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DECIDING WHEN TO INTERVENE

Data Interpretation Tools for Making Sediment Management Decisions Beyond Source Control

Based on a Workshop to Evaluate Data Interpretation Tools used to Make Sediment Management Decisions held at the Great Lakes Institute for Environmental Research at the University of Windsor on December 1-2, 1998

Prepared by: Gail Krantzberg, John Hartig, Lisa Maynard, Kelly Burch, and Carol Ancheta
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Preface

The International Joint Commission (IJC) has identified contaminated sediment as a program priority. During the 1997-1999 biennial cycle, the IJC directed the Great Lakes Water Quality Board (WQB) and its Sediment Priority Action Committee (SedPAC) to develop guidance for making decisions regarding management of contaminated sediment and to compile and disseminate information on benefits of sediment remediation.

Sediment management experts from throughout the Great Lakes Basin and beyond met for a workshop in Windsor, Ontario on December 1-2, 1998 (see Appendices 1 and 2). They examined and exchanged tools that are used to interpret environmental data to deduce scientifically whether or not to take sediment management actions beyond source control.

Please note that this report is not a manual for sediment assessment or selection of remedial technologies, compilations of which are available from federal, provincial, and state agencies. Other elements of sediment management decision-making such as socio-economic factors are not considered here, but their importance is noted within this report.

This report of SedPAC synthesizes and interprets the scientific methodologies and management experiences presented at the workshop in a fashion which provides clear, timely advice on the use of scientific data interpretation tools used to make a sediment management decision. It is intended to disseminate methodologies for evaluating the degree to which an intervention for sediment cleanup is ecologically compelling.

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I. EXECUTIVE SUMMARY

There is a consensus among diverse sectors in the Great Lakes Basin (e.g., government, industry, non-governmental organizations, Remedial Action Plan groups) that contaminated sediment is an important element leading to many of the impairments to beneficial uses of the Great Lakes. All 42 Great Lakes Areas of Concern have contaminated sediment based on application of chemical guidelines. This universal obstacle to environmental recovery in Areas of Concern can potentially pose a challenge to restoring 11 of the 14 beneficial use impairments identified in the Great Lakes Water Quality Agreement (SedPAC 1997).

> Sediment cleanup that results in a mass of contaminants being removed from the ecosystem reduces risks to fish, wildlife and humans. This type of cleanup represents incremental progress towards the ultimate success of restoring sediment-related beneficial uses.

For Remedial Action Plans (RAPs), sediment management decisions need to be made bearing in mind the relationship between contaminated sediment and restoration of beneficial uses. This goes far beyond setting a numerical chemical cleanup criteria, as these are not based on the need to fully restore beneficial uses. What is needed is a pragmatic decision-making framework that leads to the selection of ecosystem and cost-effective options for management of contaminated sediment.

The Water Quality Board (WQB) has called for a step-wise and incremental approach to management of contaminated sediment and restoration of beneficial uses (SedPAC 1997). Sediment remediation, removal of a mass of contaminants, and reduction of risk are important indicators of incremental progress. The ultimate success of sediment management activities will be judged upon restoration of beneficial uses (e.g., elimination of fish consumption advisories, restoration of fish and wildlife populations, restoration of benthos).

Bioassessment frameworks have evolved substantially recently, and in many cases large data sets have the required elements for developing a sediment management strategy. Equally important to the collection of data, however, is that sufficient attention be placed on thorough and comprehensive interpretation of the data. By employing scientifically sound methods of data interpretation, the information from an intensive sediment assessment can finally be integrated to make a decision to intervene (i.e., remediate contaminated sediment) or pursue source control and natural recovery as the preferred remedial option.

SedPAC's primary intent with this document is to share advances in data interpretation tools regarding sediment management decision-making with RAP practitioners. Presently, a great deal of data have been collected on the physical, chemical, and biological elements that modify contaminant bioavailability and ecological effects. The literature contained herein and cited below can help guide RAP practitioners through a transparent use restoration decision-making process.

In addition to this review of data interpretation tools, SedPAC recognizes that the International Joint Commission (IJC) can offer more assistance in the efforts to overcome obstacles to sediment management. Specifically, SedPAC recommends:

- **that the Commission recommends to the Parties and Jurisdictions that they develop and reach agreement on methods or programs to predict and measure successful ecological recovery in Areas of Concern (e.g., ecological benefit forecasting, monitoring and surveillance programs to measure use restoration); and**
- **that the Commission recommends to the Parties and Jurisdictions that they establish procedures for consistent data collection and interpretation across Areas of Concern, recognizing the importance of site specificity in applying methodologies and tools.**

The Commissioners also have an important role to fulfill in overcoming obstacles to sediment management for beneficial use restoration. SedPAC recommends that Commissioners:

- **develop and implement an IJC public outreach strategy to help make contaminated sediment management a priority throughout the basin.**

SedPAC notes that there are currently few, if any, simple or proven methods to predict recovery of use impairments based on sediment cleanup. More research is needed to quantify the relationships between contaminated sediment and known use impairments. The concept of ecological benefit forecasting (i.e., predicting ecological benefits and restoration of beneficial uses) is an important management need, which if accomplished, would be a substantial step forward.

Finally, deciding when to intervene is embedded with multiple elements. Data interpretation tools and techniques are a central element in developing the sediment management strategy. This report is one in a series that will explore a number of aspects affecting sediment management. Other aspects involve what is and is not known about linking sediment cleanup to ecological recovery and restoration of beneficial uses, as well as economic benefits that may accrue from effective management of contaminated sediment.

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II. INTRODUCTION

There is a consensus among diverse sectors in the Great Lakes Basin (e.g., government, industry, non-governmental organizations, RAP groups) that contaminated sediment is an important element leading to many of the impairments to beneficial uses of the Great Lakes. All 42 Great Lakes Areas of Concern have contaminated sediment based on application of chemical guidelines. This universal obstacle to environmental recovery in Areas of Concern can potentially pose a challenge to restoring 11 of the 14 beneficial use impairments identified in the Great Lakes Water Quality Agreement (SedPAC 1997).

These findings were revealed by SedPAC, which was established in 1996 by the WQB of the IJC. SedPACs' mandate is to examine the magnitude of the contaminated sediment problem in Great Lakes Areas of Concern and provide advice on how to overcome obstacles to sediment management. The challenges to progress in sediment remediation include, but are not limited to: the inability to define the extent of the problem, developing a strategy to address the problem, and defining the cleanup standard (SedPAC 1997).

By way of illustration, in many Areas of Concern, technical and community team members are struggling to reach decisions on whether or not environmental or ecological harm resulting from the presence of contaminated sediment is such that intervention is needed. For RAPs, sediment management decisions need to be made bearing in mind the relationship between contaminated sediment and restoration of beneficial uses. This goes far beyond setting a numerical chemical cleanup criteria, as these are not generally based on the need to fully restore beneficial uses.

In this light, guidance is needed on the breadth of information that should be collected and how the information or data are interpreted. No comprehensive and ecologically-based methods are commonly available that illustrate how to evaluate and integrate chemical, eco-toxicological, and ecological results in an objective, pre-defined manner to arrive at a decision surrounding the severity of sediment contamination.

To address this need, one of several initiatives of SedPAC is to explore and exchange methods to interpret sediment assessment data and formulate decisions on whether to take action beyond source control. Apart from source control, the required levels and rates for cleanup to restore uses are far from obvious, and in some cases, appear unknown. While decisions to clean up contaminated sediment depend on a large number of variables (e.g., economics, regulations, technology), sound science must be one important element. However, scientific frameworks for evaluating the ecological significance of contaminants in sediment are either lacking or not widely used or communicated. Local decision-making has been assisted by the proliferation and adoption of numerous bioassessment techniques. Such decision-making, however, is hampered by lack of guidance on defining quantitatively acceptable or unacceptable results or conditions. To add a further layer of difficulty, there are few widely-accepted methods to integrate the large number of environmental measurements that result from a comprehensive sediment assessment.

What is needed is a pragmatic decision-making framework that leads to the selection of ecosystem- and cost-effective options for management of contaminated sediment. As SedPAC (1997) has noted:

> "It is imperative that any active intervention for sediment management beyond source control be aimed at use restoration, based on the weight of evidence of the biological data that demonstrates action other than natural recovery is necessary."

Recently, the Parties and the IJC have been cooperating to develop joint decision-making tools that will allow for consistent, comprehensive, ecologically-based approaches to sediment management. This is consistent with the needs stated in Annex 14 of the Great Lakes Water Quality Agreement.

In December 1998, sediment management experts from throughout the Great Lakes Basin and beyond met in Windsor, Ontario to exchange and examine the tools that are used as a means for arriving at a decision regarding whether or not to take action beyond source control. This report synthesizes the scientific methodologies and management experiences brought together by the participants. The intent is to provide RAP decision-makers with advice on methods for resolving those considerations, in order to finalize site-specific sediment management strategies.

EXCERPTS FROM ANNEX 14

1. Objectives:
... identify the nature and extent of sediment pollution of the Great Lakes System... develop methods to evaluate... the impact of polluted sediments on the Great Lakes System

2. Research and Studies:
(a) General-
... exchange information relating to the mapping, assessment and management of contaminated sediments
(b) Surveillance Programs-
(iii) ... review practices in both countries regarding the classification of contaminated sediments and establish compatible criteria for the classification of sediment quality
(iv) ... develop a standard approach and agreed procedures for the management of contaminated sediments by December 31, 1988

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III. SYNTHESIS AND FINDINGS

A central tenet to rehabilitating sediment quality and renewing ecosystem health is that control of contaminants at their source remains the primary imperative for action. It can only be through the cessation of inputs of contaminants from sources that other sediment management actions such as sediment removal can be economically viable, ecologically successful, and sustainable.

The Imperative: Restoring Beneficial Uses

According to Annex 2 of the Great Lakes Water Quality Agreement, the purpose of RAPs is the restoration of beneficial uses. Contaminated sediment potentially poses a challenge in restoring 11 of the 14 beneficial use impairments identified in the Great Lakes Water Quality Agreement (SedPAC 1997). Therefore, decisions regarding sediment management actions in Areas of Concern should be tempered and driven by the goal of restoring beneficial uses.

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Indicators are measurable features which provide communities, scientists, and resource managers with useful information on the state of the ecosystem, environmental quality or trends, and the status of programs and activities directed at rehabilitating the Great Lakes ecosystem. Indicators measure progress toward community-based and/or government-driven management goals. If the goal of RAPs is restoration of beneficial uses, then indicators of a successful sediment management strategy should include progress toward restoration of beneficial uses.

In general, sediment management can be viewed as either activities or outcomes. Sediment management activity indicators include issuance of permits by governments, control of contaminants at their source, and sediment remediation. Outcome indicators can include environmental responses such as changes in fish and wildlife populations and human health risk (Table 1). Therefore, sediment management can and should be evaluated against a spectrum of indicators ranging from programmatic activities to ecosystem outcomes.

It must be recognized that there are considerable interrelationships among sediment management indicators and use impairments (Table 1). There can also be a temporal factor in restoring certain use impairments. For example, a sediment management activity like dredging and disposal will have an immediate impact on sediment chemistry. However, the effect of this same sediment management activity on liver tumors in fish and consumption advisories may not occur for several to many years later. Such interrelationships and temporal sequencing must be understood and considered in the assessment of sediment quality, data interpretation, and final sediment management decisions.

In general, the highest order and most important indicators in the context of restoring beneficial uses are seen as the ones that represent ecosystem outcomes. The WQB has called for a step-wise and incremental approach to management of contaminated sediment and restoration of beneficial uses (SedPAC 1997). Sediment remediation, removal of a mass of contaminants, and reduction of risk are important indicators of incremental progress. The ultimate success of sediment management activities will be judged upon restoration of beneficial uses (e.g., elimination of fish consumption advisories, restoration of fish and wildlife populations, restoration of benthos).

Table 1. The interrelationships among sediment management outcome indicators and use impairments as defined in the Great Lakes Water Quality Agreement (GLWQA)

INDICATOR OR MEASUREMENT	**USE IMPAIRMENTS MOST CLEARLY ADDRESSED (As defined in Annex 2 of GLWQA)**	**RELATIVE TIME SCALE* FOR RESTORATION OF BENEFICIAL USES**
Improvements in sediment chemistry	• Restrictions on dredging activities, added costs to agriculture and industry, degradation of aesthetics, eutrophication or undesirable algae	• Short-term
	• Degradation of phytoplankton or zooplankton populations	• Short-term to intermediate
	• Degradation of benthos, loss of fish and wildlife habitat	• Intermediate to long-term
Improvements in toxicity in sediment bioassays (invertebrates)	• Eutrophication or undesirable algae	• Short-term
	• Degradation of phytoplankton or zooplankton populations	• Short-term to intermediate
	• Degradation of benthos, loss of fish and wildlife habitat	• Intermediate to long-term
Improvements in benthic invertebrate community structure	• Degradation of benthos, loss of fish and wildlife habitat, degradation of fish and wildlife populations	• Intermediate to long-term
Decline in bioaccumulation and biomagnification	• Loss of fish and wildlife habitat, degradation of benthos, fish tumors or other deformities, bird or animal deformities or reproductive problems, restrictions on fish and wildlife consumption	• Intermediate
	• Degradation of fish and wildlife populations	• Intermediate to long-term
Improvements in	• Eutrophication or undesirable algae, fish	• Short-term to

vertebrate populations and communities	tumors or other deformities, bird or animal deformities or reproductive problems	intermediate
	• Loss of fish and wildlife habitat, degradation of fish and wildlife populations	• Intermediate to long-term
Decline in risk to human health	• Restrictions on fish and wildlife consumption	• Intermediate to long-term

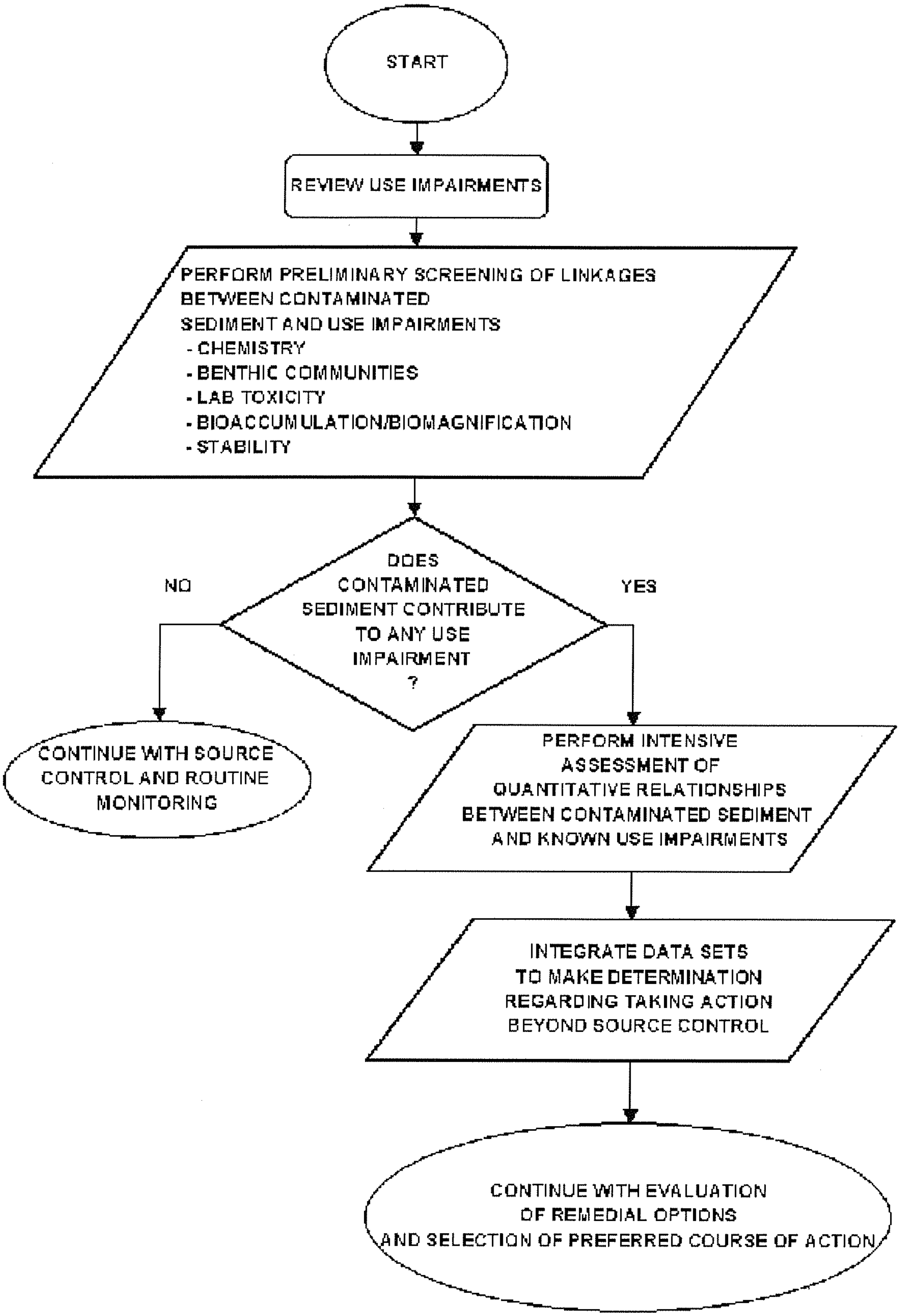
* Relative time scale: Depending on the degree of degradation, even a short-term time scale can span months to years. Subsequent response times would then be relative to achieving the earlier indicators of improved ecological conditions.

It is generally accepted that progress in sediment management should be measured by a broad spectrum of indicators. However, it must be recognized that there are considerable interrelationships and temporal complexities among sediment management indicators and the 11 beneficial use impairments potentially affected by contaminated sediment (Table 1). As a result, it is easy to understand why there is no simple approach to applying data interpretation tools to make sediment management decisions.

Considerable work has been undertaken to identify beneficial use impairments in Areas of Concern. This extensive effort to identify the status and cause of impairments provides a good foundation to guide sediment management decisions. To rehabilitate an Area of Concern, linkages between contaminated sediment and known use impairments must be considered (Figure 1). In many cases, the information needed to make the connections has been collected by assessing chemistry, benthic community structure and composition, laboratory toxicity, contaminant bioaccumulation/ biomagnification, and sediment/site stability.

If contaminated sediment is not causing or contributing to any use impairments, and site stability is clearly known to be high, then regardless of sediment chemistry, no sediment management actions are recommended beyond routine monitoring (and pollution prevention). However, if the data link contaminated sediment to one or more use impairments, and site stability cannot be ensured, then it is recommended that an intensive assessment of the quantitative relationships between contaminated sediment and use impairments be undertaken.

Figure 1. A generalized flowchart which can be used to help make a sediment management decision regarding whether or not to take action beyond source control.



How to Best Interpret the Data

Equally important to the collection of data is that sufficient attention be placed on thorough and comprehensive interpretation of the data. By employing scientifically sound methods of data interpretation, the information from an intensive sediment assessment can finally be integrated to make a decision to intervene (i.e., remediate contaminated sediment) or pursue source control and natural recovery as the preferred remedial option. A variety of data interpretation tools are available to make a decision (Table 2).

> By employing scientifically sound methods of data interpretation, the information from an intensive sediment assessment can finally be integrated to make a decision to intervene or pursue source control and natural recovery as the preferred remedial option.

By way of example, a recently well-received approach could be used consistently across jurisdictions to determine the significance or severity of benthic community structure data or laboratory toxicity results (see Appendix 5). Reference conditions can be defined using an array of reference sites for comparison with test site data using multivariate methods. A reference site database is used to predict the structure of the benthic invertebrate community or the response of bioassay species for a test site. The test site's potential for a certain faunal community or bioassay endpoint can be based on variables that are least affected by anthropogenic impacts (e.g., geographic location, particle size distribution, major elements, etc.). The distribution of the reference sites provides the range of variation in unimpaired communities. The community at the test site can then be compared to this normal variability. The greater the departure from the reference sites, as measured in ordination space, the greater the certainty of environmental effects resulting from contaminants.

The consensus among community-based and agency RAP practitioners is that consistent application of sediment assessment and data interpretation methods across the regions is desirable (i.e., collect and interpret data similarly across Areas of Concern). Site specificity, however, remains important in applying tools due to local conditions, constraints, and nature of the chemical contamination.

To ensure that sediment management decisions consider restoration of beneficial uses in a comprehensive manner, one could also use a checklist in making a sediment management decision beyond source control. These key elements are presented and related to relevant data interpretation tools in Table 3.

Table 2. A matrix of data interpretation tools and references for making a sediment management decision beyond source control to restore beneficial uses as defined in the Great Lakes Water Quality Agreement

Use Impairment	**Assessment Element**	**Data Interpretation Tools**	**Reference**
Restrictions on fish and wildlife consumption	Bioaccumulation	Equilibrium partitioning, comparison to guidelines	Appendices 6, 7, 10, 12, and 14; Beltran and Richardson (1992)
Degradation of fish and wildlife	Community structure, bioaccumulation	Food web model, weight of evidence	Appendices 6, 12, and 14; Beltran and Richardson (1992)

populations			
Fish tumors or other deformities	Bioaccumulation, chemistry	Reference frequencies	Baumann (1992); Baumann *et al.* (1982)
Bird or animal deformities or reproduction problems	Bioaccumulation, community structure	Food web model, comparison to reference conditions, weight of evidence	Appendices 6, 12, and 14; Beltran and Richardson (1992)
Degradation of benthos	Community structure, toxicity (bioassays)	Comparison to reference conditions	Appendices 4, 5, 9, 10, 12, and 14
Restrictions on dredging activities	Chemistry, toxicity (bioassays) , stability*	Comparison to guidelines and/or reference conditions	Appendices 3, 8, and 10; U.S Army Corps of Engineers web site (www.wes.army.mil/el/dots)
Eutrophication or undesirable algae	Chemistry, stability	Modeling	Gore & Storrie, Ltd. (1991); Pennsylvania DEP's "The Lake Model" (1998)
Degradation of aesthetics	Chemistry, stability	Comparison to reference conditions	Heidtke and Tauriainen (1996)
Added costs to agriculture or industry	Chemistry, stability	Comparison to reference conditions	Park and Hushak (1998); Ontario MOE and Michigan DNR (1991)
Degraded phytoplankton and zooplankton populations	Bioaccumulation, chemistry, stability	Comparison to reference conditions, target nutrient loads	Bierman *et al.* (1983)
Loss of fish and wildlife habitat	Chemistry, bioaccumulation, toxicity, benthos, stability	Comparison to reference conditions, weight of evidence	Appendices 6 and 12; Minns *et al.* (1996)

*physical sediment characteristics, quiescent vs. energetic site characteristics, etc.

Table 3. A checklist of key elements to consider in making a sediment management decision beyond source control.

ASSESSMENT ELEMENT	REFERENCE FOR FURTHER INFORMATION
Characterization of the nature and extent of chemical contamination	Appendix 3, 5, and 9; IJC (1987); IJC (1988)
Measurement of toxicity endpoints (lethal and sublethal chronic effects)	Appendix 4, 5, 9, 10, 13, and 14
Assessment of bioaccumulation/biomagnification potential	Appendix 10, 12, and 14
Characterization of benthic communities	Appendix 5, 9, 10, and 12
Evaluation of the nature and extent of fish tumors and abnormalities	Appendix 12
Assessment of human health risk from sediment contamination	Appendix 7 and 14

Assessment of wildlife risk from sediment contamination	Appendix 6, 12, and 14
Assessment of fish and other aquatic life risk from sediment contamination	Appendix 14
Evaluation of the physical stability of contaminated sediment deposits (i.e., Would a storm scour the sediment from the river resulting in a pulsed loading of contaminants to the lake?)	Beltran and Richardson (1992); U.S. EPA (1993); Lick (1992); and Cardenas and Lick (1996)
Determination of control of contaminants at source (i.e., have upstream sources of contamination also been controlled/ terminated?)	IJC (1987)

The data interpretation tools presented in Table 2 and the checklist in Table 3 have been developed to help make a decision regarding whether the scientific evidence warrants consideration of taking action beyond source control. It is beyond the intent of this report to address how decisions are tempered by factors other than the science-based tools discussed above. Once a decision has been made to intervene, however, those as well as the following additional elements require attention:

- engineering factors (e.g., technical feasibility, contaminant reduction, permanence of remedial options like capping, *in situ* treatment, dredging and disposal, etc.);
- economic factors (e.g., cost effectiveness, economic benefits);
- social factors (e.g., public acceptance, partners' opinions, adherence to public use goals, conflicting actions); and
- long-term monitoring considerations.

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IV. CONCLUDING REMARKS AND RECOMMENDATIONS

Despite the guidance provided herein, there are currently few, if any, simple or proven methods to predict recovery of use impairments based on sediment cleanup. More research is needed to quantify the relationships between contaminated sediment and known use impairments. The concept of ecological benefit forecasting (i.e., predicting ecological benefits and restoration of beneficial uses) is an important management need which if accomplished, would be a substantial step forward.

> More research is needed to quantify the relationships between contaminated sediment and known use impairments. The ability to predict ecological benefits is an important management need.

The Great Lakes WQB (1998a), in its "Review of Government Resources and Changing Program Thrusts as They Relate to Delivery of Programs Under the Great Lakes Water Quality Agreement" report, has recognized the importance of evaluating program effectiveness based on measuring ecosystem results. Further, the Great Lakes WQB (1998b) has recommended in its 1997 public meeting report "If You Don't Measure It, You Won't Manage It", that the IJC, Parties, Jurisdictions, and RAP/LaMP groups must place greater emphasis on reporting both process milestones (e.g., securing funding for implementation, volumes of contaminated sediment removed or mass of contaminants removed) and ecosystem milestones (ecosystem results as defined in the Great Lakes Water Quality Agreement) to help build a record of success. It is hoped that the data interpretation tools compiled in this report will help individuals and RAP teams make sediment management decisions regarding whether or not to take action beyond source control, and will also help ensure achievement of the long-term goals of restoring beneficial uses in Areas of Concern.

SedPAC's primary intent with this document is to share advances in data interpretation tools regarding sediment management decision-making with RAP practitioners. Presently, a great deal of data have been collected on the physical, chemical, and biological elements that modify contaminant bioavailability and ecological effects. The literature contained and cited herein can help guide RAP practitioners through a transparent use restoration decision-making process.

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In addition, the Commissioners have an important role to fulfill in overcoming obstacles to sediment management for beneficial use restoration. SedPAC recommends that Commissioners:

3. **meet with industrial representatives in selected Areas of Concern to champion and catalyze sediment remediation;**
4. **meet with stakeholders in the sediment session being convened at the Commission's Biennial Forum in Milwaukee to learn about current local obstacles and identify how the Commissioners can help overcome these obstacles and catalyze local initiatives; and**
5. **develop and implement an IJC public outreach strategy to help make contaminated sediment management a priority throughout the basin.**

Further, SedPAC recommends:

6. **that the Commission direct its WQB to define the conditions under which natural recovery is selected as the preferred remedial option in sediment management during the 1999-2001 priorities cycle.**

Deciding when to intervene is embedded with multiple elements. Data interpretation tools and techniques are a central element in developing the sediment management strategy. This report is one in a series that will explore a number of aspects affecting sediment management, including linking sediment cleanup to ecological recovery and restoration of beneficial uses, as well as economic benefits that may accrue from effective management of contaminated sediment.

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DECIDING WHEN TO INTERVENE

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Sediment Priority Action Committee
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VI. APPENDICES

APPENDIX 1

WORKSHOP FORMAT AND AGENDA

Workshop format

Agency, academic, and industrial leaders in the field of sediment management met at the University of Windsor's Great Lakes Institute for Environmental Research for a two day workshop on December 1-2, 1998 to discuss and provide advice on the use of data interpretation tools used to make sediment management decisions regarding whether or not to take action beyond source control. Forty-four people participated (Appendix 2).

On the first day of the workshop, speakers presented eleven different case studies on data interpretation tools for making a decision beyond source control (Appendices 3-13). Case study presentations included the following:

- Sediment Assessment and Remediation: Ontario's Approach (Rein Jaagumagi - see Appendix 3);
- Thunder Bay Creosote Cleanup: A Case Study in the Application of Ontario's Approach to Sediment Assessment and Remediation (Rein Jaagumagi - see Appendix 4);
- Decision Making for Sediment: Numeric Biological Guidelines (Trefor Reynoldson - see Appendix 5);
- Ecological Risk Assessment Applied in the Saginaw River/Saginaw Bay (Lisa Williams - see Appendix 6);
- The Application of Human Health Risk Assessment Techniques at Sediment Contaminated Sites Under the Superfund Program (Marian Olsen - see Appendix 7);
- U.S. Army Corps of Engineers Dredged Material Evaluation and Assessment Procedures (Bob Engler - see Appendix 8);
- 1994/1995 St. Clair River Sediment Program Defining Spatial Extent and Environmental Conditions (Tim Moran and Scott Munro - see Appendix 9);

- Trenton Channel/Detroit River Sediment Assessment and Remediation (Russell Kreis - see Appendix 10);
- A Framework for Interpreting Narrative Sediment Quality Standards (Jim Keating - see Appendix 11);
- Ecological Risk Assessment for the Contaminated Harbor Sediment Adjacent to the Ashland, Wisconsin Lakefront Property - Kreher Park (Bob Paulson - see Appendix 12); and
- The SED-TOX Index for the Assessment and Ranking of Sediment Hazard Potential: How is it Useful in Decision-Making? (Manon Bombardier - see Appendix 13).

In addition, three other case studies of data interpretation tools and approaches were submitted in writing, but not given in oral presentation because of time constraints. These included:

- Contaminated Sediment: When is Cleanup Required? The Washington State Approach (Teresa Michelsen - see Appednix 14);
- Application of Computer Modeling and Biomonitoring in Decision Making for the St. Clair River Area of Concern (John Alexander McCorquodale, Maciej Tomczak, and Gordon Douglas Haffner - see Appendix 15);
- Testing and Evaluation Procedures for Great Lakes Dredged Material Evaluations Developed by the U.S. Environmental Protection Agency and the U.S. Corps of Engineers (Jan Miller - see Appendix 8).

On the second day of the workshop, attendees were divided into two breakout groups to focus on specific topics and questions regarding decision-making frameworks, key data elements to be examined in these frameworks, and various technical tools. Each group then presented a summary of its findings and advice (Appendices 16-17). A facilitated discussion to synthesize the output of both groups followed, including a discussion of how best to transfer this technology to RAP participants.

Workshop agenda

WORKSHOP TO EVALUATE DATA INTERPRETATION TOOLS USED TO MAKE SEDIMENT MANAGEMENT DECISIONS

Great Lakes Institute for Environmental Research, Room 250
2990 Riverside Drive W., Windsor, Ontario
December 1-2, 1998

CO-SPONSORED BY: U.S. EPA, Environment Canada, IJC's Great Lakes Water Quality Board, and University of Windsor's Great Lakes Institute for Environmental Research

GOAL: To exchange and examine the tools that are used as a means for arriving at a decision regarding whether or not to take action beyond source control. Participants leave with a new set of tools they can apply locally.

WHO WAS INVITED: This was an expert level workshop for agency, academic, and industrial leaders in the field. Consideration will be given at the workshop on how best to transfer the information to RAP practitioners.

Tuesday December 1, 1998.

8:30 **Welcome, Workshop Objective**
Art Szabo - Director of the Great Lakes Institute for Environmental Research, Kelly Burch -

Water Quality Board

8:40 **Opening Comments**
Dave Cowgill, Griff Sherbin - Sediment Priority Action Committee Co-Chairs

8:50 **Background, Problem Description**
Gail Krantzberg - Ministry of Environment

Presentations of data evaluation tools which are used in decision-making, and case studies to highlight their use:

9:00 **Canada/Ontario Approach Applied in Thunder Bay, Elmira, Cornwall, and Severn Sound**
Rein Jaagumagi - Ministry of Environment, Trefor Reynoldson - Environment Canada

9:50 **Ecological Risk Assessment Applied in the Saginaw River/Saginaw Bay**
Lisa Williams - U.S. Fish and Wildlife Service

10:25 **Break**

10:40 **Human Health Risk Assessment Applied at Superfund Sites**
Marian Olsen - U.S. EPA

11:15 **A Reference-Based Tiered Approach Used by the U.S. Army Corps of Engineers**
Bob Engler - U.S. Army Corps of Engineers

11:50 **Lunch**

12:50 **Lambton Industrial Society/Pollutech Enviroquatics Ltd. Approach Applied in the St. Clair River**
Scott Munro - Lambton Industrial Society, Tim Moran - Pollutech Enviroquatics Ltd.

1:25 **U.S. EPA Approach Applied in the Trenton Channel of the Detroit River**
Russ Kreis - U.S. EPA

2:00 **A Framework for Interpreting Narrative Sediment Quality Standards**
Jim Keating - U.S. EPA

2:35 **Break**

2:50 **Weight of Evidence Approach Applied at the Ashland Coal Gasification Site**
Bob Paulson - Wisconsin DNR

3:25 **Development of a Toxicity Testing Index Approach**
Manon Bombardier - Environment Canada

4:00-5:00 **Summary, Questions, and Comments**
Dave Cowgill, Griff Sherbin - Sediment Priority Action Committee Co-Chairs, John Hartig - Water Quality Board

Wednesday December 2, 1998.

8:30-12:00 **Breakout session**

Breakout Facilitators: Marcia Damato - U.S. EPA, Gail Krantzberg - Ministry of Environment
Breakout Groups will gather in the Plenary Room and in Room 228.

Breakout Groups will discuss the following:

Decision-Making Framework Elements:

- Protocols and testing guidance
- Interpretation guidance for individual data types
- Rules for combining data types to arrive at an overall decision

- Modeling guidance including human health/ecological risk models for bioaccumulation, sediment resuspension/transport, and natural recovery

Alternative Frameworks:

- Tiered
- Weight of Evidence

Technical Tools:

- Sediment chemistry, bioassays, benthic community data, lab bioaccumulation, and tissue residue

12:00 **Lunch**

1:00 **Presentations from Breakout Groups**

2:00 **Synthesis and Recommendations**
Facilitated

3:30 **Discussion of Technology Transfer to RAP Participants**
Facilitated

4:00 **Closing Remarks**
Kelly Burch - Water Quality Board, Gail Krantzberg - Ministry of Environment

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APPENDIX 2

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APPENDIX 3

SEDIMENT ASSESSMENT AND REMEDIATION: ONTARIO'S APPROACH

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Introduction

The Ontario Ministry of the Environment has developed a protocol for determining when sediment is contaminated to a level that requires remedial action. The protocol is based upon sediment guidelines, combined with a risk assessment approach.

The first step is comparison of sediment contaminant concentrations with sediment quality criteria. The Provincial Sediment Quality Guidelines (PSQGs) are a set of numerical guidelines, using a tiered approach, that were developed for the protection of sediment-dwelling (benthic) organisms. The Guidelines also protect against biomagnification of contaminants through the food chain from sediment contaminant sources.

Provincial Sediment Quality Guidelines (PSQGs)

The PSQGs define three levels of eco-toxic effects and are based on the chronic, long-term effects of contaminants on benthic organisms. The essence of the guidelines and their significance are summarized below. Details are provided in Persaud *et al.* (1993).

The No Effect Level. This is intended as the level at which contaminants in sediment do not present a threat to water quality and uses, benthic biota, wildlife, or human health. The No Effect Level (NEL) is principally designed to protect against biomagnification through the food chain. Partitioning approaches in conjunction with Provincial Water Quality Objectives (PWQOs) are used to set these guidelines, since with appropriate safety factors PWQOs/Gs are designed to protect against biomagnification.

A PSQG NEL is derived through the equation: $PSQG = K_{OC} \times PWQO/G$

where:

PSQG = sediment quality guideline normalized to the sediment organic carbon content (TOC) of 1%
K_{oc} = organic carbon partitioning coefficient
PWQO/G = Provincial Water Quality Objective/Guideline

The Lowest Effect Level. The Lowest Effect Level (LEL) is the level that can be tolerated by the majority of benthic organisms. It is derived using field-based data on the co-occurrence of sediment concentrations and benthic species. The procedure used is based on the Screening Level Concentration (SLC) method described in Neff *et al.* (1986).

The calculation of the SLC is a two step process and is calculated separately for each parameter. In the first step, the individual SLCs (Species SLCs) are calculated for each benthic species. The sediment concentrations at all locations at which that species was present are plotted in order of increasing concentration. From this plot, the 90th percentile of this concentration distribution is determined. The 90th percentile was chosen to provide a conservative estimate of the tolerance range for that species. This would serve to eliminate extremes in concentrations that may be due to specific and unusual sediment characteristics.

In the second step, the 90th percentiles for all of the species present are plotted, also in order of increasing concentration. From this plot, the 5th percentile is calculated and this level becomes the LEL guideline.

The Severe Effect Level. This level represents contaminant concentrations in sediment that could potentially eliminate most of the benthic organisms. The procedure used is identical to the calculation of the LEL except that the 95th percentile of the SLC (the level below which 95% of all SSLCs fall) is calculated in the second step of the SLC calculation, and this level becomes the Severe Effect Level (SEL) guideline.

Table 1: Provincial Sediment Quality Guidelines for metals and nutrients (values in mg/kg dry weight unless otherwise noted)

Parameter	No Effect Level	Lowest Effect Level	Severe Effect Level

Arsenic	-	6	33
Cadmium	-	0.6	10
Chromium	-	26	110
Copper	-	16	110
Iron (%)	-	2	4
Lead	-	31	250
Manganese	-	460	1100
Mercury	-	0.2	2
Nickel	-	16	75
Zinc	-	120	820
TOC (%)	-	1	10
TKN	-	550	4800
TP	-	600	2000

Metal concentrations determined using Aqua-Regia digestion
"-" = denotes insufficient data/no suitable method
TOC = Total Organic Carbon TKN = Total Kjeldahl Nitrogen TP = Total Phosphorus

Table 2: Provincial Sediment Quality Guidelines for Organic Compounds (values in mg/kg dry weight unless otherwise noted)

Compound	No Effect Level	Lowest Effect Level	Severe Effect Level*
Aldrin	-	0.002	8
BHC	-	0.003	12
alpha-BHC	-	0.006	10
beta-BHC	-	0.005	21
gamma-BHC	0.0002	(0.003)	(1)
Chlordane	0.005	0.007	6
DDT(total)	-	0.007	12
op+pp-DDT	-	0.008	71
pp-DDD	-	0.008	6
pp-DDE	-	0.005	19
Dieldrin	0.0006	0.002	91
Endrin	0.0005	0.003	130
HCB	0.01	0.02	24
Heptachlor epoxide	-	0.005	5
Mirex	-	0.007	130
PCB(total)	0.01	0.07	530
Anthracene	-	0.220	370
Benz[a]anthracene	-	0.320	1,480
Benzo[k]fluoranthene	-	0.240	1,340

Benzo[a]pyrene	-	0.370	1,440
Benzo[g,h,i]perylene	-	0.170	320
Chrysene	-	0.340	460
Dibenzo[a,h]anthracene	-	0.060	130
Fluoranthene	-	0.750	1,020
Fluorene	-	0.190	160
Indeno[1,2,3-cd]pyrene	-	0.200	320
Phenanthrene	-	0.560	950
Pyrene	-	0.490	850
PAH (total)**	-	4	10,000

- = Insufficient data to calculate guideline
* = Numbers in this column are expressed as mg/kg organic carbon and are converted to bulk sediment values by multiplying by the actual TOC concentration of the sediment (to a maximum of 10%). For a sediment sample with a PCB value of 30 mg/kg and a TOC of 5%, the PCB SEL is converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 mg/kg and gives the SEL guideline for that sediment. The measured value of 30 mg/kg is then compared with the bulk sediment value, and is found to exceed the guideline.
** = PAH (total) is the sum of 16 PAH compounds: Acenaphthene, Acenaphthylene, Anthracene, Benzo [k]fluoranthene, Benzo[b]fluorene, Benzo[a]anthracene, Benzo[a]pyrene, Benzo[g,h,i]perylene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno[1,2,3-cd]pyrene, Naphthalene, Phenanthrene and Pyrene.

Application of the PSQGs

The PSQGs shown in Tables 1 and 2 are used in making decisions in relation to a number of sediment-related issues ranging from dredged material disposal to determination of remedial action for contaminated sediment.

In an area as geologically diverse as Ontario, local natural sediment levels of the metals may vary considerably and in certain areas, such as wetlands, the organic matter content and nutrient levels may be naturally high.

Metals. In areas where local background levels are above the LEL, the local background level will form the practical lower limit for management decisions. In some waterbodies, surficial sediment upstream of all discharges may be acceptable for calculation of background values. Where it cannot be shown that such areas are unaffected by local discharges, the pre-colonial sediment horizon is used. Site-specific background for metals is calculated as the mean of 5 replicate samples from surficial sediment that has not been directly affected by man's activities or from the pre-colonial sediment horizon. Alternatively, the mean background values for the Great Lakes Basin as calculated in the guidelines may be used.

Nutrients. Areas of high natural organic matter content, such as marshes and other types of wetlands, can be readily distinguished from those resulting from anthropogenic sources. In such cases, for the nutrients listed in Table 1, the local background would serve as the practical lower limit for management action.

It is also recognized that long-range sources such as atmospheric deposition have contributed to accumulation of organic compounds in areas remote from any specific source. Therefore, in those areas where specific sources cannot be determined, the practical lower limit for management action is the Upper Great Lakes deep basin surficial sediment concentration.

If the sediment concentration exceeds the local background value, the next step is to determine whether the sediment poses a threat to aquatic life. The severity of this effect is determined using a number of biological assessment techniques.

If the concentration of the contaminant in the sediment exceeds the SEL, then the MOE Sediment Bioassay tests for acute toxicity, described in Bedard *et al.* (1992), are required.

Assessment of contaminated sediment

Initial sediment assessment. The most important preliminary piece of information necessary for sediment evaluation is chemical data, which are compared against the PSQGs as well as background levels. The importance of sediment assessment is that it provides a good indication as to whether any further effort is required in studying sediment contamination in a given area. From a sediment management standpoint, the LEL is the point at which low-level concerns arise in relation to future worsening of the situation if existing sources are not controlled. This level would rarely warrant concerns from a remediation standpoint unless dealing with a spill in areas where the background sediment is below the LEL.

The SEL is the level that raises major concern from an environmental management standpoint. The urgency of a management response can be established by obtaining additional information through laboratory sediment bioassays on the toxicity of the sediment.

Based on comparison with the PSQGs and background levels, there are three possible outcomes from a sediment evaluation:

- The sediment is clean (i.e., all parameters tested are below the LEL) and no further action is required unless the situation changes as a result of new discharges or material spills.
- The concentrations of contaminants in sediment are above the LEL and further testing is warranted. This will necessitate gathering additional information of a quality and quantity that would facilitate a thorough review of the site and may include both chemical and biological tests.
- The sediment has been shown to have contaminant levels at or above the SEL and biological assessment is required. The detailed studies must include laboratory biological testing for potential toxic effects as described in the PSQG document. Determination of biological cleanup targets may also be necessary.

Degree of chemical contamination. After the initial assessment, the extent and degree of sediment contamination is assessed through mapping, which will permit delineation of "hot spots" and areas of lesser degrees of contamination. It is especially important to determine the outer boundaries of the affected area, as well as the depth of sediment contamination, since this will define the area of any future remediation and permit calculation of volumes of material to be dealt with.

A second but equally important aspect of sediment characterization is determination of the physical characteristics of the area. In many cases, areas of contaminated sediment may act as sources of contaminated material to adjacent or downstream areas through resuspension of material. The potential for resuspension of contaminated material through erosion (i.e., through fluctuations in discharge, currents, wave patterns, and physical obstructions such as lakefill structures, dams, and weirs) needs to be carefully assessed. Characteristics such as seasonal and yearly net sediment erosion or deposition, which may affect subsurface contamination, should be determined since this will have a major impact on the determination of a remediation plan.

The biological significance of the chemicals. An assessment of the severity of biological effects of contaminants in sediment is normally required as part of the protocol for sediment that exceeds the LEL or the SEL. Biological assessment is also necessary, since the decision to remediate is usually based on biological effects.

The nature of the effects can be broken down into two main categories: effects on individuals and effects on communities. This is achieved through a number of components such as:

- Benthic community structure and functional analysis
- Fish community studies
- Sediment bioassays (including testing with water column organisms)
- Uptake studies (e.g., caged fish and caged mussel studies)
- Tissue resides in *in-situ* organisms (e.g., sport fish, young-of-the-year fish, *in situ* benthic organisms)

A number of evaluation techniques are available to carry out a comprehensive biological assessment. These include:

- Benthic and fish community structure - functional group analysis. These studies consider the effects of contaminants at the population or community level. While generally unable to pinpoint a cause-effect relationship, they can provide a useful measure of overall ecosystem health.
- Sediment bioassays. These use benthic organisms such as chironomids, mayflies, oligochaetes, and fathead minnows to assess chronic and acute toxicity of sediment. These studies can be designed to examine mortality, reproductive impairment, mutagenicity, and a range of sub-lethal effects on individuals. They are most effective, however, in determining the potential toxicity of contaminated sediment (usually as a measured effect over a certain exposure period). The specific causative agent is difficult to isolate, especially when dealing with mixtures of contaminants. The sediment used in these tests is usually disturbed, which in most cases heightens the biological availability of the contaminants in the sediment and also through release to the water column. As a result, this test can be considered as representing the worst case scenario.
- Uptake studies. These use caged mussels, leeches, and/or caged fish placed on, or suspended just above, the sediment to determine the levels of contaminants in the water column at the study site. Similarly, this approach can be applied in the laboratory through the exposure of cultured juvenile fathead minnows to test and control sediment. Both field and laboratory studies can provide a good indication of the release of contaminants to the water column from sediment. This information, therefore, is an indirect measure of the impacts of contaminants in sediment on water use impairments.
- Contaminant residues in *in situ* organisms. Analysis of benthic organisms and fish tissue for contaminant residues can be used to determine availability of contaminants from sediment. In most cases, sediment ingesting organisms are chosen, whether benthic organisms or bottom-feeding fish, since these are most likely to accumulate contaminants directly from the sediment. This provides a measure of the availability of contaminants to biota, and the potential for transfer of contaminants through the food chain. Coupled with the mussel studies, it can provide an indication of the relative importance of the water and sediment pathways for bioaccumulation. Analysis of sport fish and comparison with consumption guidelines provides a measure of direct danger to humans through consumption of contaminated fish. Levels are designed to protect human consumers, but also provide an indication of the availability of contaminants from sediment and other sources such as prey.

A number of different biological tests are necessary at any one site in order to provide a good indication as to whether the study area presents a danger to organisms, including humans, since no single indicator can provide all the necessary information for management decision-making. This type of information will also assist in determining where to concentrate any remedial actions.

The source or origin of contaminants. Concurrent with environmental data gathering, efforts should be made to obtain information on contaminant input to the area. The usual sources of contaminants can be grouped into municipal (which will likely contain the widest range of chemicals), industrial, urban runoff, agricultural, mining, and atmospheric fallout. Knowledge of the sources will provide a good framework of the type of chemical analysis required and will also aid decision-making on remediation. In some instances it may be necessary to test material emanating from such sources to determine their current toxic impact.

Establishing the need for remediation. Once the information has been gathered and the data evaluated, the need for remediation should be assessed. This is based on evaluating the considerations listed below:

Sources:

- Presence of active contaminant sources to the area
- Types of contaminant sources - point sources or non-point (diffuse) sources

Contaminant concentrations:

- Sediment contaminants exceed LEL for 1 or more contaminants
- Sediment contaminants exceed SEL for 1 or more contaminants

Contaminant characteristics:

- Types of contaminants - i.e., nutrients, metals, persistent organics
- Presence of contaminants as a mix of metals and organics

Biological effects:

- Characteristics of benthic community - benthic organisms are abundant and evenly distributed, or the benthic invertebrate community is species poor and consists mainly of pollution tolerant organisms
- *In situ* and laboratory biological tests and sport fish data show uptake of contaminants
- Sediment results in chronic effects on aquatic organisms, or is acutely toxic

Physical factors:

- Sediment type - i.e., presence of fine-grained material (sand/clay/mud)
- Physical characteristics of area - i.e., depositional or erosional
- Presence of factors that may alter the physical nature (e.g., lakefills, flow changes, etc.) of the site

In instances where some or all of the biological effects studies yield negative results, then the reasons for such findings must be fully explored. In cases where significant adverse effects have been noted in sediment bioassays, effort should be directed towards determining whether this is in fact due to chemical factors, rather than physical factors, such as unsuitable sediment type. For example, a combination of contaminated sediment and unsuitable sediment type could result in stresses on the test organisms which, individually, would not have elicited such a severe response.

The types of adverse effects are evaluated on a case-by-case basis. The only clear-cut case is where sediment is acutely toxic. Where chronic effects and/or bioaccumulation are the primary biological effects, the need for remediation must include other considerations. These are often based upon identified use impairments and use restorations.

Setting a goal

The setting of cleanup goals can be guided by use impairments to be restored. The International Joint Commission (1985) in its "listing/delisting" criteria for Great Lakes Areas of Concern has identified several use impairments. These include:

- Restrictions on fish and wildlife consumption
- Tainting of fish and wildlife flavor
- Degraded fish and wildlife populations
- Fish tumors or other deformities
- Bird or animal deformities or reproductive problems
- Degradation of benthos
- Restrictions on dredging activities
- Restrictions on drinking water consumption or taste and odor problems
- Added costs to agriculture or industry

Sediment alone may not contribute directly to this extensive list of use impairments, but through the slow release of contaminants in some areas, may be a source of chemicals to the water column. To progress from a contaminated sediment problem to the restoration of designated uses in an area will require a strategy that involves a phased approach, likely over several years, to achieve significant improvements. It is imperative that any cleanup aimed at use restoration be based on a realistic schedule that allows sufficient time for source controls to take effect and the practical constraints of removing or covering over contaminated sediment.

Factors to consider in setting cleanup goals include:

- The size of the area affected needs to be clearly defined since it will have a significant bearing on the remedial option chosen from both a cost and technology perspective.
- The uses the area is put to and the potential for this area to affect adjoining areas through the spread of contaminated sediment must be considered. Uses may include protection of fisheries and benthic organisms. There is a need to consider both the toxic and bioaccumulative potential of contaminants. In previous sections, the need to look at a range of tests was indicated. This becomes critical at this stage since the severity of the effect will play a major role in arriving at the final decision.
- From a human health perspective, compounds that are persistent and pose a threat to water supplies or fish and wildlife will be weighted differently from compounds that do not pose similar threats. In some cases recreational/aesthetic considerations may be the driving force in a cleanup study.
- The potential for recontamination must be examined from the point of view of existing and proposed land use and source controls. Existing and new industries must incorporate features that will not lead to sediment contamination.
- There is a need to consider whether sediment removal will create additional problems, such as the exposure of historical contamination in deeper layers of the sediment. Care must be taken to

ensure that the full depth of the problem has been adequately defined.

- The physical environment of the area needs to be considered. The potential for resuspension of contaminated sediment, with resultant contamination of adjacent or downstream areas, will be an important factor in developing a remediation plan.

With the exception of spills, which must be cleaned up immediately, the most urgent need in environmental management is to protect the ecosystem from further abuse. Thus, source control must be the foundation of remedial action.

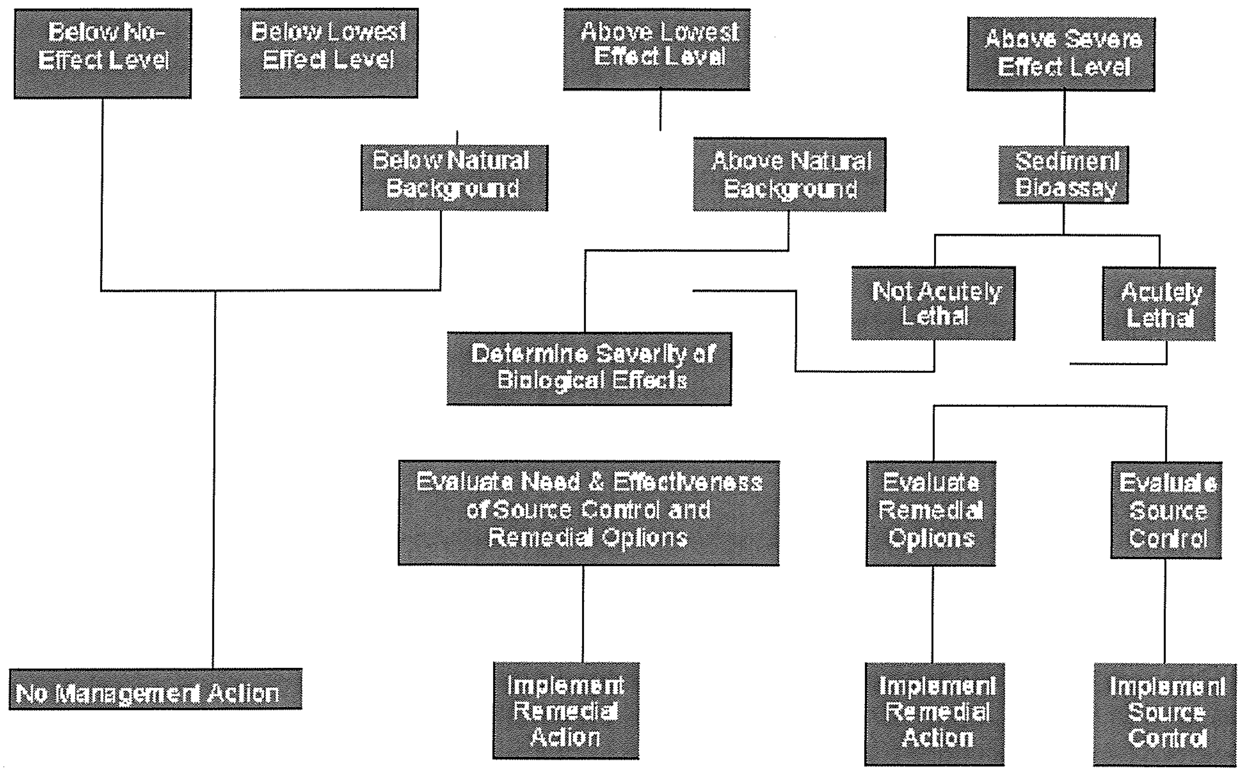
Conclusion

Consideration of remedial action in an area of contaminated sediment requires the development of a cleanup goal. This goal should be based on the "desired state of the environment" or developed in support of certain "attainable" uses. Where feasible, chemical guidelines provide a very convenient tool for setting cleanup goals, though these must be used with care, since most chemical guidelines have been developed for broad use and may require some adjustment when applied to specific sites. The final goal could also include intermediate goals, since the achievement of the goal can be phased over time or over a sequence of activities.

The ideal cleanup goal for restoration of contaminated sediment will always be the level that provides for the protection of all sediment uses. To this end, the cleanup target should be derived with heavy reliance on biological tests, rather than guideline levels. In many cases, the practical limits to cleanup will be dictated by the local background or ambient values, since cleanup to levels lower than these will be impractical and counterproductive. However, even cleaning up to this level will not always be feasible, especially when the area under consideration is large or where there are ongoing sources of contamination. Such areas may require a multi-phased approach, spread out over time, to achieve source control before any remediation work is undertaken.

In addition to these technical considerations, the final decision as to the proper course of action must also be based on considerations of social and economic criteria.

Application of Provincial Sediment Quality Guidelines to Sediment Assessment



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DECIDING WHEN TO INTERVENE

Data Interpretation Tools for Making Sediment Management Decisions Beyond Source Control

Based on a Workshop to Evaluate Data Interpretation Tools used to Make Sediment Management Decisions held at the Great Lakes Institute for Environmental Research at the University of Windsor on December 1-2, 1998

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Sediment Priority Action Committee
Great Lakes Water Quality Board

1999

APPENDIX 4

THUNDER BAY CREOSOTE CLEANUP: A CASE STUDY IN THE APPLICATION OF ONTARIO'S APPROACH TO SEDIMENT ASSESSMENT AND REMEDIATION

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Introduction

The Northern Wood Preservers Inc. site in Thunder Bay Harbour has, under various owners, produced creosoted wood products such as railway ties and telephone poles, as well as treated lumber using pentachlorophenol, for over 50 years. Earlier studies have indicated that creosote residues have accumulated in sediment adjacent to the site, often to levels in excess of the Severe Effect Levels (SEL) of the Provincial Sediment Quality Guidelines (PSQGs) (Beak Consultants, Ltd. 1988; Hayton 1989). In addition, dioxins and furans (primarily heptachloro- and octachloro- dioxins and furans) have been identified in sediment adjacent to the site (Beak Consultants, Ltd. 1988). The plant is on a dock 200 m wide that extends approximately 300 m into the harbour. Seepage from the site is believed to be the source of the contaminants.

The Ontario Ministry of the Environment and Environment Canada undertook a joint investigation in 1995 to determine the extent and degree of sediment contamination using biological tests. This information would be used to determine which area needed to be remediated in accordance with the protocol developed by the Ministry (Jaagumagi and Persaud 1996). The protocol required biological effects testing using multiple endpoints when contaminant levels exceed PSQGs (Persaud *et al.* 1993).

Methods

In order to determine the extent of contamination for cleanup evaluation, dense sampling of the area based on a grid system was undertaken. Preliminary investigation showed that most of the creosote residues were within 100 m of the site. In order to better delineate the gradation within the 100 m zone and develop a detailed sediment contaminant map of the area, sediment samples were collected at 25 m intervals along a total of 14 transect lines radiating out from the dock. Beyond the 100 m zone, samples were collected 50 m apart to a maximum distance of 500 m. A total of 93 stations were sampled for sediment PAH and TOC.

Surficial sediment samples (top 5 cm) were collected with a standard 9" x 9" (23 x 23 cm) stainless steel Ponar grab sampler. Three replicate samples were taken at each location and the top 5 cm from each replicate were combined and mixed to form a single sample. The samples were homogenized from which sub-samples of sediment were collected into appropriate sample containers for analysis. Samples for PAH (scan of 16 individual compounds) and TOC analysis were collected at 71 sites, while additional analysis for metals, PCBs, organochlorine pesticides, chlorophenols, and chlorobenzenes were undertaken at 30 of the sites, as well as at the two control sites. Sampling for dioxins and furans was only undertaken at selected sites along two transect lines and the control site. Standard Ministry analytical procedures were followed for all chemical analysis. These are described in detail in OMEE (1983).

Biological sampling involved a field and laboratory component: benthic community structure and sediment bioassays. Benthic samples were collected with a Ponar sampler along 4 transect lines as well as the two control sites. Samples were washed in the field to remove the fine debris using a U.S. # 30 mesh sieve. Three replicates were collected at each sampling station and the individual replicates were preserved separately in 10% formalin solution. Samples were subsequently sorted in the laboratory using a dissecting microscope, to separate the organisms from the debris. All three replicates were sorted individually, and from these results a mean value for each major taxonomic group was obtained. Subsequently, of the three replicates, the sample closest to the mean was selected for detailed identification of the organisms present. This involved identification to the generic level, with species identification where possible.

Sediment (top 15-20 cm) for laboratory sediment bioassays was collected with a Ponar sampler along the longest transect line (T-5.5; 13 test stations), transect T-EF (3 test stations), and one control station. Approximately 10 L of composited sediment were collected at each site, placed in polyethylene lined containers, and shipped in refrigerated transport to the Ministry laboratory. Details of the standard test procedure are provided in Bedard *et al.* (1992).

Results

Visual observations noted that the presence of creosote in sediment decreases with distance from the dock along all transect lines. In the area close to the dock (up to 100 m), creosote was often encountered on the sediment surface, especially along the north facing transects. Along one transect, significant quantities of creosote were encountered within 50 m of the dock. In some of these locations (within 25 m), liquid creosote formed over 50% of the sediment sample. Sediment creosote content decreased with distance from the dock. Beyond 100 m, creosote was encountered only as small blobs or drops in the subsurface layers of the sediment. Sediment type along all transect lines was similar, and consisted of a thin layer of fine silt overlying a silt/clay mix.

Chemical analysis. The distribution of PAH compounds in sediment showed that along the north and east sides of the site, sediment is characterized by high concentrations of PAH (up to 16,327 mg/kg), but these decrease rapidly with distance from the dock. Sediment concentrations were typically lower along the southern section of the east side and very low along the south side.

Along the north side, all transects yielded sediment concentrations of total PAH above 300 mg/kg within 25 m of the dock. However, by 50 m levels at most sites were below 200 mg/kg, and by 100 m concentrations were generally below 100 mg/kg total PAH. The exception was one transect where levels were above 300 mg/kg at 75 m from the dock. By 175 m, most sediment concentrations were below 20 mg/kg total PAH, and continued to decline to near background levels with increasing distance.

Transects to the east generally showed lower concentrations in sediment, with the exception of T-EF. This sediment contained substantial amounts of creosote, which is reflected in the higher sediment total PAH concentrations at these sites (up to 1,697 mg/kg). However, by 75 m, concentrations were below 80 mg/kg, and by 100 m were near 30 mg/kg.

Dioxin and furan analysis was undertaken on a limited number of transects. The predominant dioxin compounds in sediment were the hepta- and octa- chlorodibenzo-p-dioxins and the hepta- and octa-chlorodibenzofurans. The lower chlorinated forms were present at very low concentrations or were not detected. Typically, dioxin concentrations in sediment were higher than furan concentrations, with the octa- dioxin the predominant compound.

The distribution pattern of dioxins and furans around the site was similar to the PAH patterns. Concentrations were highest within 25 m of the dock (up to 360,000 pg/g OCDD) and decreased rapidly with distance from the dock. At 100 m, concentrations were less than 60,000 pg/g OCDD along the north and east transects.

Total TEQs for the dioxins and furans were also highest close to the dock and decreased rapidly with distance from the dock. Total TEQs were highest at sites within 25 m (up to 1,320 pg/g 2,3,7,8-T4CDD toxic equivalents), and suggests there is significant toxic and bioaccumulation potential associated with this sediment. However, since I-TEQs are based on mammalian toxicity, they may not be directly applicable to sediment. In addition, the availability of highly chlorinated compounds, such as OCDD are usually overestimated on the basis of partitioning coefficients, since molecular size has been suggested as limiting the passage of large molecules across cell membranes (Smith *et al.* 1988).

Benthic community structure. Benthic communities at the sample sites consisted primarily of oligochaetes and chironomids. Oligochaete density and diversity did not show any relationship with sediment PAH or PCDD/F levels (benthic samples were not collected in the creosote pool). Chironomid density was found to vary with sediment PAH concentrations, though the correlation was weak ($r = -.6794$; $p<0.05$). At distances greater than 150 m from the dock, neither showed a response to sediment PAH concentrations, which in this area were typically less than 30 mg/kg.

Laboratory sediment bioassay. Whole-sediment toxicity tests were conducted using the mayfly nymph, *Hexagenia limbata* (21-day exposure, survival and growth); the midge larva, *Chironomus tentans* (10-day exposure, survival and growth); and the juvenile fathead minnow, *Pimephales promelas*

(21-day exposure, survival and chemical bioaccumulation). The battery of sediment toxicity tests used provide a number of endpoints, using organisms representing different trophic levels in order to measure differences in sediment quality. Spatial differences can be ascertained among test sites, as well as against low level contamination using appropriate control sediment.

Conductivity, pH, total ammonia, un-ionized ammonia and dissolved oxygen parameters were measured in the overlying water periodically during the course of the bioassay. pH ranged from 7.0 to 8.2 and conductivity from 279 to 447 umho/cm. Total ammonia readings in the overlying water were elevated for the majority of the test sediment and the reference sediment in the minnow sediment bioassay. Temperature averaged 20°C to 21°C for each bioassay.

Mayfly lethality results showed that within 100 m of the dock mortality was significantly higher at certain test sites relative to both negative and reference control sediment ($p<0.0073$). Sediment collected from Station T-5.5-75 m and T-EF-25 m was found to be acutely toxic (100% mortality). Observations made within the first 24 hours on these test chambers indicated that all of the animals were on the sediment surface. The mayflies showed minimal activity such as swimming or attempts at burrowing, thereby exhibiting strong avoidance behavior. Mayfly avoidance was also noted at Station T-5.5-25 m during the first four days and significant lethality (50% mortality) occurred by Day 21. Mayfly percent mortality was less than 10% for all control and test sediment beyond 100 m from the dock, with no statistical differences reported between the test sediment relative to either control sediment (Dunnett's *t*-test, $p<0.05$). Significant differences in the sub-lethal growth endpoint were measured among sites within a 100 to 150 m distance along T-5.5 ($p<0.0001$). The data, represented by individual fresh weights, showed a 50% growth reduction. Animals exposed to sediment collected from beyond 175 m attained similar or higher weights as the reference control mayflies.

Chironomid lethality and growth results indicate that within 100 m of the dock, significantly higher lethality was noted for three of the test sediment ($p<0.0001$). After 10 days, percent mortality ranged from 54% to 100%. Percent mortality for the midge ranged from 0% to 17% for sites beyond the 100 m distance. Control mortality ranged from 15% to 16% and was below the acceptable control mortality criterion of 25%. Sediment which yielded poor organism survival also resulted in lower body weights ($p<0.0001$). Similar to the mayfly assay, a 50% growth reduction in the midge was reported at Stations T-5.5-100 m, -125 m and -150 m and was significantly lower than those attained for control sediment along with the remaining test sediment ($p<0.0001$).

Fathead minnow lethality results showed that within the 100 m zone percent mortality among treatments were significantly different ($p<0.0001$). The most toxic sediment was Station T-5.5-75 m (73% mortality) and Station T-EF-25 m (93% mortality). Fish exposed to Station T-5.5-75 m and T-EF-25 m sediment exhibited a loss of equilibrium with a tendency to swim in a vertical manner within 24 hours after their introduction into the test chambers. Avoidance of the sediment, reduced swimming activity, and lack of sediment disturbance continued for at least four days. Mortality first occurred on Day 16 and continued until Day 21. Beyond the 100 m zone, percent mortality for Station T-5.5-150 m (66% mortality) and T-5.5-175 m (56% mortality) was significantly higher than both control minnow survival values. Minnow mortalities began on Day 14 and continued until Day 21. Sediment avoidance behavior was also noted within the first 48 hours for Station T-5.5-100 m and T-5.5-125 m exposures.

There is an association between the concentrations of PAH compounds measured in the bioassay test sediment and the degree of biological effects. The incidence of significantly higher organism mortality was greater for sediment collected within 100 m of the dock. Acute toxicity to the mayfly and midge was measured along the two transects at distances of 25 m and 75 m, respectively. This sediment had an oily sheen and emanated a strong to moderate odor of a creosote-type compound.

Sediment collected between 100 m and 150 m along transect T-5.5 elicited significantly poorer midge and mayfly growth, relative to the sediment collected at a greater distance. Differences appear to be attributable to sediment total PAH concentrations. The LC_{50} for the mayfly and midge toxicity tests correspond to a sediment total PAH concentration of 150 mg/kg (based on field surficial sediment data). This value is similar to that reported for the amphipod, *Diporeia sp.*, in a dose-response laboratory experiment using PAH-spiked sediment in a 26 day test. Landrum *et al.* (1991) found a lethal exposure concentration of 100 mg/kg dry weight for total PAHs and the mode of toxic response was attributed to nonpolar chemical narcosis. The lack of minnow toxicity at Stations T-5.5-100 m and T-5.5-125 m appear to be correlated with fish avoidance to the contaminated sediment. Sediment collected at Station T-5.5-150 m and Station T-5.5-175 m, resulted in significantly higher fish mortality relative to the negative and reference control sediment.

Chemical bioaccumulation concentrations in *Pimephales promelas* are based on unequal sample sizes due to the loss of animals and insufficient biomass across all treatments. A gradient in PAH accumulation was evident. Minnow tissue PAH concentrations were significantly correlated to the total PAH sediment concentrations ($r=0.76$; $p<0.01$). The highest total PAH concentrations in minnow tissues was recorded for station T-5.5-150 m (8,844 ng/g), followed by station T-5.5-125 m (3,953 ng/g). Trace amounts were also detected in minnows exposed to station T-5.5-100 m sediment. Non-detectable amounts were reported for the remaining control and test animals sediment (2,680 ng/g) and were representative of pre-exposure conditions.

The significantly lower chemical accumulation by minnows at station T-5.5-100 m, despite the relatively high sediment total PAH concentration of 213 mg/kg, could be due to the stronger avoidance behavior by the minnows. Reduced feeding and sediment disturbance could have resulted in lower chemical uptake. A similar effect, but to a lesser degree, occurred at station T-5.5-125 m. The relatively low accumulation of PAHs in fathead minnows is a result of the ability of many vertebrates, including fish, to metabolize PAHs and their rapid elimination through the bile, feces and urine (Kennedy and Law 1990). The enzyme system that is principally involved in the biotransformation of PAHs is the cytochrome P-450 mixed function oxidase (MFO) system. All these factors would maintain concentrations in the fish at levels lower than those found in the sediment. However, tissue concentrations remain a valuable measure of PAH relative availability.

Discussion

The Ministry protocol requires that where sediment contaminant concentrations exceed the PSQGs SEL guidelines, additional biological assessment needs to be undertaken. Levels of total PAH in sediment exceeded the SEL for total PAH at a number of sites adjacent to the dock (SELs are based on TOC correction and are site-specific).

The biological tests included both benthic community assessment and laboratory sediment bioassays. The biological testing is designed to determine the severity of the contamination. Benthic community studies determine the in-place effects of the contaminants on the existing organisms. Laboratory bioassays assess the effects of contaminants under controlled static conditions of heightened potential availability through both toxic effects (i.e., lethal and sub-lethal effects, such as growth inhibition) and chemical bioaccumulation.

Benthic community structure. The benthic communities within the 100m zone showed effects that could be attributed to sediment PAH concentrations. In particular, the chironomid community showed reductions in density with higher sediment concentrations of total PAH. Along transects T-5.5 and T-7/9, stations close to the dock (25 m) had significantly fewer chironomids and fewer taxa. Since substrate type and depth was relatively uniform along these two transects, the most likely factor was the increase in sediment total PAH concentrations (chironomid density did show a weak negative correlation with sediment total PAH). A simple regression of density versus sediment total PAH suggests that a 50% reduction in chironomid density would correspond to approximately 150 mg/kg total PAH in sediment.

Benthic community structure analysis indicated that beyond the 100 m zone, the benthic community as a whole did not show any direct effects of high sediment concentrations of PAH. Since much of the PAH is present as discrete blobs or drops of oil, it would be relatively easy for most organisms to avoid these areas. This could account for the lack of response to higher PAH concentrations by many organisms. As noted, the distribution of the chironomid fauna does show a correlation with sediment contaminant levels along the north transect T-5.5, and the north-east transect T-7/9 as far as 150 m from the dock, and suggests that sediment PAH is affecting these organisms. Decreases in sediment total PAH concentrations are matched by increases in density of chironomids. The effects on chironomids suggest that below 30 mg/kg total PAH, there is no noticeable reduction in density.

Laboratory sediment bioassay. Sediment bioassay results indicate that there is an increase in both mortality and growth impairment in the benthic species in the sediment close to the dock. Within the 100 m zone, the sediment bioassay results indicate that sediment within 75 m of the dock along transect T-5.5 and within 25 m of the dock along transect T-EF was acutely toxic to both mayflies and chironomids. Sediment from the 100 m to 150 m distance along transect T-5.5 resulted in mayfly and midge growth impairment. At a distance of 175 m and beyond, both growth and mortality were similar to the control values and there was no detectable difference in effects between the test and control exposures. Sediment concentrations were at or below 30 mg/kg total PAH at these distances.

Therefore, at 30 mg/kg total PAH, there appeared to be no effect on these organisms relative to the control stations. Sediment bioassays tend to augment any impacts of sediment-bound contaminants. The process of preparing the sediment prior to testing results in a more complete mixing of any contaminants throughout the sediment, and also potentially heightens the bioavailability of the compounds through disturbance of the sediment. This test, in effect, simulated expected responses under dynamic conditions where mixing, resuspension, and deposition would occur. As a result, it appears from these test results that sediment up to and including 30 mg/kg total PAH could be left in place with no negative effects on benthic communities.

When the test results for the chironomid and mayfly toxicity tests were plotted against surficial field sediment total PAH concentrations, both the mayfly and the chironomid mortality data indicate that there was an increase in mortality with increasing sediment total PAH concentrations. Greater than 50% mortality was found to occur in sediment from the 25 m to the 75 m distance. This corresponded to the zone where sediment total PAH concentrations were in excess of 150 mg/kg. Regression analysis between surficial field sediment total PAH concentrations and bioassay test results found that the area of 50% mortality of chironomids coincided with the 150 mg/kg concentration of total PAH (lower 95% confidence limit) while the area of 50% mortality of mayflies coincided with approximately 130 mg/kg total PAH (lower 95% confidence limit).

Sediment beyond 75 m showed little toxicity to mayflies and chironomids, but there was growth inhibition associated with the sediment. Only at the 175 m distance, where concentrations in sediment were near 30 mg/kg total PAH, did growth rates increase. Growth rates for both mayflies and chironomids stayed high from 175 m to 500 m and equaled or exceeded levels of the control.

Minnow results indicate that there was an increase in mortality at some stations within 100 m of the dock. Along both transects T-5.5 and T-EF, mortality was highest at those locations where sediment total PAH concentrations were highest (i.e., 25 m along T-EF and 75 m along T-5.5).

The bioaccumulation data showed a gradient of PAH accumulation by fathead minnows such that locations close to the dock resulted in higher tissue residues. By 175 m north from the dock, there were no detectable levels in minnow tissues. Analysis of the data showed a significant correlation between tissue residues and sediment total PAH.

Cleanup strategy. The different levels of biological effects were used to define three zones of contamination. Each would merit a different cleanup strategy.

The first, representing the most contaminated conditions, was the area of heavy, visible contamination of sediment by creosote (a creosote 'pool'). This area was located along transect line T-5 and was found to include the 50 m distance, but did not extend to the 75 m distance. Since transects on either side (T-4.5 and T-5.5) of T-5 did not yield similar quantities of creosote in the sediment samples, this area appears to be confined to less than 50 m on either side. Cleanup of this area should proceed based on visual observation of creosote on the sediment surface. This area represents a continual source of creosote (and PAH contamination) to both the water column and adjacent sediment.

The second zone was defined on the basis of acute biological effects, i.e., greater than and including 50% mortality in the test organisms, and coincides with the area of high PAH (>150 mg/kg) and dioxin/furan contamination (>200 ppt total TEQ). This area should be isolated since the toxic potential of the sediment is very high. The approximate boundary of this zone is the area enclosed within the 150 mg/kg total PAH isopleth.

The third zone can be defined on the basis of sub-lethal biological effects and coincides with the sediment area exceeding 30 mg/kg of total PAH. This area is the area enclosed within the 30 mg/kg total PAH isopleth, and represents the area where contaminated sediment should be confined in order to minimize contaminant effects on aquatic biota. Below this concentration, there was no measurable effect on benthic organisms.

Both contaminant concentrations and biological effects are low or not apparent in those areas below 30 mg/kg, and this area would be suitable for natural remediation since existing contaminant concentrations pose little threat to biota. Comparison with an earlier study by Beak (1988) indicate that surficial sediment concentrations of total PAH have decreased since 1987, likely through deposition of cleaner material on the surface. Active deposition of new material would serve to effectively isolate the relatively more contaminated sediment in the deeper layer and would permit longer term degradation of contaminants in this area with little concern regarding potential exposure to aquatic organisms.

Conclusion

Based on the study results, a site remediation plan was developed in conjunction with the property owners. The plan calls for enclosure of the dock behind a clay barrier since seepage from the site is considered to be the source of the contamination. Outside of the clay barrier the plan calls for construction of a rock berm that encloses all of the area where sediment concentrations exceeded 150 mg/kg total PAH. Clean fill is to be placed behind this structure and is to be brought up to grade level (i.e., dry capped). The enclosed area will also contain a treatment cell that can accommodate 20,000 m^3 of sediment which is to be removed from the creosote pool and all areas where existing concentrations of total PAH are in excess of 260 mg/kg. This value is based on Ontario's soil cleanup guidelines for PAH. Soil cleanup guidelines were used since the area to be confined behind the berm will become land. At present, the plans call for biological treatment within the cell. Areas where sediment concentrations of total PAH were below 30 mg/kg would be left to remediate naturally.

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DECIDING WHEN TO INTERVENE

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Based on a Workshop to Evaluate Data Interpretation Tools used to Make Sediment Management Decisions held at the Great Lakes Institute for Environmental Research at the University of Windsor on December 1-2, 1998

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Sediment Priority Action Committee
Great Lakes Water Quality Board

1999

APPENDIX 17

REPORT FROM BREAKOUT GROUP B

Brief summary of breakout group B

Breakout Group B was facilitated by Marcia Damato (U.S. EPA) and David Cowgill (U.S. EPA).

Breakout Group B discussed the circumstances under which one would utilize the "Weight of Evidence" approach to sediment assessment vs. a "Tiered Approach". Whichever framework is selected should be consistent at a scientific level in its approach and information. It should also accommodate any size and scope of a project. The group acknowledged that there is considerable frustration associated with dealing with contaminated sediment because of the slow progress of remediation.

Weight of evidence approach vs. tiered approach

The group discussed the "Tiered Approach" and determined that it is useful for smaller, less complex sites such as Collingwood Harbour, but is not as applicable in an area such as the Detroit River Area of Concern. A "Weight of Evidence" approach should often be used on larger, more complex projects. The group noted that chemistry can't be disconnected from the biology for Superfund Sites. For example, in the Great Lakes, nearly all Superfund Projects use the "Weight of Evidence" approach. Sometimes the "Weight of Evidence" approach and the "Tiered Approach" result in the same decisions being made. The group noted that when working with industry in a partnering/cooperative forum where their involvement is voluntary, a reasonable approach is to use a limited amount of data that has been accepted by all parties. The group agreed that the cost of cleanup is a factor in both approaches.

Weight of Evidence	Tiered
Larger Scale	Smaller Scale
Complex	More simple
Non-voluntary	Voluntary parties

Multiple Sources	Single Source

After the science is accepted in defining a problem, then the next steps must be determined. There must be consistency in data interpretation. The group acknowledged the influence of social-political pressures on contaminated sediment problems. The group agreed that the approach should be science-based and the social-political influence should be limited. Science should be used to achieve a comfort level for the decision being made and social-political considerations should be considered later in the process.

Data elements and assessment

The group then discussed some of the important information that should be incorporated into a consistent framework. The following data elements were identified which will help determine the extent of risk from sediment contamination. Is there a risk to:

- Aquatic Life?
  (i.e., toxicity, bioaccumulation, chemistry, and impaired benthic community)
- Wildlife?
  (i.e., bioaccumulation, biomagnification) Human Health?
  (i.e., exposure, biomagnification, fate, and transport)

The logic of what entails a complete assessment was discussed next. The group discussed the importance of making a determination of: whether sources of contamination have been controlled; the extent of risk to aquatic, wildlife, and human receptors; whether sediment deposits will move over time; and being able to predict when the system will recover (using models to predict when fish consumption advisories will no longer be needed under various remedial options such as dredging, capping, and natural recovery) so that all 14 beneficial uses have been restored. The following logical steps were identified:

1. Risk Assessment (aquatic, wildlife, and human risk)

2. Benefits Forecasting:

Purpose-	Demonstrate benefits and restoration of beneficial uses; public, private, governments
Method-	Sources, transport, fate, effects (i.e. mass balance models)
Procedure-	Perform the following checks: What are the sources? Are they controlled? Is it feasible to remediate? Where to remediate? How much? What will happen if: No further action is taken (natural recovery)? A catastrophic event occurs? Other selected scenarios occur? We achieve the maximum remediation bound (i.e. if we take out everything, how much good will it do)?
Endpoints-	sediment contaminant concentration, fish concentrations (over time), toxicity benthic community
Engineering issues-	disposal, removal methods, risk to wildlife, risk to habitat

Summary and conclusions

Finally, the group attempted to summarize what had been discussed, recognizing that a number of important factors had been identified. One concept that was posed was that if one were asked to perform a peer review of someone else's sediment management decision, what criteria would you use to evaluate the quality of the decision? This appears to be a concept that could be of use in ensuring that all of the important factors identified above, and aggregated during the plenary session, are given thorough consideration for all Great Lakes sediment projects, regardless of the organization that is responsible for the project and the particular program making the decision.

The group discussed the importance of a Great Lakes protocol that would address sampling, QA/QC, assessment, and data interpretation. The group recommended that there may be a need for "bench marking" (baseline from which we make decisions) among the two provinces, eight states, and two federal governments for three categories of data elements and source control, natural recovery, etc. It was noted that the Great Lakes Water Quality Initiative in the United States took eight years of coordination, consensus building, and administrative rule-making to develop consistent water quality standards for the Great Lakes. Any such protocol would likely be very resource intensive and time-consuming. Therefore, a first step could be to "bench mark", or document, the existing decision-making frameworks now being used. It was noted that the United States Environmental Protection Agency published a document in 1990 entitled "Managing Contaminated Sediment: EPA Decision-Making Processes."

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APPENDIX 16

REPORT FROM BREAKOUT GROUP A

Brief summary of breakout group A

Breakout Group A was facilitated by Gail Krantzberg (MOE) and John Hartig (IJC).

Breakout Group A defined and discussed the critical data elements that should be considered within a framework, addressed the various decision-making tools, examined the role of these decision-making tools in the restoration of beneficial uses, and proposed an "Integrated Framework" for sediment management decisions.

The goal for each of the Breakout Groups was to provide advice on use of data interpretation tools used to make sediment management decisions.

Data elements and conceptual decision-making rules

The first point to be addressed was the problem with decision-making rules in regard to the exact point where we see enough scientific evidence to say "take action". Although there may be similar data at two sites, decisions to act may be for entirely different reasons. So the question was posed: Do we use the same decision-making method at every site, or should the method be more site-specific? There was an agreement throughout the Group that there should be consistent data interpretation rules and protocols applied to all Areas of Concern.

Then the following question was asked: Does a certain result of a protocol lead to the decision to act or not act? A result of a protocol doesn't necessarily determine the action, a combination of tests do. Additional knowledge is necessary. For example, in regard to research needs, ecologically defined points of departure from reference conditions needs to be defined using the direction of the trajectory with respect to distance from the reference condition and with respect to time.

- Stability
- Chemistry

You cannot base a "no action" decision on any one element solely. Generally, you base a decision on the integration of these five elements through interpreting data sets and attempting to determine causality and linkages to beneficial uses.

Proposed Framework

Review Impaired Uses

↓

Perform preliminary screening of linkages between contaminated sediment and use impairments:
-- Benthic communities
-- Lab Toxicity
-- Bioaccumulation/Biomagnification
-- Stability
-- Chemistry

↙ ↘

No major problem if first four are alright	Problem if any are substandard
↓	↓
Continue with routine monitoring	Perform intensive assessment of quantitative relationships between contaminated sediment and use impairments. Then integrate data sets to make decision "to act" or "take no further action"

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APPENDIX 18

SEDIMENT PRIORITY ACTION COMMITTEE MEMBERSHIP

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