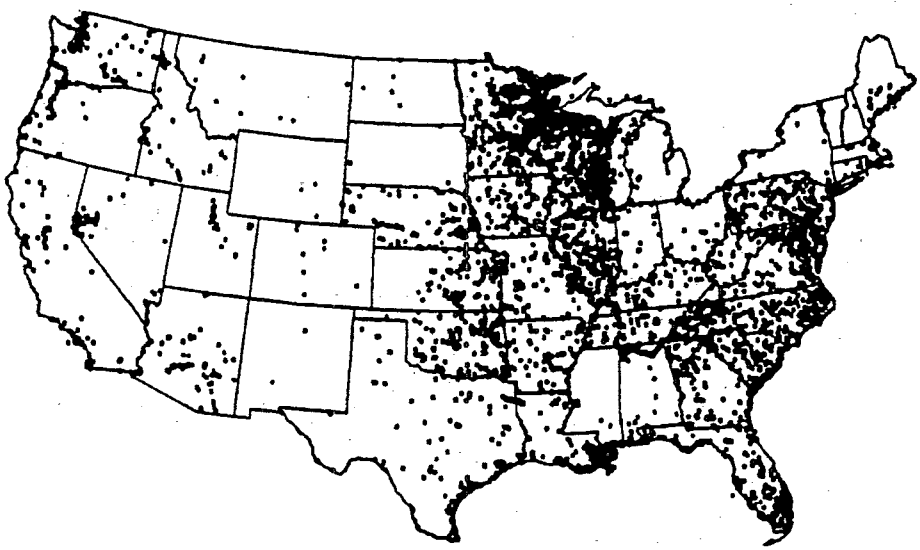
Measurement Parameters	Total # of Stations	Stations with Coordinates	
		#	% of Total Number of Stations w/Coordinates*
Sediment Chemistry	21,093	19,546	76
TOC	6,170	5,335	21
AVS	425	371	1
Tissue Residue	8,206	7,208	28
Toxicity	2,343	1,523	6
Elutriate Phase	630	--	--
Solid Phase	1,865	--	--
Benthic Abundance	3,904	1,844	7
Histopathology	259	259	1
Sed. Chem. & Tissue	1,963	1,930	8
Sed. Chem. & Toxicity	1,801	1,263	5
Sed. Chem. & Abundance	1,939	1,340	5
Sed. Chem. & Histopath.	259	259	1
Sed. Chem., Tissue, & Toxicity	389	359	1
Sed. Chem., Toxicity, & Abundance	848	733	3

*Total Number of Stations With Coordinates = 25,555

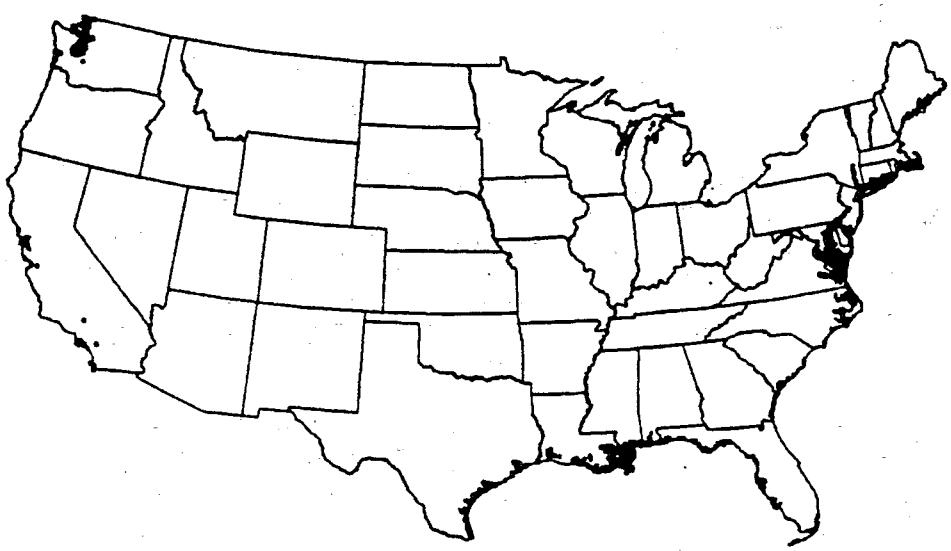
DESCRIPTION OF NSI DATA: Location of Sediment Chemistry Stations



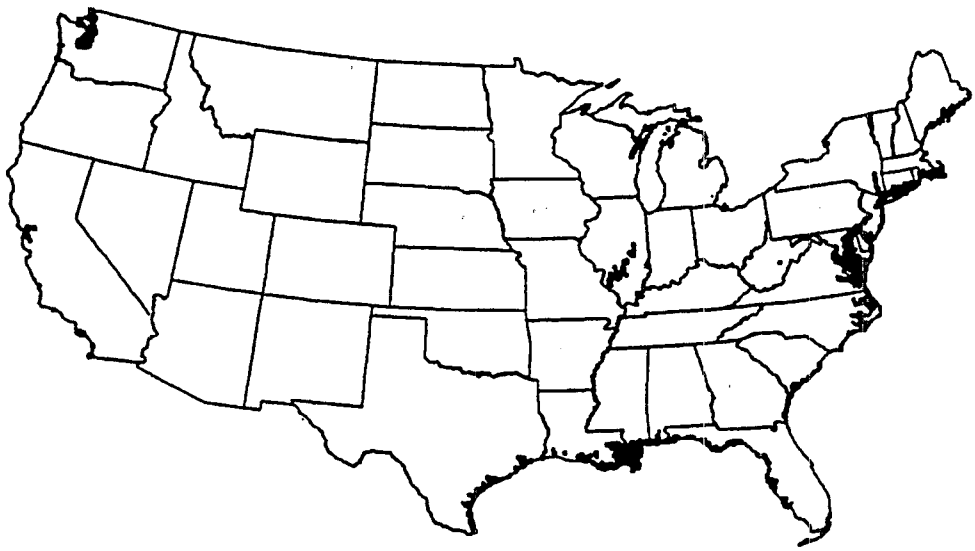
DESCRIPTION OF NSI DATA:
Location of Tissue Residue Stations



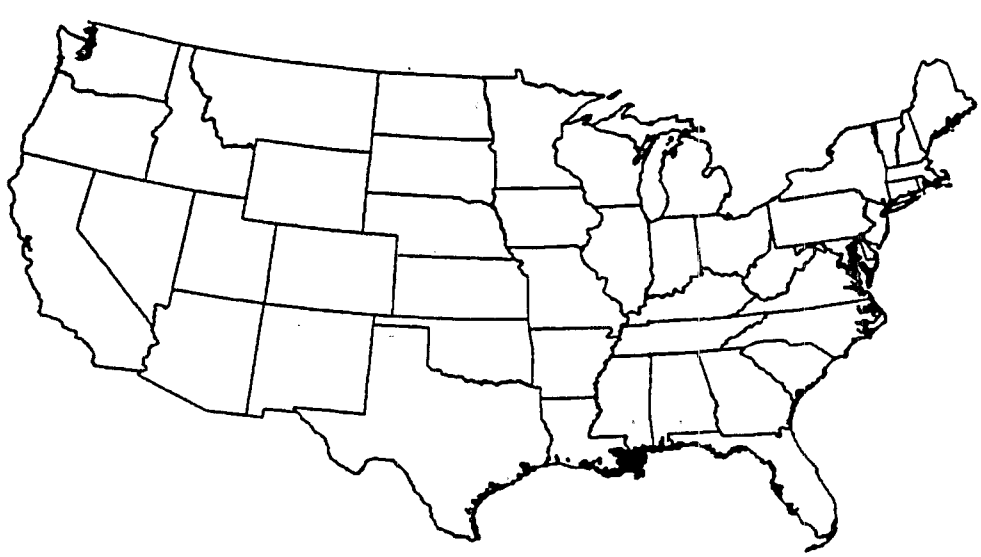
DESCRIPTION OF NSI DATA:
Location of Toxicity Stations



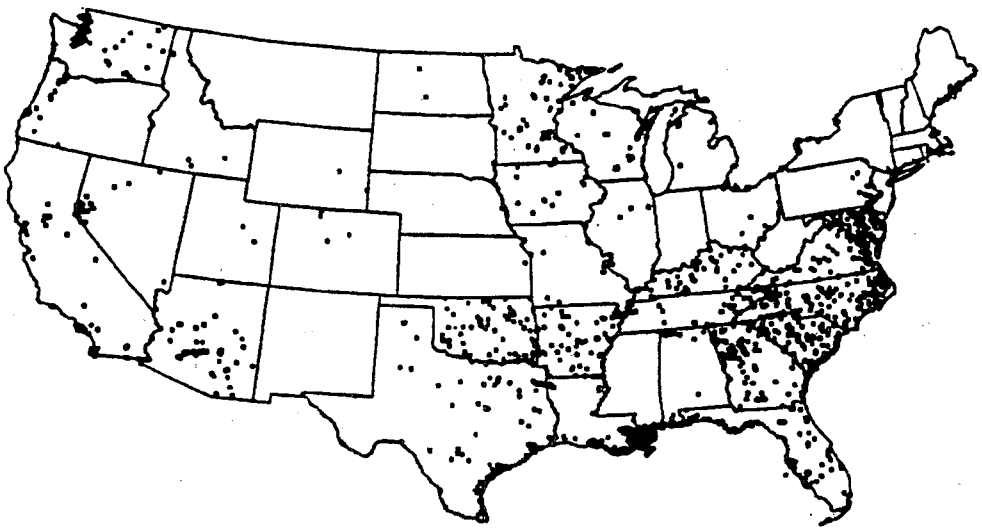
DESCRIPTION OF NSI DATA:
Location of Benthic Abundance Stations



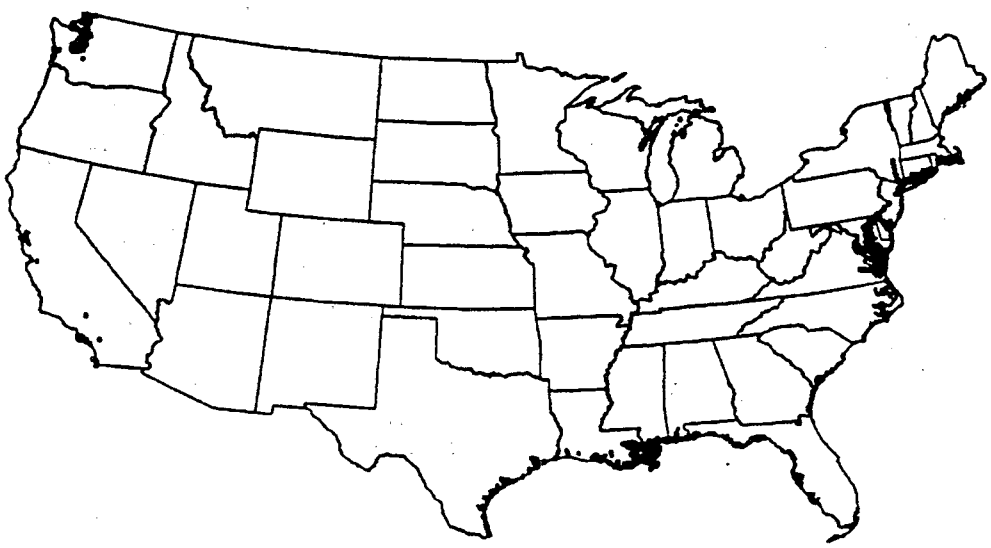
DESCRIPTION OF NSI DATA:
Location of Histopathology Stations



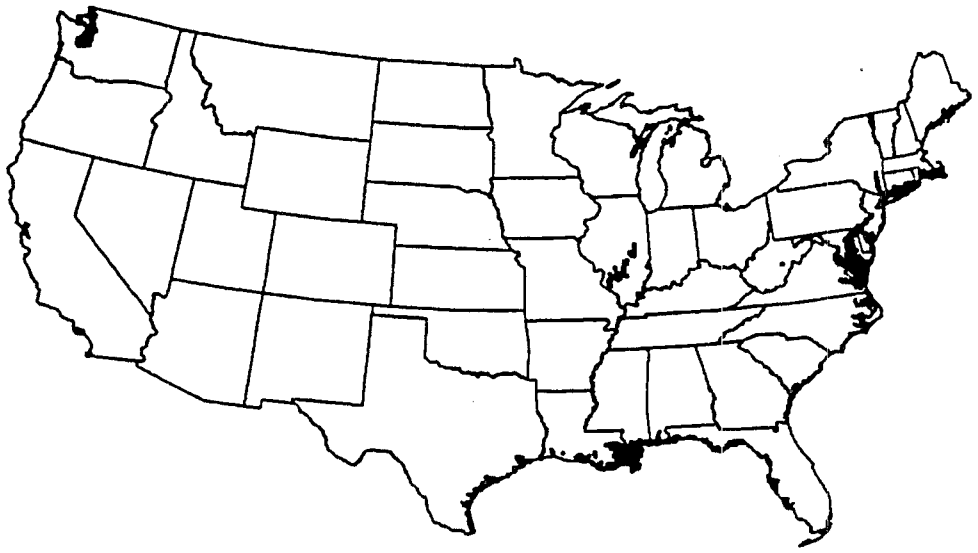
DESCRIPTION OF NSI DATA: Location of Matched Data: Sediment Chemistry and Tissue Residue



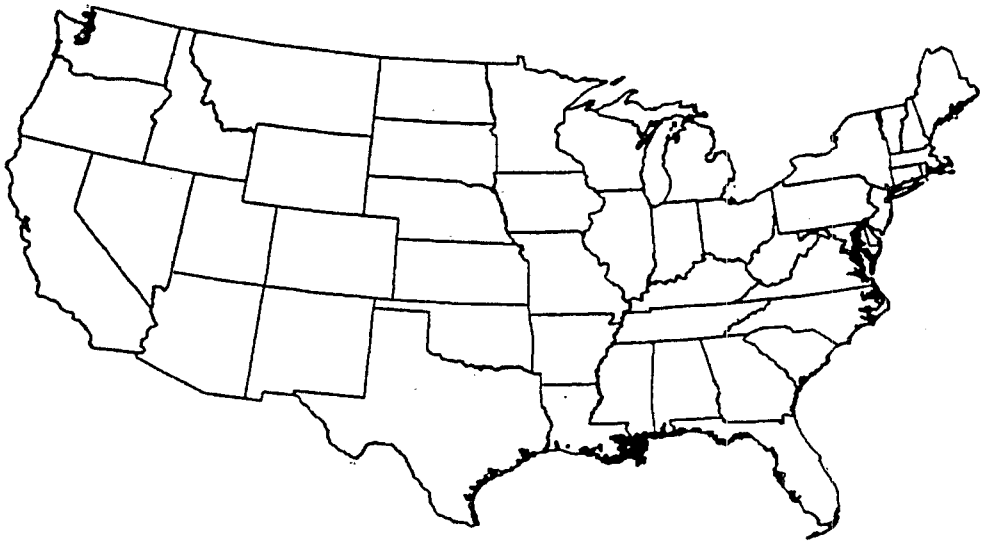
DESCRIPTION OF NSI DATA: Location of Matched Data: Sediment Chemistry and Toxicity



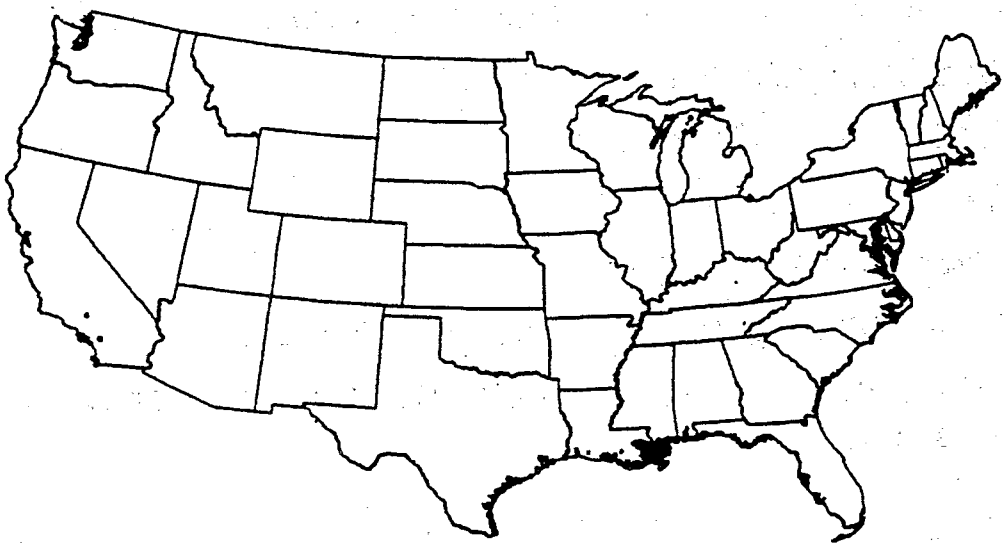
DESCRIPTION OF NSI DATA: Location of Matched Data: Sediment Chemistry and Benthic Abundance



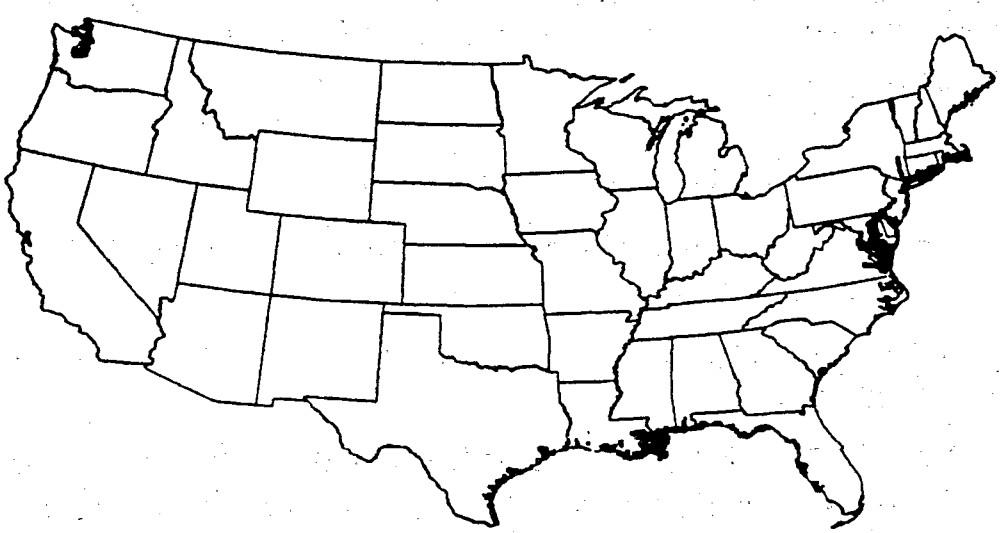
DESCRIPTION OF NSI DATA: Location of Matched Data: Sediment Chemistry and Histopathology



DESCRIPTION OF NSI DATA: Location of Matched Data: Sediment Chemistry, Tissue Residue, and Toxicity



DESCRIPTION OF NSI DATA: Location of Matched Data: Sediment Chemistry, Toxicity, and Benthic Abundance



LIMITATIONS OF NSI DATA

Limited TOC and AVS data for sediment chemistry analysis

Detection limits are often higher than threshold values

Limited biological effects data

Limited QA/QC information

Latitudes/longitudes not verified

Variation in monitoring objectives

Multiple sampling and analytical methods used

No information on bed sediment type, history of dredging, land use available yet

PRELIMINARY EVALUATION OF SEDIMENT CHEMISTRY DATA: Purpose

Provide EPA Regions with preliminary assessment of the sediment chemistry data currently housed in the NSI for their review

Allow Regions to:

- Verify sites targeted as contaminated
- Identify sites that are targeted as being a potential area of concern but may not be
- Identify potential areas of concern that were not targeted but should have been
- Provide EPA Headquarters with sediment quality data that should be included in the NSI to make it more accurate and complete

PRELIMINARY EVALUATION OF SEDIMENT CHEMISTRY DATA: Overview of Approach

Waterbody-Segment Level of Analyses

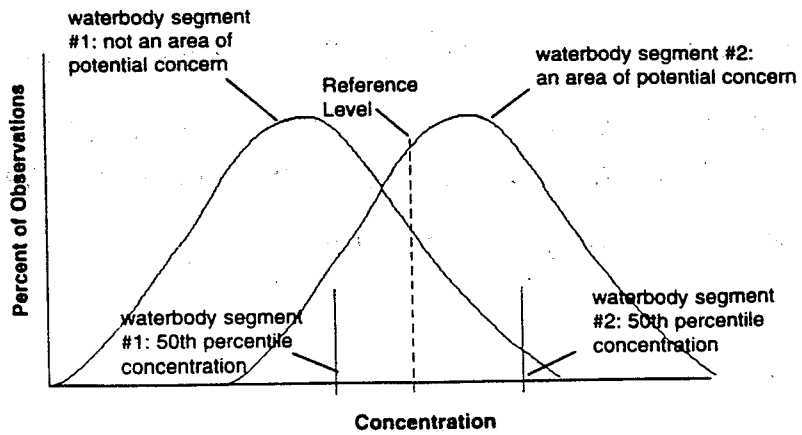
Threshold values

- **Metals - ERMs (NOAA, 1990)**
- **Nonionic organics - EQPs (1% oc)**
- **Ionic organics - lowest AETs**

Steps:

- **Identify 50th percentile (median) concentrations for all observations for each analyte (nondetects and "less thans" treated as zero)**
- **If 50th percentile concentration greater than reference value, then consider contaminant of concern for that waterbody segment**
- **Any waterbody segments in which one or more contaminants of concern were identified are targeted as potential areas of concern**

COMPARISON OF 50th PERCENTILE CONCENTRATION TO REFERENCE LEVEL



PRELIMINARY EVALUATION OF SEDIMENT CHEMISTRY DATA: Advantages of Approach

- Targets the most highly contaminated sites (based on 50th percentile concentrations)
- Comparisons based on reference levels demonstrated to cause biological impacts (i.e., ERMs, EQPs, and AETs)
- Results presented at waterbody segment level of analysis to allow Regions to compare results with known sampling results in the Region

PRELIMINARY EVALUATION OF SEDIMENT CHEMISTRY DATA: Limitations of Approach

- Sediment chemistry data analysis only
- TOC and AVS not provided for many data sets
- Variation in monitoring objectives, sampling/analytical methods, and data quality across data sources
- Lack of documented QA/QC information

PRELIMINARY EVALUATION OF SEDIMENT CHEMISTRY DATA:

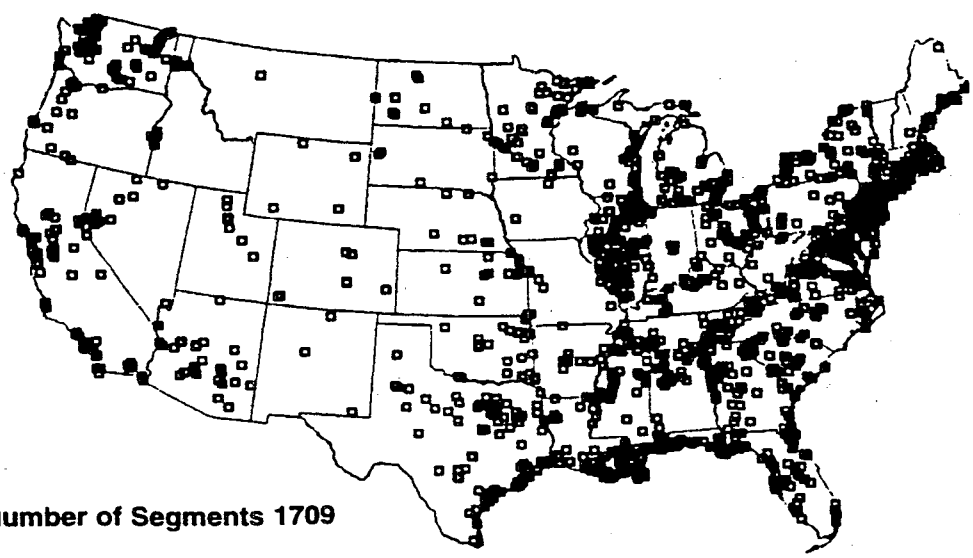
Top 20 Contaminants of Concern

(based on number of waterbody segments where 50th percentile concentrations exceed reference levels)

Contaminant	# of Waterbody Segments
Polychlorinated biphenyls	584
Chlordane	359
DDD	229
Lead	229
Zinc	226
PCB-1254	195
Anthracene	186
Pyrene	174
Heptachlor epoxide	137
DDE	130
Nickel	127
DDT	124
Heptachlor	105
PCB-1260	101
Aldrin	92
Mercury	84
Silver	83
PCB-1248	83
Cadmium	78
Chromium	77

PRELIMINARY EVALUATION OF SEDIMENT CHEMISTRY DATA:

Potential Areas of Concern



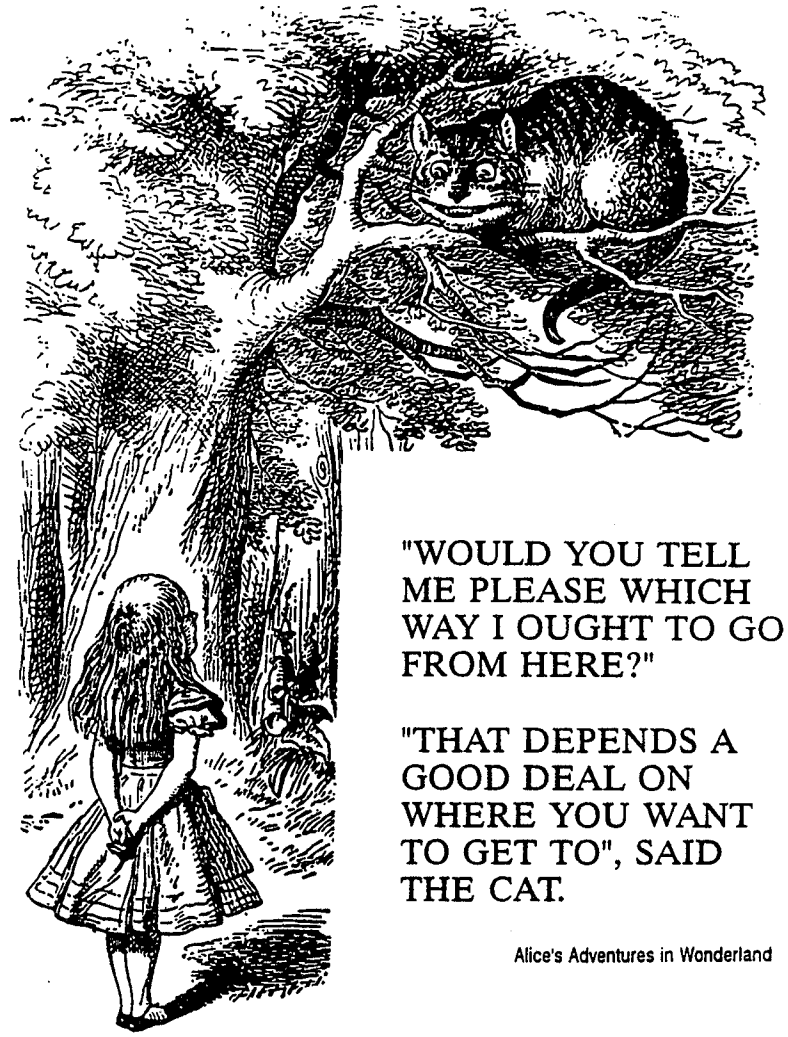
Number of Segments 1709

COPIES OF OVERHEADS

Two Talks by P. Chapman

(DAY 1) TALK 1: "Potential Methodologies for Use in Evaluating NSI Data"

(DAY 2) TALK 2: "Overview of Potential Ranking Approaches"



"WOULD YOU TELL ME PLEASE WHICH WAY I OUGHT TO GO FROM HERE?"

"THAT DEPENDS A GOOD DEAL ON WHERE YOU WANT TO GET TO", SAID THE CAT.

Alice's Adventures in Wonderland

TALK 1: POTENTIAL DATA EVALUATION METHODOLOGIES

- "Discussion Paper"
- NOT intended to be exclusive
- A starting point only

(Day One Decisions:
How to evaluate each type of data ***AND*** How to use sediment chemistry to categorize sites)

METHODOLOGIES SHOULD:

1. Make best use of data available, ***including ecological and human risk***
2. Allow use of future data (e.g., expected greater emphasis on biology)

METHODOLOGIES SHOULD: (continued)

3. ***Direct*** future data gathering activities (and not restrict same).

4. ***Answer*** a central question: Are contaminated sediments a national problem or only a "hot spot" problem?

AVAILABLE DATA

- Primarily chemistry (sediment and tissue)

- Biological measures:
  1. benthos
  2. toxicity
  3. histopathology (?)

- Some (?) matched chemistry and biology - coincident ***and*** synoptic (value of coincident data?)

STATUS OF NSI "DATABASE"

- Not a database
- SAS data sets

  Not user friendly (information retrieval/manipulation requires specialized/customized software)

- EPA/01RM guidelines prevented creation of any database - "duplicative of STORET modernization effort"
- Data evaluation to date focused on sediment chemistry

RECOMMENDED SOLUTIONS

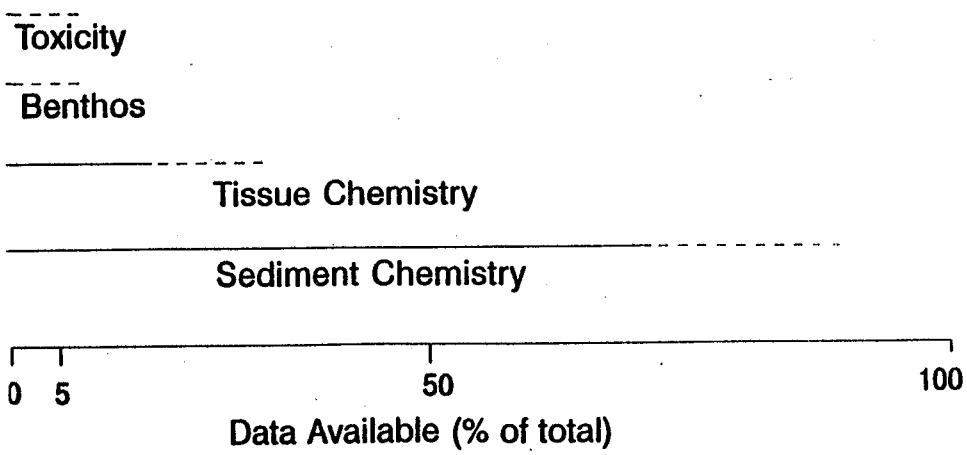
- Change to user-friendly database

  (If no other option, use STORET and tag NSI data)

- Evaluate sediment chemistry and toxicity data at a minimum)

SCHEMATIC OF OVERALL DATA DISTRIBUTION

(Scale estimated, not certain; data not necessarily synoptic or coincident)



THIS IS BASICALLY A RISK ASSESSMENT (RA)

LEVEL 1 RA REQUIRES:

1. Exposure Assessment

   - Bulk chemical concentrations (have)

   - Background chemical concentrations (determine)

   - receptors, especially exposure routes and concentrations (need overlay of resources/ sensitive areas - ***which can also direct future sampling)***

THIS IS BASICALLY A RISK ASSESSMENT (RA)

LEVEL 1 RA REQUIRES:

2. Toxicity/Hazard Assessment

   - Threshold effects concentrations relative to exposure

   (e.g., Ed Long "no-criteria" numbers?)

THIS IS BASICALLY A RISK ASSESSMENT (RA)

LEVEL 2 RA REQUIRES:

1. Direct measures of bioavailable forms
   - pore water (EqP estimates?)
   - laboratory bioaccumulation (available?)
   - tissue body burdens (have some)

2. Standard bioassessment studies
   - toxicity tests (have some)
   - benthos (have some)

SUMMARY
LEVEL 1 RA (= Tier I)

Equivalent to using sediment chemistry thresholds

BUT

1. Compare to background (for ecoregions [?] not for whole U.S.)
2. Evaluate ecoregion [?] and actual site sensitivity

Include sediment tissue data here (e.g., human health, fish advisory comparisons)

SUMMARY (continued)
LEVEL 2 RA (= Tier II)

NOW add in bioeffects data (i.e., toxicity, benthos)

- FINAL site classification
- "Test" of Tier I Thresholds
  - work
  - don't work
  - need further work

SEDIMENT CHEMISTRY

- Most of data, therefore basis for at least initial prioritization
- How many (and which) contaminants considered/included? (data base is far from symmetric; primarily metals)
- Geographic differences (e.g., in south-east metals to Al ratios important as relatively high natural metal concentrations)

POSSIBLE SEDIMENT CHEMISTRY SCREENING TOOLS

- Comparison to background - only measure applicable to ALL contaminants
- EqP
- AET
- SLC
- ERM/ERL and equivalent (e.g., PELs)
- Others??

(Only provide high and/or low concentrations - an initial, non-definitive screening; which to use?)

SEDIMENT CHEMISTRY SCREENING TOOLS

PROBLEM

- For some chemicals wide range
  e.g., Chrysene, freshwater
  ER-L = 0.4 ppm
  EP1-AQ = 409 ppm

- For other chemicals narrow range
  e.g., Arsenic, freshwater
  ER-L = 33 ppm
  ER-m = 85 ppm
  AET = 57 ppm

QUESTIONS

- Which to use?
- Why?

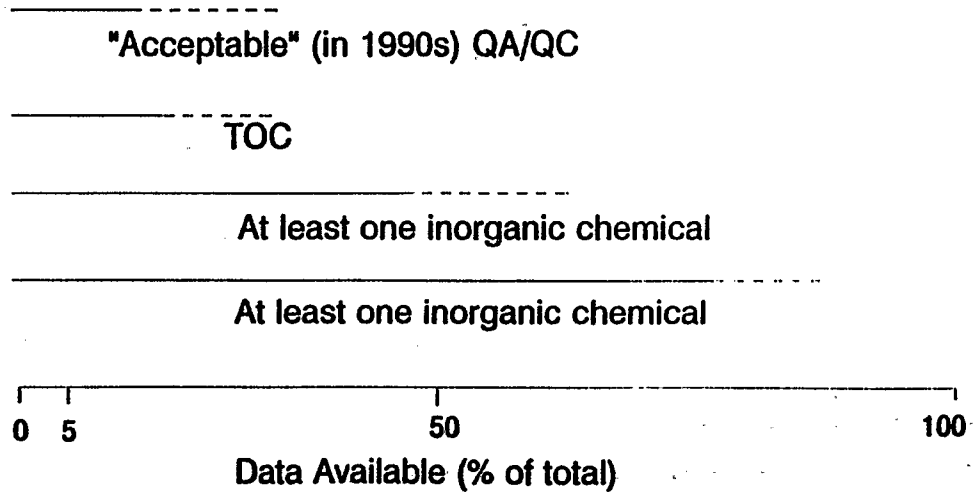
QUESTION:

Scoring on a continuum?
(= a gradation, for example, increasing concern with increasing magnitude)

or on a binary system?
(= yes or no as to whether of concern, regardless of magnitude)

SCHEMATIC OF SEDIMENT CHEMISTRY DATA DISTRIBUTION

(Scale estimated, ***not*** certain)



POSSIBLE "NORMALIZATION" OF SEDIMENT CHEMISTRY

$$\frac{\text{No. of Exceedances (of what?)}}{\text{No. of Chemicals}}$$

QA/QC

- "Appropriate Level"
- Not overly exclusive
  - geographic coverage
  - report to Congress
- Not lacking in credibility
  - dependent on use (e.g., Tier I versus higher tiers in dredging assessments)

RECOMMENDED DECISIONS: QA/QC
(for review by Workgroups)

1. Restrict analyses to data subject to at least some level of QA/QC
   - Cannot be 1990s-levels QA/QC if goal is to ensure geographic coverage
2. Set future QA/QC "minimum" expectations and communicate to data-gathering agencies
   - effective but realistic level-of-effort to ensure geographic (and programmatic) coverage

"MINIMUM" QA/QC EXPECTATIONS

[For future and any definitive site classifications]

1. Written methods (somewhere - accessible)

2. QA/QC plans and reports (somewhere - accessible)

3. Chemical analyses (sediment and tissue)
   - detection limits
   - method/reagent blanks (re: contamination)
   - split samples (re: precision)
   - Standard Reference Materials (SRMs)

"MINIMUM" QA/QC EXPECTATIONS (continued)

4. Benthos
   - sorting rechecks
   - voucher collection
   - independent taxonomic verification (a small proportion of samples)

5. Toxicity
   - negative (clean) controls
   [- positive (toxic) controls]
   - appropriate test conditions

RECOMMENDED DECISIONS: SEDIMENT CHEMISTRY

- Must meet minimum QA/QC
  - for future
  - for any definitive site classifications
- Should include TOC, grain size

RECOMMENDED DECISIONS: TISSUE CHEMISTRY

- Must meet minimum QA/QC
  - for future
  - for any definitive site classifications
- Should include ancillary measures (e.g., size, weight, age, lipid content)

RECOMMENDED DECISIONS: SEDIMENT TOXICITY

- Must meet minimum QA/QC
  - for future
  - for any definitive site classifications
- Must involve at least one whole sediment test
- Should involve more than one test type/test organism

RECOMMENDED DECISIONS: BENTHOS

- Must meet minimum QA/QC
  - for future
  - for any definitive site classifications
- Must provide species-level taxonomy (lumping upwards possible)
- Must be in raw data format (for manipulation), not only as summaries
  (true of all data)

A JOB WELL BEGUN

IS HALF DONE

TALK 2:
POTENTIAL RANKING APPROACHES

- "Discussion Paper"
- Not intended to be exclusive
- A starting point ***ONLY***
- My interpretation of different approaches is subject to correction

(Day Two Decision:
How To Use the Data for
Ranking)

TWO TYPES OF ASSESSMENT METHODS

1. INFER biological impact
   - Measure chemistry and/or biology
   - Compare to predetermined threshold
2. DEMONSTRATE biological impact
   - Site-specific measures (synoptic [or coincident] chemistry and biology)

REYNOLDSON APPROACH (Great lakes)

(DEMONSTRATION METHOD)

- Define reference communities and/or sediment toxicity based on chemical, physical, geological and geographic features unrelated to pollution
- Determine variables that can predict these communities

REYNOLDSON APPROACH (Great Lakes) - continued

- Compare predictions for non-studied areas to what actually there
- Used to date to predict benthic communities (68.9 - 79.6% accuracy in Great Lakes, 90% in Swedish lakes)
- Numerical, biological sediment guidelines

COMMENTS Re: REYNOLDSON APPROACH

- Not applicable to present NSI
- ***BUT*** may be of great future value for sediment classification

SEDRANK (PUGET SOUND)

(INFERENCE METHOD)

- Sediment chemical concentrations
  - dry weight
  - normalized to TOC
- Compared to reference areas

(Whole region is well-studied, including detailed area-specific benthos, toxicity, tissue chemistry and histopathology information)

SEDRANK (PUGET SOUND) (continued)

- Ranking of contaminated sediment sites to establish priorities for clean-up
- Includes "best professional judgement" and "preponderance-of-evidence" approach for multiple indicators (e.g., elevation above reference for 3 or more indicators)

COMMENTS Re: SEDRANK

- Partly applicable to NSI

- ***BUT***
  - NSI has little TOC data
  - Puget Sound Region is well studied, the nation is not.

CHESAPEAKE BAY APPROACH

(INFERENCE METHOD)

- Geographical basin wide targetting (as per Puget Sound)
- Demonstrated toxic substance impacts ***OR*** potential for impacts
- Benthic faunal data a major component
- Builds on Great Lakes Areas of Concern and Puget Sound Urban Bay Action programs

CHESAPEAKE BAY APPROACH (continued)

- Initially proposed simple scheme
- $\frac{\text{Average contaminant concentration}}{\text{PEL}}$
  (quotients summed for 7 metals and 8 PAHs)
- Revised approach, as per above, and
  Sediment concentrations scored

	Score
>PEL	2
>0.8 PEL	1
<0.8 PEL	0

CHESAPEAKE BAY APPROACH (continued)

FOUR CATEGORIES
("Weight of Evidence" and "Reason to Believe")

- Region of Concern
  - adverse effects or threshold exceedances
  - cause and effect
- Area of Emphasis
- Low Probability for Adverse Effects
  - no threshold exceedances
  - no advese effects compared to reference areas
- Insufficient Data

CHESAPEAKE BAY APPROACH (continued)

MEASURES:

- Water Column - Contamination
  - Toxicity
- Sediment - Contamination
  - Toxicity
- Finfish - Tissue contamination
  - Tumors
- Shellfish - Tissue contamination
- Benthos - Community structure

CHESAPEAKE BAY APPROACH (continued)

CRITERIA

- **Water Column**
  - acute/chronic WQC/WQS mean aquatic toxicity concentration data
  - Effects significantly different from controls
- **Sediment**
  - comparison with sediment quality values
  - effects significantly different from controls
- **Finfish**
  - comparison with available human health protection values
  - Tumor incidence significantly above background levels
- **Shellfish**
  - comparison with available human health protection values
- **Benthos**
  - community structure compared with Bay restoration goal

CHESAPEAKE BAY APPROACH (continued)

CRITERIA:

- Individual measures can categorize
- e.g., Criteria/Standards
  - Exceedances (Concern)
  - Within 10 - 25 % (Emphasis)
- e.g., Reference/Control Comparisons
  - Significant differences
    (e.g., acute toxicity - Concern;
    chronic toxicity - Emphasis)
- Sediment Chemistry - based on ERM/PEL comparisons

COMMENTS Re: CHESAPEAKE BAY APPROACH

- Partly applicable to NSI
- ***BUT***
  - A region, not the nation
  - Apparent reliance on statistics
    (statistics $\neq$ ecological relevance)

ARCS APPROACH

(INFERENCE METHOD)

Based on Kreis (1989)

- Bulk Sediment Chemistry
  - each contaminant ranked independently
  - scaling from 1 (minimum) to 100 (maximum)
  - independent ranks averaged
- Updated to include information on:
  - toxicology
  - ecology
  - estimated bioavailability

ARCS APPROACH (continued)

REVISED SEDIMENT CHEMISTRY RANKING:

- Chemicals not ranked independently
- Common toxicity (toxic unit) scale
  - (estimated pore water concentration [EqP or AVS] divided by water quality criterion)
- Toxic units averaged
- Ranking on a scale from 1 (minimum) to 100 (maximum)

ARCS APPROACH (continued)

LABORATORY SEDIMENT TOXICITY RANKING:

- Common scale (measured test response divided by control response)
- Responses averaged
- Ranking on a scale from 1 (minimum) to 100 (maximum)

ARCS APPROACH (continued)

BENTHOS COMMUNITY STRUCTURE RANKING:

- Common scale (% of total for each major taxon)
- Each major taxon divided by relative pollution tolerance
- Responses averaged
- Ranking on a scale from 1 (minimum) to 100 (maximum)

ARCS APPROACH (continued)

FINAL RANKING:

- Based on sediment chemistry, laboratory toxicity, benthic community structure
- Each on a scale of 1 to 100
- Average the three ranks

COMMENTS Re: ARCS APPROACH

- Partly applicable to NSI
- ***BUT***
  - NSI lacking in TOC data
  - NSI lacking in bioeffects data (ARCS = detailed, similar chemistry, toxicity and benthos)
  - a region, not the nation

REGION 5 PRIORITIZATION

(INFERENCE METHOD)

Two Tiers:

Tier 1 - Scoring Categories

1. Sediment Chemistry
2. Fish tissue chemistry
3. Sediment toxicity
4. Noted environmental impacts

REGION 5 PRIORITIZATION (continued)

POINTS "SCORED" IF THRESHOLD VALUES:

- Exceeded
- Not exceeded
- Data not available

Sediment chemistry scoring increased with increasing magnitude of exceedences

REGION 5 PRIORITIZATION (continued)

BASIS FOR SEDIMENT CHEMISTRY EVALUATION:

(All sites have SOME data)

- criteria/guidelines (lowest value)
- background concentrations

BASIS FOR FISH TISSUE CHEMISTRY EVALUATION:

(Only 50% of sites have data)

- human health risks (lowest value)

REGION 5 PRIORITIZATION (continued)

BASIS FOR SEDIMENT TOXICITY EVALUATION:
(Only 2% of sites have data)

- ≤ 50% difference from control

BASIS FOR ENVIRONMENTAL IMPACT EVALUATION:
(Information "spotty")

- Omission probably does not change prioritization
- Includes benthic community "effects", "bioaccumulation", four types of "impairment"

REGION 5 - TIER 2

- Other information than Tier 1

- Site-specific information, e.g.:

  - proximity to Great Lakes
  - population in vicinity
  - nearby facilities
  - other evidence of impacts
  - "types" of sediment pollutants
  - depth of sediment contamination
  - actions planned, completed, underway

REGION 5 FINDINGS

- 1° Prioritization Based on:
  - sediment chemistry
  - fish tissue chemistry
  - status of planning/remediation

- Other information less critical

  As only 47 sites to evaluate

  (If more sites, Other Information would be more critical)

REGION 5 CATEGORIES (Recommended Actions)

- Increased remedial activity
  - high/severe contamination*
- Further studies
  - Moderate/high contamination*
  - Data at least 5 years old
- Remedial activities underway
  - Moderate/severe contamination*
- Other Sites
  - Lowest priority*
  - But further studies desirable

* (***EITHER*** sediment chemistry ***OR*** fish tissue)

NOTE RE: REGION 5 PRIORITIZATION

- Focus on known/expected contaminated sites
  - Low probability of finding "unknown" contaminated sites
- Data errors and omissions exist in the Site Inventory
- Region 5 Inventory ***cannot*** (as includes paper sources) go directly into NSI electronic data base

COMMENTS Re: REGION 5 PRIORITIZATION

- Partly applicable to NSI (perhaps more so than any other approach)

- ***BUT***
  - only <u>one</u> region
  - only 47 sites
  - all sites known/expected to be a problem

PROBLEM WITH NSI

Most of data chemical, no relationship to bioeffects or bioavailability

PREDETERMINED CHEMICAL THRESHOLDS

(INFERENCE TECHNIQUES)

- Comparison to background - only measure applicable to ALL contaminants
- EqP
- AET
- SLC
- ERM/ERL and equivalent (e.g., PELs)
- Others??

(Only provide high and/or low concentrations - an initial, non-definitive screening; which to use?)

POSSIBLE SOLUTION

Assign chemistry data various levels of uncertainty

"Certainty" only based on:
- matched chemistry and biological data

OR

- "blow-out" chemistry concentrations (some [e.g., PCBs?] or all contaminants?)

"BLOW-OUT" CHEMICAL CONCENTRATIONS

PROBLEM

- For some chemicals wide range
  e.g., Chrysene, freshwater
  ER-L = 0.4 ppm
  EP1-AQ = 409 ppm

- For other chemicals narrow range
  e.g., Arsenic, freshwater
  ER-L = 33 ppm
  ER-M = 85 ppm
  AET = 57 ppm

GENERIC MEASURES OF SEDIMENT CONTAMINATION

DO NOT PROVIDE INFORMATION ON:

1. Whether (or not) contamination is exerting biological stress

2. Whether (or not) this stress will continue if the sources of contamination are removed

(Therefore chemistry alone ***cannot*** classify sites ***definitively***)

NO SINGLE APPROACH APPROPRIATE, "BATTERY" OF TRIGGER LEVELS DEPENDING ON THE DATA

POSSIBLE RANKING SCHEME

I. "KNOWN" - Based on matched (synoptic [coincident?]) sediment and/or tissue chemistry, toxicity, benthos

II. "SUSPECTED" - for some chemicals (e.g., PCBs) use "blow-out" concentrations
- ***or a "blow-out" biological measure (?)***
- insufficient data (e.g., only one toxicity test)