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Environment Canada
Water Science and Technology Directorate

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Environnement Canada

Contaminated Sediment Management for Ecological Recovery

By:
J. Hartig, M. Zarull, G. Krantzberg, L. Maynard

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CONTAMINATED SEDIMENT MANAGEMENT FOR ECOLOGICAL RECOVERY

John H. Hartig
International Joint Commission
P.O. Box 32869
Detroit, MI 48232

Michael A. Zarull
National Water Research Institute
Lakes Research Branch
Canada Centre for Inland Waters
867 Lakeshore Road, P.O. Box 5050
Burlington, ON L7R 4A6

Gail Krantzberg
Ontario Ministry of Environment
135 St. Clair Ave. W.
Toronto, ON M4V 1K5

Lisa Maynard
International Joint Commission
P.O. Box 32869
Detroit, MI 48232

MANAGEMENT PERSPECTIVE

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Author: J.H. Hartig, **M.A. Zarull,** G. Krantzberg and L. Maynard

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Current Status: This manuscript has been produced as a result of four years of working on the issue as part of a committee of experts formed by the International Joint Commission and reporting to the Great Lakes Water Quality Board. A synopsis of the work to date has been presented to the IJC and aspects of the work are provided on the IJC's WQB web pages.

Next Steps: Aspects of the committee's work are continuing (e.g., Economic Benefits Assessment). A brief presentation on aspects of the work will be made prior to a workshop, at the IJC's meeting in Mil

ABSTRACT

In the Great Lakes Basin there are 42 degraded areas called "Areas of Concern" where there are significant environmental problems referred to as impaired beneficial uses. In each case there is a multi-stakeholder process in place to develop and implement a Remedial Action Plan (RAP) to restore uses. All 42 Areas of Concern have contaminated sediment based on the application of chemical guidelines. In addition, there is a consensus among government, industry, non-governmental organizations, and RAP groups that contaminated sediment is a major cause of environmental problems, as well as a key factor in restoring 11 of the 14 beneficial use impairments identified in the Great Lakes Water Quality Agreement.

In general, contaminated sediment management options include: source control and natural recovery; removal and containment in a confined disposal facility or upland containment cell; removal and treatment; and *in situ* capping or treatment. Over the past thirteen years, over $570 million has been spent on 37 remediation projects in 19 Areas of Concern. Not only have substantial resources been spent on sediment remediation, but the rate has increased in recent years. In addition, substantially greater resources have been spent on pollution prevention and control of contaminants at their source as a prerequisite to sediment remediation.

Many of the sediment remediation projects were implemented as a result of regulatory actions. In the United States, 30 contaminated sediment remediation projects were implemented as a result of regulatory actions and one was the result of a public-private partnership. In Canada, 6 contaminated sediment projects have been implemented, 5 by cooperative partnerships and one as a result of industrial action.

Of the sediment remediation projects implemented thus far, only two (e.g., Waukegan Harbor, Illinois and Black River, Ohio) currently have adequate data and information on ecological effectiveness (i.e., post-project monitoring demonstrating the recovery of beneficial uses).

The practice of sediment management involves both preventive and remedial practices. Preventive practices include both: point and nonpoint source control measures to minimize sediment loading to rivers, harbors, and lakes in order to help keep ports and waterways open for navigation; and point and nonpoint source measures to control contaminants like persistent organic compounds and heavy metals at their source. Remedial practices include both: dredging to remove accumulated sediment and maintain historical navigational depths; and remediation of areas where contaminants like persistent organic compounds and heavy metals have accumulated and resulted in ecological impacts and elevated risk to human health.

Over the past 20 years, considerable progress has been made in the control and management of point and nonpoint sources of contaminants. Dredging for navigational purposes continues to be a priority in order to maintain the economic viability of ports and waterways. However, remediation of contaminated sediment has only recently increased in management priority as point and nonpoint source control efforts have matured, and yet certain beneficial uses remain impaired.

For example, reduced loadings of contaminants from point and some nonpoint sources have, in general, resulted in a 50-70% reduction of contaminant levels in fish between the early 1970s and the mid 1980s. However, since the mid 1980s, levels of contaminants have generally either leveled off or their rate of decrease has slowed substantially. Health advisories on certain fishes remain in effect in all of the Great Lakes. It is believed that the major reason why contaminant levels in fish have generally leveled off and health advisories on human consumption of fish remain in effect is that there are continued inputs of contaminants from the atmosphere, land runoff, and contaminated sediment.

Importance of Contaminated Sediment Issue

The importance of the contaminated sediment issue continues to rise in both the United States and Canada. For example, the U.S. Environmental Protection Agency's (EPA) Region V has identified cleaning up contaminated sediment as one of its top five priorities in its Agenda for Action for fiscal years 1998 and 1999. The Agenda for Action states that:

> ***"Polluted sediments are the largest major source of contaminants to the Great Lakes food chain, and over 97% (5,171 miles) of the shoreline is considered impaired. The Region V inventory contains 346 contaminated sediment sites. Fish consumption advisories remain in place throughout the Great Lakes and many inland lakes. Contaminated sediments also cause restriction and delays in the dredging of navigable waterways, which in turn can negatively affect local and regional economies. Contaminated sediments must be cleaned up before they move downstream or into open waters, which makes them inaccessible and cleanup impossible."***

Contaminated sediment has been identified as a source of ecological impacts throughout the Great Lakes Basin. While contaminated sediment is not designated as a specific impairment in Annex 2 of the Canada-United States Great Lakes Water Quality Agreement, in-place pollutants potentially pose a challenge to restoring 11 of the 14 beneficial use impairments: restrictions on fish and wildlife consumption; degradation of fish and wildlife populations; fish tumors or other deformities; bird or animal deformities or reproductive problems; degradation of benthos; loss of fish and wildlife habitat; eutrophication or undesirable algae; degradation of phytoplankton or zooplankton populations; degradation of aesthetics; added costs to agriculture or industry; and restrictions on dredging activities.

Sediment Remediation and Benefits

In the Great Lakes Basin there are 42 degraded areas called "Areas of Concern" where there are significant environmental problems referred to as impaired beneficial uses. In each case there is a multi-stakeholder process in place to develop and implement a Remedial Action Plan (RAP) to restore uses. All 42 Areas of Concern have contaminated sediment based on the application of chemical guidelines. In addition, there is a consensus among government, industry, non-governmental organizations, and RAP groups that contaminated sediment is a major cause of environmental problems, as well as a key factor in restoring 11 of the 14 beneficial use impairments identified in the Great Lakes Water Quality Agreement.

In most Areas of Concern, documentation of a sediment problem has not been quantitatively coupled to the ecological impairments. Therefore, stipulating how much needs to be cleaned up, why, and what improvements can be expected to the beneficial use impairment(s) over time has not been possible. A clear understanding of these relationships and some level of quantification is critical for the development of a complete sediment management strategy. This understanding should provide adequate justification for sediment management. In developing this requisite understanding, it is important not only to know the existing degree of ecological impairment associated with sediment contaminants, but also the circumstances under which those relationships and impacts might change (i.e., contaminants become more available or more detrimental).

In general, contaminated sediment management options include: source control and natural recovery; removal and containment in a confined disposal facility or upland containment cell; removal and treatment; and *in situ* capping or treatment. Over the past thirteen years, over $570 million has been spent on 37 remediation projects in 19 Areas of Concern (Figure 1). Not only have substantial resources been spent on sediment remediation, but the rate has increased in recent years. In addition, substantially greater resources have been spent on pollution prevention and control of contaminants at their source as a prerequisite to sediment remediation.

Many of the sediment remediation projects were implemented as a result of regulatory actions (Table 1). In the United States, 30 contaminated sediment remediation projects were implemented as a result of regulatory actions and one was the result of a public-private partnership. In Canada, 6 contaminated sediment projects have been implemented, 5 by cooperative partnerships and one as a result of industrial action.

Of the sediment remediation projects implemented thus far, only two (e.g., Waukegan Harbor, Illinois and Black River, Ohio) currently have adequate data and information on ecological effectiveness (i.e., post-project monitoring demonstrating the recovery of beneficial uses).

In Waukegan, Illinois approximately 453,600 kg (one million pounds) of PCBs were removed from the Outboard Marine Corporation site as a result of a 1989 Consent Decree. In all, 26,500 m^3 of PCB-contaminated sediment were removed. Over $20 million were spent on this sediment remediation project. Post project monitoring has shown that PCB levels in fish have declined by 80-90% as a result of sediment remediation. Substantial benefits have now been realized in Waukegan. These include:

- the Waukegan Harbor fish advisory has been removed;
- revenues in the Waukegan Port District have increased; and
- interest in harbor development has increased, which has led to increases in sales and property values for the City of Waukegan.

The other example of ecological effectiveness is the Black River, Ohio. In this case, approximately 38,000 m^3 of PAH-contaminated sediment were removed and placed in an upland containment cell as a result of a 1985 Consent Decree with USS/KOBE Steel. The cost of this project was $1.5 million. As a result of this sediment remediation project, PAH levels in sediment have declined substantially (two orders of magnitude) and cancerous liver tumors have now been eliminated in the resident brown bullhead (*Ictalurus nebulosus*) population.

Management Needs

In some cases where sediment remediation has occurred there is planned monitoring of ecological effectiveness, but the data will not be available for a number of years. In the cases where sediment remediation was undertaken as a result of regulatory action, the projects were designed to remove a mass of contaminants in order to reduce environmental risk. These projects were very effective in meeting the regulatory requirements and indeed are consistent with the step-wise and incremental approach to management of contaminated sediment called for by the International Joint Commission's Great Lakes Water Quality Board. However, it is recognized that in many cases, much more effort should be placed on forecasting and assessing ecological recovery of an Area of Concern, as well as beneficial use restoration consistent with Annex 2 of the Great Lakes Water Quality Agreement. Therefore, it is recommended:

- **that much greater emphasis be placed on post-project monitoring of effectiveness of sediment remediation (i.e., assessment of effectiveness relative to improved ecological conditions, with appropriate quality assurance/quality control).**

One way of achieving this would be for the State/Provincial/Federal agency staff responsible for sediment remediation to incorporate into settlements and cooperative agreements some specific commitments and resources required for post-project monitoring of effectiveness of sediment remediation. Good examples of this include the Welland River project (Ontario), the settlement under the National Resources Damage Assessment for Saginaw River and Bay (Michigan), and the Thunder Bay cleanup project (Ontario).

Globally, the best documented ecological changes following sediment remediation are associated with actions relating to nutrient problems, generally in small lakes and ponds and in areas of low human population density, and usually the least costly remediations. Since affiliated research and monitoring have been so lacking, it has been difficult to evaluate the overall success of sediment remediation, in a general sense (i.e., to reasonably transfer lessons learned and recommendations on what things are still essential to know, and to achieve cost-effective and essential ecological remediation).

It is also recognized that ecological benefits of sediment remediation may not be seen because of the magnitude of the contaminated sediment problem in the area and in remaining downstream areas of contamination, which would mask or delay ecological recovery (e.g., Grand Calumet River/Indiana Harbor Ship Canal, Indiana). Areas of Concern where the probability of measuring ecological benefits of sediment remediation is high include: Manistique River, Michigan; Collingwood Harbour, Ontario; River Raisin, Michigan; Newburgh Lake Impoundment on the Rouge River, Michigan; and the Ottawa River which is a tributary to the Maumee River, Ohio. It is recommended that:

- **a high priority be placed on monitoring ecological recovery at these sites.**

Although a basic understanding of aquatic ecosystem function and chemical fate is generally available, aquatic ecosystems appear to be sufficiently unique and our understanding sufficiently lacking. Therefore, an adaptive management approach is the prudent course to follow. This approach requires a much tighter coupling of research, monitoring, and management in every case to develop quantifiable, realistic goals and measures of success to achieve them.

Clearly, there are knowledge gaps in our understanding of the relationships between contaminated sediment and the 11 use impairments from the Great Lakes Water Quality Agreement that are potentially effected by contaminated sediment. Therefore, it is further recommended that:

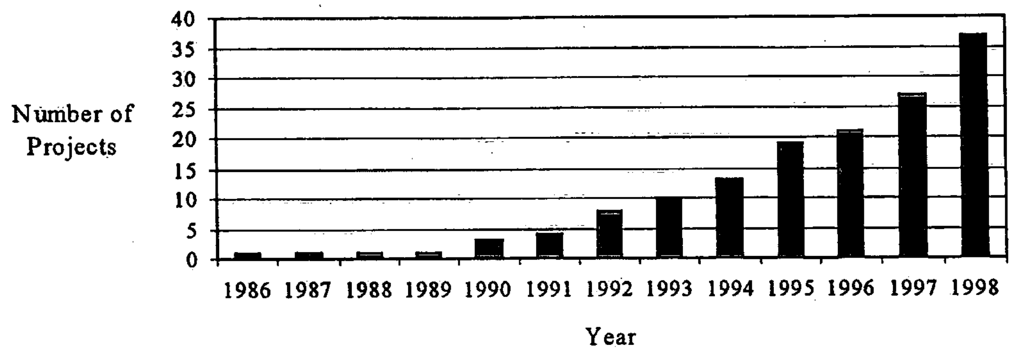
- **more research be applied to quantifying the relationships between contaminated sediment and known use impairments, in forecasting ecological benefits, and monitoring ecological recovery and beneficial use restoration in a scientifically defensible and economically feasible fashion.**

Concluding Remarks

Experience within the Great Lakes Basin has shown that good scientific assessments of contaminated sediment can save money, and that properly targeted remediation can result in both ecological and economic benefits. Therefore, contaminated sediment remediation can be a catalyst in the turnaround of waterfronts, which is important in shaping the future of many cities within the 42 Areas of Concern in the Great Lakes Basin.

Figure 1. Trends in sediment remediation in Great Lakes Areas of Concern: A. Cumulative number of sediment remediation projects; B. Cumulative financial resources expended on sediment remediation; and C. Cumulative volume of sediment removed.

A.



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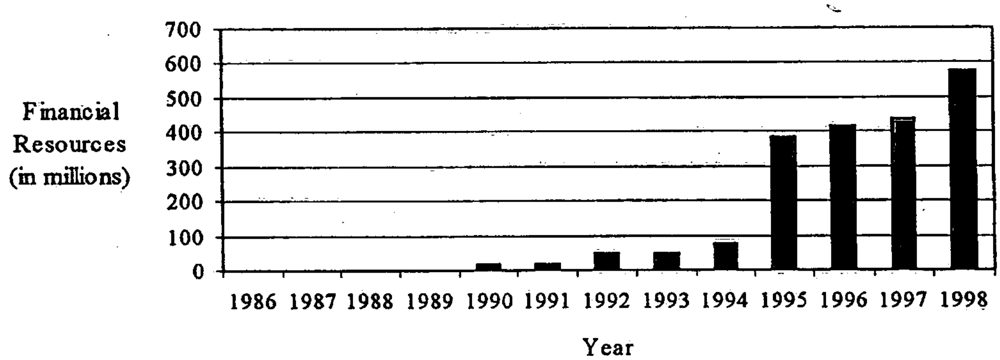

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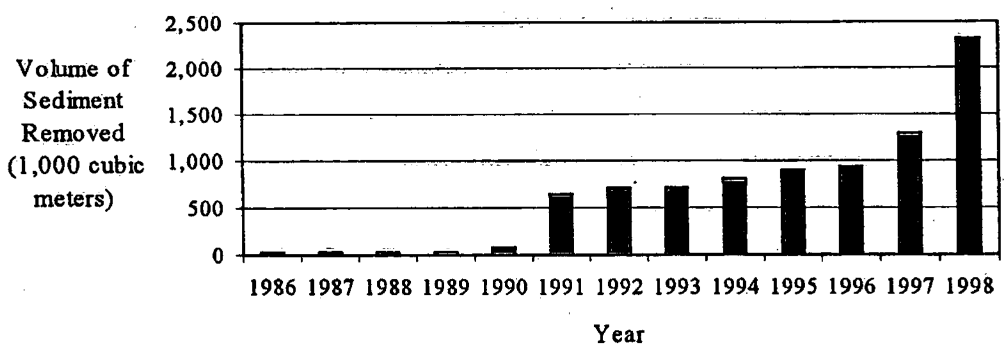

Table 1. Contaminated sediment remediation projects in Great Lakes Areas of Concern.

Area of Concern	Location or Site	Nature of Project	Sediment Volume Removed or Treated	Date	Cost
Thunder Bay	Northern Wood Preservers, Inc.	Dredging, treatment, and disposal	13,000 m^3	1998	$9.3 million (Can.)
St. Louis River/Bay	Newton Creek	Dredging, treatment, and disposal	1,900 m^3	1997	$250,000 (U.S.)
Manistique River	Harbor	Dredging and disposal	23,700 m^3	1998	Total cost - $25 million (U.S.)
	River and harbor	Dredging and disposal	19,100 m^3	1997	
	North Bay	Dredging and disposal	13,000 m^3	1995-1996	
Lower Menominee River	Eighth Street slip	Dredging and disposal	7,700 m^3	Expect completion by end of 1999	$1.3 million (U.S.)
	River	Dredging, treatment, and disposal	11,500 m^3	1993-1994	$50,000 (U.S.)
Milwaukee Estuary	Ruck Pond dam	Dredging and disposal	5,900 m^3	1994	$7.5 million (U.S.)
	North Avenue dam	Dam abandonment, and dredging and disposal	570,000 m^3	1991	$1,348,000 (U.S.)
Waukegan Harbor	Outboard Marine Corporation	Dredging, treatment, and disposal	30,000 m^3	1992	$20 million (U.S.)
Grand Calumet River	Lower river	Dredging and disposal	535,600 m^3	Expect completion in 2004	$30 million (U.S.)
	Slip adjacent to Indiana Harbor	Dredging and disposal	89,000 m^3	1994-1996	$14 million (U.S.)

Kalamazoo River	Davis Creek	Dredging and disposal	3,700 m^3	1999	$900,000 (U.S.)
	Bryant Mill Pond	Dredging, treatment, and disposal	68,900 m^3	Expect completion by end of 1999	$7.5 million (U.S.)
Saginaw River/Bay	River	Dredging and disposal	264,000 m^3	Expect completion in 2001	$10.9 million (U.S.)
	South Branch of Shiawassee River	Dredging and disposal	35,600 m^3	Expected to begin in 2001	$13,558,000 (U.S.)
Colling-wood Harbour	Harbour and shipyard slips	Dredging and disposal	8,000 m^3	1992-1993	$650,000 (Can.)
Rouge River	Newburgh Lake	Dredging and disposal	306,000 m^3	1997-1998	$11 million (U.S.)
	Evans Products ditch	Dredging and disposal	7,300 m^3	1997	$750,000 (U.S.)
	Lower river	Dredging and disposal	30,000 m^3	1986	$1 million (U.S.)
River Raisin	Lower river	Dredging and disposal	20,000 m^3	1997	$6 million (U.S.)
Maumee River	Unnamed tributary to Ottawa River	Dredging and disposal	6,100 m^3	1998	$5 million (U.S.)
	GenCorp's Textileather plant	Dredging, treatment, and disposal	4,900 m^3 and 466,170 L of liquid waste	1994	$2 million (U.S.)
Black River	River	Dredging, treatment, and disposal	38,000 m^3	1990	$1.5 million (U.S.)

Hamilton Harbour	Harbour	*In situ* capping	34 cm cap placed over 10,000 m^2	1995	$650,000 (Can.)
	Industrial boat slip	*In situ* treatment	4,800 m^2 treated 30 cm deep	1992-1994	$323,000 (Can.)
St. Clair River	South of Cole Drain	Dredging and disposal	200 m^3	1996	$350,000 (Can.)
Detroit River	Monguagon Creek	Dredging and disposal	19,300 m^3	1997	$3 million (U.S.)
	Marina near Elizabeth Park	Dredging and disposal	3,100 m^3	1993	$1.3 million (U.S.)
Niagara River	102nd Street embayment	Dredging and disposal	21,800 m^3	1996	$30 million (U.S.)
	Welland River	Dredging and disposal	10,000 m^3	1995	$2.6 million (Can.)
	Pettit Flume	Dredging and disposal	11,500 m^3	1995	$23 million (U.S.)
	Gill Creek	Dredging and disposal	6,100 m^3	1992	$10 million (U.S.)
	Black and Bergholtz Creeks	Dredging and disposal	13,000 m^3	1990	$14 million (U.S.)
St. Lawrence River	River (Reynolds Metals site)	Dredging and disposal	59,370 m^3	Expect completion by end of 2000	$62.4 million (U.S.)
	River (General Motors site)	Dredging, treatment, and disposal	11,500 m^3	1995	$10 million (U.S.)
	Grasse River (ALCOA site)	Dredging and disposal	3,000 m^3	1995	Land-based and contaminated sediment remediation totaled $250 million (U.S.)

Environment Canada Environnement Canada

Canada

Canada Centre for Inland Waters
P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
L7R 4A6 Canada

National Hydrology Research Centre
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5 Canada

St. Lawrence Centre
105 McGill Street
Montreal, Quebec
H2Y 2E7 Canada

Place Vincent Massey
351 St. Joseph Boulevard
Gatineau, Quebec
K1A 0H3 Canada

Centre canadien des eaux intérieures
Case postale 5050
867, chemin Lakeshore
Burlington (Ontario)
L7R 4A6 Canada

Centre national de recherche en hydrologie
11, boul. Innovation
Saskatoon (Saskatchewan)
S7N 3H5 Canada

Centre Saint-Laurent
105, rue McGill
Montréal (Québec)
H2Y 2E7 Canada

Place Vincent-Massey
351 boul. St-Joseph
Gatineau (Québec)
K1A 0H3 Canada